

**Promising Practices for Addressing the  
Underrepresentation of Women in  
Science, Engineering, and Medicine**

OPENING DOORS

**SUMMARY**

Rita Colwell, Ashley Bear, and Alex Helman, *Editors*

Committee on Increasing the Number of Women in Science,  
Technology, Engineering, Mathematics, and Medicine (STEMM)

Committee on Women in Science, Engineering, and Medicine

Policy and Global Affairs

A Consensus Study Report of

*The National Academies of*

SCIENCES • ENGINEERING • MEDICINE

THE NATIONAL ACADEMIES PRESS

*Washington, DC*

[www.nap.edu](http://www.nap.edu)

**THE NATIONAL ACADEMIES PRESS 500 Fifth Street, NW Washington, DC 20001**

This activity was supported by contracts between the National Academy of Sciences and The National Institutes of Health (#10004234), the National Science Foundation (#10003816), and L'Oreal USA. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project.

International Standard Book Number-13: 978-0-309-49824-1

International Standard Book Number-10: 0-309-49824-4

Digital Object Identifier: <https://doi.org/10.17226/25585>

Library of Congress Control Number: 2020933491

Additional copies of this Summary are available in limited quantities from Policy and Global Affairs, 500 Fifth Street, NW, Washington, DC 20001.

Copies of *Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine: Opening Doors*, from which this Summary was extracted, are available from the National Academies Press, 500 Fifth Street, NW, Keck 360, Washington, DC 20001; (800) 624-6242 or (202) 334-3313; <http://www.nap.edu>.

Copyright 2020 by the National Academy of Sciences. All rights reserved.

Printed in the United States of America

Suggested citation: National Academies of Sciences, Engineering, and Medicine. 2020. *Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine: Opening Doors*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25585>.

*The National Academies of*  
SCIENCES • ENGINEERING • MEDICINE

The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, nongovernmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

The **National Academy of Engineering** was established in 1964 under the charter of the National Academy of Sciences to bring the practices of engineering to advising the nation. Members are elected by their peers for extraordinary contributions to engineering. Dr. John L. Anderson is president.

The **National Academy of Medicine** (formerly the Institute of Medicine) was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected by their peers for distinguished contributions to medicine and health. Dr. Victor J. Dzau is president.

The three Academies work together as the **National Academies of Sciences, Engineering, and Medicine** to provide independent, objective analysis and advice to the nation and conduct other activities to solve complex problems and inform public policy decisions. The National Academies also encourage education and research, recognize outstanding contributions to knowledge, and increase public understanding in matters of science, engineering, and medicine.

Learn more about the National Academies of Sciences, Engineering, and Medicine at [www.nationalacademies.org](http://www.nationalacademies.org).

*The National Academies of*  
SCIENCES • ENGINEERING • MEDICINE

**Consensus Study Reports** published by the National Academies of Sciences, Engineering, and Medicine document the evidence-based consensus on the study's statement of task by an authoring committee of experts. Reports typically include findings, conclusions, and recommendations based on information gathered by the committee and the committee's deliberations. Each report has been subjected to a rigorous and independent peer-review process and it represents the position of the National Academies on the statement of task.

**Proceedings** published by the National Academies of Sciences, Engineering, and Medicine chronicle the presentations and discussions at a workshop, symposium, or other event convened by the National Academies. The statements and opinions contained in proceedings are those of the participants and are not endorsed by other participants, the planning committee, or the National Academies.

For information about other products and activities of the National Academies, please visit [www.nationalacademies.org/about/whatwedo](http://www.nationalacademies.org/about/whatwedo).

**COMMITTEE ON INCREASING THE NUMBER OF  
WOMEN IN SCIENCE, TECHNOLOGY, ENGINEERING,  
MATHEMATICS, AND MEDICINE (STEMM)<sup>1</sup>**

**[December 11, 2019 - March 31, 2020]**

**RITA COLWELL, Ph.D. (Chair)** [NAS],<sup>2</sup> Distinguished University Professor, University of Maryland at College Park and Johns Hopkins University Bloomberg School of Public Health; former Director, National Science Foundation; former Chair, National Academies Committee on Women in Sciences, Engineering, and Medicine

**GILDA A. BARABINO, Ph.D.** [NAE], Daniel and Frances Berg Professor and Dean, The Grove School of Engineering, The City College of New York; current member, National Academies Committee on Women in Sciences, Engineering, and Medicine

**MAY R. BERENBAUM, Ph.D.** [NAS], Swanlund Professor of Entomology, University of Illinois at Urbana-Champaign; Editor-in-Chief, Proceedings of the National Academy of Sciences of the United States of America; current member, National Academies Committee on Women in Sciences, Engineering, and Medicine

**VIVIAN W. PINN, M.D.** [NAM], Founding Director (retired), Office of Research on Women's Health, National Institutes of Health; former member, National Academies Committee on Women in Sciences, Engineering, and Medicine

**BILLY WILLIAMS, M.S.**, Vice President for Ethics, Diversity, and Inclusion, American Geophysical Union

*Study Staff*

**ASHLEY BEAR, Ph.D.**, Study Director, Senior Program Officer, Committee on Women in Science, Engineering, and Medicine

**ALEX HELMAN, Ph.D.**, Program Officer, Committee on Women in Science, Engineering, and Medicine

**THOMAS RUDIN, M.S.**, Director, Committee on Women in Science, Engineering, and Medicine

**ARIELLE BAKER, Ph.D.**, Associate Program Officer, Committee on Women in Science, Engineering, and Medicine

---

<sup>1</sup> The Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) and the National Academies of Sciences, Engineering, and Medicine (NASEM) are solely responsible for the final content of the report.

<sup>2</sup> Designates membership in the National Academy of Sciences (NAS), National Academy of Engineering (NAE), or National Academy of Medicine (NAM).

**MARQUITA WHITING**, Senior Program Assistant, Committee on Women in Science, Engineering, and Medicine  
**ADRIANA COUREMBIS**, Financial Officer, Committee on Women in Science, Engineering, and Medicine  
**LAYNE SCHERER, M.P.P.**, Senior Program Officer, Board on Higher Education and Workforce  
**LIDA BENINSON, Ph.D.**, Senior Program Officer, Board on Higher Education and Workforce  
**FRAZIER BENYA, Ph.D.**, Senior Program Officer, Committee on Women in Science, Engineering, and Medicine  
**MARIA LUND DAHLBERG, M.S.**, Program Officer, Committee on Women in Science, Engineering, and Medicine  
**IRENE NGUN, M.S.**, Associate Program Officer, Committee on Women in Science, Engineering, and Medicine  
**AUSTEN APPELEGATE**, Research Associate, Board on Higher Education and Workforce

