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### EDITORIAL

#### **Broadening Participation in the Life Sciences: Current Landscape and Future Directions**

*Kenneth D. Gibbs, Jr., and Pat Marsteller*

This lead editorial for the *CBE—Life Sciences Education* special issue on broadening participation defines terms, marks progress, and calls on the community to consider specific approaches going forward.

### BROADENING PARTICIPATION FEATURES

#### **From the NIH:**

#### **A Systems Approach to Increasing the Diversity of the Biomedical Research Workforce**

*Hannah A. Valentine, P. Kay Lund, and Alison E. Gammie*

The National Institutes of Health presents a systems approach to developing and sustaining a diverse biomedical workforce through interventions that promote successful transitions from training to career independence.

#### **From the NSF:**

#### **The National Science Foundation's Investments in Broadening Participation in Science, Technology, Engineering, and Mathematics Education through Research and Capacity Building**

*Sylvia M. James and Susan R. Singer*

The National Science Foundation's investments to increase inclusion of members of groups underrepresented in the science and engineering enterprise continue to grow and generate new knowledge about increasing the participation of all in STEM, yet many challenges remain for developing a diverse STEM workforce and a diverse, STEM-savvy public.

#### **From the USDA:**

#### **Educating the Next Generation: Funding Opportunities in Food, Agricultural, Natural Resources, and Social Sciences Education**

*Joyce E. Parker and David J. Wagner*

This article highlights funding opportunities at the U.S. Department of Agriculture's National Institute of Food and Agriculture Division of Community and Education.

#### **From HHMI:**

#### **Doubling Down on Diversity**

*David J. Asai and Cynthia Bauerle*

In spite of modest gains in the past 50 years, the United States has not been able to substantially improve on the pervasive underrepresentation of minorities in postsecondary STEM pathways. We suggest a way to guide a national effort to double the persistence of underrepresented minorities in STEM in the next decade.

## RESEARCH METHODS

### **Broadening the Study of Participation in the Life Sciences: How Critical Theoretical and Mixed-Methodological Approaches Can Enhance Efforts to Broaden Participation**

*Heather Metcalf*

This essay details the usefulness of critical theoretical frameworks and critical mixed-methodological approaches for life sciences education research on broadening participation in the life sciences.

## ESSAYS

### **Improving Underrepresented Minority Student Persistence in STEM**

*Mica Estrada, Myra Burnett, Andrew G. Campbell, Patricia B. Campbell, Wilfred F. Denetclaw, Carlos G. Gutiérrez, Sylvia Hurtado, Gilbert H. John, John Matsui, Richard McGee, Camellia Moses Okpodu, T. Joan Robinson, Michael F. Summers, Maggie Werner-Washburne, and MariaElena Zavala*

Members of the Joint Working Group on Improving Underrepresented Minorities (URMs) Persistence in Science, Technology, Engineering and Mathematics (STEM), utilizing Kurt Lewin's planned approach to change, describe five recommendations to increase URM persistence in STEM at the undergraduate level.

### **Toward Inclusive STEM Classrooms: What Personal Role Do Faculty Play?**

*Tess L. Killpack and Laverne C. Melón*

To broaden participation in science, technology, engineering, and mathematics (STEM), faculty must reflect on how their own privileges, implicit biases, and stereotype threat activation impact their students. This paper synthesizes data and recommends strategies for meaningful reflection and professional development to inspire faculty to create more inclusive STEM classroom climates.

### **Broadening Participation in the Life Sciences with Social–Psychological Interventions**

*Yoi Tibbetts, Judith M. Harackiewicz, Stacy J. Priniski, and Elizabeth A. Canning*

Recent randomized controlled trials have documented the positive effects of social–psychological interventions in improving the performance and retention rates of traditionally underrepresented students in the life sciences. These interventions and the mechanisms through which they operate are reviewed.

## ARTICLES

### **New Measures Assessing Predictors of Academic Persistence for Historically Underrepresented Racial/Ethnic Undergraduates in Science**

*Angela Byars-Winston, Jenna Rogers, Janet Branchaw, Christine Pribbenow, Ryan Hanke, and Christine Pfund*

Using social cognitive career theory and science identity theory, the authors validate new measures assessing persistence-related factors with students from historically underrepresented racial/ethnic groups in science.

