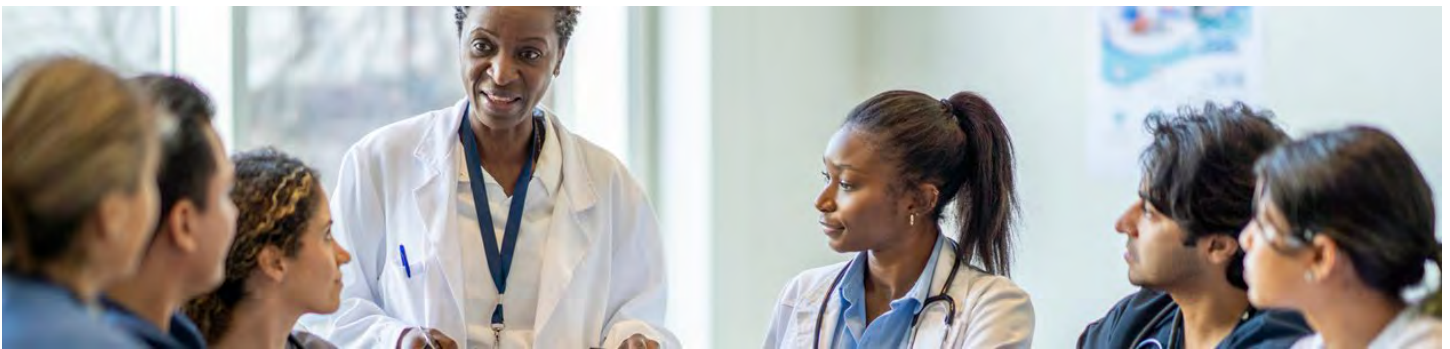


NATIONAL
ACADEMIES *Sciences
Engineering
Medicine*

Preparing the Future Workforce in Drug Research and Development

A Workshop

October 16-17, 2023



National Academy of Sciences Building, NAS 120
2101 Constitution Avenue NW
Washington, DC 20418

Preparing the Future Workforce in Drug Research and Development

October 16-17, 2023

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NATIONAL ACADEMIES

Sciences
Engineering
Medicine

Forum on Drug Discovery, Development, and Translation
Roundtable on Black Men and Black Women in Science, Engineering, and Medicine

Preparing the Future Workforce in Drug Research & Development **A Workshop**

October 16-17, 2023
Washington, DC

In 2021, the Forum on Drug Discovery, Development, and Translation of the National Academies of Sciences, Engineering, and Medicine (National Academies) hosted a public workshop, *Envisioning a Transformed Clinical Trials Enterprise for 2030*, which served as a venue for stakeholders from across the drug research and development (R&D) lifecycle to reflect on the lessons learned over the past 10 years and during the COVID-19 pandemic and consider opportunities for the future. Workshop participants considered goals and priority action items that could advance the vision of a 2030 clinical trials enterprise that is more efficient, effective, person-centered, inclusive, and integrated into the health care delivery system so that the outcomes and experiences for all stakeholders are improved. To achieve this vision, it must be supported by a resilient, culturally aware, anti-racist, and interdisciplinary workforce.

Building on this work, a National Academies planning committee will organize a public workshop to explore the opportunities and challenges for preparing the next generation of experts in the field. The workshop is co-hosted by the Forum on Drug Discovery, Development, and Translation; and the Roundtable on Black Men and Black Women in Science, Engineering, and Medicine.

The public workshop may feature invited presentations and discussions to:

- Examine the current landscape of U.S. academic, government, industry, and professional society training programs for preparing the next generation of drug R&D researchers and clinicians.
- Identify what types of expertise are needed and what disciplines should be included (e.g., nurses, physicians assistants, genetic counselors, research assistants, data scientists, engineers) to achieve the aspirations for a transformed clinical trials enterprise in 2030 and enable a workforce that can better support the evolving needs of drug R&D.
- Consider issues related to the lack of workforce diversity and approaches for engaging and preparing a more diverse person-centered drug R&D workforce, particularly at the clinician/principal investigator-level.
- Explore ways that stakeholders can better prepare the next generation workforce, including opportunities to develop career paths and incentives for academics, primary care, and community-based practitioners.

The planning committee will organize the workshop, develop the agenda, select and invite speakers and discussants, and moderate or identify moderators for the discussions. A proceedings of the presentations and discussions at the workshop will be prepared by a designated rapporteur in accordance with institutional guidelines.

PLANNING COMMITTEE

Cherié Butts (co-chair)

Biogen

Olujimi Ajijola

University of California, Los Angeles

Dowin Boatright

NYU Grossman School of Medicine

Tammy Collins

Burroughs Wellcome Fund

Lola Fashoyin-Aje

Center for Drug Evaluation and Research
U.S Food and Drug Administration

Marcus Hodges

National Center for Advancing Translational
Sciences
National Institutes of Health

Heather Pierce

Association of American Medical Colleges

Jonathan Watanabe (co-chair)

School of Pharmacy and Pharmaceutical
Sciences
University of California Irvine

Damani Piggott

Johns Hopkins University

Amir Tamiz

National Institute of Neurological Disorders and
Stroke
National Institutes of Health

Pamela Tenaerts

Medable Inc.

Lamont Terrell

GSK

Benjamin Wilfond

Department of Pediatrics
University of Washington School of Medicine

Preparing the Future Workforce in Drug Research & Development – A Workshop

October 16, 2023, 9:00 am – 5:00 pm (ET)

October 17, 2023, 8:30 am – 2:00 pm (ET)

National Academies Building, Room 120
2101 Constitution Avenue NW Washington, DC 20418

To watch a zoom livestream, please visit the workshop page [here](#).

PURPOSE

This workshop, convened by the National Academies' Forum on Drug Discovery, Development, and Translation; and Roundtable on Black Men and Black Women in Science, Engineering, and Medicine; will provide a venue for stakeholders to consider what is needed to support the next generation drug research and development (R&D) workforce – one that is resilient, culturally aware, anti-racist and interdisciplinary. Workshop participants will identify the types of expertise and disciplines needed to achieve the aspirations for a transformed clinical trials enterprise in 2030 and enable a workforce that can better support the evolving needs of drug R&D. There will also be opportunity to explore approaches for engaging and preparing a more person-centered drug R&D workforce.

The public workshop will feature invited presentations and discussions to:

- Examine the current landscape of U.S. academic, government, industry, and professional society training programs for preparing the next generation of drug R&D researchers and clinicians.
- Identify what types of expertise are needed and what disciplines should be included (e.g., nurses, physician assistants, nurse practitioners, pharmacists, genetic counselors, research assistants, data scientists, engineers) to achieve the aspirations for a transformed clinical trials enterprise in 2030 and enable a workforce that can better support the evolving needs of drug R&D.
- Consider approaches for engaging and preparing a more diverse person-centered drug R&D workforce, particularly at the clinician/principal investigator-level.
- Explore ways that stakeholders can better prepare the next generation workforce, including opportunities to develop career paths and incentives for academics, primary care, and community-based practitioners.

DAY 1: MONDAY, OCTOBER 16, 2023

9:00 am WELCOME, OPENING REMARKS, AND OVERVIEW OF ROLES IN DRUG R&D

JONATHAN WATANABE, *Workshop Co-chair*
 Professor of Clinical Pharmacy
 Director, Center for Data-Driven Drugs Research and Policy
 Associate Dean of Assessment and Quality
 University of California Irvine School of Pharmacy and Pharmaceutical Sciences

CHERIÉ BUTTS, *Workshop Co-chair*
 Medical Director
 Therapeutics Development Unit
 Biogen

9:30 am SESSION I – FUTURE STATE OF THE CLINICAL TRIALS WORKFORCE

Session Objectives:

- Identify what types of expertise are needed and what disciplines should be included to achieve the aspirations for a transformed clinical trials enterprise in 2030 and enable a more person-centered, culturally aware workforce that can better support the evolving needs of drug R&D.
- Consider key elements/guiding principles for establishing a more self-sustaining and inclusive workforce system.

9:30 am Panel Discussion

Moderator: Cherié Butts, Biogen

AMANDA BRYANT-FRIEDRICH
 Dean, Graduate School
 Professor of Pharmaceutical Sciences
 Wayne State University

SUSAN MONAREZ
 Deputy Director
 ARPA-H

MURALI ARAVAMUDAN
 Chief Executive Officer
 nference

JOHN (WIG) WIGNESWARAN
 Chief Medical Officer
 Walmart

Discussion Questions:

- What types of existing clinical trials training and expertise will become even more critical 10 years from now?
- What new types of clinical trials expertise/disciplines/training will be needed to achieve a 2030 vision of the future?
- What are some key considerations/guiding principles for enabling a more sustainable future clinical trials workforce?

- What are some key considerations/guiding principles for enabling a more inclusive future clinical trials workforce?

10:15 am **Q&A/Audience Discussion**

10:30 am **COFFEE BREAK**

11:00 am **SESSION II – CURRENT STATE OF THE CLINICAL TRIALS WORKFORCE**

Session Objectives:

- Consider the traditional roles and expertise required at each stage of drug development and how these roles have changed over time.
- Examine the current landscape of U.S. academic, government, industry, and professional society training programs for preparing the next generation of clinical trials researchers and clinicians.
- Consider critical gaps and anticipated needs for the 2030 clinical trials enterprise workforce.

11:00 am **Setting the Stage**

ROBERT WINN
Director
VCU Massey Cancer Center

11:20 am **Panel Discussion**

Moderator: Lamont Terrell, GSK

RAMITA TANDON
Chief Clinical Trials Officer
Walgreens

BLAYNE CUTLER
President and Chief Executive Officer
Heluna Health

LINDA L. DEMER
Executive Co-Director, UCLA STAR
University of California Los Angeles

Discussion Questions:

- What are the traditional roles and expertise required at different stages of drug development, and how have these roles evolved over the last 10 years (e.g., in response to technological advancements and changing priorities)?
- What are the strengths and limitations of current clinical trials training programs – are they equipped to prepare the next generation of researchers and clinicians given the evolving landscape? If not, why not?
- What are the critical gaps in training/expertise and anticipated needs for the 2030 clinical trials enterprise workforce?

12:05 pm **Q&A/Audience Discussion**

12:20 pm **LUNCH BREAK**

1:20 pm **SESSION III – OVERCOMING BARRIERS TO PROGRESS**

Session Objectives:

- Discuss approaches to remove barriers and achieve a more person-centered, culturally aware drug R&D workforce.
- Share lessons learned based on current efforts and consider what practices/approaches can be more broadly applied.

1:20 pm **Setting the Stage**

AVERY AUGUST
Professor of Immunology
Deputy Provost
Cornell University

1:35 pm **Presentation**

TONYA FANCHER
Vice Chair, Workforce Diversity
Associate Dean, Workforce Innovation and Education Quality Improvement
University of California, Davis

1:50 pm **Panel Discussion**

Moderator: Perdita Taylor-Zapata, Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH

NINA SCHOR
Deputy Director for Intramural Research
Office of the Director, NIH

ADRIAN HERNANDEZ
Executive Director
Duke Clinical Research Institute

Discussion Questions:

- What are the main barriers/challenges when it comes to the development of a more person-centered and culturally aware workforce, and how can these barriers be effectively dismantled?
- What practices/approaches have current efforts/programs taken to address these barriers?
- What practices/approaches could be more broadly applied?

2:30 pm **Audience Q&A**

2:45 pm **COFFEE BREAK**

3:15 pm SESSION IV – BREAKOUT DISCUSSION: ENVISIONING THE FUTURE LANDSCAPE

Session Objectives:

- Consider practical approaches for engaging and preparing a more diverse person-centered drug R&D workforce, particularly at the clinician/principal investigator-level.
- Explore ways to integrate key elements/guiding principles for establishing a more sustainable and inclusive workforce system.

3:15 pm Breakout Discussion

Breakout Session Topics (Role/Discipline):

- Investigator Physician
- Community Engagement
- Study Coordinator
- Precision Medicine
- AI/Machine Learning

Breakout Questions:

- What is the anticipated capability and capacity for this role/discipline to meet the needs of a 2030 clinical trials enterprise?
- What elements/programs/policies should be put in place to support this career path or area in a way that is more person-centered and inclusive?
- What key elements or guiding principles should be considered to sustainably support/enable this career path or area?
- What are 1-3 short-term (i.e., within the next five years), tangible, and measurable milestones for assessing progress towards that goal?

Breakout Session Leaders

Role: Investigator Physician

KEITH NORRIS

Professor of Medicine

University of California, Los Angeles

DOWIN BOATRIGHT

Vice Chair, Research, Emergency Medicine

NYU Grossman School of Medicine

Discipline: Community Engagement

ARCH MAINOUS

Professor and Vice Chair of Research, Community Health & Family Medicine

University of Florida

DAMANI PIGGOTT

Associate Vice Provost for Graduate Diversity and Partnerships

Associate Professor of Medicine and Epidemiology

Johns Hopkins University

Role: Study Coordinator

BENJAMIN WILFOND

Professor, Divisions of Bioethics & Palliative Care and Pulmonary & Sleep Medicine

Department of Pediatrics, University of Washington School of Medicine

Discipline: Precision Medicine

JONATHAN WATANABE, *Workshop Co-chair*

Professor of Clinical Pharmacy

Director, Center for Data-Driven Drugs Research and Policy

Associate Dean of Assessment and Quality

University of California Irvine School of Pharmacy and Pharmaceutical Sciences

Discipline: AI/Machine Learning

STEPHANIE KRAFT

Assistant Professor of Pediatrics, University of Washington School of Medicine

Director of Research

Treuman Katz Center for Pediatric Bioethics and Palliative Care, Seattle Children's Research Institute

4:15 pm

Full Group Discussion

JONATHAN WATANABE, *Workshop Co-chair, Moderator*

Professor of Clinical Pharmacy

Director, Center for Data-Driven Drugs Research and Policy

Associate Dean of Assessment and Quality

University of California Irvine School of Pharmacy and Pharmaceutical Sciences

4:50 pm

DAY 1 WRAP UP

CHERIE BUTTS, *Workshop Co-chair*

Medical Director

Therapeutics Development Unit

Biogen

5:00 pm

ADJOURN WORKSHOP DAY 1

5:00 pm

WORKING RECEPTION

DAY 2: TUESDAY, OCTOBER 17, 2023

8:30 am SESSION V – SCALING AND SUSTAINABILITY OF WORKFORCE PROGRAMS

Session Objectives:

- Explore ways that stakeholders can better prepare the next generation workforce, including opportunities to develop career paths and incentives for academics, primary care, and community-based practitioners.
- Consider opportunities/policies to accelerate and scale-up efforts to develop and support a more person-centered, culturally aware drug R&D workforce.

8:30 am Fireside Chat

MARIE A. BERNARD
Chief Officer for Scientific Workforce Diversity
Office of the Director, NIH

CHÉRIÉ BUTTS, *Workshop Co-chair, Moderator*
Medical Director
Therapeutics Development Unit
Biogen

9:00 am Panel Discussion

Moderator: Chérié Butts, Biogen

RDML RICHARDAE ARAOJO
Associate Commissioner for Minority Health
Director of the Office of Minority Health and Health Equity
Officer of the Commissioner, FDA

ANNE GRANGER
Head, Postdoctoral Program
Biomedical Research, Novartis

MARWAN FATHALLAH
President and Global Chief Executive
Drug Information Association, Inc.

BILL LINDSTAEDT
Consultant, STEM PhD Career Development
Co-Investigator, pd|hub Collections, Professional Development Hub
(Retired) Assistant Vice Chancellor for Career Advancement
University of California, San Francisco

Discussion Questions:

- How can academia, industry, and government better collaborate to create clear and attractive career paths for individuals interested in pursuing drug research and development, particularly for those from diverse backgrounds?
- In scaling up efforts, what types of opportunities/policies can accelerate the development and support for a more person-centered, culturally aware drug R&D workforce?

9:30 pm

Audience Q&A

9:45 am

SESSION VI – BREAKOUT DISCUSSION: WHAT NEEDS TO BE DONE AND WHO CAN DO IT?Session Objectives:

- Consider priority areas to be addressed to support and sustain workforce programs/efforts.
- Consider who would/should benefit from initiatives and future training programs.
- Discuss roles/responsibilities for different stakeholders to support and enable a more person-centered, culturally aware workforce.

9:45 am

Breakout DiscussionBreakout Session Topics (Stakeholder/Sector):

- Government
- Industry
- Academia
- Non-Profit

Breakout Questions:

- What are the specific roles/responsibilities for this stakeholder/sector to support and enable a more person-centered, culturally aware workforce?
- What are the essential priority areas that should be addressed by this stakeholder/sector to ensure long-term sustainability of workforce programs?
- How can this stakeholder/sector better collaborate with others to achieve these efforts?
- What are some next steps that you and your organization could do towards furthering the points above?

Breakout Session Leaders*Stakeholder/Sector: Government*

ANNE ZAJICEK

Program Director, Office of Clinical Research Education and Collaboration Outreach
Office of Intramural Research, NIH

AMIR TAMIZ

Director, Division of Translational Research
National Institute of Neurological Disorders and Stroke, NIH

Stakeholder/Sector: Industry

TYRONE QUARTERMAN

Senior Manager of Health Equity, Diversity, Equity, and Inclusion, University Affairs and Relations
Myriad Genetics

Stakeholder/Sector: Academia – Undergraduate Programs

TRACIE LOCKLEAR

Clinical Research Sciences Program Leader
Research Assistant Professor
North Carolina Central University

Stakeholder/Sector: Academia – Graduate Programs

PRISCILLA PEMU

Professor of Clinical Medicine

Medical Director of the Clinical Research Center

Vice Chair for Research in the Department of Medicine

Morehouse School of Medicine

Stakeholder/Sector: Non-profit

MARY JO LAMBERTI

Research Associate Professor at Tufts University School of Medicine

Director of Sponsored Research

Tufts Center for the Study of Drug Development

HEATHER PIERCE

Senior Director for Science Policy and Regulatory Counsel

Association of American Medical Colleges

10:30 am **COFFEE BREAK**

11:00 am **SESSION VII – POLICIES FOR WORKFORCE SUSTAINABILITY AND FUTURE-PROOFING**

Session Objectives:

- Explore policies and procedures that could be implemented to ensure a more person-centered, culturally aware drug R&D workforce in 2030.
- Consider guiding principles for different stakeholders to support and enable a more person-centered, culturally aware drug R&D workforce.

11:00 am **Setting the Stage**

ELIZABETH OFILI

Professor of Medicine

Morehouse School of Medicine

11:15 am **Panel Discussion**

Moderator: Lola Fashoyin-Aje, U.S. Food and Drug Administration

CYNTHIA FUHRMANN

Associate Professor, RNA Therapeutics Institute

Associate Professor, Biochemistry & Molecular Biotechnology

University of Massachusetts Chan Medical School

KENNETH MAYNARD

Director, Global Program Team Effectiveness and Global Program Leader Excellence

Takeda

SUSAN LANDIS
Executive Director
Association of Clinical Research Professionals

Discussion Questions:

- What policies and procedures should different stakeholders (government/industry/academia/non-profits) consider to better support sustainable career development programs and continuous training/learning for different roles/disciplines?
- What are some lessons learned/guiding principles that different stakeholders should consider that would support a more person-centered and culturally aware clinical trials workforce?

11:50 am **Audience Q&A**

12:00 pm **WORKING LUNCH (1 hour)**

1:00 pm **SESSION VIII – A PATH FORWARD**

Session Objectives:

- Consider near-term and longer-term approaches to achieve a more person-centered, culturally aware drug R&D workforce.
- Discuss how success and failure could be measured.
- Consider practical next step opportunities.

1:00 pm **Presentation**

KATHERINE TUTTLE
Executive Director for Research
Providence Health Care

1:10 pm **Panel Discussion**

Moderator: Tammy Collins, Burroughs Wellcome Fund

JULIA TIERNEY
Chief of Staff
Office of the Commissioner, FDA

JOSEPH MENETSKI
Senior Vice President
Foundation for the National Institutes of Health

ANN TAYLOR
Former Chief Medical Officer
AstraZeneca

Discussion Questions:

Based on what you heard today...

- What are 2-3 key considerations/priority goals that should be met over the next 5-10 years to ensure the workforce can meet the needs of the 2030 clinical trials enterprise?
- How can different stakeholders (e.g., government, industry, non-profits) best strike a balance between filling immediate workforce needs and laying the groundwork for workforce development in the long-term?
- What is going well and what needs to change in terms of policy/investment/career development programs?
- What are some practical next steps different stakeholders should take now to support the 2030 workforce (i.e., who needs to do what by when)?

1:40 pm

Audience Q&A

1:50 pm

WRAP UP DISCUSSION AND CLOSING REMARKS

CHÉRIÉ BUTTS, *Workshop Co-chair*
 Medical Director
 Therapeutics Development Unit
 Biogen

JONATHAN WATANABE, *Workshop Co-chair*
 Professor of Clinical Pharmacy
 Director, Center for Data-Driven Drugs Research and Policy
 Associate Dean of Assessment and Quality
 University of California Irvine School of Pharmacy and Pharmaceutical Sciences

2:00 pm

ADJOURN DAY 2

NATIONAL ACADEMIES

Sciences
Engineering
Medicine

Forum on Drug Discovery, Development, and Translation
Roundtable on Black Men and Black Women in Science, Engineering, and Medicine

Preparing the Future Workforce in Drug Research and Development A Workshop

Planning Committee Biographies

Committee Co-Chairs

CHÉRIÉ BUTTS, PhD, joined Biogen in 2012 - currently Medical Director, R&D. She was clinical lead for peginterferon beta-1a (approved for multiple sclerosis - EU in 2020, US in 2021) and completed a health equity assignment focused on addressing gaps in clinical data to empower patients to make more informed treatment decisions. She earned BA and MS degrees from The Johns Hopkins University; a Ph.D. from University of Texas MD Anderson Cancer Center; and completed a postdoctoral fellowship at the National Institutes of Health studying neuroendocrine regulation of immune cells. Prior to Biogen, she worked at the US Food & Drug Administration where she conducted research and evaluated new drug/biologics applications as immunogenicity and chemistry-manufacturing-controls reviewer. Dr. Butts is passionate about connecting research across academia, government, and industry to advance the biomedical ecosystem. She holds leadership positions in several local, national, and international organizations. This includes the Board of Celebrity Series of Boston, Board (as Treasurer) of FASEB; Trustee Advisory Board of Beth Israel Deaconess Medical Center; Board of Directors of Keystone Symposia; Board of Trustees (chair) of Salem State University; Scientific Advisory Board of Chan Zuckerberg Initiative, and educator (as Adjunct Professor) at University of Maryland.

JONATHAN WATANABE, BCGP, PHARM.D, PhD, (CO-CHAIR) is a board-certified geriatrics pharmacist, health economist, and outcomes researcher. He is the Associate Dean of Assessment and Quality at the University of California Irvine School of Pharmacy & Pharmaceutical Sciences and serves as the Director of the Center for Data-Driven Drugs Research and Policy. He serves as a Member of the National Academies of Sciences, Engineering, and Medicine (NASEM) Forum on Drug, Discovery, Development, and Translation. Professor Watanabe has been involved in methods development for pragmatic clinical trials for the NASEM Real-World Evidence Workshop Series and served on the steering committee for the Drug Research Development in Older Adults Workshop. Professor Watanabe applies real-world data to develop policy solutions to improve patient care, bolster population-health, enhance access and equity for marginalized populations and reduce medical costs applying data sourced from sources that includes clinical trials, electronic health records, population surveys, and administrative claims. He has also conducted published research on the clinical work force. He is a past National Academy of Medicine (NAM) Anniversary Fellow in Pharmacy. He served as a Scholar in the NAM Emerging Leaders in Health and Medicine Program. Dr. Watanabe's research on health implications of non-optimized medication regimens has been cited in legislative efforts to bolster patient-centered care

and medication management. He is appointed to the Task Force of the California Health Benefits Review Program of the California State Legislature and served on the Advisory Group on Pain Assessment and Management in Long-Term Care Settings for the Joint Commissions. He has been involved in national quality metrics development on long-term care and transitions of care with prior service on the Pharmacy Quality Alliance. He has previously served on the American Academy of Neurology Neurotherapies Workgroup on Pharmacoeconomics. He received his BS from the University of Washington, his PharmD from the University of Southern California, and his MS and PhD from the University of Washington Comparative Health Outcomes, Policy, and Economics (CHOICE) Institute. He has prior direct-patient care clinical experience at the Medicare-Medicaid Program of All-inclusive Care for the Elderly (PACE) program, assisted living, skilled nursing, and long-term care settings.

Committee Members

OLUJIMI AJIJOLA, MD, PhD completed his undergraduate studies at the University of Virginia and received his medical degree from Duke University. He went on to the Massachusetts General Hospital for residency training in internal medicine and completed clinical fellowships in cardiovascular medicine and cardiac electrophysiology at UCLA. He received a Ph.D. in Molecular, Cellular, and Integrative Physiology at UCLA, as part of the Specialty Training and Advanced Research (STAR) program. He is interested in novel approaches for cardiac arrhythmias and performs invasive cardiac electrophysiological procedures. His research interests revolve around peripheral neural circuits that control cardiac function in health and disease, including neural interventions that alleviate progressive cardiac dysfunction and arrhythmias. In addition to the NIH Director's New Innovator award, he is a recipient of the Jeremiah Stamler Cardiovascular Research Award, an A. P. Giannini Foundation post-doctoral award, and a Young Physician Scientist Award from the American Society for Clinical Investigation (ASCI). He is a member of the New Voices program of the National Academies of Science, Engineering, and Medicine. He is a recipient of the Chan Zuckerberg Science Diversity Leadership Award and an elected member of the ASCI. He is the Associate Director of the UCLA Cardiac Arrhythmia Center & EP Programs, and directs the Neurocardiology Research Program at UCLA. He also co-directs the NIH-funded UCLA-Caltech Medical Scientist Training Program.

DOWIN BOATRIGHT, MBA, MD, MHS is the Vice Chair of Research for the department of Emergency Medicine at the New York University Grossman School of Medicine. Previously, he had a fellowship as a Robert Wood Johnson Foundation Clinical Scholar at the Yale School of Medicine. Prior to this, he completed his residency in Emergency Medicine at Denver Health/University of Colorado where he also served as Chief Resident and among many honors received the Denver Health Program Director's Award in 2015. Dr. Boatright's research interests include diversity in the health care workforce and bias and discrimination in medical education. His work has been funded by the National Institute on Minority Health and Health Disparities and by the National Institute of General Medical Sciences. He is also board certified by the American Board of Emergency Medicine. Dr. Boatright is a graduate of Morehouse College, receiving his medical degree from Baylor College of Medicine, and a Master in Business Administration from Rice University.

TAMMY COLLINS, PhD joined the Burroughs Wellcome Fund (BWF) in the fall of 2022. At BWF, Dr. Collins serves as a Program Officer where she directs the Career Awards at the Scientific

Interface (CASI) program and the Innovations in Regulatory Science Awards (IRSA). Prior to joining BWF, Dr. Tammy Collins was the Director of the Office of Fellows' Career Development at the National Institutes of Health | National Institute of Environmental Health Sciences (NIH | NIEHS). In this role, Dr. Collins provided professional development training to prepare postdoctoral scholars for the workforce and was focused on making their career outcomes transparent. To this end, she published research on NIEHS postdoctoral scholar outcomes in Nature Biotechnology and led a national effort for the Graduate Career Consortium to review career outcome classification and visualization methodologies in North America. She received an NIH Director's Award for these efforts. Dr. Collins obtained her bachelor's in chemistry from Appalachian State University (ASU), where she became ASU's first Goldwater Scholar, and her Ph.D. in biochemistry from Duke University. After a brief postdoc at Duke, she joined NIEHS as a postdoc in 2009 where she developed her passion for helping foster scientific leaders.

LOLA FASHOYIN-AJE, MD, MPH is a medical oncologist and Deputy Director in the Division of Oncology 3 (DO3) in the Office of Oncologic Diseases at the Center for Drug Evaluation and Research- Food and Drug Administration (FDA). In this role, she provides clinical, scientific, and regulatory policy guidance and oversight to multidisciplinary teams reviewing drugs and biologics under development for the treatment of solid tumor malignancies. Dr. Fashoyin-Aje is also an Associate Director in the FDA Oncology Center of Excellence (OCE) where she leads initiatives to address clinical and regulatory science and policy issues impacting oncology drug development. One such initiative is Project Equity- a public health initiative established to ensure that the data submitted to the FDA for approval of oncology medical products adequately reflects the demographic representation of patients for whom the medical products are intended. (<https://www.fda.gov/about-fda/oncology-center-excellence/project-equity>). Prior to joining the FDA, Dr. Fashoyin-Aje completed her undergraduate and graduate training at Columbia University and Yale University, respectively, and received her M.D. degree from the University of Rochester School of Medicine and Dentistry. She completed postgraduate training in internal medicine and medical oncology at Johns Hopkins.

MARCUS HODGES, PHD is the lead of intramural trainee development for NCATS' Division of Preclinical Innovation (DPI), where he develops, markets, implements and evaluates training and professional development activities for DPI intramural trainees. Serving as an advocate for NCATS fellows, Hodges ensures that trainees have opportunities to acquire and enhance the skills needed to succeed in a preclinical, translational science environment. Prior to joining NCATS, Hodges served as the fellowship director for the National Biosafety and Biocontainment Training Program (NBBTP), overseeing the planning, coordination, and execution of all didactic and experiential training for fellows. Hodges helped enhance the training curriculum and established developmental assignment partnerships with more than twenty-five government, academic and private-sector institutions. Hodges received his doctorate in biology from Howard University, Washington, DC. He then joined the NIAID Laboratory of Allergic Diseases as a postdoctoral fellow, and later completed a second postdoctoral fellowship, specializing in biological safety and biocontainment. Hodges aspires to increase awareness of translational science in populations that are underrepresented among biomedical scientists. Furthermore, he seeks to identify and apply strategies to recruit and retain people from these underrepresented populations for DPI training programs.

HEATHER PIERCE, JD, MPH is the senior director for science policy and regulatory counsel at the Association of American Medical Colleges (AAMC). In this role, she serves as AAMC's staff leader for scientific regulatory issues including clinical research, conflicts of interest, evidence-based regulation, and collaborations between industry, government, and academia in biomedical research. She is also the designated subject matter expert for the AAMC Forum on Conflict of Interest in Academe and for Convey, the AAMC's global financial interest disclosure system. Ms. Pierce is Chair of the Board of Directors of Public Responsibility in Medicine and Research (PRIM&R), and regularly speaks at national forums on issues related to the protection of human subjects, conflicts of interest, scientific misconduct, and the regulation of research. She has served on ad hoc committees and task forces convened by organizations including the National Academies, The Pew Charitable Trusts, the National Dialogue on Healthcare Innovation, and PRIM&R. Prior to joining AAMC, Ms. Pierce was an attorney in the Health Care Group of the law firm of Ropes & Gray LLP in New York. Her regulatory practice focused on medical research and clinical care. She received her law degree from NYU School of Law and her M.P.H. in Health Law from Boston University.

DAMANI PIGGOTT, MD, PHD is Associate Professor in the Division of Infectious Diseases and the Department of Epidemiology and Associate Vice Provost for Graduate Diversity and Partnerships at Johns Hopkins University. Dr. Piggott directs the Vivien Thomas Scholars Initiative, a \$150 million effort supported by Bloomberg Philanthropies directed at connecting students from Historically Black Colleges and Universities and Minority Serving Institutions to STEM graduate education and future STEM leadership. Dr. Piggott has worked on clinical and research projects in urban and rural communities in the United States, the Caribbean, West Africa, and South Africa. His research centers on understanding the biological, behavioral, and social determinant pathways necessary to improve survival and quality of life for persons aging with HIV. Dr. Piggott received his Bachelor of Science degree in Biology and Spanish from Morehouse College. He obtained his PhD degree in Immunology and his medical degree from Yale University. He completed residency training in Internal Medicine and Pediatrics at Yale New Haven Hospital and fellowship training in Infectious Diseases and Epidemiology at Johns Hopkins. Dr. Piggott is a Fellow of the Infectious Diseases Society of America.

AMIR TAMIZ, PHD is the Director of the Division of Translational Research (DTR) at the National Institute of Neurological Disorders and Stroke (NINDS). DTR provides funding and resources (approximately \$200 million annually) through grants, cooperative agreements, and contracts to academic and industry researchers to advance early-stage neurological technologies, devices, and therapeutic programs to industry adoption (i.e., investor funding and corporate partnerships). Dr. Tamiz has oversight for many flagship programs within NINDS/NIH including the NIH Blueprint Neurotherapeutics Network (BPN) and Blueprint MedTech programs, NIH Helping to End Addiction Long-term (HEAL) Preclinical Screening Platform (PSPP) and Pain Therapeutics Development Program (PTDP), NINDS Small Business Program, Office of Neural Exposome and Toxicology (ONETOX), NINDS Biomarker Program, Innovation Grants to Nurture Initial Translational Efforts (IGNITE), and NINDS Epilepsy Therapy Screening Program (ETSP). Prior to joining NIH in 2012, Dr. Tamiz had held scientific and management positions in research and development of therapeutic programs at Corvas International (acquired by Dendreon), CovX (now part of Pfizer), and Alba Therapeutics.

PAMELA TENAERTS, MBA, MD is Chief Scientific Officer at Medable, Inc. Dr. Tenaerts leads the scientific office at Medable to drive responsible advancement of decentralized research methodologies with evidence-based metrics and best practices. Dr. Tenaerts joins Medable from Duke, where she led the Clinical Trials Transformation Initiative's efforts to develop and drive adoption of practices that increase the quality and efficiency of clinical trials. Tenaerts is one of the leading advocates for innovation in clinical trials, with an emphasis on patient engagement, responsible evidence generation and clinical trial methodology improvements. With more than 30 years' experience in the conduct of clinical trials across a number of stakeholders, she practiced medicine in both the emergency department and as a family practitioner in the private practice setting for several years before embarking on a career in research. She received her MD from Catholic University of Leuven, Belgium, and a MBA from the University of South Florida. She speaks five languages and has obtained Six Sigma Green Belt certifications.

LAMONT TERRELL, PHD is currently the Diversity, Equity, and Inclusion Lead for the R&D organization. He is responsible for developing and implementing the DEI strategy for the global business. Prior to his pivot into leading Human Resource efforts to shape the R&D organization, he spent 14 years as a medicinal chemist leading project in early drug discovery. As the DEI Lead for R&D, one responsibility for Lamont is developing talent pipeline programs and recruitment strategies to increase the diversity of the R&D workforce. He serves as the GSK representative on the steering committee for the Philadelphia STEM Equity Collective (PSEC). PSEC's mission is to increase the number of underrepresented individuals in the Philadelphia workforce. Outside of work, Lamont is dedicated to the scientific community by serving on executive committees of several professional scientific organizations (i.e. American Chemical Society, NOBCCHE). Lamont Terrell graduated salutatorian from Texas Southern University as a Fredrick Douglas honor scholar earning a B.S degree in chemistry in 1995. He earned his Ph.D. in 2001 in organic chemistry from Michigan State. His graduate studies consisted of the total synthesis of the antileukemic natural product amphidinolide A and the development of catalytic tin hydride reactions. Upon completion of his graduate studies at MSU, he continued his synthetic training with a two-year postdoctoral stint at Stanford University.

BENJAMIN WILFOND, MD Benjamin S. Wilfond MD, is an investigator at the Treuman Katz Center for Pediatric Bioethics and a pulmonologist at Seattle Children's Hospital. He is professor, Division of Bioethics & Palliative Care and Pulmonary & Sleep Medicine, Department of Pediatrics, University of Washington School of Medicine. He founded and is former division chief, Bioethics and Palliative Care and former director, Treuman Katz Center for Pediatric Bioethics, the first such programs in the US. He founded and is the former chair, National Human Genome Research Institute intramural IRB and founded and is the former chair, Clinical Research Ethics Consultation Collaborative, a national network to advance research bioethics consultation practice. Dr Wilfond's scholarship has focused on ethical and policy issues related to disabilities, genetics, and clinical research. His current scholarship relates to improving access for diverse communities to advanced technologies including genomic sequencing, cellular therapeutics, and home mechanical ventilation, as well as pragmatic research conducted within the context of health care delivery systems. Dr Wilfond is the research ethics case co-editor of the American Journal of Bioethics and on the editorial boards of the Hastings Center Report, Ethics and Human Research, and Journal of Genetic Counseling. He is a past president of the Association of Bioethics Program Directors, has been elected to the American Pediatric Society and is a fellow at the Hastings Center.