*Consultants*

**JENNIFER SAUNDERS, Ph.D.**, Writer and Rapporteur  
**MICHELLE RODRIGUES, Ph.D.**, Postdoctoral Fellow, University of Illinois  
**KATHRYN CLANCY, Ph.D.**, Associate Professor of Anthropology, University of Illinois  
**EVAVA PIETRI, Ph.D.**, Assistant Professor, Indiana University–Purdue University Indianapolis  
**CORINNE MOSS-RACUSIN, Ph.D.**, Associate Professor, Skidmore College  
**LESLIE ASHBURN-NARDO, Ph.D.**, Associate Professor, Indiana University–Purdue University Indianapolis  
**JOJANNEKE VAN DER TOORN, Ph.D.**, Professor, Leiden University  
**CHRISTINE LINDQUIST, Ph.D.**, RTI International  
**TASSEL McCAY, M.P.H.**, Social Science Researcher, Division of Applied Justice Research, RTI International

**COMMITTEE ON UNDERSTANDING AND ADDRESSING THE  
UNDERREPRESENTATION OF WOMEN IN PARTICULAR  
SCIENCE AND ENGINEERING DISCIPLINES<sup>1</sup>**

**(October 5, 2018 - December 10, 2019)**

- MAE JEMISON, M.D., (Chair)** [NAM],<sup>2</sup> President and Founder the Jemison Group, Inc., Principal, 100 Year Starship
- DIANA BILIMORIA, Ph.D.**, KeyBank Professor and Chair, Department of Organizational Behavior, Case Western Reserve University
- JOHN C. BOOTHROYD, Ph.D.**, (NAS), Burt and Marion Avery Professor of Immunology, Department of Microbiology and Immunology, and Associate Vice Provost for Graduate Education and Postdoctoral Affairs, Stanford University
- PHYLLIS L. CARR, M.D.**, Associate Professor of Medicine, Harvard Medical School, and Physician in the Women’s Health Associates, Massachusetts General Hospital
- SAPNA CHERYAN, Ph.D.**, Professor, Department of Psychology, University of Washington
- JAIME CURTIS-FISK, Ph.D.**, Scientist, The Dow Chemical Company
- ELENA FUENTES-AFFLICK, MD, MPH** (NAM), Professor of Pediatrics and Vice Dean for Academic Affairs, University of California, San Francisco (*resigned November 2019*)
- IRENE FONSECA, Ph.D.**, Kavčić-Moura University Professor of Mathematics, Carnegie Mellon University
- ANN Q. GATES, Ph.D.**, Professor and Chair, Department of Computer Science, The University of Texas at El Paso
- KELLY M. MACK, Ph.D.**, Vice President for Undergraduate STEM Education, Executive Director, Project Kaleidoscope, Association of American Colleges and Universities
- RONKE OLABISI, Ph.D.**, Assistant Professor, Samueli Faculty Development Chair, Department of Biomedical Engineering, University of California, Irvine
- PATRICIA RANKIN, Ph.D.**, Professor of Physics, Department of Physics, University of Colorado, Boulder

---

<sup>1</sup> The members of the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines contributed actively to the content of the report from October 5, 2018, to December 10, 2019, and deserve special recognition for their substantial intellectual contributions. They are not responsible for the content of this report, including the findings and recommendations.

<sup>2</sup> Designates membership in the National Academy of Sciences (NAS), National Academy of Engineering (NAE), or National Academy of Medicine (NAM).

**KEIVAN G. STASSUN, Ph.D.**, Stevenson Professor of Physics & Astronomy, Professor of Computer Science, and Director of the Frist Center for Autism & Innovation at Vanderbilt University

**DENISE SEKAQUAPTEWA, Ph.D.**, University Diversity and Social Transformation Professor of Psychology, University of Michigan

**SONYA T. SMITH, Ph.D.**, President-elect Sigma Xi: The Scientific Research Honor Society, and Professor, Department of Mechanical Engineering, Howard University

**STEVEN J. SPENCER, Ph.D.**, Robert K. and Dale J. Weary Chair, Social Psychology, Ohio State University

**ABIGAIL J. STEWART, Ph.D.**, Sandra Schwartz Tangri Distinguished Professor of Psychology and Women's Studies, University of Michigan-Ann Arbor

### *Study Staff*

**MARILYN BAKER**, Study Director (October 2019-December 2019)

**ASHLEY BEAR, Ph.D.**, Study Director (October 2018-September 2019), Senior Program Officer, Committee on Women in Science, Engineering, and Medicine

**ALEX HELMAN, Ph.D.**, Program Officer, Committee on Women in Science, Engineering, and Medicine

**THOMAS RUDIN, M.S.**, Director, Committee on Women in Science, Engineering, and Medicine

**ARIELLE BAKER, Ph.D.**, Associate Program Officer, Committee on Women in Science, Engineering, and Medicine

**MARQUITA WHITING**, Senior Program Assistant, Committee on Women in Science, Engineering, and Medicine

**JOHN VERAS**, Senior Program Assistant, Board on Higher Education and Workforce

**ADRIANA COUREMBIS**, Financial Officer, Committee on Women in Science, Engineering, and Medicine

### *Consultants*

**KATHLEEN COLGAN, Ph.D.**, Writer

**JENNIFER SAUNDERS, Ph.D.**, Writer and Rapporteur

**MICHELLE RODRIGUES, Ph.D.**, Postdoctoral Fellow, University of Illinois

**KATHRYN CLANCY, Ph.D.**, Associate Professor of Anthropology, University of Illinois

**EVAVA PIETRI, Ph.D.**, Assistant Professor, Indiana University-Purdue University Indianapolis

**CORINNE MOSS-RACUSIN, Ph.D.**, Associate Professor, Skidmore College



**LESLIE ASHBURN-NARDO, Ph.D.**, Associate Professor, Indiana  
University–Purdue University Indianapolis  
**JOJANNEKE VAN DER TOORN, Ph.D.**, Professor, Leiden University  
**CHRISTINE LINDQUIST, Ph.D.**, RTI International  
**TASSELi McCAY, M.P.H.**, Social Science Researcher, Division of Applied  
Justice Research, RTI International



*“I hadn’t been aware that there were doors closed to me until I started knocking on them.”*

Gertrude B. Elion, 1988 Nobel Laureate in Physiology and Medicine



# Preface

In the 21st century, the fields of science, engineering, and medicine contribute significantly to supporting and advancing our nation's security, prosperity, and health. However, scientific discoveries, engineering innovations, and medical advances don't appear out of thin air; they arise from the passion, ingenuity, and hard work of dedicated individuals. To meet the challenges of today, and of those yet to come, full and productive engagement of all members of society is critical.

Unfortunately, many fields of science, engineering, and medicine continue to face a formidable shortage of talent, and women—who make up more than 50 percent of the population—are significantly underrepresented in these fields. Although the number of women pursuing education and careers in science, technology, engineering, mathematics, and medicine (STEMM) has increased in many STEMM fields, and has even reached parity in some of those fields, representation of women in STEMM is a persistent challenge. Women of color are severely underrepresented in every STEMM discipline. Notably, women are underrepresented in engineering, computer science, and physics and at every level. In those fields in which women are at parity among degree earners and early career professionals, such as medicine, they are underrepresented in senior leadership positions.

