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Last March, we traveled to Charlotte, North Carolina, for a first round game in the 2018 NCAA Men's Basketball Tournament. On that evening was a game between No. 1 seed University of Virginia and No. 16 seed University of Maryland, Baltimore County (UMBC). As is widely known, the unimaginable happened that evening when our beloved UMBC Retrievers beat the UVA Cavaliers. The upset victory became a widely celebrated sensation. Something else, once almost as unimaginable, also happened that evening that is not as widely known and celebrated, but should be. With us in the crowd that evening were four black men. All were alumni of UMBC. All had been athletes. All had participated in UMBC's Meyerhoff Scholars Program. Three went on to earn MD-PhDs and the fourth an MD and a JD. All four are now on the faculty at Duke Medical School. They are all engaged in cutting-edge research. One, for example, is working on the development of a pacemaker for the brain that promises to address such conditions as depression, autism, and schizophrenia.

Challenging US Research Universities and Funders to Increase Diversity in the Research Community

Building on successful approaches to increasing diversity in science and engineering education could help achieve ambitious goals in the number of doctorates awarded to minority students.

This example of progress in academic diversity is what we need to see more of if the United States wants to develop and sustain the robust, diverse science, technology, engineering, and mathematics (STEM) workforce that draws on talent of all backgrounds and allows the nation to compete in today's science- and technology-driven global economy. We need to see more like this because the nation is not yet drawing on all its talent. At a time when African Americans comprise 13.4% of the US population, they comprised just 3.5% of new doctorates in the natural sciences and engineering from US institutions in 2007, a figure that climbed to only 3.9% a decade later in 2016. At a time when Latinos comprise 18.1% of the population, they comprised just 4% of new doctorates in the natural sciences and engineering from US institutions in 2007, a figure that climbed to just 4.9% a decade later in 2016. We can see some slight progress in these numbers, but it is too slow. At this rate, the United States will not achieve its goals of an inclusive research workforce for another century or more—and the nation will have missed many opportunities in the meantime for breakthroughs and innovations that would have increased its quality of life and improved the nation's health.

In 2011, the National Academies of Sciences, Engineering, and Medicine published a report that documented the significant underrepresentation of African American and Hispanic research doctorates in the natural sciences and engineering and made recommendations for short- and long-term actions that would make the science and engineering enterprise more inclusive, diverse, and robust. The report, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, widely called the *Crossroads* report, was a congressionally mandated follow-up to *Rising Above the Gathering Storm*, the National Academies' seminal work on national economic competitiveness that led directly to the bipartisan America COMPETES Act. Congress mandated the *Crossroads* report because key senators recognized that success in an increasingly complex, globalized twenty-first century economy would depend on whether the United States produced and sustained a robust and dynamic STEM workforce. And more to the point, they recognized that to do this the country must draw on talent from all backgrounds.

The *Crossroads* report urged the country to invest in the success of students of all backgrounds in STEM from preschool through graduate school and on into early careers, with specific recommendations for each educational stage. Although it acknowledged the importance of improvements in K-12 STEM education for the long run, it identified and focused on the "low-hanging fruit" that could be picked almost immediately with a focused and sustained effort. It found that among African

American or Hispanic students who matriculated at a four-year institution with an intent to major in STEM, just 20% actually graduate with a bachelor's degree in STEM within five years. This is a jaw-dropping statistic given that most of the students who leave STEM are prepared for work in these fields. What astounded us further was that just 33% of white and 42% of Asian American undergraduates who aspire to major in STEM do so as well. In other words, most students of any background do not succeed in STEM.

This is a national problem requiring a national solution. The report urged that the nation focus on retaining and advancing well-prepared undergraduates of all backgrounds who seek to major in STEM when entering college. It argued that best practices for course redesign and student support that would help institutions do this have already been identified. Redesigning introductory courses through active, problem-based group learning has been shown to improve learning and student outcomes in science courses. Providing underrepresented minority students in STEM with appropriate academic, social, and financial support has been shown to boost their retention and completion in STEM, and even send them on for a successful experience in graduate school.

In spring 2017, we published an article in this journal updating the available data from the National Science Foundation (NSF) on the baccalaureate origins of African American doctorate recipients. In the two tables we have included in this article, we provide another update on the baccalaureate origins of African American doctorate recipients as well as a new update on the origins of Hispanic doctorate recipients. These tables display the top 30 baccalaureate-origin institutions for these individuals. The top 30 institutions for African Americans educated 1,966, or 32% of African Americans who earned their PhDs from US institutions. The top 30 institutions for Hispanics educated 3,484, or 44% of those who earned their PhDs from US institutions. Future analyses should examine data on doctorates who are Native Americans, Alaska Natives, and Pacific Islanders.