### **Science That Matters: The Importance of a Cultural Connection in Underrepresented Students' Science Pursuit**

*Matthew C. Jackson, Gino Galvez, Isidro Landa, Paul Buonora, and Dustin B. Thoman*

A mixed-methods study demonstrates that freshman minority students who enter with a greater belief that science can be used to help their communities identified as scientists more strongly over time and had higher interest in science careers, but this effect was noted only among first-generation college students.

### **Principles and Practices Fostering Inclusive Excellence: Lessons from the Howard Hughes Medical Institute's Capstone Institutions**

*Patricia Marten DiBartolo, Leslie Gregg-Jolly, Deborah Gross, Cathryn A. Manduca, Ellen Iverson, David B. Cooke, III, Gregory K. Davis, Cameron Davidson, Paul E. Hertz, Lisa Hibbard, Shubha K. Ireland, Catherine Mader, Aditi Pai, Shirley Raps, Kathleen Siwicki, and Jim E. Swartz*

This paper describes common elements and assessments of persistence programs at 11 Capstone institutions designated by the Howard Hughes Medical Institute and complements the resources on our companion website. Together, the paper and website provide detail and synthesize principles informed by our experiences in pursuit of inclusive excellence.

### **Increasing URM Undergraduate Student Success through Assessment-Driven Interventions: A Multiyear Study Using Freshman-Level General Biology as a Model System**

*Mary C. Carmichael, Candace St. Clair, Andrea M. Edwards, Peter Barrett, Harris McFerrin, Ian Davenport, Mohamed Awad, Anup Kundu, and Shubha Kale Ireland*

Xavier University of Louisiana leads the nation in awarding BS degrees in the biological sciences to African-American students. In this multiyear study with ~5500 participants, data-driven interventions were adopted to improve student academic performance in a freshman-level general biology class.

### **Scientist Spotlight Homework Assignments Shift Students' Stereotypes of Scientists and Enhance Science Identity in a Diverse Introductory Science Class**

*Jeffrey N. Schinske, Heather Perkins, Amanda Snyder, and Mary Wyer*

The authors evaluated a series of homework assignments featuring counterstereotypical examples of scientists in an introductory biology class. Following the intervention, students exhibited nonstereotypical views of scientists and conveyed an enhanced ability to personally relate to scientists. These shifts correlated with science interest and course grades.

### **Coming Out in Class: Challenges and Benefits of Active Learning in a Biology Classroom for LGBTQIA Students**

*Katelyn M. Cooper and Sara E. Brownell*

Seven students who identified as part of the lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) community from an active-learning biology class were interviewed. It was found that active-learning classrooms present a number of challenges for LGBTQIA students to navigate based on their social identities, but also offer some opportunities to come out to their peers.

### **Situating Second-Year Success: Understanding Second-Year STEM Experiences at a Liberal Arts College**

*Leslie Gregg-Jolly, Jim Swartz, Ellen Iverson, Joyce Stern, Narren Brown, and David Lopatto*

This paper evaluates the development and analysis of programming to support inclusive success of second-year undergraduates. Programming improved success rates of students of color and first-generation students in some intermediate-level gateway courses, but these rates were still lower than those of other students despite evidence of high levels of belonging and support.

### **Active Learning Outside the Classroom: Implementation and Outcomes of Peer-Led Team-Learning Workshops in Introductory Biology**

*Philip Kudish, Robin Shores, Alex McClung, Lisa Smulyan, Elizabeth A. Vallen, and Kathleen K. Siwicki*

Since the implementation of a voluntary peer-led team-learning program in introductory biology courses at a selective liberal arts college, the persistence of students from underrepresented minority (URM) groups as life sciences majors and minors has improved dramatically and is now equal to the persistence rate of non-URM students.

**Broadening Participation of Women and Underrepresented Minorities in STEM through a Hybrid Online Transfer Program**

*Jennifer C. Drew, Sebastian Galindo-Gonzalez, Alexandria N. Ardisson, and Eric W. Triplett*

Development of a new model of a transfer program that blends online learning with face-to-face labs in microbiology significantly broadens participation of women and underrepresented minorities in science, technology, engineering, and mathematics while maintaining retention and academic performance.

