One of the most powerful influences on the experiences of students underrepresented in science, technology, engineering, and mathematics (STEM) fields is also one of the most difficult to measure: the perceptions a student has of his or her ability and of others’ opinions and beliefs. Students of all backgrounds can experience stress in navigating STEM fields, but underrepresented students of color and women frequently experience additional strains because of feelings of isolation, unwelcoming or hostile climates, racial and gender stereotypes, and perceptions of unequal treatment and bias. At the same time, perceptions of social support can improve academic outcomes and increase resiliency to stress. Several speakers addressed these issues and described research aimed at explicating their effects.

CHANGE, FLIP, AND UNDERSTAND

Before 1941, David Asai’s father, who had a bachelor’s degree from the University of California, Berkeley, but worked as a gardener, was a member of a small community of Japanese Americans on Terminal Island in Long Beach, California. When the United States entered World War II, he was sent to a concentration camp in Arizona. He later relocated to Michigan and worked as a janitor, after which he trained to be a minister in a seminary just outside Boston. As a congregational minister, he worked in small churches in Vermont, where David and his brother joined the family. The family then moved to Kansas, where the boys were the only nonwhites in their schools.

Knowing how race shaped his father’s life has informed his thinking on ethnicity, race, and diversity, explained Asai, who is senior director of science and education programs at the Howard Hughes Medical Institute (HHMI). He cited Scott Page’s book The Difference, which explains the importance of
diversity.\textsuperscript{1} First, diversity is a property of a group, and science depends on groups. Diversity also adds perspectives, interpretations, and tools, all of which are crucial to solving the problems of science. And diversity trumps ability when a problem is hard and large numbers of people are working on it.

“The good news,” Asai said, “is that in this country we have a huge opportunity to take advantage of a diverse set of scientists.” However, he explained, the United States, and the science professions in particular, have done a poor job of diversifying the workforce. Today the talent pool is about 29 percent minorities who are underrepresented in science, technology, engineering, and mathematics (STEM) fields—including African Americans, Hispanics, Asian/Pacific Islanders, American Indians, and Native Hawaiians—while the scientific workforce remains at only about 9 percent underrepresented minorities (Figure 1-1).

“This is a real challenge for any organization that’s interested in advancing science,” Asai said. If the U.S. population were to remain steady at 30 percent underrepresented minorities, it would take the country about 100 years to establish a representative population of PhDs. But the minority population is growing and is projected to exceed 50 percent by 2050.

Studies that control for preparation of students entering college find that minority undergraduate students leave STEM fields at a rate twice that of white and Asian students. “There’s something we are not doing right at the undergraduate level,” Asai said. About 30 percent of entering undergraduates who intend to study science are underrepresented minorities, reflecting the U.S. population well. However, by the time those freshmen receive science baccalaureates, the proportion who are underrepresented minorities is only about 17 percent underrepresented, and by the time they receive PhDs the number drops to 9 percent (Figure 1-2). This trajectory suggests a great need to prepare undergraduates for success.

Asai suggested that research universities in particular are underachieving. In natural sciences, these schools enroll about 3.3 million undergraduates, of which 18 percent are underrepresented minorities. The research universities graduate about 73,000 baccalaureates in the natural sciences per year, of which about 12 percent are underrepresented minorities.

About 4,200 students with baccalaureate degrees from the top research universities receive science PhDs each year, representing 5.7 percent of the annual production of science baccalaureates. But only 280 minorities from these universities receive a PhD each year, a yield of just 3.1 percent of the 9,000 underrepresented students who receive baccalaureates.

Asai presented three ideas for improvement—change the metaphor, flip the formula, and understand difference. The first is the easiest, he said. Metaphors are very powerful, and they influence the way we behave. The domino theory is one example; fiscal cliffs are another. In science education a common metaphor is the pipeline, which has a beginning and an end with leakage along the way.