In our original article, we urged federal agencies, such as NSF and the National Institutes of Health (NIH), along with foundations, corporations, and other donors that invest in the STEM workforce, to target funding to those institutions that have developed successful approaches to educating minority students who go on to earn PhDs in the natural sciences and engineering or those institutions that seek to emulate them and replicate their practices. If federal agencies, foundations, and individual donors were to focus the financial support they target toward increasing diversity in STEM—both scholarships and institutional funding—on these top 30 institutions for African Americans and Hispanics, those that are

Table 1. TOP 30 US BACCALAUREATE-ORIGIN INSTITUTIONS OF 2007-16 BLACK SCIENCE AND ENGINEERING* DOCTORATE RECIPIENTS, BY INSTITUTIONAL CONTROL, 2010 CARNEGIE CLASSIFICATION, AND HBCU STATUS

RANK	BACCALAUREATE INSTITUTION	INSTITUTIONAL CONTROL	2010 CARNEGIE CLASSIFICATION	HBCU STATUS	2007-16 BLACK S&E DOCTORATE RECIPIENTS
	All black S&E doctorate recipients	na	na	na	7,206
	From US institutions	na	na	na	6,104
	From foreign institutions	na	na	na	905
	From unreported institutions	na	na	na	197
1	Howard U.	Private	Research-high	Yes	130
2	U. Maryland, Baltimore County	Public	Research-high	No	119
3	Florida A&M U.	Public	Doctoral/research	Yes	112
4	North Carolina Agricultural and Technical State U.	Public	Doctoral/research	Yes	108
5	Xavier U. Louisiana	Private	Baccalaureate	Yes	103
6	Spelman C.	Private	Baccalaureate	Yes	102
7	Morgan State U.	Public	Doctoral/research	Yes	85
8	Southern U. and A&M C., Baton Rouge	Public	Masters granting	Yes	78
9	Hampton U.	Private	Masters granting	Yes	75
9	U. Florida	Public	Research-very high	No	75
11	Morehouse C.	Private	Baccalaureate	Yes	69
12	U. Maryland, College Park	Public	Research-very high	No	63
13	Jackson State U.	Public	Research-high	Yes	62
13	Tuskegee U.	Private	Baccalaureate	Yes	62
15	Massachusetts Institute of Technology	Private	Research-very high	No	61
16	U. Michigan, Ann Arbor	Public	Research-very high	No	60
17	Tennessee State U.	Public	Doctoral/research	Yes	54
18	U. Illinois, Urbana-Champaign	Public	Research-very high	No	52
19	Georgia Institute of Technology	Public	Research-very high	No	49
20	U. North Carolina, Chapel Hill	Public	Research-very high	No	46
21	North Carolina State U.	Public	Research-very high	No	44
22	Alabama A&M U.	Public	Masters granting	Yes	43
23	Florida State U.	Public	Research-very high	No	42
24	Clemson U.	Public	Research-high	No	41
24	Rutgers, State U. New Jersey, New Brunswick	Public	Research-very high	No	41
24	U. Virginia, Charlottesville	Public	Research-very high	No	41
27	CUNY, City C.	Public	Masters granting	No	38
28	Cornell U.	Private	Research-very high	No	37
28	Harvard U.	Private	Research-very high	No	37
28	Prairie View A&M U.	Public	Masters granting	Yes	37

HBCU = Historically Black College or University; na = not applicable; S&E = science and engineering.

* For the purposes of this table, science and engineering includes health and excludes psychology and social sciences.

Notes: Includes only US citizens and permanent residents. Institutions with the same number of doctorate recipients are listed alphabetically.

Source: National Science Foundation, National Center for Science and Engineering Statistics, 2016 Survey of Earned Doctorates; special tabulation (October 2018).

Table 2. TOP 30 US BACCALAUREATE-ORIGIN INSTITUTIONS OF 2007-16 HISPANIC OR LATINO SCIENCE AND ENGINEERING* DOCTORATE RECIPIENTS, BY INSTITUTIONAL CONTROL, 2010 CARNEGIE CLASSIFICATION, & HSI STATUS

