

At a Crossroads: Reimagining science, engineering, and medicine—and its practitioners

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The coronavirus disease 2019 (COVID-19) pandemic has cast a bright light on the importance of science and evidence (1). Epidemiologists have provided public health advice informed by experience with epidemics and are sharing best practices for halting the spread of the virus. Biomedical scientists are researching how the virus works, testing treatments, and racing to develop a safe and effective vaccine. This work reinforces previous calls from the National Academies and others for strong investments in science and mathematics education; science, engineering, and medicine research; and the translation of new knowledge into products and processes that improve public health, spur economic growth, and maintain national security (2–4).

Although its high level of contagion means that everyone is vulnerable to the virus, the pandemic has

also shined a bright light on intractable inequalities in our society. Several months ago, we, along with others, advocated for release of COVID-19 case data by race, arguing that we could not understand the impact of the virus unless we could see how it affected communities differently. When data were finally made available, the disparities were clear. Elderly and low-income Americans, African Americans, Native Americans, and Hispanics are infected by and dying from the virus in disproportionate numbers. Ibram Kendi has shown that the African American community has been particularly hard hit because of structural racism, economic inequalities, and health disparities (5). To paraphrase others, these differences provided the kindling and police brutality the match for the widespread fire of racial



Recent events have shined a bright light on intractable inequalities in US society. The science enterprise is far from immune. Although there has been progress, the science community can do much more. Image credit: Shutterstock/Tverdokhlib.

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protest that has called for broad policy changes to address structural racism in America.

The pandemic and racial protest have together done something else as well: They have provided an opportunity to reshape our institutional cultures to support the success of students and faculty of all backgrounds and, in turn, enhance science and public health and reduce disparities. In light of the current racial unrest, many are asking “What can I do?” Many of our African American colleagues, in particular, are providing practical advice.

COVID-19 provides a “Sputnik moment,” one that allows us to reimagine the role of science in our society and elevates the importance of inclusion within the scientific community.

By considering and acting on this advice—including what we offer in this article—we can better recruit a broader range of students in science, support their success, and help them succeed in professions that would benefit from greater diversity. When we do so we can enrich scientific, professional, and policy conversations with new information, life experiences, and perspectives that could lead to better health and social outcomes.

Meeting the Moment

In *Science: The Endless Frontier*, a report released 75 years ago, Vannevar Bush re-envisioned the science and engineering enterprise to benefit our economy, health care, and national security (6). His vision provided the template for a federally funded basic research enterprise located in research universities and carried out by faculty in conjunction with their graduate students. Bush’s recommendations led to the establishment of the National Science Foundation in 1950.

Then, in 1957, the successful Soviet launch of Sputnik transfixed America and led us to increase federal investment in scientific education and research. In the decades since, these investments have yielded exponential dividends. We placed a man on the moon, protected the Earth’s ozone shield, created a revolution in computing and telecommunications, developed cancer treatments, decoded the human genome, and much, much more (7).

During the current COVID-19 lockdown, many have expressed a strong longing for a “return to normal.” As New York Governor Andrew Cuomo has argued in his daily briefings, however, the current crisis provides the opportunity for us not to merely reopen our society but also to reimagine it. Life will be different anyway. Our increased use of digital learning, telework, online grocery shopping, telehealth visits, and vote by mail are shifting our perceptions of what is possible and effective. These temporary measures will have permanent long-term consequences for teaching and learning and the nature of work, transportation, retail, healthcare, and democracy.

But we can go beyond these changes to envision and implement structural changes that would create a better society. COVID-19 provides a “Sputnik moment,” one that allows us to reimagine the role of science in our society and elevates the importance of inclusion within the scientific community.

This past January, Holden Thorp, Editor-in-Chief of *Science*, lamented that although we continually articulate important goals for science, we have not taken the steps to achieve them (8). He wrote that the mantra of the scientific community has been a “diverse scientific workforce; policymakers who recognize the importance of science; a voting public that understands the scientific process.” But, Thorp added, “these words don’t match actions” and inaction is “costing society a generation of researchers, educators, a population that better grasps science, and maybe more.” The lack of progress is not attributable to a lack of proven solutions. Reimagining our work means drawing on models that work to support better outcomes for our students.