The data on underrepresentation of women in STEMM and personal stories of the adverse effects of bias, discrimination, and harassment in the scientific enterprise, underline the fact that there is much that needs to be done to improve recruitment, retention, and advancement of women in STEMM. There is reason for optimism to expect that positive change is possible. It is critical for us all to consider the lessons learned from the scholarly research presented in this report and to take note of the many success stories that are described, demonstrating

that an intentional, evidence-based approach in implementing concrete policies, programs, and interventions can yield an incredibly positive impact in a relatively short period of time.

In my career I have had the privilege of considering this issue from many different perspectives: as a scientist, as the leader of a federal agency, as the leader of a scientific institute, as an advisor to government and nonprofit organizations, and, now, as the chair of this study. I come away from these experiences with a strong conviction that the challenge of realizing a more diverse, equitable, and inclusive science, engineering, and medical enterprise can be met with great success, if all stakeholders share the passion, will, and perseverance to achieve positive change.

Rita Colwell, *Chair*

## Special Acknowledgment

This report is the culmination of the work of two committees: the Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) [Rita Colwell, Chair] and the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines (Mae Jemison, Chair). The Committee on Understanding Underrepresentation contributed actively to the report's content from October 5, 2018, to December 10, 2019, and the Committee on Increasing Women in STEMM contributed actively to the report's content starting on December 11, 2019, through its review, completion, and publication.

Members of the Committee on Understanding Underrepresentation made substantial intellectual contributions to this report. They are not, however, responsible for the content of this report, including the findings and recommendations. The Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) and the National Academies of Sciences, Engineering, and Medicine (the National Academies) are solely responsible for the final content of the report.





## Committee Acknowledgments

This committee would like to thank the members of the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines for their diligent work and the substantial intellectual contributions they made to this report. Those committee members analyzed the data on the status of women in multiple STEM disciplines, documented factors contributing to the persistence of women's underrepresentation despite decades of efforts to mitigate it, and presented examples of the intentional and unintentional resistance that women face at many levels. They also identified effective intervention programs, provided insights into the importance of institutional context in implementing successful programs, and proposed actions to increase the participation of women and girls in STEM.

In preparing this report, we drew from the full range of resources that had been assembled for the project, including a significant existing research base, recommendations from previous National Academies reports, three individually authored papers commissioned by the National Academies, existing data sets, and substantial background research and writing by the project staff. We also examined new research and conducted our own analysis, drawing on the evidence and the expertise of committee members. In addition, the report builds significantly on the ideas, interpretations of the research, and conclusions of the members of the Committee on Understanding the Underrepresentation of Women. Their analyses are used extensively in the discussions of data and conclusions from the commissioned research papers in Chapters 2 and 3. Also, many of the strategies to implement changes in academic recruitment, retention, and advancement in Chapter 4—which presents 17 practical strategies for higher education institutions to implement change—are strategies articulated by that committee, whom we gratefully acknowledge.

The committee would also like to acknowledge the work of the consultants who have contributed to the report: Jennifer Saunders, Michelle Rodrigues, Kathryn Clancy, Evava Pietre, Corinne Moss-Racusin, Leslie Ashburn-Nardo, Jojanneke Van Der Toorn, Christine Lindquist, and Tasseli McCay. Their commissioned research and writing contributed substantially to the foundation of evidence presented in the report.

We want also to sincerely thank the staff of this project for their valuable leadership and guidance and for the extensive research and writing activities they undertook in support of the study through their work with both committees. Specifically, we would like to thank Ashley Bear, Alex Helman, and Tom Rudin.

Next, we thank the reviewers of the report. This Consensus Study Report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published report as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their review of this report: Molly Carnes, University of Wisconsin; Gabriele González, Louisiana State University; Eve Higginbotham, University of Pennsylvania; Stacie Furst Holloway, University of Cincinnati; Charles Isbell, Georgia Institute of Technology; Anne-Marie Nunez, Ohio State University; Claire Parkinson, NASA Goddard Space Flight Center; Charles Phelps, University of Rochester (Emeritus); Julia Phillips, Sandia National Laboratories (Retired); and Joan Reede, Harvard Medical School.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report nor did they see the final draft before its release. The review of this report was overseen by Maryellen Giger, University of Chicago, and Catherine Kling, Cornell University. They were responsible for making certain that an independent examination of this report was carried out in accordance with the standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authoring committee and the National Academies.

Finally, the committee would like to thank the sponsors that made this study possible: the National Institutes of Health, the National Science Foundation, and L'Oréal USA.

# Table of Contents

OVERVIEW	1
SUMMARY	3
The Task, 4	
Conclusions, 4	
The Important Role of Public Policy, 6	
Recommendations, 6	
I. Driving Transparency and Accountability, 7	
II. Targeted, Data-Driven Interventions by Colleges and Universities, 10	
III. Prioritize, Recognize, Reward, and Resource, 17	
IV. Filling Knowledge Gaps, 19	

**The contents of the entire Consensus Study Report,  
from which this Summary is extracted, are listed below.**

1	AN INTRODUCTION TO THE PROBLEM OF GENDER INEQUITIES IN U.S. STEMM FIELDS	21
	Study Approach, 32	
2	FACTORS THAT DRIVE THE UNDERREPRESENTATION OF WOMEN IN SCIENTIFIC, ENGINEERING, AND MEDICAL DISCIPLINES	37
	Barriers to Women’s Progress, 38	
	Common Dynamics Across STEMM Fields, 39	

Intersectionality and the Double Bind, 47	
Differences Across STEMM Fields, 57	
Conclusion: Systemic Issues in STEMM Culture, 69	
Findings: Chapter 2, 69	
<b>3 EDUCATIONAL INTERVENTIONS TO IMPROVE RECRUITMENT AND RETENTION</b>	<b>73</b>
Educational Interventions in STEMM Classrooms, 74	
The Importance of Role Models, 83	
Creating Inclusive Relationships Through Mentoring, 85	
Male Allies, 89	
Findings: Chapter 3, 89	
<b>4 EFFECTIVE PRACTICES FOR ADDRESSING GENDER DISPARITY IN RECRUITMENT, ADVANCEMENT, AND RETENTION IN STEMM</b>	<b>91</b>
Acknowledgement of Research Limitations, 91	
What Works to Improve Recruitment, 93	
What Works to Improve Advancement, 102	
What Works to Improve Retention and Organizational Climate, 107	
Findings: Chapter 4, 117	
<b>5 OVERCOMING BARRIERS TO IMPLEMENTATION</b>	<b>121</b>
Committed, Sustained Leadership, 122	
Dedicated Financial and Human Resources, 126	
Understanding Institutional Context, 129	
Data Collection for Accountability and Targeted Intervention, 130	
Ensuring that All Women Benefit from Equity and Diversity Efforts by Accounting for Intersectionality, 136	
Findings: Chapter 5, 141	
<b>6 RECOMMENDATIONS</b>	<b>145</b>
Recommendations, 146	
I. Driving Transparency and Accountability, 147	
II. Targeted, Data-Driven Interventions by Colleges and Universities, 151	
III. Prioritize, Recognize, Reward, and Resource, 158	
IV. Filling Knowledge Gaps, 160	
<b>REFERENCES</b>	<b>167</b>
<b>APPENDIX A</b>	<b>197</b>
<b>APPENDIX B</b>	<b>205</b>

# Overview

In recent years, the absolute number of women earning degrees across science, technology, engineering, mathematics, and medicine (STEMM) fields has increased relative to men. Despite these gains, women—especially women of color—remain underrepresented with respect to their presence in the workforce and the U.S. population. The disparities in representation vary by discipline and field, yet even in professions in which women are at parity or overrepresented, as is the case in certain sub-disciplines within biology and medicine, there remains a dearth of women among the senior ranks.