Dr Wilfond attended Muhlenberg College, Rutgers University-New Jersey Medical School, and completed his postgraduate training at the University of Wisconsin. He has held faculty appointments at the University of Arizona, National Institutes of Health, and Johns Hopkins University.

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Preparing the Future Workforce in Drug Research and Development A Workshop

Speaker and Panelist Biographies

REAR ADMIRAL RICHARDAE ARAOJO, PHARM.D., serves as the Associate Commissioner for Minority Health and Director of the Office of Minority Health and Health Equity at the U.S. Food and Drug Administration (FDA). In this role, RDML Araojo provides leadership, oversight, and direction on minority health and health disparity matters for the Agency. RDML Araojo previously served as the Director of the Office of Medical Policy Initiatives in FDA's Center for Drug Evaluation and Research (CDER), where she led a variety of broad-based medical and clinical policy initiatives to improve the science and efficiency of clinical trials and enhance professional and patient labeling. RDML Araojo joined FDA in 2003, where she held several positions in CDER. RDML Araojo received her Doctor of Pharmacy Degree from Virginia Commonwealth University, completed a Pharmacy Practice Residency at University of Maryland, and earned a Master's degree in Pharmacy Regulation and Policy from the University of Florida.

MURALI ARAVAMUDAN, M.S., a serial entrepreneur, inventor, and engineer, is a founder and CEO of nference, a life sciences startup using AI to unlock healthcare data through strategic partnerships with world-renowned healthcare systems, including the Mayo Clinic, Duke Health, Vanderbilt University Medical Center. By offering real-time access to the richest multimodal data available, nference amplifies the impact and effectiveness of research and development and lifecycle management strategies across the biomedical and life sciences communities. Innovations at nference have led to the creation of affiliate ventures like Anumana, focusing on transforming cardiac care with AI solutions (ECG-AI), Pramana, revolutionizing digital pathology with a software-first approach to whole slide imaging, and Vimana focused on diagnostic and therapeutic interventions in Neuroscience. The parent and the affiliate companies have raised around \$300M in venture capital. Murali previously co-founded Veveo, focusing on efficient content discovery on devices, acquired by Tivo for over \$75M, and Winphoria Networks, a pioneer in mobile wireless soft switch and instant communications applications, acquired by Motorola for \$200M. He holds a Master's degree in Electrical Communication Engineering from the Indian Institute of Science, Bengaluru, and has authored 137 U.S. patents with over 100 pending patents and academic publications in areas like machine learning, AI systems, computational biology, and clinical informatics.

AVERY AUGUST, PH.D., is a Howard Hughes Medical Institute Professor, Professor of Immunology, Deputy Provost, and a Presidential Advisor on Diversity and Equity at Cornell University. He received a BS in Medical Technology from California State University at Los Angeles, a PhD in Immunology from Cornell University's Weill Cornell Graduate School of

Medical Sciences and a post-doctoral fellowship at the Rockefeller University from the National Science Foundation. After a brief stint in industry at the R.W. Johnson Pharmaceutical Research Institute as a Scientist in Drug Discovery, he moved to The Pennsylvania State University, where he was Distinguished Professor, prior to moving to Cornell as Chair of the Department of Microbiology & Immunology in the College of Veterinary Medicine. His research focuses on understanding the immunological basis for the balance of inflammation and pathology in the lung during infectious and non-infectious insults. He is the chair of the Steering Committee for ABRCMS, and has led the development of a number of funded programs aimed at diversifying STEM at all levels. He is a Fellow of the AAAS, and the ASM, and has won a number of awards for his research and for his work in diversifying science. He has served on a number of national and international government and non-profit committees, and is currently on the Board of Trustees for the New York Blood Center and The Guthrie Clinic.

MARIE A. BERNARD, MD, is the National Institutes of Health (NIH) Chief Officer for Scientific Workforce Diversity (COSWD). As the COSWD, she leads NIH thought regarding the science of scientific workforce diversity, assuring that the full range of talent is accessed to promote scientific creativity and innovation. Dr. Bernard co-lead the development and is co-leading the implementation of the Fiscal Years 2023 – 2027 NIH-wide Strategic Plan for Diversity, Equity, Inclusion, and Accessibility (DEIA). She also cochairs the NIH Advisory Committee to the Director Working Group on Diversity, the NIH Steering Committee Working Group on DEIA, and the NIH UNITE initiative to identify and address any structural racism that may exist within NIH and throughout the biomedical and behavioral workforce. Prior to being selected as the COSWD, Dr. Bernard served as the Deputy Director of the National Institute on Aging (NIA), following a productive research and leadership career as an academic geriatrician.

AMANDA BRYANT-FRIEDRICH, PHD, MS, is Dean of the Graduate School and Professor of Pharmaceutical Sciences at Wayne State University. Her early training was in organic chemistry at North Carolina Central University and Duke University. She obtained her doctorate in Pharmaceutical Chemistry at the Ruprecht-Karls Universität Heidelberg, Heidelberg, Germany followed by postdoctoral training at the Universität Basel, Basel, Switzerland. She held the positions of assistant and associate professor at Oakland University in Rochester, Michigan before moving to the University of Toledo. She is a Fellow of the American Association for the Advancement of Science, The American Chemical Society, and an Academic Leadership Fellow of the American Association of Colleges of Pharmacy. She is the immediate past Chair of the American Chemical Society (ACS) Division of Medicinal Chemistry and Past Chair of the ACS Multidisciplinary Planning Group and has served several roles in the ACS Division of Chemical Toxicology including Program Chair. She also held leadership positions in the Radiation Research Society. Her research interest center around the development of tools to investigate processes and treat diseases related to nucleic acids and their metabolism.

BLAYNE CUTLER, MD, PHD, is President and CEO of Heluna Health, a national nonprofit leader providing program and support services to optimize population health. She is a physician trained in infectious disease and epidemiology. Prior to joining Heluna Health in 2014, Dr. Cutler served as New York City's Assistant Commissioner for HIV Prevention and Control under Mayors Michael Bloomberg and Bill DiBlasio, and as the City's Director of HIV Prevention from 2007-2013. She has published widely on topics related to HIV, epidemiology, history and public health.

Dr. Cutler has lectured at universities around the world and has assisted in the scale-up of HIV treatment and care in Africa. She received her medical degree at the University of Pennsylvania; completed her residency training at Brown University; and her infectious diseases fellowship at Columbia University. Blayne also has a love of the humanities: she holds a doctorate in history from Yale and worked as a journalist prior to becoming a physician.

LINDA L. DEMER, MD, PhD, is a Professor in the departments of Medicine, Physiology and Bioengineering at UCLA and Vice Chair of the department of Medicine. She received her MD, concurrently with a PhD in bioengineering, at the Johns Hopkins School of Medicine. Her research group pioneered the field of vascular calcification and made paradigm-shifting discoveries showing that artery wall cells to transform into bone cells in cardiovascular calcification. Dr. Demer has served as Associate Editor and Editorial Board member for multiple cardiovascular journals, and she served as President of the Association of Professors of Cardiology, the Western Society for Clinical Investigation, the Association of University Cardiologists, and the North American Vascular Biology Organization. She founded and has directed for 30 years the unique UCLA Specialty Training and Advanced Research (STAR) program, which provides PhD training for physicians at the latest stages of subspecialty training, with over 235 graduates to date. She also serves as Co-Director for Physician Scientist Career Development in the Dean's Office for the David Geffen School of Medicine at UCLA.

TONYA FANCHER, MD, MPH, is Vice Chair for Workforce Diversity, Associate Dean of Workforce Innovation, and Professor and Interim Head of General Internal Medicine at the University of California, Davis School of Medicine. As Director of the Center for a Diverse Healthcare Workforce, she has worked to address physician shortages with grants from HRSA and the AMA, and with partnerships with regional employers. She has created medical school pathways to improve care for medically underserved communities, a community college to medical school pathway, and helped UC Davis to become the 3rd most diverse in the U.S. Dr. Fancher serves on the ACGME's DEI Advisory Committee and HRSA's Advisory Committee on Training in Primary Care Medicine and Dentistry. Dr. Fancher graduated from Cornell University (Classics and Biology) and completed medical school and residency at NYU and Bellevue Hospital. Her scholarly work focuses on challenges and solutions to inequities in medical education.

MARWAN FATHALLAH, MS, MBA, has three decades of global life science leadership experience in pharmaceutical, medical device, diagnostic, and biotechnology product research and development and has served as DIA President and Global Chief Executive since January 2023. Prior to joining DIA, Marwan was the Operating Officer and EVP at Ortho Clinical Diagnostics, accountable for Operations, Post-Market Product Science and Engineering, Regulatory, Quality, Medical, Clinical, Scientific Affairs, and Process Excellence. Before joining Ortho, he held Executive and Senior Leadership roles in Research and Development, Operations, and Regulatory Medical and Clinical Affairs at Avantor, Danaher, Pfizer, Hospira, and Abbott Laboratories. Marwan holds Masters and Bachelor of Science degrees in Mechanical Engineering from the University of Wisconsin-Madison and an MBA from the Kellogg School of Management at Northwestern University.

CYNTHIA FUHRMANN, PHD, directs the Professional Development Hub and is Associate Professor of the RNA Therapeutics at UMass Chan Medical School. Fuhrmann's work sits at the nexus of practice, scholarship, and policy to advance the professional development of early-career scientists. She has 18 years' experience founding professional development programs for graduate students, postdoctoral scholars, and faculty, with educational innovations funded by the NIH, NSF, and Burroughs Wellcome Fund and honored by two awards from the Association of American Medical Colleges. She is a pioneer of Individual Development Plans in graduate/postdoctoral education, including co-developing myIDP (an online tool used worldwide), integrating career planning into curricula, and co-developing survey instruments for studying IDP use. Fuhrmann's national service includes NASEM's Roundtable on Mentorship, Well-being, and Professional Development, advising the Council of Graduate School's NSF Innovations in Graduate Education Hub, and serving on grant review boards and numerous training advisory boards. She leads Professional Development Hub, a cross-stakeholder national initiative to advance equitable, evidence-based practices in STEM PhD professional development. She earned her Ph.D. in Biochemistry and Molecular Biology at UCSF and B.S. in Chemistry at University of California, Davis.

ANNE GRANGER, PHD, is the Head of the Postdoctoral Program and a member of the Academic Partnerships and External Innovation team at Novartis Biomedical Research. The Biomedical Research Postdoctoral Program, which counts over 550 alumni, currently hosts 70 Fellows in four campuses across the United States and Switzerland. Dr. Granger designed and launched the Novartis Innovation Fellowship, a training program for aspiring drug hunters complementing the existing academically oriented program. Prior to joining Novartis Biomedical Research, Dr. Granger was a Senior Scientific Editor for the Cell Press journal *Cell Metabolism* for 7 years. She received her PhD in Molecular and Cellular Biology from the University Pierre and Marie Curie (Paris, France) and was a postdoctoral fellow at the University of Pennsylvania and the Childrens' Hospital of Philadelphia, where she studied cardiovascular biology and diabetes.

ADRIAN HERNANDEZ, MD, MHS, is Executive Director, Duke Clinical Research Institute, and Vice Dean of the Duke University School of Medicine. He is a cardiologist who aims to improve health by accelerating clinical evidence through outcomes research, clinical trials, comparative effectiveness and health policy. He has led multiple large-scale patient-centered research programs, registries and clinical trials across multiple health conditions including the NIH's Health System Collaboratory and PCORI-funded PCORnet®. He is an elected member of the American Society for Clinical Investigation, the Association of American Physicians and serves on the board of directors of the Reagan-Udall Foundation

STEPHANIE A. KRAFT, JD, is an Assistant Professor in the Division of Bioethics and Palliative Care, Department of Pediatrics at the University of Washington School of Medicine, as well as a Principal Investigator and the Director of Research at the Truman Katz Center for Pediatric Bioethics and Palliative Care at Seattle Children's Research Institute. Professor Kraft is a bioethics scholar with a focus on ethics and equity in clinical research and emerging biomedical technologies. Her research aims to incorporate the voices of research participants, patients, and community members, particularly those of marginalized and minoritized groups, into research practices and technology development to ensure biomedical advances reduce, rather than exacerbate, health disparities. Her work is currently funded by the National Human Genome Research Institute and the National Center for Advancing Translational Sciences.

MARY JO LAMBERTI, PHD, is a Research Associate Professor at Tufts University Medical School and Director of Sponsored Research at the Tufts Center for the Study of Drug Development. She has extensive experience in benchmarking drug development operating practices. Her research focuses on a variety of areas including clinical research workforce issues, investigative site initiation and management, and patient recruitment and retention in clinical trials. In addition, she has examined the impact of technology and remote work on clinical research professionals. Through her work on health disparities among underrepresented populations, she has focused on identifying strategies that create clinical trial awareness and education and approaches to improve access among diverse populations. She has been a frequent speaker at global industry conferences and has published extensively. She holds a B.A. from Wellesley College and a Ph.D. from Boston University.

SUSAN P. LANDIS serves as the Executive Director for the Association of Clinical Research Professionals. With more than 14,000 members, ACRP is the only non-profit organization solely dedicated to representing, supporting, and advocating for clinical research professionals. ACRP's mission is to ensure excellence in clinical research. Prior to joining the Association, Susan led Strategic Engagement & Marketing Communications for the Duke Clinical Research Institute (DCRI). While at Duke, Susan established and led the DCRI Research Communications & Engagement group and created ResearchTogether™, a model for championing patient engagement at every phase in clinical research trials and studies. Susan also served as a team member on commercial-funded interventional and outcome studies and several large government-funded trials, including the Environmental Influences on Child Health Outcomes program (ECHO), the ABC Science Collaborative, and RADx-UP. Prior to joining Duke, Susan worked at Quintiles (now IQVIA) as an executive for the company's Patient Engagement division. She also managed the company's branding initiatives and thought leadership program and served as a corporate communications business partner for the company's business units that represented more than \$5 billion and 30,000 employees.

BILL LINDSTAEDT, MS, has been helping scientists and engineers launch successful careers for 30 years. From 2001-2023, he supported the career development needs of PhD students, postdocs and their faculty mentors at the University of California San Francisco. In his career counseling practice, he developed particular expertise working with biomedical scientists as they transition from academic positions to careers in the biotech/pharma sector. While at UCSF, Bill co-authored Science's "myIDP", a web-based career development tool which has been used by more than 300,000 scientists and is recommended by dozens of graduate and postdoctoral programs around the country. Recently retired from UCSF, he now serves as co-Investigator on an NIH-funded initiative to build STEM PhD professional development resources across institutions. Additionally, he serves as a contracted career consultant with the Office of Academic Programs at St. Jude Children's Research Hospital and with Emory University's Office of Postdoctoral Education.

TRACIE LOCKLEAR, PHD, is the Director of the Clinical Research Sciences Program at North Carolina Central University. The program was established in 2019 to build a clinical research workforce of the future with a strong focus on workforce diversity, health equity and community engagement. She serves as the NCCU lead for the Workforce Development Core under the Duke-

NCCU Clinical and Translational Science Award (CTSA) and a member of Consortium of Academic Programs in Clinical Research (CoAPCR). She is a community-based researcher focused on improving health outcomes for rural communities, historically marginalized communities in particular.

ARCH G. MAINOUS III, PHD, is Professor and Vice Chair for Research in the Department of Community Health and Family Medicine and Professor in the Department of Health Services Research, Management and Policy at the University of Florida. He is an internationally-recognized leader in primary care research, with more than 450 peer reviewed publications. His work has been cited more than 29,500 times with an H index of 84. He has been active in developing the health care workforce. He has received the Distinguished Research Mentor award and the Maurice Wood Award for Lifetime Contribution to Primary Care Research from the North American Primary Care Research Group. He has served as a Special Advisor for Health and Healthcare to the Prime Minister of Haiti. He currently serves as the Deputy Editor of the journal Family Medicine and the Specialty Chief Editor of Frontiers in Medicine: Family Medicine and Primary Care.

KENNETH MAYNARD, PHD, FAHA, is Director, Global Program Team Effectiveness at Takeda Pharmaceuticals. He previously led global drug discovery and clinical development teams in neuroscience, external innovation, portfolio strategy and pharmacovigilance. Before pharma, Dr. Maynard was an academic stroke neuroscientist researcher and Assistant Professor (Neurosurgery) at Massachusetts General Hospital and Harvard Medical School. He earned his BSc, MSc, and PhD degrees in Neurobiology at University College, London. He is a Fellow of the American Heart Association (FAHA) and serves on several advisory boards, including the Society for Neuroscience Council, Worcester Polytechnic Institute's College of Arts & Sciences, the National Institute of Nervous Disorders and Stroke (NINDS), and the University of Seattle's Broadening the Representation of Academic Investigators in NeuroScience (BRAINS). He previously served on the NIH Director's Program on Broadening Experiences in Scientific Training and the National Academies of Sciences Committee on the Next Generation of Biomedical and Behavioral Sciences Researchers.

JOSEPH P. MENETSKI, PHD, has been at the Foundation for the NIH as Senior Vice President of Science Partnerships and Chief Translational Science Officer since 2016. In this role, he leads a group to identify, develop and execute multi-stakeholder medical research partnerships in the areas of cancer, neuroscience, inflammation and immunity, metabolic disorders and rare disease. FNIH provides a forum that allows all project stakeholders, from NIH, academia, pharmaceutical industry, patient advocacy and profession organizations, the opportunity to contribute directly to the direction and governance of these projects. Prior to joining to FNIH, he worked at Merck where he was involved in initiating the osteoarthritis new targets and biomarker program, biomarker discovery using molecular profiling, scientific knowledge discovery and management and competitive intelligence. Joseph has also worked at Pfizer (Parke-Davis) where he established a discovery research program in cellular inflammation mechanisms. He received his Ph.D. from Northwestern University Medical School in Chicago.

SUSAN C. MONAREZ, PHD, is a globally recognized leader with over twenty years of experience in health innovation. She currently serves as the Deputy Director at the Advanced Research Projects Agency for Health (ARPA-H). ARPA-H supports the development of high-impact

research to drive biomedical and health breakthroughs to deliver transformative, sustainable, and equitable health solutions for everyone. Prior to this position, Dr. Monarez was at the Health Resources and Services Administration, the largest funder of safety-net health programs in the Department of Health and Human Services. Dr. Monarez has also served at the White House as the Assistant Director for National Health Security and International Affairs in the Office of Science and Technology Policy (OSTP) and as the Director of Medical Preparedness Policy on the National Security Council (NSC). In both White House roles, she led multiple efforts to enhance the nation's biomedical innovation capabilities. Dr. Monarez has led the development of several Presidential-level national strategies, action plans, and policy directives related to domestic and global health. Prior to the White House, Dr. Monarez served in leadership positions at the Homeland Security Advanced Research Projects Agency (HSARPA) within the Department of Homeland Security and the Biomedical Advanced Research Projects Agency (BARDA) within the Department of Health and Human Services (HHS). In addition to leadership roles within the Federal government, Dr. Monarez has been called upon to serve on numerous advisory panels to include at the National Academies of Science, the National Science Advisory Board for Biosecurity, and the Federal Experts Science Advisory Panel. Dr. Monarez has also served as the U.S. representative on several international cooperative initiatives including with the European Union, Canada, France, the Netherlands, and the United Kingdom in bilateral and multilateral engagements. Dr. Monarez was an American Association for the Advancement of Science (AAAS) Science and Technology Policy fellow and a research scientist in microbiology and immunology at the University of Wisconsin and at the Stanford University School of Medicine.

KEITH NORRIS, MD, PHD, is an internationally recognized clinician scientist and health policy leader who has been instrumental in shaping clinical practice guidelines for chronic kidney disease (CKD), developing policy initiatives to address health disparities, and increasing diversity in clinical trials and in the biomedical sciences. He is Distinguished Professor and Executive Vice Chair for Equity, Diversity, and Inclusion for the UCLA Department of Medicine, and Co-Director of the UCLA Clinical and Translational Science Institute Community Engagement Research Program.

He was one of twenty site Principal Investigator for the multi-site NIH-NIDDK funded African American Study of Kidney Disease and Hypertension (AASK) and the AASK Cohort Study, the largest comparative drug intervention trial focusing on renal outcomes conducted in African Americans. He has conducted NIH and FDA related trials and/or community partnered research for 40 years. He serves as PI or Multi-PI for 6 NIH research and training grants focused on addressing health disparities and increasing biomedical workforce diversity.

ELIZABETH O. OFILI, MD, MPH, FACC, is a Professor of Medicine, at Morehouse School of Medicine, and a practicing cardiologist with Morehouse Healthcare in Atlanta, Georgia.

A national and internationally recognized clinician scientist with particular focus on cardiovascular disparities and women's health, Dr. Ofili has helped to raise over \$200 million to fund pioneering research and training infrastructure at Morehouse School of Medicine. She leads multi institutional regional and national networks funded by the NIH, to address diversity and inclusion in the biomedical workforce, as well as community engagement to ensure participation of underrepresented populations in NIH, Foundation, and Industry sponsored research, including multi-PI of the statewide Georgia Clinical and Translational Science Alliance (Georgia CTSA), at

Emory University, Morehouse School of Medicine, Georgia Institute of Technology and the University of Georgia; contact PI of the RCMI Coordinating Center, for twenty two NIH funded Research Centers in Minority Institutions (RCMI) to support investigator development, community engagement, and evaluation; principal investigator of the National Research Mentoring Network (U01) and contact principal investigator of the Coordination and Evaluation Center for the NIH Faculty Institutional Recruitment for Sustainable Transformation (FIRST) Program for Inclusive Excellence. She has received over 50 national awards, including “Changing the Face of Medicine: The Rise of America’s Women Physicians” Exhibit at the National Library of Medicine. She is an elected member of the National Academy of Medicine.

PRISCILLA PEMU, MD, is a Medical Doctor specializing in the care of adults with complex medical problems under treatment in clinic and hospital settings. She also trains medical students and new medical doctors specializing in Internal Medicine. As a physician-scientist, she leads research funded with grants from the National Institutes of Health and the American Heart Association, informed by her daily experiences with patients. She’s continuously inspired to investigate the best ways to improve the long-term health of patients living with chronic illnesses (e.g., cancer, diabetes, etc.). Dr. Pemu is currently a Professor of Clinical Medicine, Medical Director of the Clinical Research Center and Vice Chair for Research in the Department of Medicine at Morehouse School of Medicine (MSM) in Atlanta, GA. As part of a team at MSM, she developed a system and method for providing care to patients with chronic illnesses that empowers patients to change their behaviors relevant to their health; this is achieved by efforts to improve patient’s knowledge, provide support for their goal setting and accountability so they may sustain their lifestyle changes. Dr. Pemu continues to explore and implement key patient-centered concepts that are relevant to improving health outcomes and transforming health care. She’s passionate about speaking to audiences such as health care managers and funders, affected patient groups, health coaches and other scientists who are interested in achieving that goal as well.

TYRONE QUARTERMAN, MPH, is the current Senior Manager of Health Equity and Diversity at Myriad Genetics, Inc. Within Myriad he is responsible for health equity and access, diversity, equity, and inclusion (DEI), university affairs and relations, learning and development, and charitable giving. Tyrone has an extensive background ranging from equity and access in clinical and non-clinical research, to addressing community needs and health disparities in urban and rural environments. An avid proponent of health equity and social justice in healthcare – Tyrone prides himself on continuing to advance the mission of equal access for all within healthcare in the pharmaceutical and biotech space. He is known for a variety of discussions and lectures on Health Equity, addressing Disparities, and health inequalities.

NINA F. SCHOR, MD, PHD, is currently NIH Deputy Director for Intramural Research, a post she has held since August 2022. Before coming to NIH, Dr. Schor spent 20 years on faculty at the University of Pittsburgh, ultimately becoming the Carol Ann Craumer Professor of Pediatric Research, Chief of the Division of Child Neurology in the Department of Pediatrics, and Associate Dean for Medical Student Research at the medical school. In 2006, Dr. Schor became the William H. Eilinger Chair of the Department of Pediatrics, and Pediatrician-in-Chief of the Golisano Children’s Hospital at the University of Rochester, posts she held until January 2018, when she became Deputy Director of the NINDS. For 27 years in academia, her research on neural crest development and neoplasia was continuously funded by NIH. At NINDS, she led the Division of

Intramural Research and the Ultra-Rare GENE-targeted Therapies (URGenT) Network and strategic planning and career development programs. She also continues to serve as a Neurology Director for the American Board of Psychiatry and Neurology.

RAMITA TANDON, MPH is the Chief Clinical Trials Officer at Walgreens and responsible for leading and driving growth for the Company's new clinical trials business. In her role, Ramita works across the healthcare and life sciences industries to enable next-generation clinical trials so that breakthrough treatments reach patients faster. Ramita's motto is "talk less and do more." Every day, she lives this out by showing and setting industry standards on addressing access and health equity. She and her team are working to make clinical research an inherent care option across this nation when the standard of therapy is not a viable option.

Ramita brings more than 25 years of leadership and operational experience across a portfolio of industry-leading businesses and services in real-world evidence and patient-centered health outcomes. Prior to joining Walgreens, she served as the Chief Operating Officer at Trio Health, and prior to that she was the Executive Vice President, Commercialization and Outcomes at ICON. Ramita was recently named to the Center for Healthcare Innovation's Board of Directors. As a transformational leader, Ramita is passionate in her belief that a best-in-class operating model employing insights and innovation can deliver gains in operations and forge stronger connections with all stakeholders, including biopharmaceutical companies, healthcare systems and payers. Ramita was recently named to Mass Market Retailers' 2023 Most Influential Women, Drug Store News' Top Women in Health, Wellness & Beauty class of 2022 for Business Excellence, Fierce Healthcare's 2022 Women of Influence and she was listed in the PharmaVOICE 100 in 2023 and 2018.

On top of her individual accolades, under Ramita's leadership the Walgreens clinical trials business was nominated at the 2022 Prix Galien USA in the category for "Incubators, Accelerators and Equity," commended in the 2022 Clinical Trials Arena Excellence Awards, and was just shortlisted in the PRWeek Healthcare Awards 2023 "Best Healthcare Product Launch" category. Ramita is an internationally recognized speaker and author whose focus is on how to bridge the gap between commercial and clinical development. She is a graduate of the University of Michigan and the Boston University School of Public Health.

ANN TAYLOR, MD, is currently the Co-Chair of the Forum on Drug Discovery, Development, and Translation of the NASEM. Her career has spanned academic medicine, pharmaceutical development, and biotechnology. She currently is on the Board of several biotechnology companies. Her most recent pharmaceutical company roles included Chief Medical Officer at AstraZeneca, Head of Clinical Biologics at Medimmune, Head of the Program Office at Novartis Institutes for Biological Research, acting head of Cardiovascular and Metabolic Research, and Head of Translation Medicine for Metabolism at NIBR. Prior to joining Novartis, Ann worked as an early clinician at Pfizer Global Research and Development. Ann received her undergraduate degree from the University of California, San Diego, and her M.D. from Harvard Medical School. She trained in Internal Medicine and Endocrinology and Metabolism at Massachusetts General Hospital, before joining the faculty there. She is passionate about improving representation in clinical trials.

PERDITA TAYLOR-ZAPATA, MD, is a pediatrician from the Washington, DC Metropolitan area. She attended DC public schools and graduated from Howard University for both college and medical school. After completing her pediatric residency at the Children's National Medical Center, she joined the National Institutes of Health (NIH) Clinical Center as a staff physician in the Pediatric HIV Program.

In 2004, Dr. Taylor-Zapata joined the National Institute of Child Health and Human Development (NICHD), where she is currently responsible for the oversight and implementation of a pediatric drug development research program called the Best Pharmaceuticals for Children Act (BPCA) Clinical Program. She also manages and maintains a portfolio of grants in the area of pharmacoepidemiology and pharmacovigilance in pediatric research.

JULIA (JULIE) TIERNEY, JD, is the Chief of Staff of the FDA, overseeing the daily management of the agency and leading agency activities on major initiatives. In this role, she provides strategic direction to senior leadership to advance the FDA's policy priorities and works closely with the leadership of all FDA product centers and field operations to support their implementation of agency policies. She also serves as the Acting Commissioner's direct liaison to other executive agencies and organizations and engages across government on critical public health initiatives. Ms. Tierney also plays a key role in legislative engagement, communications and stakeholder outreach. Most recently, Ms. Tierney was the Chief of Staff for FDA's Center for Biologics Evaluation and Research (CBER). In that capacity, she served as the principal advisor to CBER Center Director Peter Marks, M.D., and facilitated planning and implementation of CBER priorities. Ms. Tierney first joined CBER in early 2017 as a Senior Policy Advisor for Strategic Planning and Legislation. From 2015 to 2016, Ms. Tierney was FDA's detailee to the U.S. Senate Health, Education, Labor & Pensions (HELP) Committee as a Senior Health Policy Advisor. She joined the FDA in 2008, as an Associate Chief Counsel for Drugs in FDA's Office of Chief Counsel, providing ongoing legal counsel to FDA leadership and program staff on drug and biologic-related legal issues. Prior to working at the FDA, Ms. Tierney practiced food and drug law at private law firms. She received her J.D. from Georgetown University Law Center and her undergraduate degree in Biology and History from Johns Hopkins University.

KATHERINE R. TUTTLE, MD, FASN, FACP, FNKF, is Executive Director for Research at Providence Inland Northwest Health, Regional Principal Investigator of the Institute of Translational Health Sciences and Professor of Medicine at the University of Washington. She oversees a regional network of 17 clinical research centers and chairs the research Regional Executive Council for the University of Washington. Dr. Tuttle's major research interests are in diabetes and chronic kidney disease. She has published over 320 peer-reviewed articles, including an early landmark study elucidating physiological principles underlying kidney hemodynamics in humans with diabetes. This led to a number of studies that laid a foundation for new therapeutic targets in clinical trials. Her work has helped establish SGLT2 inhibition as the most impactful therapy to date to reduce risks of kidney failure, cardiovascular events, and death in persons with diabetes. She also leads the Center for Kidney Disease Research, Education and Hope (CURE-CKD) Registry of real-world data from nearly 4 million health system patients. She has chaired numerous working groups and committees for the National Institutes of Health, the American Society of Nephrology, the International Society of Nephrology, Kidney Disease Improving Global Outcomes, the National Kidney Foundation, and the American Diabetes Association. Dr.

Tuttle has received many honors and awards including the John P. Peters Lifetime Achievement Award from the American Society of Nephrology.

JOHN (WIG) WIGNESWARAN, MD, MBA, came to Walmart after working in the pharmaceuticals, medical device, health services and pharmacy benefit manager industries. He joined Walmart from Cigna where he served as Chief Medical Officer for Express Scripts helping lead clinical program development and business development in the commercial, health plan and regulated market segments. Prior to this he was Chief Medical Officer at DaVita Rx, at that time the country's largest renal PBM leading specialty clinical programs; Vice President Market Development at Fresenius Medical Care growing several business lines outside of chronic dialysis and leading supply chain transformation; nephrology lead of medical affairs at Johnson & Johnson (Scios®); Chief Medical Officer for CHF Solutions/Gambro. He has over a decade of clinical experience as a practicing nephrologist and serves as a renal fellowship preceptor in the Division of Nephrology at Rhode Island Hospital/Brown University. Dr. Wig completed his undergraduate studies at Cornell University, medical school at Tufts University School of Medicine, MBA at the Massachusetts Institute of Technology Sloan School of Management and internal medicine residency and nephrology fellowship training at New York Hospital/Cornell University and Rhode Island Hospital/Brown University. Dr. Wig currently serves as a board member for the National Kidney Foundation.

ROBERT A. WINN, MD, serves as a member of the External Advisory Board for the Indiana University Simon Comprehensive Cancer Center, the Director of the Virginia Commonwealth University (VCU) Massey Cancer Center (MCC), and a Professor in the VCU Department of Internal Medicine, Division of Pulmonary Disease and Critical Care Medicine. As MCC Director, Dr. Winn is ultimately responsible for setting the vision, scientific and clinical goals, and strategic direction of the Center. He is in charge of identifying and providing the resources needed for strategic plan implementation and monitoring Center progress. Dr. Winn is also a member of the Cancer Prevention and Control Program. As a pulmonologist and physician-scientist, his research centers on lung cancer and health disparities. Dr. Winn's has focused on developing novel in vitro and in vivo models to study the translational aspects of the role that various signaling pathways (e.g. WNTs, PRMT, KS RP) pathway plays in lung cancer, which has resulted in a number of peer-reviewed journal publications. He has been awarded several NIH and Veteran Affairs grants and has a long history of developing productive collaborations with other successful R01-funded researchers. Dr. Winn has served as the Principal Investigator on several team science community-based projects funded by the NIMHD and NCI, including the All of Us Research Program, an NIH precision medicine initiative. He is committed to developing methods to eliminate health disparities, and will continue to focus his efforts on underserved patient populations, to improve health care delivery, and ensure equal access to cutting-edge medical treatments.

ANNE ZAJICEK, MD, PHARM D, is a board-certified pediatrician and pediatric clinical pharmacologist, and Program Director of the Office of Clinical Research Education and Collaboration Outreach (OCRECO) at the National Institutes of Health. Dr. Zajicek develops and oversees online clinical pharmacology and clinical research training programs, and strategic partnerships with the extramural community. Dr. Zajicek earned her Bachelor's degree in Pharmacy from Duquesne University and a PharmD from the State University of New York at Buffalo; completed a fellowship at St. Jude Children's Research Hospital; and served as faculty at

the University of Colorado School of Pharmacy and a Clinical Pharmacist at National Jewish Health. In 1995 Dr. Zajicek earned her medical degree at the University of Pittsburgh, and completed her residency in pediatrics at the Children's Hospital of Pittsburgh. She practiced primary care pediatrics, and then continued her training as a pediatric clinical pharmacology fellow at Stanford University. She subsequently joined the U.S. Food and Drug Administration (FDA) as a clinical pharmacology reviewer. In 2003, she joined the Eunice Kennedy Shriver National Institute of Child Health and Human Development, and was appointed Chief of the Obstetric and Pediatric Pharmacology and Therapeutics Branch in 2010. In 2017, Dr. Zajicek moved to the NIH OCRECO.

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*Forum on Drug Discovery, Development, and Translation
Roundtable on Black Men and Black Women in Science, Engineering, and Medicine*

Funding and Disclaimers

This workshop was supported by the pooled funds of the Forum on Drug Discovery, Development, and Translation and Roundtable on Black Men and Black Women in Science. A list of sponsors can be found on page **36** and **43** in this briefing book or at <https://www.nationalacademies.org/our-work/forum-on-drug-discovery-development-and-translation/about> and <https://www.nationalacademies.org/our-work/roundtable-on-black-men-and-black-women-in-science-engineering-and-medicine/about>.

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Complaints should be filed as soon as possible after an incident. To ensure the prompt and thorough investigation of the complaint, the complainant should provide as much information as is possible, such as names, dates, locations, and steps taken. The Office of Human Resources will investigate the alleged violation in consultation with the Office of the General Counsel.

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Information contained in a complaint is kept confidential, and information is revealed only on a need-to-know basis. NASEM will not retaliate or tolerate retaliation against anyone who makes a good faith report of discrimination, harassment, or bullying.

Updated June 7, 2018



ABOUT THE FORUM

The Forum on Drug Discovery, Development, and Translation (the forum) of the National Academies of Sciences, Engineering, and Medicine (the National Academies) was created in 2005 by the National Academies Board on Health Sciences Policy to foster communication, collaboration, and action in a neutral setting on issues of mutual interest across the drug research and development lifecycle. The forum membership includes leadership from the National Institutes of Health, the U.S. Food and Drug Administration, industry, academia, consortia, foundations, journals, and patient-focused and disease advocacy organizations.

