Final Report
of the
2018 AAS Task Force on Diversity and Inclusion
in Astronomy Graduate Education

Task Force Members:
Marcel Agüeros, Columbia Univ. (AAS Board liaison)
Gibor Basri, UC Berkeley (co-Chair)
Ed Bertschinger, MIT
Kim Coble, San Francisco State Univ. (CSMA representative)
Megan Donahue, Michigan State Univ., ex-officio (President, AAS)
Jackie Monkiewicz, ASU (WGAD representative)
Alex Rudolph, Cal Poly Pomona (co-Chair)
Angela Speck, Univ. of Missouri (CSWA representative)
Keivan Stassun, Vanderbilt Univ. (SGMA representative)

Advisors to the Task Force:
Rachel Ivie, AIP
Christine Pfund, Univ. of Wisconsin-Madison
Julie Posselt, Univ. of Southern California (Senior advisor)

AAS Staff Liaison to the Task Force:
Michelle Farmer, AAS

Admissions Working Group:
Marcel Agüeros, Columbia Univ., co-Chair
Keivan Stassun, Vanderbilt Univ., co-Chair
Peter Frinchaboy, Texas Christian Univ.
Jenny Greene, Princeton Univ.
Emily Levesque, Univ. of Washington
Julie Posselt, Univ. of Southern California, Advisor
Seth Redfield, Wesleyan Univ.
Alex Rudolph, Cal Poly Pomona

Retention Working Group:
Kim Coble, San Francisco State Univ., co-Chair
Angela Speck, Univ. of Missouri, co-Chair
Maryangelly Diaz-Rodriguez, Florida State Univ.
David Helfand, Columbia Univ.
Eric Hooper, Univ. of Wisconsin
Jackie Monkiewicz, ASU
Christine Pfund, Univ. of Wisconsin, Advisor
Alex Rudolph, Cal Poly Pomona

Data Collection and Metrics for Success Working Group:
Ed Bertschinger, MIT, co-Chair
Jackie Monkiewicz, ASU, co-Chair
Richard Anantua, UC Berkeley
Gibor Basri, UC Berkeley
Megan Donahue, Michigan State Univ.
Jarita Holbrook, University of the Western Cape, South Africa
Rachel Ivie, AIP, Advisor
Douglas Richstone, Univ. of Michigan
Meg Urry, Yale Univ.

Table of Contents

2018 AAS Diversity and Inclusion Task Force Executive Summary

EXECUTIVE SUMMARY

At the January 2017 AAS[1] meeting in Texas, the AAS Council approved the creation of a Task Force on Diversity and Inclusion in Graduate Astronomy Education. The Task Force consisted of 8 members of the community chosen to represent a wide range of stakeholders and interests. The membership included two co-chairs, one from a Minority Serving Institution (MSI) and one from a research university, liaisons to each of the four AAS diversity committees (CSWA, CSMA, SGMA, and WGAD[2]), and liaisons to the AAS Board of Trustees. In addition, the Task Force had three advisors, social scientists with expertise in the three main areas of focus of the Task Force: Admissions, Retention, and Data Collection and Metrics for Success. These advisors fully participated in all activities of the Task Force, providing input on the research and practice in support of each recommendation of the Task Force. See Appendix I for short bios of the advisors.

The charge to the Task Force was that the final report to the AAS Board of Trustees should include:

1. the consideration of practices in recruiting, admissions, and retention of students into programs that offer astronomy-related Master's degrees and PhDs, with the goal of identifying those practices that promote diversity and inclusion in graduate programs with regard to race and ethnicity, gender, LGBTIQA* status[3], disability status, neurodiversity, socioeconomic status, and possibly other areas;
2. the building of consensus on evidence-based best practices for recruitment, admissions, mentoring, retention, and (to the extent feasible) curriculum and outcome optimization of a diverse student population in astronomy graduate programs that closely matches the diversity of the US;
3. the development of a statement of best practices for potential adoption by the AAS;
4. the development of guidelines to help astronomy graduate programs who wish to implement these best practices do so; and
5. the development of recommendations for ongoing data collection from graduate programs in astronomy, in order to assess progress in increasing diversity in graduate programs and also in the astronomical field in general.

The Task Force held its first meeting in November 2017. At that first meeting, the Task Force members, to facilitate the work of the Task Force, approved the creation of three working groups, as follows:

1. Working Group on Admissions (including Recruiting)
2. Working Group on Retention (including Mentoring)
3. Working Group on Data Collection and Metrics for Success

Each working group was co-chaired by two Task Force members who recruited additional members from the community. These working groups took primary responsibility for soliciting input from the community around their topic and developing the recommendations contained in this report. In addition, presentations were made to the four AAS Diversity committees (CSWA, CSMA, SGMA, and WGAD) by the Task Force liaisons from each committee to directly solicit their input and feedback. The committees were also given a chance to review this report in draft form to comment. All recommendations were discussed and approved by the entire Task Force. See Appendix II for details of the Task Force creation and timeline of activities.

The Task Force's list of detailed recommendations by category is summarized below. Details of each recommendation, and the justification behind it, including references from social science research supporting the recommendation, are found in the main report. Evidence-based resources and tools that will help in the implementation of the recommendations are included in the Appendices.

[1] American Astronomical Society (AAS)

[2] CSWA is the Committee on the Status of Women in Astronomy; CSMA is the Committee on the Status of Minorities in Astronomy; SGMA is the Committee for Sexual-Orientation and Gender Minorities in Astronomy; WGAD is the Working Group on Accessibility and Disability

[3] LGBTIQA* refers to Lesbian, Gay, Bisexual, Transgender, Intersex, Queer, and Asexual. The * indicates the existence of other sexual preferences and gender identities not listed here

A. Admissions: Goals and Recommendations to Departments

Goals

A. The demographics of students admitted to PhD programs in astronomy should reflect those of the availability pool at the undergraduate level
B. Admissions criteria and processes should be designed to broaden the definitions of excellence and merit to create greater diversity in admitted cohorts
C. Applying to a graduate program should be a transparent, informed process

Recommendations to Departments

1. Partner with and recruit from undergraduate programs that produce large numbers of graduates from underrepresented groups (e.g., MSIs, HSIs[4], and Tribal Colleges)
2. Implement evidence-based, systematic, holistic approaches to graduate admissions, based on the existing literature as well as on self-study when possible
3. Coordinate with graduate schools and other campus offices to ensure that program level policies and practices aimed at diversity and inclusion are supported and amplified at the institutional level

B. Retention: Goals and Recommendations to Departments

Goals

A. End harassment and bullying in and around astronomical workplaces
B. Provide an accessible environment, including but not limited to full ADA[5]-compliance
C. Provide a healthy, welcoming, family-friendly environment
D. Provide effective mentoring through evidence-based practices and expanded networking opportunities
E. Adopt teaching and learning practices that support all students, especially those with marginalized identities

Recommendations to Departments

1. Engage in genuine, open, and sometimes difficult conversations
2. Conduct assessments to identify areas of need or opportunities
3. Create short- and long-term actionable department plans with measurable outcomes that address the five goals
4. Incentivize and support professional development in the support of the five goals
5. Take actions based on the departmental plan and monitor progress toward outcomes, employing inclusive processes
6. Encourage ongoing improvements toward inclusiveness by iterating through the process represented in steps 1-5

C. Data Collection and Metrics for Success: Goals and Recommendations to Departments

Goals

A. Measure progress toward the recommendations regarding Admissions and Retention
B. Measure trends in field-wide demographic and climate data to assess which practices are effective and for whom
C. Help departments advance their goals for diversity, equity, and inclusion using data and metrics for success

[4] Hispanic Serving Institutions (HIS)

[5] Americans with Disabilities Act (ADA) of 1990, a civil rights law that prohibits discrimination based on disability

C. Data Collection and Metrics for Success: Goals and Recommendations to Departments (cont.)

Recommendations to Departments

1. Participate in the recommended AAS/AIP[6] national demographic and climate survey, and encourage all relevant members (e.g., graduate students, postdocs, researchers, faculty) to participate
2. Regularly collect and analyze data relevant to graduate education, including the demographics of applicant pools, admitted and enrolled students, and disaggregated progress and success rates
3. Assess the success of steps taken to improve the educational experience of graduate students using an evidence-based rubric
4. Report results on progress in implementing the recommendations of this Task Force on the platform provided by the AAS, and on departmental websites

D. Goals and Recommendations to the AAS

Goals

A. Measure the status and progress of diversity and inclusion in programs producing graduate degrees in astronomy
B. Provide a platform that incentivizes, recognizes, and disseminates steps that these programs take to increase diversity and inclusion in astronomy
C. Actively participate in the effort to produce, test, and disseminate new promising practices that increase diversity and inclusion in astronomy

Recommendations to AAS

1. Partner with the AIP Statistical Research Center to collect demographic and climate data
2. Recruit departments to adopt the recommendations of this Task Force
3. Create a platform for encouraging departments to adopt best practices and to track their adoption over time
4. Invest in the continued development, sharing, and curation of research- and best-practice-based toolkits that enable graduate programs to implement evidence-based recruitment, admissions, and mentoring practices
5. Encourage participation by the AAS equity committees and working groups in the AAAS[7] SEA Change[8] initiative

[6] American Astronomical Society (AAS) and American Institute of Physics (AIP)

[7] American Association for the Advancement of Science (AAAS)

[8] Science Technology Engineering and Science (STEM) Equity Achievement (SEA) Change

Full Report of the 2018 AAS Diversity and Inclusion Task Force on Astronomy Graduate Education

1. Introduction

1.1 Purpose of the Task Force and National Context

The purpose of the AAS Task Force on Diversity and Inclusion in Astronomy Graduate Education is to provide guidance to leaders in the discipline and its constituent departments about strategies for (1) improving access to advanced education for people from populations that have long been underrepresented and (2) improving the climates of departments where students enroll. The twin goals of improving access to increase diversity and improving climate to enhance inclusiveness are mutually reinforcing, and they are both predicated on a fundamental problem of inequality in participation.

According to the latest statistics from the National Science Foundation (NSF 2015), underrepresented minority (URM)[9] students made up only 3% of PhDs in astronomy between 2002-2012, yet they comprise 30% of the general population. There was a total of 4±2 URM PhDs per year in astronomy during that period nationally – a percentage and a number that are unacceptable and, if astronomy is to succeed as a largely publicly funded and publicly supported endeavor in America, ultimately unsustainable. The 2010 Decadal Survey of Astronomy highlighted this problem, noting that "Little progress has been made in increasing the number of minorities in Astronomy," and recommending "Partnerships of community colleges and minority-serving institutions [MSIs] with research universities and with national centers and laboratories" to overcome this underrepresentation. Little has changed since that report was published.

The inequalities we are looking to address are not new problems for the field, nor are we the first to engage with them. Reports from the National Academies of Sciences, Engineering, and Medicine (NASEM) in 2007, 2011, and 2018 each called attention to the fact that the available talent pool in US STEM is not being utilized and this has been the case for at least 50 years – with rather little progress (NASEM 2007; 2011; 2018a; 2018b). Efforts in astronomy to date, while making a difference in specific places and making a dent in specific problems, are not moving the needle quickly enough at the field level, particularly because the nation's demographics are evolving to make patterns of underrepresentation (and therefore talent underutilization) even worse. For example, the fastest growing racial/ethnic group in the US is Hispanic/Latinx, and although people identifying as such have seen impressive gains in overall academic preparation and college attendance, their rates of PhD attainment and representation in the professoriate lag well behind their share of even the current population.

Graduate education is a crucial place for intervention, for without graduate degrees, astronomers cannot be a part of the research enterprise. It is a crucial part of the opportunity structure in the discipline. The 2011 NASEM report, *Expanding Underrepresented Minority Participation: America's Science and Technology at the Crossroads* named the "transition to graduate study" as one of two key action areas (NASEM 2011). The most recent report, *Graduate STEM Education for the 21st Century* acknowledged the need for a systems approach to improving graduate education, and the commitment of a broad group of stakeholders in the scientific enterprise; they included among its recommendations a suite of actions to make STEM graduate education learning environments more equitable, diverse, and inclusive (NASEM 2018a). Our recommendations thus align well with those that NASEM has made.

Simply by looking at the population of first-year graduate students relative to the population of bachelor's degree recipients, the fact that it so poorly reflects the population implies that barriers exist in recruitment and admissions processes. And if we consider both the academic and demographic characteristics of those who start PhD programs, and assess who ultimately completes the degree, the need to improve PhD programs' mentoring and retention efforts becomes clear. In short, the best available research and data compel a need to look beyond student characteristics to the operation and climate of institutions. Improving graduate education means we need to take a hard look at institutional priorities and their processes of assessing who is qualified, can contribute, and ultimately belongs. In the end, encouraging diversity and inclusion means thinking holistically about student potential and who belongs in the discipline. In many places, a conversation about the imperative to address racial inequalities has also raised attention to the need to make our communities more inclusive of other marginalized groups. Our own Task Force has tried

[9] Underrepresented minorities (URM) categories include Black/African American, Latinx/Hispanic, Native American/American Indian, Alaskan Native, and Pacific Islander

to address diversity with respect to race/ethnicity, gender identity, sexual orientation, and neurodiversity and disability status. Rather than focusing on a particular type of "perfect" or "ideal" student or particular processes of admission or retention, we should promote practices that will enable all of us to see and develop talent and potential more broadly than we have before, so as not to miss potential contributors to the field of astronomy.

1.2 Prior Studies of Graduate Education in Astronomy

Twenty years ago, a report on graduate education, entitled *The American Astronomical Society's Examination of Graduate Education in Astronomy* was jointly created by the AAS Education Policy Board and Graduate Advisory Board (AAS 1996). The primary goal of that report was to address the perceived overproduction of PhDs at a time of great funding uncertainty. Its three key recommendations were:

1. Define and Support Experiments to Enrich Graduate Education
2. Re-examine the Master's Degree in Astronomy
3. Provide Students with the Information and Experience Necessary to Make Informed Career Decisions

A great deal of effort went into producing that report, and much of what it found and recommended is still relevant today. As such, any effort to assess graduate education today should be informed by the findings of that report. The one explicit mention of diversity in the report occurred in Section 4.1.3 entitled, *Deliberate reduction of the population of graduate students or of graduate departments is not wise*:

> "…it was agreed that the admissions process is imperfect; identifying college seniors with the combination of intelligence and temperament matched to a research career is, with few exceptions, extremely difficult. Practicing "birth control" at this stage would result in premature evaluations based more on "objective" criteria than on assessment of a student's performance in a graduate research department. Moreover, "birth control" at this early stage would almost certainly compromise the ability of graduate departments to meet their stated goal of enhancing diversity in the physical sciences."

This statement highlights a key point: graduate admissions criteria are one of the steepest barriers to increasing diversity in astronomy. Education and other social science research have shown that common uses of traditional measures of ability used in graduate admissions, particularly the general Graduate Record Exam (GRE) and Physics subject GRE (PGRE), disproportionately exclude groups who are already underrepresented (Miller and Stassun 2014; Posselt 2016; Steele and Aronson 1995). Further, these same measures are poor predictors of PhD completion and long-term success in research, the two main goals of most PhD programs (Petersen et al. 2018; Miller et al. in press; Glanz 1996; Sternberg and Williams 1997; Helms 2009).

Admissions was one topic of the 2015 Inclusive Astronomy meeting, which produced an extensive report known as the Nashville Recommendations (2015). Our report continues efforts in that vein, and includes a number of recommendations for departments from the Nashville report that will lead to the improvement of recruitment, admissions, climate, mentoring, and retention. Increasing the uptake of the Nashville Recommendations is part of the motivation for this Task Force.

The AAS Council was the first disciplinary society to recommend that its constituent PhD programs eliminate or make optional the GRE exam in graduate admissions, and a number of major astronomy departments have recently voted to eliminate or make optional the PGRE in their graduate admissions requirements (Astrobites 2016). No single reform alone, however, will solve the diversity and inclusion problem. Graduate faculties need to examine their entire programs to consider how, through admissions and financial aid decisions, curriculum requirements and qualifying processes, as well as their mentoring and support structures (or lack thereof) for graduate students, they enable or suppress diversity and inclusion in their programs and ultimately in the field overall.

In most departments, there are both leaders for diversity and those who have resisted changes to this end. However, as a field, astronomy has also been a leader among STEM disciplines in encouraging both grass-roots and top-down efforts to improve admissions. Many of the top-tier astronomy PhD-producing institutions – almost none of which are MSIs – have begun sincere and genuine efforts to improve access to their graduate programs for URMs, women, and other underrepresented groups (such as LGBTIQA* and

the differently-abled). Other notable efforts have included the creation of "bridge programs" and novel summer research programs designed to reach large numbers of URM students who do not traditionally participate in Research Experience for Undergraduate (REU) programs. Furthermore, professional societies aligned with AAS have also moved to address the issue of diversity and inclusion in graduate education: notably, the American Physical Society (APS) has convened a national meeting on physics graduate education and bridge programs and has piloted a network for access and inclusion in graduate education through an NSF-INCLUDES award. It is time for the AAS to formally engage in these efforts.

Meanwhile, the three principal recommendations of the 1996 report remain relevant. The connections between our discipline and the wider economy have multiplied in the past twenty years: from robotics to statistical inference, and from design to big data, the prospects for an astronomy PhD student outside the traditional academic track have brightened. Both our curricula and our cultural attitudes need adjustments to reflect this new reality. Furthermore, many potential future members of the astronomical community – perhaps especially URM students, who disproportionately face difficult economic circumstances – need viable options for employment and professional development other than a traditional doctorate leading to an academic position, as well as viable career "off-ramps" if they do not complete the PhD for any reason.

Finally, we see a continuing need to provide prospective students with complete and accurate information about graduate program opportunities, climates, and outcomes. The 1996 report contained explicit recommendations for offering such information to prospective students, recommendations on which action has been minimal. It is our hope that more explicit actions that can be taken to this end will encourage coordination of this sort. Indeed, the AAS has coordinated the postdoc market in astronomy by imposing uniform decision deadlines and creating a universally used job register. A similar initiative for the graduate education market could likewise develop an enforceable set of community standards for the provision of information to prospective students.

1.3 Theory of Change

Underlying the Task Force's recommendations is current organizational and social theory about why and how large, distributed organizations change. Collectively, the strategy that we outline consists of recommendations to AAS to take actions that will motivate astronomy PhD programs to adopt equitable, inclusive practices and climate as well as recommendations to individual departments. The AAS recommendations are for top-down changes that include measuring the climate and other characteristics of astronomy PhD programs, investing in the development and advancement of evidence-based practices, and recognizing departments that adopt such practices. Alongside the top-down change that AAS has the leverage to encourage, we also make recommendations to astronomy departments, to encourage change from the bottom up. Departments that wish to participate in this effort will find in this report a selection of inclusive graduate admissions, retention, and data collection recommendations that, together, will position them to make progress toward embodying the diversity and inclusion that so many say they seek.

The recommendations herein and the actions we hope will follow continue a decades-long process of improving the discipline's inclusiveness. AAS has been, at varying points in time, more or less engaged in that effort. The Women in Astronomy and Inclusive Astronomy meetings, in addition to the work of the 1996 AAS Education Policy Board and the Graduate Advisory Board, have each issued reports and recommendations for the field that hold implications for the policies and practices that shape access, equity, diversity, and inclusion in graduate programs.