This report reviews the current state of knowledge of factors that drive underrepresentation of women in STEMM and provides an overview of existing research on policies, practices, programs, and interventions for improving recruitment, retention, and advancement of women in these fields. The report also evaluates why promising practices have not been implemented by a greater number of institutions. Importantly, the focus of this report is not on “fixing the women,” but rather on promoting systemic change in the STEMM enterprise in an effort to mitigate structural inequities, bias, discrimination, and harassment that a substantial body of literature demonstrates significantly undermines the education and careers of women in STEMM.

While several National Academies reports have addressed underrepresentation of women in STEMM fields (see Appendix B for an overview of findings and recommendations from previous National Academies reports), this report distinguishes itself by placing emphasis on the experiences of women of color and women from other marginalized groups who experience intensified biases and barriers. Moreover, the report highlights those shared and distinct barriers faced by women in STEMM disciplines—engineering, computer science, physics,

biology, medicine, mathematics, and chemistry—in order to clarify why national patterns of underrepresentation differ according to discipline.

To address specific barriers, the committee obtained evidence of the efficacy of a diversity of strategies and practices that institutions can adopt to improve recruitment, retention, and advancement of primarily White women across a broad range of STEMM disciplines and multiple stages of the educational and career paths. The committee concluded that additional investigation is needed to understand how to support most effectively the participation of women of color and women of other intersecting identities in STEMM and understand better the impact of promising practices on women studying and working in a greater range of institutional contexts (e.g., minority-serving institutions, community colleges).

Research accomplished to date points to a common set of conditions that support institutional adoption of practices to improve recruitment, retention, and advancement of women in STEMM. These include: (1) committed leadership at all levels; (2) dedicated financial and human resources; (3) a deep understanding of institutional context; (4) accountability and data collection—especially as a tool to inform and incentivize progress; and (5) adoption of an intersectional approach that explicitly addresses challenges faced by women of color and other groups who encounter multiple, cumulative forms of bias and discrimination.

Based on analysis of existing evidence, the report offers to a range of stakeholders—Congress, federal agencies, faculty and administrators in higher education, and professional societies—a set of actionable recommendations on how to drive systemic change in STEMM education and careers. The recommendations are intended to work synergistically to incentivize and inform broad adoption of evidence-based promising practices for improving recruitment, retention, and advancement of women in STEMM. Specifically, the nine recommendations and their associated implementation actions support a process by which data-driven accountability, committed leadership, and tangible rewards, resources, and recognition for equity and diversity efforts drive an iterative cycle that comprises four steps: (1) an institution, school, or department collects, analyzes, and monitors quantitative and qualitative data to diagnose issues specific to recruitment, retention, and advancement of both White women and women of color; (2) institutional leaders take action to address shortcomings at the program, school, or department level by drawing upon existing research findings and practices suitable to adopt or adapt for a targeted, evidence-based approach; (3) institution, school, or department repeats the data collection and monitoring to determine whether the intervention has been effective or a new approach is needed; and (4) leaders formally institutionalize effective practices by changes in policy to sustain modification of leadership, budget, and other disruptors with the potential to undermine sustainability.

The research reviewed in this report provides a strong foundation for institutional action to improve recruitment, retention, and advancement of women in STEMM fields.

# Summary

Careers in science, engineering, technology, mathematics, and medicine (STEMM) offer opportunities to advance knowledge, contribute to the well-being of communities, and support the security, prosperity, and health of the United States. Many women, however, do not pursue or persist in these careers or advance to leadership positions. The bulk of evidence indicates that underrepresentation of women in STEMM—including at leadership levels—is driven by a wide range of structural, cultural, and institutional patterns of bias, discrimination, and inequity that do not affect men of comparable ability and training.

To date, there have been seven National Academies reports published over the past two decades that have addressed causes and consequences of the underrepresentation of women in science, engineering, and medicine. Among those consequences are:

- (1) A national labor shortage in many science, engineering, and medical professions, particularly in technical fields, that cannot be filled unless institutions and organizations recruit from a broad and diverse talent pool.
- (2) Lost opportunities for innovation and economic gain, particularly since research shows that more diverse teams generate more innovative solutions to problems, publish higher impact articles, and raise a company's bottom line. In other words, there are opportunity costs to perpetuating a scientific workforce that lacks diversity.
- (3) Lost talent as a result of discrimination, unconscious bias, and sexual harassment, which often prevents women from pursuing careers in science, engineering, and medicine.

In this report, which is based on an analysis of current research, the committee provides a range of stakeholders with actionable recommendations on how to take coordinated action to drive necessary changes to the system of science, engineering, and medical education, research, and employment. The committee's recommendations are not aimed at "fixing the women," but instead focus on changing the culture through systemic actions. To do so will require the men and women in Congress, the White House, federal funding agencies (particularly the National Institutes of Health and the National Science Foundation), colleges and universities, and professional societies to approach this issue armed with a heightened sense of urgency and an evidence-based strategy for action.

This report aims to provide both.

### THE TASK

The committee was tasked by the National Institutes of Health, the National Science Foundation, and L'Oreal USA to do three things: (1) carry out an analysis and synthesis of the current research on the factors that drive gender disparities in recruitment, retention, and advancement across a range of scientific, engineering, and medical disciplines and throughout the educational and career life course; (2) review the research on evidence-based strategies and practices that research has shown can improve the recruitment, retention, and advancement of women in these fields, with a particular emphasis on improving the representation and inclusion of women of color; and (3) an exploration of why effective interventions have not been scaled up or adopted by more institutions.

In short, the report addresses four questions:

- (1) What is the problem? (Chapters 1 and 2)
- (2) What are possible solutions? (Chapters 3 and 4)
- (3) Why don't we see more progress? (Chapter 5)
- (4) What can be done to open doors for women in STEMM? (Recommendations) (Chapter 6)

See Chapter 1 for the full statement of task.

### CONCLUSIONS

The committee reached six major conclusions, which are supported by the findings that appear at the end of each chapter in the report.

**Conclusion 1:** Although the absolute number of women earning degrees across science, engineering, and medical fields has increased in recent years, women—especially women of color—are underrepresented relative to their presence in the workforce and the U.S. population. National patterns of underrepresentation vary by career stage, race and ethnicity, and discipline.



**Conclusion 2:** Bias, discrimination, and harassment are major drivers of the underrepresentation of women in science, engineering, and medicine; they are often experienced more overtly and intensely by women of intersecting identities (e.g., women of color, women with disabilities, LGBTQIA<sup>1</sup> women).

**Conclusion 3:** While some institutions have seen improvements in the representation of women in science, engineering, and medical education and careers, national patterns of underrepresentation are still prevalent at most institutions, especially for women of color.

