Written Testimony
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by
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Chairman Lipinski, Ranking Member Ehlers and members of the Subcommittee, thank you for the opportunity to testify today on the critically important topic of broadening participation in science, technology, engineering and mathematics (STEM).

The American Association for the Advancement of Science (AAAS) is the largest multidisciplinary scientific society and publisher of the journal *Science*. The association encompasses all fields of science, engineering, mathematics, biomedicine and their applications. Our commitment to and involvement in education extends from pre-Kindergarten through post-graduate and into the workforce.

***Women in STEM***

I want to begin my discussion of this topic with some evidence that this is an important policy issue that deserves national attention. In 2006 women received almost 58 percent of all bachelor's degrees awarded in the United States and almost 51 percent of the bachelor's degrees awarded collectively in science, technology, engineering and mathematics, the so-called *STEM* fields. Their representation in STEM ranged from highs of over 77 percent of psychology and almost 62 percent of biological sciences bachelor's degrees to lows of 19.4 percent and 20.2 percent, respectively, of engineering and computer science bachelor's degrees. (See Figure 1).The story of participation that each field tells is an interesting one. Among the low performing fields, for example, the engineering levels represent a slight improvement from a decade ago; but the representation in computer science has declined from the percent of women in the field a decade ago.

In trying to understand the patterns, it is important not only to look at levels of representation, but also at trends over time. Are things better or worse? And what accounts for the patterns that we see? Broad field designations can hide a "multitude of sins." For example, the representation in the physical sciences is driven by increases in chemistry, where women received almost 52 percent of bachelor's degrees in 2006, as opposed to physics, where they received less than 21 percent. Similarly in the social sciences, women received about 31 percent of bachelor's degrees in economics and 70 percent of such degrees in sociology in 2006.

***Underrepresented Minorities in STEM***

Un-packing the numbers is critical to understanding how to move them. This is even more the case when considering participation of minorities in STEM. Interestingly,

underrepresented minorities are as likely to be present among the STEM bachelor's pool as they are among the pool for all fields. In 2006 African Americans received 9.1 percent of all bachelor's degrees awarded and 8.7 percent of STEM bachelor's degrees, this while representing 12.4 percent of the total population in the United States. Hispanics, meanwhile, received 8.1 percent of all bachelor's degrees and 8.0 percent of STEM bachelor's degrees. American Indians/Alaskan Natives received 0.7 percent of all degrees and 0.7 percent of STEM bachelor's degrees in 2006. On the other hand, Asian Americans/Pacific Islanders are more likely to be in the STEM pool than their representation among all bachelor's degree recipients in 2006, 9.7 percent versus 6.7 percent, respectively. White, non-Hispanic degree recipients received 67.2 percent of STEM bachelor's degree and 69.7 percent of bachelor's degree recipients for all fields. It should be noted, however, that White, non-Hispanic recipients of bachelor's degrees in STEM represent a declining proportion of degree recipients over the past decade, while the reverse is true for all other groups.

Another important trend for underrepresented minorities is that their present levels are being driven by women. Underrepresented minority males are under-participating in all fields including STEM. Again, as we look at the individual groups we see a vast set of differences within and across fields. For African Americans, participation levels ranged from highs of 11.6 percent of bachelor's degrees in computer science, 10.5 percent in psychology and 10.3 percent in social sciences to lows of 1.5 percent and 2.8 percent, respectively in earth, atmospheric and ocean sciences and agricultural sciences. For Hispanics, representation levels were highest for bachelor's degrees in psychology (9.4 percent) and social sciences (8.9 percent) and, as for African Americans, lowest in earth, atmospheric and ocean sciences, and agricultural sciences at 3.6 percent and 3.8 percent, respectively (See Figure 2).

Once again, broad fields hide wide variations of participation. For example, African Americans received 6.6 percent of 2006 bachelor's degrees in the physical sciences. This representation is being driven by chemistry, where they received 7.6 percent of degrees awarded. In contrast, they received 3.7 percent of 2006 physics bachelor's degrees. Interestingly, of 166 bachelor's degrees awarded in physics to African Americans in 2004, 49 percent of these were awarded by Historically Black Colleges and Universities (HBCUs). http://www.aip.org/statistics/trends/highlite/minority/table5.htm

For Hispanics in the social sciences, the 10.3 percent of bachelor's degree in 2006 conceals the differences in participation between economics, where they represented fewer than 6 percent of degree recipients, and sociology, where they received well over 10 percent of bachelor's degrees.

***Persons with Disabilities in STEM***

Persons with disabilities have been recognized by AAAS for almost thirty-five years as a community that deserves special focus and intervention in terms of STEM education and careers. Yet we are unable to present the data on participation for this community as we did for women and minorities. This lack of systematic data makes it difficult to paint a clear picture of the presence of members of this community within STEM education or workforce and to identify field-specific obstacles.

Our extensive networks of and experiences with the community of scientists and engineers with disabilities have led us to a number of conclusions as to the needs and potential of persons with disabilities in STEM:

- Today, advances in medical science, cognitive interventions and assistive technologies have made it possible to take advantage of the talent and perspectives available for STEM that are resident among persons with disabilities more than ever before.
- The focus within STEM on "ability rather than disability" makes these fields attractive career and employment options for persons with disabilities.
- The major barriers to persons with disabilities are often in the area of "employment," though AAAS has developed a number of partnerships with government and the private sector, where we have been able to successfully place scientists and engineers with disabilities in internships, many leading to full employment and advancement potential.