What will it take to catalyze widespread adoption of these recommendations? We think that at least three major factors have been missing, and our report addresses them directly:

1) The absence of a coordinated data collection effort with standard metrics has prevented departments from making meaningful comparisons – both with prior versions of themselves (to benchmark their progress) and with other astronomy departments (to gauge their equity and inclusiveness relative to that of the field and/or peer departments). Data of various types provide a mirror through which departments – and the field – can see themselves more clearly. Therefore, underlying both the top-down (i.e., AAS-driven) and bottom-up (i.e., department-driven) efforts will be an ongoing conversation about data and evidence, and an entire section (2.3) of our report is dedicated to the data that progress demands

2) Clarity and evidence have been missing about the practices that hold potential to move the needle on equity, diversity, and inclusion. Although there was widespread support in principle for the Nashville Recommendations, some departments struggled to adopt them in the absence of strong evidence at the time for their effectiveness. Therefore, an important part of this report – and the Task Force's composition – was to bring the best current evidence and research to bear in making the case for inclusive practices. It is important to note that although the research base for graduate education is growing quickly, it remains much smaller than that for K-12 and undergraduate education. Therefore, although we bring current research to bear on our recommendations wherever possible, we also offer examples from individual and small groups of departments throughout the field, recognizing that these individual cases and stories do not permit the same generalizability that research offers – and which faculty in a data-driven field like astronomy may yet need to be persuaded that a given recommendation will be effective

3) Finally, although astronomy has been a leader in grassroots efforts of individual faculty and departments, widespread adoption of inclusive practices will also be encouraged by institutionalizing systems to incentivize good behavior. Research from the LEED[10] certification system for environmental stewardship in building design and construction has demonstrated the potential of centralized recognition systems for motivating socially conscious organizational behavior. Athena SWAN and the Race Equality Charter take a similar approach in the United Kingdom to recognize universities adhering to practices that encourage gender and race equity, and a similar system, the STEM Equity Achievement (SEA) Change system, is under development here in the United States. It uses self-assessment, common metrics, and public certification to recognize American universities for transformations aligned with goals of equity, diversity, and inclusion

In addition to these major factors, the process by which departments engage in the work of improving admissions and retention will matter much for the likelihood of its short and long-term success. It is not only *that* we are working toward diversity and inclusion, but also *how* we are working on it that embodies our commitment to these goals. To that end, when targeting needs and opportunities, we advise faculty to engage in open and sometimes difficult conversations motivated both by people's lived experiences as well as by formal assessments and the data derived from them. Departments should then produce and enact strategic plans with measurable outcomes in order to track progress and incentivize professional development opportunities in the domains of practice that need change (e.g., admissions, mentoring). Details on how a department might undertake the process of change is included in the Recommendations to Departments for Retention (Section 2.2).

To summarize, we believe the best way for astronomy to make progress as a field toward diversity and inclusion is through a combination of top-down actions by AAS and bottom up actions by departments. Diversity and inclusion should be not only our goals, but also principles to embody in the change process. We hope that the structure of our recommendations – and our attention to data, research evidence, and the need for incentives – catalyzes widespread adoption of practices that have already gained support across the field, by improving the data environment, by bringing clarity about what the most promising practices are, and by creating a system that motivates desired behaviors. Collectively, following these recommendations holds potential to both restructure the system by which students gain access to graduate education in astronomy and improve the climates in PhD programs and the field.

1.4 Composition of the Task Force

The membership of the Task Force represents a broad range of stakeholders, including faculty from leading astronomy PhD-producing programs and MSIs/HSIs, leaders of successful Bridge and other diversity/inclusion programs, and graduate students. In addition, the Task Force had representatives of the four AAS diversity committees and working groups (CSMA, CSWA, SGMA, and WGAD). We also appointed education and social science researchers who have studied the problems we wish to address and are knowledgeable about both the current research and its limits regarding inclusive practice in these areas.

[10] Leadership in Energy and Environmental Design (LEED)

2. Goals and Recommendations of the Task Force to Departments

2.1. Admissions: Goals and Recommendations to Departments

A number of the Nashville Recommendations (2015) are designed to enable the recruitment and admission of diverse cohorts of graduate students. In the intervening years, some graduate programs in astronomy and other disciplines have taken up the practices described in these recommendations, to positive effect. Below, we make several specific recommendations for the improvement of graduate admissions based in part on the Nashville Recommendations (2015).

Our goal is to have the demographics of graduate programs reflect those of the national population of college graduates with a physical sciences degree. While this "availability pool" does not reflect the full diversity of the nation, having the population of candidate astronomy PhDs mirror that of physical science graduates would be a significant step toward a more representative field.[11]

Recruitment activities form the shoulders of the admissions process and should regularly be re-evaluated and improved. Outreach efforts by graduate schools, PhD programs, individual faculty, and specific organizations shape the pool of who applies to our graduate programs and condition who we can admit. In addition, how we recruit admitted students (i.e., to maximize yield) shapes enrollment.[12]

2.1.1. Summary of Goals and Recommendations: Admissions

Goals

A. The demographics of students admitted to PhD programs in astronomy should reflect those of the availability pool at the undergraduate level
B. Admissions criteria and processes should be designed to broaden the definitions of excellence and merit to create greater diversity in admitted cohorts
C. Applying to a graduate program should be a transparent, informed process

Recommendations to Departments

1. Partner with and recruit from undergraduate programs that produce large numbers of graduates from underrepresented groups (e.g., MSIs, HSIs, and Tribal Colleges)
2. Implement evidence-based, systematic, holistic approaches to graduate admissions, based on the existing literature as well as on self-study when possible
3. Coordinate with graduate schools and other campus offices to ensure that program level policies and practices aimed at diversity and inclusion are supported and amplified at the institutional level

2.1.2. Discussion of Recommendations: Admissions

2.1.2.1. Partner with and recruit from undergraduate programs that produce large numbers of graduates from underrepresented groups (e.g., MSIs, HSIs, and Tribal Colleges)

Whereas PhD programs typically privilege applicants who have attended elite universities, that small group of institutions is not where most students from underrepresented backgrounds receive baccalaureate degrees in physics, astronomy, or other physical sciences (see Appendix III). Diversifying the set of undergraduate institutions from which we recruit students before the point of application is a critical precursor to admissions reform.

Minority-serving institutions (MSIs), which include Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), and Tribal Colleges, are major producers of minority undergraduates in physics. Tapping the undergraduate talent at these institutions may be key to enhancing diversity at the

[11] URMs earn about 4% of the astronomy, and 6% of the physics, PhDs awarded nationally every year, but represent ~12% of the Bachelor's degrees in physics in a given year, and make up about 33% of the college-age U.S. citizens. See https://apsbridgeprogram.org/about/diversity.cfm

[12] For a rigorous quantitative study of the common misperceptions that faculty hold about how women and URM students choose among graduate programs to which they have been admitted, see Bersola et al. (2014).

higher levels of the astronomy profession. The loss of these students at the undergraduate/graduate transition represents a significant leak in the pipeline of minority talent into astronomy.

The AAS Committee on the Status of Minorities in Astronomy reviewed best practices in recruiting for diversity and produced a report (Stassun 2003). We briefly summarize its recommendation below.

- Establish relationships with MSIs. This requires efforts that are deliberate, aggressive, and ongoing. Continuity is key to building successful partnerships. Visitation programs need to be sustained efforts; one-shot recruiting is generally not effective
- Work with MSIs to develop programs in which students first participate in research at their home institution, with thoughtful and nurturing transitions to mentors at other institutions
- Create, and take advantage of, informal networks to open pathways from MSIs into astronomy graduate programs. Implicit here is that relationship-building requires cooperation both logistical and personal; building trust with MSI faculty is central to building successful partnerships with those institutions
- Address the perceived disconnect between the educational atmosphere present at many MSIs and that which characterizes many of our graduate programs. MSI faculty are working to develop dynamic undergraduate programs that respond to student needs, that incorporate current pedagogical methods, and that inculcate an appreciation for teaching as part of the profession. These values should be extended to the graduate level to allow for a more seamless handoff of students from one program to the next, and to address the issue of minority retention at the graduate level. MSI faculty might not trust that their students will be taken care of in graduate programs at majority institutions, and many students believe the teaching activity is undervalued
- Increase the visibility of a diversity of astronomers to put a face on the profession, and to communicate opportunity and inclusiveness. This emphasizes the value of "having diversity to get diversity"

In addition, graduate programs should seek to build connections with post-baccalaureate bridge and programs that are or have been supported by the NSF Astronomy Division (AST) Partnerships in Astronomy and Astrophysics Research and Education (PAARE) program (e.g., the APS, Columbia University, Fisk-Vanderbilt Master's-to-PhD and Cal-Bridge bridge programs, as well as summer research programs such as CAMPARE[13], AstroCom NYC, etc.).

Finally, venues for recruiting that bring together students and scientists of color should become more regularly attended and supported by astronomers. These include major annual conferences such as the APS Conferences for Undergraduate Women in Physics (CUWiP) and the Conference for Undergraduate Underrepresented Minorities in Physics (CU^{2}MiP), and meetings of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS), the National Society of Black Physicists (NSBP), the National Society of Hispanic Physicists (NSHP), and others.

2.1.2.2. Implement evidence-based, systematic, holistic approaches to graduate admissions, based on the existing literature as well as on self-study when possible

Holistic review in graduate admissions should be 1. *comprehensive*, considering a variety of student qualities including their socioemotional/non-cognitive competencies, 2. *systematic*, articulating how reviewers should look for these qualities, and 3. c*ontextualized*, considering how students' characteristics and achievements reflect not only their potential, but also the opportunities they have had, their developmental trajectories, and known sources of error in standard metrics (Posselt and Miller 2018). In developing systems of holistic review, some graduate programs will find value in collecting and examining data on their own students' outcomes and the extent to which those outcomes correlate with the admissions process[14]. To our knowledge, few astronomy graduate programs conduct such self-study in a systematic way or on a regular basis. Programs that have done this and that have shared the results (see, e.g., the

[13] California Minority Partnership for Astronomy Research and Education (CAMPARE)

[14] This kind of analysis is only appropriate, however, with a large sample size of students, including sizable numbers of students from underrepresented groups. Small sample sizes overall and of sub-groups will yield both a highly imbalanced sample and insufficient statistical power, which violate statistical relationships and lead to invalid inferences.

self-study by the University of Texas, Austin (UT), summarized in Appendix IV) have found compelling evidence for reducing reliance on standardized tests and for increasing the use of holistic evaluations of prospective students. Furthermore, new research on the GRE in STEM disciplines reinforces the AAS's 2016 call that departments should not require these tests for admission. A 2018 study of STEM PhD programs found that,

> "Men who completed STEM doctoral degrees had significantly lower GRE Q[15] scores than those who left their programs. In fact, men in the lowest quartile of GRE Q scores finished their degrees at a higher rate (74 percent) than their counterparts in all higher quartiles." (Petersen et al. 2018).

A forthcoming validity study, the largest to date in the physical sciences and using robust multivariate regression methods, found that the PGRE score is not associated with PhD completion (Miller et al. in press). Such research adds weight to evidence that common use of GRE scores in the physical sciences disproportionately excludes populations who are already underrepresented (Miller and Stassun 2014; Posselt 2016), and arguments that the cost, design, and content of the PGRE, in particular, are both prohibitive and ill-suited to capture potential to become a successful scientist.

To implement holistic admissions, the information about prospective students that reviewers have available to them and their interpretations of that information both require attention. Programs should reduce reliance on standardized tests, structure information gathered via recommendation letters, and incorporate assessment of socioemotional competencies (i.e., non-cognitive skills). Faculty reviewers should also approach prospective students as learners, not only as research or teaching assistants, and evaluate them for their potential to grow into great scientists, not only for their accomplishments to date. Because opportunities to learn and conduct research vary considerably with forms of social privilege, it is critical that programs working to mitigate inequalities, not simply admit the students with the most impressive credentials. Tools such as evaluation rubrics help ensure that reviewers attend to a broad set of student qualities and do so in structured ways while preserving flexibility in determining which ones are critical to success in their program.

To enable holistic review of this sort at a field-wide level, the AAS is working with graduate admission scholars to create a toolkit for graduate programs to more easily implement best practices for graduate recruiting and admissions. This Task Force has assembled relevant templates, protocols, rubrics, and guides, which can then form the basis for a first version of the toolkit. However, some resources from the AAS may be needed to create user-friendly guides (including perhaps tutorial videos) to accompany the toolkit. In any event the AAS should curate the toolkit and make it readily available to member institutions.

2.1.2.3. Coordinate with graduate schools and other campus offices to ensure that program level policies and practices aimed at diversity and inclusion are supported and amplified at the institutional level

Graduate programs must operate within the framework of policy established in collaboration with their graduate schools/divisions. Astronomy PhD programs should therefore work in concert with their graduate schools (and other campus offices when relevant) to ensure that program-level decisions aimed at diversity and inclusion are supported and amplified at the institutional level.

There are at least two ways in which this coordination can positively impact recruitment and admissions: (1) it will provide admissions committees the authority and flexibility to design and implement their own form of holistic review; (2) it will allow departments to minimize the financial and logistical barriers that can limit the full participation of underrepresented groups in the admissions process. For example:

- Programs can help to educate their graduate schools about the issues surrounding the over-reliance on standardized test scores. A case in point: the University of Michigan Medical School undertook a division-wide discussion on the pros and cons of continuing to require the GRE as part of admissions to its PhD program in biomedical sciences, and has made the substance of the internal debate as well as the resulting policy, removing the requirement of the GRE for admission, publicly available

[15] GRE Quantitative exam (GRE Q)

- Programs can work to ensure that appropriate mechanisms are in place to make the application process as affordable as possible. Eliminating GRE requirements can be a significant positive step in and of itself, as the requirement of official score reports from Educational Testing Services (ETS), which administers the tests, is costly and can add up to many hundreds of dollars for students. For institutions that charge graduate application fees, making fee waivers available and easy to apply for can also be a significant positive step. For example, the Vanderbilt University Graduate School's application process clearly describes the eligibility criteria for a fee waiver, and it permits applicants to claim a waiver, which is later verified; this method is preferred over waiver processes that require pre-approval or that issue refunds, as these tend to dissuade applicants from applying

2.1.3. Background: Admissions

2.1.3.1. Socio-emotional competencies

In all educational and professional domains, what we think of as individual performance is determined both by the support and resources afforded in one's environment as well as by individual factors that include clusters of cognitive/academic competencies as well as social and emotional intelligence (Boyatzis 2008). Social and emotional intelligence manifest in competencies such as perseverance, creativity, conscientiousness, realistic self-appraisal, and leadership, among others.

There is limited formal research to date about the predictive validity of these skills to success in graduate education, making it difficult to claim they are inherently better or more important selection criteria. However, they are at minimum complementary to academic qualities and already listed among the qualities that faculty say they are looking for in prospective students (Kyllonen, Walters, and Kaufman 2005). These qualities are skills that can be cultivated, and measures of many do not hold the gender and racial gaps that we see in GRE scores and in attending elite colleges and universities.

For these reasons, and because most students who leave PhD programs do so for non-academic reasons, we need to thoughtfully and systematically consider socio-emotional qualities within the context of holistic admissions review. And indeed, developments are underway to more systematically assess these competencies in higher education generally and in graduate/professional education, specifically. We offer descriptions of several efforts in this area:

Work by social psychologist Bill Sedlacek defined a set of non-cognitive competencies observed among populations of Black and Latino students (Sedlacek 2004), and these competencies informed the development of the interview rubric used by the Fisk-Vanderbilt Master's-to-PhD program. It is specifically tailored to assess qualities in such a way as their definition does not disadvantage students who obtained relevant socio-emotional competencies outside academic domains. For example, its operationalization of leadership enables students to be rated as "High" for "Demonstrates involvement and leadership ability in either academics, family, community, religious group, or athletics."

An NSF-funded project led by physicist Casey Miller is creating systems for holistic review in physics and astronomy, including a non-cognitive assessment tool measuring a number of qualities desired in STEM PhD students: self-awareness, self-control, teamwork/collaboration, achievement orientation, adaptability, professionalism, and grit. Field testing and validation of the assessment is underway, with the goal being a short online assessment taken both by an applicant and by individuals who can rate the applicant. Scores would then be reported to admissions committees.

Social psychologists William Sternberg and Karin Sternberg have also been creating an assessment that could be deployed in the graduate admissions context, albeit focused on research-relevant scientific reasoning skills (e.g., ability to generate hypotheses, generate experiments, and draw conclusions). In a recent study published in the *Journal of Intelligence*, Sternberg and Sternberg (2017) report satisfactory convergent-discriminant validity of this tool, albeit with advantages for European American test-takers in generating hypotheses and generating experiments.

ETS experimented with non-cognitive assessment as well with a tool called the Personal Potential Index (PPI). That system asked applicants to create an online PPI profile and asked faculty writing letters of recommendation to complete an auxiliary form evaluating the applicant on a number of qualities. Reports were then sent to graduate programs where the student was applying and could be added to their file. A

strength of the PPI – faculty evaluation – circumvented the risks of faking and lying about oneself that have been a persistent barrier in self-assessments of this sort; however, due to a lack of adoption by applicants and graduate programs, ETS has discontinued the PPI.

2.1.3.2. Developing a system of holistic review

To broaden how graduate admissions committees think about student potential, systems of holistic review should consider multiple strengths that a student might bring, and should assess those qualities in multiple ways. This multiplicity is important both because work within the discipline demands different strengths, and because some types of assessments tend to privilege certain types of students. For example, White, Asian, male, and wealthy students often earn higher mean scores on standardized tests from elementary school through the GRE. However, simply replacing such tests with unstructured interviews is not a silver bullet, because interviews may privilege neurotypical students and, if not carefully structured, can be places where other implicit biases creep in (see discussion below).

Collecting multiple types of information about students through multiple methods – and ensuring faculty have appropriate training in the implementation of those methods (e.g., how to use tools, implicit bias, what a diversity mindset means in admissions) – will minimize the chances that new systems will unintentionally reinforce or create new types of inequalities. An example of a well-developed, proven system of holistic review is the Fisk-Vanderbilt Master's-to-PhD Bridge Program toolkit, available here. This includes resources for admissions committee, including rubrics for scoring interviews. Examples of rubrics used to evaluate entire applications are included in Appendix V.

2.1.3.3. Incorporating interviews in the admissions process.

A number of astronomy programs include interviews as part of their admissions process. Academic disciplines vary widely in their use of interviews (Posselt 2012), and there is evidence from the science of evaluation and selection that highly structured interview processes can add valuable information in the review process. Unstructured interviews, however, can quickly become a breeding ground for biases and should be avoided (Kahneman and Egan 2011). We surveyed a few of these programs, including the University of Texas, Austin (UT), the University of Washington (UW), the University of Maryland College Park (UMD), the University of California, Santa Cruz (UCSC), and the Fisk-Vanderbilt Master's-to-PhD Bridge Program about their interview process. In Appendix VI, we summarize these programs' responses and we provide sample e-mails sent to applicants before the interview, a sample interview script, and a sample rubric for scoring interviews.

2.1.3.4. Letters of recommendation

Letters of recommendation are an essential piece of the evaluation of any graduate application, but they are notoriously difficult to assess accurately. In Appendix VII, we provide a rubric for evaluating letters of recommendation based on scoring non-cognitive competencies. Especially for components of the application that require significant discretion and subjective judgment on the part of reviewers, a rubric can reduce the potential that well-documented gender biases (see, for example, Madera et al. 2009; Trix and Psenka 2003) in letters of recommendation will negatively affect an applicant's chances, and the additional potential for a reviewer to come away from reading the letter with biased judgment of their own. For example, rubrics provide structure and clarity about what reviewers should be looking for in letters of recommendation, so that are they are less likely to inaccurately "read between the lines" or focus on random comments in letters during periods of close comparison of a small number of candidates – two documented trends (Posselt 2016).

2.1.4. Resources: Admissions

Importance of MSIs and Bridge Programs:

- The Norman et al. (2009) Astro2010 decadal white paper on the need for partnerships with MSIs and for support for Bridge Programs

Key items pertaining to reducing reliance on GRE:

- Past AAS President C. Megan Urry's December 2015 open letter to astronomy graduate programs
- The Levesque et al. (2015) study of GRE scores among top astronomy postdoctoral fellows
- UT's study of the PGRE scores for applicants, matriculants, and successful postdocs

Statistics on increased number of applicants to astronomy graduate programs:

- Past AAS President David Helfand's report from his 2018 survey of department chairs, showing growth in the number of applications of ~100% over past five years
- Summary admission statistics since 2013 from a top-ranked astronomy department that *continues to require the PGRE*, showing growth predominantly among domestic applicants
- Summary admissions statistics since 2013 from a top-ranked astronomy department *that no longer requires the PGRE*, also showing growth predominantly among domestic applicants

2.2. Retention: Goals and Recommendations to Departments

Research shows that scientific breakthroughs and innovation most often occur in teams and are enhanced by diverse perspectives (Hong and Page 2004; Ely, Padavic, and Thomas 2012; Nielsen et al. 2017). Diverse organizations generate and support excellence (Page 2007). And yet, in order to reap the benefits that diversity has to offer, we must recruit and retain diverse talent. The section above outlines a number of recommendations for recruiting diverse students into graduate training in astronomy. This section focuses on ways to retain those students up to and through graduate school.