**Conclusion 4:** There are numerous effective, evidence-based strategies and practices that institutions can adopt to improve the recruitment, retention, and advancement of White women across a broad range of scientific, engineering, and medical disciplines and multiple stages of the educational and career pathway. However, additional investigation is needed specifically to understand how to support more effectively the participation of women of color and women of other intersecting identities in science, engineering, and medicine.

**Conclusion 5:** Improving recruitment and retention of women in STEMM throughout their education and training is important, particularly in mathematics-intensive fields such as computer science and engineering. Educational strategies that challenge stereotypes about the essential attributes of a successful STEMM professional and about the nature of work in STEMM can increase interest, improve performance, and instill a sense of belonging in these fields among White women, women of color, and other underrepresented groups (e.g., first-generation college students and men of color).

**Conclusion 6:** Both research literature and the findings of focus groups that were carried out by the independent nonprofit research institute RTI International on behalf of this study point to a common set of conditions that support institutional adoption of practices to improve the recruitment, retention, and advancement of women, including:

- Committed leadership at all levels, especially from those in positions of authority (such as policy makers, college and university presidents and deans, and individual faculty that manage training programs and large laboratories) who can implement, allocate resources toward, and monitor progress on new policies and strategies that close the gender gap.
- Dedicated financial and human resources—including new or re-directed funds and appropriately compensated individuals in positions of power and authority whose work is dedicated toward opening doors to opportunity and success for women.

---

<sup>1</sup> Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, and Asexual.

- Accountability and data collection—especially when used as a tool to inform and incentivize progress.
- Adoption of an intersectional approach that explicitly and concretely addresses the challenges faced by women of color and other groups who encounter multiple, cumulative forms of bias and discrimination.

## THE IMPORTANT ROLE OF PUBLIC POLICY

This report has multiple audiences because underrepresentation of women in STEMM is a systemic problem that must be addressed by many actors and across many levels. However, the committee has placed significant emphasis in this report on policy change. Congress, the White House, and government agencies have both the capacity and the obligation to assume an important catalytic role in incentivizing the creation and implementation of policies, programs, and strategies to mitigate the biases and barriers currently undermining the recruitment, retention, and advancement of women in science, engineering, and medicine. Accordingly, although much of the leadership responsibility falls on faculty and administrators in the nation's colleges and universities to remedy inequities within the academic community, *the policy community has powerful levers to encourage innovation and action.*

The committee's recommendations offer guidance to leaders from multiple sectors on how to move forward with intentional, evidence-based strategies and policies to improve recruitment, retention, and advancement of women in science, engineering, and medicine and thereby significantly enhance national prosperity, security, and well-being.

## RECOMMENDATIONS

The committee's recommendations are grouped into four broad categories, which are targeted at incentivizing and informing the broad adoption of evidence-based promising practices for improving the recruitment, retention, and advancement of women in science, engineering, and medicine:

1. **Driving transparency and accountability.** Institutions must articulate and deliver on measurable goals and benchmarks that are regularly monitored and publicly reported. Multiple studies have demonstrated that transparency and accountability can drive behavior change.
2. **Adopting data-driven approaches to address underrepresentation of women in STEMM.** The committee recommends a targeted data-driven approach to closing the gender gap in science, engineering, and medicine. Such an approach includes, for example, dissecting the barriers by discipline and career stage, recognizing explicitly that interventions and

strategies that generally work well for White women may not work well for women of color and, in addition, using disaggregated data collection, analysis, and monitoring as the basis for constructing specific interventions within the unique context of each institution.

3. **Rewarding, recognizing, and resourcing equity, diversity, and inclusion efforts.** Equity, diversity, and inclusion efforts by institutions are often hindered by a lack of sufficient resources and by the expectation that individuals, particularly women and men of color, who are most affected by these issues, will assume a leadership role in promoting positive change without appropriate compensation, authority, or promise of reward or recognition.
4. **Filling knowledge gaps.** Although scholarly research on gender disparities in science, engineering, and medicine has yielded an abundance of information that can be applied toward reaching gender equity, there are critical knowledge gaps that require closer attention.

These four broad categories are not, in fact, distinct, but rather are fundamentally interconnected components of a complex system of actors, incentives, and information. Drivers of transparency and accountability yield new information that can inform targeted, data-driven interventions, while at the same time providing incentives for greater resource allocation toward equity, diversity, and inclusion. The committee contends that the interconnectedness of these recommendations underlies their strength. This is not to say that individual recommendations, if implemented by stakeholders, cannot have a tangible impact, but that systemic change is needed to effect rapid change on this issue and is suited to a systemic approach.

In addition to high-level recommendations, for each recommendation the committee offers a series of implementation actions designed to provide stakeholders with specific practical advice. In many instances, the committee intentionally developed these implementation actions so that they can take advantage of existing infrastructure and activities and modify them in specific ways to facilitate execution of the recommendations.

## I. DRIVING TRANSPARENCY AND ACCOUNTABILITY

The legislative and executive branches of the federal government have the power to serve as drivers of transparency and accountability in the scientific, engineering, and medical enterprise. In Chapter 5, the committee found that transparency and accountability are critical levers for driving positive change in equity and diversity efforts. Therefore, the committee recommends several actions that can increase public transparency and accountability so that the nature,

extent, and impact of federal agency and university efforts will ensure equity, diversity, and inclusion in the scientific, engineering, and medical workforce. In addition to increasing transparency and accountability, these recommendations serve other functions. For example, if implemented with fidelity, the recommendations can highlight the extent to which each federal agency makes equity, diversity, and inclusion a priority by documenting the qualitative and quantitative impact of their efforts.

**RECOMMENDATION 1: The legislative and executive branches of the U.S. government should work together to increase transparency and accountability among federal agencies by requiring data collection, analysis, and reporting on the nature, impact, and degree of investment in efforts to improve the recruitment, retention, and advancement of women in STEMM, with an emphasis on existing efforts that take an intersectional approach.**

### **Implementation Actions**

**Action 1-A:** The director of the White House Office of Science and Technology Policy, in collaboration with the National Institutes of Health (NIH) and National Science Foundation (NSF) co-chairs of the Subcommittee on Safe and Inclusive Research Environments of the Joint Committee on the Research Environment, should annually catalog, evaluate, and compare the various efforts by the federal science agencies to broadly support the recruitment, retention, and advancement of women in science, engineering, and medicine. The director should task the subcommittee with publishing an annual, open-access report, modeled after NSF's summary table on programs to broaden participation in their annual budget request to Congress, that documents existing programs at each agency, with particular emphasis on programs that take an intersectional approach, accounting for the experiences of women of color and women of other intersecting identities (e.g., women with disabilities, LGBTQIA), and the qualitative and quantitative impact of these programs, using program evaluation metrics and data, when collected.<sup>2</sup>

**Action 1-B:** Congress should commission a study by an independent entity, such as the Government Accountability Office, to offer an external evaluation and review of the existing federal programs focused on supporting greater equity, diversity, and inclusion in science, engineering, and medicine. Such a study should result in a publication that documents the nature, impact across

---

<sup>2</sup> The committee recognizes that programs will have different metrics of success, depending on what the goals of the program are and that direct comparison of programs across agencies will not be possible. However, the evaluation will examine the data collected on the outcomes of the programs included and the extent to which the program met its goals.

various groups, and prioritization of these programs, as described above, across federal agencies.