FIGURE 1-1 Though 28.5 percent of the U.S. workforce consists of minorities underrepresented in STEM fields, underrepresented minorities (URM) account for only 9.1 percent of the scientific workforce. Source: National Science Foundation.

This is not a good metaphor for student persistence, Asai argued, because today’s students often do not have a very linear story. “They have many experiences that my generation didn’t have,” he pointed out. One example is transfer students, who are an important source of talent. Among students getting a baccalaureate degree in STEM fields, 50 percent have studied at a

FIGURE 1-2 Underrepresented minorities leave STEM fields at higher rates during their undergraduate (arrow) and graduate years. Source: National Science Foundation.
community college. They also may have experiences with work, the military, or other sectors along the way to a degree.

Instead of a pipeline, Asai suggested the watershed as a metaphor. The Chesapeake Bay watershed has 150 different tributaries and involves six states. It has input from many sources, with different pathways and velocities. The boundaries between stages are not always exact and can change with conditions. The outcomes are many and diverse. This may not be the perfect metaphor, he said, but rethinking the pipeline metaphor is essential.

Asai’s second suggestion involved looking at investments and payoffs differently. Undergraduates have an opportunity to learn the processes of science, and it is important for them to become comfortable with uncertainty and to learn how to explore the unknown. One way to foster a spirit of scientific inquiry is to engage students in research experiences. HHMI runs a course where freshmen isolate bacteriophages from soil samples, sequence the DNA, and annotate the genomes, with more than 2,000 students at 73 schools currently taking the course. Over six years, the students have isolated more than 3,000 new viruses and have identified 48,000 genes, of which 865 were never seen before. The students have better grades in their elective courses, and they stay in school at a higher rate.

The cost of the program is about $200 to $250 per student. But a summer research experience costs between $5,500 and $10,000 per student, Asai said. In an informal survey, HHMI asked research universities how much they spend per student on introductory biology lab courses, excluding faculty salaries. The answers fell in a range between $10 and $337 per student. Asai suggested that instead of choosing top students to engage in expensive summer research courses over the summer, universities could invest in improving the research experience during the school year and reach a broader pool of undergraduates. “Advanced courses aren’t the best place to put the money, because those students have mostly already decided,” Asai said. “You miss the kids who never make it that far.”

His third point addressed the issue of understanding difference. Understanding difference takes practice and has to do with listening, understanding privilege, and changing behavior. He emphasized intent versus impact, explaining that when someone has privilege in a relationship, his or her intent does not matter. What matters is the impact of what they say or how they treat the other person.

Asai cited two examples to illustrate this point. The first was a study, involving 6,500 faculty members in 89 disciplines at 259 universities, who were sent an email with a fictitious name containing a request from a student to work with that faculty member in graduate school. The emails with the fictitious name contained either a request for help or for advice. The results showed that faculty members were more likely to respond to requests for help than requests for advice. The study also showed that faculty members were more likely to respond to requests for help from students who had similar backgrounds.

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names of women and minorities were ignored at a higher rate than requests from white males. The response rate decreased with higher paying disciplines and more elite universities. Also, response rates were the same regardless of race and gender of faculty respondent.

The second example had to do with the mismatch hypothesis, which posits that if black and Hispanic students are placed at a school that is not a good fit for them, underperformance is more likely because they are less academically prepared than the students with whom they have to compete. Two researchers in 2013 tested that hypothesis by looking at students in the University of California system in 2004, when a budgetary problem led to offers to students from the less elite campuses to have a guaranteed transfer option to more elite schools. A total of 491 students accepted the option. The mismatch hypothesis predicted they would not succeed, but the data show that the GPAs of the transfer students were statistically the same as the other students at those schools, and they were no more or less likely to drop out.

The implementers of interventions believe that they know what kinds of activities will make a difference for minority students, Asai said. He encouraged the conference attendees to question those beliefs and examine why they have chosen certain interventions and whether those interventions have achieved the desired outcomes. The Understanding Interventions conference, he emphasized, is a critical place for communities to come together and ask these kinds of questions.