RANK	BACCALAUREATE INSTITUTION	INSTITUTIONAL CONTROL	2010 CARNEGIE CLASSIFICATION	HSI STATUS	2007-16 HISPANIC S&E DOCTORATE RECIPIENTS
	All Hispanic or Latino S&E doctorate recipients	na	na	na	9,083
	From US institutions	na	na	na	7,852
	From foreign institutions	na	na	na	1,044
	From unreported institutions	na	na	na	187
1	U. Puerto Rico, Mayaguez	Public	Doctoral/research	Yes	559
2	U. Puerto Rico, Rio Piedras	Public	Research-high	Yes	326
3	U. Texas, El Paso	Public	Research-high	Yes	189
4	U. Florida	Public	Research-very high	No	184
5	U. California, Los Angeles	Public	Research-very high	No	144
6	U. California, Berkeley	Public	Research-very high	No	134
7	U. Texas, Austin	Public	Research-very high	No	132
8	Massachusetts Institute of Technology	Private	Research-very high	No	129
9	Florida International U.	Public	Research-high	Yes	128
10	U. California, Davis	Public	Research-very high	No	117
11	Texas A&M U., College Station and Health Science Center	Public	Research-very high	No	101
12	U. California, Irvine	Public	Research-very high	Yes	101
13	U. Arizona	Public	Research-very high	Yes	93
14	U. California, San Diego	Public	Research-very high	No	92
15	Cornell U.	Private	Research-very high	No	89
16	U. New Mexico, Albuquerque	Public	Research-very high	Yes	85
17	U. Puerto Rico, Humacao	Public	Baccalaureate	Yes	84
18	New Mexico State U., Las Cruces	Public	Research-high	Yes	81
19	U. Miami	Private	Research-very high	No	80
20	U. California, Santa Cruz	Public	Research-very high	Yes	70
21	U. California, Riverside	Public	Research-very high	Yes	66
22	Florida State U.	Public	Research-very high	No	64
23	U. Puerto Rico, Cayey	Public	Baccalaureate	Yes	62
24	Stanford U.	Private	Research-very high	No	57
24	U. California, Santa Barbara	Public	Research-very high	Yes	57
26	U. Texas, San Antonio	Public	Research-high	Yes	55
27	Arizona State U.	Public	Research-very high	No	52
27	Rice U.	Private	Research-very high	No	52
29	California State U., Los Angeles	Public	Masters granting	Yes	51
30	U. Michigan, Ann Arbor	Public	Research-very high	No	50

HSI = Hispanic-Serving Institution; na = not applicable; S&E = science and engineering.

* For the purposes of this table, science and engineering includes health and excludes psychology and social sciences.

Notes: Includes only US citizens and permanent residents. Includes only institutions in the United States. Institutions with the same number of doctorate recipients are listed alphabetically.

Source: National Science Foundation, National Center for Science and Engineering Statistics, 2016 Survey of Earned Doctorates; special tabulation (October 2018).

already doing relatively well, that would represent a solid investment that would pay off with many more students.

NIH's BUILD and NSF's INCLUDES programs provide institutional grants for initiatives to increase the participation and success of underrepresented minority students in STEM. The Howard Hughes Medical Institute (HHMI) has developed a new Inclusive Excellence Initiative that provides grants to build institutional capacity for inclusion of students from all backgrounds in science. Should these programs build on the work of institutions that are already producing underrepresented minority students who succeed in earning research doctorates, or should they focus on building capacity at additional institutions?

It is instructive to look at the current intersection between the lists of top baccalaureate institutions for underrepresented minority doctorates and the lists of institutions that have received funding to support underrepresented minority success from these major diversity initiatives:

- NIH's BUILD program provided 10 grants in 2014. Four of these institutions, or 40%, were top 30 institutions: UMBC, Morgan State, Xavier, and the University of Texas at El Paso.
- NSF's INCLUDES program has provided funding to a much larger set of institutions through three funding rounds. About 25% are top 30 baccalaureate-origin institutions and about 40% are in the top 50 of such institutions.
- With a goal of building institutional capacity, HHMI's Inclusive Excellence Initiative deliberately targets institutions that are not yet major baccalaureate-origin institutions. Just five of their 60 grant recipients are already on the top 30 lists.

We applaud BUILD and INCLUDES for funding networks to share best practices across grantees. This is important programmatic work, building on rigorous evaluation of what is working, that helps build capacity at institutions that are already among the top 30 as well as others that might also increase their support for underrepresented minority students. We also applaud any future effort to coordinate work on addressing diversity in STEM across federal agencies (this was a recommendation of the *Crossroads* report.) Coordinating and building synergy across NIH's BUILD, NSF's INCLUDES, and HHMI's Initiative to focus on the top 30 baccalaureate institutions for African American and Hispanic doctorates is another approach to consider for building institutional capacity.

Because we believe those institutions that are already among the top 30 baccalaureate-origin institutions for

African Americans and Hispanics are poised to build on existing efforts and contribute even more to the national goal, we urge another step. We challenge each university among the top 30 in baccalaureate origins for African American or Hispanic students who go on to earn PhDs in the natural sciences and engineering to focus on doubling the number of such students from their institutions who do so. The results would be a significant achievement for the nation:

- If the top 30 institutions for African Americans were to accomplish this, then a decade hence the United States would have almost 2,000 more African American doctorates in the natural sciences and engineering. This would represent an increase of almost one-third over the 6,000 or so African Americans who earn their bachelor's degree at a US institution.
- If the top 30 institutions for Hispanics were to accomplish this, then a decade hence the nation would have almost 3,500 more Hispanic doctorates in the natural sciences and engineering. This would represent an increase of almost 45% over the nearly 8,000 Hispanics who earn their bachelor's degree at a US institution including those in Puerto Rico.