Through the forum's activities, participants have been better able to bring attention and visibility to important issues, explore new approaches for resolving problem areas, share information and find common ground, and work together to develop ideas into concrete actions and new collaborations.

Forum work is based on four thematic priorities:

Spurring INNOVATION and IMPLEMENTATION

Revolutionary advances in biomedical research and technology present new and exciting opportunities for the discovery and development (R&D) of new therapies for patients. The evolution of health care is expanding possibilities for integration of clinical research into the continuum of clinical care and new approaches are enabling the collection of data in real-world settings. Innovative modalities, such as digital health technologies and artificial intelligence applications, can now be leveraged to overcome challenges and advance clinical research. The forum unites key stakeholders to identify opportunities, address bottlenecks, and spur innovation in drug discovery, development, and translation.

Increasing PERSON-CENTEREDNESS and EQUITY

There is much greater awareness around the need for more person-centered and inclusive approaches that prioritize lived experience, equity, and justice in the discovery, development, and translation of new treatments. The forum seeks to center priorities of people living with disease and those who have been traditionally under-represented or excluded from the clinical trials enterprise, advance the science of patient input, and help bring to fruition innovations that better address the needs of patients.

Promoting COLLABORATION and HARMONIZATION

The forum provides a neutral platform for communication and collaboration across sectors and disciplines to better harmonize efforts throughout the drug R&D life cycle. It does this by convening a broad and evolving set of stakeholders to help integrate patients, caregivers, researchers, trialists, community practitioners, sponsors, regulators, payers, patient and disease advocacy groups, and others into the continuum of research and clinical care. The forum also strives to enable shared decision-making and ensure that patients have input into research questions, researchers have insight into clinical practice, and practitioners are engaged in the clinical trials enterprise.

Enhancing the WORKFORCE and INFRASTRUCTURE

The forum has fostered the development of strategies to improve the discipline of innovative regulatory science and continues to focus on building a workforce that is diverse, adaptable, and resilient. Considerable opportunities remain to improve and expand the evolving clinical trials workforce and infrastructure, integrate community-based practices, and engage early-career scientists and clinicians in drug discovery, development, and translation. The forum will continue to anticipate and promote adaptation to changes in the infrastructure of health care delivery.

For more information about the Forum on Drug Discovery, Development, and Translation, please visit at:

[NATIONALACADEMIES.ORG/DRUGFORUM](https://www.nationalacademies.org/drugforum)

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Established in 2019, the [Roundtable on Black Men and Black Women in Science, Engineering, and Medicine](#) convenes twice annually and hosts 2-3 national or regional workshops and symposia each year. Roundtable members, drawn from academia, government, and industry, focus on the barriers and opportunities encountered by Black men and Black women as they navigate the pathways from K-12 and postsecondary education to careers in science, engineering, and medicine. The goals of the Roundtable are to:

- Compile and discuss quantitative and qualitative data relevant to the representation and experiences of Black men and Black women in science, engineering, and medicine;
- Convene a broad array of stakeholders representing higher education, industry, health care, government, private foundations, and professional societies;
- Highlight promising practices for increasing the representation, retention, and inclusiveness of Black men and Black women in science, engineering, and medicine; and
- Advance discussions that can lead to increasing systemic change.

In 2023, the Roundtable is in its third 3-year cycle of workshops. The upcoming October 2023 workshop, *Engaging Black Men and Black Women in the Breadth of Engineering* will be the second of this third cycle.

EVENTS AND PUBLICATIONS

CYCLE 3: 2023

Protecting Diversity, Equity, and Inclusion in Higher Education and the Workforce: A Workshop: This May 1-2, 2023 workshop highlighted case studies of how various organizations use diverse criteria to ensure the inclusion of incoming students and employees from underrepresented and under-resourced populations. Additionally, the workshop will explore the impact of efforts to undermine or eliminate DEI initiatives, such as Affirmative Action, that seek to increase diversity, equity, and inclusion in SEM. Major objectives of the workshop included: identifying practices with demonstrated success that have led to increased diversity in student and workforce populations; highlighting best practices in the selection process for undergraduate, graduate, and medical school admissions and industry workforce development programs; and exploring the impact of movements to reverse legal precedents, such as Affirmative Action, on diversity, equity, and inclusion initiatives in science, engineering, and medicine. A rapporteur-authored workshop Proceedings are forthcoming. (Recordings of the workshop are available at <https://bit.ly/3OJ6Nh8>)

Planned Cycle 3 events

Engaging Black Men and Black Women in the Breadth of Engineering: A Workshop: A planned October 4-5, 2023 workshop examine how engaging in engineering disciplines can lead to generational success in the Black community through educational attainment and social mobility. The workshop will highlight the lived experiences of Black engineers from early education through their careers, the impact of pursuing engineering as a conduit for socioeconomic mobility, and how engineering and engineering professionals can better partner with Black community organizations to support community needs and the increase of Black men and women entering engineering career pathways. Primary objectives of the workshop include: spotlighting the lived experiences of Black engineers from diverse backgrounds; exploring opportunities for academic institutions, affinity associations, and other groups to cultivate a culture of anti-Black racism, belonging, and inclusion; highlighting the breadth of career pathways and opportunities available for Black people interested in engineering and the impact of engineering on personal and community socioeconomic mobility; and investigating best practices and structural interventions for engaging with Black community organizations to address community needs and make pursuing careers in engineering more accessible. The workshop panels will feature academic institutions, disciplinary associations, industry, and community organizations, in addition to support and expertise from the National Academy of Engineering (NAE). Following the workshop, a rapporteur-authored workshop proceedings will be published.

Pathways to Greatness in STEM: A Workshop (tentative title): this December 2023 workshop will consider the

various past, current, and possible “blueprints” for Black American eminence in academia and industry, in addition to the impact of these individuals on public health and education policy. The Roundtable is interested in studying the nomination and membership considerations for the three National Academies. The workshop will engage with and feature individuals of note and champions in the leadership of both academic institutions and industry. Following the workshop, a rapporteur-authored workshop proceedings will be published.

Post Affirmative Action Symposium Series: the Roundtable is planning a symposia series focused on admissions policies and the future inclusion of Black men and Black women in science, engineering and medical education, training and careers after the U.S. Supreme Court decision on Affirmative Action. Lessons and actions from the May 2023 *Protecting Diversity, Equity, and Inclusion in Higher Education and the Workforce* workshop will inform the development of this series. The Roundtable will include a variety of partners in the planning of the events and the panels, with representatives across higher education and industry.

Proposed series topics include:

- Interpreting the New Legal Precedent (late October/early November 2023)
- Unheard Voices (January/February 2024)
- Novel Ideas for Black Men and Black Women in SEM Higher Education (March/April 2024)

Conversations with Living Legends

- This annual feature series of the Roundtable spotlights preeminent individuals across sectors that have significantly impacted the disciplines of science, engineering, or medicine and have been integral to the advancement of Black students and professionals throughout SEM. Honorees exemplify what it means to be a trailblazer. Whether it's groundbreaking discoveries, mentoring scholars and leaders, creating a space for others to thrive, or transforming systems to drive change, the Roundtable's Living Legends Honorees represent individuals who have dedicated their lives to advancing justice and equity. The series continues in the third cycle.
 - o 2023 Honorees
 - Vivian Pinn, MD
 - James West, PhD

Recent Roundtable publications

- [*Psychological Factors That Contribute to the Dearth of Black Students in Science, Engineering, and Medicine: Proceedings of a Workshop \(2023\)*](#)
- [*The State of Anti-Black Racism in the United States: Reflections and Solutions from the Roundtable on Black Men and Black Women in Science, Engineering, and Medicine: Proceedings of a Workshop \(2023\)*](#)

Potential topics for future events and activities

- Public engagement and advocacy by Roundtable members in national publications, on topics such as the U.S. Supreme Court's recent decision on Affirmative Action
- Building capacity through collaboration at HBCUs
 - o Exploring unique niches that some HBCUs have such as foci in medicine, engineering, veterinarian medicine, agriculture, etc.,
 - o Leveraging HBCUs strengths towards multi-institutional research and portfolio development
 - o Developing HBCU research consortiums
- Community/Technical/Vocational education for future careers in Black SEM professionals
- Racism in Veterinarian medicine – nurturing Black veterinarian professionals from degree to practice
- Jim Crow 2.0

CYCLE 2: 2022

2022 Living Legends

- The February 22, 2022 conversation featured Dr. Louis W. Sullivan, interviewed by Dr. Wayne Riley, President of Downstate Medical Science University, about Dr. Sullivan's life and work promoting education and access and diversifying health professions and medical education. The recording is

available at <https://bit.ly/3jhc1QA>.

- On February 24, 2022, Dr. Shirley M. Malcom spoke with Dr. Evelyn Hammonds, director of the Project on Race and Gender in Science and Medicine at the Hutchins Center for African and African American Research at Harvard, about science, social justice, and their long-term mentoring relationship. The recording is available at <https://bit.ly/3LMGORx>.

Supporting Black Students through their SEM Career Journeys: A Workshop. This May 2-3, 2022, workshop spotlighted financial and supportive programs and services for Black students in Science, Engineering, and Medicine. Building on prior workshops held in 2021 and 2020, the day and a half convening focused on policies and practices that aim to mitigate long-standing barriers for Black students pursuing degrees and careers in SEM. Included in the discussions were examinations of SEM employment trends, the role of professional societies in advancing diversity, equity, and inclusion, and how diverse funding streams may assist in supporting Black students' SEM education and career development. A rapporteur-authored workshop Proceedings are forthcoming. (Recordings of the session are available at <https://bit.ly/3NKxSgh>)

Advancing Anti-Racism, Diversity, Equity, and Inclusion in STEM Organizations: Joint Session with Roundtable on Black Men and Women in STEMM. This May 16, 2022, session brought together the Roundtable on Black Men and Black Women in Science, Engineering, and Medicine and the Committee on Advancing Anti-Racism, Diversity, Equity, and Inclusion in STEMM Organizations to discuss synergies in their respective charges. Speakers provided insight into ongoing anti-racist programs and personal anecdotes about their lived experiences. [Recordings of the session are available at <https://bit.ly/3rQxrvs>; the conversations at this session informed the National Academies' consensus study [Advancing Antiracism, Diversity, Equity, and Inclusion in STEMM Organizations: Beyond Broadening Participation \(2023\)](#)]

Community Support, Partnerships, and Inclusive Environments for Black Students in SEM: A Workshop. This September 19-20, 2022 workshop examined local, regional, and national opportunities to engage with and leverage community support and mutually-beneficial partnerships that build inclusive environments for Black undergraduate, graduate, and medical students and increase the representation of Black professionals in science, engineering, and medicine (SEM). The workshop participants will engage each other and helped identify practices, policies, and partnerships with demonstrated success, lay a foundation for collaborative dialogue, and identified the resources and actions necessary to further positive change for Black SEM student and professionals. A rapporteur-authored workshop Proceedings are forthcoming. (Recordings of the workshop are available at <https://bit.ly/45gsx9o>)

Leveraging Trust to Advance Science, Engineering and Medicine in the Black Community: A Workshop. This December 15-16, 2022 workshop examined local, national, and global strategies used by community groups, such as the Black church, across the Black diaspora to build trust and advance issues in science, engineering, and medicine within Black communities. Participants provided a historical overview demonstrating the degradation of trust in scientific and medical institutions, leading to adverse health outcomes and environmental inequalities. Speakers spotlighted best practices for building trust and identifying actions to address emerging public health and environmental issues impacting Black communities. The workshop also highlighted best practices for science, engineering, and medical (SEM) professionals to develop sustainable and effective relationships with the Black community, in addition to examining how communication with Black communities influences trust and acceptance of SEM. A rapporteur-authored workshop Proceedings are forthcoming. (Recordings of the workshop are available at <https://bit.ly/45ccWry>)

CYCLE 1: 2019 – 2021

The State of Anti-Black Racism in U.S. Science, Engineering, and Medicine: A Workshop. This December 6-7, 2021 capstone workshop reviewed the Roundtable's work on the state of anti-Black racism in U.S. SEM. Each Action Group designed a session that came together to explore how racism continues to be a barrier to increasing the number of African-Americans in SEM. Discussions included how systemic, anti-Black racism affects the educational pathways and mentoring and advising relationships of Black students in SEM, how anti-Black racism contributes to the financial barriers and psychological factors that impact Black Students in SEM, and the role of anti-Black racism in the disproportionate impact of the COVID-19 pandemic on Black Communities. (Proceedings available at www.nap.edu/26692)

Roundtable on Black Men and Black Women in SEM COVID-19 Update: Vaccination, Immunity, and Virus

Variants. This October 25-26, 2021 symposium served as an update to and reflection on previous activities of the Roundtable on Black Men and Black Women in Science, Engineering, and Medicine. With a focus on reviewing the challenges faced and assessing how those challenges were handled, we will look forward with hope to how we may help end the pandemic. Held for two short sessions over two days, speakers and other participants will explore whether the trajectory of vaccine and treatment development was equitable, and how trust - or lack thereof - was managed to insure equitable distribution. (Agenda available at <https://bit.ly/3OwbrOj>)

Psychological Factors that Contribute to the Dearth of Black Students in Science, Engineering, and Medicine. This September 14-15, 2021 workshop examined the psychological barriers that contribute to decreased representation of Black students in science, engineering, and medicine (SEM), including the chronic environmental stressors that contribute to anxiety, depression, and substance use and abuse as well as the racially insensitive educational barriers that Black youth face. Speakers and laid a foundation of knowledge for others to more effectively engage on these issues and the discussions focused on systemic solutions to overcome negative stereotypes and systemic racism and biases, including policy changes that can support Black students, scientists, engineers, and physicians, strengthening their academic and racial identity and enhancing their mental health. (Proceedings available at www.nap.edu/26691)

Reducing Financial Barriers for Black Students in Science, Engineering, and Medicine: A Workshop. This April 19-20, 2021 workshop explored the financial barriers to increasing the number of African-Americans in science and medicine with a focus on the intersection of public, private, philanthropic and university investment to reduce the cost for African-Americans pursuing careers in science, engineering and medical fields. Speakers and panelists examined the business case for increasing the number of African-Americans in science, engineering and medical careers and the potential impact of increasing the public and private financing of HBCU's on expanding opportunities for African-Americans pursuing science and medical careers. The goal of the workshop was to enable the development of policies that build and sustain a workforce of Black engineers, scientists and physicians for the greater good of our society so that it can heal, grow and thrive. (Proceedings available at www.nap.edu/26576)

Mentoring and Advising of Black Students in Science, Engineering, and Medicine: A Workshop. This December 7-8, 2020 workshop examined how to strengthen mentoring and advising of Black students in science, engineering, and medicine, to increase the number of Black people pursuing careers in those fields. Workshop participants explored the current models used for mentoring and advising (with well-articulated outcomes), and the effectiveness of those models, with a particular focus on the reality of structural barriers and systemic racism. Discussions also addressed the role of institutional leadership in the academic setting in strengthening mentoring and advising. Major objectives of the workshop included: (1) to examine the criteria needed to evaluate a successful pipeline program for Black people pursuing education and careers in science, engineering, and medicine; and (2) to explore the definitions and practices of mentoring, advising, sponsorship, and related roles to clarify their functions. (Proceedings available at www.nap.edu/26462)

Reckoning with Structural Racism and Sexism, COVID 19, and the Urgent Need for Diverse Leaders in Academic Medicine. This October 15, 2020 joint meeting with AAAS explored what academic medicine can do to transform institutional culture and climate to dismantle structural racism and sexism; measure inclusivity, diversity and equity; and hold leadership accountable for effectively implementing systemic change. It was also an opportunity to help shape the development of the framework for American Association for the Advancement of Science (AAAS) *SEA Change Biomedicine* by providing input on systemic priorities for developing the equity-minded, inclusive, and diverse leaders that we need in academic medical centers. (More information available at <https://bit.ly/3OIgyR9>)

Educational Pathways for Blacks in Science, Engineering, and Medicine: Exploring Barriers and Possible Interventions: A Workshop. This September 2-3, 2020 workshop examined (1) current educational pathways for Blacks in science, engineering, and medicine (SEM); (2) the barriers and inadequacies that exist along those pathways, including financial barriers; and (3) promising interventions to overcome the barriers. The workshop covered SEM educational pathways at the primary, secondary, undergraduate, and graduate levels, and featured the perspectives of SEM education experts, practitioners, and students at different points in their education. (Proceedings available at <https://www.nap.edu/26391>)

COVID-19 Vaccines, Treatments, and a Return to Sports: A Symposium. Resuming more normal activities amid the COVID-19 pandemic poses significant challenges to American society, and particular challenges to Black

Americans, who are disproportionately harmed by the virus⁴¹ as well as by the suspension of educational and economic activities caused by COVID-19. A symposium on August 26, 2020, explored two critical topics: 1) the anticipated trajectory of vaccine and treatment development- the science behind these technologies, how they will be delivered equitably to Black communities, and how trust will be built in these communities to ensure distribution; and 2) the resumption of organized athletic activities, where much discussion has focused on intercollegiate and professional athletics. Blacks constitute a significant percentage of elite athletes in several sports and speakers addressed issues facing those returning to sports participation. (More information at nas.edu/covid-and-sports)

COVID-19 and Black Communities: A Workshop. On June 23rd, 2020, a workshop investigated ways to fully invest in the human capital available in Black communities by training doctors, engineers, and scientists who are then well-positioned to provide rapid and effective responses to subsequent waves of COVID-19 and other medical crises. The workshop explored what's driving disparities with Black Americans getting sick and dying from COVID-19 at higher rates than white Americans and what can be done to remedy them. (Proceedings available at www.nap.edu/26146)

The Impacts of Racism and Bias on "Black" People Pursuing Careers in SEM: A Workshop. On April 13-14, 2020, a workshop examined the role of racism and bias in the decline of Black students in science, engineering, and medicine. The workshop explored the historical trends in the enrollment of Black students in medical and engineering schools and the sciences, including the use of race in admissions, as well as trends in Black faculty representation in science, engineering, and medicine. Participants considered the efficacy of training on implicit and explicit bias to mitigate the impacts of bias on Black students. (Proceedings available at www.nap.edu/25849)

APPROACH

The roundtable uses the innovative mechanism of action groups to increase focus on specific issues. The current actions groups are:

1. **Racism and (Conscious & Unconscious) Bias:** This Action Group will establish specific instances of racism operating in STEMM and identify mechanisms for both policy intervention and programs. For example, the low prioritization of the shortage of Black men in medicine and Black men and women in STEM fields itself is a form of racism. There are multiple junctures where racism mediates barriers to goods, services, and opportunities in the country, negatively impacting the standard of living, education and employment. Further, impervious to the oppressed is the unconscious acceptance of limited ability and even lesser personal worth, which results in despondency.
2. **K-Grad Education:** This Action Group will assess the state of public schooling disparities in education. It will also discuss the educational pipeline and address parity initiatives, especially as they focus on STEM. Early access and exposure to STEM disciplines is fundamental. Available resources include the community colleges and the historically black colleges, universities, and medical schools to expand their reach, as well as implement health related curricula. Fundamentally, STEM education, beyond the technical, should bolster self-confidence of the individual and provide role models. This group will also look at efforts to increase the recognition of identity as central to building confidence (e.g., DC Public School initiative on identity). It will also look at the types of efforts that can focus on the pool of Black students who apply but are not accepted to medical schools to ensure that they reapply with better preparation.
3. **Financing:** This Action Group will address the financial barriers to higher education and the impact on students and families. Knowledge about scholarships, preparatory fellowship programs and concerned philanthropies is missing for many young students pursuing health and other STEM related careers. There are social and family dynamics that complicate the financial burden, especially for high-cost medical education for Black men and women, particularly if there are interruptions in the training sequence to residency. A practical consideration is the promotion of financial literacy beginning in high school to help students make better financial decisions related to loans and indebtedness for higher education.
4. **Public Advocacy & Engagement:** This Action Group will determine how advocacy and public policy can be utilized to raise awareness of the problem and issues associated with black men and women in STEM fields, especially in the biomedical space. NIH programs to promote diversity are fundamental components of the outreach. For example, there are NIH diversity supplements, administrative grants allowing NIH grantees the opportunity to fund students from underrepresented groups, and pipeline programs such as PREP (Post-baccalaureate Research Education Program) and BUILD (Building Infrastructure Leading to Diversity), which support pre-doctoral training. Marketing outreach and communications through social media and technology

should be implemented to reach potential students⁴² and increase public awareness.

5. **Mentorship & Advising:** This Action Group will explore mentorship programs that are tailored to student needs and inclusive of different learning styles. For example, programs connecting selected students with faculty and peers can provide tutoring and academic support beginning in college, as well as support during medical school. NIH's National Research Mentoring Network is an example of an activity that can be looked at as a mechanism to connect mentors and mentees in person and online. There is also a need to mentor the mentor to embrace culture-sensitive leadership and diversify the mentoring skills beyond pure research. The group can also look at how colleges, universities, and medical schools can implement programs for their faculty to teach and train a diverse student body with varying learning styles and social support needs.
6. **Mental Health Factors:** This Action Group will have an initial focus on the psychological factors leading to the dearth of Black men in American medicine. How Black men could enhance their self-perception and esteem in the face of discrimination and racism is a challenge for all American society. Redefining mental health as part of wellness and resilience would be a key change in thinking about this problem. The psychological barriers to becoming a physician as a Black man should be anticipated at the K-12 level by enhancing a strong racial and personal identity. In addition, substance use disorders set back educational attainment and require early intervention to halt the school-to-prison progression. Identifying the most vulnerable youth, exposed to emotional trauma, would be critical for early interventions and mental health services. There is a need for research in these mental health issues ensconced in the black community.
7. **Health Equity:** Established during 2020, this Action Group initially focused on the impacts and responses to the COVID-19 pandemic. Shifting from exclusively exploring the dynamic and disruptive nature of the pandemic, this Action Group works across the Roundtable and with the other Action Groups to highlight the differential outcomes and impacts on Black men and Black women and the stark healthcare inequities that have direct and dire outcomes for Black men, women, and communities.



Sponsoring Members of the National Academies

Roundtable on Black Men & Black Women in Science, Engineering & Medicine

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ROUNDTABLES AND FORUMS

IN THE HEALTH AND MEDICINE DIVISION

nationalacademies.org/HMD

**ROUNDTABLES AND FORUMS
IN THE HEALTH
AND MEDICINE DIVISION:
ADVANCING THE DISCUSSION
AND FOSTERING
DIALOGUE ON CRITICAL
HEALTH TOPICS**

*The National
Academies of*

SCIENCES
ENGINEERING
MEDICINE

The National Academies of Sciences, Engineering, and Medicine ("the National Academies") 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.

The Health and Medicine Division (HMD) is a program unit of the National Academies. The aim of HMD is to help those in government and the private sector make informed health policy decisions by providing evidence upon which they can rely. HMD advises the nation through consensus committees but also provides opportunities for open dialogue on complex and diverse topics through roundtables and forums.

Representatives from government, private businesses, academia, and other stakeholder groups gather regularly on neutral ground in order to identify and discuss contemporary issues of mutual interest and concern. Roundtables and forums cover a range of topics, including health care at the local and global levels, health literacy, health equity, health professional education, obesity solutions, violence prevention, and medical and public health preparedness.

Contact HMD:

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ROUNDTABLES AND FORUMS

Roundtables and forums create communal environments to foster dialogue across sectors and institutions. Although roundtables and forums do not produce solutions themselves, they illuminate issues that need to be resolved, and opportunities for further work often develop from their meetings, workshops, and publications. For example, the activities of a roundtable or forum may result in the establishment of separate consensus study committee.

Unlike a consensus committee, which publishes a report with conclusions and recommendations, a roundtable or forum may not issue work with such advice.

ROUNDTABLE AND FORUM MEMBER SELECTION

Usually, roundtable and forum members are selected based on each individual's expertise, but other considerations may be a factor. Since roundtables and forums do not give advice, their membership is not restricted with regard to financial or other types of bias and conflicts of interest.

The membership of a roundtable or forum is approved by the HMD Executive Office and appointed by the chair of the National Academies for three years (or a shorter duration, depending on the activity). Government officials from sponsoring agencies are appointed on an ex officio basis upon the recommendation of their agencies, and the length of their service will match the length of their term in office. Nongovernmental membership appointments to the roundtable or forum may also be considered ex officio if they are by virtue of the office in a professional society, corporation, or other independent organization—particularly if the sponsoring organization chooses the person and office to be on the roundtable or forum.

ROUNDTABLE AND FORUM ACTIVITIES

Roundtables and forums host a number of activities such as discussion meetings, workshops, and symposia. Within the scope of their approved topic, roundtables

and forums are self-governing in that, for example, they decide their own agendas for meetings. A chair, who presides at the meetings, is nominated by HMD and appointed by the chair of the National Academies, just as the members are.

Because they do not give advice, roundtables, forums, and their activities are not subject to Section 15 of the Federal Advisory Committee Act, an act that guarantees independence from government interests and necessitates disclosure of all reference materials to the public.

However, roundtable and forum meetings and workshops are announced on the HMD website in advance and are open to the public, except in two cases: if the meeting includes only members and is dedicated to administrative matters, or if the meeting will discuss issues described in U.S. Code Title 5 Section 552(b). Under this law, closed meetings may be held if the discussion delves into such topics as security, privacy, or legal matters.

Roundtables and forums often use authored background papers or workshops to help inform their discussions. These follow the same rules of public access as above. Workshops are organized by planning committees, which may include roundtable or forum members. A roundtable or forum member may also serve as a speaker at a workshop.

PLANNING COMMITTEES

Planning committees develop workshop agendas for roundtables and forums and are not subject to the same rules and limitations placed on study committees. However, all planning committee members must complete bias and conflict of interest forms, which ask about affiliations and opinions, and they must also participate in bias and conflict of interest discussions.

Potential sources of bias usually relate to individuals holding positions that arise from the close identification or association with a particular point of view.

Most, if not all, planning committee members will have some level of intellectual bias in relation to a particular topic, but those biases should be declared. An ideal planning committee will represent a balance of positions. In the face of evidence, an ideal member of a planning committee will be able to engage in dialogue with others and consider adopting a new point of view.

INNOVATION COLLABORATIVES

Roundtables and forums may establish innovation collaboratives—also called action collaboratives—to engage participants with similar interests and responsibilities in cooperative activities to advance aspects of each roundtable or forum’s statement of task. These ad hoc convening activities foster information sharing and

collaboration toward roundtable and forum aims as well as evaluation on progress on findings and recommendations highlighted in prior National Academies reports.

PUBLICATIONS

If a roundtable or forum holds a workshop, this workshop may result in a *Proceedings of a Workshop* or a *Proceedings of a Workshop—in Brief*, published by the National Academies Press (NAP), the publishing arm of the National Academies. Workshop proceedings are typically authored by some combination of HMD staff and hired consultants, serving as rapporteurs.

Like consensus committee reports, workshop proceedings are reviewed by an independent panel of experts, which may include roundtable and forum members. The *Proceedings* may not be transmitted to a sponsor or released to the public until review has been completed to the satisfaction of the Report Review Committee of the National Academies and the HMD Executive Office.

Other types of publications may develop from roundtables and forums. Independent, cooperative projects between sponsors and members, spin-off studies, and individually authored papers are some of the most common projects that grow out of roundtable and forum discussions. For instance, discussion papers and commentaries (collectively termed *Perspectives*) are individually

authored with the goal of further elucidating topics covered in roundtable or forum discussions. Small groups of roundtable or forum members, or individual members, may author a discussion paper or commentary to offer a particular perspective on a topic. Though distributed by the National Academy of Medicine (NAM), the views in the discussion papers and commentaries represent only those of the authors, not necessarily of the authors' organizations, the NAM, or the National Academies. These papers are not subject to the review procedures of the National Academies. All discussion papers and commentaries are designed to be shared publicly.

ROLE OF HMD STAFF

Each roundtable and forum is assisted in its work by a team of highly qualified staff members. Staff assist with research contributing to meetings and workshops, and they may act as the authors of a workshop proceedings. As with any HMD activity, staff may not insert their personal opinions into the publication. Overall, HMD staff is responsible for ensuring that the institutional procedures are followed and that the roundtable or forum stays within its budget.

COMMUNICATIONS

Although roundtables and forums do not issue advice or recommendations, it is important to emphasize communications to stimulate further discussion, attract workshop attendees, hold successful workshops, issue informative workshop proceedings, and inform a broader readership.

To help with these goals, HMD and the National Academies have a number of offices focused on communications support:

The HMD Office of Communications is responsible for HMD's report production functions as well as communications strategies and activities. One of its primary objectives is to communicate effectively the active messages of HMD activities and publications to its key audiences.

The Office of Congressional and Government Affairs is responsible for dissemination and outreach to congressional members and staffs. This may include congressional briefings and testimonies.

The Office of News and Public Information (ONPI) is the liaison between the National Academies and the news media and general public. ONPI should be informed of substantive conversations with the news media, especially if there is a problem.

The NAP website (nap.edu) makes all National Academies publications available online. All publications are free in PDF format to the public. As volunteers, roundtable and forum members receive a 25 percent discount on all books purchased from the NAP.

Our ROUNDTABLES AND FORUMS

FOOD FORUM

Sylvia Rowe, Chair
Heather Cook, Director

Established in 1993, the Food Forum convenes scientists, administrators, and policymakers from academia, government, industry, and public sectors on an ongoing basis to discuss problems and issues related to food, food safety, and regulation. The forum provides a mechanism for these diverse groups to explore possible approaches for addressing food and food safety problems and issues surrounding the often complex interactions among industry, academia, regulatory agencies, and consumers.

FORUM ON AGING, DISABILITY, AND INDEPENDENCE

Stephen Ewell and Rebecca Jackson Stoeckle,
Co-Chairs
Tracy Lustig, Director

The Forum on Aging, Disability, and Independence fosters dialogue and addresses issues of interest and concern related to aging and disability. This includes aging and the related disabling conditions that can occur, as well as aging with an existing disability. The forum seeks to promote bridging of the research, policy, and practice interests of the aging and disability communities to accelerate the transfer of research to practice and identify levers that will effect change for the benefit of all. Of particular concern is promoting healthy aging, independence, and community living for older adults and people with disabilities. This is a joint activity of HMD and the Division of Behavioral and Social Sciences and Education.

FORUM FOR CHILDREN'S WELL-BEING: PROMOTING COGNITIVE, AFFECTIVE, AND BEHAVIORAL HEALTH FOR CHILDREN AND YOUTH

Cheryl Polk and David W. Willis, Co-Chairs
Erin Kellogg, Director

Cognitive, affective, and behavioral disorders incur high psychosocial and economic costs for the young people who experience them, their families, and the communities in which they live, study, and will work. The Forum for Children's Well-Being aims to inform a forward-looking agenda for building a stronger research and practice base around the development and implementation of programs, practices, and policies to promote the health and well-being of all children, including those with disabilities. Forum members engage in dialogue and foster partnerships to connect the prevention, treatment, and implementation sciences with the places where children are seen and cared for, including health care settings, schools, social service and child welfare agencies, and the juvenile justice system. This is a joint activity of HMD and the Division of Behavioral and Social Sciences and Education.

FORUM ON DRUG DISCOVERY, DEVELOPMENT, AND TRANSLATION

Robert Califf and Gregory Simon, Co-Chairs
Carolyn Shore, Director

The Forum on Drug Discovery, Development, and Translation was created in 2005 by the Board on Health Sciences Policy to provide a unique platform for dialogue and collaboration among thought leaders and stakeholders in government, academia, industry, foundations, and patient advocacy with an interest in improving the system of drug discovery, development, and translation. The forum brings together leaders from private sector sponsors of biomedical and clinical research, federal agencies sponsoring and regulating biomedical and clinical research, the academic community, and patients. The forum has identified four core components of translational science across this continuum that serve as thematic pillars to frame the forum's focus areas and activities: (1) Innovation and the Drug Development Enterprise; (2) Science Across the Drug Development Lifecycle (Basic, Translational, and Regulatory Sciences); (3) Clinical Trials and Clinical Product Development; and (4) Infrastructure and Workforce for Drug Discovery, Development, and Translation.

FORUM ON MEDICAL AND PUBLIC HEALTH PREPAREDNESS FOR DISASTERS AND EMERGENCIES

Suzet McKinney and Dan Hanfling, Co-Chairs
Scott Wollek and Lisa Brown, Co-Directors

The Forum on Medical and Public Health Preparedness for Disasters and Emergencies was established in September 2007 and provides a neutral venue for broad-ranging discussions that serve to facilitate coordination and cooperation among public and private stakeholders and enhance the nation's medical and public health preparedness for, response to, and recovery from disasters and other emergencies. The forum also serves as a catalyst for collaboration among voluntary public–private partners; raises attention and visibility to important preparedness, response, and recovery issues; explores new approaches for identifying and resolving challenges; sets the stage for future policy action; and elevates the understanding of medical and public health preparedness among the broader research, public policy, and practice communities.

FORUM ON MENTAL HEALTH AND SUBSTANCE USE DISORDERS

Margarita Alegria and Howard Goldman,
Co-Chairs
Alexandra Andrada, Director

The Forum on Mental Health and Substance Use Disorders, launched in early 2019, provides a structured environment and neutral venue to discuss data, policies, practices, and systems that affect the diagnosis and provision of care for people with mental health and substance use disorders. Forum participants engage in dialogue on a range of issues, such as facilitating access to care services in various settings; coordination and integration of services in primary and specialty health care delivery systems; advancing patient-centered care; promising strategies to translate knowledge to practice and to monitor implementation; innovative practices to facilitate and optimize data collection, integration, and use; and improving care spanning the medical, mental health and substance use disorder workforce and care delivery systems. Forum sponsors include federal agencies, health professional associations, addiction treatment providers, pharmaceutical manufacturers, and other public and private sector organizations.

FORUM ON MICROBIAL THREATS

Peter Daszak, Chair;
Kent E. Kester and Rima F. Khabbaz, Vice Chairs
Julie Liao, Director

The Forum on Microbial Threats was created in 1996 at the request of the U.S. Centers for Disease Control and Prevention and the National Institutes of Health to provide a structured opportunity for discussion and scrutiny of critical, and possibly contentious, scientific and policy issues related to infectious disease research and the prevention, detection, surveillance, and responses to emerging and reemerging threats in humans, plants, and animals as well as the microbiome in health and disease. The forum brings together leaders from government agencies, industry, academia, nonprofit and philanthropic organizations, facilitating cross-sector dialogue and collaboration through public debate and private consultation, to stimulate original thinking about the most pressing issues across the spectrum of microbial threats.

FORUM ON NEUROSCIENCE AND NERVOUS SYSTEM DISORDERS

Frances Jensen and John Krystal, Co-Chairs
Clare Stroud, Director

The Forum on Neuroscience and Nervous System Disorders was established in 2006 to provide a venue for building partnerships, addressing challenges, and highlighting emerging issues related to brain disorders, which are common, major causes of premature mortality, and, in aggregate, the largest cause of disability worldwide. The Forum's meetings bring together leaders from government, industry, academia, disease advocacy organizations, and other interested parties to examine significant—and sometimes contentious—issues concerning scientific opportunities, priority setting, and policies related to research on neuroscience and brain disorders; the development, regulation, and use of interventions for the nervous system; and related ethical, legal, and social implications.

FORUM ON REGENERATIVE MEDICINE

Timothy Coetzee and Katherine Tsokas, Co-Chairs
Sarah Beachy, Director

The Forum on Regenerative Medicine provides a convening mechanism for interested parties from academia, industry, government, patient/provider organizations, regulators, foundations, and others to discuss difficult issues in a neutral setting. The overall goal is to engage in dialogue that addresses the challenges facing the application of, and the opportunities for, regenerative medicine to improve health through the development of effective new therapies. The forum identifies potential barriers to scientific and therapeutic advances and discusses opportunities to facilitate more effective partnerships among key stakeholders. The forum examines the impact of current policies on the discovery, development, and translation of regenerative medicine therapies and addresses the unique challenges of identifying, validating, and bringing regenerative medicine applications to market. Ethical, legal, and social issues posed by regenerative medicine advances are also explored.