The issues here deserve more focus particularly as we consider how to support, with education and training, U.S. veterans who are returning from combat in Iraq and Afghanistan with significant disabilities.

**A Total Pathways Perspective**

Although I began this testimony focusing on bachelor's degrees in STEM for under-participating groups, I want to acknowledge the larger issues of "pathways to STEM," from K-12 education to graduate education leading to the doctoral degree.

***A Focus on K-12***

Many of the challenges with retention and time to degree for underrepresented minority students can be traced back to inadequate early preparation in K-12:

- Students who leave high school without the prerequisites for success in college, such as four years of rigorous mathematics and science instruction.
- Lack of access to Advanced Placement courses.
- Attendance in schools with poor facilities and poorly prepared faculty.
- Lack of expectations for students to enter and be successful in STEM fields.

And the list goes on. In many cases these factors relate to failures of policy at every level, from the individual school and district to the state and federal government, from local teacher placement and assignment policies to a focus on meeting No Child Left Behind requirements to the exclusion of opportunities for learning. Proposed initiatives to provide resources to support STEM education transformation, to increase standards, to push for more rigorous courses, and to require accountability by disaggregated groups are steps in the right direction. But, by themselves, they are not enough. Engagement with the resources of entire communities, colleges and universities, youth-serving groups, faith-based groups and others is needed. Students actually spend a small fraction of their waking hours in formal education settings. We must build out beyond schools to support **learning**, not just education. AAAS

has experience with engaging such groups in "community-wide" initiatives, and we have evidence that such approaches have merit.

***Community Colleges***

There are many roads that students take, whether they are "traditional" students who enter higher education immediately following high school or so-called "non-traditional" students who pursue such education some years after completion of high school or acquiring a GED.

The pathways to STEM education and careers via community colleges are different for students from different population groups. Over 38 percent of African American, 51 percent of Hispanic and 42 percent of American Indian/Alaskan Native students are enrolled in community colleges. In addition, 20 percent of those who go on to become teachers begin in community colleges. Fifty percent of teachers attended community college at some point, and about 40 percent completed some of their mathematics and science preparation in the community college.

All of these factors cry out for more focused attention on this critical component of the STEM pathway. Many students choose to go to community college because of the lower cost of such institutions; others choose to attend community colleges for reasons of proximity to their home community. The older age of typical community college students is indicative that many individuals use the institutions as a "second chance," for retraining and/or seeking new educational and career prospects. Students who are under-prepared often use the open access to community colleges as a way to make up the deficiencies; still others, especially in states where there is strong competition for slots in the university system, take advantage of the rules around "articulation" to access the university. Whatever the reason, one cannot consider the pathways to STEM without considering the role of community colleges. Tribal colleges represent a special case, serving populations that are geographically isolated in ways that respect local needs and cultural traditions.

***HBCUs and HSIs***

Other roads to STEM come through Historically Black Colleges and Universities (HBCUs) and Hispanic Serving Institutions (HSIs). In the days when state institutions were segregated by law, HBCUs were the only options for higher education for Black students, especially in the South. As options opened up for African American students to attend previously all-White institutions in the region, the proportions of African American undergraduates who were enrolled in HBCUs fell, from 30 percent in 1976 to 18 percent in 2006. Yet, despite the shifting population of African American students in higher education, including some of the most competitive students, HBCUs outperformed other institutions in the proportion of 2004 bachelor's degrees awarded to African Americans in chemistry (39 percent) and mathematics (37 percent) and remained leaders as the top 10 baccalaureate origins institutions for Black students who received STEM doctorates between 2003 and 2007.
http://www.nsf.gov/statistics/wmpd/pdf/tabf-7.pdf

A number of institutions have been designated as "Hispanic-serving." Except for those in Puerto Rico, however, few of these institutions were expressly established to address the political, social and cultural needs of these populations. Their designation has emerged over

time as their demographics have changed. And many such institutions have, in like manner to HBCUs, emerged as disproportionate contributors to STEM fields and as baccalaureate origins institutions for Hispanics who received STEM doctorates. A mixed group of HSIs and non-HSIs made up the top 10 list of baccalaureate origins institutions. http://www.nsf.gov/statistics/wmpd/pdf/tabf-8.pdf

***The Road to the Doctorate and Beyond***

Attending to the issue of PhD degree production for women and underrepresented minorities depends, of course, on the adequacy in numbers and preparation of the bachelor's degree production process, as well as the efforts that are made to attract, retain, mentor and support STEM students in graduate education (See Figure 3). While the progress in this arena has been slower than we have wished it is important to note the successes that have emerged due, in part, to a number of NSF-funded programs.

Prominent among the efforts to increase the numbers of underrepresented minority doctorates in STEM is the NSF Alliances for Graduate Education and the Professoriate (AGEP). For over 10 years, AAAS has been the research arm and technical assistance provider to AGEP. In this role we work with our partner, Campbell-Kibler Associates, to collect data on enrollment and degree production from the individual Alliance institutions and monitor and report on the collective findings. The most recent report, released in February 2010, indicates an almost 50 percent increase in the average number of PhDs awarded to underrepresented minorities in natural sciences and engineering fields over the three year period 2007-2009 when compared with the average for the baseline years of 2001-2003.