In his keynote plenary address, Asai also announced the Meyerhoff Adaptation Program, which is an experimental effort to adapt components of the highly successful Meyerhoff Scholars Program to work with existing programs at Pennsylvania State University and the University of North Carolina, Chapel Hill. (The initiative is described in detail in Chapter 5.) The experiment will last five years and will attempt to find out whether Meyerhoff components can be successfully adapted, what the desired outcomes are of those components, how to measure progress of the various programs, and what pieces might be helpful to other universities.

Asai concluded by quoting Supreme Court Justice Sonia Sotomayor’s dissent in the case Schuette v. Coalition to Defend Affirmative Action, which powerfully describes the experiences many students face in trying to pursue a career in science:

Race matters for reasons that really are only skin deep, that cannot be discussed any other way, and that cannot be wished away. Race matters to a young man’s view of society when he spends his teenage years watching others tense up as he passes. . . . Race matters to a young woman’s sense of self when she states her hometown, and then is pressed, “No, where are you really from?” . . . Race matters to a young person addressed by a stranger in a foreign language, which he does not understand because only English was

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spoken at home. Race matters because of the slights, the snickers, the silent judgments that reinforce that most crippling of thoughts: “I do not belong here.”

ATTITUDES AMONG AFRICAN AMERICAN MALES TOWARD STEM COLLEGE MAJORS AND CAREERS

The lack of a viable STEM workforce increasingly threatens the position of the United States as a leader in science and technology, said LaVar Charleston, assistant director of the University of Wisconsin Equity Inclusion Laboratory (WeiLAB). In particular, the nation’s declining scientific workforce, specifically as it relates to participants of color and Black males, will continue to jeopardize the country’s ability to solve complex technological challenges. STEM jobs are expected to grow 17 percent by 2018, while non-STEM jobs will attain only 10 percent growth over the same period, Charleston observed. Meanwhile, despite higher wages, interventions, and recruitment and education efforts, minorities remain underrepresented in STEM fields. Approximately 238,000 Black men are scientists and engineers, compared with 5 million who are white and 840,000 who are Asian or Asian American. African Americans represent 13 percent of the U.S. population but less than six percent of all faculty members at American colleges and universities.

The higher the academic level, the lower the participation rate among minorities. In 2007 the total number of black doctoral recipients was just under 2,000, or about 4 percent of the total—705 men and 1,251 women. In 1977, 754 doctoral degrees were awarded to African American men, and 440 to African American women. Thus, males went from 63 percent of African American doctoral degree recipients in 1977 to 36 percent in 2007. From 1977 to 2007, Black males were the only males from an ethnic or racial group whose numbers for doctorate attainment dropped.

In 2008 the State of Arizona created an organization called the State of Black Arizona to bring together representatives from the academic community, the research community, and the government community to explore and understand issues of concern for African American citizens. The idea was to compel the community and educational entities to make a concerted effort to help improve the experiences of African Americans in the state. Charleston and his colleagues were brought in to do evaluations, looking at educational attainment. Key partners include the Arizona Community Foundation, Arizona Public Service, the Greater Phoenix Urban League, Arizona State University, and Rio Salado Community College.

The issues facing African Americans in Arizona mirror those in the rest of the country. African American degrees in STEM are not keeping up with the growth of the STEM economy within Arizona, which is projected to produce about 4,000 new jobs per year up until 2018. By that year, the state will have tens of thousands of jobs filled or available in such fields as computer and mathematical occupations, engineering, and the life and physical sciences. It is critical for the state’s well-being that these employees come from within the state, Charleston said. Yet more than 70 percent of African American students in Arizona from grades four to eight have yet to reach proficiency in critical
mathematics and science courses. The State of Black Arizona has a vested interest in ensuring that this population of individuals receives the education necessary to fulfill these roles. In particular, key goals of the initiative are to focus attention on academic achievement in elementary and secondary schools and increase exposure and promote STEM fields as career options early in students’ academic trajectories.