Research on retention has pointed to many factors that can impact students' decisions to persist as undergraduates and graduate students (Lovitts 2001; Ong et al. 2011; Espinosa 2011; Griffin, Muñiz, and Espinosa 2012; Posselt et al. 2017; Posselt, Porter, and Kamimura 2018). These include research experience, science identity, sense of belonging, training environment, and research and career self-efficacy (McGee and Keller 2007; Hurtado et al. 2009; Estrada et al. 2011; Chemers et al. 2011; Chang et al. 2011; Byars-Winston et al. 2015; National Academies 2018a). Other critical factors include mentoring and teaching (see 2018a National Academies Graduate STEM Education report for review). Our approach has been to outline for graduate departments the actions they can take to assure excellence through diversity. In drafting these recommendations, our overarching goal has been to assure that the places where we work and interact are spaces that are inclusive of a broad range of ideas, identities, and abilities. The recommendations described here focus on five critical factors that research suggests will lead to increased retention. These include: (A) ending workplace harassment and bullying; (B) meeting or exceeding accessibility requirements; (C) providing healthy, welcoming environments; (D) optimizing mentoring relationships, and (E) fostering equitable teaching practices.

Academic departments and research institutes are the nexus of the growth and renewal of our discipline. We fully recognize that the task of creating a diverse and inclusive environment is a complex one, involving work at the level of the individual, the research group, the department, the school, the institution, and the broader astronomical community. We have sought here to provide recommendations and resources that apply at multiple levels. In doing so, we acknowledge that not all members of a local community can effectively advocate for change at every level. For example, a dean or provost will be more effective than a graduate student at pushing for non-discriminatory health insurance for all employees, and a department chair, not an undergraduate, is best positioned to assure that the scheduling of departmental events provides for the inclusion of everyone. The department should endeavor to create and normalize a culture where all members feel empowered to become educated and responsible for personal and group behaviors and systems essential to creating a welcoming and supportive environment.

Acknowledging the various levels at which this essential work must proceed, we focus our recommendations at the department level – where undergrads are advised, graduate students are admitted and mentored, and new faculty are hired. Leadership on these critical issues at this level will create the environments where diverse communities are nurtured, transforming our discipline to one in which genuine inclusion leads to scientific excellence.

2.2.1 Summary of Goals and Recommendations: Retention

Goals

A. End harassment and bullying in and around astronomical workplaces.
B. Provide an accessible environment, including but not limited to full ADA-compliance.
C. Provide a healthy, welcoming, family-friendly environment.
D. Provide effective mentoring through evidence-based practices and expanded networking opportunities.
E. Adopt teaching and learning practices that support all students, especially those with marginalized identities.

Recommendations to Departments

1. Engage in genuine, open, and sometimes difficult conversations
2. Conduct assessments to identify areas of need or opportunities
3. Create short- and long-term actionable department plans with measurable outcomes that address the five goals

Recommendations to Departments (cont.)

4. Incentivize and support professional development in the support of the five goals
5. Take actions based on the departmental plan and monitor progress toward outcomes, employing inclusive processes
6. Encourage ongoing improvements toward inclusiveness by iterating through the process represented in steps 1-5

Examples of ways to create a plan, promote good practices, and take concrete steps for intervention are outlined in Section 2.2.2 and expanded upon, with specific examples and supporting resource materials, in Appendix VIII.

2.2.2 Discussion of Recommendations: Retention

2.2.2.1. Engage in genuine, open, and sometimes difficult conversations

- Departments should engage in conversation and self-reflection on how they will create a plan and identify what new or revitalized events, structures, etc., are needed to effect goals A-E (e.g., a faculty retreat, a full department retreat, agenda slots at regular department meetings, creation of a focused committee, etc.)
- While the path to creating this plan will differ among departments, it is vital that all department members participate in these discussions.
- This conversation process will be tailored to the individual department.
- As part of this process, it may be helpful to invite colloquium speakers that discuss inclusive practices.

2.2.2.2. Conduct assessments to identify areas of need or opportunities

- Perform self-audits on equity, inclusion, accessibility, and learning environment. A template rubric is provided in Appendix X
- Participate in the AAS/AIP national department climate and demographic survey discussed in Section 3
- Departments should consider participating in the AAS (or APS, if appropriate) climate site visits program, during which an external committee gauges the climate for all members at various places in the institutional hierarchy

2.2.2.3. Create short- and long-term actionable department plans with measurable outcomes that address the five areas for intervention

As part of this process, provide an opportunity for members of the institution (in particular people with marginalized identities) to review the plans as they are being drafted. Plans should be tailored to the department's goals and needs as identified by self- and external assessments. Below in Table 1 is a list of recommended areas for action and concrete examples for each area. Further details for each area are provided in the Appendix VIII.

Table 1. Recommended Areas for Action to Support Retention, with Examples of Good Practices

Area	**Examples**
A. End harassment and bullying in and around astronomical workplaces *An effective anti-harassment policy should be bottom-up as well as top-down, both implicit and explicit. While academics and their departments are required to work within their institutional guidelines, departments can and should be more proactive about addressing harassment and bullying, and create their own culture for combatting it.*	1. Form an equity and inclusion committee that meets monthly to develop and guide policies and practices and to provide a reporting mechanism for people in the department 2. Adopt a code of conduct, with clear anti-harassment policies and procedures, including highly transparent reporting avenues 3. Provide a centralized location for anti-harassment resources. Publicize policies, procedures, reporting avenues, and contact information 4. Provide mechanisms for anonymous reporting of harassment and bullying, including a designated intake person. First response is critical 5. Leadership must speak up in support of the impacted groups in clear and unequivocal terms 6. Provide oversight mechanisms for people in positions of power to reduce the likelihood of abuses of power 7. Work to create an institutional and departmental culture where harassment and bullying are not tolerated and are actively challenged 8. Work toward normalizing, providing, and publicizing training opportunities, whether departmental, institutional, or external, and encourage department members to attend
B. Provide an accessible environment, including but not limited to full ADA-compliance *While academics and their departments are required to work within their institutional guidelines, departments can and should be proactive about facilitating accessible environments.*	1. Ensure that departmental facilities are accessible, i.e. fully ADA compliant. This includes historic structures which are normally exempted from ADA regulations. Work with your disabilities office which often has resources (or lobbying credentials) to bring your facilities into compliance 2. Department-wide events (colloquia, seminars, picnics, and any other activities) should be held in spaces accessible to everyone 3. Publish links to campus-wide disability resources and accommodation request processes on the graduate program webpage 4. Assure that classroom environments meet or exceed ADA compliance. Work with students and disabilities office to obtain and implement accommodations 5. Apply principles of accessibility to qualifying exams as well. This includes alternate format requests, flexible deadlines, and extended exam periods 6. Apply principles of accessibility to time-to-degree requirements, including flexible deadlines

Area	Examples
C. Provide a healthy, welcoming, family-friendly environment *Productive, creative, and sustained research requires an environment where everyone feels welcomed, valued, and safe, including a robust work-life balance.*	1. Department-wide events (colloquia, seminars, picnics, and any other activities) should be attended by, accessible to, and comfortable for everyone 2. Enact policies that are friendly to people of all genders 3. Enact family-friendly policies, broadly interpreted 4. Provide and advocate for sufficient medical leave, family leave, health care coverage, and mental health care 5. Publish links to details of graduate healthcare and insurance on graduate program webpage. Include prescription, dental, vision, specialist, and mental health coverage, as well as co-pays and maximums 6. Change the work culture to value mental health 7. Make discussions about diversity, equity and inclusion part of the departmental discourse
D. Provide effective mentoring through evidence-based practices and expanded networking opportunities *Mentorship is critical to creating a learning environment that facilitates student retention and helps advance students' careers.*	1. Provide mentoring structures that give students more than one person as a close advisor 2. Provide/require mentoring training for faculty and other parties involved in mentoring, such as postdocs, research scientists, staff, etc. 3. Provide mentee training to help mentees be more proactive in their mentoring relationships 4. Create and support near-peer mentoring structures 5. Provide access to mentors of color and mentors from other marginalized groups 6. Increase networking opportunities for students, including marginalized students 7. Establish a positive culture around non-academic careers 8. Establish a non-judgmental culture around time to degree
E. Adopt teaching and learning practices that support all students, especially those with marginalized identities *Adopting research-validated practices and principles of inclusive design can eliminate barriers to learning and biases in assessment, making educational opportunity available to all.*	1. Work to create a thriving, inclusive educational environment in the department. Use department, campus, and external resources and experts to provide training on inclusive practices to facilitate implementation of evidence-based classroom techniques and revision of qualifying exams and other evaluation procedures 2. Know what strengths, weaknesses, needs, and resources your students bring to the classroom, and adopt appropriate teaching and assessment strategies. Foster a growth mindset in yourself and your students 3. Be aware of classroom participation and dynamics

2.2.2.4. Incentivize and support professional development in the five areas for intervention

- Identify incentives and support (e.g. financial, release time) for participation in professional development activities offered by the institution or external bodies such as the professional societies
- Build structures that align learning/professional development activities designed to improve inclusiveness into accountability structures such as annual review, tenure, and promotion

2.2.2.5. Take actions based on the departmental plan and monitor progress toward outcomes, employing inclusive processes

- Perform regular evaluations and receive critical feedback to ensure that efforts are in the best interests of all members of the community, with special attention paid to those with marginalized identities
- Review data collection and reporting policies to ensure they are inclusive, e.g.,
    - Follow Institutional Review Board best practices in data collection to ensure safety and anonymity of participants
    - Use gender-neutral and inclusive language in reports
    - Ensure that all demographics questions are at the end of surveys to mitigate stereotype threat
    - Review data collection forms and records to determine when demographic information is needed and to ensure appropriate and inclusive language is used throughout (e.g., understanding that many people do not fit into the gender binary, or into the standard "categories" asking about race). Include disability categories in data collection and reporting, using the terminology and identities used by people with disabilities
- Issue progress reports that describe successes, setbacks, challenges, new opportunities, and next steps. Archive these documents on the institutional website

2.2.2.6. Encourage ongoing improvements toward inclusiveness by iterating through process represented in steps 1-5

2.2.3. Resources: Retention

For detailed suggested practices, concrete steps, and resources, see Appendix VIII and Appendix IX.

2.3. Data Collection and Metrics for Success: Goals and Recommendations to Departments

The Data Working Group was charged with providing recommendations for data that astronomy departments should collect to assess the effectiveness of recruitment and mentoring practices recommended by the other working groups. Our recommendations are based on a framework of Diversity, Inclusion, Equity, and Sustainability. That is, data should be collected that relate to the demographic diversity of a department, the climate for inclusion, and practices that promote equitable treatment of all groups in the department. A capacity for the department and higher administrative units (school or college, university) to continue the data collection through departmental transitions should be sustained.

In keeping with the structure of the Task Force, data should be collected relating to admissions, recruiting, mentoring, and retention. This appears to be done most naturally by distinguishing three kinds of data: demographic data, information about the climate for inclusion, and a summary of departmental practices. Some demographic data are currently collected by departments and universities, typically through Institutional Research offices. Information about the climate for inclusion may be present in university or departmental surveys, although this practice is uneven. In Section 3 below we recommend systematic national collection of demographic and climate data. Finally, departmental practices are often known only by department members. We propose a self-assessment rubric for departments to be used to summarize their practices and to guide strategic planning of additional steps to strengthen diversity, equity and inclusion at the departmental level. In all cases, departments should standardize data collection practices in a sustainable manner. We recommend that departmental practices be made public on the department's website and on a national platform supported by the AAS as recommended in Section 3.

2.3.1. Summary of Goals and Recommendations: Data Collection and Metrics for Success

Goals

A. Measure progress towards the recommendations regarding admissions and retention
B. Measure trends in field-wide demographic and climate data to assess which practices are effective and for whom
C. Help departments advance their goals for diversity, equity, and inclusion using data and metrics for success

Recommendations to Departments

1. Participate in the recommended AAS/AIP[16] national demographic and climate survey, and encourage all relevant members (e.g., graduate students, postdocs, researchers, faculty) to participate
2. Regularly collect and analyze data relevant to graduate education, including the demographics of applicant pools, admitted and enrolled students, and disaggregated progress and success rates
3. Assess the success of steps taken to improve the educational experience of graduate students using an evidence-based rubric
4. Report results on progress in implementing the recommendations of this Task Force on the platform provided by the AAS, and on departmental websites

2.3.2 Discussion of Recommendations: Data Collection and Metrics for Success

2.3.2.1 Participate in the recommended national demographic and climate survey to be conducted by the AIP for the AAS, and encourage all relevant members (e.g., graduate students, postdocs, researchers, faculty) to participate

Data will be gathered directly from individuals nationally (Section 3.2.1). Departments should respond to the AAS/AIP request to provide emails for all relevant members (not including undergraduates). Graduate students, postdocs, researchers, and faculty will be invited to respond to this brief survey. The climate survey will be constructed by experts in quantitative research with consultation of interested partners including other AAS committees and working groups, and graduate student and postdoctoral

[16] American Astronomical Society (AAS) and American Institute of Physics (AIP)

representatives of different social identities following the Participatory Action Research model. The demographic and climate data should be refreshed every two years.

Full results from the AAS/AIP climate survey should not be reported for individual departments nor for groups that have fewer than 5 individuals in order to protect anonymity. AIP will hold the data and use it to support longitudinal studies of how the composition and climate of astronomy departments is changing with time. Departments can negotiate with the AAS/AIP on the content of summary reports for them.

2.3.2.2. Regularly collect and analyze data relevant to graduate education, including the demographics of applicant pools, admitted and enrolled students, and disaggregated progress and success rates

Departments should make use of data that are already collected by the department's institution, or nationally through federal agencies or professional societies. The data should be used to better understand departmental processes and their outcomes. For example, departments should produce degree completion curves with disaggregation by demographic categories, similar to the Massachusetts Institute of Technology (MIT) one shown below in Figure 1.

More detailed climate surveys may sometimes be conducted by the department's institution. For internal use, departments could also conduct carefully constructed surveys of attitudes towards the educational climate they provide, but should do so only after consultation with experts. More detailed information is provided in Section 2.3.3.2.

2.3.2.3. Assess the success of steps to improve the educational experience of graduate students using an evidence-based rubric, incorporating recommendations made throughout this report. The self-assessment should be made annually, analyzed, and acted upon

Section 2.1 and section 2.2 of this report provide detailed recommendations to improve the educational experience of graduate students. Several appendices provide details, especially IV through X (which provides a self-assessment rubric for departments).

2.3.2.4. Report results on progress in implementing the recommendations of this Task Force on the platform provided by the AAS, and on departmental websites

The AAS platform for reporting progress (Section 3.2.3) will show which departments have adopted which recommendations. It will also include a small textual component in which each department gives a short description of how it has implemented each recommendation. Departments should also be encouraged to publish some of the data collected from the main recommendations of this Task Force on their own websites, particularly those they have identified as their "metrics of success". A platform with similar intent can be found at this website of the APS Committee on the Status of Women in Physics.

2.3.3. Background: Data Collection and Metrics for Success

2.3.3.1. Demographic data: admissions, recruiting, enrollment, retention, graduation

In Section 3 below, the Task Force (along with several other committees) is asking the AAS to institute an ongoing national demographic and short climate survey. Such data could be collected directly by the AIP, as mentioned in Recommendation 3.2.1 below. In contrast with the AAS demographic survey of all members, this AIP survey will focus on graduate students, postdocs, researchers, and faculty in astronomy departments. Demographic data should not be reported out for individual departments because of the small numbers of individuals. Instead, demographic trends for astronomy as a whole can be followed with such a national database. The rest of this section is in addition to that national effort, and discusses what is recommended at the campus level.

Departments already collect data on graduate admissions: applicants, offers, acceptances. They also maintain information about enrolled students and their progress toward degrees, and they know who obtains degrees in the end. Ideally, departments should save such data for a number of years in order to track trends. Generally, either the department, the Graduate School, or the Institutional Research Office record the citizenship, undergraduate institution, binary gender, and race/ethnicity of each student enrolling (the latter using IPEDS[17] categories). Institutions are not required to request or record other demographic data such as gender identity, sexual orientation, or disability status. They may offer applicants or enrolled students the option to self-report these data, but few campuses do so at this time (UMass Amherst is one; some campuses allow students to change their binary gender identity and/or to designate preferred names different from their legal names). While departments can be encouraged to ask for voluntary specification of gender identity, sexual orientation, and disability status, such efforts may run into institutional barriers unless the Graduate School does so for all students as part of its confidential student records system. Department chairs should seek advice from their Deans on these issues.

To the maximum extent possible, departments should collect similar information for applicants as for enrolled students. At least, they should offer applicants the opportunity to specify citizenship, undergraduate institution, binary gender, and race/ethnicity.[18] An alternative to citizenship (which may be sensitive) is a question about whether the high school degree was obtained in an American school. In order to fully assess admissions and recruitment success and program outcomes, departments should distinguish between applicants, admitted students, enrolled students, and graduating students. Post-graduation plans and longer term career outcomes are also of interest and may be recorded by departments; the AIP Longitudinal Study of Astronomy Graduate Students provides such information for a national cohort.

Departments requesting optional data from applicants or enrolled students should ensure informed consent. Participants should be informed about the uses of such data and they must be permitted to restrict its use, by providing permission for each specific use. Maintaining these data for at least 15 years provides a baseline for departments to perform longitudinal studies by assessing the diversity of their doctoral students over several cohorts.

Collection of such data enables measuring outcomes for graduate students of different social identities. Astronomy is not the first field seeking to measure outcomes for graduate students in STEM including gender and race/ethnicity, and it should not implement recommendations that conflict with other efforts. First, of course, are the national resources: IPEDS and the NSF Survey of Earned Doctorates. Obtaining disaggregated data (e.g., PhD degrees with gender and race/ethnicity) for one field is not easy, and is best left to data experts such as the AIP Statistical Research Center.

More relevant to the AAS effort, a coalition of universities pledged in Fall 2017 to provide data on graduate admissions, recruitment, enrollment and retention for students in the life sciences. The Coalition for Next Generation Life Science is a group of 10 institutions whose presidents co-authored an article in *Science* (Blank et al. 2017) describing their plans to publish:

[17] Integrated Postsecondary Education Data System (IPEDS)

[18] Race/ethnicity categories are less meaningful for international students. A common practice is to collect and report race/ethnicity only for US citizens and permanent residents.

- Admissions and matriculation data of PhD students
- Median time-to-degree and completion data for PhD programs
- Demographics of PhD students and postdoctoral scholars by gender, underrepresented minority status, and citizenship status
- Median time in postdoctoral status at the institution
- Career outcomes for PhD and postdoctoral alumni, classified by job sector and career type

Table 2. Recommended Demographic Data for Graduate Programs

Data for departments to collect	Applicants	Admitted students	Enrolled students
Citizenship/visa status	Optional	Required	Required
Undergraduate institution	Required	Required	Required
Binary gender F/M*	Optional	Optional	Optional
Race/ethnicity using IPEDS categories*	Optional	Optional	Optional
Gender identity*,**	Optional	Optional	Optional
Sexual orientation*, **	Optional	Optional	Optional
Disability status*,**	Optional	Optional	Optional
Neurodiversity*,**	Optional	Optional	Optional

* Providing optional data is voluntary, and a refusal to provide it will have no effect on the respondents' application. Optional data will be used only in statistical summaries to assess the diversity of applicants, admitted students, and enrolled students and will not be used in any way that identifies the respondent. The data may also be used in statistical summaries tracking progress of students through the graduate program, including progression through milestones and completion of degrees. Such summaries may be shared publicly.
** Provide a short list of possible responses as recommended by the AIP Statistical Research Center, the AAS Demographics Committee or the Division of Planetary Science (DPS) Professional Culture and Climate Subcommittee.

By collecting the information in Table 2, supplemented by degree completion and next career steps, astronomy departments will be able to compare their data with national data to be collected by the AAS/AIP.

In some cases, universities are providing this data for all departments, not merely life sciences departments. One example is the equity reports provided to each department during the academic program review process at UC Berkeley. Another excellent demonstration is at MIT, which has publicly posted substantial amounts of graduate student data for all fields. Gender and race/ethnicity statistics are presented for enrolled graduate students, time to degree, and retention. Perhaps the most informative measure is PhD

completion fraction versus time in the doctoral program, averaged over enough entering years to provide statistically robust results, and disaggregated by social identity where the numbers are large enough. MIT does not have an astronomy department, but in Figure 1 we present its completion curve for physics (which includes astronomy and astrophysics), disaggregated by race/ethnicity (with three non-overlapping categories: international citizens, US citizens and permanent residents of White or Asian race/ethnicity called non-URM, and US citizens and permanent residents of all other race and ethnicity called URM).