This is a stunning result and points to what is possible when research, monitoring, use of collaborative, evidence-based models and institutional leadership and commitment come together. Of course questions could be raised about the output of non-AGEP institutions among doctoral degree granting institutions, especially given the regular research support that most receive from federal and other sources. Some examples of critical questions of commitment that need to be addressed are: the significant levels of graduate school debt that underrepresented minority students incur on their way to the doctorate; the primary forms of support that they indicate (e.g., less likely to indicate research assistantships); and the adequacy of the mentoring they receive. Often the stories that emerge are those related to isolation and failure to find community.

Women's presence within the doctoral population is more significant, though this differs greatly by field. In 2007, women received over 50 percent of doctorates in all fields and over 40 percent of STEM doctorates. Women were 49 percent of biological sciences doctorates and almost 73 percent of psychology doctorates. But they were only 20.9 percent of engineering doctorates and 20.5 percent of computer science doctorates. Compared with participation levels in 1998, there have been gains in all fields surveyed (See Figure 3).

Women have received a significant proportion of STEM doctorates for well over a decade. Yet they are not appearing among the STEM faculty, especially among leading research institutions, at proportions that should reasonably be expected given their presence in the

available pool of candidates; nor are they being retained and advanced in the ranks. Another NSF-funded program has taken on the challenge of addressing these issues. ADVANCE has focused on the institution-specific challenges of understanding and affecting the policies and processes that govern identifying, recruiting, hiring and promoting faculty as well as the system impediments that often lead to the loss of talented women faculty. These would include issues such as: parental leave and "stop the clock" policies; spousal/partner hires; transparency of the requirements for promotion and tenure and so on. Many of the obstacles relate to the desire for women (and men) to be able to integrate the personal/family and career aspects of their lives.

Recent Nobel Laureates Elizabeth Blackburn and Carol Greider addressed these issues directly in interviews after the announcement of their award as they talked about the need for institutions to reconsider the male models upon which the job expectations of STEM faculty are based; e.g., to consider part-time (as well as part-time tenure track) and other more flexible arrangements. This is not an issue of being able or "good enough" to do the science. And separating the aspects of careers that are necessary and those that are simply "tradition" has been a critical component of department and institutional reviews and responses. Often included in this work have been studies of the "climate" and attitudes that surround the departments and decision making regarding hiring and promotion. While every ADVANCE grant has been differently focused to respond to the particulars of each institution, the focus of all has included research and evidence-based models that can then inform programs and practices.

Some data are available on STEM doctorates with disabilities. Looking just at STEM doctorate recipients who reported disabilities in 2007, we find "learning" and "physical/orthopedic" disabilities as the leading forms of disabilities reported. They were less likely than persons without disabilities to have received their doctorates in STEM fields (over 66 percent versus over 51 percent of all degrees awarded). The leading field for PhDs for both doctorate recipients with and without disabilities was biological sciences (11.2 versus 15 percent of all doctorates awarded, respectively).

In STEM fields, postdoctoral experiences provide important training in conducting independent research and establishing a research agenda: functions that are critical to becoming a STEM faculty member. Not much is known about the postdoctoral experiences of minority and women scholars; however, it is essential that underrepresented groups benefit from mentoring from STEM faculty in Research I universities.

**Greatest Challenges to/Needs for Achieving Diversity in STEM**

The processes of providing quality education to all in STEM, to enabling individuals to choose careers in these fields and to supporting the success of STEM professionals are many and complex. Challenges to broadening participation in STEM vary by group, by field and level, but include many of the issues listed below.

K-12 STEM Education (Issues affect especially underrepresented minorities and persons with disabilities)

- Quality of K-12 education (rigorous standards and courses and appropriate support, facilities, technology and other resources to meet these standards)
- Preparation of students in mathematics and science as well as reading
- Teachers who are well prepared to support student learning in STEM and who have high expectations of all students
- Access to the right K-12 courses and to career guidance
- Opportunities for out-of-school experiences to reinforce STEM learning and careers

Undergraduate STEM Education

- Better introductory courses and better teaching: focusing on cultivating an interest rather than weeding students out
- Early access to experiences that support STEM, including undergraduate research
- Financial access to institutions of higher education for STEM students
- Debt as a deterrent to continuous enrollment, progress to degree and consideration of graduate study
- Support for community colleges to enable them to more adequately play a pathway role, including better articulation
- More support for institutions that are shouldering a disproportionate role in bringing underrepresented minorities to STEM
- More accountability on Research I institutions to take responsibility for student success in STEM
- Real physical and attitudinal accessibility to STEM programs (“beyond the ramps”)

Graduate-level and Beyond

- Provide a “mix” of support that research has deemed most effective in ensuring student progression through to the doctorate, including fellowships/traineeships, research assistantships, and teaching assistantships
- Burden of rising tuition rates and creating mechanisms to reduce debt
- Isolation and lack of supportive environment and effective mentoring
- Need for skill building that addresses other aspects of job requirements, beyond research
- Encouragement and career guidance, including more guidance on what students can do outside of academia
- Opportunities for network development, publishing, presenting and interacting in a global environment
- Opportunities for post-doctoral experience to support career development