GLOBAL FORUM ON INNOVATION IN HEALTH PROFESSIONAL EDUCATION

Patrick DeLeon and Zohray Talib, Co-Chairs
Patricia Cuff, Director

The Global Forum on Innovation in Health Professional Education brings together stakeholders from multiple nations and professions to network, discuss, and illuminate issues within health professional education. Currently, there are over 55 appointed members to the Forum who are academic experts and health professionals representing 18 different disciplines from 8 developed and developing countries. Of these members, 46 are sponsors. Members of the forum gather twice a year to attend forum-sponsored events that address critical issues within the education to practice continuum. Topics for these activities have included discussions on financing health professional education; addressing the social determinants of health; and ensuring a mentally and physically stable health workforce.

NATIONAL CANCER POLICY FORUM

Edward Benz, Jr., Chair
Sharyl Nass and Erin Balogh, Co-Directors

The National Cancer Policy Forum serves as a trusted venue in which experts can work collaboratively to identify emerging high-priority policy issues in cancer research and care and to examine those issues through convening activities that promote discussion about opportunities for action. The forum provides a continual focus within the National Academies on cancer, addressing issues in science, clinical medicine, public health, and public policy that are relevant to the goal of reducing the cancer burden, through prevention and by improving the care and outcomes for those diagnosed with cancer. Forum activities inform stakeholders about critical policy issues through published proceedings and often inform consensus committee studies. The forum has members with a broad range of expertise in cancer, including patient advocates; clinicians; and basic, translational, and clinical scientists. Members represent patients, federal agencies, academia, professional organizations, nonprofits, and industry.

ROUNDTABLE ON ENVIRONMENTAL HEALTH SCIENCES, RESEARCH, AND MEDICINE

Kathleen Stratton, Director

The Roundtable on Environmental Health Sciences, Research, and Medicine was organized in 1988 to provide a mechanism for parties interested in environmental health from the academic, industrial, and federal research perspectives to meet and discuss sensitive and difficult environmental health issues of mutual interest in a neutral setting. Since its inception, the roundtable has addressed current and emerging issues in environmental health through discussions related to the state of the science, research gaps, and policy implications. The roundtable has moved toward an increasingly global perspective in its discussions on the UN Sustainable Development Goals, the relationship between trade and health, and corporate social responsibility in environmental health. The roundtable is currently focused on issues of domestic and international importance, such as climate change, sustainable drinking water, transportation-related energy use, and environmental health decision making.

ROUNDTABLE ON GENOMICS AND PRECISION HEALTH

W. Gregory Feero and Michelle Ann Penny,
Co-Chairs
Sarah Beachy, Director

The Roundtable on Genomics and Precision Health provides both a mechanism and a venue for interested parties from government, academia, industry, and other stakeholder groups to discuss global issues of mutual interest and concern regarding the translation of genomic research findings for medicine and health in a neutral setting. The purpose of the roundtable is to foster dialogue across sectors, as well as to illuminate and scrutinize critical scientific and policy issues in which roundtable engagement will help further the field. The roundtable explores strategies for improving health through the translation of genomics and genetics research findings into medicine, public health, education, and policy. Current areas of emphasis include precision therapeutics; clinical implementation of genomic medicine; health care disparities related to the introduction of a new technology; health information technology and digital health; use of genomic information for health care decision making; use of genomic information and data science to generate knowledge for clinical practice and research; education; and ethical, legal, and social issues.

ROUNDTABLE ON HEALTH LITERACY

Lawrence G. Smith, Chair
Rose M. Martinez, Acting Director

The Roundtable on Health Literacy envisions a society in which the demands of the health and health care systems respect and align with people's skills, abilities, and values. The mission of the roundtable is to inform, inspire, and activate a wide variety of stakeholders to support the development, implementation, and sharing of evidence-based health literacy practices and policies, with the goal of improving the health and well-being of all people. In order to accomplish its mission, the roundtable brings together leaders from academia, industry, government, foundations and associations, and patient and consumer groups to meet in a neutral setting in order to discuss complex issues regarding health literacy research, practice, and strategies for promoting health literacy through mechanisms and partnerships in both the public and the private sectors.

ROUNDTABLE ON OBESITY SOLUTIONS

Nicolaas Pronk, Chair; Christina Economos and
Ihuoma Eneli, Vice Chairs
Heather Cook, Director

The Roundtable on Obesity Solutions engages leadership from multiple sectors to solve the obesity crisis. Many sectors have recognized the need for action, and a number of groups have formed across the country to tackle specific aspects of the epidemic. Nonetheless, a significant gap exists between what we have learned about obesity solutions and the implementation of those solutions. Through meetings, public workshops, background papers, and innovation collaboratives, the roundtable provides a trusted venue for accelerating the discussion, development, and implementation of multisectoral collaborations and policy, as well as environmental and behavioral initiatives, that will reduce the prevalence and adverse consequences of obesity and eliminate obesity-related health disparities.

ROUNDTABLE ON POPULATION HEALTH IMPROVEMENT

Raymond J. Baxter and Kirsten Bibbins-Domingo,
Co-Chairs
Alina Baci, Director

The Roundtable on Population Health Improvement brings together multiple sectors and disciplines to broaden the national conversation about the factors that shape our health and to support cross-sector relationships and engagement to transform the conditions for health across US communities. By hosting workshops, spurring individually-authored papers, and organizing action collaboratives, the roundtable engages members and outside experts, practitioners, and stakeholders around models, best practices, and other evidence about actions that will contribute to building a strong, healthy, and productive society that cultivates human capital and equal opportunity. The roundtable has explored a range of connected issues including collaboration between the education and health sectors, partnerships between faith-based and health sector entities, the shifting definitions of value that are helping reorient investments in the health care and business sectors toward health and well-being, and the nature and needs of the population health workforce, broadly conceived.

ROUNDTABLE ON THE PROMOTION OF HEALTH EQUITY

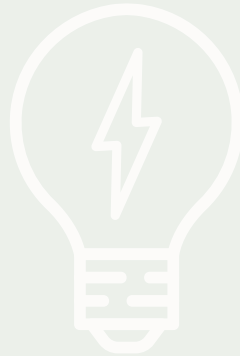
Kat Anderson, Director

The Roundtable on the Promotion of Health Equity serves as the conveners of the nation's experts in health disparities and health equity, with the goal of raising awareness and driving change. The roundtable promotes health equity and the elimination of health disparities by: (1) advancing the visibility and understanding of inequities in health and health care among racial and ethnic subpopulations; (2) amplifying research, policy, and community centered programs; and (3) catalyzing the emergence of new leaders, partners, and stakeholders.

ROUNDTABLE ON QUALITY CARE FOR PEOPLE WITH SERIOUS ILLNESS

Peggy Maguire and James A. Tulsky, Co-Chairs
Laurie Graig, Director

The Roundtable on Quality Care for People with Serious Illness, which launched in mid-2016, works to foster an ongoing dialogue about critical policy and research issues to accelerate and sustain progress in care for people of all ages with serious illness. Inspired by previous work at the National Academies, including the 2014 Institute of Medicine report *Dying in America: Improving Quality and Honoring Individual Preferences Near the End of Life*, the roundtable convenes key stakeholders to focus on five priority areas: (1) delivery of person-centered, family-oriented care; (2) communication and advance care planning; (3) professional education and development; (4) policies and payment systems; and (5) public education and engagement. Roundtable membership includes patient advocates, health care professional organizations, health care providers and insurers, foundations, federal agencies, researchers, and others interested in the topic.



MAKING A DIFFERENCE

Our convening activities bring together stakeholders from across the health spectrum, creating a communal environment to explore complex health topics and work toward shared understanding.



INFLUENCE

Policies & Programs

Our work can inform policy and legislation; programmatic planning, direction, and budgets; educational initiatives, such as curricula and training programs; and other activities.



FOSTER

Relationships & Collaboration

By bringing together a diverse group of participants around a particular topic, our activities foster new professional relationships, facilitate cross-sector collaborations, and enable professional development and networking, including the cultivation of new leaders.



INSPIRE

New Ideas & Shape the Field

Our work can advance and shape the field by framing issues and shining a light on important topics, and by generating novel approaches to overcome existing challenges, spurring progress and inspiring action.

Impact Highlights from our Roundtables and Forums



INFLUENCE

Policies & Programs

A January 2015 report issued by Senator Lamar Alexander and Senator Richard Burr, "Innovation for Healthier Americans: Identifying Opportunities for Meaningful Reform to Our Nation's Medical Product Discovery and Development," cited a workshop series of the Forum on Drug Discovery, Development, and Translation addressing clinical trials, which began in 2008, as a foundational resource in identifying and addressing the challenges facing the U.S. clinical trials enterprise. The report highlights concepts Congress might consider to better align public policy to support medical innovation and patient access to new medicines and technologies. One key concept explored in the report is the modernization of clinical trials.



FOSTER

Relationships & Collaboration

The Global Genomic Medicine Collaborative (G2MC), an action collaborative launched in 2014 under the auspices of the Roundtable on Genomics and Precision Health, was incorporated as a 501(c)3 nonprofit organization and obtained administrative support provided by the Global Alliance for Genomics and Health (GA4GH) between 2016 and 2017. During their time as an action collaborative, G2MC hosted three international meetings (in Washington DC, Singapore, and Athens), bringing together more than 25 countries to work towards creating a global toolbox for genomic medicine implementation; facilitating collaborations that could enable effective implementation; and discussing solutions for obstacles encountered during implementation. As a result of the collaborative's work, participants have published papers in journals such as Science Translational Medicine and began hosting virtual Grand Rounds on topics related to genetics education. G2MC currently has six working groups including Education; Evidence; IT/Bioinformatics, National Programs and Implementation; Pharmacogenomics, and Policy, and has hosted additional meetings to convene more than 40 countries in Durham, NC, and Cape Town, South Africa.



INSPIRE

New Ideas & Shape the Field

Nemours Children's Health System published a white paper, "State Quality Rating and Improvement Systems: Strategies to Support Achievement of Healthy Eating and Physical Activity Practices in Early Care and Education Settings," in June 2016, focusing on four strategies to prevent childhood obesity: healthy eating, breastfeeding, physical activity, and limited screen time (referred to as "HEPA"). The Roundtable on Obesity Solutions' Early Care and Education (ECE) Innovation Collaborative, whose members include researchers, practitioners, and policy makers with expertise in ECE or childhood obesity prevention, identified the need for the study and served as the advisory group for this project. Throughout the project, ECE IC members provided input on key deliverables during their quarterly meetings. The goal of the study was to measure the extent to which states with Quality Rating Improvement Systems are using specific implementation strategies to promote HEPA practices in ECE settings.

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BUILDING THE BIOWORKFORCE OF THE FUTURE

EXPANDING EQUITABLE PATHWAYS INTO
BIOTECHNOLOGY AND BIOMANUFACTURING JOBS

JUNE 2023



THE WHITE HOUSE
WASHINGTON

Building the Bioworkforce of the Future

Expanding Equitable Pathways into Biotechnology and Biomanufacturing Jobs

June 2023

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About This Report

In September 2022, President Biden signed [Executive Order \(E.O.\) 14081](#) on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy. The E.O. directs the United States Government to expand training and education opportunities for all Americans in biotechnology and biomanufacturing. Specifically, the E.O. directs that to support this objective, the Secretary of Commerce, the Secretary of Labor, the Secretary of Education, the Assistant to the President for Domestic Policy (APDP), the Director of the Office of Science and Technology Policy (OSTP), and the Director of the National Science Foundation (NSF) produce and make publicly available a plan to coordinate and use relevant federal education and training programs, while also recommending new efforts to promote multidisciplinary education programs. As directed in the E.O., this plan promotes the implementation of formal and informal education and training (such as opportunities at technical schools and certificate programs), career and technical education, and expanded career pathways into existing degree programs for biotechnology and biomanufacturing. This plan also includes a focused discussion of Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), and Minority Serving Institutions (MSIs) and the extent to which agencies can use existing statutory authorities to promote racial and gender equity and support underserved communities, consistent with the policy established in [Executive Order 13985](#). Finally, the E.O. directs this plan to account for funds appropriated in prior fiscal years and proposed funds in the President’s Budget.

Stakeholder Consultation

This plan, “Building the Bioworkforce of the Future,” builds upon recent reports and assessments of the workforce needs for biotechnology and biomanufacturing and input from stakeholders across government, business, educational institutions, and community-based organizations. Public input was collected through listening sessions and an OSTP-led Request for Information posted in December 2022.¹ Input from this outreach informed the recommendations and action steps.

Interagency Working Group

The interagency working group included representatives from:

- Domestic Policy Council (DPC) (co-chair)
- Office of Science and Technology Policy (OSTP) (co-chair)
- Gender Policy Council (GPC)
- National Economic Council (NEC)
- Office of the First Lady (OFL)

¹ [Request for Information; National Biotechnology and Biomanufacturing Initiative](#)

- Department of Agriculture (USDA)
- Department of Commerce (DOC)
- Department of Defense (DOD)
- Department of Education (ED)
- Department of Health and Human Services (HHS)
- Department of Labor (DOL)
- National Science Foundation (NSF)

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Executive Summary

Global industry is on the cusp of a revolution powered by biotechnology² and biomanufacturing.³ By harnessing the power of biotechnology and biomanufacturing, we can produce almost anything that we use in our day-to-day lives—from medicines to fuels to plastics. We can program microorganisms to make specialty chemicals and compounds that can replace fossil fuels with more climate-friendly alternatives. We can develop new treatments for debilitating diseases like cancer, diabetes, autoimmune disorders, and rare diseases. We can develop improved crops and animal varieties that produce food, fuel, and fiber with less resources. These are but a few examples of the innovation and potential of biomanufacturing powered by advanced biotechnology.

The United States is a leader in this growing “bioeconomy.” The President’s Investing in America agenda, including the American Rescue Plan, the Bipartisan Infrastructure Law, the CHIPS and Science Act, and the Inflation Reduction Act, are helping to maintain the nation’s leadership. Since the beginning of the Biden-Harris Administration, private companies have announced \$470 billion in manufacturing and clean energy investments—including in biomanufacturing. But we need to continue to act to remain competitive as other countries are positioning themselves to become the world’s resource for biotechnology solutions and bio-based products.

That is why President Biden signed the Executive Order (E.O. 14081)⁴ that launched a National Biotechnology and Biomanufacturing Initiative in September 2022. This initiative aims to ensure that cutting-edge products resulting from biotechnology *invented in* the United States are *manufactured in* the United States. By doing so, we will create jobs at home, build stronger supply chains, and lower prices for American families.

However, this initiative will only succeed if our nation has a skilled and diverse workforce to meet the needs of the growing bioeconomy today and into the future. Studies and stakeholder consultations demonstrate: 1) consistent growth in the bioeconomy; 2) increasing demand for talent for many bioeconomy occupations requiring a wide range of skills and post-secondary credentials—including many that do not require a four-year college degree; and 3) a need to remove barriers for students and workers—particularly those who have been underrepresented in the bioeconomy—to prepare for, secure, and advance in good jobs and careers in biotechnology and biomanufacturing. Research and consultations also emphasize that to build a skilled and

² For this report, biotechnology is defined as technology that applies to and/or is enabled by life sciences innovation or product development.

³ Biomanufacturing is the use of biological systems to produce goods and services at commercial scale. Both definitions are derived from the NIST Bioeconomy Lexicon (<https://www.nist.gov/bioscience/nist-bioeconomy-lexicon>). See more definitions in the Appendix.

⁴ <https://www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-advancing-biotechnology-and-biomanufacturing-innovation-for-a-sustainable-safe-and-secure-american-bioeconomy/>

diverse workforce for the bioeconomy, collaboration across government, business, unions, community-based organizations, community colleges, and other stakeholders is essential. No one entity can meet this need alone.

This report—developed by the Office of Science and Technology Policy (OSTP), Domestic Policy Council (DPC), Department of Commerce (DOC), Department of Labor (DOL), Department of Education (ED), and the National Science Foundation (NSF) in collaboration with other agencies—outlines a plan for expanding education and training opportunities for biotechnology and biomanufacturing in the United States. It refers to the broad set of occupations in biotechnology and biomanufacturing as the “bioworkforce.”

The goals of the plan are to ensure that:

1. U.S. education and training programs can meet the rapidly changing skill needs for good jobs and careers in the bioeconomy and increasing demand for workers;
2. A diverse pipeline of workers, including women, people of color, people living in rural communities, individuals with disabilities, justice-involved individuals, individuals returning to the workforce, and others underrepresented in emerging fields, can prepare for, secure, and advance in good bioeconomy jobs and careers;
3. Federal resources are directed at evidence-based education and training approaches that advance equity.

This plan presents the following core recommendations, along with select new and ongoing actions that the Administration is taking and will take—in collaboration with employers; unions; state, local and Tribal governments; high schools; institutions of higher education; industry associations; and other stakeholders.

1. Expand and diversify the talent pool for biotechnology and biomanufacturing jobs and careers to promote innovation and advance equity.
2. Strengthen worker-centered sector strategies and other partnerships between employers, labor organizations, community colleges, and other training providers to grow and diversify the bioworkforce.
3. Develop and rigorously evaluate innovative approaches to education and training for biotechnology and biomanufacturing jobs and careers, scaling and promoting those found to be most effective.
4. Partner with state, local, and Tribal governments, education and training providers, bioscience associations, unions and other worker-serving organizations, and other stakeholders to raise awareness about the promise and potential of careers in the bioworkforce.
5. Improve data and analytic capacity and cross-sector collaboration to advance equity and support effective workforce development—including the development of industry-recognized credentials and competency models.

Over the coming months and years, the interagency working group—led by OSTP, DPC, ED, DOL, and DOC—will continue to push this work forward—including identifying and

undertaking new actions in support of this plan's goals as opportunities arise. Consistent with the E.O., the group will provide a report on progress to the President within the next two years.

Bioworkforce State of Play

The bioeconomy comprises a wide range of industries—including biopharmaceuticals, medical diagnostics, crop and livestock genetics, and other life science research and development endeavors. Innovations and manufacturing in these industries touch on a variety of areas of national importance including climate change; energy production, utilization and storage; food security; supply chain resilience; public health; rural economic development; and national and economic security. Failure to sufficiently invest in the bioworkforce carries great risk to the broader bioeconomy and related industries. The President’s Council of Advisors on Science and Technology recently found that “U.S. biomanufacturing capacity is not keeping pace in terms of both the workforce needed to meet the demand to scale up new bioproducts and the biomanufacturing infrastructure necessary to move products to pilot scale production. This has led some entrepreneurs and companies to move to Europe or Asia to begin scaling up production.”⁵ Furthermore, a 2020 National Academies of Science, Engineering, and Medicine report found that “insufficient federal funding for U.S. universities and bioeconomy training programs has the potential to diminish the ability to produce and retain a skilled technical workforce.” Furthermore, it highlighted that increased federal support for science, technology, engineering, and mathematics (STEM) education and partnerships between community colleges and industry aimed at growing a technically skilled workforce could create employment opportunities in U.S. cities and regions, including rural communities, whose traditional employment opportunities may have changed.⁶

There is a strong and growing American bioeconomy—as demonstrated by reports^{7,8,9,10} and stakeholder consultations, especially in state and regional hubs, and the President’s Investing in America agenda is spurring further investment in biomanufacturing. With this growing bioeconomy, there is an increasing demand for talent to fill occupations requiring a wide range of skills and postsecondary credentials—from scientists to engineers to laboratory managers to manufacturing technicians. For bioworkforce occupations that may require some college, but less

⁵ Report to the President: Biomanufacturing to Advance the Bioeconomy. https://www.whitehouse.gov/wp-content/uploads/2022/12/PCAST_Biomanufacturing-Report_Dec2022.pdf. December 2022.

⁶ National Academies of Sciences, Engineering, and Medicine. 2020. Safeguarding the Bioeconomy. <https://nap.nationalacademies.org/download/25525>. Washington, D.C.: The National Academies Press. <https://doi.org/10.17226/25525>

⁷ <https://readymag.com/MassBio/2022IndustrySnapshot/>

⁸ https://go.bio.org/rs/490-EHZ-999/images/TEconomy_BIO_2022_Report.pdf?_ga=2.175760546.1427577292.1676210229-2134826967.1667953931

⁹ <https://cabiotech.org/wp-content/uploads/2023/01/2022-California-Economic-Impact-Report-Biocom.pdf>

¹⁰ <https://califescienceworkforcetrends.org/wp-content/uploads/2021/10/2021-CA-Life-Science-Workforce-Trends-report.pdf>

than a four-year degree—such as biological technicians, manufacturing production technicians, and food science technicians—employers are hiring students from community college programs before they even complete their credentials.¹¹ This demonstrates both the employers’ need for talent, as well as the need to ensure students can both take advantage of job opportunities and complete education and training programs. Community colleges in Maryland, Texas, and California reported that they could not train students fast enough to meet employer demand.¹²

Furthermore, investments by the Biden-Harris Administration are likely to contribute to the growing need for a strong bioworkforce. For example, to support the improvement and expansion of domestic biomanufacturing production capacity and processes, the Department of Defense (DOD) has secured \$1.2 billion in new investments over five years to build, innovate, and transition biomanufacturing facilities and products.¹³ This should catalyze a domestic supply of facilities and capabilities and create an increased need for skilled talent. Additionally, the U.S. Economic Development Administration (EDA)’s Build Back Better program has invested over \$104 million to support the growth of biotechnology and biomanufacturing across the United States.¹⁴

More work is needed to understand the job, skill, and credential needs for the bioworkforce, particularly at the state and regional level. The chart below outlines key sectors within the bioeconomy and sample occupations with each sector.

Table 1. Major Sectors within the Bioeconomy and Selected Occupations

Biomedical	Agricultural	Bioindustrial
This includes any medical products or services resulting from research and development, or innovation, in the life sciences.	This includes sectors focused on expanding the production of food, fiber, biomass, and other agricultural products through the use of biotechnology; marker-assisted breeding and genetic engineering to develop plants, animals, or microorganisms; informatics databases for breeding applications or enhanced agricultural productivity; and use of biomass in downstream bioprocessing or fermentation.	This includes chemicals, materials, or other goods and services produced using biological systems. This can include recombinant DNA technology or other novel bio-based production methods.

¹¹ <https://coecccc.net/california/2022/10/biotechnology-5/>; Working group stakeholder consultations between November 2022 and February 2023.

¹² Working group consultations.

¹³ <https://www.defense.gov/News/Releases/Release/Article/3157504/new-biotechnology-executive-order-will-advance-dod-biotechnology-initiatives-fo/>

¹⁴ <https://www.eda.gov/sites/default/files/2022-09/Build-Back-Better-Announcement-Awardee-Fact-Sheet.pdf>

Examples include: - Pharmaceutical products like vaccines - Medical devices	Examples include: - Genetically modified crops and animals - Improving plant genetics for increasing biomass - Food ingredients produced with precision fermentation	Examples include: - Biobased chemicals - Biofuels - Biobased plastics
Sample occupations include: - Scientist - Biomedical engineer - Biomedical technician - Process engineer - Microbiologist - Medical manufacturing technician - Fermentation engineer	Sample occupations include: - Plant and animal scientists and geneticist - Food scientist - Soil and plant scientist - Field technician - Laboratory assistant - Fermentation engineer	Sample occupations include: - Biochemist - Biofuels technology and product development manager - Fermentation engineer - Research engineer - Operations manager
Cross-Cutting Tools, Kits, and Services All of the sectors above require a wide range of tools, kits, and services that support or enable the advancement of biotechnology and biomanufacturing. Examples include: - Software and databases - Specialized equipment or instruments (e.g., robotic liquid-handlers, mass spectrometers, and DNA sequencers) - Patenting support Sample occupations include: - Computer systems analyst - Software developer - Data scientist - Machine learning engineer - Patent lawyer - Bioethicist - Computational genomics researcher		

Sources: Interagency working group and stakeholder consultations; National Academies of Sciences, Engineering, and Mathematics, *Safeguarding the Bioeconomy*, Washington, D.C. 2020

Biden-Harris Administration Investments to Date

The Administration is already taking significant steps to help workers—particularly women, people of color, individuals who live in rural communities, individuals with disabilities, justice-involved individuals, individuals returning to the workforce, and other underserved populations—equitably access good jobs and advance in careers in growing industries like biotechnology and biomanufacturing. In 2022 alone, the Administration invested more than \$21 billion in training and workforce development programs—including through Pell Grants, Registered Apprenticeships, career and technical education (CTE), and the public workforce system. Many of these programs already support, or can be leveraged to support, education and training for the bioworkforce—including programs delivered by community colleges. Furthermore, dedicated education and training programs have sought to develop, scale, and expand education and training for the bioworkforce. These include NSF’s Advanced Technological Education (ATE)¹⁵ and Experiential Learning for Emerging and Novel Technologies (ExLENT)¹⁶ programs and education and workforce development efforts undertaken by Manufacturing USA institutes connected to the bioeconomy—BioMADE,¹⁷ NIIMBL,¹⁸ and BioFabUSA.¹⁹ (See Appendix C for more.) Furthermore, as discussed in the recommendations, the Administration has proposed significant additional education and training investments that would strengthen and expand the bioworkforce—including historic increases in Pell Grants, expanding free community college, and increases for career-connected learning and CTE.

¹⁵ <https://beta.nsf.gov/funding/opportunities/advanced-technological-education-ate>

¹⁶ <https://beta.nsf.gov/funding/opportunities/experiential-learning-emerging-novel-technologies>

¹⁷ <https://www.biomade.org/>

¹⁸ <https://niimbl.force.com/s/>

¹⁹ <https://www.armiusa.org/>

Recommendations and Action Steps

This section outlines forward-looking recommendations for expanding education and training opportunities for biotechnology and biomanufacturing—as well as key actions that federal agencies will take over the next two years to advance these goals, as called for in Executive Order 14081. All five core recommendations highlight the critical need for and call for partnership with a wide range of stakeholders—including employers; state, local, and Tribal governments; unions; and other organizations—to build and strengthen the bioworkforce. Industry, in particular, has an important role to play in the recommendations outlined below. Additionally, many of these activities may be complemented by inbound education and training exchange opportunities that build the global perspective and networks of U.S. STEM companies (e.g., the Early Career STEM Research Initiative); outbound exchanges that allow U.S. scientists in bioeconomy-relevant fields to further their skills abroad (e.g., Fulbright Fellowships); and through international engagement with foreign partners to share best practices towards growing a diverse domestic bioeconomy workforce.

Recommendation #1: Expand and diversify the talent pool for biotechnology and biomanufacturing jobs and careers to promote innovation and advance equity.

To meet the needs of critical and emerging industries like biotechnology and biomanufacturing, our nation must channel the skills and talents of all students and workers—especially those who have been underrepresented in these growing sectors, such as women, people of color, individuals with disabilities, persons who live in rural communities, veterans, and justice-involved individuals. An analysis of a sample of key biotechnology and biomanufacturing occupations by DOL finds that workers in the selected occupations are about 55 percent male and 75 percent white.²⁰ An industry analysis found somewhat greater representation by women and people of color in the biotechnology industry overall than DOL’s analysis. However, this industry analysis also found executive teams to be far less diverse by gender, race, and ethnicity than the workforce as a whole.²¹

Research and stakeholder consultations highlighted a wide range of strategies to help a more diverse pool of students and workers prepare for, secure, and advance in good jobs and careers in the bioworkforce. To build a diverse workforce, employers must create quality jobs. Through DOL’s Good Jobs Initiative, the Administration is collaborating with employers, unions, state and local governments, and others to ensure that all jobs—including those in growing industries

²⁰ Analysis by Department of Labor, Employment and Training Administration.

²¹ https://www.bio.org/sites/default/files/2022-06/261734_BIO_22_DEI_Report_P4.pdf

like biotechnology and biomanufacturing—align with the Good Jobs Principles²² developed by DOL and DOC.

Furthermore, expanding and diversifying the bioworkforce requires increasing support for Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), and Minority Serving Institutions (MSIs)²³ and the students they serve. MSIs include Hispanic-Serving Institutions, Alaska Native-Serving Institution, Native Hawaiian-Serving Institutions, Predominantly Black Institutions, Asian American and Native American Pacific Islander-Serving Institutions, and Native American-Serving Nontribal Institutions. These colleges and universities already educate and train a diverse pool of students, including women of color and people of color with disabilities, to fill critical roles in the bioworkforce—including biomanufacturing technicians, bioengineers, plant and animal scientists, and food scientists. But they face barriers to expanding their programs in these fields—including the high cost of building out the cutting-edge labs and other infrastructure required.

NSF, DOD, ED, USDA, HHS, and other agencies support a range of programs and initiatives targeted at helping HBCUs, TCUs, and MSIs: 1) strengthen their research and development (R&D) programs, and 2) build partnerships with employers and other partners to ensure curricula are aligned to industry needs and students have clear career pathways into the bioworkforce, including through mentoring, internship, and Registered Apprenticeship programs. (See Appendix C.) These efforts can be expanded by providing additional resources for Manufacturing USA institutes and public-private partnerships to support HBCUs, TCUs, and MSIs, with an emphasis on providing hands-on biomanufacturing experience to underrepresented and underserved undergraduate students. Additionally, research partnerships between HBCUs, TCUs, and MSIs and universities with R1 status²⁴ can help to build the capacity of HBCUs, TCUs, and MSIs and can expand opportunities for students from underrepresented and underserved populations—provided these partnerships fully engage research and education across the institutions.

Additionally, providing supportive services, expanding skills-based hiring, and supporting mentoring programs are all part of a comprehensive approach to diversifying and expanding the bioworkforce talent pool. Supportive services, like child care, mental health supports, transportation, and emergency aid, can help all students and workers—especially women, people of color, people with disabilities, individuals returning to the workforce, and others who are underrepresented in the bioworkforce—have equitable opportunities to prepare for, secure and advance in good jobs and careers in the bioworkforce. Women, in particular, are more likely to stay in education and training programs and the bioworkforce overall when they have access to affordable and reliable child care. Many jobs in the bioworkforce do not require a four-year degree, and removing degree requirements from job postings, where unnecessary, and instead

²² <https://www.dol.gov/general/good-jobs/principles>

²³ <https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html>

²⁴ https://carnegieclassifications.acenet.edu/classification_descriptions/basic.php

focusing on the skills necessary to perform the job, can help reduce barriers to bioeconomy jobs for workers without a bachelor's degree. These strategies can also remove bias from the hiring process, ensuring equal opportunities for qualified applicants—especially women, people of color, individuals with disabilities, and others who traditionally have been underrepresented in the bioworkforce. Furthermore, mentors, especially those of the same gender or race and ethnicity as their mentees, can increase their mentees' confidence and skill-building, supporting them to stay in a job and advance in their careers. Mentorship has been shown to be a particularly important strategy for supporting women in non-traditional occupations, such as the bioworkforce.²⁵

Furthermore, federal agencies, employers, education and training providers, and others must partner to ensure work environments are inclusive and accessible, and design education and training programs to allow a wide range of learners and workers—including youth and individuals with disabilities—to succeed.

Finally, as further addressed under recommendation #4, increasing the diversity of the bioworkforce in an equitable and inclusive way will require increasing awareness and creating programs for communities across the United States—particularly for individuals from underserved communities and rural areas.

Key sub-recommendations and select action steps to expand and diversify the bioworkforce include:

1. Support HBCUs, TCUs, and MSIs to expand their programs and provide support for more of their students to move into biotechnology and biomanufacturing careers.

- a. Action:** Several NSF programs are enhancing the research capacity of HBCUs, TCUs, and other MSIs, supporting their students, and building pathways into the skilled technical workforce through programs at these institutions. NSF's Centers of Research Excellence in Science and Technology (CREST) program provides support to enhance the research capabilities of HBCUs, TCUs, and MSIs through the establishment of centers that effectively integrate education and research. NSF's Historically Black Colleges and Universities-Undergraduate Program (HBCU-UP) works to establish research capacity of faculty to strengthen STEM undergraduate education and research, and NSF's HBCU-RISE program supports the expansion of institutional research capacity as well as the successful training of doctoral students, especially those from groups underrepresented in STEM. In addition, the HBCU-Excellence in Research (HBCU-EiR) program provides opportunities for both public and private HBCUs, particularly for those which have not been successful in larger NSF Research & Related Activities competitions, to stimulate sustainable improvement in their research and development capacity by establishing stronger

²⁵ <https://www.dol.gov/sites/dolgov/files/WB/media/BearingTheCostReport.pdf>;
https://wdr.doleta.gov/research/FullText_Documents/ETAOP_2012_10.pdf

connections between researchers at those HBCUs and NSF's research programs. NSF's Enabling Partnerships to Increase Innovation Capacity (EPIIC) and Accelerating Research Translation (ART) programs are providing support to emerging research institutions to grow their innovation and translational research portfolios. Finally, NSF's ATE program supports both national centers and projects that support the education of the skilled technical workforce across a range of advanced technologies, including biotechnology and biomanufacturing. Twenty-three percent of active awards across the entire ATE portfolio are at HBCUs, TCUs, and MSIs.²⁶ Projects include recruitment strategies, micro-credentials and stackable certificates, and program structures offered on evenings and weekends to support students more effectively.

- b. Action:** The National Institutes of Health (NIH) is taking several actions to support HBCUs, TCUs, and MSIs and increase the participation of women, people of color, and other underrepresented groups in biomedical and related research. The agency recently issued its first ever Notice of Special Interest encouraging small businesses to partner with HBCUs, TCUs, and MSIs in upcoming Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) applications. Partnerships through these programs—the largest source of early-stage capital for the life sciences in the United States (over \$1.2 billion every year)—offer the opportunity for students, faculty, and staff to engage in hands-on, practical biomedical research and development. Additionally, NIH is expanding the Institutional Development Award Networks of Biomedical Research Excellence (INBRE) to support new statewide networks of higher education and research institutions, including HBCUs, in historically underfunded regions to build biomedical research capacity over the next eight years. These networks will facilitate faculty research and research mentoring, student participation in research, and enhancement of institutional research infrastructure.²⁷ Furthermore, NIH established a new program to develop a diverse pool of highly trained clinician-scientist biomedical research leaders by providing support for training at HBCUs, TCUs, and other institutions in historically underfunded states over the next several years²⁸ and provides additional funding²⁹ to SBIR and STTR grants to improve the diversity of the research workforce and to increase the participation of women and socially and economically disadvantaged individuals in small businesses by recruiting and supporting students, postdocs, and eligible investigators from groups that are underrepresented in health-related research. Additionally, NIH supports the Data and Technology Advancement (DATA) National Service Scholar Program to bring to NIH a two-year diverse cohort of experienced

²⁶ ATE annual survey, 2021 <https://evalu-ate.org/>

²⁷ <https://grants.nih.gov/grants/guide/pa-files/PA-23-100.html>

²⁸ <https://grants.nih.gov/grants/guide/pa-files/PA-23-030.html>

²⁹ <https://seed.nih.gov/support-for-small-businesses/supplemental-funding-to-diversify-the-entrepreneurial-workforce>

data and computer scientists and engineers to tackle challenging biomedical data problems with the potential for substantial public health impact.