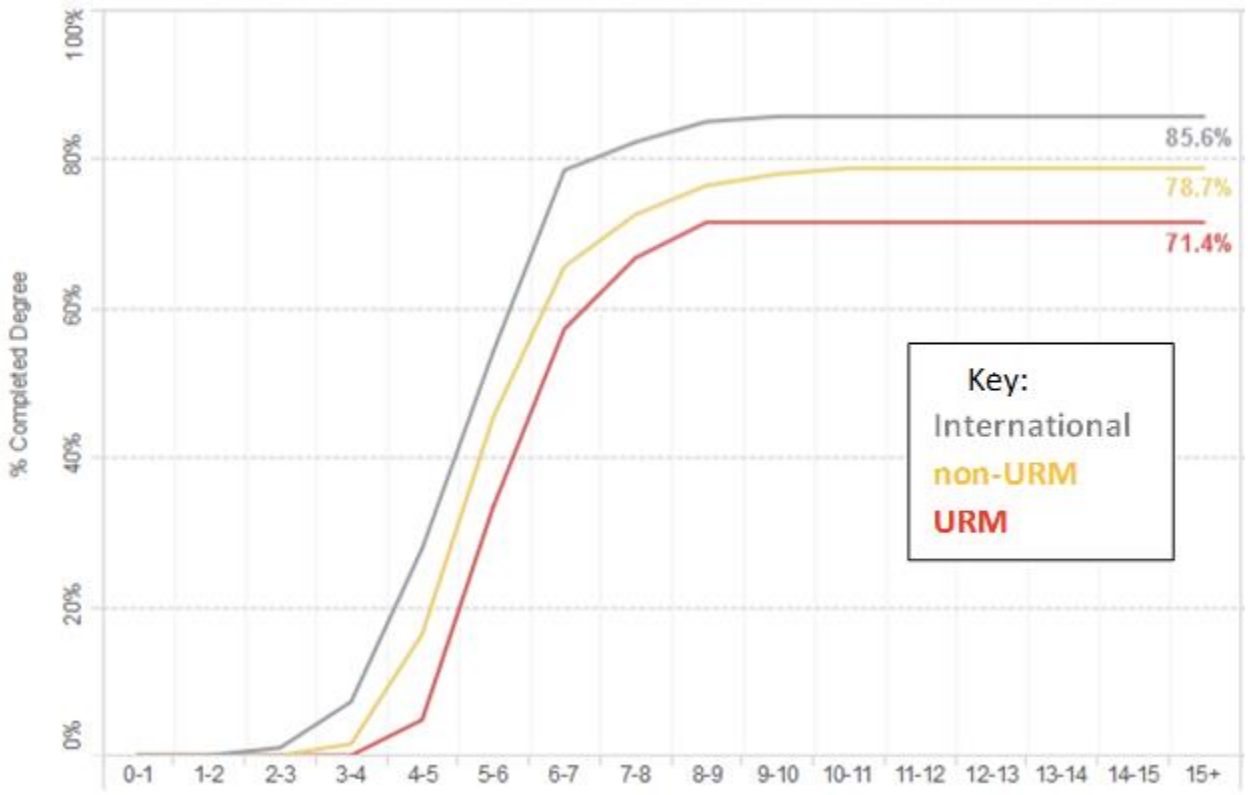


Figure 1: MIT Physics PhD completion curves, cohorts entering 1997-2010

We recommend that astronomy departments, working with their Graduate School and/or Institutional Research offices, compile data (in tabular form, or plotted versus time; see, e.g. MIT) on the applicant pool, offers made, enrolled students, and PhDs awarded, including binary gender, race/ethnicity, and, optionally where such data are voluntarily collected, gender identity, sexual orientation, and neurodiversity and disability status. We encourage departments to collect the latter data, provided that permission is obtained from the relevant university officer (e.g., Graduate School Dean) and informed consent is obtained from the students. Finally, departments (if not the entire university, separately for each department) should produce PhD completion curves like the MIT example in Figure 1.

2.3.3.2. Climate data: mentoring and implications for retention

As already mentioned, it is hoped that one outcome of this report will be that the AAS, through AIP, will conduct an ongoing short climate survey at the national level, with the express encouragement of each department for their members to participate in it (see Section 3). That survey will be professionally constructed, and collected in a manner that preserves confidentiality. Only aggregated results will be made public from it.

Many universities conduct one-time or periodic surveys of institutional climate. Individual departments can, and often do, conduct such surveys independently of the rest of the university. It is crucial that the survey methodology protect students' confidentiality and be conducted with an awareness of power and social relationships in the best interests of the students. For these reasons, it is preferable that climate surveys

be conducted, and the responses held, by people outside of a department. Institutional Research offices are generally well equipped to do this. Of 38 universities with astronomy doctoral programs in the US, 16 have, since 2013, conducted comprehensive climate surveys whose respondents included graduate students.[19] Most other campuses have conducted a survey narrowly focused on sexual misconduct, for example the AAU[20] Survey on Sexual Assault and Misconduct.

If a university, college, or graduate school conducts climate surveys, results should be shared with departments, in order to help them assess their climate and facilitate improvements. In practice, results should never be shared when there are fewer than 5 respondents in any reported subgroup, in order to protect anonymity. In any survey instrument, respondents should be allowed to specify their social identities at the end of the survey (to avoid stereotype threat) after being provided with a clear statement of how their responses may be used. Moreover, special attention must be paid to power differences, i.e., real or perceived differences in status that may depend not only on role and seniority, but on demographic or other social factors. In departments where bullying or harassment have occurred, students will fear retaliation.

There are pros and cons to utilizing existing survey data collected across the entire university. Advantages: internal power dynamics issues are mitigated because the survey is not conducted by the department; response rates are generally good (sometimes exceeding 50%); the university has an infrastructure in place for analyzing, reporting and archiving survey results. Disadvantages: survey frequency is often very low; often the surveys do not ask about gender identity, sexual orientation or disability status; finally, survey questions vary from university to university, making it hard to directly compare different universities.

In Section 3 we recommend a collective effort between AAS and AIP to collect climate data that removes the burden from departments and eliminates the role of power dynamics.

We recommend that departments do not conduct detailed climate studies on their own. Social scientists recommend in such circumstances to use the Participatory Action Research (PAR) framework. PAR is a collaborative, democratic approach to social change through information gathering, action, and reflection (Baum, MacDougall, and Smith 2006; Pain, Whitman, and Milledge 2017). The approach is context-specific and requires that the "subjects" of evaluative research (e.g., astronomy graduate students) be partners in the whole process of survey design, data collection, analysis, and any action steps taken following the research. Special attention must be paid to power and privilege, including the roles of class and other social identities. Best practice uses a PAR framework combining quantitative analysis of surveys with qualitative methods based on interviews and focus groups (mixed methods research). In general, astronomy departments should not be expected to develop such expertise. However, they can still undertake constructive steps in collaboration with other university resources.

For example, the UC Berkeley Astronomy Department, working with experts in the university-wide Office for Equity and Inclusion, has established a participatory process for conducting annual climate surveys of its undergraduate and graduate students, postdocs, staff, and faculty and using the results to improve the department. Climate Advisors representing each group worked with the Office for Equity and Inclusion to create a survey, variations of which have been given annually since 2015. The results are disaggregated by social identity (though without intersections of these identities; the smaller size of an individual department severely limits intersectional analysis such as disaggregating by both gender and race/ethnicity). Their survey and action steps have been made public.

Another example comes from a university-wide process at MIT. During 2013–2014, focus groups and interviews with several hundred community members identified the following topics important in the experience of university community members (Bertschinger 2015):

- Belonging and inclusion
- Unconscious (implicit) bias
- Micro-aggressions
- Discrimination and harassment based on social identity
- Abrasive conduct (bullying)
- Excessive stress and mental well-being
- Sexual harassment and assault

[19] Arizona State, U. Arizona, Cornell, Dartmouth, UC Berkeley, UCLA, UC Santa Cruz, CU Boulder, U. Chicago, Iowa State, U. Florida, U. Maryland, UMass Amherst, U. Michigan, U. Minnesota, U. Wisconsin

[20] Association of American Universities (AAU)

MIT conducts a university-wide climate survey of all community members every four years. The survey is tailored to each population (e.g. undergraduate students, graduate students, postdocs, faculty, staff). Students, faculty, and staff members recommended new survey questions for the 2016–2017 surveys in order to more fully assess the topics listed above, and student groups were provided detailed results of the surveys beyond what was published. The survey instruments and results were published (students, others), as well as an analysis of climate based on intersectionally defined social groups (e.g., both gender and race/ethnicity; Bertschinger 2018). Although the survey and results were done university-wide, individual department chairs can access results for their own department (with the proviso that groups with fewer than 5 responses are not reported).

The Berkeley and MIT surveys did not investigate in detail the mentoring of graduate students or the persistence and retention of graduate students. Doing so, especially at the department level, is fraught because of the power dynamics and the worry students may have that any concerns raised might be used against them. Moreover, climate surveys are not ideal for gathering data with nuances in which individual stories are important or numbers of individuals in any group are small. For these reasons, we recommend that departments engage outside resources, for example, the AAS Climate Site Visits Program, when dealing with mentoring or serious climate challenges where power dynamics are an important factor. A Graduate Dean or Chief Diversity Officer can recommend other resources.

2.3.3.3. Departmental practices

In order for a department to sustain its success in recruiting, admissions, retention, mentoring, and data collection, it must adopt a set of regular practices that become part of "how we do things" and which continue (and are even improved) through leadership transitions. Every department is unique, and we do not recommend attempting to prescribe one set of practices as ideal. Instead, we want to encourage departments to assess their practices regularly and to engage in continual process improvement through reflection and innovation.

The many recommendations made in this report lend themselves to the creation of a self-assessment rubric for departments to assess their practices. This is a natural part of the planning process given in Section 2.2. An excellent model is provided by the New England Resource Center for Higher Education (NERCHE) *Self-Assessment Rubric for the Institutionalization of Diversity, Equity, and Inclusion in Higher Education*. The NERCHE rubric was developed for universities and colleges, not astronomy departments; however its methodology is transferable. The rubric presents best practices in six areas (Philosophy and Mission, Faculty Support, Curriculum, Staff Support, Student Support, and Administrative Leadership) and, for each item, invites administrators to judge for themselves whether their organization is Stage 1: Emerging, Stage 2: Developing, or Stage 3: Transforming. For each area there are several items such as "Student Success" or "Faculty knowledge and awareness of diversity, inclusion, and equity in relation to disciplines" along with descriptions of a department or university in each of the 3 stages. These six areas must be modified for our purposes, but the self-assessment methodology and the discrete stage evaluation are quite useful. Many organizations use tools like this (or the somewhat similar Jackson-Hardiman Multicultural Organizational Development tool (Jackson 2014), the Equity Scorecard, or the commercially available Intercultural Development Inventory).

Our Task Force structure suggests the following set of areas for a self-assessment rubric:

1. Recruiting and admissions
2. Mentoring
3. Doctoral program and process
4. Departmental climate
5. Assessment
6. Accountability

Although category 3 is not directly covered by our Task Force, it is relevant to outcomes (for example, how students are supported financially, whether they get TA experience, the departmental curriculum and exam structure, whether students are supported to attend and present at conferences).

A sample self-assessment rubric is provided in Appendix X. Each of the six categories has a set of indicators. Departmental practices relating to each indicator are grouped into three stages of maturity of

practice: Emerging, Developing, and Transforming (these names are taken from the NERCHE rubric). The practices are cumulative—Stage 3 (Transforming) includes promising practices listed in Stage 1 (Emerging) and 2 (Developing).

Category 6 includes external certifications. Many engineering departments are in the ABET[21] accreditation process, which provides an educational standard that has had great impact on curriculum and practice for undergraduate and Master's degree programs. Some have suggested that professional societies develop a similar accreditation mechanism, possibly focusing on diversity, equity, and inclusion. Fortunately, the largest scientific professional society in the world has already done so: the AAAS SEA Change initiative.

SEA Change provides a LEED-like certification for institutional efforts to promote equity, diversity, and inclusion in colleges and universities, focusing on the STEM disciplines. Participation requires agreeing to a set of guiding principles, conducting an evidence-based self-assessment, and developing a plan to make progress. The institutional application is completed by a cross-functional team with access to and support of key stakeholders including university senior leaders. Once the university as a whole has an entry-level certification, individual STEM departments can apply for their own rating. Astronomy departments will be able to begin applying for SEA Change certification in the early 2020s.

[21] Accreditation Board for Engineering and Technology (ABET)

3. Goals and Recommendations of the Task Force to the AAS

3.1 Summary of Goals and Recommendations: AAS

Goals

A. Measure the status and progress of diversity and inclusion in programs producing graduate degrees in astronomy
B. Provide a platform that incentivizes, recognizes, and disseminates steps that these programs take to increase diversity and inclusion in astronomy
C. Actively participate in the effort to produce, test, and disseminate new promising practices that increase diversity and inclusion in astronomy

Recommendations to AAS

1. Partner with the AIP Statistical Research Center to collect demographic and climate data
2. Recruit departments to adopt the recommendations of this Task Force
3. Create a platform for encouraging departments to adopt best practices and to track their adoption over time
4. Invest in the continued development, sharing, and curation of research- and best-practice-based toolkits that enable graduate programs to implement evidence-based recruitment, admissions, and mentoring practices
5. Encourage participation by the AAS equity committees and working groups in the AAAS SEA Change initiative

3.2 Discussion of Recommendations: AAS

3.2.1 Partner with the AIP Statistical Research Center to collect the recommended demographic data, including but not limited to race/ethnicity, gender identity, sexual orientation, neurodiversity and disability status, for astronomy graduate students, postdocs, researchers, and faculty. This should be done together with a short survey inquiring about departmental climate

The AAS should contract with the AIP Statistical Research Center to collect the demographic data recommended in Section 2.3.3.1 as part of a climate survey to participants in astronomy programs. The climate survey should be constructed by experts in quantitative research with consultation of interested partners including other AAS committees and working groups, and graduate student and postdoctoral representatives of different social identities following the Participatory Action Research model. The demographic and climate data should be refreshed every two years.

Results from the AAS climate survey should not be reported for individual departments nor for groups that have fewer than 5 individuals in order to protect anonymity. AIP will hold the data and use it to support longitudinal studies of how the composition and climate of astronomy departments is changing with time. AIP should be contracted to analyze the survey data and produce aggregated reports for AAS. Departments are likely to be interested in summary reports for themselves (which would also have to be produced by AIP with confidentiality preserved). These are likely to be less informative given small sample sizes in some categories. AAS will need to establish policies about this process.

3.2.2 Recruit departments to enact recommendations in this report

The recruitment of departments will have to be pursued through contact with department chairs (or active faculty members of departments involved with AAS). While there is no formal adoption process, departments will signal their involvement through participation in the national department survey, and posting of materials and answers on the AAS platform (once it is available). There should be preliminary discussions by the AAS with departments to recruit “early adopters”, starting with those identified by the Task Force as promising collaborators.

3.2.3. Create and maintain a platform for departments to report adoption of best practices, in order to provide public recognition to adopting departments and to serve as a resource for prospective graduate students

Such a platform would provide public recognition to adopting departments and be a resource for prospective graduate students. It could be modeled on the APS website Assessing Graduate Programs. The site should show in quick graphical form which departments have adopted which recommendations. It should also include a small textual component in which each department gives a short description of how it has implemented each recommendation (perhaps linked to the "check-off" indicating adoption). Departments should also be encouraged to publish some of the data collected from the main recommendations of this Task Force on their own websites, particularly those they have identified as their "metrics of success".

3.2.4. Invest in the continued development, sharing, and curation of research- and best-practice-based toolkits that enable graduate programs to thoughtfully implement evidence-based recruitment, admissions, and mentoring practices

At the very least, the collection of such toolkits as they are developed under other auspices should be coordinated. This will require funding, through the submission of collaborative grants and the encouragement to funding agencies through the Decadal White Paper process. Interest in these toolkits from the community should be solicited.

3.2.5. Encourage participation by the AAS equity committees and working groups in the AAAS SEA Change initiative to develop a department-level SEA Change certification

The AAS equity committees and working groups should work with the AAAS and other STEM professional societies to develop a department-level STEM Equity Achievement (SEA) Change certification. While some astronomers feel a sense of urgency to quickly start an astronomy-only certification, we recommend instead a partnership model in which AAAS provides the overall framework and infrastructure for the program. Astronomy will benefit from the social science expertise present in the AAAS SEA Change initiative, the engagement AAAS has with funding agencies and charitable foundations, and the staffing needed to implement a major initiative across higher education. AAS and other professional societies may pilot departmental certification efforts, but ultimately should collaborate with AAAS to support SEA Change.

References

Ackerman, N., Atherton, T., Avalani, A.R. et al. (2018). LGBT+ Inclusivity in Physics and Astronomy: A Best Practices Guide https://arxiv.org/abs/1804.08406

American Association for the Advancement of Science. *AAAS SEA Change*. (https://seachange.aaas.org/, last accessed November 2, 2018).

American Astronomical Society (1996). The American Astronomical Society's Examination of Graduate Education in Astronomy. *Bull. of the AAS* 29(5). (https://aas.org/archives/BAAS/v29n5/edrpt.html, last accessed November 20, 2018).

American Institute of Physics. *Roster of Astronomy Departments with Enrollment and Degree Data, 2017*. (https://www.aip.org/statistics/reports/roster-astronomy-2017, last accessed November 2, 2018).

American Institute of Physics. *The Longitudinal Study of Astronomy Graduate Students*. (https://www.aip.org/statistics/lsags, last accessed November 2, 2018).

Association of American Universities. AAU Announces 2019 Survey on Sexual Assault and Misconduct. (https://www.aau.edu/newsroom/press-releases/aau-announces-2019-survey-sexual-assault-and-misconduct, last accessed November 2, 2018).

Astrobites (2016). (astrobites.org/2016/09/09/the-impact-of-the-physics-gre-in-astronomy-graduate-admissions/)

Barthelemy, R. McCormick, M. and Henderson, C. (2016). Gender discrimination in physics and astronomy: Graduate student experiences of sexism and gender microaggressions, *Phys. Rev. Phys. Educ. Res.* 12, 020119

Baum, F., MacDougall, C., and Smith, D. (2006). Participatory action research. *J. Epidemiol. Community Health.* 60(10), 854–857.

Bersola, S.H., Stolzenberg, E.B., Fosnacht, K., and Love, J. (2014). Understanding admitted doctoral students' institutional choices: Student experiences versus faculty and staff perceptions. *American Journal of Education*, *120*(4), 515-543.

Bertschinger, E. (2015). *Advancing a Respectful and Caring Community: Learning by Doing at MIT*. (http://iceoreport.mit.edu/, last accessed November 2, 2018).

Bertschinger, E. (2018). Climate and Accountability. *MIT Faculty Newsletter*, September/October 2018. (http://web.mit.edu/fnl/volume/311/bertschinger.html, last accessed November 2, 2018).

Blake-Beard, S.D. (2001). Mentoring relationships through the lens of race and gender. *Center for Gender in Organizational Insights* 10, 1-4.

Blank, R., Daniels, R.J., Gilliland G., Gutmann, A., Hawgood, S., Hrabowski, F.A., et al. (2017). A new data effort to inform career choices in biomedicine. *Science*, 358(6369), 1388–1389.

Boyatzis, R. E. (2008). Competencies in the 21st century. *Journal of Management Development*, *27*(1), 5-12.

Byars-Winston, A.M., Branchaw J., Pfund C., Leverett P., and Newton J. (2015). Culturally Diverse Undergraduate Researchers' Academic Outcomes and Perceptions of Their Research Mentoring Relationships. *Int. J. Sci. Educ*. 37, 2533–2554.

Chang, M., et al. (2011). Considering the Impact of Racial Stigmas and Science Identity: Persistence Among Biomedical and Behavioral Science Aspirants. *J. High. Education* 82, 564–596.

Chemers, M.J., Eagan, M.K., Lin, M.H., and Hurtado, S. (2011a). The Role of Efficacy and Identity in Science Career Commitment among Underrepresented Minority Students. *J. Soc. Issues* 67, 469–491.