Charleston and his colleagues have been conducting an evaluation of the initiative, with a particular focus on self-efficacy. Research has found that vocational interest alone is not a significant predictor of persistence in a career field. However, self-efficacy and interest contribute to unique variances with regard to occupational considerations. For example, students with stronger self-efficacy in mathematics are more likely to choose science-based majors than students with lower self-efficacy. “Given the role of self-efficacy in career development, the theory provides a means to explain the match between confidence and the decision to pursue educational or occupational careers in STEM fields,” Charleston said.

Their research is looking at two questions: first, do attitudes toward STEM fields among African American males in Arizona influence decisions to pursue college degrees and careers in these fields after controlling for other personal characteristics; second, what are the significant factors that lead to pursuit of STEM education or occupation amongst this population? Data came from the State of Black Arizona STEM Attitudes survey, a statewide investigation that targeted 24 churches, two community events, and five community centers in Phoenix, Flagstaff, and Tucson. The researchers received 634 usable surveys, with 62 percent female respondents and 38 percent male. The average age of survey respondents was 48 years.

A logistic regression analysis of the data measured dependent variables such as STEM majors and jobs in STEM-related fields and independent variables that included age and parental status. It also considered 14 attitudes about STEM, including whether respondents felt STEM careers were difficult, interesting, and well respected.

The results showed that African American males who seriously considered selecting a major in STEM were more likely to pursue STEM majors and careers. Although that sounds fairly intuitive, Charleston said, it reveals that individuals must be exposed to opportunities that help to present STEM majors and careers as options. It points toward self-efficacy as a predictor of workforce-related desires and interest, with self-confidence in one’s ability increasing the likelihood of aspiration toward STEM.

The results also showed that African American males who felt that STEM majors led to high paying positions were less likely to pursue STEM careers. This could point to misunderstandings about what majors and careers belong to STEM fields, Charleston pointed out. The career development literature talks about being able to socially identify with a career area and excluding other career areas that do not seem to be a good fit. One possibility is that some respondents think that these high-paying jobs are not ones in which they would succeed.

Another finding is that African American males who felt they get more opportunities for self-development and growth in STEM fields are more likely
to pursue STEM majors. Thinking about how STEM could be beneficial to you, your development, your desires, and your lifestyle can motivate people toward those careers, Charleston said.

African American males whose families support their efforts to pursue a STEM degree were more likely to pursue STEM majors and careers. Prior research has documented the role that social networks, including family and friends, play in shaping career decisions and aspirations. While a certain level of aptitude is necessary, considerable research has found that persistence rates are mainly socially constructed. In addition, many minority students are drawn to the helping professions. By helping these students connect STEM fields to these professions, the potential of STEM professionals can be further illuminated.

Overall, the data and findings emphasize the importance of promoting strategies that encourage the involvement of African American males in extracurricular activities while building a support system for their college and STEM pursuits, Charleston said. These efforts need to start earlier in an academic trajectory, he continued. This can be done by engaging students in fun activities, such as science clubs, fairs, and robotics competitions, which are all avenues through which students can engage with STEM professionals and apply science and mathematics to something visible. “We’re dealing with a time where kids really need immediate gratification to see results,” he said.

Partnerships with STEM-related businesses and colleges can give students opportunities to participate in research as soon as possible, Charleston suggested. Introducing programming and coding in middle school can help students enjoy computer classes and see the impacts of what they are learning. Another valuable tool for African American males that can help build community support around succeeding in STEM is living and learning community. More and more research is showing that living and learning communities are a productive way to increase participatory rates and persistence rates in STEM fields for underrepresented students, he said.