- c. **Action:** The Department of Energy (DOE) Bioenergy Technologies Office (BETO) is establishing and expanding research partnerships between HBCUs, TCUs, and MSIs and DOE National Laboratories. BETO is partnering with the Minority Serving Institution STEM Research & Development Consortium (MSRDC) and its member institutions to develop collaborative R&D projects that pair HBCUs, TCUs and MSIs with relevant, world-class R&D capabilities and facilities at DOE National Laboratories to focus on biomass and algal feedstock systems and catalyst development for biofuel production. BETO has successfully established partnerships with Tuskegee University, North Carolina Agricultural and Technical College, Florida A&M University, and the University of Puerto Rico.
 - d. **Action:** USDA has a history of supporting MSIs and increasing diversity in the agriculture and forestry sciences. USDA has specific programs to fund research, education and Extension at 1890's and 1994's Land Grant Universities (LGUs), Alaska Native-serving institutions and Native Hawaiian-serving institutions, and Hispanic Serving Institutions. In 2023, USDA launched its NEXTGEN program which aims to cultivate the next generation of diverse food and agriculture professionals and spur rural economic development. NEXTGEN supports workforce opportunities for students from MSIs to take part in meaningful paid internships, fellowships, job opportunity matching, and receive scholarship support. In addition, USDA supports faculty at 1890s LGUs to take part in sabbatical opportunities at Agricultural Research Service (ARS) labs through the 1890s Faculty Sabbatical Research Program. The program allows faculty to take advantage of ARS resources in addition to their university resources to advance their research.
- 2. Provide supportive and wrap-around services, including child care, housing, and transportation assistance, to help students and workers stay in and complete education and training programs.**
- a. **Action:** Federal agencies, including DOL, ED, and DOC,³⁰ are seeking to ensure, where allowable, that education, training, and other investments provide students and workers with critical supportive and wrap-around services.
 - b. **Action:** NIH is helping institutions foster family-friendly environments for the biomedical research workforce, including students and trainees, through its policies and funding opportunities. Most NIH grant awards allow for reimbursement of costs incurred for child care, parental leave, or additional technical support. Additional family-friendly initiatives include funding to facilitate workforce re-entry for researchers who have taken time off to care for children or attend to other responsibilities and want to bring their research skills and knowledge up-to-date.³¹

³⁰ <https://www.commerce.gov/issues/workforce-development>

³¹ <https://grants.nih.gov/grants/policy/nih-family-friendly-initiative.htm>

- c. **Action:** The Child Care Access Means Parents in School (CCAMPIS) program makes competitive grants to institutions of higher education to support the participation of parents from low-income backgrounds in postsecondary education through the provision of campus-based childcare services. In FY 2023, ED is conducting a \$13.6 million competition for new awards. The FY 2024 President's Budget requests a \$20 million increase for CCAMPIS to make additional awards in FY 2024.
 - d. **Action:** The Basic Needs for Postsecondary Students program provides competitive grants to eligible institutions of higher education to support programs that address the basic needs of students, including housing, food, transportation, childcare, technology, and access to physical and mental health services and to report on practices that improve outcomes for students. In FY 2023, ED will make \$10 million in awards. Building off of the Basic Needs for Postsecondary Student program, the proposed new Systemwide Holistic Student Supports program would provide competitive grants to state agencies, systems or institutions of higher education, or other large consortia of institutions of higher education to improve the systems and structures necessary to simplify and expand student access to federal, state, Tribal, and local benefits beyond Title IV student aid programs, such as the Supplemental Nutrition Assistance Program and the Housing Choice Voucher program, and to improve coordination of critical services such as mental health care and child care. For FY 2024, the President's Budget requests \$30 million for the new program.
 - e. **Action:** NSF has a long-standing [Career-Life Balance Initiative](#) that is designed to clear the obstacles from the STEM Career-Life pathways leading from graduate education through to full professor. NSF policy also permits reimbursements for dependent care travel costs and conference attendance costs. Other dependent care expenses are also allowed provided they are charged through the application of fringe benefits or indirect costs.
3. **Encourage employers to adopt skills-based hiring.**
- a. **Action:** The Administration is seeking to build momentum for skills-based hiring by expanding this approach in federal government hiring, including, as appropriate, outreach to community-based and training organizations to ensure a diverse pool of potential applicants. Most federal jobs do not require a college degree, unless there is an affirmative need for it (e.g., occupational licensing requirements). Through [E.O. 13932](#): Modernizing and Reforming the Assessment and Hiring of Federal Job Candidates and follow up [implementation guidance](#) and support from the Office of Personnel Management (OPM), agencies have begun transitioning to a skills-based approach in select occupations and plan to accelerate this progress in the year ahead.
 - b. **Action:** The President's FY 2024 Budget continues to support a proposal from DOL and DOC to provide technical assistance for private sector employers to adopt skills-based hiring practices.

4. Ensure pathways into the bioworkforce include clear onramps for all young workers, especially opportunities for youth who may be disconnected from the formal education system.

- a. Action:** ED, with support from DOL and DOC, is leading a career and college pathways initiative, which seeks to engage all high school students in career-connected learning in high-growth, high-demand, high-wage sectors, such as the bioworkforce. By making learning relevant and innovative through real-world, accessible, and hands-on learning across high school and community college, youth who may be disconnected or only marginally connected to formal education and training will become inspired and re-engaged to pursue these critical careers.
- b. Action:** DOL will work to build strong career pathway strategies that include recruiting and training partnerships with public workforce system programs including local Workforce Innovation and Opportunity Act (WIOA) (Pub. L. 113-128) youth programs, Job Corps Centers, reentry employment opportunity programs, and YouthBuild programs. These programs will prioritize offering paid work experiences for young people including but not limited to pre-apprenticeship and youth apprenticeship programs and on-the-job training. DOL is also supporting a [Youth Systems Building Academy](#) to offer technical assistance to local community teams, workforce agencies, and other critical partners to create no-wrong-door approaches to offering workforce development opportunities and wraparound services to young people, especially opportunity youth. Tools and resources developed during the Academy will be accessible for participants with disabilities, and shared broadly.
- c. Action:** USDA partners with the LGU system to bring science education to local and regional communities, especially in rural areas. For example, USDA works with the Cooperative Extension System (CES) to engage local and regional communities with education and scientific information from the LGUs with a focus on using practical science information to support agricultural producers, small business owners, consumers, families, and young people. In addition, USDA partners with 4-H, the youth outreach program from LGUs, to engage youth in professional development, and hands on education. Both the CES and 4H provide opportunities to engage rural youth communities in the newest agriculture and forestry science, foster an interest in agriculture biotechnology and biomanufacturing, and inform youth on possible career paths to support the bioeconomy. The new USDA NEXTGEN program also provides opportunities for students from MSIs to learn about job opportunities in the agriculture biotechnology and biomanufacturing sectors, as part of the broader agricultural workforce.
- d. Action:** NSF has launched ExLENT Program, a joint effort of the Directorate for Education and Human Resources (EDU) and the newly established Directorate for Technology, Innovation and Partnerships (TIP) that seeks to support experiential learning opportunities for individuals from diverse professional and educational backgrounds that will increase access to, and interest in, career pathways in emerging technology fields including biotechnology.

5. Promote diversity and inclusion by encouraging mentorship and cohort-based programs—especially for biomanufacturing occupations and for senior and leadership positions.

- a. Action:** Agencies can support mentoring programs with a comprehensive approach, including effective engagement role-models and audience specific messaging, support from a strong peer cohort and committed senior mentors, and empowerment by addressing social and structural barriers to advancement through workplace policy changes.

6. Design education and training programs in a way that allows a wide range of students and workers to succeed.

- a. Action:** Federal agencies and other stakeholders can incorporate the principles of the Universal Design for Learning framework³² into education and training programs to help ensure they are inclusive. These practices are beneficial for people with disabilities, particularly individuals who are neurodiverse. For example, the prevalence of autism spectrum disorder, one kind of neurodiversity, is estimated to be one in 44 in 2021. Young adults on the autism spectrum have the lowest rate of employment compared to their peers with other disability types. In many cases, employers have found that with relatively small changes, many individuals who are neurodiverse are able to fully participate in the workforce.
- b. Action:** NSF’s ATE program supports projects focused on supporting students on the autism spectrum including Stairway to STEM³³ and Expanding a Multi-skilled STEM Technician Pipeline to Meet Industry Needs.

7. Ensure programs and working environments are inclusive and accessible.

- a. Action:** Agencies and other stakeholders will assess their technology systems, applications, and websites to ensure they meet Section 508 accessibility standards, including to ensure that materials are accessible to individuals with blindness or deafness, or who are vision- or hearing-impaired. In addition, agencies and other stakeholders should examine the accessibility of their research, lab, training, and manufacturing environments. These practices should include provisions to meet Section 504 for timely reasonable accommodations and supports for people with disabilities to further enable student success.
- b. Action:** Agencies will assess their workplace policies, practices, and culture to ensure that they support advancing diversity, equity, accessibility, and inclusion in the Federal workforce, recognizing that the United States is at its strongest when our Nation’s public servants reflect the full diversity of the American people. Consistent with Executive Order 14035, agencies and other federal stakeholders should ensure that their education and training programs reflect the full understanding of the systemic and institutional racism and bias impacting underserved communities, and

³² <https://www.cast.org/>

³³ <https://www.stairwaytostem.org/>

build programs to promote safe, respectful, and inclusive workplaces. These efforts will help to ensure greater recruitment and retention of individuals from underserved communities in the bioworkforce.

8. Strengthen the bioworkforce by welcoming and retaining foreign-born talent.

- a. Action:** Consistent with the President’s order to remove barriers to legal immigration under [Executive Order 14012](#), Restoring Faith in Our Legal Immigration Systems and Strengthening Integration and Inclusion Efforts for New Americans, agencies should, to the extent possible, align immigration policies and procedures to welcome and retain foreign-born talent with STEM expertise into the nation’s bioworkforce. This includes foreign-born advanced STEM degree holders who are trained in the United States and are positioned to contribute to the bioworkforce.

Recommendation #2: Strengthen worker-centered sector strategies and other partnerships between employers, labor organizations, community colleges, and other training providers to grow and diversify the bioworkforce.

Regional hubs for biotechnology and biomanufacturing exist in states like California, Massachusetts, and North Carolina, where state governments have provided multi-year focused investments and incentives to grow the industry and support the workforce. Growth in biotechnology and biomanufacturing is also spreading to many other states and regions. Worker-centered sector strategies can effectively address regional workforce needs and help diverse groups of workers advance in their careers—leading to sustained earnings gains (11-40 percent).³⁴ This systems-level approach to equitable workforce development aligns employer demand for a skilled workforce with available workers by bringing together a range of key partners—including employers, unions and worker-serving organizations, community colleges, high schools, community-based organizations, and other key stakeholders. These partners collaborate to analyze their regional labor market, anticipate future job and skill needs, develop and implement education and training programs, and recruit and support a diverse pool of workers. A best practice for multi-sector partnerships is to have a trusted organization coordinate the partnership, like a local or state workforce board. Furthermore, these efforts can be targeted towards priority areas across the country to support inclusive growth and regional educational investment, including economic development in rural communities³⁵

The Administration is prioritizing investment and support for worker-centered sector strategies. For example, through the American Rescue Plan’s Good Jobs Challenge,³⁶ DOC invested \$500

³⁴ https://scholar.harvard.edu/files/lkatz/files/krhs_sectoral_jole_final.pdf

³⁵ <https://www.schmidtfutures.com/our-work/task-force-on-synthetic-biology-and-the-bioeconomy/>

³⁶ <https://www.eda.gov/funding/programs/american-rescue-plan/good-jobs-challenge#:~:text=The%20Good%20Jobs%20Challenge%20highlights,achieve%20economic%20mobility%20and%20security.>

million in workforce development aligned to regional economic needs—with grantees in Texas³⁷ and Connecticut³⁸ focusing on the bioworkforce.

Key sub-recommendations and select action steps to advance worker-centered sector strategies include:

1. Expand funding for worker-centered sector strategies.

- a. Action:** The President’s FY 2024 Budget proposes \$300 million to support worker-centered sector strategies at DOL and DOC. Forthcoming investments by DOL will also seek to advance this approach.³⁹ DOL recently released a Request for Information on Sector Strategies to Meet Critical Workforce Needs Across Industries,⁴⁰ which seeks input from key stakeholders in local and regional economies to further inform policymakers and workforce practitioners at the Federal, state, and local levels.

2. Secure commitments from employers, unions, community colleges, and other stakeholders to start new partnerships to train workers for and place them in biotechnology and biomanufacturing jobs, including through Registered Apprenticeship and pre-apprenticeship programs, and youth career and college pathways.

- a. Action:** DOL, ED, NSF, and DOC, with support from DOD and other agencies, are working with the Manufacturing USA Institutes—including BioMADE, NIIMBL and BioFabUSA—to increase awareness and support the expansion of worker-centered sector strategies for biotechnology and biomanufacturing.
- b. Action:** ED, in partnership with DOL and DOC, will elevate and emphasize the roles of business and industry, community colleges, high schools, and others in creating cross-sector collaborations to advance sector-focused career pathways in bioworkforce and other in-demand areas through the Unlocking Career Success initiative and through CTE.
- c. Action:** The NSF ATE program supports both national centers and projects that support biotechnology and biomanufacturing technician education programs, including the InnovATEBIO National Center for Biotechnology Education. InnovATEBIO is providing leadership in biotechnology technician education, including support for development and sharing of best practices and emerging technologies in biotechnology workforce development at 134 biotechnology or biomanufacturing programs at community and technical colleges in 39 states. The ExLENT and INTERN programs support similar efforts.

³⁷ <https://www.eda.gov/funding/programs/american-rescue-plan/good-jobs-challenge/awardees/Dallas-College>

³⁸ <https://www.eda.gov/funding/programs/american-rescue-plan/good-jobs-challenge/awardees/Office-of-Workforce-Strategy>

³⁹ <https://www.dol.gov/agencies/eta/skills-grants/h1-b-skills-training>

⁴⁰ <https://www.federalregister.gov/documents/2023/01/23/2023-01142/notice-of-request-for-information-rfi-on-sector-strategies-to-meet-critical-workforce-needs-across>

3. Support sector partnerships by facilitating the sharing of knowledge and capabilities across sectors and regions to enhance impact, including through communities of practice.

- a. Action:** ED, in collaboration with other agencies, will launch a professional learning series that focuses on bioworkforce needs and the role that K-12 schools and postsecondary institutions can play in creating pathways into the industry.
- b. Action:** NSF will support activities through the newly established Directorate for Technology, Innovation and Partnerships (TIP) to facilitate partnerships with the biotechnology and biomanufacturing industry and sharing of best practices in workforce training and recruitment.
- c. Action:** NSF will expand activities supporting community and technical college faculty and students engaging in research at Industry University Collaborative Research Centers (IUCRC), Engineering Research Centers (ERC) and their partner industry sites.
- d. Action:** DOL is launching a Job Quality Academy, which will bring up to 16 workforce communities together to develop collaborative strategies to address job quality within their communities through in-person meetings and technical assistance. This work builds on the guidance provided in [Training and Employment Guidance Letter \(TEGL\) 07-22](#), Increasing Employer and Workforce System Customer Access to Good Jobs, as well as DOL’s Good Jobs Initiative.

Recommendation #3: Develop and rigorously evaluate innovative approaches to education and training for biotechnology and biomanufacturing jobs and careers, scaling and promoting those found to be most effective.

The Administration is committed to ensuring that all Americans have a pathway to a good career—whether they go to college or not. Many jobs in the bioworkforce do not require a four-year degree. The Administration is leveraging historic funding provided for Registered Apprenticeships to expand this high-quality “earn and learn” model and has proposed to expand free community college.

Ideally, education and training programs should be structured as part of a career pathway—allowing students and workers to transition between work and structured learning (on and off the job) as they progress through their careers. Employers, education and training providers, and other stakeholders identified a range of opportunities to build these career pathways. Research and consultations highlighted how expanded career exploration investments beginning as early as middle school can introduce students to bioworkforce career pathways. Additionally, increased investments in high school and postsecondary CTE career pathways can support dual enrollment in secondary schools and institutions of higher education, work-based learning opportunities, and opportunities to earn industry-recognized credentials alongside an academic degree.

Nonetheless, barriers to advancing in bioworkforce career pathways remain. For example, in many cases, credits earned in a biotechnology or biomanufacturing program at a community college do not always transfer to four-year institutions, and where they do, the credits often only count towards general science credits, not towards specific biotechnology or biomanufacturing programs. Credit transfer is a challenge across many fields, not just biotechnology and biomanufacturing, creating barriers as individuals seek to continue their education and attain credentials required for high-paying jobs and careers. The ability to link two- and four-year degree programs is one way that institutions of higher education and employers can design bioworkforce programs as part of a career pathway.

Blended learning approaches use asynchronous learning modules for students to develop conceptual knowledge and baseline skills specific to equipment as preparation for experiential learning in industrial labs. Accessible game-based learning and virtual reality simulations have immense potential to enhance these distance and blended learning models. Enriched distance and blended learning models can expand the reach of an instructor to a larger student body, supporting specialization and time-sharing models for scarce and costly equipment and instructors. Expanding the use of these learning tools and models could enhance the effectiveness of education and training offerings for the bioworkforce.

Key sub-recommendations and select action steps include:

- 1. Expand pathways into the skilled technical workforce through community colleges, Registered Apprenticeships, partnerships with state and local workforce boards, integrated education and training programs, and other high-quality work-based learning models.**
 - a. Action:** The President’s FY 2024 Budget has proposed to expand free community college and requested additional funding for agency programs that support education and training at two-year and four-year institutions, with an emphasis on community college programs that support both short-term credentials and certificate and degree programs in biotechnology and biomanufacturing, particularly at HBCUs, TCUs, and MSIs.
 - b. Action:** The Administration has secured historic increases in and proposed additional funding for Registered Apprenticeship programs, including pre-apprenticeships and youth apprenticeships, including for key occupations such as bioworkforce occupations. This includes support from DOL’s Office of Apprenticeship, Registered Apprenticeship industry intermediaries, and state apprenticeship agencies, where relevant. In the State Apprenticeship Expansion Formula grant⁴¹ opportunity, DOL included advanced manufacturing, including biomanufacturing, as a target industry.

⁴¹ <https://www.grants.gov/web/grants/view-opportunity.html?oppld=345785>

- c. **Action:** The Administration has continued to support funding for DOL’s Strengthening Community Colleges Training Grants, which build capacity for community colleges to develop new and accelerated career pathways programs in in-demand and critical sectors and strengthen connections between community colleges and the public workforce system to support sector-based solutions to employer needs.
- 2. **Encourage states and institutions to support full articulation and transfer between biotechnology and biomanufacturing courses provided at community colleges and similar programs at four-year institutions.**
 - a. **Action:** Where relevant and feasible, ED, DOL, DOC, and other agencies will encourage the inclusion of evaluation criteria that promote credit articulation agreements where relevant when offering funding for education and training. Through 2024, ED, in collaboration with other agencies, will offer technical assistance to the field on best practices to strengthen and improve the transfer of credit from non-credit to credit programs within two-year institutions, and from two-year to four-year institutions.
- 3. **Expand and modernize career and technical education (CTE)—including career-connected high schools—for biotechnology and biomanufacturing jobs.**
 - a. **Action:** The Administration has grown funding for CTE at ED to \$1.43 billion in FY 2023. This specifically funds career education and training across secondary and postsecondary institutions. FY 2023 appropriations included a new \$25 million grant program, in response to the Administration’s request, to strengthen career-connected high schools that partner with community colleges and industry to create innovative career pathways to growing fields such as the bioeconomy, as well as an increase of \$50 million in Perkins state funding for CTE. The President’s FY 2024 Budget proposes further increases in these programs.
- 4. **Ensure that faculty and educators working in the biotechnology and biomanufacturing fields have sufficient institutional support to ensure recruitment and retention of instructors who are responsible for training the bioworkforce of the future, including provision of timely reasonable accommodations as needed.**
 - a. **Action:** ED will issue guidance to the field on innovative practices to bring industry expertise into CTE through both improved recruitment and retention of educators with relevant in-demand sector experience and expertise, and through strong education-industry partnerships.
 - b. **Action:** Agencies will explore opportunities to prepare K-12 teachers and postsecondary faculty to teach courses that deliver both academic knowledge and skills for biotechnology and biomanufacturing using updated instructional methods such as blended learning and competitions featuring team-based learning, digital skills, and systems thinking.
 - c. **Action:** NIH is addressing concerns about the postdoctoral training system and recruiting qualified postdoctoral candidates. Postdoctoral researchers are the foundation of academic research programs and are trained to be future instructors

and independent researchers across academia, government, and private industry. Continued strength and growth of the bioworkforce is threatened by the reduction in postdoctoral trainees in recent years. In December 2022, the Advisory Committee to the Director Working Group on Re-envisioning NIH-Supported Postdoctoral Training was charged with exploring the status of the postdoctoral training system, identifying and understanding critical factors and issues relating to the decline in postdoctoral fellows, and providing recommendations to address those factors.⁴² To support this effort, the NIH Office of the Director recently issued a Request for Information seeking public input to guide the re-envisioning of U.S. postdoctoral research training and career progression within the biomedical research enterprise.⁴³

- d. **Action:** NSF’s Research Traineeship (NRT) Program supports interdisciplinary, evidence-based traineeships that advance ways for graduate students in research-based master’s and doctoral degree programs to pursue a range of STEM careers, and is designed to encourage the development and implementation of bold, new, and potentially transformative models for STEM graduate education training. Over the past five years, the program has made 19 bioengineering- and biotechnology-related NRT investments.
- e. **Action:** BETO’s Bioenergy Research and Education Bridge (BRIDGES) is an education and workforce development program designed to assist educators in teaching bioenergy topics to help prepare a national bioenergy workforce. BRIDGES creates partnerships with high schools, community and technical colleges, and universities to develop educational case studies aligned to the needs of the bioenergy industry workforce. The bioenergy-themed case studies are based upon foundational bioenergy research at DOE national laboratories. As a workforce development tool, the BRIDGES case studies help educate the U.S. bioenergy workforce through equitable and authentic learning—where students explore bioenergy research that solves urgent and relevant societal challenges in energy and the environment.

5. Expand and disseminate advanced learning technologies and practices across traditional and non-traditional learning pathways for biotechnology and biomanufacturing.

- a. **Action:** Agencies can prioritize investments in advanced digital learning resources that support blended learning delivery. This includes, at the secondary and postsecondary levels, the use of advanced simulations, along with the use of physical biotechnology and biomanufacturing equipment.

⁴² <https://www.acd.od.nih.gov/working-groups/postdocs.html>

⁴³ <https://grants.nih.gov/grants/guide/notice-files/NOT-OD-23-084.html>

- b. Action:** Agencies can expand upskilling and reskilling pathways using advanced learning technologies to reach more students and increase exposure and access to biotechnology and biomanufacturing occupations.
- c. Action:** NIH is supporting creative educational activities designed to equip a diverse cohort of participants with the technical, operational, and professional skills required for careers in the biomedical research workforce. Through its Innovative Programs to Enhance Research Training and new Modules for Enhancing Biomedical Research Workforce Training programs, NIH has allocated over \$66.9 million to support courses for skills development, curriculum or methods development for freely available training modules, and mentoring activities, and plans to support additional projects in the coming years.⁴⁴

Recommendation #4: Partner with state, local, and Tribal governments, education and training providers, bioscience associations, unions and other worker-serving organizations, and other stakeholders to raise awareness about the promise and potential of careers in the bioworkforce.

Overwhelmingly, employers, education and training providers, and other stakeholders cite a lack of awareness of biotechnology and biomanufacturing careers as a barrier to building a more diverse talent pipeline for the sector. Many students and workers—including women, people of color, youth, and others underrepresented in the bioworkforce—are unaware of the career opportunities that exist in the bioworkforce—including those that do not require a four-year degree. This is also true for many educators and parents. Partnerships focusing on culturally responsive outreach to and working with groups that are underrepresented in the bioworkforce can help increase awareness of bioworkforce careers among a diverse pool of students and workers. They can also foster engagement that helps federal agencies, employers, unions, state and local government, and other stakeholders understand how to craft policies and practices to attract and retain a skilled workforce. This is particularly important for people with disabilities, for whom engagement at an early age, including through access to extracurricular activities like science and coding camps, is critical to ensure their access to and later advancement in bioworkforce careers.

Key sub-recommendations and select action steps include:

1. Build awareness of biotechnology and biomanufacturing careers through engagement with underserved communities, K-12 systems, the public workforce system, youth-serving organizations, veteran’s organizations, and other stakeholders.

- a. Action:** OSTP, DPC, other Executive Office of the President (EOP) components, and federal agencies will uplift opportunities in biomanufacturing and

⁴⁴ <https://grants.nih.gov/grants/guide/pa-files/PAR-21-196.html>; <https://grants.nih.gov/grants/guide/pa-files/PAR-20-296.html>

biotechnology through convenings with employers, unions, youth-serving organizations, and other stakeholders, through fact sheets and media engagement, and by integrating discussion of bioworkforce opportunities into existing programs including extracurricular student activities, and technical assistance efforts as appropriate and relevant. These materials should be accessible to people with disabilities, and welcoming to diverse audiences.

- b. Action:** NIST funding will support a NIIMBL pilot program designed to attract high school students into biopharmaceutical manufacturing career pathways. Project partners Merck, Pfizer, Pitt Community College and the North Carolina Biotechnology Center will develop and test materials for an awareness campaign in local high schools representing diverse racial, ethnic, socioeconomic, and geographic student populations. The project will make leader manuals, videos, and other materials available online at no cost to the public to encourage teachers to implement the program and host subject matter experts from industry or academia in their classrooms.
 - c. Action:** NIIMBL, in partnership with NextFlex, BioMADE, and the North Carolina Biotechnology Research Center, will leverage DOD support to provide extensive hands-on learning opportunities to high school students as part of the BioBuilders and bioLOGIC programs. Through bioLOGIC, students from Southern High School of Energy and Sustainability in Durham, North Carolina, the vast majority of whom are students of color, will engage in a five-week internship, designed to foster greater awareness and access to biopharmaceutical careers.
- 2. Develop public-private partnerships with state, local, and Tribal governments, state bioscience associations, and industry organizations to raise awareness of bioworkforce careers.**
- a. Action:** Since 2022, NIH has partnered with MedTechColor⁴⁵ to advance the representation of persons of color in the medical device industry. This collaborative community of investors and company executives provides mentoring, training, and early-stage financing to increase the number of underrepresented executives who enter, stay, and contribute to the medical device industry.
 - b. Action:** NIST funding will support the expansion of the NIIMBL eXperience pilot program to three additional U.S. regions through partnerships with Albany College in New York, BioKansas and Raritan Valley Community College in New Jersey. This biopharmaceutical manufacturing immersion program provides an all-expenses paid opportunity for Black, Latino, and Indigenous community college or university students to learn about careers in this field through hands on activities and connections with industry leaders, regulators, and research scientists

⁴⁵ <https://medtechcolor.org/>

across the sector. Funding from DOC will help NIIMBL triple the participation of students in the program in 2023.

- c. **Action:** NSF has launched a new initiative, the NSF Regional Innovation Engines, or NSF Engines, to catalyze and foster innovation ecosystems across the United States. Its main goals are to: advance critical technologies; address national and societal challenges; foster partnerships across industry, academia, government, nonprofits, civil society, and communities of practice; promote and stimulate economic growth and job creation; and spur regional innovation and talent. Through this program, NSF will foster biotechnology and biomanufacturing regional innovation ecosystems, and in particular support industry engagement with local education and training programs.
- 3. Build a national cohort of trusted individuals with ties to local communities, who can raise awareness of career opportunities with an emphasis on outreach to underserved areas and populations.**
- a. **Action:** NSF's ATE program supports mentoring projects where experienced faculty (e.g., current or former Principal Investigators, former NSF ATE Program Officers) work with faculty teams from institutions with little to no experience crafting proposals for federal funding to craft and submit proposals to the ATE program. The Mentor Connect further supports a Mentor Fellows program to grow additional mentors. As the ATE program requires committed industry partners, the Engaging Educators, Strengthening Practice: Creating & Sustaining Successful Industry-Education Partnerships project provides a series of workshops to provide faculty with the skills needed to effectively engage and sustain industry partnerships. In addition, NSF's Regional Innovation Engines program is also building innovation cohorts with ties to regional communities.
 - b. **Action:** NIST funding will allow NIIMBL to continue to build a cohort of diverse NIIMBL eXperience graduates with strong social media presence documenting their successes and enthusiasm for biopharmaceutical manufacturing beyond the time spent in the immersion program.
 - c. **Action:** NIST will facilitate collaborations across Manufacturing USA to leverage the relationships each institute has with local and regional partners with long term community presence to scale bioworkforce awareness and training programs.
 - d. **Action:** USDA works with regional and local communities through many trusted partners, including the Cooperative Extension System, Climate Hubs, and Land Grant Universities. These partnerships are leveraged to engage local and regional communities, especially in rural areas, in agriculture and forestry science and education.

Recommendation #5: Improve data and analytic capacity and cross-sector collaboration to advance equity and support effective workforce development—including the development of industry-recognized credentials and competency models.

Effective and equitable workforce development depends on a clear understanding of the real-time job, skill, and credential needs of employers. With this data, employers, unions, education and training providers, and other stakeholders can assess the extent to which workers of all backgrounds already possess the required skills and whether education and training programs will effectively prepare workers for good jobs. Reliable and timely data on job and skill needs underpins efforts to deploy skills-based hiring approaches. These approaches allow employers to remove unnecessary degree requirements that prevent many workers—particularly underserved and underrepresented workers—from advancing in their careers. Additionally, a national, standardized, industry-recognized certified training program for biomanufacturing and bioproduction technicians will support the growth of this workforce and ensure workers have the skillsets needed by the biomanufacturing industry.⁴⁶

Employers, industry associations, community colleges and other training providers, and other stakeholders highlighted a need for better, more real-time data on future labor market demand for bioworkforce occupations and the skills required. This is particularly challenging in rapidly evolving industries like biotechnology and biomanufacturing that are driven by emerging technologies. It can only be achieved through 1) strong partnership between industry players, government, education and training providers, and unions and other worker-serving organizations; and 2) strengthening state and local data and analytic capacity to respond to regional workforce needs.

Traditional methods of developing and maintaining competency models and occupational codes must be updated for biotechnology and biomanufacturing. As the biotechnology and biomanufacturing industries grow, the marketplace for educational programs will not be able to effectively support the workforce needed to enable this growth without a continuously evolving system of industry-led, competency-based, and nationally portable credentials. Such credentials give earning power to workers, planning indicators to employers, and clear investment signals to the education and training community. Such credentialing program must be accessible to people with disabilities, which includes testing and certification processes. Well-designed credentials can create substantial economic value by allowing industry to identify the latest knowledge, skills, and abilities of value in the labor market.

Key sub-recommendations and select action steps include:

- 1. Enhance labor market data and analytical capacity to support regional sector strategies and other workforce efforts.**

- a. Action:** DOL will collaborate with ED and other agencies to send clear and timely labor market information to workforce partners nationally to help them understand where federal investments are being made so the education and workforce ecosystem can build and scale programs to meet emerging demand—including for the bioworkforce.

⁴⁶ <https://www.schmidtfutures.com/our-work/task-force-on-synthetic-biology-and-the-bioeconomy/>

2. Develop, identify and promote industry-recognized competency models, credentials and certificates.

- a. Action:** NSF, in partnership with DOL, NIST, and other relevant agencies, along with key industry representatives, will convene a forum to build alignment on recognized competency models, [development of new competency models](#) where needed, and exploration of credentialing mechanisms for the bioworkforce. In addition, there is opportunity to leverage the framework and approach developed in related sectors, like the Talent Hub for the semiconductor industry, created by the National Institute for Innovation and Technology (NIIT) with support from NSF, DOL, SUNY Polytechnic Institute, and industry representatives from companies throughout the semiconductor industry supply chain.
- b. Action:** NIST will work in partnership with other agencies to identify opportunities and potential mechanisms for the development of a standard, industry-recognized certified training program for biomanufacturing and bioproduction technicians.
- c. Action:** To rigorously identify best practices and models, NIH funds research that tests interventions to enhance interest, motivation, persistence, and preparedness for careers in the biomedical research workforce. Through its Research on Interventions that Promote the Careers of Individuals in the Biomedical Research Enterprise program, NIH has allocated over \$52 million to research that guides the implementation of interventions in a variety of academic settings and career levels, and plans to support additional projects in the coming years.⁴⁷

3. Improve the tracking of career outcomes for participants in government-sponsored training programs.

- a. Action:** In response to recommendations from the National Science and Technology Council (NSTC)'s Working Group on Research Business Models and the Advisory Committee to the NIH Director, NIH requires participants in Research Training, Fellowship, Research Education, and Career Development Awards to utilize persistent digital identifiers⁴⁸ that can be used to connect participants with their contributions to science over time and across changes of name, location, and institutional affiliation. Persistent digital identifiers facilitate an evidence-based approach to the evaluation of training and career development programs.

⁴⁷ <https://grants.nih.gov/grants/guide/pa-files/PA-21-269.html>

⁴⁸ <https://grants.nih.gov/grants/guide/notice-files/NOT-OD-19-109.html>

Appendix

Appendix A: Key Definitions

Bioeconomy: economic activity derived from the life sciences, particularly in the areas of biotechnology and biomanufacturing, including industries, products, services, and the workforce

Bioengineering: the application of engineering principles and practices (including from chemical, mechanical, and electrical engineering disciplines) to the life sciences

Biomanufacturing: the use of biological systems to produce goods and services at commercial scale

Bioproducts: products determined by the Secretary of Agriculture to be commercial or industrial products (other than food or feed) that are (A) composed, in whole or in significant part, of biological products, including renewable domestic agricultural materials and forestry materials, or (B) intermediate ingredients or feedstocks

Biotechnology: technology that applies to and/or is enabled by life sciences innovation or product development

Bioworkforce: the broad set of occupations supporting the bioeconomy

Community college: a public 2-year postsecondary institution that primarily award associate's degrees and certificates

Competency model: A collection of multiple competencies that together define successful performance in a defined work setting. A competency model provides a clear description of what a person needs to know and be able to do—the knowledge, skills, and abilities—to perform well in a specific job, occupation, or industry

Good job: DOC and DOL have partnered to identify what comprises a good job. These [eight principles](#) create a framework for workers, businesses, labor unions, advocates, researchers, state and local governments, and federal agencies for a shared vision of job quality

Opportunity youth: young people who are between the ages of 16 to 24 years old and are disconnected from school and work

Registered Apprenticeship: An industry-driven, high-quality career pathway through which employers can develop and prepare their future workforce, and individuals can obtain paid work experience, receive progressive wage increases, classroom instruction, and a portable, nationally-recognized credential. Registered Apprenticeships are industry-vetted and approved and validated by the U.S. Department of Labor or a State Apprenticeship Agency.

Skills-based hiring: an approach to hiring that reduces employers' reliance on degrees as a way to screen out candidates, and instead asks them to evaluate whether a candidate has the knowledge, skills, and abilities to succeed in the role. It values skills equally, whether they were learned in the classroom, on the job, or on one's own.

Supportive services: Also known as wrap-around services, supportive services help individuals, and especially those from underrepresented and underserved groups, enroll in and successfully complete training. These services include, but are not limited to, child and dependent care, tools, work clothing, application fees and other costs of apprenticeship or required pre-employment training, transportation and travel (including lodging) to training and work sites, and services aimed at helping to retain underrepresented groups such as mentoring, tutoring, support groups, and peer networking.

Underserved communities: populations sharing a particular characteristic, as well as geographic communities, that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life, such as Black, Latino, and Indigenous and Native American persons, Asian Americans and Pacific Islanders and other persons of color; women; members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality.