Clancy, K.B., Lee, K.M., Rodgers, E.M., and Richey, C. (2017). Double jeopardy in astronomy and planetary science: Women of color face greater risks of gendered and racial harassment. *Journal of Geographical Physics* 122)7, 1610-1623.

Committee on the Status of Women in Physics, *Assessing Graduate Programs*. (https://www.aps.org/programs/women/female-friendly/index.cfm, last accessed November 10, 2018).

Ellis, E. (2000). Race, gender, and the graduate student experience: recent research. Diversity Digest, available at: www.diversityweb.org/Digest/F00/graduate.html (accessed 19 February 2007)

Ely, R.J., Padavic, I., and Thomas, D.A. (2012). Racial diversity, racial asymmetries, and team learning environment: Effects on performance. *Organ. Stud.* 33, 341–362.

Espinosa, L. (2011). Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence. *Harvard Educational Review*. 81(2), 209-241.

Estrada, M., Woodcock, A., Hernandez, P.R., and Schultz, P.W. (2011). Toward a model of social influence that explains minority student integration into the scientific community. *J. Educ. Psychol.* 103, 206.

Estrada, M., Eroy-Reveles. A., and Matsui, J. (2018). The Influence of Affirming Kindness and Community on Broadening Participation in STEM Career Pathways, *Social Issues and Policy Review,* 12(1), 258-297.

Ginther, D.K., Schaffer, W.T., Schnell, J., Masimore, B., Liu, F., Haak, L.L., and Kington, R. (2011). Race, Ethnicity, and NIH Research Awards. *Science* 19, 1015-1019.

Glanz, J. (1996). How Not to Pick a Physicist? *Science*, 274(5288), 710-712.

Griffin, K.A., Muñiz, M.M., and Espinosa, L. (2012). The influence of campus racial climate on diversity in graduate education. *The Review of Higher Education* 35(4), 535-566.

Helms, J.E. (2009). Defense of tests prevents objective considerations of validity and fairness. *American Psychologist* 64, 283-284.

Hong, L. and Page, S. E. (2004). Groups of diverse problem solvers can outperform groups of high-ability problem solvers. *Proc. Natl. Acad. Sci.* 101, 16385–16389.

Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., and Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Res. High. Educ*. 50, 189-214.

Jackson, B. W. (2014). “Theory and Practice of Multicultural Organization Development,” in B. B. Jones and M. Brazzel (eds.), *The NTL Handbook of Organization Development and Change: Principles, Practices, and Perspectives* (pp. 175–192). New Jersey: Wiley.

Johnson, A., Ong, M., Ko, L.T., Smith, J., and Hodari, A. (2017). Common Challenges Faced by Women of Color in Physics, and Actions Faculty Can Take to Minimize Those Challenges, *The Physics Teacher,* 55, 356.

Kahneman, D., and Egan, P. (2011). *Thinking, fast and slow* (Vol. 1). New York: Farrar, Straus and Giroux.

Kyllonen, P., Walters, A. M., and Kaufman, J. C. (2005). Noncognitive constructs and their assessment in graduate education: A review. *Educational Assessment*, 10(3), 153-184.

Levesque, E.M., Bezanson, R., and Tremblay, G.R. (2015). Physics GRE Scores of Prize Postdoctoral Fellows in Astronomy. arXiv:1512.03709

Lovitts, B. E. (2001). *Leaving the ivory tower: The causes and consequences of departure from doctoral study*. Maryland: Rowman and Littlefield.

Madera, J. M., Hebl, M. R., and Martin, R. C. (2009). Gender and letters of recommendation for academia: agentic and communal differences. *Journal of Applied Psychology*, 94(6), 1591.

McGee, R. and Keller, J. L. (2007). Identifying future scientists: predicting persistence into research training. *CBE Life Sci. Educ*. 6, 316-331.

Miller, C. and Stassun, K. (2014) A test that fails: A standard test for admission to graduate school misses potential winners. *Nature Careers* 510, 303.

Miller, C., Zwickl, B., Posselt, J., Silvestri, R. and Hodapp, T. (in press). Typical PhD admissions criteria exclude women and minorities but fail to predict doctoral completion. *Science Advances.*

MIT Office of Institutional Research. *Diversity Dashboard*. (http://web.mit.edu/ir/pop/students/graduate_statistics.html, last accessed November 2, 2018).

MIT Office of Institutional Research. *Graduate Education Statistics*. (http://web.mit.edu/ir/pop/students/graduate_statistics.html, last accessed November 2, 2018).

Mollica, M., and L. Nemeth. 2014. Outcomes and characteristics of faculty/student mentorships in PhD programs. *American Journal of Educational Research* 2(9):703-708.

Nashville Recommendations (2015), https://tiki.aas.org/tiki-index.php?page=Inclusive_Astronomy_The_Nashville_Recommendations.

National Academies of Sciences, Engineering, and Medicine (2007). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11463.

National Academies of Sciences, Engineering, and Medicine (2011). *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. Washington, DC: The National Academies Press. https://doi.org/10.17226/12984.

National Academies of Sciences, Engineering, and Medicine (2018a). *Graduate STEM Education for the 21st Century*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25038.

National Academies of Sciences, Engineering, and Medicine (2018b). *Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24994.

National Center for Educational Statistics, Integrated Postsecondary Education Data System (IPEDS). *Collecting Race and Ethnicity Data from Students and Staff Using the New Categories*. (https://nces.ed.gov/ipeds/report-your-data/race-ethnicity-collecting-data-for-reporting-purposes, last accessed November 2, 2018).

National Science Foundation. *Survey of Earned Doctorates*. (https://www.nsf.gov/statistics/srvydoctorates/, last accessed November 2, 2018).

National Science Foundation, National Center for Science and Engineering Statistics (2015). Women, Minorities, and Persons with Disabilities in Science and Engineering: 2015. Special Report NSF 15-311. Arlington, VA. www.nsf.gov/statistics/wmpd/

New England Resource Center for Higher Education. *NERCHE Self-Assessment Rubric for the Institutionalization of Diversity, Inclusion and Equity in Higher Education*. (http://rengaconsulting.com/wp-content/uploads/2018/04/nerche_pi_rubric_self-assessment_2017.pdf, last accessed November 2, 2018).

Nielsen, M.W., Alegria, S., Börjeson, L., Etzkowitz, H., Falk-Krzesinski, H.J. et al. (2017). Opinion: Gender diversity leads to better science. *Proc. Natl. Acad. Sci.* 114, 1740-1742.

Norman, D. et al. (2009). Increasing the Number of Underrepresented Minorities in Astronomy at the Undergraduate, Graduate, and Postdoctoral Levels (Paper I). Astro2010: The Astronomy and Astrophysics Decadal Survey, Position Papers, no. 39

O'Meara, K., K. Knudsen, and J. Jones. (2013). The role of emotional competencies in faculty-doctoral student relationships. *Review of Higher Education* 36(3), 315-347.

Ong, M., Wright, C., Espinosa, L.L., and Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review*, 81(2), 172-209.

Pain, R., Whitman, G., and Milledge, D. (2017). *Participatory Action Research Toolkit: An Introduction to Using PAR as an Approach to Learning, Research, and Action*. (http://communitylearningpartnership.org/wp-content/uploads/2017/01/PARtoolkit.pdf, last accessed on November 2, 2018).

Page, S. (2007). *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies*. Princeton University Press.

Petersen, S. L., Erenrich, E.S., Levine, D.L. and Vigoreaux, J., and Gile, K. (2018). Multi-institutional study of GRE scores as predictors of STEM PhD degree completion: GRE gets a low mark. *PLOS ONE*. 13(10), e0206570

Posselt, J. R. (2012). To interview or not to interview? *Chronicle of Higher Education.* (https://www.chronicle.com/article/To-Interview-or-Not-to/135582, last accessed on November 3, 2018)

Posselt, J. (2016). *Inside Graduate Admissions: Merit, Diversity, and Faculty Gatekeeping.* Cambridge, MA: Harvard University Press.

Posselt, J. R., and Miller, C. (2018). On Holistic Admissions. Paper presented at the International Doctoral Education Research Network. Hiroshima, Japan.

Posselt, J. R., Reyes, K. A., Slay, K. E., Kamimura, A., and Porter, K. B. (2017). Equity efforts as boundary work: How symbolic and social boundaries shape access and inclusion in graduate education. *Teachers College Record*, 119(10), 1-38.

Posselt, J. R., Porter, K. B., and Kamimura, A. (2018). Organizational Pathways toward Gender Equity in Doctoral Education: Chemistry and Civil Engineering Compared. *American Journal of Education*, 124(4), 383-410.

Sedlacek, W. E. (2004). *Beyond the Big Test: Noncognitive Assessment in Higher Education*. Indiana: Jossey-Bass, An Imprint of Wiley.

Solem, M., Lee, J. and Schlemper, B. (2009) Departmental Climate and Student Experiences in Graduate Geography Programs. *Res High Educ* 50, 268.

Solorzano, D. (1993). The Road to the Doctorate for California's Chicanas and Chicanos: A Study of Ford Foundation Minority Fellows. In California Policy Seminar, (Berkeley, CA)

Stassun, K. (2003). Enhancing Diversity in Astronomy: Minority-Serving Institutions and REU Programs. *Bulletin of the American Astronomical Society* 35, 1448-1452.

Steele, C.M. and Aronson, J. (1995). Stereotype Threat and the Intellectual Test Performance of African Americans. *Journal of Personality and Social Psychology* 69, 797.

Sternberg, R. and Williams, W. (1997). Does the Graduate Record Examination Predict Meaningful Success in the Graduate Training of Psychologists? *American Psychologist* 52, 630-641.

Sternberg, R.J., and Sternberg, K. (2017). Measuring Scientific Reasoning for Graduate Admissions in Psychology and Related Disciplines. *Journal of Intelligence* 5(3), 29

Thomas, D. A. (2001). The truth about mentoring minorities. Race matters. *Harvard Business Review*, 79(4), 98-107.

Trix, F., and Psenka, C. (2003). Exploring the color of glass: Letters of recommendation for female and male medical faculty. *Discourse and Society*, 14(2), 191-220.

White, J. and Nonnamaker, J. (2008). Belonging and Mattering: How Doctoral Students Experience Community. *NASPA Journal* 45:3, 350-372.

Appendices

Appendix I: Short Bios of Task Force Advisors

Each of the three Working Groups has a social science expert as advisor to their work. These advisors are each nationally recognized experts in their field. They are:

1) **Admissions: Dr. Julie Posselt**, Assistant Professor of Higher Education in the USC Rossier School of Education. Dr. Posselt is the author of the book *Inside Graduate Admissions: Merit, Diversity, and Faculty Gatekeeping* (2016, Harvard University Press), which is based on an award-winning ethnographic study of faculty judgment in 10 highly ranked doctoral programs in three universities. This research has led to partnerships with departments, graduate schools, and other associations that are re-examining graduate admissions practices, including the University of California, American Physical Society, and Council of Graduate Schools. She has received the 2017 Association for the Study of Higher Education Early Career Award and the 2017 USC Rossier School of Education, Outstanding PhD faculty member award

2) **Retention: Dr. Christine Pfund**, Scientist, Wisconsin Center for Education Research at the University of Wisconsin-Madison. Dr. Pfund's work focuses on developing, implementing, documenting, and studying a seminar to train research mentors across science, technology, engineering, mathematics and medicine (STEMM). She has co-authored a manual for facilitators of this seminar, *Entering Mentoring*, and co-authored several papers documenting the effectiveness of this approach. Currently, Dr. Pfund is co-leading two studies focused on the impact of training on both mentors and mentees and understanding specific factors in mentoring relationships that account for positive student outcomes including the role of culture. Dr. Pfund is one of the principal investigators of the National Research Mentoring Network (NRMN) and directs both the NRMN Mentor Training and Administrative Cores. She is also director of the Center for the Improvement of Mentored Experience in Research at UW-Madison (CIMER)

3) **Data Collection and Metrics for Success: Dr. Rachel Ivie**, Director, Statistical Research Center (SRC), American Institute of Physics (AIP). The SRC collects, analyzes and disseminates data on education and employment in physics and related fields. Dr. Ivie specializes in questionnaire design and methods for improving response rates. Her research interests focus on the careers of physicists and astronomers, particularly the careers of women in these fields. She has designed and carried out numerous studies on these topics: from a global study of physicists outlining gender differences in career progress by country to a longitudinal study of astronomy graduate students that explains the factors that may make women more likely to leave the field

Appendix II: Background and Creation of the Task Force

At the January 2017 AAS meeting in Texas, the AAS Council approved the creation of a Task Force on Diversity and Inclusion in Graduate Astronomy Education. The Task Force was empaneled in November 2017 and held their first meeting that month. At that first meeting, the Task Force members approved the creation of three working groups: Admissions, Retention, and Data Collection and Metrics for Success. In addition to members of the astronomical community from a wide variety of types of institution and career status, including representatives of the four AAS Diversity committees (CSWA, CSMA, WGAD, and SGMA), the Task Force engaged social science experts as advisors in each of the three areas represented by the three Working Groups, to make sure that all recommendations of the Task Force were based on a solid research basis and/or best practice. See Appendix I for short bios of these advisors.

The Task Force continued to meet approximately monthly through November 2018, including two in-person meetings, one in March 2018 in Berkeley, California and a second time in November 2018 in Chicago, Illinois. The Task Force held a special session at the June 2018 AAS meeting in Denver to solicit community input. In addition, presentations were made to the four AAS Diversity committees by the Task Force liaisons from each committee to directly solicit their input and feedback. The committees were also given a chance to review this report in draft form to comment. Finally, the Task Force co-Chairs made presentations to the AAS Board in October 2018 and to the Astronomy Department Chairs' meeting in November 2018.

Charge. AAS Graduate Education Task Force Official Charge

The final report from this Task Force to the AAS Board of Trustees should include:

1. the consideration of practices in recruiting, admissions, and retention of students into programs that offer astronomy-related Master's degrees and PhDs, with the goal of identifying those practices that promote diversity and inclusion in graduate programs with regard to race and ethnicity, gender, LGBTIQA*, disability status, and possibly other areas;
2. the building of consensus on evidence-based best practices for recruitment, admissions, mentoring, retention, and (to the extent feasible) curriculum and outcome optimization of a diverse student population in astronomy graduate programs that closely matches the diversity of the US;
3. the development of a statement of best practices for potential adoption by the AAS;
4. the development of guidelines to help astronomy graduate programs who wish to implement these best practices do so; and
5. the development of recommendations for ongoing data collection from graduate programs in astronomy, in order to assess progress in increasing diversity in graduate programs and also in the astronomical field in general.

The final report of this Task Force, as well as the data that will be collected in the course of the work by the Task Force, will be shared, utilized, and/or incorporated with the current or subsequent work of a broader AAS Task Force on graduate education, which the AAS is still working to form, and which will address in greater detail, issues such as curriculum and teaching methods.

The work of the Task Force will take place from October 2017 to December 2018 and the Task Force will deliver its report to the AAS Board of Trustees in time for the report to be discussed at the January 2019 Board meeting. During this time interval, we request that the Task Force provide short monthly progress reports to the Board.

Goals. The goals of the Task Force will be:

1. the strengthening of a consensus on evidence-based best practices for recruitment, admissions, and retention of a diverse student population for US astronomy PhD programs that more closely matches the diversity of the United States;
2. the development of a statement of these best practices for adoption by the AAS Board of Trustees;
3. taking the work already begun through the "Inclusive Astronomy" process to the next level by documenting existing implementations of these best practices, and gaining firm commitments from other key players to implement some of the AAS recommendations; and

4. the development of recommendations (with selected initial implementations) for ongoing data collection to monitor progress in increasing diversity in astronomy.

The metrics of success are:

1. The adoption of best practices by the AAS Board of Trustees, goal (2), will be taken as clear evidence that goal (1) has been achieved;
2. Commitment to implement some of these recommendations by 4-6 key astronomy PhD programs (i.e., thought and reputation leaders) concurrently with our report in January 2019 would constitute a real step forward. We would expect follow-up activities in the next few years to bring that number to 10-15 or more;
3. The success of goal (4) will be demonstrated by the number of new relevant statistics that begin to be collected, and the creation of a site where all relevant statistics can easily be accessed by departments and organizations. After a few years, these statistics will serve to measure whether these efforts have had a real impact on diversity in astronomy.

Working Groups. To facilitate the work of the Task Force, three Working Groups were created as follows:

1. Working Group on Admissions
2. Working Group on Retention
3. Working Group on Data Collection and Metrics for Success

Each working group was co-chaired by two Task Force members who recruited additional members from the community. These working groups took primary responsibility for soliciting input from the community around their topic and developing the recommendations contained in this report. However, all recommendations were discussed and approved by the entire Task Force.

Timeline of Activities.

2017 Apr-Oct	Select Task Force co-Chairs, members
2017 Nov	First meeting (virtual) of Task Force to refine charge, plan activities, responsibilities, refine budget request
2017 Dec	Second meeting (virtual) of Task Force to finalize charge, deliverables, plan for in-person meeting and subsequent activities
2018 Jan	Preliminary meetings of Task Force and working groups at AAS meeting
2018 Mar 9-10	First in-person meeting of Task Force to formally plan year's activities
2018 Jun	Special session at AAS meeting in Denver
2018 Mar-Oct	Working group meetings
2018 Mar-Oct	Task force/working groups collect data/information on best practice from PhD programs (with help/advice from advisors)
2018 Mar-Oct	Monthly Task Force meetings to hear reports and interim results from each working group, provide feedback and direction to the working groups
2018 Oct 27	Interim report and presentation to AAS Board
2018 Nov 2-3	Final Task Force meeting (in-person) to finalize recommendations and write report
2018 Nov 3	Co-chairs attend one day of Department Chairs meeting to make presentations and report to this group for input and buy-in (90 minutes)
2018 Dec	Presentation of final recommendations to AAS Board including draft official statement from AAS for consideration and approval
2019 Jan	Plenary to present findings to community at AAS meeting in Seattle Special session on Holistic Admissions

Appendix III: Rankings of Universities that Award the Most Physics Bachelor's Degrees to Black/African-American and the Most Physical Science Bachelor's Degrees to URM students

Universities awarding the most *physics* bachelor's degrees to Black/African-American students
Rank

1. Morehouse College
2. Dillard University
3. University of Maryland, College Park
4. Xavier University of Louisiana
5. Tuskegee University
6. Hampton University
7. Delaware State University
8. Jackson State University
9. North Carolina A&T State University
10. Massachusetts Institute of Technology
11. Florida A&M University
12. Howard University
13. Spelman College
14. Chicago State University
15. Norfolk State University

List includes institutions that conferred 10 or more physics bachelor's degrees to Black/African-Americans during a 5-year period, 2012-2016. If a department did not provide data in one of the five years, their total number is reduced due to missing data. Source: AIP Statistical Research Center

Universities awarding the most *physical science* bachelor's degrees to URM students
Rank

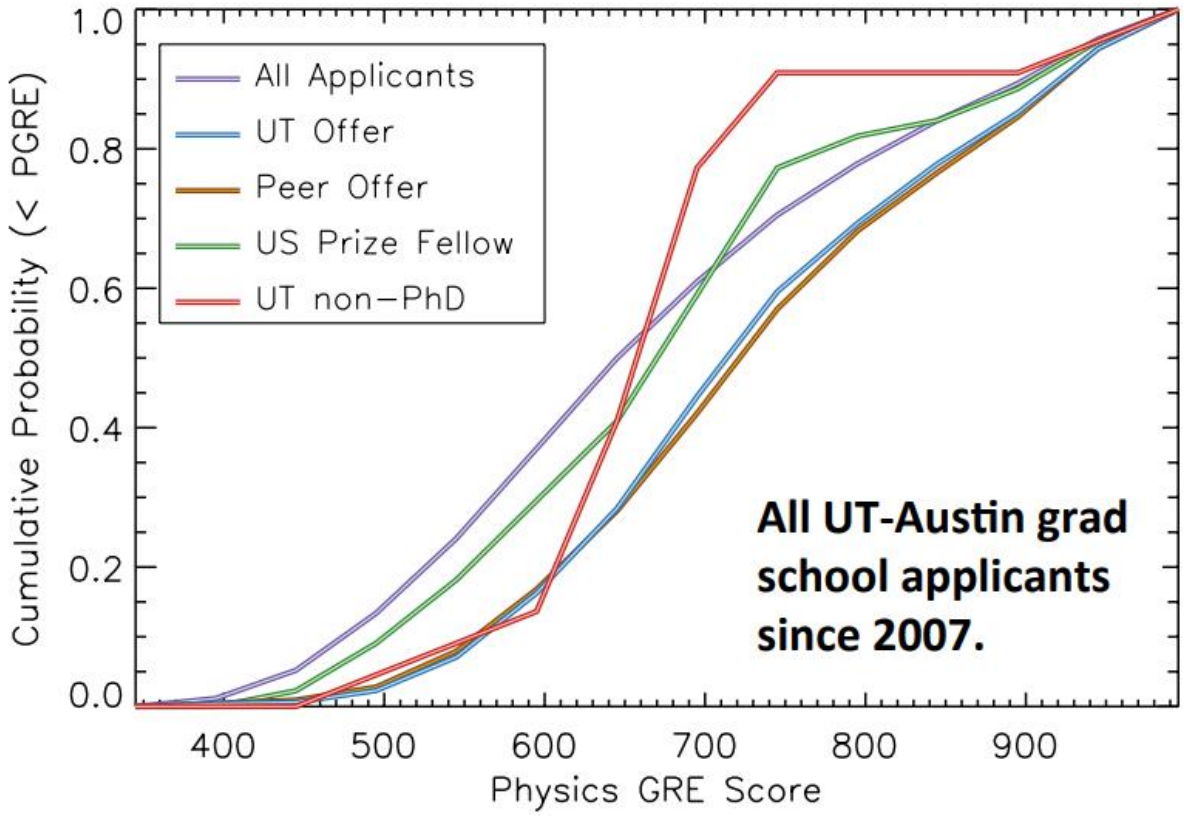
1. Florida International University (85 degrees/year)
2. Xavier University of Louisiana
3. The University of Texas at Austin
4. University of California-Santa Barbara
5. Texas A&M University-College Station
6. The University of Texas at El Paso
7. University of California-Los Angeles
8. University of Florida
9. Spelman College
10. University of California-Irvine
11. University of North Carolina at Chapel Hill
12. University of California-Santa Cruz
13. University of Arizona
14. University of New Mexico-Main Campus
15. Florida State University
16. Georgia State University
17. Jackson State University
18. The University of Texas at San Antonio
19. Columbia University
20. University of Memphis
21. CUNY City College
22. CUNY Graduate School and University Center
23. Savannah State University
24. Alabama A&M University
25. Georgia Southern University
26. Tennessee State University (15 degrees/year)

Source: Integrated Postsecondary Education Data System

Appendix IV: An Example of a Departmental Self-study on the PGRE

The University of Texas, Austin (UT) astronomy PhD program recently conducted a self-study of the relationships between their use of the physics GRE in admissions and the receipt of prizes, the number of first-authored publications, and other outcomes for their graduate students and other applicants. We provide this example because it is relatively recent and comprehensive, and because of the willingness of the UT astronomy program to share this information.