**Influences on Faculty Willingness to Mentor Undergraduate Students from Another University as Part of an Interinstitutional Research Training Program**

*Danielle X. Morales, Sara E. Grineski, and Timothy W. Collins*

Faculty who valued the opportunity to increase diversity in the academy and those who believed that mentoring undergraduates benefited their own research expressed greater willingness to serve as research mentors to visiting undergraduates.

**Mentoring for Inclusion: The Impact of Mentoring on Undergraduate Researchers in the Sciences**

*Heather Haeger and Carla Fresquez*

The impact of mentoring strategies within research experiences on broadening access to the life sciences was analyzed by examining both how these experiences impacted student success and how the quality of mentorship affected the development of research and academic skills for a diverse population of students at a public, minority-serving institution.

**Factors Influencing Student Gains from Undergraduate Research Experiences at a Hispanic-Serving Institution**

*Heather Daniels, Sara E. Grineski, Timothy W. Collins, Danielle X. Morales, Osvaldo Morera, and Lourdes Echegoyen*

When factors relevant to student gains from undergraduate research were examined, results revealed that students who reported receiving higher-quality mentorship, spending more hours caring for dependents, and receiving more programmatic resources experienced significantly greater gains in science competency, personal growth, and skills.

**Fine-Tuning Summer Research Programs to Promote Underrepresented Students' Persistence in the STEM Pathway**

*Medeva Ghee, Micere Keels, Deborah Collins, Cynthia Neal-Spence, and Earnestine Baker*

This study documents the impact of Leadership Alliance Summer Research Early Identification Program components on students' research skills knowledge and career pathway planning in relation to student demographic and academic characteristics. These experiences contribute to the ongoing formation of confidence, goals, and motivational behaviors that shape academic/career pursuits.

**Efforts at Broadening Participation in the Sciences: An Examination of the Mentoring Experiences of Students from Underrepresented Groups**

*Amy Prunuske, Janelle Wilson, Melissa Walls, Hannah Marrin, and Benjamin Clarke*

Diversifying the scientific enterprise entails understanding how students from underrepresented backgrounds experience mentored research. Qualitative data were collected from mentees enrolled at community colleges about their research experiences. The themes were compared with previously collected data from mentors associated with the program.

**Outcomes and Processes in the Meyerhoff Scholars Program: STEM PhD Completion, Sense of Community, Perceived Program Benefit, Science Identity, and Research Self-Efficacy**

*Kenneth I. Maton, Tiffany S. Beason, Surbhi Godsay, Mariano R. Sto. Domingo, TaShara C. Bailey, Shuyan Sun, and Freeman A. Hrabowski, III*

Studies found that African-American Meyerhoff Scholars were 4.8 times more likely to complete STEM PhDs than comparison sample students (study 1) and that perceived benefits of program components fully mediated the relationship between sense of community and both science identity and research self-efficacy (study 2).

### **Beyond Academic and Social Integration: Understanding the Impact of a STEM Enrichment Program on the Retention and Degree Attainment of Underrepresented Students**

*Tonisha B. Lane*

This case study investigated how a science, technology, engineering, and mathematics (STEM) enrichment program supported retention and degree attainment of underrepresented students. A model emerged that encompassed four components: proactive care, holistic support, community building, and catalysts for STEM identity development.

### **Preparation of Underrepresented Males for Scientific Careers: A Study of the Dr. John H. Hopps Jr. Defense Research Scholars Program at Morehouse College**

*Rahmelle C. Thompson, Thema Monroe-White, Jeffrey Xavier, Courtney Howell, Myisha Roberson Moore, and J. K. Haynes*

This paper demonstrates the impact of the Hopps Scholars Program on undergraduate academic performance and graduate enrollment of science, technology, engineering, and mathematics (STEM) Morehouse students. The program's focus on academic achievement, coaching and counseling, and consistent exposure to research resulted in persistence outcomes that exceed similarly prepared Morehouse STEM students.

### **Scientific Growth and Identity Development during a Postbaccalaureate Program: Results from a Multisite Qualitative Study**

*Robin Remich, Michelle E. Naffziger-Hirsch, J. Lynn Gazley, and Richard McGee*

This study reveals how Postbaccalaureate Research Education Programs (PREP) enable growth and development among participants along domains of readiness for academics, research, and presentation of themselves as legitimate future scientists. All domains contribute to formation or growth of an identity as a future PhD student and scientist.