Workforce

- Flexibility in the structure of employment and positions (e.g., part-time, shared, etc.)
- Valuing diversity and what it brings to the workplace, the classroom and the lab
- Transparency in expectations and in what is needed for promotion
- Fair and transparent processes in hiring, promoting and advancing, especially with regard to STEM faculty

Issues Specific to Persons with Disabilities

- Definitional issues, including the situation for individuals with apparent vs. non-apparent disabilities
- Disclosure concerns (risking discrimination or shifts in attitude, e.g., with the disclosure of a non-apparent disability)
- Issues regarding age of onset of disability and its differential impact on education and careers
- Generational differences (the situation is quite different for persons who began education and/or careers prior to the passage of laws related to non-discrimination)
- Differences related to presence and/or availability of assistive technology which can ameliorate (though never cancel) the impact of a disabling condition

**AAAS Efforts to Broaden Participation in STEM**

AAAS has a long history of efforts to increase the participation of girls and young women, underrepresented minorities and persons with disabilities and to enhance the status of these groups in science, technology, engineering and mathematics. The association has communicated this commitment to equal opportunity through its mission statement, its programs, and its governance. This work is consistent with the AAAS mission to "advance science, engineering, and innovation throughout the world for the benefit of all people." To fulfill this mission, the AAAS Board has set out broad goals that include strengthening and diversifying the science and technology (S&T) workforce and fostering education in science and technology for everyone.

The AAAS Directorate for Education and Human Resources that I head combines concerns around diversity of the STEM community with issues related to strengthening STEM education for **everyone**, from pre-K to post-graduate, and public engagement to promote STEM literacy overall, with special attention focused on efforts to:

- Increase participation of women, underrepresented minorities (African Americans, American Indians and Hispanics) and persons with disabilities in science, mathematics, engineering and biomedical education and careers.
- Heighten the visibility and promote the advancement of these groups in STEM.
- Raise awareness and recognition of the barriers faced by these groups and help to remove them.
- Increase the involvement of these groups within the activities of the AAAS as well as in the larger STEM enterprise.

We make progress in these areas by exploring how programs, policies and practices combine to determine the shape of STEM. While we work **across** the issues presented for the different groups we work to understand where concerns may overlap as well as where they may differ. We know that context matters and that it is important to know when we should “lump” as well as when we must “split.” For example, we came to understand quite early that the situation for minority women in science and engineering is unlike the situation either for White women or for minority men, and that even within the category of minority females,

differences of history, culture and expectations play a key role. On the other hand, the lack of transparency in university hiring and promotion has a detrimental effect on the retention of all underrepresented groups, and this concern may be addressed as a single issue or a "theme with variations."

We have pursued models that have been attentive to differences and similarities in our search for effective strategies for addressing different elements of the complex ecosystem of STEM education and careers. And at every turn, even as we target, we work to effectively mainstream issues related to diversity.

In many ways we credit our work with persons with disabilities for bringing this aspect clearly into focus. While *persons with disabilities* may be the programmatic and statistical category that we use, the needs of each individual are unique given the "particularistic" nature of each disability and especially as these play out in each educational or job setting. A person may have a disability, but a person can also be dis-abled by an unsupportive environment.

**Overview of AAAS Programs**

***Teachers for Diverse Student Populations.*** We have developed projects to cultivate teacher leaders in mathematics and science for middle schools in the District of Columbia through a master's program developed in collaboration with George Washington University, funded by the Office of the State Superintendent of Education. In this program veteran teachers get critical subject matter instruction as well as courses that focus on emerging insights in the learning sciences, effective pedagogy and the use of technology. The emphasis is on developing "change agents" who can work with their peers to improve student performance in schools serving diverse student populations. We not only affect area schools; we also develop and test interventions as possible national models.

***Careers for the Future.*** Another current project is focusing on introducing students, their parents, teachers and counselors to STEM careers, looking especially at those related to energy and the environment. This NSF-funded ITEST project introduces quality curriculum, career exploration, appropriate role models, projects, and a focus on learning both in and beyond the school day. We are interested not only in undertaking the project, but also in learning from it. For example, does it make a difference to have learning coherence across a program, and does "dosage" matter? That is, what is the difference in the learning of students who are engaged in multiple program elements?

***Learning in Out-of-School Environments.*** We use science and technology-focused clubs and "gaming" to support student learning. We have been able to demonstrate through evaluations of our Kinetic City out-of-school clubs, for example, that students not only learn the science, but they also improve in reading and writing. **"Find out what will work, and make it as accessible as possible,"** has been a guiding principle of our work.

***Undergraduate Teaching.*** At the level of higher education, through a current partnership that involves both disciplinary and education units of the National Science Foundation along with

HHMI and the MORE Division of NIGMS of NIH, we are working to address the larger issue of the quality of introductory college courses in biology. We are a partner in bringing together a community of practice that seeks to create a movement to develop courses that will more effectively engage students and advance their understanding of the nature of science, instead of courses that turn them off and leave them "science averse."