The data collected was for the years 2007-2016. In that time, UT received 1382 applications; 175 applicants attended UT or a peer institution that could be identified, and 22 received prize fellowships (from years 2007-2010). The figure below shows the PGRE score distribution for all applicants, those who received offers from UT or a peer institution, and those who obtained a prize fellowship.



The UT faculty concluded that their department (and peer departments) accept students with higher PGRE scores than those of the applicant pool, but that despite that selection bias, prize fellows look like the applicant pool. This was one factor in their decision to stop accepting PGRE scores from applicants starting in Fall 2016.

Appendix V: Sample Evaluation Rubrics for Graduate Applications

- *Example 1 (University of Texas, Austin):*

Category	Elements of evaluation	Weight	Score	Comments
Academic Preparation	GPA[22], choice of courses taken, upper division technical GPA, trajectory	35%		
Research Experience	Research experience, off-campus research undertaken, tangible products (i.e., journal articles)	35%		
Grit/Initiative	Concrete demonstrations of overcoming adversity	10%		
Professional Maturity	Independence, useful discussion of what they expect to do in astronomy, demonstrations that they understand what research entails, discussion of how their interests fit	10%		
Community Engagement	Participating in public outreach or departmental events, or otherwise demonstrating that they will be engaged members of the community	10%		
Final Score		100%		
General Comments	Other aspects of application that don't fit in the rubric but should be discussed			

- *Example 2 (developed by Casey Miller and Julie Posselt for the Inclusive Graduate Education Network):*

Item	High	Medium	Low	Notes
Academic Preparation				
Research Potential				

[22] Grade Point Average (GPA)

Item	High	Medium	Low	Notes
Diversity Contributions				
Fit with Program Research and Community				
Realistic Self-Appraisal				
Preference for Long-Term Goals				

- *Example 3 (evaluation system developed by Ecology Graduate Program at the University of California, Davis). There are eight trait scores; for each, the possible scores are -1 (the trait is weak in the application), 0 (the trait is present at the average level), and 1 (the trait is strong in the application):*

Trait	Score
Creativity and ability to link ideas in novel ways. Original approaches. For example, brings concepts from other fields to the study of ecology. Demonstrates use of varied experiences and background to formulate and answer scientific questions.	
Ability and willingness to work hard and steadily towards a goal. This can be demonstrated both by academic and non-academic work. Long-term goals.	
Experience with diverse cultures, groups, and ecological or socioeconomic environments.	
Leadership and motivation to do service and outreach, and interact with historically underrepresented or socially disadvantaged communities. Strong desire to help others.	
High GPA or steady academic growth, especially in the sciences, e.g., sustained increase in GPA in the last years of study. High performance in relevant coursework and high GRE scores. For example, consider grades in math and quantitative courses in addition to the quantitative GRE score.	
Perseverance in the face of academic and other life challenges. For example, starting college in community college, being a 1st generation college student, a member of recent immigrant family, or having socioeconomic disadvantages.	
Balance between focus and flexibility. Adaptability. Comfortable with a future with variable options.	
Takes advantage of opportunities in science; has research or work experiences and a realistic perspective on how to conduct and/or complete research projects. For example, this can be demonstrated through publications, presentations at scientific meetings, extended post-baccalaureate research, relevant graduate-level coursework, summer research experience at external institution, undergraduate research experience, work in science education, work in private sector science.	

Appendix VI: Admissions Interview Procedures and Resources Used by Selected Astronomy Departments

Abbreviations used in this appendix: University of Texas, Austin (UT), University of Washington (UW), University of Maryland College Park (UMD), University of California, Santa Cruz (UCSC)

- *Examples of interview procedures*

Question	**UT**	**UW**	**UMD**	**UCSC**	**Fisk-Vanderbilt Bridge Program**
When do you interview?	After final candidate list has been established	After two rounds of application reviews, where each application is read by at least three people on a committee of four	After long list of candidates has been established	After final candidate list has been established	After long list of candidates has been established
How long are your interviews?	20 min	10 min	30 minutes. Usually scheduled back to back, so they don't run longer	30 min	30 min
How many candidates do you interview?	10% or so	Top ~17-20% of applicants	Roughly 1/3. I think this past year we did over 50 interviews	In 2017-18 we interviewed ~9% of applicants and the year before it was slightly more	We aim to interview ~three times as many candidates as there are final admission slots

Question	**UT**	**UW**	**UMD**	**UCSC**	**Fisk-Vanderbilt Bridge Program**
How many people participate in the interviews?	We try for 3, sometimes 2. It's generally members of the admissions committee. If there's a clear common interest between the student and a potential advisor who is actively looking for students, we try to include that potential advisor as well	Ideally each interview has 3 faculty members in it: 2 are always members of the admissions committee, and the third is someone whose research interests overlap with the student. No one person is in on every interview, but the numbers work out such that every admissions committee member has a pretty sizeable basis of comparison (sitting in on anywhere from ~20-40 of the interviews depending on the schedule)	There are 3 faculty on admissions, and a subset of 2 sit in (sometimes a 4th faculty substitutes), plus one grad student. Faculty are members, except when there is a conflict. Grad students are not (they are not included on admissions committee)	1-2 faculty participate in each interview, along with 1 current student, and the grad advisor. The faculty are not always part of the admission committee. We generally try to have faculty with matching research interests to those of the prospective student	Two faculty interviewers in each interview. A given faculty pair will typically interview at most ~10 candidates to keep the workload manageable for any given faculty member

Question	**UT**	**UW**	**UMD**	**UCSC**	**Fisk-Vanderbilt Bridge Program**
Do you use a script?	We try to establish a rough script to start, but if specific topics come up in discussing their application, we also ask about those. And will follow up on topics like research experiences in a way that is unique to each interview	There isn't an exact script, but in practice the interview formats tend to follow the email outline pretty closely [see below]. Every once in a while, we will have a specific topic that we want to ask a student about. When asking about research and outreach we like to phrase this as asking about experiences that are "particularly meaningful to the students," as a way of encouraging to talk about the things that made the biggest impression on them	Yes, adapted from the Fisk-Vanderbilt toolkit [and included below]	Yes. We have a fairly free-flowing conversation and tell the interviewees in advance about what we are covering (usually one week in advance)	Yes, we use a "protocol" with a set of sample questions as a guide. These are scored using a rubric

- *Sample pre-interview email 1 (UW):*

We're looking forward to speaking with you tomorrow! You'll shortly be receiving a Skype contact from me, and 1-2 other faculty will be joining us for the interview as well.

We'll only have 10 minutes, which can go by quickly, so here is the format and what to expect:

1. Introduction
2. We'll ask you to give us the "elevator pitch" of a research project you have been involved in, emphasizing your intellectual contribution and obstacles you were able to overcome.
3. We'll ask you to share briefly about an outreach or teaching experience (either in astronomy or otherwise), and what impact this had.
4. We'll ask you to share how UW fits into your interests, and why you would like to come here.

5. You can ask us any specific questions about UW/Seattle/admissions etc.
6. We'll let you know the next steps in the admissions process.

With only 1-2 minutes per item, it is going to be a whirlwind Skype meeting, but we hope it will be helpful on both sides!

In case of Skype problems, be aware that we may try to contact you via phone instead, using the contact information that you gave us in your application.

- *Sample pre-interview email 2 (UCSC):*

We would like to hear about your research background/interests, academic preparation, and thoughts about graduate school and getting a PhD in Astronomy at UCSC. In particular, we'd like you to choose a research project that you are doing/have done and tell us about:

1. the project's broader motivation/background/context
2. the specific project tasks that you have carried out (as opposed to work that has been done by your mentors/collaborators)
3. the research that you see yourself doing in graduate school at UCSC

- *Sample interview script (UMD):*

Thank you for your interest in UMD. [Interviewers: introduce yourselves --name and job title]
Like we mentioned in the email, we will ask you some questions to help us better understand you as an applicant beyond what we can learn from just the paper application. The interview will last about 30 minutes, and we'll leave time at the end for your questions. Do you have any questions about the interview procedure before we start?

Interview question	**Primary rubric item addressed (other rubric item(s) potentially addressed)**
You did a research project on [topic of research] at [place]. Tell me/us about what you did and why it was scientifically relevant	research experience
Why are you interested in graduate school? What are your long-term goals?	long vs short term goals; (interest and fit with UMD)
What are you most proud of in your undergraduate career?	positive self-concept; (realistic self-appraisal)
What was your biggest challenge in your undergraduate career? How did you address this?	realistic self-appraisal; perseverance
What do you think will be the biggest challenge for you in graduate school? -Why do you think this?	realistic self-appraisal
What are you most excited about for graduate school? What excites you most about UMD specifically? If working with [specific single faculty they want to work with] doesn't work out, what would you do?	interest and fit with UMD; (positive self-concept)
What, if any, extracurricular or non--required academic activities (athletics, outreach activities, clubs, etc.) have you been highly involved in? What role did you play? [interviewer could point out specific activities	leadership and community involvement

Interview question	Primary rubric item addressed (other rubric item(s) potentially addressed)
listed on application, e.g., I see you've been involved in [activity].]	
[if time/need] Give an example of a time in your academic career or elsewhere when you were derailed from making steady progress toward a goal you had set. How did you overcome this, if at all?	perseverance; (positive self-concept)
Are there any other aspects of your application that you'd like to explain in more detail? Is there anything that didn't show up on your application that you want to add?	
Do you have any questions for me/us? [leave at least 5 minutes for this]	(interest and fit with UMD)

- *Sample rubric for scoring interviews (UMD)[23]:*

Attribute	**Rating: High**	**Rating: Medium**	**Rating: Low**
Positive self--concept	Expresses confidence they can complete challenging goals, makes positive statements about abilities	Shows confidence and independence but may be unsure about adequacy or skills	Exhibits low self--esteem and low confidence in their abilities
Realistic self--appraisal	Can clearly and realistically delineate strengths and weaknesses, works on self-development	Has trouble identifying strengths and weakness but appreciates/seeks both positive and negative feedback	Over or understates abilities, does little to no self--assessment, does not appear to have learned from experiences
Preference for long vs short--term goals (motivation for wanting an astronomy PhD)	Clearly communicates long--range goals beyond the PhD, passionate about astronomy	Primary goal is PhD completion, but reasons for wanting a PhD are not well--articulated	Is vague about long--term goals, or goals are short term
	Demonstrates extensive involvement and/or leadership ability in academics, family, community, or athletics.	Demonstrates involvement in academic or community groups, but has not shown leadership or extensive engagement.	No or minimal involvement in academic or community activities, no demonstrated leadership.
Research experience	Able to articulate both the science of their specific research and how it fits into the bigger scientific picture.	Able to describe the specific science in their own research but little to no ability to articulate how it fits into the bigger picture.	Only able to articulate a superficial understanding of their own work, and little to no understanding of the bigger picture.
Perseverance	Can describe a time they failed or encountered an obstacle and successfully coped.	Can identify a time they hit an obstacle but has trouble defining how they overcame the challenge.	Has little experience with failure/obstacles. Cannot provide an example or describe response.
Interest and fit with UMD	Can name and describe multiple interests in UMD: specific people, resources, programs, or collaborations that are specific to our program.	Research or programmatic interests are aligned with UMD, but cannot identify multiple specific aspects of our program that interest them.	No specific knowledge of UMD's program, and interests are strongly misaligned with our department's resources.

[23] Adapted from Fisk-Vanderbilt toolkit

Appendix VII: Sample Rubric for Scoring Non-cognitive Competencies in Recommendation Letters

Indicator	**Rating: High**	**Rating: Medium**	**Rating: Low**
Knowledge, creativity, intellectual ability	Has a deep and broad perspective on the field; is among the most imaginative persons I know; produced novel ideas; is intensely curious	Generates original ideas for next steps; exhibits an open-mind to new ideas; is resourceful	Relies heavily on detailed instructions; unable to develop new ideas
Communication skills and potential as a teacher	Speaks in a clear, organized, and logical manner; shows poise when communicating; writes with precision and style; organizes writing well	Has potential in teaching concepts to others; is able to identify and communicate the interesting aspects of ideas	Has difficulty in conveying ideas to others through speaking or writing
Teamwork	Supports the efforts of others; gives criticism/feedback to others in a constructive way	Behaves in an open and friendly manner; works well in groups settings	Exhibits difficulty in working with a group; unable to work toward consensus or develop ideas for resolution of disagreements
Perseverance and emotional maturity	Works well under stress; can overcome challenges and setbacks; works extremely hard	Accepts feedback without getting defensive; is reliable; with support shows resilience	Evidence of significant setbacks and lack of initiative to resolve issues
Planning and organization	Sets and meets realistic goals; organizes work and time effectively; makes plans and sticks to them	Meets deadlines; shows self-discipline	Disorganized; unable to bring projects to a conclusion
Ethics and Integrity	Maintains high ethical standards; demonstrates sincerity; evidence of courage in the face of difficult circumstances	Demonstrates honesty; is worthy of trust from others	Displays little humility
Motivation for proposed program of study	Demonstrates an intense drive and industriousness; shows a mature understanding of the career paths in the field	Is focused on goals and career objectives; seeks career advice	Unclear what the reasons are for pursuing their course of action

Appendix VIII: Detailed Suggested Practices, Concrete Steps, and Resources for Retention

To help participating graduate programs in establishing and carrying out plans with measurable outcomes deriving from recommendations in five areas from the Inclusive Astronomy 2015 report (the Nashville Recommendations), this appendix provides a detailed set of good practices and examples of concrete steps that departments can take to address these five areas.

A. End harassment and bullying in and around astronomical workplaces

Problem: Many people surveyed in astronomy and planetary science feel unsafe in the workplace as a result of their identities.

Astronomers have the right to work in places that are free of harassment (NASEM 2018b). This includes sexual harassment, racial harassment, harassment based on real or perceived gender identity or sexual orientation, ableist harassment, physical harassment, verbal harassment, and bullying. Because of intersectionality, these different forms of harassment often occur simultaneously (Clancy et al. 2017). Power dynamics are also a vital aspect of harassment and bullying, and must be considered when developing anti-harassment policies to ensure that all members can report harassment by their superiors safely and without fear of reprisal.

An effective anti-harassment policy should be bottom-up as well as top-down, both implicit and explicit. This is a tall order: it is easier to say you are against harassment and bullying than it is to actually take the steps necessary to change existing department culture and enforce anti-harassment rules. “Mandatory reporting” policies, while arguably necessary under the law, are often designed to protect the institution rather than the victims of harassment and bullying. While academics and their departments are required to work within their institutional guidelines, departments can and should be more proactive about addressing harassment and bullying, and create their own culture for combatting it.