Taking the Initiative

The scientific community has understood the problem of underrepresentation in science and engineering for some time; we’ve also observed what works to enhance and sustain diversity and inclusion. *Expanding Underrepresented Minority Participation: America’s Science and Technology Talent at the Crossroads*, a 2011 report from the National Academies, argued that we are likely as a society to miss out on important innovations unless we draw on the talents of students from underrepresented groups, especially because they are also the fastest growing groups in the U.S. population (9). When we bring more people with different life experiences to the table, we also enrich the conversation with new information, perspectives, and questions. To expand diversity, the *Crossroads* report called for faculty to redesign introductory college science and mathematics courses to improve teaching and learning and support persistence in science, technology, engineering, and mathematics (STEM) majors. It also argued that universities must, drawing on models that work, create programs that build community, encourage group study, and provide experiential learning for all students, and particularly those from underrepresented groups.

The Meyerhoff Scholars Program at the University of Maryland, Baltimore County (UMBC) began as an experiment in 1989 to support African American undergraduates who would go on to earn doctorates in the natural sciences and engineering. Lessons learned from that program have helped us support students of all races and backgrounds, by instilling high expectations in students, promoting the goal of doctoral study, using a cohort approach to build community, encouraging group study and peer tutoring, providing financial support, and bringing students into faculty research (10, 11).

The results are promising. Forty percent of our students go on to graduate or professional school. Our alumni are now playing important roles during this pandemic. For example, Jerome Adams is the U.S.

Surgeon General. Letitia Dzirasa is the Baltimore City Health Commissioner. Kizzmekia Corbett is the scientific lead for COVID-19 vaccine development at the National Institute of Allergies and Infectious Disease (NIAID) in Bethesda, MD; she's joined by alumnus Olubukola Abiona. Darian Cash is a senior researcher at Cambridge, MA-based Moderna, the firm partnering with NIAID in COVID-19 vaccine development. Kaitlyn Sadtler is leading the NIH study that will estimate the number of adults in the United States who have not had a confirmed infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)—the virus that causes COVID-19—yet have antibodies to the virus. Each of these young researchers can point to teachers, professors, and mentors who supported them at each stage of their journey.

Federal science agencies and national associations have taken steps to support diversity in undergraduate science and engineering since the publication of the *Crossroads* report. In the past decade, for example, the NIH established the Building Infrastructure Leading to Diversity (BUILD) program providing grants to ten “undergraduate institutions to implement and study innovative approaches to engaging and retaining students from diverse backgrounds in biomedical research.” And the National Science Foundation (NSF) established the Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES) program in 2018 to build on and scale up what works in broadening participation. With funding from INCLUDES, the Association of Public and Land-grant Universities (APLU) and the Center for the Integration of Research, Teaching, and Learning have established the ASPIRE Alliance to identify best practices for preparing, attracting, and retaining underrepresented STEM faculty and help universities adopt them.

Meanwhile, the Howard Hughes Medical Institute (HHMI) has funded a replication of UMBC's Meyerhoff program at the University of North Carolina (UNC) in Chapel Hill and Pennsylvania State University (Penn State) in State College. A recent article in *Science* found that institutional partnerships, such as those between UMBC, UNC, and Penn State, can successfully establish programs in new institutional settings and produce similar educational outcomes for underrepresented groups in science and engineering (12). Informed by these results, HHMI is funding replication at six more universities. The Chan Zuckerberg Initiative (CZI) has committed to replication at the University of California, Berkeley and the University of California, San Diego in La Jolla. The Alfred P. Sloan Foundation has nurtured another program, supporting minority doctoral candidates in engineering and the sciences at eight universities designated as Sloan University Centers for Exemplary Mentoring.

Daunting Statistics

We are encouraged by all these national initiatives, but we must distinguish activities from outcomes. The work the science community has done has moved the needle only slightly with respect to increasing the

proportion of underrepresented minorities pursuing advanced science degrees and securing faculty positions. There remains more to do. Whereas African Americans constitute 13% of our nation's population, they account for just 5% of higher education faculty across all disciplines and 4% of new Ph.D.s in the natural sciences and engineering. Whereas Hispanics constitute 18% of the population, they account for about 4% of higher education faculty and 5% of new Ph.D.s in the natural sciences

The ineluctable question is whether university leaders and faculty are sufficiently committed to broadening participation in STEM so that the professoriate and STEM workforce become more reflective of the American population.

and engineering (13, 14). One analysis estimates that among selective research universities, Blacks constitute 0.7% of the biology faculty and 1.4% in chemistry and Hispanics constitute 3.0% in biology and 2.5% in chemistry (15). Blacks constitute fewer than 2% of researchers at NIH and other federal agencies and Hispanics just 4% (16). A National Academies report on the underrepresentation of women in science and engineering released earlier this year highlights the intersectional challenges for women of color in these fields. Qualitative differences in their experiences urge us to develop further efforts to support these groups (17).