***Building Institutional Capacity.*** Returning to the notion of the "personalized nature" of barriers and opportunities, nowhere is this issue more clear than in the work of the **AAAS Center for Advancing Science and Engineering Capacity** directed by Dr. Daryl Chubin. This "fee for service" consulting organization, embedded within AAAS, works with institutions to help them build internal capacity to respond to the need to better serve **all** STEM students and to diversify their student populations and faculty. Center staff and consultants help to move lessons learned across institutions even as they address the needs of particular departments, schools and colleges. Center clients have included many different types of institutions (e.g., an undergraduate research program at Harvard; a "scholars" program at LSU) and funded programs (e.g., NSF GK-12; NSF Broadening Participation in Computing). The work has included evaluation, technical assistance and training.

Currently the Center is engaged in addressing an issue that touches every higher education institution in the country. Given the current structure of laws, regulations and court decisions, how do institutions put in place programs, policies and practices to achieve diversity among undergraduate and graduate STEM student populations and faculty that are both **effective and legally defensible**?

Early efforts (from the mid-1960's through the 1970's) undertaken by colleges, universities, school systems, agencies and others to broaden participation in STEM often took the form of so-called "special programs," projects set aside for different groups to respond to the particular challenges and barriers that each circumstance might present. A series of district and Supreme Court decisions, along with the passage of anti-affirmative action referenda in a number of states, raised serious concerns as to whether certain practices and programs might be able to withstand legal challenge. For example, in the 1995 post-*Adarand* review of programs at the federal level, a number of NSF programs were discontinued.

In universities, post-*Adarand* concerns and the absence of guidance after the *Grutter v. Bollinger* and *Gratz v. Bollinger* Michigan decisions of the U.S. Supreme Court led to confusion in universities about what was and was not allowed. Outside of clarifying what was permissible in admissions decision-making the rulings were silent in addressing concerns related to aspects so critical in STEM education such as outreach and support programs. It was not clear how the institutions might capture the educational value of diversity noted by Justice O'Connor and address the national need to develop a diverse STEM workforce.

Following a conference held in 2004, in partnership with the National Action Council for Minorities in Engineering (NACME), and co-publication in the same year of *Standing Our Ground: A Guidebook for STEM Educators in the Post-Michigan Era*, we began to consider

what more could be done to help clarify what might be possible to advance STEM diversity even in light of legal and judicial constraints.

AAAS and NACME co-sponsored a meeting in 2008, with the support of the Alfred P. Sloan Foundation that included academic, corporate and legal representatives to discuss the legal barriers to and the compelling national interest of advancing diversity in STEM. From that gathering was born the idea of undertaking a deep analysis, both legal and programmatic, to identify initiatives and practices capable of satisfying both requirements for effectiveness and legal defensibility.

This initial meeting has resulted in follow-up workshops with continued support from Sloan and now the National Science Foundation as well as AAAS and our partner organization, the Association of American Universities (AAU). The project has:

- Identified and partnered with two law firms who, through considerable *pro bono* work, have identified the bodies of law that applies both to student and faculty employment issues.
- Developed materials to guide institutional leaders through the analysis of the law and its implications as related to diversifying STEM students and faculty.
- Conducted a pilot workshop with ten AAU institutional teams, including the general counsel and provost or representative of each institution.
- Revised and refined the materials in response to feedback.
- Held a second workshop to disseminate the materials as well as to test the format of the sessions.

In these workshops there are opportunities for extensive networking among counsels and provosts, and chances to consider issues from both education/mission concerns as well as through a legal frame. We are currently seeking support to enable us to adapt the materials and case studies to other types of institutions and to expand the dialogue beyond the research universities that belong to AAU. A number of higher education organizations have written letters of support and signaled their interest in having this work extended to their membership.

**The Federal Role in Broadening Participation**

President Obama has articulated both the need for attention to education in STEM and the value of engaging the broadest base of talent in these fields. This leadership, coupled with coordination across the federal government and thoughtful implementation of evidence-based efforts, can do much in addressing broadening participation in STEM.

***Improving K-12 Education for All.*** Effective implementation of Race to the Top, for example, by emphasizing STEM and success for all students in science, mathematics and literacy, could over time affect the challenge of weak preparation that too many minority students bring to higher education. But it will be important to know that the affected populations are being served, that attention to diverse learners is a part of the overall strategy, and that communities are engaged beyond the school walls and the school day.

***Coordination of Programs.*** At the same time that this support seeks to affect the infrastructure for learning from the statehouse to the school room, federal science agencies and departments need to be able to support the development of programs and strategies that are "mission specific" and that can ensure that an expanded talent base also includes people who bring the skill sets specific to their mission and needs. Overarching this needs to be a coherent plan for talent expansion and development that is coordinated through an NSTC-type mechanism. This is not the time for misplaced concerns about the "duplication of effort." Any agency charged with carrying out a mission needs the authority to help construct the future human resources pool required to advance its mission.

***Coherent Approaches to Community College Support.*** Given the fact that community colleges are enrolling so many underrepresented minority students, there is a need to carefully craft support strategies for these institutions that can enable them to do a better job, both of providing education in technical and allied health fields but also in the transfer of STEM students to four-year colleges and universities. There is a need to do this while being honest about the strengths that community colleges could bring to a total pathways approach to STEM and as access points for higher education, as well as about the weaknesses they currently display in moving such a small proportion of their STEM students to the next level. In many states expenditures for students in community colleges fall below levels for either K-12 or four-year colleges. Because these institutions are continually being called upon to do "more with less" and to serve so many different missions, injections of funding need to be targeted and purposeful to address the concerns relevant to smoothing the pathway to STEM.