Examples of good practices include:

1. Form an equity and inclusion committee that meets monthly to develop and guide policies and practices and to provide a reporting mechanism for people in the department
2. Adopt a code of conduct, with clear anti-harassment policies and procedures, including highly transparent reporting avenues

   Examples of concrete steps:
   - A code of conduct can be modeled on AAS codes and policies and/or campus codes and policies.
   - Adhere to Title IX anti-discrimination policies on recruitment, admissions, counseling, financial assistance, sex-based harassment, treatment of pregnant and parenting students, discipline, employment and retaliation for any recipients of federal financial assistance from the US Department of Education
   - Adhere to Title VII of the Civil Rights Act
3. Provide a centralized location for anti-harassment resources. Publicize policies, procedures, reporting avenues, and contact information

   Examples of concrete steps:
   - Website with relevant documents
   - Signs around the department
4. Provide mechanisms for anonymous reporting of harassment and bullying, including a designated intake person. First response is critical: a complainant’s first attempt to tell their story is often the deciding factor in whether they will press forward with their complaint, or view the institution as their “enemy”

   Examples of concrete steps:
   - The intake person should be someone in a position of relative power, who is both committed to reducing harassment and bullying and is to trained to listen and report as appropriate
   - Practice active/reflective listening. Repeat what the complainant is saying to make sure they feel understood

- Do not correct, contradict, or dismiss the complainant's account at any point
- Do not place limitations on possible actions at this point
- Ask the complainant what action/outcome they would prefer. This is not a promise, though their preferences should be weighted heavily. It is also not binding – the complainant can (and likely will) change their mind later on. Asking will create trust, and it will trigger both parties to consider concrete outcomes. Explain requirements of mandatory reporting early in the conversation (if triggered by a complaint)
- Practice gift-receiving behavior: thank the complainant, express appreciation for their report. They have done a hard thing. Think about what happens when we reject a gift, or question the motives of the giver
- Recognize that the individual who intakes the report is likely to find themselves in the position of advocating for or emotionally supporting the complainant. Acknowledge this is an emotionally fraught position. Reward the individual who performs this service, and consider rotating periodically

5. Leadership (i.e., department chair) must speak up in support of the impacted groups in clear and unequivocal terms

   Examples of concrete steps:
   - Encourage leadership to participate in mediation training
   - Particularly when (tenured) faculty members are involved, the department chair is the only person who can nip bad behavior in the bud, before it escalates to the point of involving the dean or institutional Human Resources (HR)
   - The department chair can mitigate the "Friends-of-the-Accuser" effect among other tenured faculty by believing the complainant and shutting down behind-the-scenes grumbling about investigations. The "Friends-of-the-Accuser" effect occurs when colleagues enable harassment and bullying by ignoring or denying it, e.g., "I've known Professor so-and-so, and he would never do that…this false accusation is a baseless attempt to discredit him by jealous junior scientists." This creates an environment that is actively hostile to reporting
   - Willingness to admit a problem and provide transparency creates institutional trust, and mitigates community anger
   - Unwillingness to admit a problem and/or claiming helplessness builds community resentment and facilitates further bad behavior from serial offenders

6. Provide oversight mechanisms for people in positions of power to reduce the likelihood of abuses of power. Recognize the large power imbalance inherent in the advisor/doctoral candidate relationship, and how that produces opportunities for abuse

   Examples of concrete steps:
   - Guarantee funding for students. Graduate assistantships mean access to health insurance, rent, food, and, for foreign students, visa status. Pulling research funding is one of the first steps of control and retaliation used to deter reporting. Responsibility for funding all students making satisfactory progress toward a degree should be recognized as a collective responsibility and guaranteed by the department, not subject to the whim of individual faculty members
   - Letters of recommendation are another piece of leverage commonly used to control/retaliate against complaints. Create mentoring committees with annual or more frequent meetings and formal reporting, so students have a network of involved faculty members familiar with their work, and are not completely dependent on a single faculty member
   - Allow research advisor changes. This may add time to a student's time-to-degree. Make sure the student is supported (see above)
   - Include students in faculty review and hiring committees. Ideally these representatives should be chosen by the grad students collectively, rather than the faculty

7. Work to create an institutional and departmental culture where harassment and bullying are not tolerated and are actively challenged. Proportionate response is critical

   Examples of concrete steps:
   - Hold serial harassers and bullies accountable for their actions, up to and including termination of employment, guided by Office of Civil Rights and Title IX (or equivalent) processes of the institution
   - People who have demonstrated an established pattern of abusive behavior should be excluded from positions of power or authority over others
   - Recognize the myth of tenure: the perception of tenure creates a myth (shared by both students and staff) that a tenured individual is invincible. This perception further means that administrators and department chairs are allowed to perceive themselves as helpless. This is not true – tenure has its limits
   - Affirmative findings of harassment or abuse should trigger external climate assessment
   - While sexual assault is always a serious matter, harassment and bullying can span a wide spectrum that may not necessarily trigger mandatory reporting
   - Informal, proportionate response stops potential serial offenders who are "testing limits"
   - Articulate and widely disseminate a policy on what constitutes professional behavior (what is offensive language, bullying, etc.) This includes intersectional bullying and abuse
8. Work toward normalizing, providing, and publicizing trainings, whether departmental, institutional, or external, and encourage department members to attend

   Examples of concrete steps:
   - Promote anti-harassment training sessions on bystander intervention techniques, best practices for responding to complaints, institutional policies and resources, and content relevant to the astronomical workplace
   - Training on diversity, equity, and inclusion includes training around being an ally, privilege, gender, race, LGBTIQA* Safe Zone, and disabilities/ADA compliance. Training sessions should focus not only on the legal definition of harassment, but how to prevent the many stages of inappropriate behavior that do not cross the legal line

Resources

- Department of Education Title IX: http://www2.ed.gov/about/offices/list/ocr/docs/tix_dis.html
- Title IX coordinator finder: https://www.aauw.org/resource/find-your-title-ix-coordinator
- Fran Sepler's talk at Women in Astronomy IV: Beyond the Whisper Net: Policies, Logistics, and Strategies to Curtail Harassment: https://osf.io/3kscw/
- Title VII: https://www.aauw.org/what-we-do/legal-resources/know-your-rights-at-work/title-vii/

B. Provide an accessible environment, including but not limited to full ADA-compliance

Problem: As discussed in the Nashville Recommendations, "there are little data available on the numbers or experiences of persons with disabilities in astronomy, but anecdotal reports make clear that people with disabilities still experience significant lack of access to both physical spaces and to the tools of the profession".

While academics and their departments are required to work within their institutional guidelines, departments can and should be proactive about facilitating accessible environments.

Examples of good practices include:

1. Ensure that departmental facilities are accessible, i.e. fully ADA compliant. This includes historic structures which are normally exempted from ADA regulations. Work with your

disabilities office which often has resources (or lobbying credentials) to bring your facilities into compliance

2. Department-wide events (colloquia, seminars, picnics, and any other activities) should be held in spaces accessible to everyone
3. Publish links to campus-wide disability resources and accommodation request processes on the graduate program webpage
4. Assure that classroom environments meet or exceed ADA compliance. Work with students and disabilities offices to obtain and implement accommodations

   Examples of concrete steps
   - Include explicit wording in syllabi outlining your commitment to extend reasonable accommodations to all students with disabilities, whether visible or invisible
   - Know what accommodations are permitted by your campus's disabilities office, and assure that students are receiving these accommodations in the classroom (for example, alternative formats, extended time, flexible deadlines)
   - Work with students who are in the process of obtaining accommodations to complete paperwork, and work with your campus disabilities office to recognize and reduce barriers for students seeking accommodations
   - Make available testing environments free from distraction and follow universal/inclusive design. For example, designing tests such that the last person finishing the exam has sufficient time
   - Provide resources to faculty so that class notes and other teaching materials can be made available in multiple formats (audio, visual, captioned video, etc.)
   - Provide students with spaces to move as needed; allow students free access to come in and out of class
   - If attendance is required, allow students a well-defined leeway in arrival/departure times, particularly for those with disabilities and when teaching on large campuses
   - Make sure class activities are fully accessible; if they are site-specific (e.g., observatory, planetarium), assure full access to disabled students; if they are at night, assure there are escorts available or on call
5. Apply principles of accessibility to qualifying exams as well. This includes alternate format requests, flexible deadlines, and extended exam periods
6. Apply principles of accessibility to time-to-degree, including flexible deadlines. While universities often impose maximum (10 year) deadlines, and the practicalities of research funding incentivize shorter PhDs, the popular movement to push PhDs out in 5 years or less creates a substantial barrier to disabled and neurodiverse students

Resources

- WGAD website: https://wgad.aas.org/wgad_resources
- Creating a Culture of Accessibility in the Sciences: https://www.sciencedirect.com/book/9780128040379/creating-a-culture-of-accessibility-in-the-sciences
- Example of creating an accessible environment: https://aas.org/meetings/aas228/accessibility_inclusion

C. Provide a healthy, welcoming, family-friendly environment

Problem: For graduate students, department-level communities are critical and yet many students report a lack of connection and do not experience a welcoming climate (White and Nonnamaker 2008; Solem, Lee, and Schlemper 2009; National Academies 2018a). Graduate students are rarely covered under robust leave and health care policies.

Productive, creative, and sustained research requires an environment where everyone feels welcomed, valued, and safe, including a robust work-life balance. Research shows that refusing to talk about identity, equity, and inclusion is harmful to underrepresented students who struggle with these social aspects of the scientific workplace. Talking about these issues can ensure that students feel more supported and visible.

Institutions also have the responsibility to enact family-friendly policies. These policies should specifically include LGBTIQA* families and non-traditional family structures (Ackerman et al. 2018). High quality, affordable health care should be easily accessible. Health care that is of poor quality, prohibitively expensive, or contains exclusions for LGBTIQA* health limits the ability of astronomers to perform at their highest potential. While departments may not have direct control over health care and leave policies, they can and should advocate for them.

Examples of good practices include:

1. Department-wide events (colloquia, seminars, picnics, and any other gatherings) should be attended, accessible, and comfortable for everyone

   Examples of concrete steps
   - Ensure balanced involvement in the conceptualization, development, and participation in departmental events
   - Specifically invite everyone to department-sponsored social events
   - When refreshments are provided at events, provide a variety of options (e.g. non-alcoholic beverages, food that is gluten-free, halal, kosher, diabetic-friendly, allergen-free, vegetarian, vegan, vegetarian/vegan options that include protein, ingredients listed, etc.)
   - Do not schedule seminars, exams, or other deadlines on religious holidays
   - Schedule seminars, meetings, and events at family-friendly times and be flexible when scheduling
   - Track the demographics of personnel involved in events, such as organizers, invited speakers, awardees, etc. to determine if people with marginalized identities are being fairly represented, as compared to their proportion of the U.S. (or relevant national) population
   - Establish clear and reasonable expectations for work effort and work-life balance (e.g., number of hours of lab time or work time expected). Support and adhere to these expectations
   - Honor group and collaborative accomplishments in the same manner as individual accomplishments
2. Enact policies that are friendly to people of all genders
   - Ensure there are gender neutral bathroom facilities
   - Facilitate name and gender changes on organizational records and establish a "preferred name" policy. Ensure that the preferred name is the one used within the department. Such changes should not be contingent on "proof", such as doctor's notes, or changes on legal documents such as birth certificates, passports, or driver's licenses. Such "proof" is expensive to obtain and therefore excludes many students
3. Enact family-friendly policies, broadly interpreted. Everyone has a family

   Examples of concrete steps
   - Develop mechanisms to facilitate geographic proximity for dual-career academic couples, including graduate students
   - Provide, advertise, and encourage the use of telecommuting options
   - Provide mechanisms for students who take time off for family, health, or other reasons to return (e.g., stop-the-clock policies, extensions of deadlines after birth/adoption, serious injury, mental health issues, and/or care for a family member)
   - Establish policies allowing paid leave or part-time leave for family (child, elder, partner) care that includes adoption, fostering, and LGBTIQA* couples
   - Provide conveniently located, accessible lactation rooms. Provide dedicated refrigerators for storing breast milk separately from employee food
   - Advocate for access to affordable, quality childcare. The childcare should be conveniently located (e.g., with options on campus) and not require excessive waits. Provide childcare subsidies

- Leverage departmental/university status to facilitate processes that disproportionately burden marginalized students, such as delayed stipend payments, housing discrimination or difficulty, etc.

4. Provide and advocate for sufficient medical leave, family leave, health care coverage, and mental health care

   Examples of concrete steps
   - Allow sick leave to be used for care of family members and mental health
   - Ensure that healthcare is affordable. Advocate for plans with low co-pays and deductibles. If co-pays are high, create funds to support students who need it
   - Advocate for a mechanism for students to take family/medical/other leave and still stay on the university health insurance without increased cost to them. In many cases, even when it is possible to take medical leave, doing so means losing access to benefits
   - Advocate for plans that include mental health, dental, vision, and reproductive health care
   - Advocate for health insurance plans that specifically cover transgender health care, same-gender couples, domestic partners, and dependents
5. Publish links to details of graduate healthcare and insurance on graduate program webpage. Include prescription, dental, vision, specialist, and mental health coverage, as well as co-pays and maximums
6. Change the work culture to value mental health

   Examples of concrete steps
   - Ensure that mental health services are advertised widely and openly
   - Talk openly about mental health
   - Work with mental health providers to host annual departmental workshops
7. Make discussions about diversity, equity and inclusion part of the departmental discourse

   Examples of concrete steps
   - Create or use a journal club to discuss articles on equity and inclusion
   - Establish a diversity seminar series. Strive to pay an honorarium to speakers
   - Openly discuss identity, equity, and inclusion
   - Encourage department members, especially leaders, to:
     - Practice actively being an ally
     - Recognize multiple axes of identity both in themselves and in others
     - Learn about the history of oppression against marginalized groups in your own culture and the culture you are in (they may not be the same)
     - Learn and use best practices for discussing racism and its intersections
     - Understand and reduce the negative impact of power imbalances
     - Reduce the occurrences, triggers, and impacts of conscious and unconscious bias, stereotype threat, and microaggressions

Resources

- Ackerman et al. (2018), LGBT+ Inclusivity in Physics and Astronomy: A Best Practices Guide https://arxiv.org/abs/1804.08406
- Why So Few? Women in Science, Technology, Engineering, and Mathematics, 2010 report by AAUW: https://www.aauw.org/research/why-so-few/
- AAUW Playbook on Best Practices for Gender Equity in Tech: https://www.aauw.org/research/best-practices-playbook/
- Implicit bias and the Implicit Association Test (IAT): https://implicit.harvard.edu/implicit/aboutus.html
- CSMA diversity and inclusion resources: https://csma.aas.org/resources/diversity
- CSWA webpage: https://cswa.aas.org
- SGMA webpage: https://sgma.aas.org
- AstroBetter diversity resources: http://www.astrobetter.com/wiki/Diversity
- AstroBetter diversity blog posts: http://www.astrobetter.com/blog/category/diversity/
- Council of Graduate Schools PhD Completion Project: http://www.phdcompletion.org/promising/environment.asp

D. Provide effective mentoring through evidence-based practices and expanded networking opportunities

Problem: Mentees from traditionally underrepresented groups report having less access to mentors and lower quality mentoring relationships (Ginther et al. 2011; Thomas et al. 2001; Smith et al. 1992; Ellis 2000; Blake-Beard 2001).

Mentorship is critical to creating a learning environment that facilitates student retention. Studies show that effective mentors influence a student's research productivity, career commitment, sense of inclusion, and overall satisfaction with their graduate experience (O'Meara et al. 2013; Mollica and Nemeth 2014). Graduate students being mentored are more likely to persist in their academic decisions with positive mentoring being cited as the most important factor in degree attainment (McGee and Keller 2007; Solorzano 1993). Inclusive support of all astronomers requires robust networks of peers, effective mentors and advocates. Student-advisor, mentee-mentor and employee-employer relationships are among of the most important in a young scientist's career. However, these relationships can fail for a variety of reasons. Providing evidence-based mentor and mentee training, having clear, non-stigmatized pathways for changing groups/advisors, having independent and senior advocates of students and postdocs, and developing community-based mentor networks are ways to prevent scientists from being derailed in their career progression.

Examples of good practices include:

1. Provide mentoring structures that give students more than one person as a close advisor

   Examples of concrete steps
   - Make sure there is both time and funding available for mentoring activities
   - Ideally, a mentoring committee is formed and a student should be able to meet with the committee WITHOUT their advisor as well as vice versa
   - This committee should meet no less than once per semester and provide a place to catch poor communication as well as harassment and bullying
   - Providing effective mentoring structures may include a formal network established by the department and an informal network endorsed by leaders
2. Provide/require mentoring training for faculty and other parties involved in mentoring, such as postdocs, research scientists, staff, etc.

   Examples of concrete steps
   - Mentors should help students reach their potential and goals; it is not their job to eliminate students (for example by telling students they "don't belong" in the field or program)
   - Explore evidence-based materials and trainings: See www.cimerproject.org for examples and links as well as Appendix IX
   - Normalize and publicize evidence-based training for mentors focused on best practices in advising/mentoring: See https://cimerproject.org/#/curricula/recruiting
   - Include modules on culturally aware mentoring, paying particular attention to the needs of underrepresented/LGBTIQA*/disabled students.
     See https://nrmnet.net/research-mentor-training/
3. Provide mentee training to help mentees be more proactive in their mentoring relationships

   Examples of concrete steps
   - Explore evidence-based materials and trainings. See www.cimerproject.org for examples and links
   - Meet mentees' diverse and changing needs and address issues of equity, inclusion and culture such as cultural resilience and navigation
   - Use individual development plans to help students identify their goals and needs and help them to find mentors to meet those needs.
     See, for example: https://ictr.wisc.edu/mentoring-2/individual-development-plan/

4. Create and support near-peer mentoring structures; e.g., senior graduate students mentoring junior/incoming graduate students

   Examples of concrete steps
   - Establish a mentoring ladder to span multiple career stages to support transitions; e.g., graduate mentors of undergraduates, postdoc mentors of graduate students, junior faculty mentors of postdocs, senior faculty mentors of junior faculty, etc.

5. Provide access to mentors of color and mentors from other marginalized groups

   Examples of concrete steps
   - Hire faculty from marginalized groups
   - Invite faculty from marginalized groups to visit, present, take a sabbatical at your institution

6. Increase networking opportunities for students, including marginalized students and encourage faculty to volunteer to serve as mentors in these networks

   Examples of concrete steps
   - Provide funds for travel to meetings of NSBP, SACNAS, OSTEM[24], etc.
   - Connect with (or establish) local chapters of groups like NSBP and SACNAS to provide networks beyond the department
   - Support and publicize identity support networks within and across STEM departments and connect to institution-level resources. e.g., Black Resource Center, Queer Resource Center, DREAMer[25] Alliance, etc.
   - Support meet-and-greet activities
   - Encourage mentees to explore online mentoring programs such as https://mentornet.org/

7. Establish a positive culture around non-academic careers

   Examples of concrete steps
   - Encourage all students to consider multiple career options after graduate school
   - Partner with on-campus career services to provide training for transitioning away from academia
   - Emphasize that success can take many forms

8. Establish a non-judgmental culture around time to degree
   - Recognize the popular push to graduate everyone in five years is deeply ableist, not family-friendly, and drives some students out of the field at an alarming rate

Resources

- National Society of Black Physicists (NSBP): https://www.nsbp.org
- National Society of Hispanic Physicists (NSHP): http://network.nshp.org
- Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS): http://sacnas.org

A full list of mentoring resources is provided in Appendix IX.

E. Adopt teaching and learning practices that support all students, especially those with marginalized identities

Problem: Students from minority/marginalized groups often experience classroom environments and dynamics differently than people from majority groups, and in ways that may reduce the effectiveness of learning opportunities. Furthermore, underrepresentation can lead to isolation and additional obstacles beyond challenging content (Johnson et al. 2017), such as stereotype threat, microaggressions, lack of micro-affirmations, and imposter syndrome. Departments can take steps to counter these effects (e.g. Estrada et al. 2018 and Barthelemy et al. 2016).

[24] Out in Science, Technology, Engineering, and Mathematics (OSTEM)

[25] Development, Relief, and Education for Alien Minors (DREAM)

The foundation of a successful career in astronomy is educational opportunity. Deliberately adopting research-validated practices and principles of inclusive design can eliminate barriers to learning and biases in assessment, making educational opportunity available to all.

Examples of good practices include:

1. Work to create a thriving, inclusive educational environment in your department. Use departmental, campus, and external resources and experts to provide training on inclusive practices to facilitate implementation of evidence-based classroom techniques and revision of qualifying exam practices and other evaluation procedures

   Examples of concrete steps
   - Encourage and provide opportunities for instructors, potential instructors, and teaching assistants to learn inclusive pedagogical and assessment techniques (e.g. workshops, mentoring for teaching, pedagogy courses)
   - Provide incentives, opportunities, and support (e.g. financial, release time) for instructors to adopt and develop research-based inclusive learning practices and curricula
   - Work with departmental experts (such as education researchers) campus resources (such as Centers for Teaching and Learning), or external experts to evaluate and improve instruction in your department
   - Attend events at meetings of professional societies that offer professional development in evidence-based inclusive teaching and learning practices (e.g., AAS, AAPT, New Faculty Workshop)
   - Collect and use classroom/department data to identify achievement/opportunity gaps or issues of classroom climate
   - Create a setting where marginalized students and faculty can find validation and a sense of belonging in the field, vent frustrations, and express their full identities
2. Know what strengths, weaknesses, needs, and resources your students bring to the classroom, and adopt appropriate teaching and assessment strategies. Foster a growth mindset in yourself and your students

   Examples of concrete steps
   - Approach the classroom with an asset rather than deficit model of your students
   - Convey that physics is mastered through practice and hard work, not innate, unchangeable talent
   - Reflect on teaching practice individually and collaboratively
   - Inform your teaching with results from education research and existing research-based curricula
   - Diversifying your instruction techniques and resources can significantly improve inclusion; get to know your students and what works best for each of them
   - Provide opportunities for community building in classes, including spaces and times for students to get to know each other and work together
   - When implementing interactive teaching methods, make sure that students who do not want to participate (e.g., introverts, those with social phobias) are not forced to do so
   - When fostering group work, monitor group interactions and progress. Provide for some quiet process time to allow students to collect their thoughts
   - When appropriate, provide opportunities for peer mentoring. Actively recruit (more than blanket emails) peer mentors, tutors, etc. across many dimensions of diversity
   - Consider including low-stakes diagnostics at the beginning of the course to identify what students' skills are coming into the course; design your teaching based on what the students know, not what you assume they should know
   - Make clear policies on accommodation for students who have conflicts due to religious practice, medical treatment, family and/or personal emergencies. Universities or departments may have existing policies in place
   - Beware of organizing off-schedule activities that might exclude some students. For example, review sessions at unscheduled times might be difficult for students who have to work and/or commute via public transportation. Commuting at odd times

is particularly challenging for undocumented students, for whom obtaining a driver's license is extremely difficult in some states
    - Recognize that a “no-device” policy may inhibit the learning of some students; consider best practices such as separate seating areas in class for students who require devices versus students who find devices distracting
    - Recognize that not all students have access to technology (e.g., their own laptops, calculators, clickers) and strive to eliminate technology barriers
3. Be aware of classroom participation and dynamics

   Examples of concrete steps
    - Highlight the scientific contributions of a variety of astronomers, not just those who are white, male, able-bodied, and heteronormative
    - Pay attention to the classroom climate, and address discriminatory behavior promptly and respectfully; it is often helpful to have student representatives available for reporting
    - Create environments that mitigate the effects of isolation and stereotypes, by rejecting any stereotypes that are brought up and, directly affirming that women of color belong
    - Insist that micro/macro-aggressions are decreased and micro/macro-affirmations are increased
    - Monitor your own biases. Be aware of and refrain from using racist, sexist, ableist, gender-discriminatory, transphobic, or homophobic language in the classroom; if such language is part of the instructional material (which should be rare in an astronomy course), give students content warnings
    - Be aware of whom you are calling on for questions and answers; avoid choosing one demographic group over another (e.g., only the men) or focusing on one section of the room (e.g., only the front). One way to achieve this is to wait until at least three students have raised their hands. When appropriate and feasible, move away from the front of the room and speak from and to different parts of the class
    - Be aware of students who appear visually different from most in class (e.g., people of color, those with visible disabilities) that are sitting in isolated areas. Do not take steps that may make them feel more self-conscious, such as announcing to the whole class that people should move closer to the students in question; rather, take more subtle and universal steps such as calling for students to talk to the person behind, to the right/left, of them
    - Be aware that a student's preferred pronoun may not be the one you assume. In smaller classes, students can be invited, if they wish, to indicate a preferred pronoun on a name-tag or tent. Some students may prefer to avoid pronouns if possible. In larger classes the instructor can seek to minimize the number of times a pronoun is used

Resources

- PhysPort provides research-based physics education resources, recommendations, curricula, and assessments for the classroom: https://www.physport.org
    - Articles by experts on general classroom practices: https://www.physport.org/recommendations/
    - Recommendations for handling biases in the classroom:
    - https://www.physport.org/recommendations/Entry.cfm?ID=93333:
    - How to engage with students more effectively with active learning:
    - https://www.physport.org/recommendations/Entry.cfm?T=productive%20engagement
- Special volume of Physical Review Physics Education Research (PRPER) focused on gender issues: https://journals.aps.org/prper/collections/gender-in-physics
- Special volume of The Physics Teacher that focuses on race:
- https://www.aapt.org/Resources/Race-and-Physics-Teaching.cfm
- The New Faculty Workshop is organized annually by the American Association of Physics Teachers. Resources and information on the workshop can be found here: http://aapt.org/Conferences/newfaculty/nfw.cfm

Appendix IX: Further Mentoring Resources

Resources to improve mentoring relationships and experiences of graduate students.