Worker-centered sector strategy: a systems-level approach to equitable workforce development that aligns employer demand for a skilled workforce with available workers by bringing together a range of key partners—including employers, unions and worker-serving organizations, community colleges, high schools, and community-based organizations

Appendix B: Acronym Guide

APDP	Assistant to the President for Domestic Policy
ATE	Advanced Technological Education
BETO	Bioenergy Technologies Office
CREST	Centers of Research Excellence in Science and Technology
CTE	Career and Technical Education
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOL	Department of Labor
DPC	Domestic Policy Council
ED	Department of Education
EOP	Executive Office of the President
FY	Fiscal Year
HBCU	Historically Black College or University
HBCU-RISE	HBCU Research Infrastructure for Science and Engineering
HBCU-UP	HBCU-Undergraduate Program
HHS	Department of Health and Human Services
HSI	Hispanic Serving Institution
MSI	Minority Serving Institution
NEC	National Economic Council
NIH	National Institutes of Health
NIIMBL	National Institute for Innovation in Manufacturing Biopharmaceuticals
NIST	National Institute of Standards and Technology
NSF	National Science Foundation
OPM	Office of Personnel Management
OSTP	Office of Science and Technology Policy
R&D	Research and Development

STEM	Science, Technology, Education, and Mathematics
TCU	Tribal College or University
USDA	Department of Agriculture

Appendix C: List of Select Federal Programs that Could Support Biotechnology and Biomanufacturing Education and Training

Program Name	Federal Administering Agency
AFRI Education and Workforce Development Program - Predoctoral and Postdoctoral Fellowships	USDA
National Needs Graduate and Postgraduate Fellowship Grants Program Funding Opportunity	USDA
Scholarships for Students at 1890 Institutions	USDA
1890 Capacity Building Grants	USDA
New Beginning for Tribal Students	USDA
Tribal Colleges Education Equity Program	USDA
Secondary Education, Two-Year Postsecondary Education, and Agriculture in the K-12 Classroom Challenge Grants Program	USDA
Women and Minorities in Science, Technology, Engineering, and Mathematics Fields Program (WAMS)	USDA
Education Grants for Hispanic Serving Institutions	USDA
AFRI Education and Workforce Development Program - Research and Extension Experiences for Undergraduates	USDA
AFRI Education and Workforce Development Program - Agricultural Workforce Training at Community Colleges	USDA
AFRI Education and Workforce Development Program - Food and Agricultural Non-Formal Education	USDA
Higher Education Multicultural Scholars Program	USDA
Higher Education Challenge Grants Program	USDA
Capacity Building Grants for Non-Land-Grant colleges of agriculture	USDA
Alaska Native-Serving and Native Hawaiian-Serving Institutions Education Competitive Grants Program	USDA
AFRI Education and Workforce Development (EWD) Program - Meat and Poultry Processing -Agricultural Workforce Training	USDA
From Learning to Leading: Cultivating the Next Generation of Diverse Food and Agriculture Professionals	USDA
Biotechnology Risk Assessment Research Grants	USDA
NIIMBL/Manufacturing USA Institute	DOC
BioFabUSA/Manufacturing USA Institute	DOD
BioMADE/Manufacturing USA Institute	DOD
NDEP STEM Education and Outreach Grant Awards	DOD

NDEP Biotech (Congressional)	DOD
Emerging Technologies - Biotech	DOD
HBCU/MSI Biotechnology Center of Excellence	DOD
Algae Technology Educational Consortium	DOE
Adult Education and Family Literacy Act State Grants, Title II of the Workforce Innovation and Opportunity Act	ED
The Carl D. Perkins Career and Technical Education Act State Grants	ED
Pell Grants	ED
Innovation and Modernization Grants	ED
Native American Career and Technical Education Program	ED
Native Hawaiian Career and Technical Education Program	ED
HBCU Capital Financing Loan Program	ED
HBCUs/MSIs R&D Infrastructure Grants	ED
Job Corps	DOL
Registered Apprenticeship	DOL
Workforce Innovation and Opportunity Act Adult, Dislocated Worker and Adult Programs	DOL
YouthBuild	DOL
H-1B Skills Training Grants	DOL
Strengthening Community Colleges Training Grants	DOL
Advanced Technological Education (ATE)	NSF
Career-Life Balance (CLB) Initiative	NSF
Graduate Research Fellowship Program (GRFP)	NSF
Hispanic-Serving Institutions (HSI)	NSF
Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)	NSF
Historically Black Colleges and Universities - Excellence in Research (HBCU-EiR)	NSF
Historically Black Colleges and Universities - Research Infrastructure for Science and Engineering (RISE)	NSF
Non-Academic Research Internships for Graduate Students (INTERN) Supplemental Funding Opportunity	NSF
Louis Stokes Alliances for Minority Participation (LSAMP)	NSF
NSF Research Traineeships (NRT)	NSF
NSF Scholarships in Science, Technology, Engineering, and Mathematics	NSF
Research Experiences for Undergraduates	NSF
Experiential Learning for Emerging and Novel Technologies (ExLENT)	NSF

<u>Enabling Partnerships to Increase Innovation Capacity (EPIIC)</u>	NSF
<u>IDeA Networks of Biomedical Research Excellence (INBRE)</u>	HHS
<u>Leading Equity and Advancing Diversity in the Medical Scientist Training Program (LEAD MSTP)</u>	HHS
<u>Administrative Supplements to Promote Diversity in Research and Development</u>	HHS
<u>Research Supplements to Promote Diversity in Health-Related Research</u>	HHS
<u>Research Supplements to Promote Re-Entry into Biomedical and Behavioral Research Careers</u>	HHS
<u>Administrative Supplements to Promote Research Continuity and Retention of NIH Mentored Career Development (K) Award Recipients and Scholars</u>	HHS
<u>Administrative Supplement for Continuity of Biomedical and Behavioral Research Among First-Time Recipients of NIH Research Project Grant Awards</u>	HHS
<u>Innovative Programs to Enhance Research Training (IPERT)</u>	HHS
<u>Research on Interventions that Promote the Careers of Individuals in the Biomedical Research Enterprise</u>	HHS
<u>Training Modules for Enhancing Biomedical Research Workforce Training</u>	HHS
<u>NIH Family-Friendly Initiatives</u>	HHS



2022 Massachusetts Life Sciences Workforce Analysis Report

PRODUCED FOR THE MASSACHUSETTS BIOTECHNOLOGY COUNCIL (MASSBIO)

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Introduction

The Massachusetts Biotechnology Council (MassBio) commissioned BW Research Partnership to conduct primary and secondary research identifying the workforce needs and challenges within Massachusetts' life sciences industry. Released in August 2021, MassBio's report—The 2021 Industry Snapshot—highlights the significant growth anticipated in this industry over the next several years. Conservative estimates identify a near-term demand of up to 40,000 new workers by 2024.¹

Massachusetts' life sciences industry is a significant segment of the statewide economy, with marked revenue, wage, employment, and venture capital growth. Recent investments over the last couple years have propagated this growth trend, further expanding the life sciences footprint in Massachusetts. To meet the workforce demands of a rapidly growing industry, however, employers require access to a streamlined and connected talent pipeline. Investments, partnerships, and program development that ensure K-12 access and awareness, appropriate skills training, greater diversity, and regional equity, as well as on-the-job and other experience-based opportunities can help the state to meet these projected workforce demands.

The primary objectives of this research effort are as follows:

1. Understand hiring expectations and challenges for life sciences businesses in Massachusetts
2. Identify specific skillsets, certification, experience, and degree outcomes that are required and preferred by life sciences employers
3. Highlight opportunities for partnership or program development

The research presented here is a synthesis of surveys and interviews with life sciences employers in Massachusetts as well as a review of secondary data on current labor market trends, the life sciences training landscape, and federal and state workforce programs.

For more information on the employer survey methodology, please refer to Appendix A of this report.

Our sister organization, MassBioEd, produced the 6th Annual Massachusetts Life Sciences Employment Outlook. The report spotlights the full size of the Massachusetts Life Sciences sector like never before. It complements MassBio's Workforce Analysis Report by breaking down types of jobs that are growing and where talent is being produced using state and federal employment data for the booming Massachusetts Life Sciences workforce and comparing it to the Massachusetts labor market and Life Sciences in the United States. The report provides best practices and recommendations for industry and its workforce and talent development partners to diversify the short- and long-term talent pool of the sector. MassBioEd's 2022 Massachusetts Life Sciences Employment Outlook can be downloaded here: <https://www.massbioed.org/labor-market-information/>.

¹ Massachusetts Biotechnology Council. 2021 Industry Snapshot. August 2021. https://www.massbio.org/wp-content/uploads/2021/08/2021-INDUSTRY-SNAPSHOT_FINAL.pdf.

Executive Summary

Key Findings

INDUSTRY & EMPLOYMENT PROFILE

Main Takeaway

Overall, Massachusetts' life sciences industry is a strong and growing cluster. The data illustrate both historical and projected future growth as well as a significant competitive advantage in life sciences that is unique to the region.

Research and development (R&D), hospitals, and pharmaceutical manufacturing are central to Massachusetts' life sciences labor market.² Altogether, these sectors account for almost nine out of every 10 life sciences jobs in Massachusetts (87.0 percent). At the end of 2021, there were a total of almost 93,000 jobs across R&D firms, hospitals, and pharmaceutical manufacturing companies in the state. Biotechnology R&D tops the list, accounting for roughly 56,800 total jobs at the end of 2021, or just over half of all life sciences workers; this sector is also 9.4 times more concentrated in Massachusetts compared to the national average (see Table 1).

The life sciences labor market has more than doubled in size over the last decade and a half. Life sciences employment has grown by almost 60,500 jobs from 2006 through 2021—a growth rate of 131.1 percent in 15 years. To date, there are 106,600 life sciences employees across Massachusetts.

Job growth in the life sciences industry far outpaces other industry sectors and the statewide average. Between 2006

and 2021, Massachusetts' labor market grew by 6.9 percent, compared to a 131 percent growth rate for the life sciences industry. Growth in life sciences outpaces job growth in utilities, education, construction, retail trade, and finance and insurance. With the additional lab and manufacturing space set to come online by the end of 2024, employment projections estimate a near-term demand of up to 40,000 new workers by 2024.³

Of the top life sciences occupations, data science and biotech jobs have seen the greatest growth over the last several years. Specifically, the following occupations grew by 28 to 87 percent between 2015 and 2021: biological scientists, biochemists and biophysicists, natural sciences managers, medical scientists, biological technicians, software developers, and computer and information systems managers. Many of these jobs are also significantly more concentrated in Massachusetts compared to the national average (see Table 2).

Most surveyed life sciences firms expect to grow their workforce over the next 12 months with both entry- and non-entry-level new hires. More than three-quarters of firms indicated that they would be hiring more workers in the coming year (77.9 percent). Most companies are seeking to

² For a definition of the life sciences industry and employment percent contributions used for this report, please see Appendix D.

³ Massachusetts Biotechnology Council. 2021 Industry Snapshot. August 2021. https://www.massbio.org/wp-content/uploads/2021/08/2021-INDUSTRY-SNAPSHOT_FINAL.pdf. Conservatively, the projections assume two employees per 1,000 square foot.

fill both entry- and non-entry-level positions (81.9 percent), though a few respondents indicated that they are only hiring for entry-level (1.4 percent) or non-entry-level positions (16.7 percent).

HIRING CHALLENGES

Main Takeaway

Despite strong growth expectations, concerns regarding talent supply are creating bottlenecks in Massachusetts' life sciences industry. Employers report talent competition, up titling, wage inflation, and a skills and experience gap that is resulting in significant hiring difficulties.

Firms have had difficulty filling open entry- and non-entry-level positions over the last 12 months. In general, it has been more difficult to fill non-entry-level positions; 94.2 percent of businesses reported some level of hiring difficulty when trying to find qualified candidates for non-entry-level roles. At the same time, just under three-quarters of firms also indicated some level of hiring difficulty when trying to find qualified entry-level candidates (73.5 percent).

Insufficient supply and industry experience are the top reasons for reported hiring difficulty. In general, firms noted that a small applicant pool and lack of experience or industry-specific knowledge contributed to hiring difficulty for both entry- and non-entry-level positions. These two topped the list of reasons for hiring difficulty. Additionally, firms also noted that insufficient non-technical skills and competition from other life sciences companies was contributing to difficulties filling open positions.

Talent competition is high in Massachusetts' life sciences industry. Firms are facing competition from other life sciences companies in Massachusetts and out-of-state as well as competition from big tech for data science-related talent. Because of this, many firms are employing creative ways of attracting and retaining talent, including increasing wages, improving benefits packages, adding tuition and relocation assistance, and offering remote work options.

Up titling and wage inflation are major contributors to talent competition in Massachusetts' life sciences industry. Small and large firms indicated this as a major issue for recruitment and retention; the prevailing attitude is that there is always a company that is willing to pay more or offer a better title to potential candidates.

There is a skills and experience gap between firm expectations and available or prospective hires. Across both entry- and non-entry-level roles, firms indicated that the title and salary levels they are hiring for often do not match the skills prospective hires are able to confidently execute.

TRAINING, ASSETS, & RESOURCES

Main Takeaway

Life sciences firms benefit from an active training network and a number of federal and state-run programs and resources supportive of Massachusetts' life sciences cluster, including financial and employee recruitment support.

Training Landscape

This analysis focused on pathways that do not require a four-year degree and as such, does not include life sciences degree programs at universities in Massachusetts. The focus on non-four-year degree pathways is key for expanding the pipeline of available workers, especially those from underrepresented communities, while engaging community colleges in supporting life sciences workforce development initiatives. For more information, please refer to the Industry Assets & Resources section of this report.

Most non-four-year life sciences programs in Massachusetts aim to provide scientific background and training for careers in biotechnology and biomanufacturing, particularly for biological technicians. Both Quincy College and the Biomanufacturing Education and Training Center (BETC) at Worcester Polytechnic Institute (WPI) currently offer the most biomanufacturing programs, while Middlesex Community College (MCC) leads the charge in biotechnology training. Overall, community colleges currently have the highest number of non-four-year life sciences training programs. Associate degrees are the most popular outcome of Massachusetts' non-four-year life sciences training programs, with MCC and MassBay Community College being the top two institutions for associate degrees. Benjamin Franklin Institute of Technology (BFIT), the only private college on the list of community colleges, is still developing an associate program that would cover biotechnology and biomanufacturing.

Middlesex County currently leads the state in the total number of non-four-year life sciences training programs. Training in the county takes place in apprenticeship, internship, research, and academic settings leading to varied certificate, degree, and experience outcomes. In particular, Middlesex, Norfolk, and Suffolk—counties with the highest number of training programs and the most growth for research and development (R&D) jobs—are well-positioned to supply talent for biotechnology positions. At the same time, Worcester and Middlesex, the counties with the highest growth for biomanufacturing jobs, represent half of the identified biomanufacturing training programs.

State & Federal Workforce Development Resources

There are a variety of state and federal financial assets, programs, and resources to support the life sciences industry. Public tax credits, grants, tax exemptions, capital funding, wage reimbursement, and investments, including the suite of programs administered by the Massachusetts Life Sciences Center (MLSC), are available to support qualifying life sciences businesses in Massachusetts. Broadly, these mechanisms include supporting recruitment and workforce development, broadening equity and workforce diversity, supporting entrepreneurship, and creating jobs. For more detailed information, see Table 8 and Table 9. In addition, other states, including New Jersey, California, Pennsylvania, and Rhode Island also have strong life sciences support mechanism. For more information on these policies, please refer to Appendix E.

Programs offering “general support” are most common, though there are a significant number of federal and state programs that support recruitment, training, and employee retention. “General support” programs provide broad support to the life sciences industry through tax credits, tax exemptions, cost sharing benefits, and unemployment benefits. About a quarter of identified assets and resources (23.1 percent) support life sciences businesses with recruitment of employees and interns. These programs assist life sciences businesses in attracting new talent through sponsored internships and apprenticeships, wage reimbursement, and targeted grant programs.

There are also a number of programs focused on increasing equity and workforce diversity within Massachusetts’ life sciences industry. Equity-focused programs account for 11.5 percent of all programs; these programs sponsor internships targeting recruitment in underserved communities, wage reimbursement, and grants for female-led early-stage life sciences companies.

WORKFORCE DEVELOPMENT NEEDS

Main Takeaway

Traditional channels will be unable to meet the supply gap for Massachusetts’ life sciences industry. Increasing outreach and awareness, offering applied learning opportunities, new biotech modules, and non-four-year degree opportunities as well as expanding access to disadvantaged and underrepresented communities will be key to closing the supply gap and expanding the funnel of talent for life sciences employers.

Though the majority of employers prefer entry-level candidates with a Bachelor’s degree, many are willing to hire applicants with less than a Bachelor’s degree and have done so in the past. About seven in 10 surveyed firms indicated that they prefer entry-level applicants to have a Bachelor’s degree (70.6 percent), but only 58.8 percent actually require a Bachelor’s degree. In fact, about one-third of surveyed employers indicated that their required level of education for entry-level candidates is an Associate’s degree or less, which includes a certification or postsecondary nondegree award or a high school diploma/equivalent. Just over half of firms indicated that they would hire an entry-level applicant with less than a Bachelor’s degree (50.6 percent), and 62.4 percent have previously hired an applicant with less than a Bachelor’s degree for an entry-level position.

Unclear or unpredictable training pipelines and information gaps are resulting in a hiring

bottleneck for entry-level talent. Low awareness or access to information among middle and high school students is contributing to fewer entrants into the life sciences labor market. Employers indicated the need to engage students early on in their educational careers, highlighting the employment options available in the life sciences industry. Educational partnerships and outreach are key to developing these long-term workforce pipelines.

Internships, co-ops, and apprenticeships are valuable models for bridging the information and experience gap in the industry. Many employers indicated their preference for entry-level candidates with on-the-job and experiential training. In particular, Northeastern graduates with co-op experience were identified as the most sought-after candidates; Worcester Polytechnic Institute graduates were also identified as well-prepared for their roles. Out of a list of potential

program and resource offerings which included mentorships, career days, and wage reimbursement, 43.2 percent of firms indicated interest in an apprenticeship-type program for their future employees.

Community colleges are valuable sites of potential investment for non-traditional workforce development (i.e., hiring for people without four-year degrees). While most job postings require at least a bachelor's degree for certain entry-level positions, companies are interested in reevaluating their hiring structure to include more candidates without four-year degrees. While some companies already work with community colleges, some of those which did not highlight their willingness and enthusiasm to partner with community colleges to hire candidates with associate degrees. One interviewee suggested that community colleges are valuable for the certification options they offer, as any employee could enroll in a certification course to upskill for future roles within the company.

Companies identified manufacturing and quality control functions as the most likely spaces for non-traditional training initiatives to be implemented successfully. Companies have already reevaluated the minimum qualifications for these positions. Hires without 4-year degrees can be successful in these roles, but employers noted that a scientific background is instrumental for their success in the training program. Certificates, lab experience, and associate degrees were identified as sources for people to develop a science foundation for these roles.

Certificates from two-year colleges are especially important for entry-level candidates. Seven in 10 employers indicated that certificates in specialized topics from two-year colleges covering topics such as cell culture or biomanufacturing are important for entry-level applicants (69.1 percent). Third-party certifications, including RAPS and Six Sigma, are also important to 48 percent of surveyed employers.

Life sciences firms largely partner with 4-year universities for recruitment efforts, but less so with community colleges, high schools, or vocational technical schools. Six in 10 employers reported partnering with 4-year universities such as Northeastern, Harvard, and the Massachusetts Institute of Technology to recruit talent for open positions (61.7 percent). Fewer than 20 percent of firms also indicated partnering with both in-state and out-of-state community colleges (19.8 percent), high schools (11.1 percent), and vocational technical schools (7.4 percent). About a quarter (25.9 percent) of firms do not partner with any training providers or educational institutions for recruitment.

Conclusions & Recommendations

There are several key themes that converge across the high-level data findings in this report to produce a number of strategic recommendations. Namely, Massachusetts is expected to see significant workforce demand in the life sciences industry—by some estimates, the industry will require 40,000 new workers over the next couple years⁴—and the industry must re-think the current workforce development pipeline for life sciences occupations to meet it, prioritizing regionalization and diversity.

Beyond the significant growth rate, life sciences firms are faced with labor market competition from out-of-state firms and other industries, such as information technology and data science. Given that employers project to see growth across several different entry- and non-entry-level positions over the next couple years as well as the significant hiring difficulties attributed to a small applicant pool and lack of experienced or qualified applicants, the life sciences industry will require significant workforce development support mechanisms from the state, educational institutions, and other workforce development stakeholders.

Short-Term Interventions

In the short-term, there are a number of interventions that can provide a relief valve for life sciences firms in Massachusetts:

Add contextualized biopharma-specific modules to existing four-year degree programs. Degree programs where a need exists in the sector, such as accounting and marketing, may consider adding additional courses or modules to their existing course frameworks specifically geared toward the life sciences industry. These could include the addition of biopharma-specific courses or modules into existing course frameworks that are geared towards skills in the life sciences industry, such as accounting with pharmacy or biotech applications.

Scale up short-term, customized certification programs that align with employer needs. Education providers can consider scaling customized certification programs, such as successful programs like MassBioEd's Life Sciences Apprenticeship Program, Gloucester Marine Genomics Institute (GMGI), and Just-A-Start, that are based on the specific skill, knowledge, and educational needs of different types of companies in Massachusetts' life sciences industry. These programs are short-term in nature, allowing workers to either transition into the life sciences industry with the appropriate skills or enter the industry with a minimum of the requirements to begin working on the job immediately.

Increase laboratory or hands-on experience in educational settings. Investment in physical space and programs to allow increased access to lab time would ensure that incoming life sciences workers have the hands-on training needed to enter a lab setting. Lab experience programs may be designed to include a core curriculum plus a one- to two-year apprenticeship where individuals may work part-time and spend the rest of their time in school or in lab modules. Such a learn-and-earn model would be similar to union apprenticeships for trade positions.

Expand internship programs with life sciences companies. To build on the success of the Massachusetts Life Science's Internship Challenge program and Project Onramp would require increased partnerships among high schools, community colleges, workforce development agencies, and life sciences firms. An active network of stakeholders could create a pipeline of

⁴ Massachusetts Biotechnology Council. 2021 Industry Snapshot. August 2021. https://www.massbio.org/wp-content/uploads/2021/08/2021-INDUSTRY-SNAPSHOT_FINAL.pdf.

diverse talent from high schools, community colleges, and workforce development organizations that connect jobseekers to internships at life sciences firms across the state. MassBio could seek out additional scalable internship programs and advocate for continued state funding.

Grow role-specific certification programs. These programs would be designed with region- and firm-specific needs in mind to meet industry needs focused on cell and gene technologies, manufacturing, regulatory, QA, QC, and other manufacturing roles. These types of certification programs should be developed in conjunction with community colleges to take advantage of regional resources and networks.

While the above recommendations can provide some short-term relief, there are larger workforce issues that must be recognized in order to meet industry needs over the coming years. Most importantly, employment growth in the life sciences industry presents a significant opportunity to advocate for inclusive workforce development planning that targets traditional disenfranchised or underrepresented communities. These types of workforce development efforts must meet residents where they are at, providing support mechanisms to alleviate the trauma of poverty and create pathways that include the ability to earn-and-learn in a true apprenticeship-style program.

Long-Term Strategy

To re-think the current workforce development pipeline for life sciences occupations as this report indicates, the ecosystem must move away from four-year degrees and more towards apprenticeship-style programs, particularly for the manufacturing sector. MassBio, along with other key stakeholders, must support and advance an earn-and-learn program that is focused on the “job” aspect, as opposed to the “training” aspect. This program would immediately support a living wage for individuals, providing them with the opportunity to build their skills and experience—similar to the construction and building trades—while simultaneously supporting themselves and their families. Such a program would likely include a combined effort of on-the-job and classroom or lab training. The following are some final key takeaways and recommendations that must be coupled with diversity-focused workforce development initiatives for Massachusetts’ life sciences industry:

1. Create partnerships with Minority Serving Institutions (MSIs). Throughout program development, concerted efforts must be made to ensure partnership with federally designated minority serving institutions, either through their specific program offerings or generally, ensuring adequate representation of MSIs in workforce planning efforts moving forward.
2. Develop a central organizing workforce institute run by MassBio. To ensure maximum efficiency and programmatic success, all activities—from the coordination and facilitation of discussions with industry and academia to the creation of new modules and short-term certification programs—must be run or managed under a single organizing body. MassBio can act as a leading convener, bringing together university, academia, workforce development, industry, and government agencies, creating alignment amongst stakeholders.
3. Enlist state support through financial resources. The above efforts will require significant investment, much of which can be provided through state programming and funds. The state can mobilize significant financial resources to support upward mobility for individuals from disenfranchised populations, transition them into long-term sustainable careers.

Current Labor Supply

Employment in Massachusetts' life sciences industry has seen continual growth dating back to 2006. Over the last 15 years, from 2006 through 2021, the industry grew by 131 percent, or about 60,500 workers. As of 2021, there were just under 106,600 life sciences jobs across the state.⁵

Life sciences employment growth has far outpaced other industries in Massachusetts as well as the statewide average. Between 2006 and 2021, Massachusetts' labor market overall grew by 6.9 percent, compared to a 131.1 percent growth rate for the life sciences industries. Job growth in the life sciences sector has outpaced employment growth in utilities, education, construction, retail trade, and finance and insurance.

FIGURE 1. EMPLOYMENT GROWTH BY INDUSTRY, 2006-2021⁶

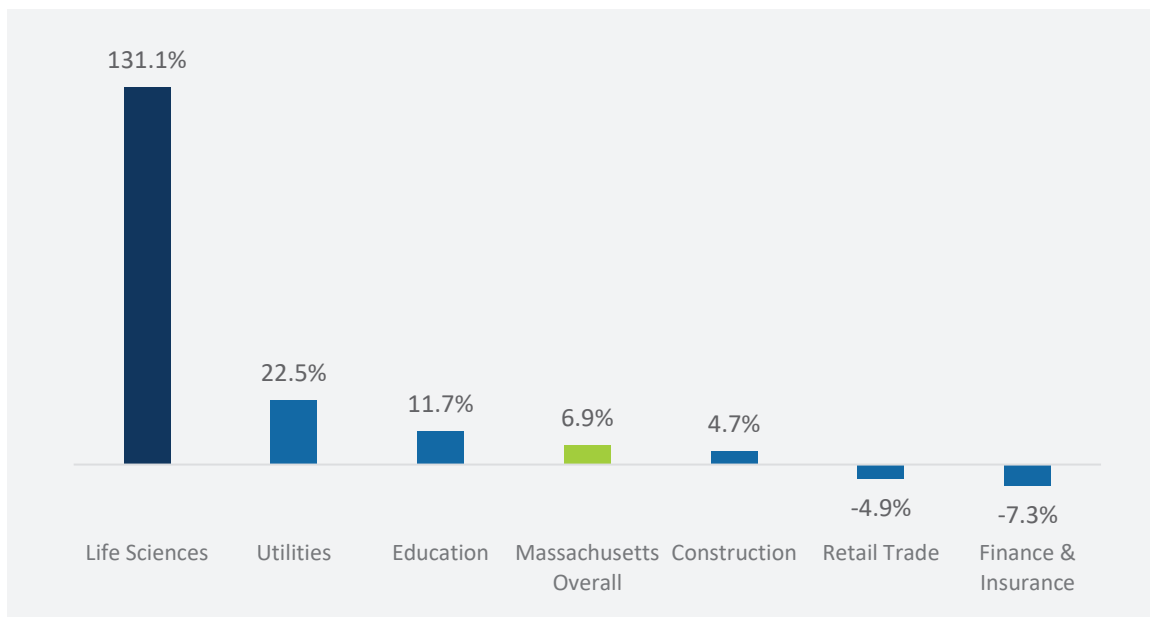


Table 1 highlights the specific industries that constitute Massachusetts' "life sciences industry cluster".⁷ In general, the state is a leader in both research and development (R&D), hospitals, and pharmaceutical manufacturing. These sectors alone account for almost nine out of every 10 life sciences jobs in Massachusetts (87.0 percent).

⁵ JobsEQ 2021 Q4. Accessed April 2022. JobsEQ extrapolates an extra quarter out in advance of the BLS QCEW data release. As such, this data may be slightly updated following the QCEW data release for 2021 Q4.

⁶ *Id.*

⁷ For a definition of the life sciences industry and employment percent contributions used for this report, please see Appendix D.

Biotechnology R&D tops the list, with more than 56,800 total jobs at the end of 2021—just over half of all life sciences jobs. This sector is also 9.4 times more concentrated in Massachusetts compared to the national average, indicating that biotechnology R&D is a significant economic specialty or strength for the state. Between 2016 and 2021, biotechnology R&D employment grew by 64.7 percent, or 22,300 net new jobs.

R&D firms in the physical, engineering, and life sciences sector accounted for about 22,100 jobs in 2021—20.7 percent of all life sciences jobs. Employment in this sector is 2.78 times more concentrated in Massachusetts compared to the U.S. average and has grown by 54.3 percent since 2016—roughly 7,800 new jobs.

General medical and surgical hospitals employed 8,100 workers at the end of 2021 for a growth rate of 1.9 percent or 150 new jobs. This industry is 1.27 more concentrated in Massachusetts. Lastly, pharmaceutical manufacturing firms employ almost 5,700 jobs across the state, with a concentration that is 1.09 times, or nine percent, above the national average.

TABLE 1. LIFE SCIENCES INDUSTRIES IN MASSACHUSETTS⁸

NAICS	Industry	Total Jobs, 2021	Location Quotient (LQ)	Growth, 2016 - 2021
541714	Research and Development in Biotechnology (except Nanobiotechnology)	56,816	9.36	64.7%
541715	Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)	22,096	2.78	54.3%
622110	General Medical and Surgical Hospitals	8,100	1.27	1.9%
325412	Pharmaceutical Preparation Manufacturing	5,672	1.09	-25.2%
621511	Medical Laboratories	4,478	0.82	-2.5%
611310	Colleges, Universities, and Professional Schools	3,546	1.74	2.4%
325413	In-Vitro Diagnostic Substance Manufacturing	1,788	2.23	14.2%
325414	Biological Product (except Diagnostic) Manufacturing	1,438	1.48	57.6%
541713	Research and Development in Nanotechnology	1,064	2.65	17.4%
622310	Specialty (except Psychiatric and Substance Abuse) Hospitals	820	3.34	3.1%
541380	Testing Laboratories	396	0.81	-8.2%
325411	Medicinal and Botanical Manufacturing	335	0.37	29.0%
622210	Psychiatric and Substance Abuse Hospitals	45	1.32	-8.0%

⁸ *Id.*

Table 2 highlights the top 15 occupations that are found across the “majority” life sciences sectors in the preceding table.⁹ Overall, nearly all occupations, with the exception executive secretaries and administrative assistants, have seen job growth since 2015. Of these top life sciences occupations, data science and biotech jobs have seen particularly high growth in Massachusetts, including biological scientists (86.5 percent), biochemists and biophysicists (76.6 percent), natural sciences managers (74.9 percent), medical scientists (48.1 percent), biological technicians (43.6 percent), software developers (34.6 percent), and computer and information systems managers (28.1 percent).

TABLE 2. TOP 15 OCCUPATIONS IN MASSACHUSETTS’ LIFE SCIENCES INDUSTRY¹⁰

SOC	Occupation	Life Sciences-Specific Jobs, 2021	Life Sciences % of Overall Occupation	Total Jobs in MA, 2021	Total Occupational Growth, 2015-2021	Location Quotient (LQ)
19-1042	Medical Scientists, Except Epidemiologists	9,893	73.1%	13,527	48.1%	4.3
15-1256	Software Developers and Software Quality Assurance Analysts and Testers	4,229	6.0%	70,067	34.6%	1.53
19-4021	Biological Technicians	4,063	71.7%	5,666	43.6%	2.82
19-1021	Biochemists and Biophysicists	3,665	89.6%	4,092	76.6%	4.57
11-9121	Natural Sciences Managers	3,558	79.1%	4,500	74.9%	2.66
11-1021	General and Operations Managers	3,349	4.0%	84,170	15.3%	1.44
13-1198	Project Management Specialists and Business Operations Specialists, All Other	2,614	6.8%	38,239	33.6%	0.92
19-2031	Chemists	2,286	62.2%	3,674	15.2%	1.81
17-2141	Mechanical Engineers	1,981	22.8%	8,672	22.7%	1.19
19-1029	Biological Scientists, All Other	1,827	74.5%	2,451	86.5%	2.37
17-2112	Industrial Engineers	1,752	15.7%	11,129	19.1%	1.59
11-3021	Computer and Information Systems Managers	1,673	8.5%	19,749	28.1%	1.71
11-3031	Financial Managers	1,654	5.4%	30,572	12.7%	1.9
11-9041	Architectural and Engineering Managers	1,652	22.0%	7,503	14.5%	1.59

⁹ These occupations are based only on those industries or NAICS from Appendix D for which at least 50 percent of employment is considered part of the “life sciences” industry; for the purposes of this report, these are called “majority” life sciences sectors. These include the following: medicinal and botanical manufacturing; pharmaceutical preparation manufacturing; in-vitro diagnostic substance manufacturing; biological product (except diagnostic) manufacturing; research and development in nanotechnology; research and development in biotechnology; research and development in the physical, engineering, and life sciences; and medical laboratories.

¹⁰ *Id.*

43-6011	Executive Secretaries and Executive Administrative Assistants	1,574	7.9%	20,013	-46.5%	1.6
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Workforce Needs & Challenges

The Workforce Needs & Challenges section highlights the quantitative and qualitative research findings from both the quantitative employer survey and a series of qualitative interviews conducted with talent acquisition professionals, executives, and leaders in Massachusetts' life sciences industry. Their feedback and insights have been compiled here for analysis and understanding.

Business Survey Results

The following section details the results of the employer survey outreach. Through an iterative process, the research team developed a survey instrument tailored to meet the needs and inquiries of MassBio. The survey is meant to gather quantitative data and statistics to better understand employer perceptions of challenges, needs, and trends in the life sciences labor market. For more information on the survey research methodology, please refer to Appendix A.

Reporting of the survey results is broken out into the following sub-sections:

1. Firm profile
2. Employment Profile
3. Hiring Expectations & Challenges
4. Hiring Requirements & Preferences
5. Partnerships & Program Interest

FIRM PROFILE

The majority of surveyed firms indicated they are in the drug development industry (73.4 percent). Other surveyed industries include research products and instrumentation (11.7 percent), bioinformatics (9.4 percent), and human diagnostic development (7.8 percent).

Most surveyed firms were larger in size, with 25 employees or more (84.3 percent). About one in 10 (13.2 percent) survey respondents indicated that their firm has 10 to 24 employees. The remaining businesses have fewer than 10 workers.