Self-efficacy needs to be attained at each level of the educational trajectory. Thus, it is important to identify and develop strategies for promising practices that engage students at each stage of the transitional points on the education pipeline. For example, research has found that students in computer science who achieved measures of success at the bachelor’s level need to reestablish efficacy in outcome expectation for the master’s level, which is also true for students moving from a master’s to a PhD. The fast-moving rate of change in technology could contribute to this need, he pointed out, because concepts are always changing. Engaging students’ interest, challenging them, building communities around them, and helping them build identity around scientific and technological knowledge will all help students build confidence.

Identifying mentors early in the educational trajectory is also important, Charleston said. For example, the Institute of African American Mentors in Computer Science has built a program around in-person and virtual mentoring. Without such programs, minority students can go through the computing trajectory and never see another person of color, particularly at the PhD level.

Given the importance of families in STEM success, strategies for the involvement of families need to be developed. At WeiLAB, researchers re-
recently received a $15 million grant to expand Families and Schools Together (FAST), which has a robust curriculum centered on bringing families together and helping them support their children’s education. Charleston also cited a fatherhood initiative in Detroit that centers around encouraging children and promoting the importance of education.

Success will continue to come from the formation of new partnerships involving K–12 schools, colleges and universities, community organizations, and business and industry, Charleston concluded. Policymakers, business owners, community members, and university faculty and administrators all share the goal of improving the academic success of African American males. The State of Black Arizona can help achieve that goal by tapping into additional resources and bringing people together.

A MOTIVATIONAL FACTOR IN BROADENING PARTICIPATION AMONG UNDERREPRESENTED MINORITY STUDENTS

National data on the results of science training program investments suggest that training programs that provide students with support and resources are necessary but not sufficient for meeting the nation’s broadening participation and diversity aims, explained Dustin Thoman, assistant professor of psychology at California State University, Long Beach. He and his colleagues have been seeking to identify theoretically driven elements that could be added to improve these interventions.

Thoman cited the recent approach from NIGMS’s Training, Workforce Development, and Diversity Division to capitalize on the cultural strengths of underrepresented minority students and to remove cultural roadblocks in science education, in addition to providing support and resources. This is consistent with higher education theory, he said, and particularly with Shaun Harper’s work on anti-deficit theory. Whereas traditional deficit approaches examine what underrepresented minority students might be missing that majority students have, anti-deficit or cultural strengths approaches emphasize changing institutions instead of the students. By changing the nature of science education to capitalize on cultural strengths, interventions could be much more effective at sparking and holding the interest of traditionally underrepresented students.

Research has demonstrated that, when students perceive cultural roadblocks in STEM, they tend to see themselves as not fitting the “science image” and ultimately leave, observed Thoman (Figure 1-3). Many of these students are talented and have other options, so it is more attractive to find a place where their cultural and academic identities can feel more connected. Researchers have documented the fact that students who feel these cultural barriers struggle to integrate their identity as a scientist with their cultural identity, which may lead them to choose an area where they feel a better fit. This idea of “fit” is seen throughout the psychological and sociological literature.

The population Thoman and his colleagues have studied consists of advanced undergraduate students who are already working in faculty biomedical research laboratories. These students have demonstrated their ability
to be invited and accepted by faculty members; the researchers are therefore interested in whether they maintain an interest in scientific research. Psychological theory has consistently shown that the fit between personal goals and perceptions of what is afforded by a situation or a career is highly predictive of career interests, Thoman explained. The researchers sought to explore this fit by asking about students’ goals and perspectives on their future careers.

One of the cultural barriers identified in the research literature for underrepresented minority students in biomedical research is the perception that science is driven only by an intrinsic purpose. However, underrepresented minority students and majority students alike value passion, problem solving, and curiosity, which is usually what they cite when people ask why they do science: “I’m interested, I’m passionate, I enjoy the process.” Secondary or multiple motives for underrepresented minority students can include wanting to help or wanting to give back to their communities, which is a cultural connection, Thoman said.