### **Preparing Postbaccalaureates for Entry and Success in Biomedical PhD Programs**

*Joshua D. Hall, Jessica R. Harrell, Kimberley W. Cohen, Virginia L. Miller, Patricia V. Phelps, and Jeanette G. Cook*

An intensive, 1-year biomedical training program to support underrepresented scholars during the critical transition from baccalaureate to PhD is described. In 5 years, this program has transitioned 91% of scholars to PhD programs with 95% retention through a combination of skill- and confidence-building interventions.

### **The Benefits of Attending the Annual Biomedical Research Conference for Minority Students (ABRCMS): The Role of Research Confidence**

*Bettina J. Casad, Amy L. Chang, and Christine M. Pribbenow*

Students who attended Annual Biomedical Research Conference for Minority Students (ABRCMS) reported many benefits, including greater research self-efficacy, research confidence, sense of belonging in science, and intentions to pursue a research degree in graduate school. Increase in research confidence predicts graduate school plans and intentions for a research career in science.

### **Psychosocial Pathways to STEM Engagement among Graduate Students in the Life Sciences**

*Sheri L. Clark, Christina Dyar, Nina Maung, and Bonita London*

Perceived support from one's advisor may promote science, technology, engineering, and mathematics (STEM) engagement among women by predicting greater gender-STEM identity compatibility for women, which predicts higher perceived STEM importance, which in turn predicts a higher sense of belonging and increased STEM self-efficacy. The implications of this work for educational policy are described.

**The Dissertation House Model: Doctoral Student Experiences Coping and Writing in a Shared Knowledge Community**

*Wendy Y. Carter-Veale, Renetta G. Tull, Janet C. Rutledge, and Lenisa N. Joseph*

The Dissertation House model provides a voluntary, supplementary professional development activity that expands single-mentor and single-department approaches to create shared learning communities with multiple mentors across several academic disciplines. We find that participating in the Dissertation House increases the likelihood of retention and graduation for PhD candidates.

**Analysis of Postdoctoral Training Outcomes That Broaden Participation in Science Careers**

*Brian J. Rybarczyk, Leslie Lerea, Dawayne Whittington, and Linda Dykstra*

This study about a postdoctoral program presents findings that include research, teaching, and professional development; career outcomes of the postdoctoral scholars; an analysis of factors that predict career outcomes into academic faculty positions; and how the economic downturn of 2008 did not affect these outcomes.

**Diversity Exiting the Academy: Influential Factors for the Career Choice of Well-Represented and Underrepresented Minority Scientists**

*Rebekah L. Layton, Patrick D. Brandt, Ashalla M. Freeman, Jessica R. Harrell, Joshua D. Hall, and Melanie Sinche*

The relative importance of reasons for current career choices for science, technology, engineering, and mathematics PhDs was examined. Reasons why underrepresented minority scientists chose faculty careers differed in some respects from those of well-represented scientists, with implications for graduate/postdoctoral training, formal and informal social support networks, and faculty career decisions.

**Learning to Thrive: Building Diverse Scientists' Access to Community and Resources through the BRAINS Program**

*Cara Margherio, M. Claire Horner-Devine, Sheri J. Y. Mizumori, and Joyce W. Yen*

BRAINS: Broadening the Representation of Academic Investigators in NeuroScience is a national program designed to diversify neuroscience by increasing retention of early-career neuroscientists from underrepresented groups. This paper highlights particular programmatic innovations and discusses recommendations to broaden participation in the life sciences.

**A “Scientific Diversity” Intervention to Reduce Gender Bias in a Sample of Life Scientists**

*Corinne A. Moss-Racusin, Jojanneke van der Toorn, John F. Dovidio, Victoria L. Brescoll, Mark J. Graham, and Jo Handelsman*

A workshop increased awareness of diversity issues, reduced gender bias, and increased readiness to take action on diversity issues from pretest (2 weeks before the intervention) to posttest (2 weeks after the intervention) among a sample of life science instructors.

*On the Cover*

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