FIGURE 2. SURVEYED INDUSTRIES

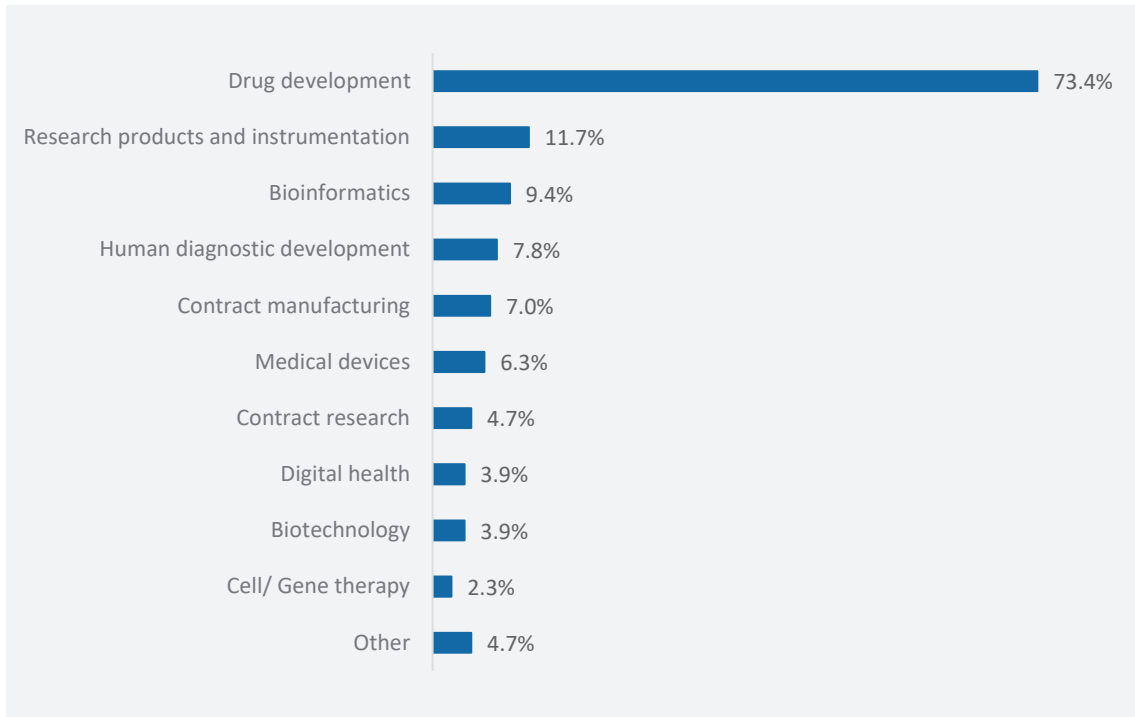
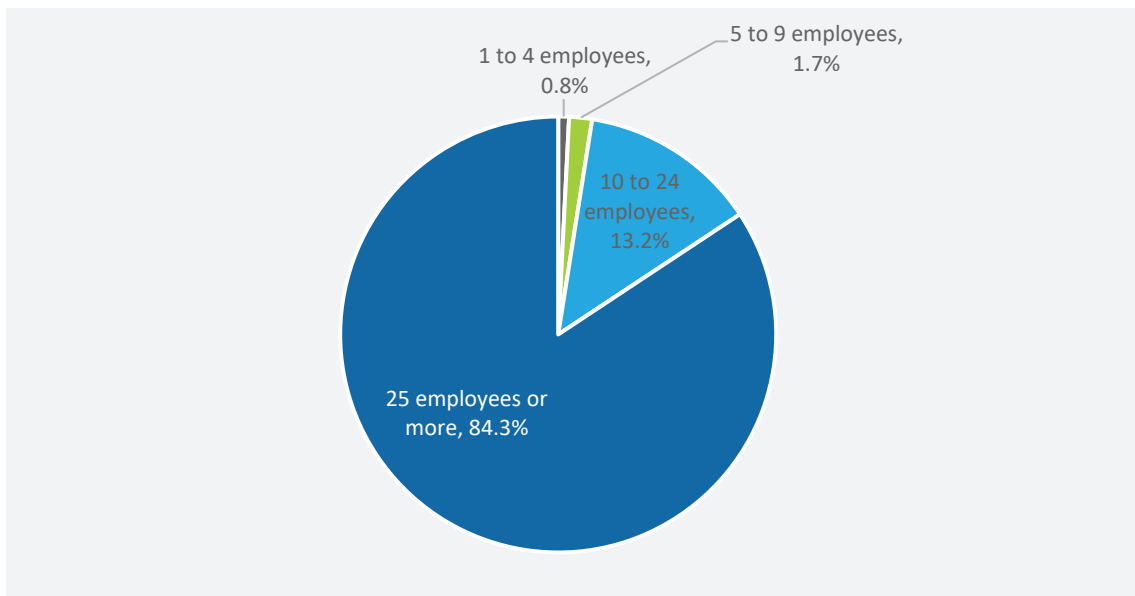
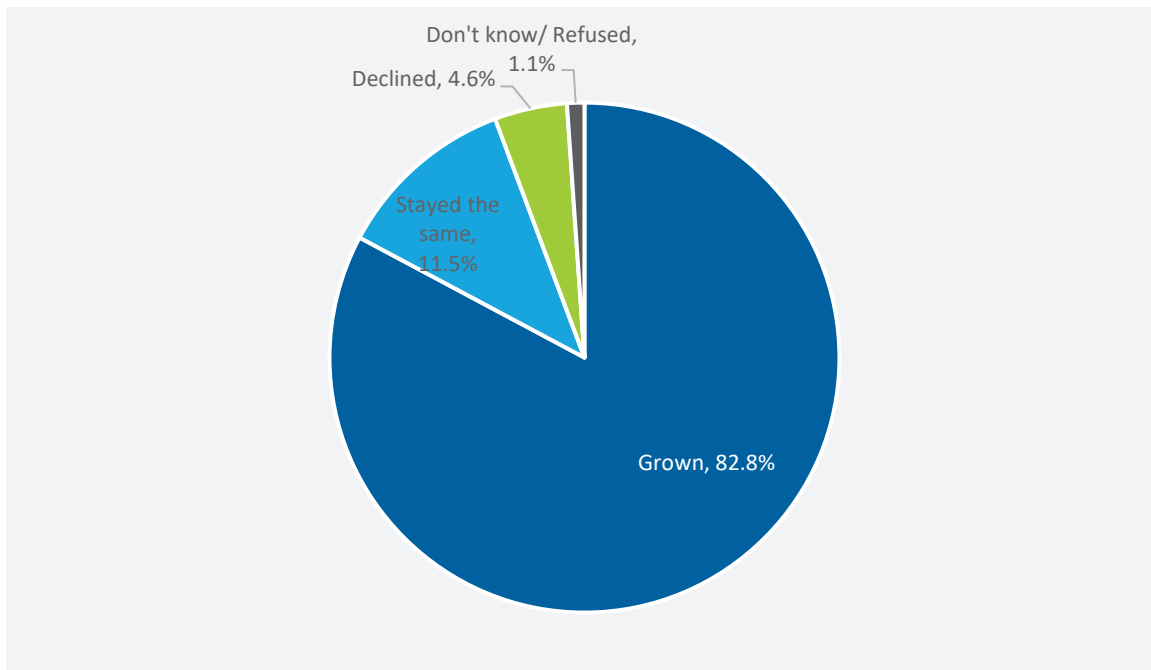


FIGURE 3. BUSINESS SIZE



Over the last three years, eight in 10 surveyed businesses indicated that their company has grown in terms of total employment (82.8 percent). About one in 10 firms indicated their workforce has stayed the same size (11.5 percent), and less than five percent noted that their labor force has decreased in size over the last three years.

FIGURE 4. EMPLOYMENT GROWTH OVER LAST THREE YEARS



EMPLOYMENT PROFILE

Across surveyed life sciences firms in Massachusetts, the majority of full- and part-time permanent employees have at least a Bachelor's degree. Four in 10 employees have a Bachelor's degree (40.8 percent) and another four in 10 have a Master's degree, Doctoral, or professional degree (43.1 percent). Sixteen percent of life sciences workers in Massachusetts have less than a Bachelor's degree.

The majority of the life sciences workforce is engaged in scientific or research roles (65.1 percent), with the remaining roughly one-third of workers engaged in non-scientific roles, such as office and administrative support (34.9 percent).

FIGURE 5. EMPLOYEE EDUCATIONAL ATTAINMENT

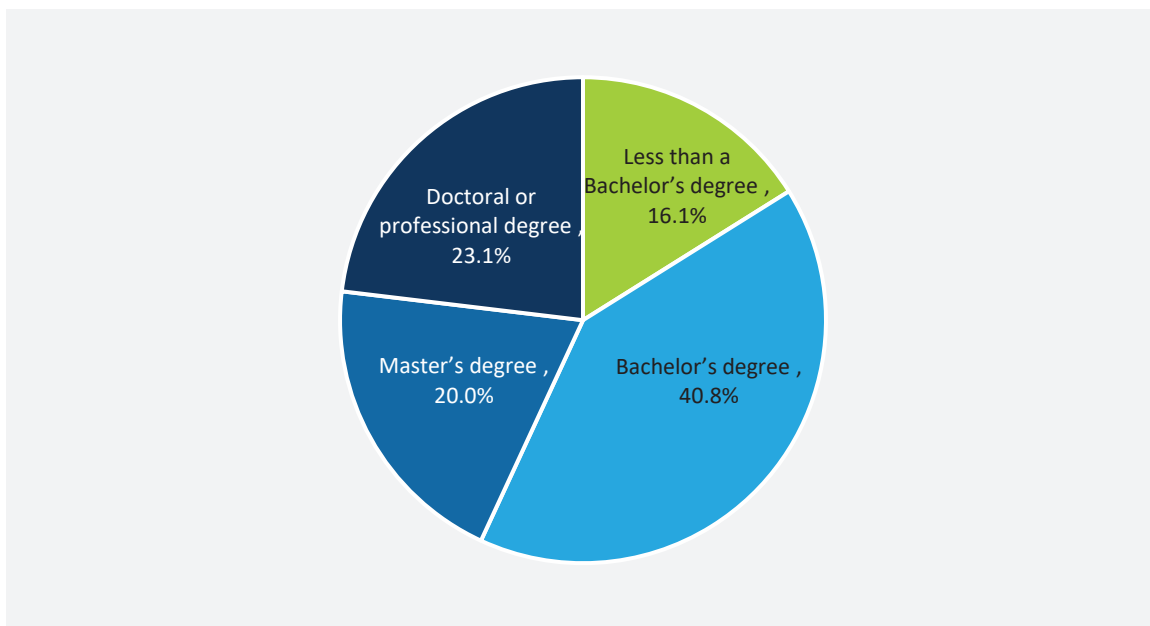


FIGURE 6. EMPLOYEE ROLES

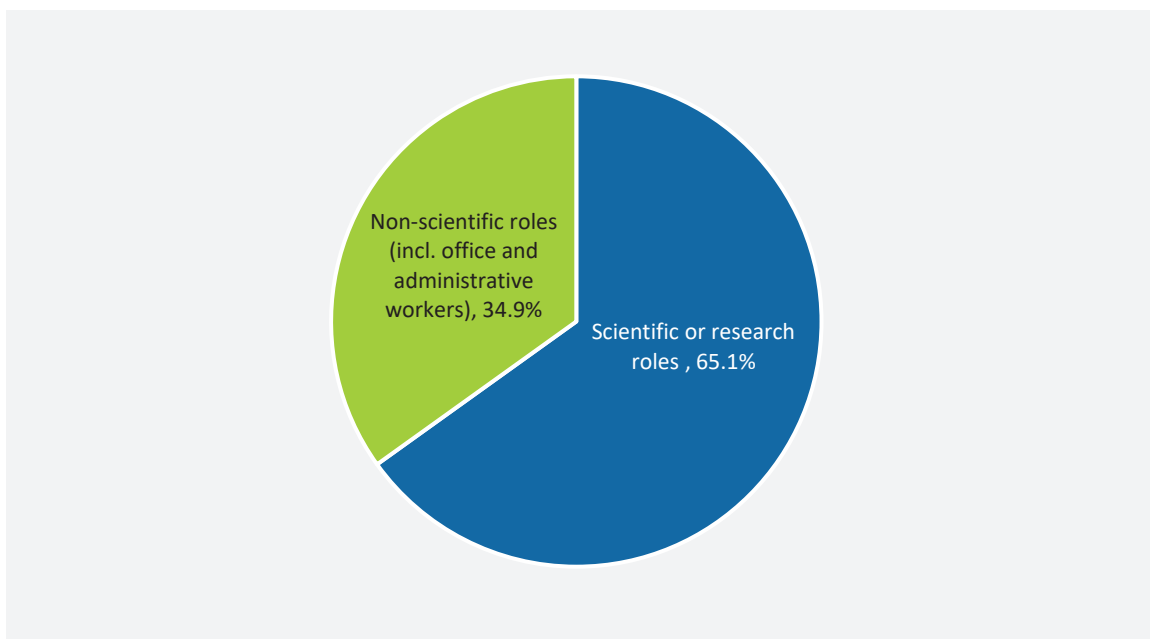
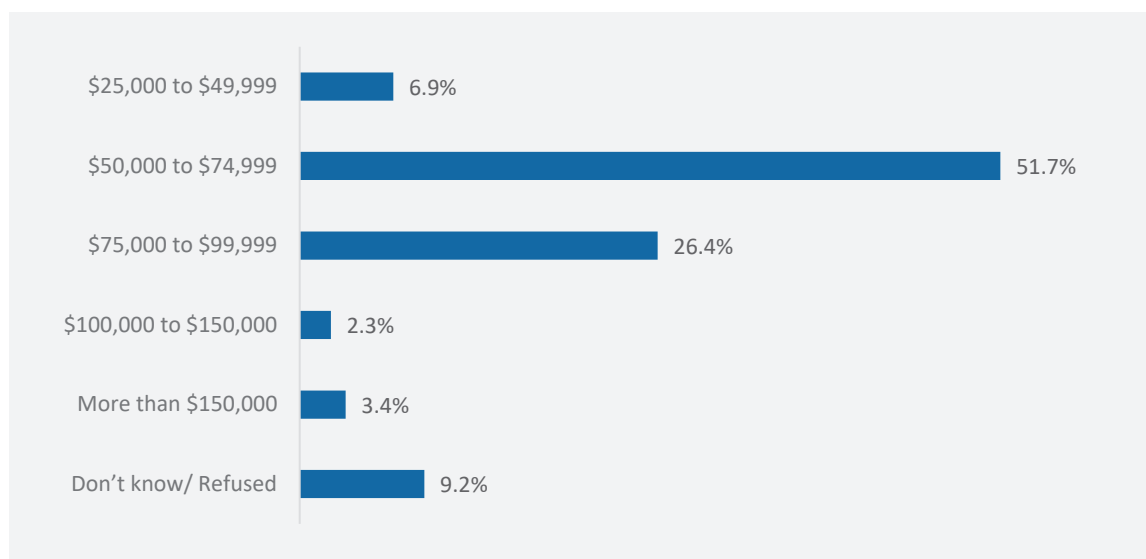


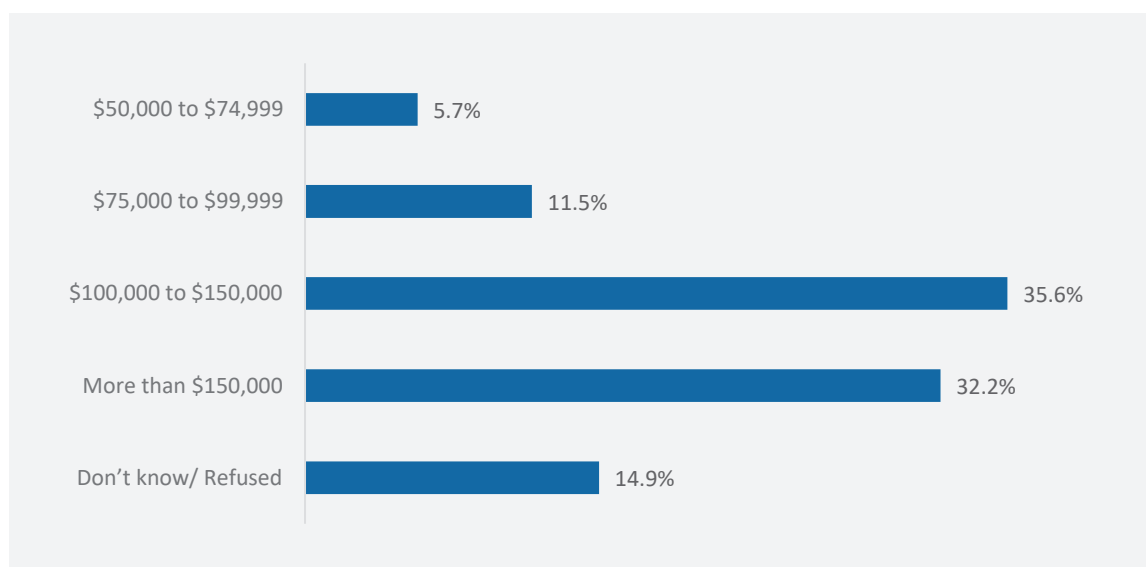
FIGURE 7. AVERAGE ENTRY-LEVEL WAGE



Entry-level wages for life sciences workers are largely concentrated in the \$50,000 to \$99,999 range; about eight in 10 survey respondents indicated that their firms offer an annual salary for entry-level positions somewhere within this range (78.1 percent). Only 6.9 percent provide entry-level salaries below \$50,000, while 5.7 percent reported entry-level wages \$100,000 or higher.

The average annual salary for non-entry-level positions is typically \$100,000 or greater; 67.8 percent of survey respondents indicated that their firm provides an average annual wage for non-entry-level positions that is at least \$100,000.

FIGURE 8. AVERAGE NON-ENTRY-LEVEL WAGE



HIRING EXPECTATIONS & CHALLENGES

Just over three-quarters of surveyed firms indicated that they expect to hire more employees over the next 12 months (77.9 percent). About one in 10 firms expect to maintain the same number of workers, and 2.6 percent of respondents expect their workforce to shrink over the next 12 months.

Firms that indicated they will be hiring for open positions are mostly looking for both entry- and non-entry-level workers (81.9 percent). About two in 10 firms (16.7 percent) are looking for only non-entry-level workers, while 1.4 percent of firms indicated that they are only hiring for entry-level positions.

Firms indicated hiring difficulty for both entry-level and non-entry-level positions, however, there was markedly greater hiring difficulty for non-entry-level positions compared to entry-level positions. Ninety-four percent of firms indicated difficulty (“very difficult” and “somewhat difficult”) filling non-entry-level positions over the last 12 months (94.2 percent). Just under three-quarters of firms reported difficulty filling entry-level positions (73.5 percent).

FIGURE 9. PROJECTED GROWTH OVER NEXT 12 MONTHS

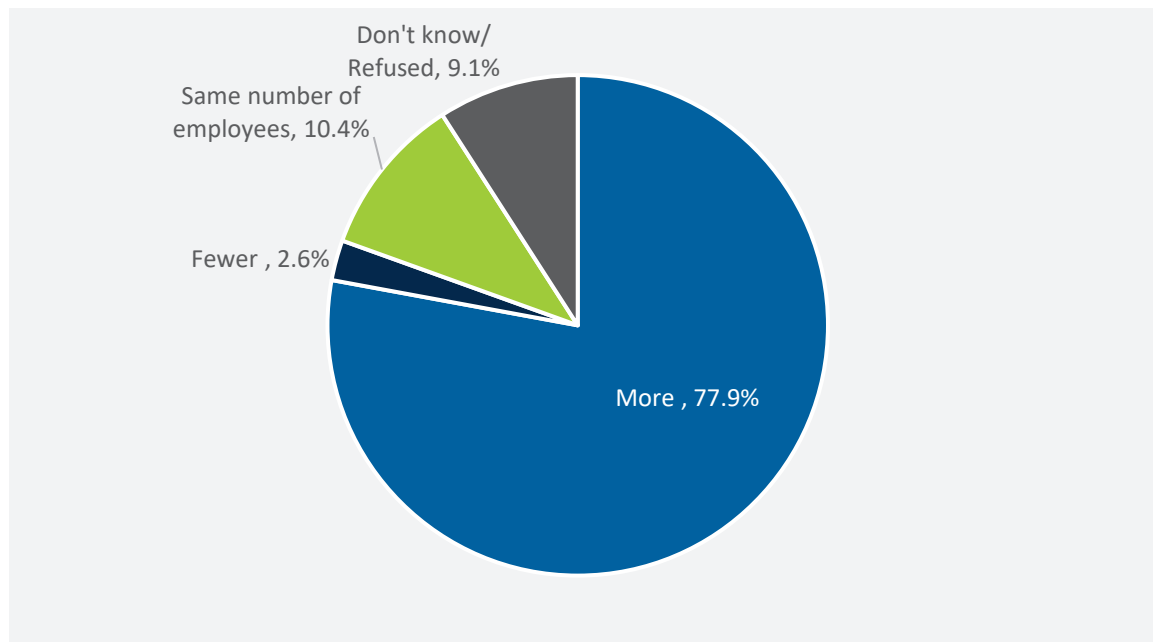


FIGURE 10. TYPES OF POSITIONS

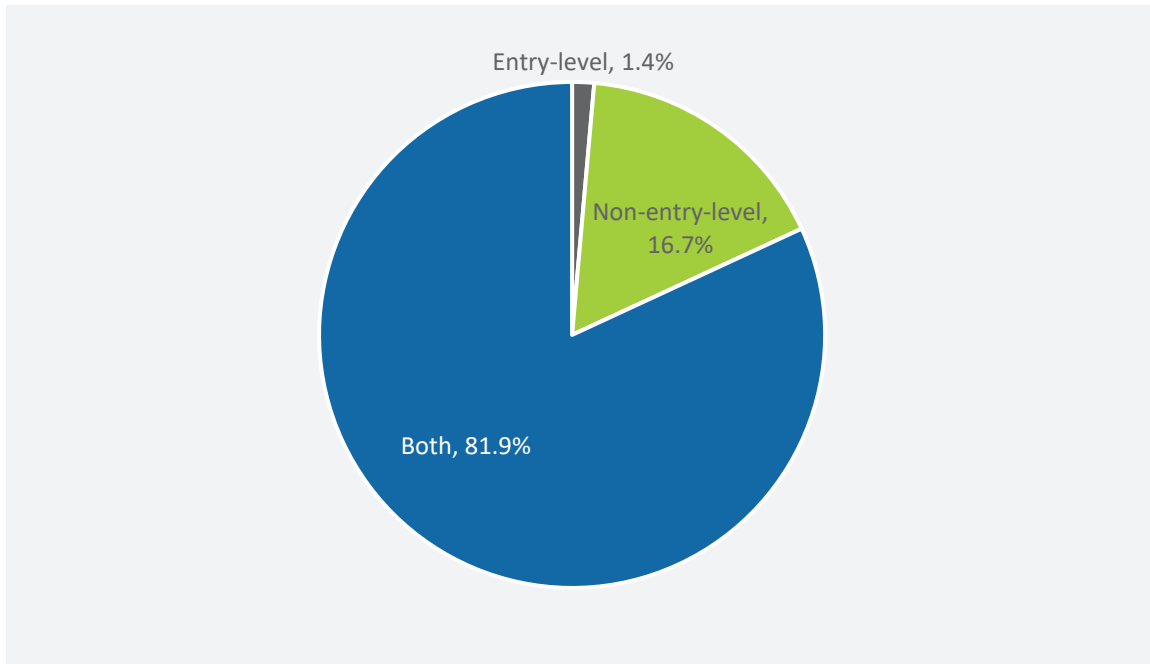
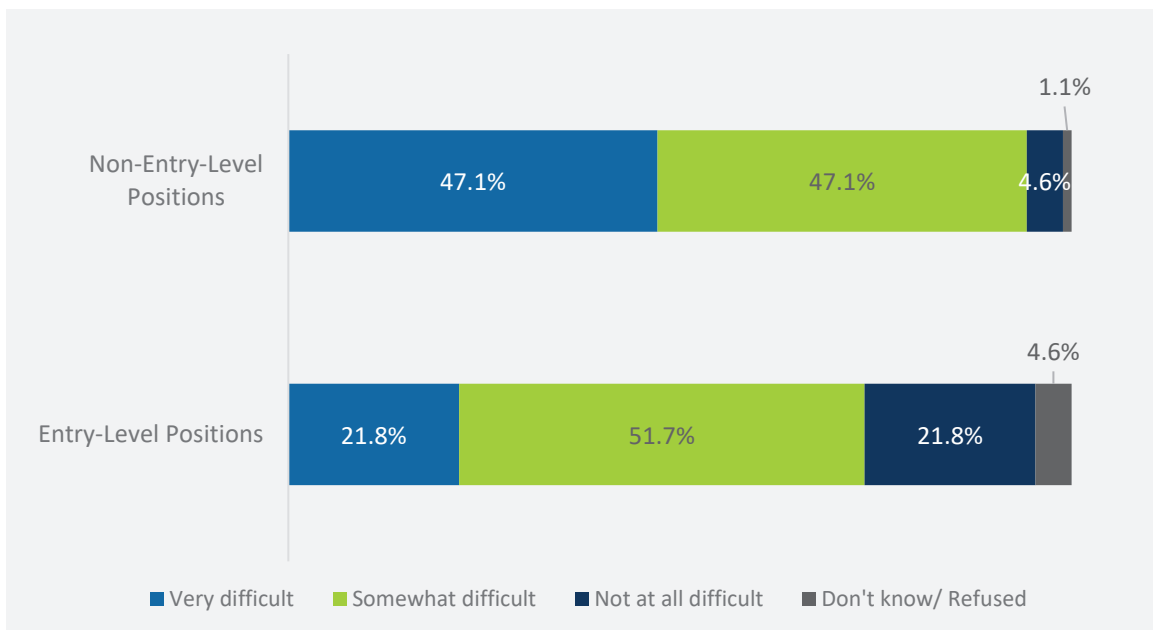


FIGURE 11. HIRING DIFFICULTY (ENTRY-LEVEL & NON-ENTRY-LEVEL POSITIONS)

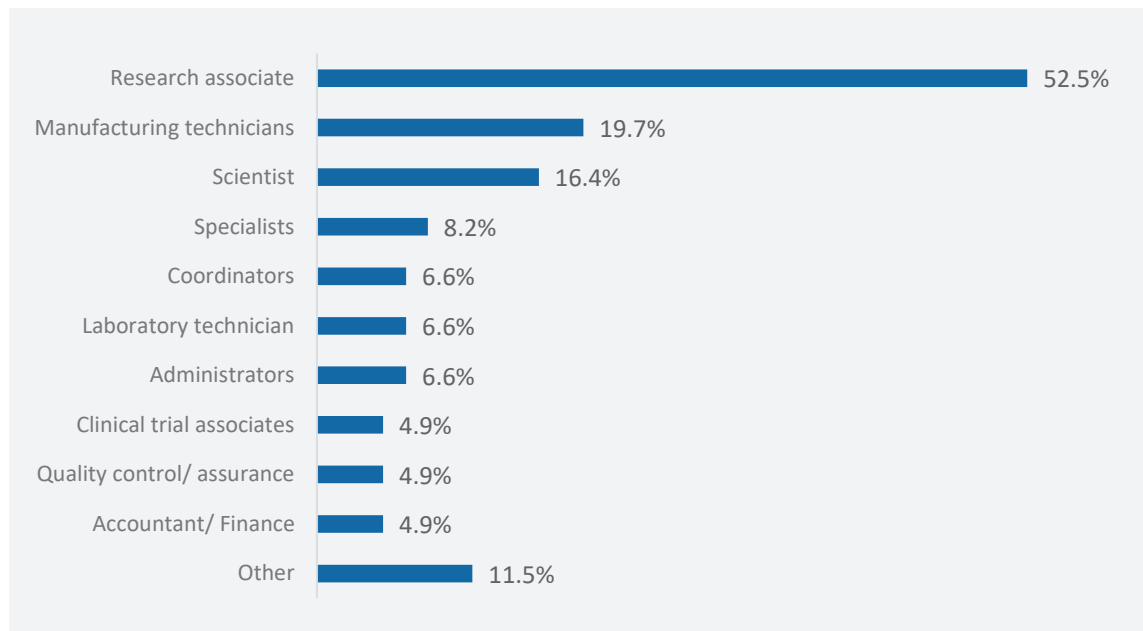


Across both entry- and non-entry-level positions, firms indicated similar challenges and reasons for their reported hiring difficulty, including a small applicant pool, lack of experience or industry-specific knowledge, competition from other life sciences, and insufficient non-technical skills, such as problem-solving, critical thinking, communication, teamwork, and adaptability.

FIGURE 12. REASONS FOR HIRING DIFFICULTY (ENTRY-LEVEL)



FIGURE 13. OCCUPATIONS WITH GREATEST HIRING DIFFICULTY (ENTRY-LEVEL)



The most difficult entry-level positions to fill include research associates (52.5 percent), followed by manufacturing technicians (19.7 percent). The most difficult non-entry-level roles to fill include senior scientists (34.2 percent) and direct level or higher managerial positions (26.6 percent).

FIGURE 14. REASONS FOR HIRING DIFFICULTY (NON-ENTRY-LEVEL)

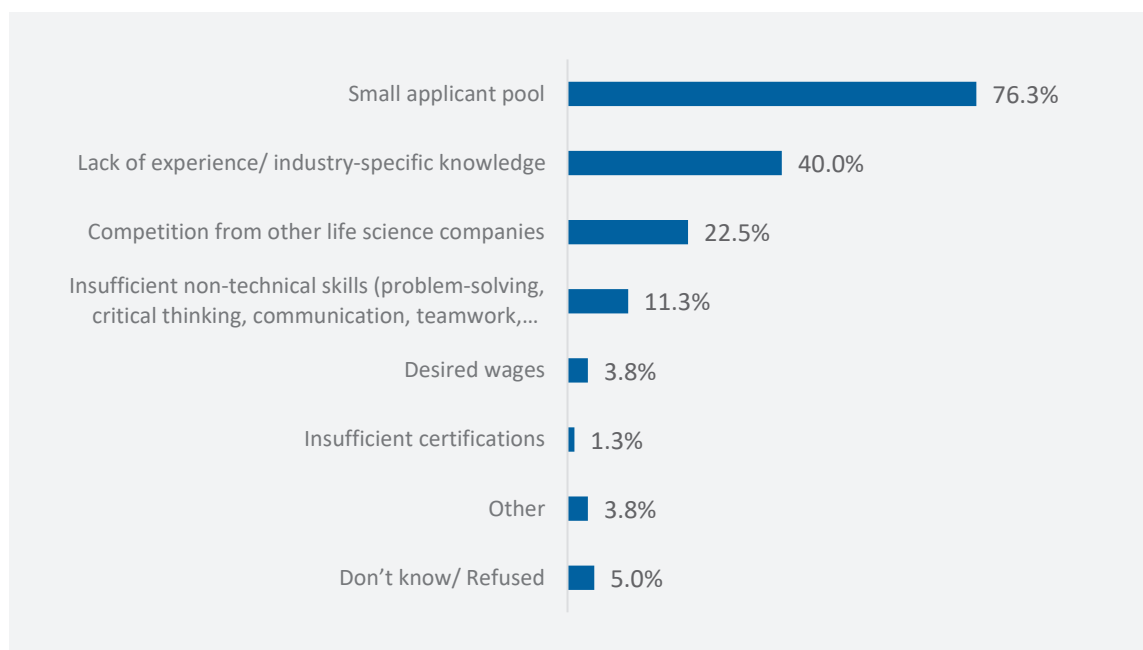
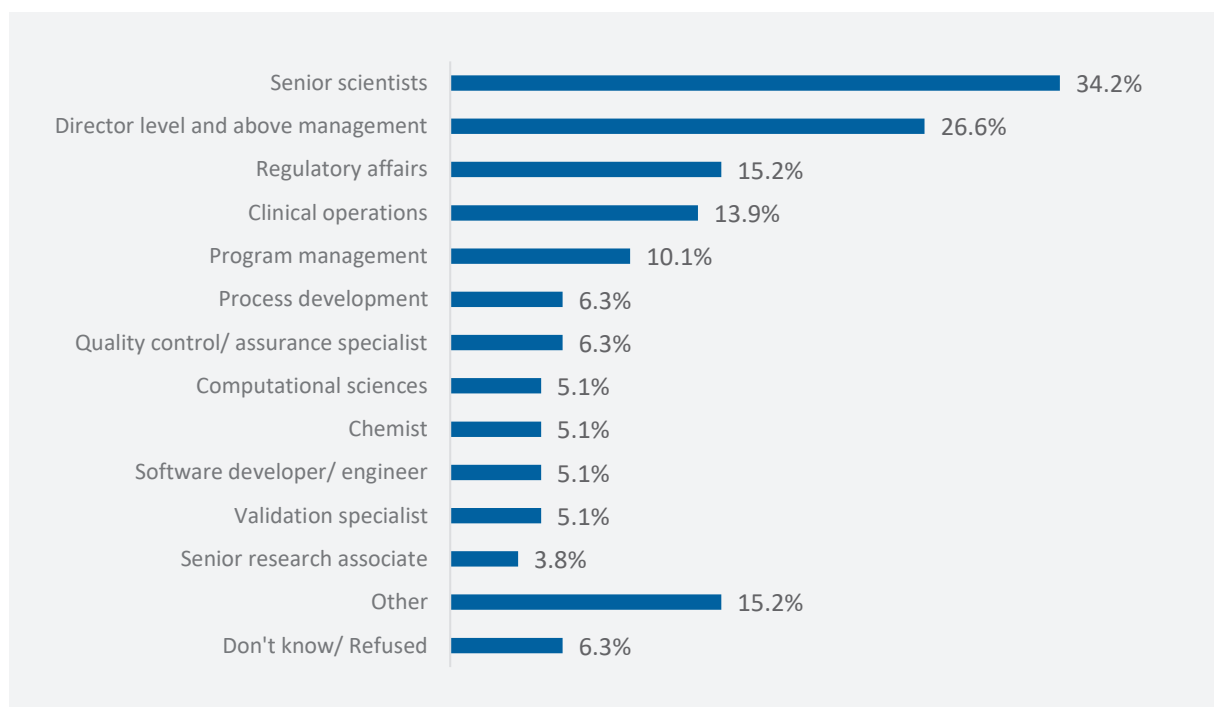


FIGURE 15. OCCUPATIONS WITH GREATEST HIRING DIFFICULTY (NON-ENTRY-LEVEL)

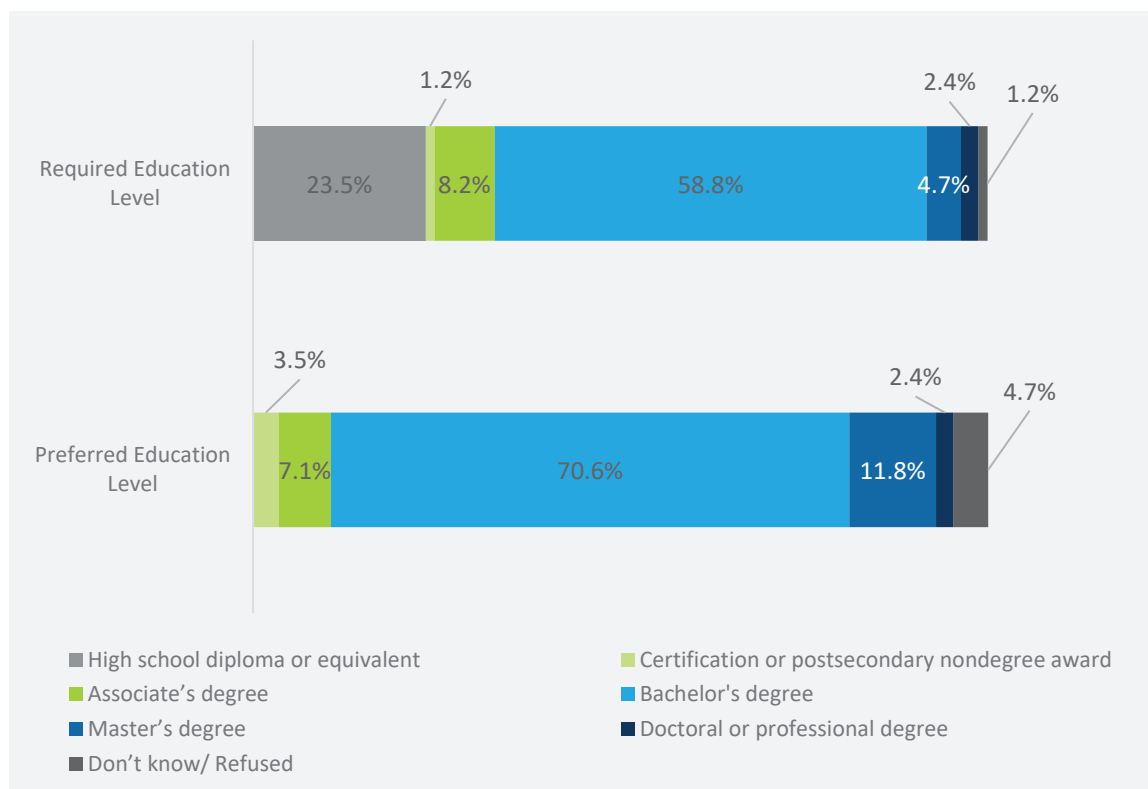


HIRING REQUIREMENTS & PREFERENCES

Required education levels are often lower compared to employers' preferred educational attainment for entry-level positions. Seven in 10 employers indicated that they would like their entry-level candidates to have a Bachelor's degree (70.6 percent), and 14.2 percent would prefer if their entry-level candidates have a Master's degree or higher. However, only 58.8 percent of employers actually require a Bachelor's degree of entry-level candidates, and 7.1 percent require a Master's degree or higher.

A third of surveyed employers reported that their required level of education for entry-level candidates is an Associate's degree or less, including a certification or postsecondary nondegree award or a high school diploma/equivalent (32.9 percent).