What would it take for an institution to accomplish this? As shown in Table 1, UMBC is the number two baccalaureate institution (after Howard University) for African Americans who go on to complete PhDs in the natural sciences and engineering as a result of the Meyerhoff Scholars Program. With support from Robert Meyerhoff, UMBC launched the program in 1989. Based on a multifaceted approach, the program has emphasized high expectations, strong community commitment, academic success, research experiences, financial support, and rigorous program assessment.

This approach is based on what we call a "social transformation theory of change" in which we create empowering settings for minority student achievement within a broader institutional change process focusing on transforming campus culture to emphasize inclusion and excellence. We enact these changes through a process that involves deep and sometimes difficult conversations, analysis of student data, use of best practices from other institutions, and the identification of faculty allies and champions who become central to program implementation and student success. We build evaluation into the program from its inception to inform and evolve it and promote sustainability.

Inspired by the *Crossroads* report, HHMI has funded an effort to replicate and adapt the Meyerhoff program through the Chancellor's Science Scholars Program

at the University of North Carolina at Chapel Hill and the Millennium Scholars Program at Penn State, both of which are showing great promise. Building on the HHMI funding, these two institutions have committed significant existing funding and raised substantially more from external sources to support their efforts. Howard University's Bison STEM Scholars Program is also adapting Meyerhoff to their campus with institutional support. (Interested readers can contact these campuses for more details on their programs and funding.)

Other institutions can follow their lead. If the nation's research universities were to identify students of color who are performing well in science, engineering, and mathematics and then support and guide them toward STEM degrees and the goal of earning a research doctorate, this focused effort could easily double the numbers the nation is currently seeing. A successful effort will require campus leadership to make this work a priority and become its champion; it will also need faculty to become deeply involved in the program and bring students into the work. Universities should identify, support, and retain faculty—of all backgrounds—who invest themselves in this work. Although we believe that students need to see faculty of the same race or ethnicity as them—and increasing faculty diversity is a crucial national goal—we recognize the importance of majority faculty to this work. On our own campus, majority faculty have played a critical role in teaching and mentoring underrepresented minority students.

Research universities should focus energy and resources on this issue and set of goals.

- Institutions that are in the top 30 for African Americans currently graduate between about 4 and 13 African American students per year. What would it take, for example, for Clemson to graduate 8 African Americans per year who go on to earn a PhD in the natural sciences or engineering instead of 4? Or the University of Illinois to graduate 10 instead of 5, MIT 12 instead of 6, Spelman 20 instead of 10, or UMBC 24 instead of 12?
- Institutions that are in the top 30 for Hispanics currently graduate between 5 and 19 on the US mainland and 32 and 56, respectively, for the two larger campuses of the University of Puerto Rico. What would it take, for example, for the University of Michigan to graduate 10 Hispanic students who go on to earn a PhD in the natural sciences or engineering each year instead of 5? Or for the University of Arizona to graduate 18 instead of 9, UC Berkeley 26 instead of 13, or the University of Texas at El Paso 38 instead of 19?

In many cases, these institutions are already providing some level of support for minority undergraduates in the natural sciences and engineering. In other cases, though, many African Americans and Hispanics are graduating and continuing on to graduate school despite the institution, not because of its support. Further, many of the top institutions have major fundraising capacity. How can the nation incentivize institutions to leverage public funds in raising additional money to support underrepresented minority students who aspire to earn research doctorates in STEM?

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Peter H. Henderson is senior advisor to the president at UMBC, and he formerly served as director of the Board on Higher Education and Workforce at the National Academies of Sciences, Engineering, and Medicine. They were chair and study director, respectively, of *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*.

Recommended reading

Freeman A. Hrabowski III, *Holding Fast to Dreams:*

Empowering Youth from the Civil Rights Crusade to STEM Achievement (Boston, MA: Beacon Press, 2015).

Freeman A. Hrabowski III and Peter H. Henderson,

"Toward a More Diverse Research Community: Models for Success," *Issues in Science and Technology* 33, no. 3 (Spring 2017).

Kenneth Maton, Freeman A. Hrabowski, Metin Ozdemir, and Harriette Wimms, "Enhancing Representation, Retention, and Achievement of Minority Students in Higher Education: A Social Transformation Theory of Change," in *Toward Positive Youth Development: Transforming Schools and Community Programs*, Marybeth Shinn and Hirokazu Yoshikawa, eds. (New York, NY: Oxford University Press, 2008).

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