Research findings suggest that these secondary motivations matter for interest in addition to, not instead of, the intrinsic motive for science for underrepresented minority students. Thus, part of the barrier in science education, Thomas suggested, is the focus on the individual. Within the context of text-based analysis, few science educators and very few education materials include communal connections, anything about social agency, or information

about how science can be used to help. Most science education is focused on understanding and basic knowledge without communal or social context.

Preliminary evidence from a survey of undergraduates and interviews with graduates looking at the importance of social change as a work value found that it was more important for underrepresented minority students in STEM fields. It also was found to be a predictor of choosing to leave or stay for those students but not for majority students. The study also found that students who redefine for themselves what science is about and bring a social agency perspective into it are more likely to stay in STEM fields. Some interviews from 2008 asked alumni of minority training programs what they believed were the two most attractive aspects of pursuing a PhD in science research. Number one was satisfaction and interest, but number two was helping members of their community.

However, psychological research has shown that people are good in describing why they think they do what they do but bad at knowing the real cause. People tend to underemphasize many of the social-contextual features that drive their behaviors. Thus, Thoman and his colleagues approached their work with a multiple goals perspective. They built upon previous data from interviews and retrospective data by using a prospective study design with qualitative multivariate analysis. They wanted to build stronger study designs to account for the relationship between altruistic and career interests while also controlling for other motivations.

As part of a larger four-year longitudinal study, data were collected from 337 students from two universities and seven tribal colleges in Montana, including 100 underrepresented students, who were recruited through faculty biomedical research laboratories. Initial survey data were collected six weeks into the semester, with a follow-up survey conducted at the end of the semester. The study asked whether perceptions of altruistic affordances predict higher involvement in laboratory work and greater career interest at the end of the semester. It also analyzed whether the altruistic affordances matter even when controlling for effects of other motives.

The baseline measurements asked students about their personal values—including altruistic, intrinsic, and extrinsic types of items—and whether those values were likely to be fulfilled by research laboratory work. Follow-up measures included level of laboratory involvement and career interest. Psychological data point to high correlations between measures of research career interest, particularly at the end of undergraduate study, and actual behavior.

Underrepresented minority students in the study said that it is more important to pursue science for intrinsic goals, and their answers were not statistically different from majority students. However, altruistic goals for underrepresented minority were equally high, whereas for white students they were significantly lower.

To determine what higher altruistic affordances predict, the researchers did a multiple regression analysis and looked for statistical interactions. For white students, the researchers found that fulfilling altruistic goals did not matter for laboratory involvement, but it made a significant difference for underrepresented minority students. Those who saw that the research work allowed them to fulfill greater altruistic goals expressed higher engagement
and higher involvement in their laboratories, with the same pattern appearing in career interest. When the analysis was repeated in a logistic regression, underrepresented minority students who perceived high versus low altruistic affordances were more than three times more likely to have high involvement and two-and-a-half times more likely to have high career interest.

To find the relative contribution of altruistic affordances, the researchers did a multivariable analysis that accounted for all three goals. They found that intrinsic goal affordances predicted research involvement and career interest for everyone, not moderated by ethnicity, and that even controlling for intrinsic and for extrinsic values, altruistic affordances significantly predict career interest for underrepresented minority students. From subsequent statistical mediation analysis, they concluded that the effect of altruistic goal affordances on career interests for underrepresented minority students is driven through greater laboratory involvement.

These findings suggest that the altruistic motivation for doing science is important in addition to, not instead of, intrinsic motivation for underrepresented minority students. Young students have different reasons for approaching a domain than mid-career scientists, and framing interventions from that perspective could result in a greater positive effect. Thus, it may be important to change how scientists talk about science, without needing to change the science itself, to broaden participation. Thoman advised principal investigators to talk to their students about how research helps communities and policymakers. “They are being educated in a culture that often sees science as narrow, objective, and disconnected,” he pointed out. Scientists can help change this culture by talking about why science is important in the broader world.