**RECOMMENDATION 2: Federal agencies should hold grantee institutions accountable for adopting effective practices to address gender disparities in recruitment, retention, and advancement and carry out regular data collection to monitor progress.**

### **Implementation Actions**

**Action 2-A:** Federal funding agencies should carry out an “equity audit” for grantee institutions that have received a substantial amount of funding over a long period of time to ensure that the institution is working in good faith to address gender and racial disparities in recruitment, retention, and advancement. Institutions could be electronically flagged by the funding agency for an equity audit after a certain length of funding period is reached. An evaluation of the representation of women among leadership should be included in such an audit. Equity audits should include a statement from institutions to account for the particular institutional context, geography, resource limitations, and mission and hold that institution accountable within this context. It should also account for progress over time in improving the representation and experiences of under-represented groups in science, engineering, and medicine and should indicate remedial or other planned actions to improve the findings of the audit. The equity audit should result in a public facing report that will be available on the agency’s website.

**Action 2-B:** Federal agencies should consider institutional and individual researchers’ efforts to support greater equity, diversity, and inclusion as part of the proposal compliance, review, and award process. To reduce additional administrative burdens, agencies should work within existing proposal requirements to accomplish this goal. For example, NSF should revise the guidance to grantees on NSF’s “Broader Impact” statements, and NIH should revise the guidance to grantees on the “Significance” section in the research plan to include an explicit statement on efforts by the prospective grantee and/or institution to promote greater equity, diversity, and inclusion in science, engineering, and medicine. While many grantees currently describe equity, diversity, and inclusion efforts as part of these sections of NSF and NIH proposals, historically, these sections of the proposals have served, first and foremost, to document the societal impact of the research (e.g. addressing climate change, curing cancer, etc.). The latter function of these sections of the proposal is critical and should not be replaced by the description of equity, diversity, and inclusion efforts. Rather this section of the proposal should be expanded to include commentary on *both* of these critical components of federally funded research. Moreover, these sections of

proposals should be scored and taken seriously in funding recommendations by review panels and funding decisions by agency personnel. If such sections of proposals are given different consideration by different institutes, departments, and directorates, effort should be made to standardize the weight given to these sections of the proposal across the agency. For example, the National Science Board could carry out a review of past NSF awards to determine how the NSF Directorates have accounted for gender equity, diversity, and inclusion among the metrics evaluated in proposals submitted to NSF.

## **II. TARGETED, DATA-DRIVEN INTERVENTIONS BY COLLEGES AND UNIVERSITIES<sup>3</sup>**

In many ways, the recommendations in this section represent the most direct action items of this report. These recommendations are based on the committee's comprehensive analysis of data on specific strategies and best practices that can improve the participation and advancement of women in science, engineering, and medicine.

The recommendations offered by the committee in this section also outline a change process. The process starts with an administrative unit (e.g., department, school, or university) collecting, analyzing, and monitoring quantitative and qualitative data to diagnose specific problems with recruitment, retention, and advancement and then to take action to address shortcomings by drawing upon existing research and practices to adopt targeted, evidence-based solutions. The next step in the process is to repeat the data collection and monitoring to determine whether the treatment has been effective or whether a new approach is needed. The final step in the process is to formally institutionalize effective practices through policy changes so they can sustain transitions in leadership, budget fluctuations, and other potential disruptors that could undermine the sustainability of the effort.

The committee recommends a change process, rather than a single blueprint for action, because there is no single approach that will work in every institutional context. Institutions vary in mission, student demographics, student needs, and resource constraints and a particular strategy may work well at one institution and poorly at another. For this reason, the committee recommends that institutions adopt or adapt the strategies and practices outlined in this report and iterate over time to develop an approach that will work well for their particular institution and the people it serves.

---

<sup>3</sup> Because there is a significant academic orientation to this report—with college and university administrators being a primary audience—the committee has configured recommendations targeted directly to higher education leaders. Many of the ideas and recommendations here, however, can be easily adopted or adapted by private sector employers and government agency employers that also aim to close the gender gap in science, engineering, and medical fields.

**RECOMMENDATION 3:** College and university deans and department chairs should annually collect, examine, and publish<sup>4</sup> data on the number of students, trainees, faculty, and staff, disaggregated by gender and race/ethnicity, to understand the nature of their unit's particular challenges with the recruitment, retention, and advancement of women and then use this information to take action (see Recommendations 5 and 7 for guidance on specific strategies and practices leaders can adopt or adapt to address issues with recruitment, retention, and advancement, piloting and modifying them as appropriate, such that they are effective within the particular context of the institution).

### Implementation Actions

**Action 3-A:** College and university deans and department chairs should collect and monitor department-level demographic data, leveraging data already being collected by their institution in compliance with data reported to the Integrated Postsecondary Education Data System, annually to determine whether there are patterns of underrepresentation among students, trainees, residents, clinical fellows, faculty, and staff, including in leadership roles. Specifically, deans and department chairs should request the following types of data and track these data over time:

- a. Demographic composition of the students currently enrolled and recently graduated in a given department or college. These data should be disaggregated by gender and race/ethnicity and should be tracked over time.
- b. Longitudinal demographic composition of the faculty disaggregated by faculty rank, department, gender, and race/ethnicity.
- c. Longitudinal demographic composition of postdoctoral researchers, residents, clinical fellows and staff scientists, disaggregated by department, gender, and race/ethnicity.

This information should be used to adopt or adapt evidence-based promising and effective practices, taking into account the particular context of the institution (see Recommendation 5).

**RECOMMENDATION 4:** College and university administrators should dedicate resources to carry out qualitative research on the climate in the school or department and the experiences of underrepresented groups and use this information to shape policies and practices aimed at promoting an inclusive climate and supporting underrepresented groups enrolled or employed at the institution.

---

<sup>4</sup> Except in cases for which reporting such data would publicly identify individuals and breach anonymity. For such data, the report should indicate that the numbers are "too low to report."

### Implementation Actions

**Action 4-A:** College and university administrators should work with an evaluator outside the relevant unit to support periodic climate research to assess the climate in the school or department in a manner that is methodologically sound, independent, objective, and free from bias and conflict of interest. Climate research can take the form of surveys, focus groups, and/or interviews.

**Action 4-B:** Given the extremely low representation of women of color in most science, engineering, and medical fields, administrators and external evaluators should work together to adopt a methodological approach that can protect the anonymity of such individuals and accurately capture their experiences. In some instances, interviews may serve as the most appropriate means to gather this information. It should be noted that, in some settings, researchers from a single institution may not be able to sufficiently protect the anonymity of women of color, who make up an extreme minority in certain fields, and so it may be best to conduct such research across an institutional system. Protecting sensitive, personal information will also be aided by the use of an external consultant that can hold the raw data and report only aggregated findings to the departmental leadership.