***Money Matters.*** We have begun to understand how significant the financial impediments may be for those pursuing graduate study in STEM, and that the accumulation of undergraduate and graduate debt may be a serious deterrent to underrepresented minority and low-income students. Addressing the access and financial aid issues at both undergraduate and graduate levels is not just a matter of "throwing money," but merits thoughtful consideration as to the conditions surrounding support. For example, providing stipends associated with undergraduate research participation accomplishes at least four worthy outcomes at the same time: providing a positive educational experience; reinforcing a commitment to STEM and aiding in retention; providing a source of needed financial support; and linking students to potential mentors. At the graduate level mixed forms of support over time (a portable fellowship or traineeship coupled with a research assistantship, which may help reinforce mentoring relationships and build a publications record) may be the smartest form of investment. For many fields of science and all fields of engineering, domestic students of every race and ethnicity are falling further behind in receipt of doctorate degrees. We need to understand how debt and the opportunity costs of graduate education might be affecting these results. In cases where we are looking to the talent of the future to innovate and address global challenges of water, food security, health, climate change, loss of species diversity, and many others, we must invest in the development of the talent base.

***Role of the NSF.*** As with the corporate leaders who in our 2008 workshop spoke so compellingly of the need to utilize the full extent of the nation's talent base to support STEM, we have acknowledged consistent commitment to the idea of broadening

participation in STEM by the leadership of the National Science Foundation. The NSF has a special role, emerging from the mandate of its organic act as well as through the provisions of the Science and Engineering Equal Opportunities Act of 1980 to see to concerns related to STEM education the health of the human resources base for STEM.

Many of NSF's efforts are hitting the right targets (for example, Broadening Participation in Computing). Computing is an area in special need of attention. As noted earlier the participation trend lines for women in computer science, for example, are headed in the wrong direction. There is a real irony that women received their largest percentage (37.2 percent) of bachelor's degree in computer science in 1984! Since that time their participation has plummeted to a little over 20 percent. Meanwhile U.S. citizens and permanent residents received only about 37 percent of the PhDs in computer and information sciences in 2008. AAAS, through the Capacity Center, has been a partner with the NSF program, assisting institutions to understand how to monitor and assess progress toward their goals.

The ADVANCE program has provided commendable leadership in helping institutions assess and address their processes, policies and procedures to support women faculty in the areas of hiring, promotion, tenure and development of family-friendly environments that ultimately benefit all. The program of Alliances for Graduate Education and the Professoriate (AGEP) has demonstrated what is possible in increasing the numbers of underrepresented minority PhDs through supporting alliances of doctoral degree granting and minority serving institutions. The programs aimed at strengthening HBCUs and Tribal Colleges are affecting the capacity of those institutions to make a difference for their students in the quality of preparation and the diversity of fields of study. The Louis Stokes Alliances for Minority Participation (LSAMP) Program is helping to increase the bachelor's production of underrepresented minority students in STEM, fostering alliances of majority and minority institutions in the process. In the case of HBCUs we see the impact of their work as they make a disproportionate contribution to the STEM PhD production of African Americans. And I anticipate that a carefully crafted program of support for HSIs with **demonstrated capacity to support the success of Hispanic students in STEM** could make a similar contribution.

The challenge is not the program goals themselves, but the modest scale of the investments! The programs need to be used as critical components to a portfolio approach to broadening participation. In the 2011 documentation to the proposed NSF budget, there is considerable language about consolidation of such programs. Looking at efforts to date it is not clear that such a major consolidation is desirable or prudent at this time. To what extent is the rest of NSF's budget being used in support of the integration of research and education in ways that support broadening participation? Why are the overwhelming majority of research universities doing so little to advance the broadening participation goals of the Foundation? Can we track the current impact of the "broader impacts" criterion on broadening participation goals?

How much is being invested in sharing lessons learned from program investments in broadening participation efforts beyond the community that is currently committed and active? At this point it is important to continue investing in initiatives that seek to identify

and test effective broadening participation strategies in departments and institutions. At the same time we must transfer lessons learned in ways that mainstream the concerns into the directorates and divisions of the Foundation, and from them into the institutions they support, as part of the regular way that the NSF's business is done, without introducing "lethal program mutations" where the true intent or practices of initiatives are lost.

When undertaking any efforts at mainstreaming, it is crucial to monitor progress, to insist on the use of evidence-based strategies, and to provide technical assistance and capacity building. The risk is great in mainstreaming, however, of losing sight of the special and particular needs, histories and issues of different types of institutions, and different groups in the context of different fields. It is critical to know when to lump and when to split.

Despite the difficulty of doing the work related to broadening participation, there are institutions that have enjoyed some success in this goal while others have not. Leadership and political will must combine with successful strategies. There are effective efforts that can be mounted that are legally defensible. But first you must want to make a difference.