The ineluctable question is whether university leaders and faculty are sufficiently committed to broadening participation in STEM so that the professoriate and STEM workforce become more reflective of the American population. We can do more as institutions and individuals. Changing the culture of our institutions requires persuading the people who have the power—presidents, provosts, deans, and senior faculty—to examine their views, become allies in the work, and pull underrepresented students into the science (18).

At UMBC, Mike Summers, a professor of biochemistry, HHMI investigator, and National Academy of Sciences (NAS) member, has mentored numerous minority and women students in his lab, where they study how HIV-1 and other retroviruses assemble in infected cells. Many of these undergraduate and graduate students have become faculty at research universities and other institutions nationwide. Whenever Summers is invited to speak, he actually gives two separate talks: one on his scientific research, and a second on how to support students of color in science and engineering. It takes researchers to produce researchers, including researchers of color; we must all take this kind of ownership of the problem of creating a diverse science and engineering community.

The ASPIRE Alliance observes in a report released this year that although many universities now have programs to support underrepresented minority students at the undergraduate and graduate levels, “support appears to diminish at the postdoctoral and early career levels.” (19) We have also noted this trend as we

observe the career progression of Meyerhoff alumni. Without the connections needed to advance, many talented minority doctorates leave bench science even as colleges and universities say they have difficulty finding minority faculty candidates. We need to do much more to support these students as they make the transition from graduate and postdoctoral programs into their careers.

Crossroads recommended a program like the NSF's ADVANCE but geared toward underrepresented minorities, a program that would provide institutions with resources for improving the recruitment, hiring, and advancement of underrepresented minority faculty in the sciences and engineering. UMBC received an ADVANCE grant that allowed us to make significant progress in recruiting and promoting women. We held discussions of and workshops on implicit bias and institutionalized faculty recruitment plans; we also developed transparent faculty promotion guidelines and consistent family support plans, provided research support for new women faculty, and facilitated leadership development. We have used lessons learned from that grant to also increase the recruitment and hiring of underrepresented minority faculty (18).

As we reimagine science and engineering in America, let us remind ourselves that success requires each of us to encourage our institutions to build a broader talent pool. Several years ago, Sandy Williams, then dean of the Duke University Medical School in Durham, NC, had serious conversations with Duke faculty about identifying and investing in a more diverse candidate pool. By becoming a champion for diversity and inclusion, Williams created a culture that supported the transition of minority students into the professoriate. A stunning outcome of his leadership is that four of our African American alumni—three who have earned the M.D.-Ph.D. and one who has earned an M.D. and a J.D.—are now on the faculty at Duke Medical School and engaged in cutting-edge work. Kafui Dzirasa, for example, is now a tenured associate professor at Duke in psychiatry and neurobiology with an endowed chair. Last fall, the Society for Neuroscience awarded Dzirasa its Young Investigator Award. This is science reimaged.

Taking Action

When people take action—individually and collectively—that's when we see results. Now is the time to act as

individuals and institutions. We challenge our colleagues and institutions to take these tangible actions.

- We can adopt practices, initiatives, and models that have been successful in supporting students and faculty of color, including those cited in this article (9). We can continue by also being scientific about the problem of diversity and how to address it. A place to start is rigorous analysis of data about students on our own campuses to understand both our challenges and our opportunities (18).
- As individual researchers and engineers we can mentor students of color and become their champions as they make the transition to graduate school, postdoctoral fellowships, and junior faculty positions (9). We can actively recruit applicants of color for faculty positions (18, 20). We can support colleagues of color as we do any colleague by collaborating with them on grants, research, and papers; reading and citing their work; and inviting them to give talks (20).
- As institutions, we can replicate and adapt those practices and programs, setting and working toward goals for significantly increasing the numbers of students and faculty of color who are succeeding (12, 21).
- In the longer term, the scientific community—agencies, funders, research universities—should continue to focus on and invest in the productive work of replicating practices and initiatives that work in undergraduate and graduate education as well as in cases of career advancement for underrepresented minorities (9, 21). Among other steps, we call on the NSF to institute an "ADVANCE program for underrepresented minority faculty" similar to the ADVANCE program for women in science and engineering that was established two decades ago and has delivered results in the years since its establishment (9).

To paraphrase Aristotle, choice, not chance, determines our destiny. In the end, progress depends on the choices we make. If we take advantage, now—of the COVID-19– and antiracism-driven energy in our social dynamic—seizing the opportunity to reduce underrepresentation in science, engineering, and medicine, and take responsibility for the work that needs to be done, then we can finally make real progress in creating and sustaining an inclusive enterprise that delivers benefits to America.

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