**RECOMMENDATION 5: Taking into account the institutional context, college and university presidents, deans, department chairs, and other administrators should adopt or adapt actionable, evidence-based strategies and practices (see Implementation Actions 5A–5C) that directly address particular gender gaps in recruitment, retention, and advancement of women in science, engineering, and medicine within their institution, as observed by quantitative and qualitative data analysis and monitoring (see Recommendations 3 and 4 above).**

### Implementation Actions

**Action 5-A:** To work to improve the recruitment and retention of women in STEMM education, faculty and administrators in higher education and K-12 education should adopt the following approaches:

- a. Reorganize STEMM courses to incorporate *active learning exercises* (e.g., having students work in groups, use clickers) and integrated peer-led team learning.
- b. Promote a growth mindset by communicating to students that ability in STEMM fields can be improved by learning.
- c. Challenge stereotypical assumptions about the nature of STEMM careers by communicating to students that scientists often work in teams, conduct research focused on helping others, and have lives outside of work.



- d. Take steps to expose students to a diverse set of role models in STEMM that challenge the persistent societal stereotype that STEMM professionals are heterosexual, cis-gendered, White men. For example, faculty and administrators should give assignments that require students to learn about the work of women who have made significant contributions to the field; work to ensure that the faculty in the department are diverse, such that students take courses and conduct research with people from a range of different demographic groups; and invest in educational materials (e.g., textbooks and other instructional media) that highlight the diverse range of people who have contributed to science, engineering, and medicine.
- e. Strive for gender balanced classroom and group composition, and take steps to promote equitable classroom interactions.

**Action 5-B:**<sup>5</sup> To address issues with the recruitment of women into academic programs and science, engineering, and medical careers, admissions officers, human resources officers, and hiring committees should:

- a. Work continuously to identify promising candidates from underrepresented groups and expand the networks from which candidates are drawn.
- b. Write job advertisements and program descriptions in ways that appeal to a broad applicant pool and use a range of media outlets and forms to advertise these opportunities broadly.
- c. Interrogate the requirements and metrics against which applicants will be judged to identify and either eliminate or lessen the emphasis given to those that are particularly subject to bias and may also be poor predictors of success (e.g., certain standardized test scores).
- d. Decide on the relative weight and priority of different admissions or employment criteria *before* interviewing candidates or applicants.
- e. Hold those responsible for admissions and hiring decisions accountable for outcomes at every stage of the application and selection process.
- f. Educate evaluators to be mindful of the childcare and family leave responsibilities often faced by women, especially when considering “gaps” in a resume.
- g. When possible, use structured interviews in admission and hiring decisions.
- h. Educate hiring and admissions officials about biases and strategies to mitigate them.
- i. Increase stipends and salaries for graduate students, postdocs, nontenure-track faculty, and others to ensure all trainees and employees are paid a living wage.

---

<sup>5</sup> See Chapter 4.

**Action 5-C:**<sup>6</sup> To address issues with retention of women in academic programs and within science, engineering, and medical careers, university and college administrators should:

- a. Ensure that there is fair and equitable access to resources for all employees and students.
- b. Take action to broadly and clearly communicate about the institutional resources that are available to students and employees and be transparent about how these resources are allocated.
- c. Revise policies and resources to reflect the diverse personal life needs of employees and students at different stages of their education and careers and advertise these policies and resources so that all are aware of and can readily access them.
- d. Create programs and educational opportunities that encourage an inclusive and respectful environment free of sexual harassment, including gender harassment.
- e. Set and widely share standards of behavior, including sanctions for disrespect, incivility, and harassment. These standards should include a range of disciplinary actions that correspond to the severity and frequency for perpetrators who have violated these standards.
- f. Create policies that support employees during times when family and personal life demands are heightened—especially for raising young children and caring for elderly parents. For example, stop-the-clock and modified duty policies, which should be available to as wide a group as possible, should be a genuine time-out from work and should not penalize those who take advantage of the policies.
- g. Provide private space with appropriate equipment for parents to feed infants and, if needed, to express and store milk.
- h. Create policies and practices that address workers' need to balance work and family roles (including not only child and family care but also responsibilities for attending to children's school and extracurricular activities).
- i. Limit department meetings and functions to specified working hours that are consistent with family-friendly workplace expectations.

**Action 5-D:** In order to be effective mentors and to create more effective mentorship relationships, faculty and staff should recognize that identities influence academic and career development, and thus are relevant for effective mentorship. As such:

- a. Institutional leadership should intentionally support mentorship initiatives that recognize, respond to, value, and build upon the power of diversity.

---

<sup>6</sup> See Chapter 4.

- Leaders should intentionally create cultures of inclusive excellence to improve the quality and relevance of the STEMM enterprise.
- b. Mentors should learn about and make use of inclusive approaches to mentorship such as listening actively, working toward cultural responsiveness, moving beyond “colorblindness,” intentionally considering how culture-based dynamics can negatively influence mentoring relationships, and reflecting on how their biases and prejudices may affect mentees and mentoring relationships, specifically for mentorship of underrepresented mentees.
  - c. Mentees should reflect on and acknowledge the influence of their identities on their academic and career trajectory and should seek mentorship that is intentional in considering their individual lived experiences.

**Action 5-E:** Institutional leaders, as well as individual faculty and staff, should support policies, procedures, and other infrastructure that allow mentees to engage in mentoring relationships with multiple individuals within and outside of their home department, program, or institution, such as professional societies, external conferences, learning communities, and online networks, with the ultimate goal of providing more comprehensive mentorship support.

**Action 5-F:** Colleges and universities should provide direct and visible support for targets of sexual harassment. Presidents, provosts, deans, and department chairs should convey that reporting sexual harassment is an honorable and courageous action. Regardless of a target filing a formal report, academic institutions should provide means of accessing support services (social services, health care, legal, career/professional). They should provide alternative and less formal means of recording information about the experience and reporting the experience if the target is not comfortable filing a formal report. Academic institutions should develop approaches to prevent the target from experiencing or fearing retaliation in academic settings.

**Action 5-G:** Colleges and universities should create “counterspaces”<sup>7</sup> on their campuses that provide a sense of belonging and support for women of color and serve as havens from isolation and microaggressions. Such counterspaces can operate within the context of peer-to-peer relationships; mentoring relationships; national STEMM diversity conferences; campus student groups; and science, engineering, and medical departments. Counterspaces can be physical spaces, as well as conceptual and ideological spaces.

---

<sup>7</sup> Researchers have defined counterspaces to be “academic and social safe spaces that allow underrepresented students to: promote their own learning wherein their experiences are validated and viewed as critical knowledge; vent frustrations by sharing stories of isolation, microaggressions, and/or overt discrimination; and challenge deficit notions of people of color (and other marginalized groups) and establish and maintain a positive collegiate racial climate for themselves” (Solorzano and Villalpando, 1998; Solorzano et al., 2000).