## Appendix

**Shirley M. Malcom, Ph.D**.
Head of the Directorate for Education and Human Resources Programs
American Association for the Advancement of Science (AAAS)

Shirley M. Malcom is Head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science (AAAS). The directorate includes AAAS programs in education, activities for underrepresented groups, and public understanding of science and technology. Dr. Malcom serves on several boards — including the Heinz Endowments and the H. John Heinz III Center for Science, Economics and the Environment — and is an honorary trustee of the American Museum of Natural History. In 2006 she was named as co-chair (with Leon Lederman) of the National Science Board Commission on 21st Century Education in STEM . She serves as a Regent of Morgan State University and as a trustee of Caltech. In addition, she has chaired a number of national committees addressing education reform and access to scientific and technical education, careers and literacy. Dr. Malcom is a former trustee of the Carnegie Corporation of New York. She is a fellow of the AAAS and the American Academy of Arts and Sciences. She served on the National Science Board, the policymaking body of the National Science Foundation from 1994 to 1998, and from 1994-2001 served on the President's Committee of Advisors on Science and Technology. Dr. Malcom received her doctorate in ecology from Pennsylvania State University; master's degree in zoology from the University of California, Los Angeles; and bachelor's degree with distinction in zoology from the University of Washington. She also holds 16 honorary degrees. In 2003 Dr. Malcom received the Public Welfare Medal of the National Academy of Sciences, the highest award given by the Academy.

Figure 1. Percent of Bachelor's Degrees Awarded to Women by Broad Field, 2006

| All fields | All S&E | Engineering | Physical Sciences | Earth, atmospheric, ocean sciences | Mathematics and Statistics | Computer Sciences | Biological Sciences | Agricultural Sciences | Social Sciences | Psychology |
|---|---|---|---|---|---|---|---|---|---|---|
| 58.1% | 50.8% | 19.4% | 42.3% | 41.1% | 45.2% | 20.2% | 61.7% | 51.4% | 53.7% | 77.4% |

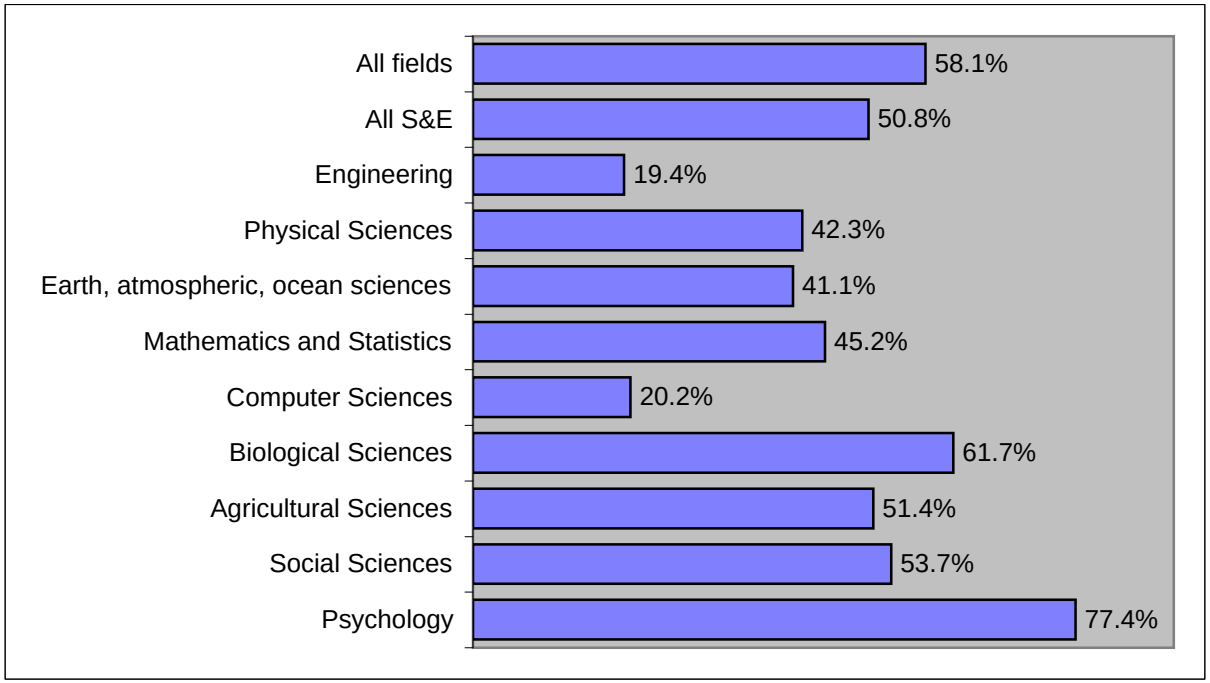

Figure 2. Percent of Bachelor's Degrees Awarded by Broad Field, 2006

| | All fields | All S&E | Engineering | Physical Sciences | Earth, atmospheric, ocean sciences | Mathematics and Statistics | Computer Sciences | Biological Sciences | Agricultural Sciences | Social Sciences | Psychology |
|---|---|---|---|---|---|---|---|---|---|---|---|
| African Americans | 9.1% | 8.7% | 5.0% | 6.6% | 1.5% | 5.8% | 11.6% | 7.6% | 2.8% | 10.3% | 10.5% |
| Hispanics | 8.1% | 8.0% | 7.7% | 6.3% | 3.6% | 6.0% | 7.2% | 7.2% | 3.8% | 8.9% | 9.4% |
| AI/AN | 0.7% | 0.7% | 0.6% | 0.7% | 0.9% | 0.4% | 0.6% | 0.7% | 1.1% | 0.9% | 0.7% |
| Asian/Pacific Islander | 6.7% | 9.7% | 13.5% | 10.4% | 2.4% | 10.0% | 11.0% | 14.2% | 3.2% | 8.5% | 6.1% |
| White, non-Hispanics | 69.7% | 67.2% | 68.6% | 70.5% | 85.9% | 72.2% | 60.7% | 65.6% | 84.5% | 65.1% | 68.4% |