Free, online, self-paced training modules and resources of mentors to help them advance their practice
90 minute, online self-study for the mentors of graduate students, postdocs, and junior faculty to optimize their mentoring practices
Online self-study module for mentors on how to better motivate their mentees (Coming soon: See NRMN website)
Resources for mentees for each phase of the mentoring relationship: selection, alignment, cultivation, closure
Introduction to culturally aware mentoring training available
Example Mentoring Compacts
Example Individual Development Plans
Free, online, self-paced training modules and resources for undergraduate, graduate and postdoctoral mentees to help them build skills and effectively navigate their mentoring relationships.
Online course for "Planning Your Scientific Journey" which helps undergraduates and graduate students acquire knowledge and developing experimental skills (primarily for life science students but broadly applicable)
Resources for mentees for each phase of the mentoring relationship: selection, alignment, cultivation, closure
Example Mentoring Compacts
Example Individual Development Plans
Platforms for mentors and mentees to expand their mentoring networks
MyMentor: Online social networking platform for mentors and mentees engaged in biomedical science, broadly defined provided by the National Research Mentoring Network (NRMN)

Platforms for mentors and mentees to expand their mentoring networks (cont.)
MyNRMN: Social networking platform from NRMN for students and researchers across the biomedical, behavioral, social, and clinical sciences to connect with one another for anything from general questions about research and professional development as a scientist to scheduling more formal mentorship appointments one-on-one or as a group
MentorNet: Online, structured virtual Guided Mentorship program for mentors and mentees across broad areas of science and career pathways
Physics National Mentoring Community: The American Physics Society National Mentoring Community (NMC) facilitates and supports mentoring relationships between African American, Hispanic American, and Native American undergraduate physics students and local physics mentors
Designing and implementing research mentor training for implementation on your campus (based on Entering Mentoring curricula)
Evidence of training effectiveness for use in convincing stakeholder and colleagues
Scheduling and group size tips for mentor training
Facilitation tips for mentor training
Facilitator training opportunities
Complete training curricula with case studies, activities and facilitator notes - including one specifically for mentors of undergraduates in astrophysics and one for mentors of graduate students
Build-your-own training curricula
Culturally aware mentor training
Other available curricula and training materials

Designing and implementing research mentee training for implementation on your campus (based on Entering Research curricula; cont.)
Evidence of training effectiveness for use in convincing stakeholder and colleagues as well as potential mentors
Scheduling and group size tips for mentor training
Facilitation tips for mentee training
Facilitator training opportunities
Complete training curricula with case studies, activities and facilitator guides for undergraduates in STEM
Build-your-own training curricula
Other available curricula and training materials
Evaluation of mentors, mentees, mentoring relationships, and/or mentored research experiences
CIMER Assessment Platform: Allows groups to set up common metrics surveys for their program and assess mentors, mentee, training and mentoring relationships
Learning Assessment for Undergraduates and Graduate Students in Mentored Research Experiences. Contact Janet Branchaw (branchaw@wisc.edu)
Mentor self-assessment tool
National Academies Study of Mentoring (with an online toolkit coming in 2019)

Appendix X: Departmental Self-assessment Rubric

Recruiting and Admissions	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Recruiting members of underrepresented groups	Departmental website encourages women and underrepresented minorities to apply	Department members attend conferences like CUWiP, OSTEM, SACNAS, and NSBP	Department hosts or participates in a Bridge Program, student affinity groups present at conferences, Department partners with HSI/MSI/HBCUs
Non-cognitive assessment	Faculty recognize the importance of motivation and perseverance	Department interviews women and minorities, but leaves it up to individual faculty how they assess and report	Interviewers are trained in non-cognitive assessment and use a rubric. Promising candidates are invited to visit and form relationships before applying
Use of GRE	General and Physics GRE are used with cutoffs for admission	Physics GRE is optional, and committee members are aware of its effect in suppressing women and minorities	Department has studied predictive ability of GRE in the past and no longer uses it in admissions decisions
Letters of recommendation	Department takes letters at face value, especially those from faculty of highly ranked departments	Letter writers are requested to address specific issues pertaining to student preparation for graduate school; committee members recognize that bias exists	Admissions committee members use a rubric to evaluate recommendations fairly. They are aware of gendered language
Unconscious bias	Evaluators are assumed to be objective	Admissions committee members have attended a bias workshop	Committee members use an assessment rubric, a committee member is delegated to advocate for each member of an underrepresented group, and selection criteria are discussed in advance

Mentoring	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Assignment	Graduate students have no mentor besides their research advisor	Faculty, postdocs, senior graduate students, new graduate students and undergraduate students participate in a mentoring ladder	Mentoring committees are assigned to every graduate student, taking into account the student's background and social identities. The committee meets with the student at least three times per year
Guidelines and training	No materials or workshops are provided. Mentors may attend workshops at their professional society	Mentors are informed of materials or provided opportunities for training such as those provided by NRMN or CIMER	Both mentors and mentees take training aimed at optimizing their relationships(s) and discuss mentoring guidelines together. This may include a mentoring compact
Evaluation and feedback	Research advisors give students feedback on writing and, when requested, on research performance	Mentees fill out an annual review form including specific aspects of mentoring, which is read by the mentor and discussed together	Mentors help mentees develop an Individual Development Plan that helps students identify their goals and track progress and helps the mentor identify needs of their mentee(s). Mentees value feedback through a trusting relationship
Students with marginalized identities	The department has a culture to "treat everyone the same" with the belief that everyone's struggles are equal	The department recognizes that inclusion and equity are not the same. The department may host affinity groups for women and students of color, who support each other	The department has faculty and other mentors of color and from other marginalized groups. All faculty are committed to establishing a caring environment where all students can thrive. The department connects marginalized groups with external support networks

Mentoring	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Professional development	Students are expected to learn on their own or by engaging in opportunities "on their own time". Opportunities are not offered by the department	The research advisor provides opportunities for and feedback on giving research and public talks, writing proposals, and peer review, and supports engagement in professional development	The department or partner on-campus offices offers professional development in many areas, including non-academic careers. Students are encouraged to consider multiple career options. Faculty recognize that success comes in many forms
Mentoring networks	Students can seek advice from postdocs or senior graduate students in their research group	Students from marginalized groups participate in peer/ near peer support networks across STEM departments	Students and faculty participate in local chapters and national meetings of CUWiP/OSTEM/SACNAS/ NSBP as well as other networks such as MentorNet

Doctoral program and process	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Financial support	Students are responsible for finding a research advisor with funding	The department provides a guarantee of transitional support for one or two semesters if a student changes research group	The department provides a guarantee of financial support for at least five years and states in advance how much of that comes from TA support. The department helps students apply for external fellowships
Teaching experience	Students may or may not get TA experience and they receive little or no training for it	All students receive a year of TA experience following a teaching workshop	Students have the option to participate in a teaching practicum and to give public outreach talks. Such activities are valued as part of professional development
Fostering equitable teaching practice	The department culture presumes that students learn mainly on their own, and that they must "tough it out" because graduate school is difficult	Faculty receive training in inclusive pedagogy and strive to create welcoming classrooms. They are aware of impostor syndrome, stereotype threat, social dynamics and differential participation of privileged and marginalized groups	The department hosts colloquia and workshops on inclusive practices to facilitate implementation of evidence-based classroom techniques and has examined its qualifying exam and evaluation procedures to ensure that all students can thrive. All classroom environments meet or exceed ADA compliance
Conference participation	Students attend conferences when suggested and supported by their research advisor	Research groups regularly attend conferences, all members prepare and practice giving talks, and they debrief afterwards	The department has funds set aside to support student travel when their supervisor lacks funding or the travel supports department activities such as recruiting

Doctoral program and process	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Family-friendly policies	The department culture values long working hours. Graduate students are expected to work evenings and weekends	The department recognizes the demands of childbirth and child-rearing, eldercare, and other major personal commitments	Department culture supports flexible work schedules. When events are necessary during evenings or weekends, childcare is provided or subsidized for parents. All department members, including graduate students, receive paid maternity/paternity leave for childbirth or adoption, eldercare, or personal medical or other serious needs

Departmental climate	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Communications	Department website provides information on policies and procedures and points to university-wide resources. Departmental communications use minimal language around equity and inclusion	Department chair communicates the importance of equity and inclusion in person and in writing shared with all department members. The department website provides details on family-friendly policies, mentorship, inclusive teaching, and responding to harassment and bullying	The department has adopted a values statement and a code of conduct. The department chair advises other departments on how to improve the climate for all people. The department chair periodically hosts colloquia on topics related to diversity, equity, and inclusion in academia
Training	Department members participated in mandatory university trainings on lab safety, Title IX, etc.	New faculty receive training on teaching, mentoring, and on university resources to support the success of all people. Faculty search committee members receive training on implicit bias and best practices for inclusive searches	Department chairs receive training on diversity, equity, and inclusion, and on mediation and conflict management. They receive regular coaching. The department hosts trainings for all members on topics such as “being an ally”, responding to microaggressions and harassment, and inclusive teaching practices. The majority of faculty attend these trainings

Departmental climate	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Ending workplace harassment and bullying	The department refers complainants to HR	The department chair communicates university policies aimed at ending harassment and bullying and offering multiple reporting options. University ombuds are engaged with the department. Faculty are knowledgeable about mandatory reporting requirements	Sexual harassment claims are promptly reported to university authorities. The department chair actively engages faculty accused of bullying recognizing the large power imbalance present in many situations. Outside help is utilized when needed, including climate site visits and use of mental health experts. The department has faculty, staff, postdoc, and student advocates identified to support a harassment-free environment
Creating welcoming environments	Department website includes a letter of welcome by the Chair, but no specific welcome to members of marginalized groups	The department has an equity and inclusion committee that meets monthly and includes members of multiple roles and social identities. The committee advises the department chair	The department hosts conferences like CUWiP/CU^{2}MiP and hosts a Bridge Program. The chair convenes a monthly equity and inclusion luncheon open to everyone in the department. Community members are nominated for and receive university and national awards for their work advancing equity and inclusion. The department utilizes climate surveys and input from student groups to identify and resolve concerns
Community dialogues	The department holds an annual picnic to which all members and their families are invited	The department chair hosts ad hoc informational meetings for faculty and students on matters of importance, for example building and renovation plans, other major initiatives, and healing from tragedies	The department hosts annual department-wide dialogues planned collaboratively by faculty, staff, and students, on topics such as steps to improve departmental climate, the impact of national events and social movements, or other issues raised by the equity and inclusion committee. A trained social justice facilitator presides

Assessment	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Faculty hiring	Assessment of new faculty teaching and mentoring abilities is based on a job talk	Faculty applicants are requested to provide a statement of diversity and inclusion. Interviewees meet with students and members of specific groups: women, people of color, LGBTIQA*, etc.	Graduate students and postdocs select their own representatives to participate in faculty search committees. Committee members all receive the same training and follow a committee-designed rubric for evaluating contributions to and promise in research, teaching, mentoring, and supporting a diverse and inclusive environment
Departmental internal review	The department contributes to university accreditation or other top-level processes	The department has standing committees on education, diversity and inclusion, etc., that constantly seek feedback and advise leadership on ways to improve	Department leadership performs annual self-audits on equity, inclusion, and accessibility as well as education, recruitment, and other processes, using self-assessment rubrics similar to this one. Assessment is built into administrative roles in the department
Departmental external review	The department participates in program reviews or visiting committees dictated by the university. The scope of the review is interpreted narrowly and generally does not include diversity, equity, or inclusion	Departmental academic program review and/or visiting committees include assessment of diversity, equity, and inclusion. If such reviews are not a regular university practice, the department requests support of the Dean to hold one every five years	The department requests and obtains an external climate site visit organized by the AAS or APS. Reviewers are asked to assess the climate regarding multiple social identities and intersectionality Department metrics for diversity, equity, and inclusion are a model adopted by other departments at the same university undergoing external reviews

Assessment	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Individual performance review	Faculty are reviewed for promotion and tenure; staff and postdocs receive reviews as required by HR; students receive only classroom grades	Faculty annual performance review includes tabulation of efforts to advance diversity, equity, and inclusion in addition to teaching and research	Faculty annual performance review considers committee work, mentoring, recruitment efforts, public outreach, and other efforts supporting an inclusive and welcoming environment. These factors play a role in merit raises Graduate students and postdocs prepare an annual performance review that is shared with mentors and research supervisors and discussed together with an Individual Development Plan

Accountability	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Data collection	Department collects basic demographic data for every enrolled student, postdoc, and employee: binary gender, race/ethnicity, citizenship/visa status, educational history	Department requests additional optional data on all social identities listed in Section 2.3.2 above and more as appropriate. Climate data are held by confidential groups to ensure safety and anonymity of participants	Data collection forms and records are reviewed annually to determine when demographic information is needed and to ensure appropriate and inclusive language is used throughout Progress reports are issued describing successes, setbacks, challenges, new opportunities, and next steps. These documents are archived on the departmental website
Strategic planning and response	The department prepares a strategic plan when called upon for external reviews. The plan is narrowly tailored and generally does not discuss the goals mentioned in Section 2.2.1 (harassment and bullying; accessibility; healthy, family-friendly policies; mentoring; inclusive learning environments)	Departmental equity and inclusion committee uses a Participatory Action Research (PAR) framework to creating a departmental plan with measurable outcomes that address the goals mentioned in Section 2.2.1. The plan is presented to faculty	Before the departmental plan is written, the department holds a series of meetings including staff, postdocs, students, and faculty for dialogue and reflection on department values and vision. Input from this process feeds into a PAR-based committee process to construction an action plan The department chair takes responsibility for implementation of the plan, with progress monitored by the equity and inclusion committee The plan and its implementation status are shared with external assessment bodies

Accountability	**Stage 1: Emerging**	**Stage 2: Developing**	**Stage 3: Transforming**
Internal reporting	The department presents no climate data or action plans	The department chair reports annually to faculty concerning plans and accomplishments regarding education, diversity, equity, and inclusion	The departmental equity and inclusion committee holds an annual town hall open to all department members. Departmental leadership attends. Climate survey updates are shared along with progress towards a PAR-based action plan
Public reporting	The department presents no climate data or action plans	Climate survey results and action plan are posted on the department's public website	Departmental representatives present their institutional change methodology at AAS and similar conferences. A how-to guide describing their process and results is posted online
Certification	The department seeks an improved ranking in US News and World Report and other national and international rankings	The department receives recognition of its practices through university-wide recognition and through major funding awards such as NSF INCLUDES and LSAMP	Following university-wide certification, the department receives its own AAAS SEA Change certification of its efforts to advance equity and inclusion
Sustainability	Staff members may record policies and procedures, though there is no recording of demographic or climate data, committee processes and plans, or department action plans and follow up, nor is there a mechanism to sustain initiatives through department leadership transitions	The department documents its policies and procedures in education, diversity, equity, and inclusion. It prepares a how-to guide. Demographic and climate data are saved allowing for statistically significant longitudinal studies. Orientation for new faculty, postdocs, staff, and students includes discussion of departmental values, policies, and practices around equity and inclusion	Department members, including faculty, are offered workshops in leadership, mediation, and multiple aspects of diversity and inclusion. New leaders at every level (department chair, graduate chair, staff leaders, student leaders) receive coaching and onboarding to ensure they are familiar with current issues. The department strives for continual improvement. SEA Change is renewed every four years, with progress from bronze to silver to gold certification

Appendix XI: Glossary of Acronyms Used

AAAS	American Association for the Advancement of Science
AAS	American Astronomical Society
AAU	Association of American Universities
ABET	Accreditation Board for Engineering and Technology
ADA	Americans with Disabilities Act
AIP	American Institute of Physics
APS	American Physical Society
ASU	Arizona State University
CAMPARE	California Minority Partnership for Astronomy Research and Education
CIMER	Center for the Improvement of Mentored Experience in Research
CSMA	Committee on the Status of Minorities in Astronomy
CSWA	Committee on the Status of Women in Astronomy
CU^2MiP	Conference for Undergraduate Underrepresented Minorities in Physics
CUWiP	Conferences for Undergraduate Women in Physics
DPS	Division of Planetary Science
DREAM	Development, Relief, and Education for Alien Minors
ETS	Educational Testing Services
GPA	Grade Point Average
GRE	Graduate Record Exam
GRE Q	Graduate Record Quantitative Exam
HBCU	Historically Black Colleges and Universities
HR	Human Resources
HSI	Hispanic Serving Institution
IPEDS	Integrated Postsecondary Education Data System
LEED	Leadership in Energy and Environmental Design
MIT	Massachusetts Institute of Technology
MSI	Minority Serving Institution
NASEM	National Academies of Sciences, Engineering, and Medicine
NERCHE	New England Resource Center for Higher Education
NRMN	National Research Mentoring Network
NSBP	National Society of Black Physicists
NSF	National Science Foundation
NSHP	National Society of Hispanic Physicists
OSTEM	Out in Science, Technology, Engineering, and Mathematics
PAARE	Partnerships in Astronomy and Astrophysics Research and Education
PGRE	Physics Graduate Record Exam
PPI	Personal Potential Index
REU	Research Experiences for Undergraduates
SACNAS	Society for the Advancement of Chicanos and Native Americans in Science
SEA	STEM Equity Achievement
SGMA	Committee for Sexual-Orientation and Gender Minorities in Astronomy
SRC	Statistical Research Center
STEM	Science, Technology, Engineering, and Mathematics
STEMM	Science, Technology, Engineering, Mathematics, and Medicine
UCSC	University of California, Santa Cruz
UMD	University of Maryland, College Park
URM	Underrepresented Minority
UT	University of Texas, Austin
UW	University of Washington
WGAD	Working Group on Accessibility and Disability