**RECOMMENDATION 6: Federal agencies should support efforts and research targeted at addressing different profiles of underrepresentation in particular scientific, engineering, and medical disciplines throughout the educational and career life course.**

### **Implementation Actions**

**Action 6-A:** Given that women are underrepresented in computer science, engineering, and physics as early as the undergraduate level, agencies that support research, training, and education in these fields should incentivize institutions to adopt educational practices that research shows can improve interest and sense of belonging in these fields among women. For instance, the NSF director should direct the deputy directors of the NSF Directorates for Engineering, Computer and Information Science and Engineering, and Mathematical and Physical Sciences to set aside funding and work collaboratively with the Education and Human Resources Directorate to support education grants that address the following:

- a. Adoption by college and university faculty and administrators of classroom and lab curricula and pedagogical approaches that research has demonstrated improve interest and sense of belonging in computer science, engineering, and physics among women, such as:
  - i. those that incorporate growth mindset interventions that impress upon students that skills and intelligence are not fixed, but, rather, are increased by learning;
  - ii. those that highlight that scientists and engineers are well positioned and equipped to do work that has a positive societal impact;
  - iii. those that highlight the contributions of a diverse array of people to the scientific, engineering, and medical enterprise today and throughout history.
- b. Research and development of new models of curriculum development in engineering, computer science, and physics that take into account the experience level that different students bring to introductory courses and draw upon the lessons learned from successful programs at other institutions (e.g., Harvey Mudd, Carnegie Mellon).
- c. Development of new media (e.g., podcasts, videos, television, graphics, and instructional materials [e.g., textbooks, syllabi]) that provide students with a diverse array of role models and feature the diversity of individuals whose contributions to science, engineering, and medicine are substantial but may not be as well known by the public. Such an effort could benefit from an interagency collaboration between NSF and the National Endowment for the Arts, which could operate under an existing memorandum of understanding (MOU) between these two agencies.

**Action 6-B:** Across all science, engineering, and medical disciplines, federal agencies should:

- a. Address funding disparities for women researchers, particularly for women of color. For example, NIH should address disparities in success rates of Type I R01 awards for African American women compared with White women;
- b. Directly (e.g., through supplements) and indirectly (e.g., through specific programs) support the work-life integration needs of women (and men) in science, engineering, and medicine; and
- c. In addition to programs designed to support mentorship, support investigation into the impact of sponsorship on advancement of both White women and women of color into leadership roles in science, engineering, and medicine.

### III. PRIORITIZE, RECOGNIZE, REWARD, AND RESOURCE

The committee recommends that institutions, both academic and governmental, sustainably allocate resources and authority to the leaders of equity, diversity, and inclusion efforts, while providing positive incentives for faculty—in the context of promotions and rewards and recognition by honorific and professional societies—that could promote culture change yielding broader recognition that fostering an inclusive scientific, engineering, and medical enterprise is a broadly shared responsibility.

**RECOMMENDATION 7: Leaders in academia and scientific societies should put policies and practices in place to prioritize, reward, recognize, and resource equity, diversity, and inclusion efforts appropriately.**

#### Implementation Actions

**Action 7-A:** University administrators should institutionalize effective policies and practices so that they can sustain transitions in leadership by, for example, writing them into the standing budget and creating permanent diversity, equity, and inclusion-related positions.

**Action 7-B:** University and college administrators should appropriately compensate and recognize individuals responsible for equity and diversity oversight and equip them with sufficient resources and authority.

**Action 7-C:** Academic senates of universities should adopt amendments to faculty-review committee criteria that formally recognize, support, and reward efforts toward increasing diversity and creating safe and inclusive research environments. Adopting these criteria sets the expectation that promoting inclusivity is everyone's

responsibility and encourages faculty involvement in university diversity initiatives. Formal recognition of efforts to promote equity, diversity, and inclusion should include consideration of effective mentoring, teaching, and service during hiring decisions, in determining faculty time allocations, and in decisions on advancement in rank, including tenure decisions.

**Action 7-D:** Professional and honorific societies should:

- a. Create special awards and honors that recognize individuals who have been leaders in driving positive change toward a more diverse, equitable, and inclusive scientific, engineering, and/or medical workforce.
- b. Monitor the diversity of nominees and elected members in the society over time.
- c. Adopt policies that discourage panels of speakers composed entirely of a single demographic group (e.g., White men) at meetings.

**RECOMMENDATION 8: Federal agencies and private foundations should work collaboratively to recognize and celebrate colleges and universities that are working to improve gender equity.**

### **Implementation Actions**

**Action 8-A:** NIH and NSF should collaborate to develop a recognition program that provides positive incentives to STEMM departments and programs on campuses to make diversity, equity, and inclusion efforts a high priority. Departments and programs would compete to be recognized for their success in closing gender gaps in STEMM. Such a program would include multiple rounds: the first to allow departments and programs to develop plans to self-assess their progress and plans toward the goal; the second to create and implement new programs and practices; and the third to show improvement from the original evaluation. In order for institutions to compete equitably for this recognition, departments and programs that apply should compete against similar institutions. For instance, departments and programs that apply could compete only against other institutions within the same Carnegie Classification. After initial exploration of this model by NIH and NSF, other federal agencies could be encouraged to adopt a similar model.

**Action 8-B:** Federal agencies should provide financial assistance to institutions that would like to be recognized for their efforts to improve diversity, equity, and inclusion. These grants would support the resource-intensive data collection that is required to compete for these awards, which, for example, in the United Kingdom often falls to women, and would be granted on a needs-based justification, with priority given to underresourced universities.

**Action 8-C:** Private foundations should require that awardee institutions complete a self-evaluation, specific to the departmental policies, similar to the New York Stem Cell Foundation’s Initiative on Women in Science and Engineering, which required institutions to complete a gender-equity report card before receiving funding. To continue receiving funding from these private foundations, departments must show improvement, or plans to make improvements, to gender equity in their departments.

#### IV. FILLING KNOWLEDGE GAPS

Although the committee’s recommendations speak to actions that leaders and employees at academic institutions and in the government can initiate immediately to promote positive change more broadly experienced by women in science, engineering, and medicine, critical knowledge gaps still exist and must be filled, with deliberate speed, to support most effectively the improved recruitment, retention, and advancement of all women in science, engineering, and medicine.

**RECOMMENDATION 9:** Although scholarly research on gender disparities in science, engineering, and medicine has yielded an abundance of information that can be applied toward reaching gender equity, critical knowledge gaps remain and require very close attention. These include:

- a. Intersectional experiences of women of color, women with disabilities, LGBTQIA women, and women of other intersecting identities (e.g., age).
- b. Strategies and practices that can support improved recruitment, retention, and advancement of women of color and women of other intersecting identities.
- c. Factors contributing to the disproportionate benefit accruing to White women of practices adopted to achieve gender equity.
- d. Specific factors contributing to successes and failures of institutions that have adopted policies and/or implemented programs aimed at diversifying the science, engineering, and medical workforce.
- e. Long-term evaluation of the promising practices listed in the report—specifically, how their sustained implementation influences the recruitment, retention, and advancement of women over time.
- f. Strategies and practices that have been demonstrably most effective in supporting STEM women faculty and students in nonresearch-intensive institutions, such as community colleges.
- g. Characteristics of effective male allies and approaches to training allies.