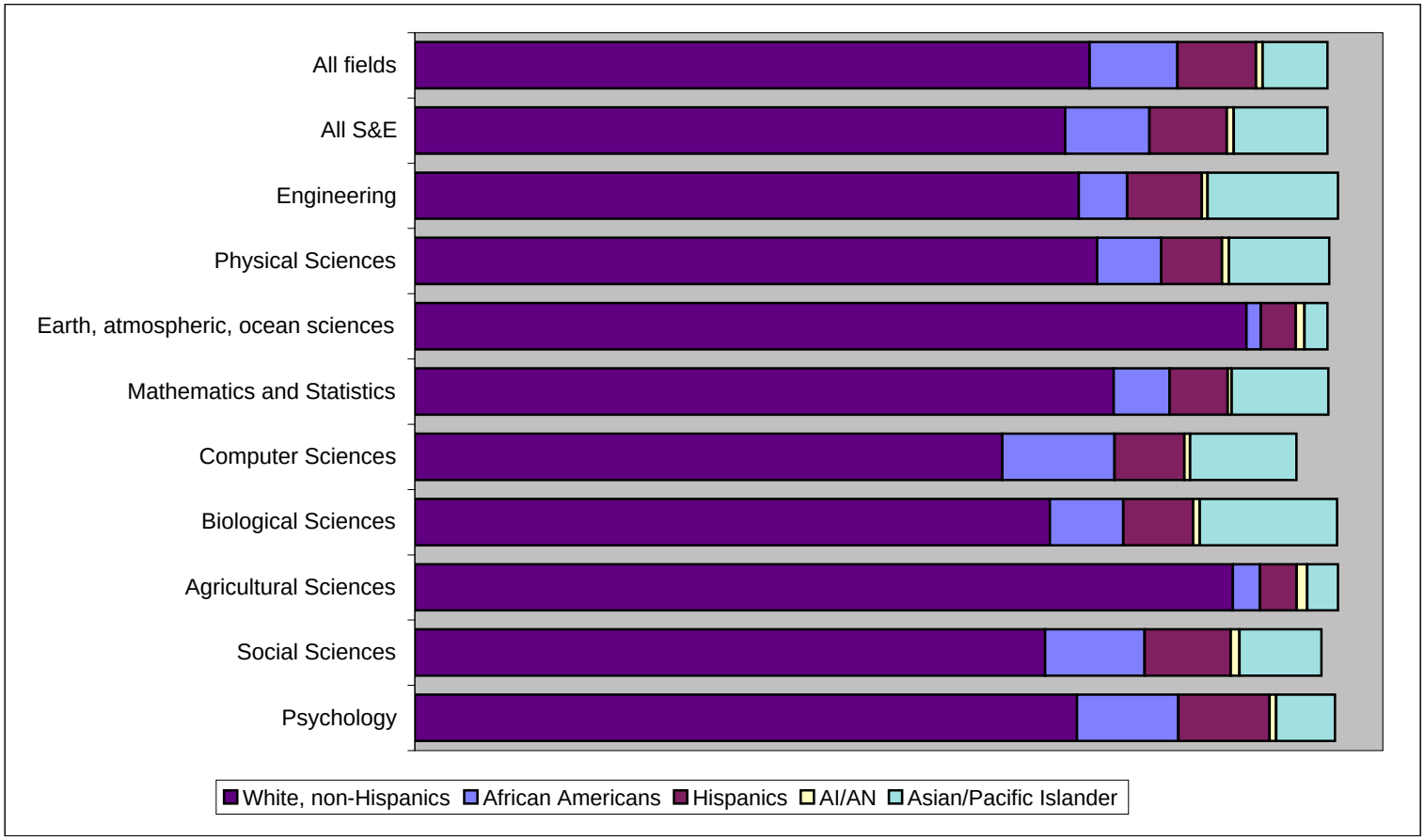

Figure 3. S&E Doctoral Degrees Awarded to Women by Broad Field, 1998 and 2007

| | All fields | S&E | Agricultural Sciences | Biological Sciences | Computer Sciences | Earth, atmospheric and ocean sciences | Mathematics and Statistics | Physical sciences | Psychology | Social Science | Engineering |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 42.1 | 34.4 | 29.9 | 42.7 | 16.3 | 25.8 | 25.7 | 25.2 | 67.5 | 41.6 | 12.2 |
| 2007 | 50.2 | 40.4 | 41.0 | 49.0 | 20.5 | 39.3 | 29.9 | 30.5 | 72.7 | 48.9 | 20.9 |