FIGURE 16. REQUIRED VS. PREFERRED EDUCATION LEVEL (ENTRY-LEVEL)



Just over half of firms indicated that they would hire an entry-level applicant with less than a Bachelor's degree; 50.6 percent of surveyed employers indicated they would either be "very likely" or "somewhat likely" to hire an entry-level worker with less than a Bachelor's.

Though 44.7 percent of firms reported that they are "not at all likely" to hire an applicant for an entry-level position with less than a Bachelor's degree, about six in 10 firms have done so in the past; 62.4 percent of firms reported that they have previously hired an applicant with less than a Bachelor's degree for an entry-level position.

For non-entry-level positions, firms are much less likely to hire applicants with less than a Bachelor's degree. About three-quarters of firms indicated that they are not likely to do so (72.9

percent), 22.4 percent indicated they'd be somewhat likely, and only 2.4 percent reported that they would be very likely to hire a non-entry-level candidate with less than a Bachelor's degree.

FIGURE 17. LIKELIHOOD OF HIRING LESS THAN A BACHELOR'S DEGREE (ENTRY-LEVEL)

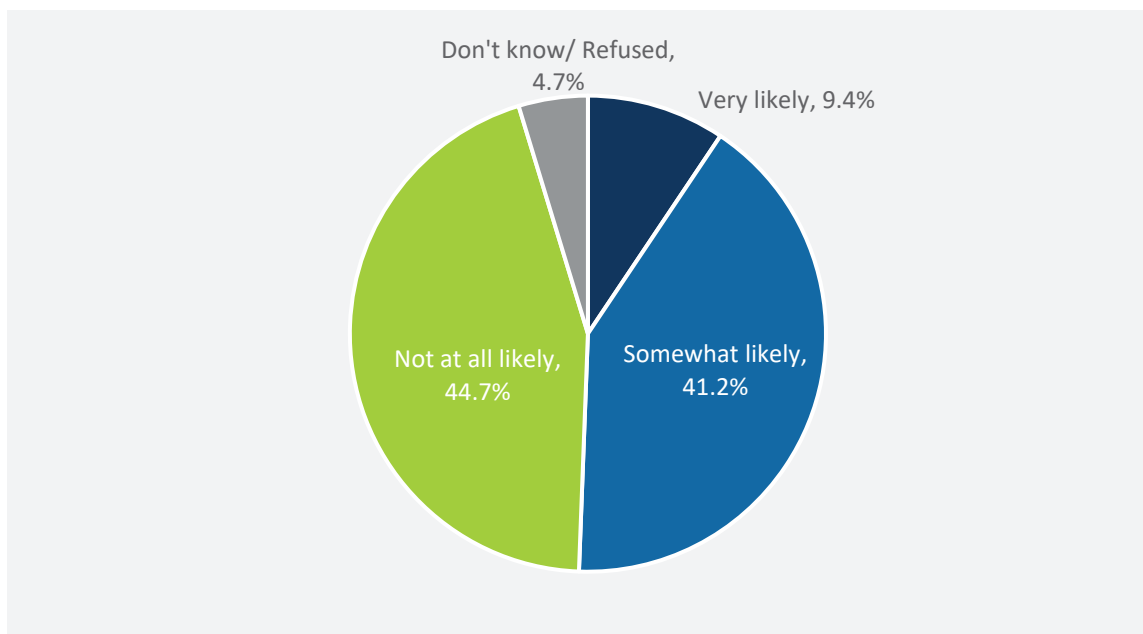


FIGURE 18. HISTORY OF HIRING LESS THAN A BACHELOR'S DEGREE (ENTRY-LEVEL)

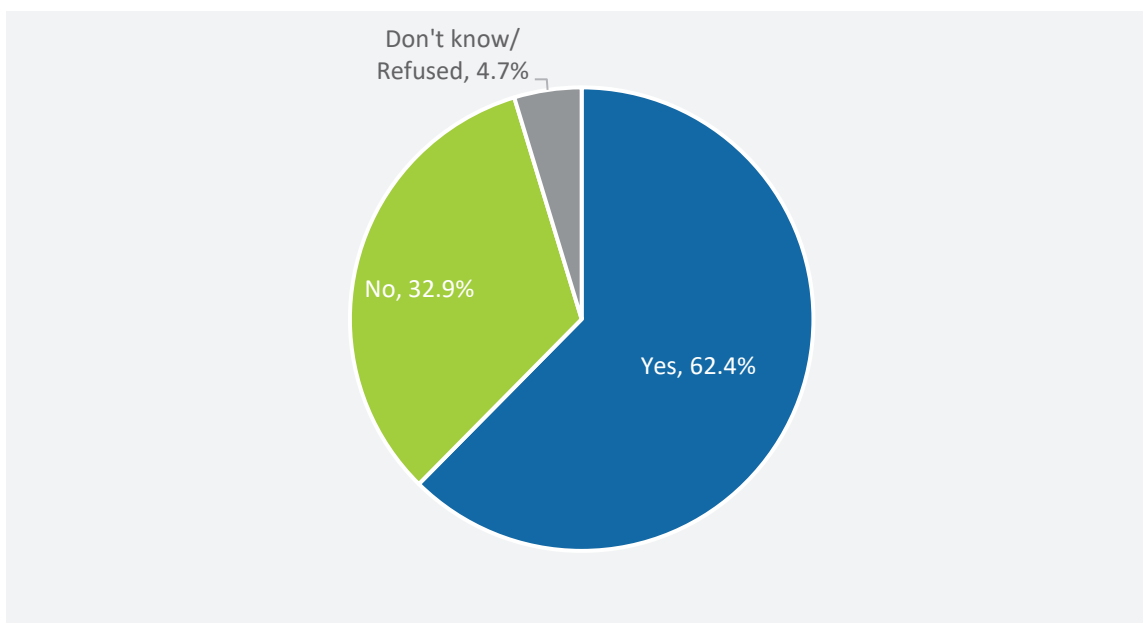
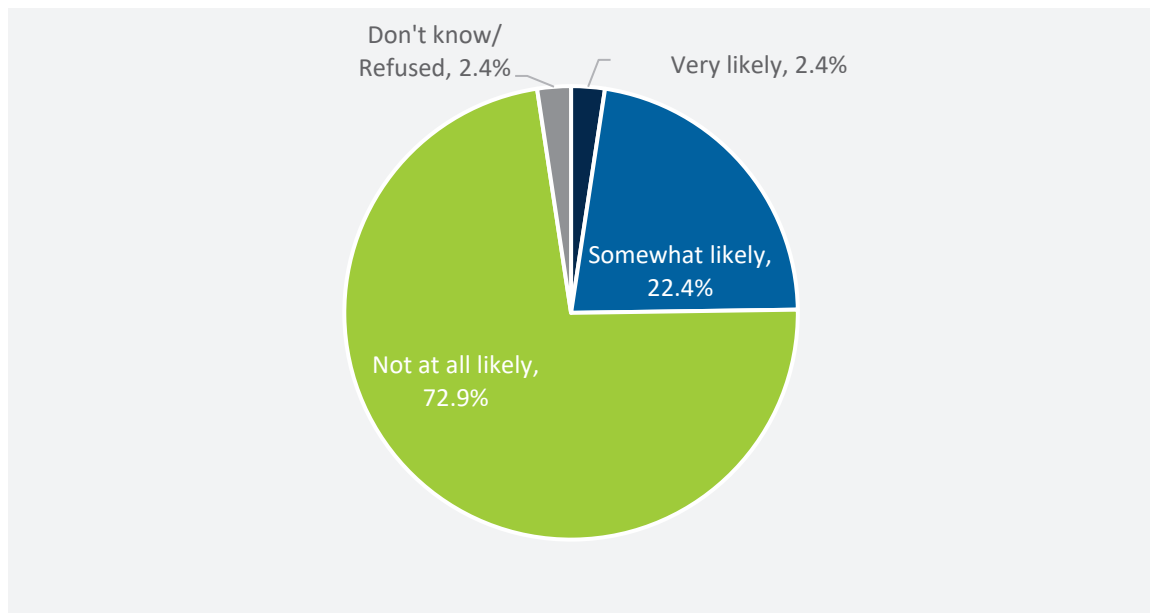


FIGURE 19. LIKELIHOOD OF HIRING LESS THAN A BACHELOR'S DEGREE (NON-ENTRY-LEVEL)



PARTNERSHIPS & PROGRAM INTEREST

For both entry- and non-entry-level positions, firms reported interest in more STEM program offerings in their region, as these types of programs and certificates would meet their firm's skill requirements and hiring needs; 19.2 percent of firms reported they would like to see STEM programs for entry-level positions and 17.0 percent indicated they would like to see these programs for non-entry-level positions.

Additional program offerings firms would like to see for entry-level positions include lab skills (17.3 percent) and biotechnology manufacturing (17.3 percent). For non-entry-level positions, firms would like to see some leadership training (12.3 percent) and manufacturing certificates (9.7 percent).

For entry-level applicants, it is especially important for these individuals to have certificates in specialized topics from two-year colleges, such as cell culture or biomanufacturing; seven in 10 firms indicated that this is either very or somewhat important for entry-level candidates (69.1 percent). Third-party certifications, including RAPS and Six Sigma, are also important to 48 percent of surveyed employers, while badges are not really important to the majority of employers.

FIGURE 20. PROGRAM OR CERTIFICATE INTEREST (ENTRY-LEVEL)

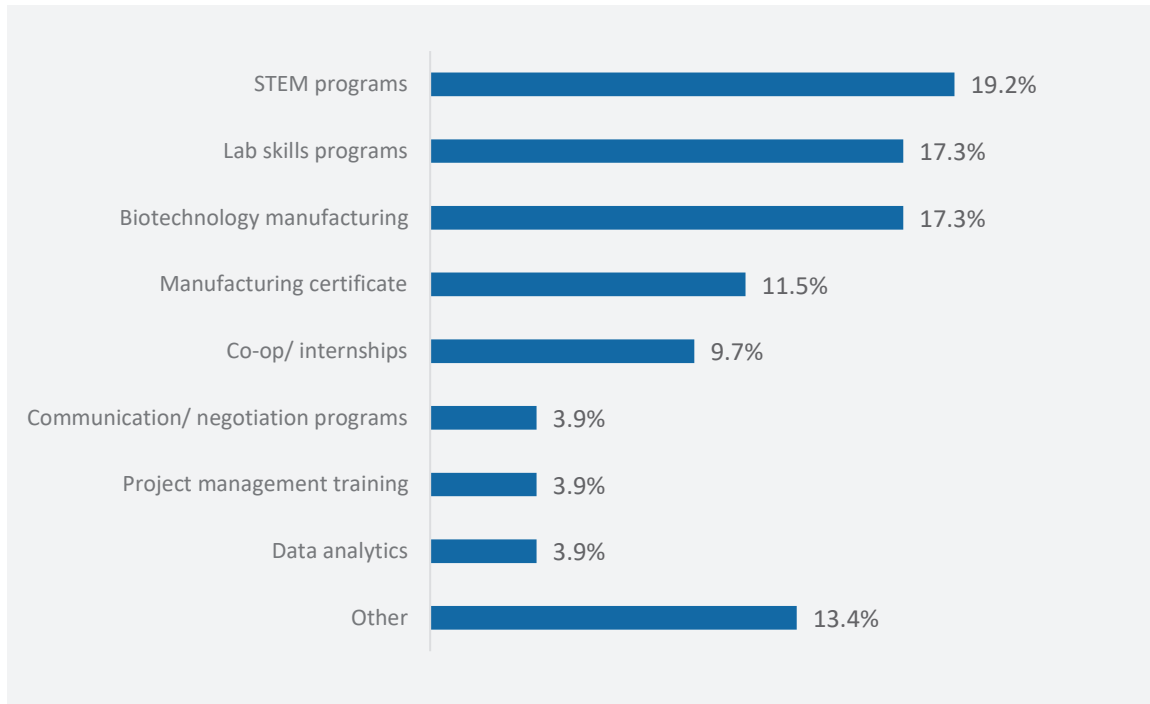


FIGURE 21. PROGRAM OR CERTIFICATE INTEREST (NON-ENTRY-LEVEL)

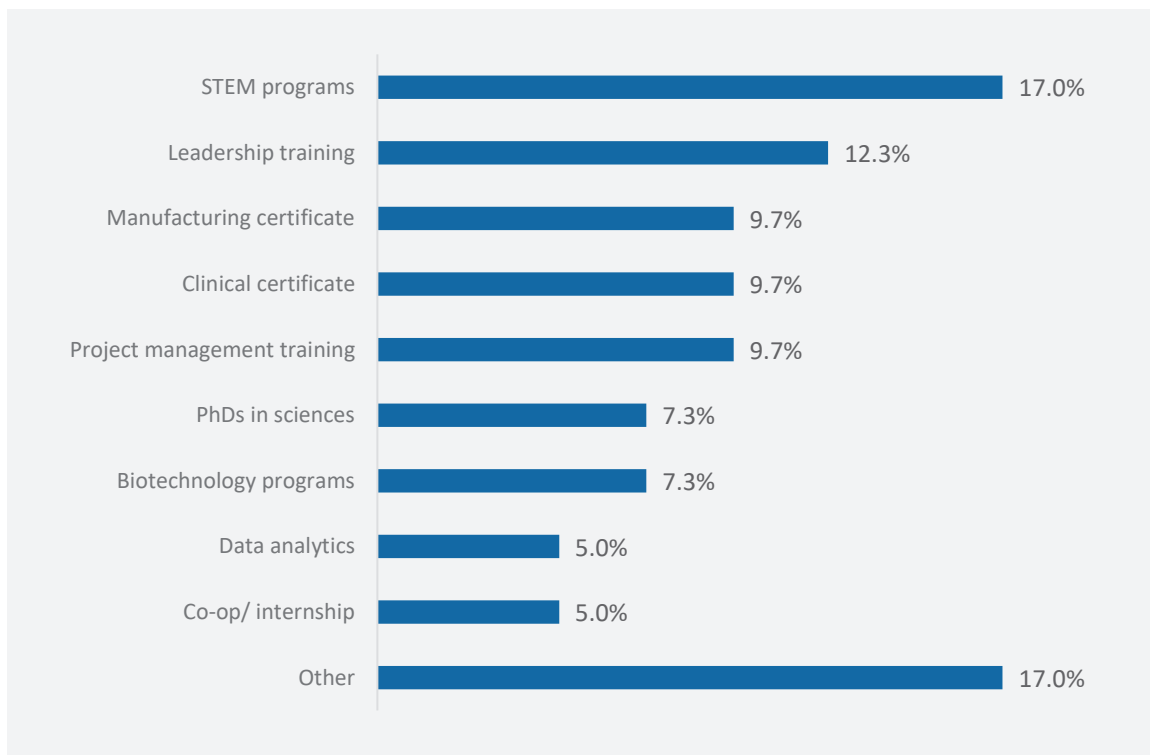
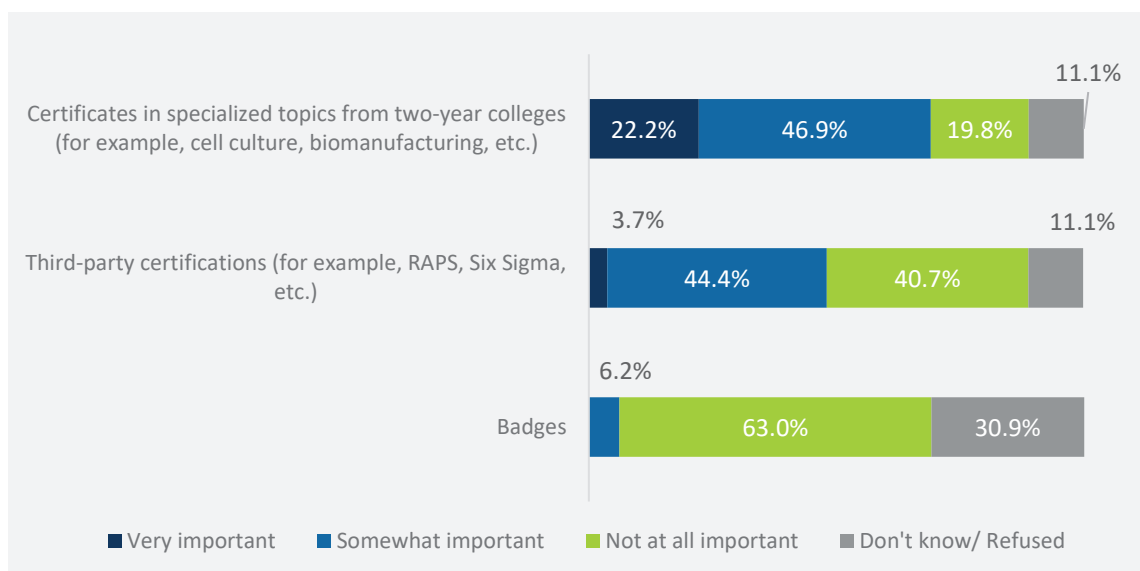


FIGURE 22. CERTIFICATION & BADGE IMPORTANCE LEVEL (ENTRY-LEVEL)

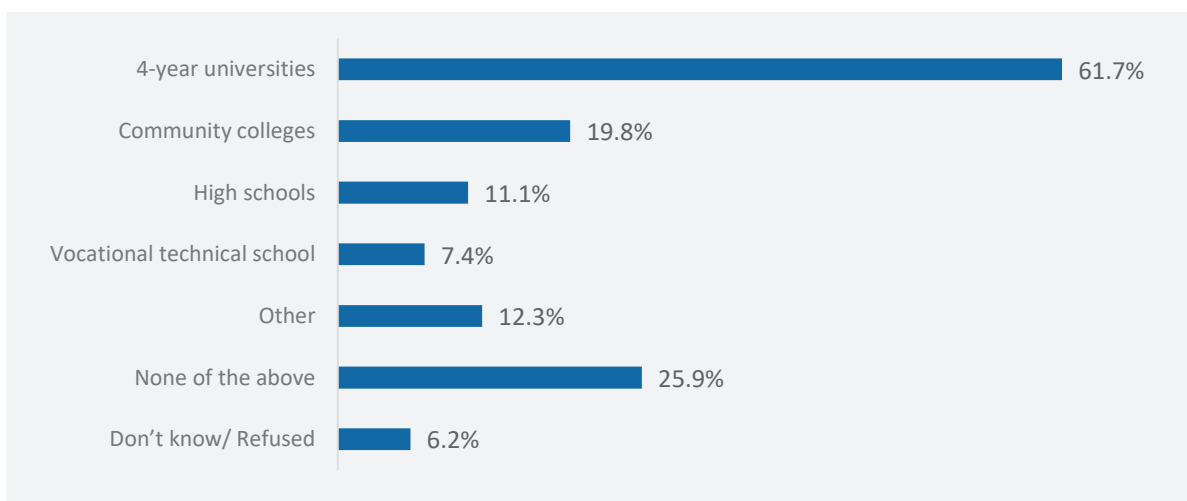


Most life sciences firms partner with 4-year universities to recruit talent for open positions; 61.7 percent of surveyed businesses indicated that they partner with 4-year universities, such as Northeastern, Harvard, and the Massachusetts Institute of Technology. About two in 10 firms (19.8 percent) also partner with community colleges on recruitment efforts, including Middlesex, Roxbury, North Shore, Bunker Hill, Bristol, and other out-of-state community colleges.

A few employers also partner with high schools (11.1 percent) and vocational technical schools (7.4 percent).

Just over a quarter of firms indicated that they do not partner with any educational institutions (25.9 percent).

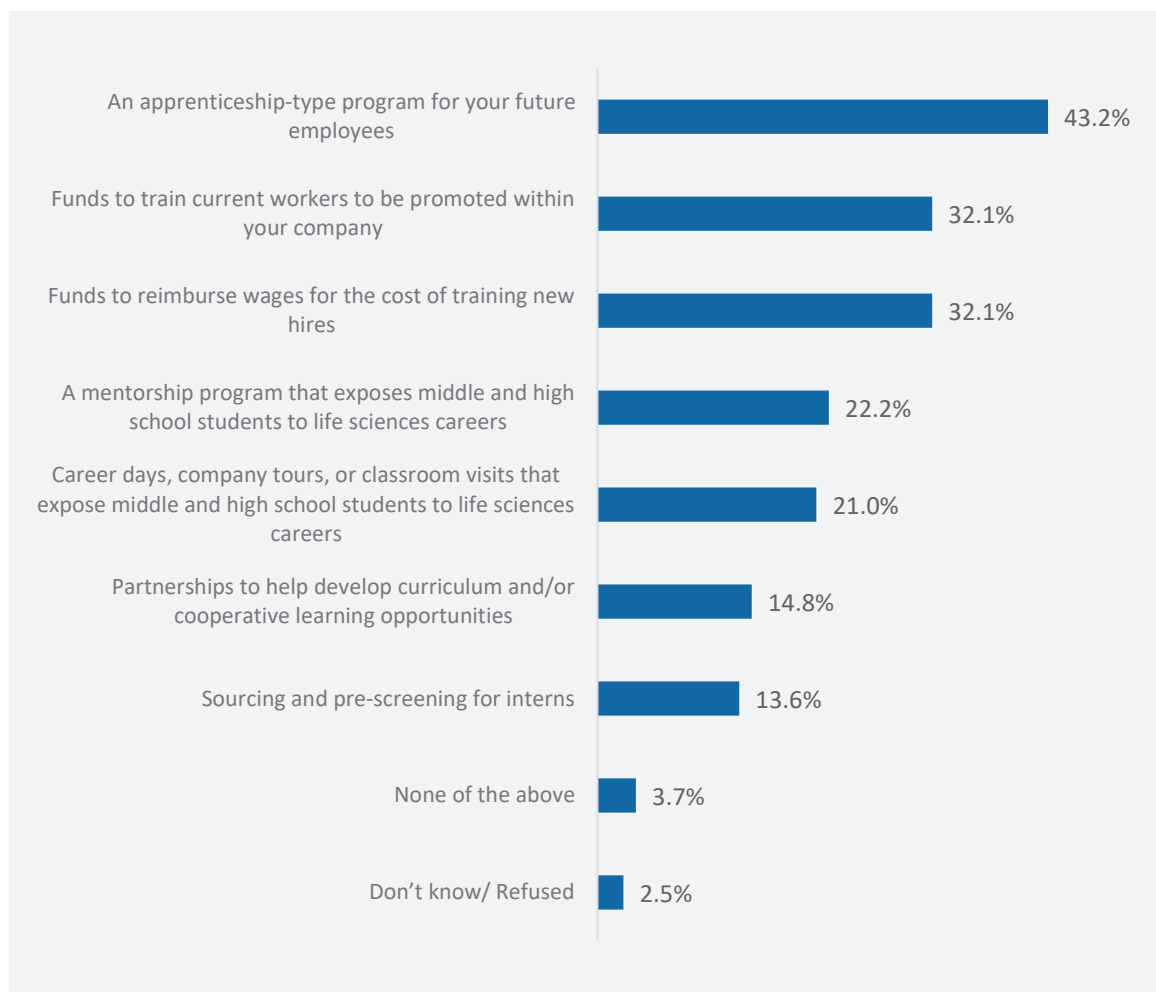
FIGURE 23. TRAINING PROVIDER PARTNERSHIPS



When offered the following list of potential programs or services, firms indicated the most interest in an apprenticeship-type program for their future employees (43.2 percent), followed by funds to train current workers (32.1 percent), funds to reimburse wages for the cost of training new hires (32.1 percent), a mentorship program that exposes middle and high school students to life sciences careers (22.2 percent), and career days, company tours, or classroom visits that expose middle and high school students to life sciences careers (21.0 percent).

Fewer than 15 percent of firms also indicated interest in partnerships to help develop curriculum and/or cooperative learning opportunities (14.8 percent) and sourcing and pre-screening for interns (13.6 percent).

FIGURE 24. PROGRAM INTEREST



Executive Interview Findings

The following section details findings from a series of interviews and a roundtable conducted between February and April 2022. The research team spoke with a total of 28 life sciences companies based in Boston, the MetroWest, and Central Massachusetts. Companies that participated include, but are not limited to, the following: Vertex, Lykan Bioscience, Mustang Bio, Alkermes, Thermo Fisher Scientific, Cyteir, Be Biopharma, and Blueprint Medicines.

BW Research sought to gather qualitative data on the perceptions of workforce needs and challenges for life sciences firms in Massachusetts. The key themes and findings from these interviews are broken out into the follow sub-sections:

1. Talent Competition & the Skills Gap
2. Industry Awareness & the Early Education Pipeline
3. Non-Traditional Training Pathways

TALENT COMPETITION & THE SKILLS GAP

Competition for talent is very high in the Life Sciences industry, and companies have had to get creative to attract and retain talent. There was a broad consensus that the life sciences industry, in Massachusetts and elsewhere, is facing high levels of competition and representatives noted how they have never experienced such a market. Life Sciences firms are facing competition from other life sciences companies in Massachusetts and out-of-state; however, the industry is also facing competition from big tech for data science-related talent.

Many firms are employing various methods to attract and retain talent, including higher wages, improved benefits, and hybrid work models. Large- and mid-sized firms indicated how biotech startups were attracting talent they could not afford to keep because their policies surrounding salaries and titles were more “old school” and not as fast-moving as startups. On the flip side, startups indicated financial considerations as the main source of their retention issues, citing immaturity as a company for their financial disadvantage. Firms also cited hybrid remote work models as one method they have used to retain talent while others have prioritized upskilling and reviewing benefits packages, offering tuition or relocation assistance.

“It is tough out there these days, there has been an incredible flux. We know that we need to start getting creative and think differently about how to access talent and build it for the industry.”

“[It’s hard to find people in] IT/Data Science because we are always competing with the CS industry, and we need to convince people to come out of tech into our industry. [We’re] focusing on the data science side so we have to attract people with the experience...”

“Some of the roles can be hybrid in nature so that helps us expand in this competitive biotech market.”

“Big tech, and smaller biotech companies are the biggest competition. [We’re] very big, and sort of old school compared to the newer smaller biotech companies.”

“Most of our competition is in biotech and biopharma, not much in healthcare.”

"[For] manufacturing, lab-based researchers, some of the roles can be hybrid in nature so that helps us expand in this competitive biotech market."

"We have tuition assistance and we are working on reviewing our relocation package. Retention is up to us. We need help getting people in, but it is up to us to help people want to stay... we are losing people to the small guys and we are hiring from the big guys."

"The attrition rate has been pretty low for us, we're not in Cambridge or Boston, and we have benefitted because people figured out that they don't have to brave long commutes to do good science. We've had to add more benefits that aren't typical for people with less experience especially if you are attracting people from outside the state like we are."

Up titling and wage inflation are major contributors to talent competition in Massachusetts' life sciences industry. Small and large firms indicated this as a major retention and attraction issue as the prevailing attitude is that there is always a company that is willing to pay more or offer a higher salary to potential candidates.

"We have a lack of talent because there is a war for talent. With so much up titling and offering higher salaries... sometimes people come in for higher salaries and higher titles and we have had turnover because some do not stretch and grow in their titles as much as they should, and their skills do not match [the] title."

"This is nothing like I've seen before, we are competitive and seek high-level talent. There's a lot of small biotech everywhere, even entry-level people (little to no experience) go to those [small firms] for salaries and elevated titles (associate scientist I and II)."

"Small and large companies are running into the overtitling issue and it's everywhere, even from the hiring groups I am connected to, it seems this is a new thing that's happening."

"...it is very easy for a small startup to give [hires] an inflated title. We get beat out in total rewards (PTO, titles, promise of more [long-term incentives] than base salary, comp package flexibility), we lose a lot of our talent there. We are losing our underrepresented talent at a much faster rate because they are being targeted."

"We've had to loosen our standards in a way I have never seen before... most of the concessions we make are unheard of... and this is something we are seeing in the hiring communities I am connected to as well... we do pay higher scale but not off the scale for all levels including entry."

There is a mismatch in the experience and skills firms are willing to give certain titles and salaries for versus skills prospective hires and employees can confidently execute. Identified skills included bench skills for employees who need to work in labs, interpersonal skills (referred to as cultural fit by some interviewees), and professional skills (i.e., communication and punctuality). Firms have observed this across entry and non-entry level roles.

"The transition has been relatively recent for us, supply wasn't there for those roles (that had a bachelor's appended to them). There was a mismatch in the skills and goals... we've struggled to make connections with schools and some of those specialize in a way that is not compatible with the roles we need."

"It takes a lot of resources, investments, and a lot of communication and branding materials to [attract and retain people], it is not sustainable. [We] still have [the] difficulty once they are here,

they are not 100% qualified, we have to be creative and look at skills and capabilities in lieu of certain qualifications."

"Yes, bench skills and lab experience in general... we had a potential hire who wanted to come in at a higher title but did not have the necessary skills... and like I said, we do oncology research and we cannot afford to hire people without the relevant skills... the person went with a higher title at a different company..."

"It comes down to getting people trained and the pipeline ready enough, so they come out of school informed and experienced"

INDUSTRY AWARENESS & THE EARLY EDUCATION PIPELINE

Multiple employers cited unpredictable and unclear pipelines for hiring entry-level talent as a limiting factor and identified information gaps as a potential reason for this. Interviewees expressed frustration with the lack of credible information for students who are interested in life sciences careers and indicated a desire to communicate industry needs to students and educational institutions from as early as high school. Companies highlighted individual outreach and partnerships efforts with educational institutions and non-profit associations to develop clear entry points and pathways in the industry. Multiple firms indicated a desire for long-term pipeline development strategies. Interviewees expressed how they view such partnerships as instrumental for training the professionals and scientists needed not only for their own companies, but for the entirety of the life sciences industry.

"There isn't much of a pipeline in Massachusetts, we've struggled to make connections with schools and some of those specialize in a way that is not compatible with the roles we need."

"Sourcing is on LinkedIn primarily, but we need to put together a comprehensive recruitment plan that covers college grads, co-ops, and interns across the board. We are trying to establish that pipeline."

"We would love to take advantage of interns in Mass Life Sciences. The challenge is education and attracting the talent because people are hard to find."

"We're not picky. I just haven't had much luck with schools being responsive or having any kind of focus for trying to help people move into the workplace."

"Quincy and Middlesex have been good... we sit on panels and do some resume reviews with connections from professors. One recent role had about 15 applicants from those schools in the space of two weeks."

"We need to get into the high schools and earlier, educating about the industry early, also in more underprivileged areas, developing diversity early in the game, this is a long-term game."

"People get into the industry and don't have any idea what the roles are and what you'll be doing in the role."

"Kids in the Commonwealth cannot grasp the level of opportunity here, and we need to help them to stop seeing it as something for someone else. Looking at models around the world for centralized training centers (Ireland, North Carolina, Belgium), we need to have some investment [in these models]."

Internships, co-ops, and apprenticeships were cited as valuable models for covering the information and experience gap in the industry. For the employers who have developed or are developing internship programs, hiring manager buy in and involvement was identified as the most effective way to run an internship program. While some firms indicated their current limited ability to develop internship programs due to their current hiring needs, multiple employers indicated their preference for entry-level candidates with training from these experiences. Northeastern graduates with co-op experience were identified as the most sought-after candidates; Worcester Polytechnic Institute graduates were also identified as well-prepared for their roles.

"Co-ops and internships are the greatest opportunity for people to get experience and education, they are both important for the future of the industry because in most cases, 60-70% of hiring is coming from there."

"We are currently working with Northeastern's co-op program..."

"Northeastern grads are sought after, and we love them because they've had more work experience compared to the pale academic experience offered in other places."

"Northeastern is the standard and a fabulous program and we are excited by what they have done so far."

"...we are not super strict about experience. Any internship experience is huge."

"The internship program we have is applicable to a few different places. The training aspect gets our hiring managers involved in the development of the program and that is a solid practice. The internship piece is great to see how individuals perform and for them to figure out if it's for them. The continued check-ins and skill building (what I like to call scaffolding) is good too."

"If we can strategically work with colleges and universities to get students into intern, co-op, and apprentice roles, that would benefit us."

"We participate in an earn-and-learn program in which we have four interns who come from MCC every six months."

"The types of jobs [at the new manufacturing plant] will be straight forward. We will have an apprenticeship program..."

"Apprenticeships are just one tool... we're going to have about 20 apprentices joining us. In Cambridge, they work for people transitioning out of the military, meteorology in the Navy or nuclear energy because those people are stellar, they are the best."

NON-TRADITIONAL TRAINING PATHWAYS

Community colleges were identified as being valuable sites of potential investment for non-traditional workforce development (i.e., hiring for people without four-year degrees). Interviewees mostly agreed that community colleges are underutilized resources that could fill the information and experience gap the industry is undergoing. While most job postings require at least a bachelor's degree for certain entry-level positions, companies are interested in reevaluating their hiring structure to include more candidates without four-year degrees. While some companies already work with community colleges, some of those which did not

highlighted their willingness and enthusiasm to partner with community colleges to hire candidates with associate degrees. One interviewee suggested that community colleges are valuable for the certification options they offer, as any employee could enroll in a certification course to upskill for future roles within the company.

"Community colleges are an underutilized source of talent for us."

"We don't have a specific call out system to draw from Bunker Hill, we do hire people with associates. It's somewhat random still..."

"Once you have the core skills, how do you go back and get the new skills that you need to be competitive? Tech schools and community colleges play a key part in offering those certifications to people who want to get them."

"We are looking at community colleges as another source, and potentially as a longer-term investment. It's an opportunity for people to stay with us for a longer time if we hire them as an intern or grad and we train them for the long term."

"I think, too, that you don't always need a four-year degree in manufacturing (unlike QC or QA where the expectation is a bachelor's) and I have hired kids coming straight out of high school."

"The UMass system is very attractive; community colleges could be attractive and that's what we're trying to establish right now in Roxbury."

Companies identified manufacturing and quality control functions as the most likely spaces for non-traditional training initiatives to be implemented successfully. Companies have already reevaluated the minimum qualifications for these positions. Hires without 4-year degrees can be successful in these roles, but employers noted that a scientific background is instrumental for their success in the training program. Certificates, lab experience, and associate degrees were identified as sources for people to develop a science foundation for these roles.

"In manufacturing, I think the answer is yes [you do not need a four year degree], because we do train in the process, but I think it's important that some people have a foundational experience of working in the laboratory and understanding biology."

"I think someone who cares is number one. Attention to detail, ability to recognize when something doesn't work right, that's where that scientific background and experience and foundation really comes in here."

"QC is the entry-level steppingstone; you need to have scientific background/foundation though."

"I think in manufacturing it could work for sure. And in quality on the QA side it could work, but once you get beyond that QC analyst, we really look for people with GMP experience and you can really only get that in the lab. It's really important to us and we must have it in QC."

"A certificate in biotech is helpful because we find that it's easier to train for those folks. [They] do not need a degree which is related to the life sciences; we've had a variety of people with foreign language degrees, history degrees, medical assistants, [and] more recent applicants have not had a bachelor's."

"[Hiring folks without 4-year degrees for manufacturing, R&D, and IT activities] is one area where we have challenged ourselves and we have identified a number of roles that do not require it. We just saw to fruition 10 interns who are high school grads, interned in QC and supply chain for six months after biotech and business for six months and nine were offered full time roles. We'll be starting a new cohort in the fall."

Industry Assets & Resources

The Industry Assets & Resources section provides an overview of the life sciences training landscape in Massachusetts as well as available federal and state workforce development programs—both specific to life sciences and more generally available for businesses—that may be used by life sciences firms to augment and support their recruitment and hiring efforts.

Training Landscape

INTRODUCTION

The life sciences training landscape seeks to provide a greater understanding of the landscape of biotechnology and biomanufacturing training in Massachusetts. The training inventory focuses on pathways that do not require a four-year degree or lead to graduate certificates for baccalaureate holders with an interest in pivoting.¹¹

The research team augmented MassBio’s original list of biotechnology and biomanufacturing training programs by relying on publicly available information on program websites to supplement the original training inventory. The inventory, which contains 23 programs across 15 different institutions, provides a basic understanding of the distribution of existing non-four-year training programs by industry, geography, degree outcome, and program provider.

PROGRAM OFFERINGS

This section highlights the current training programs in Massachusetts that are presently involved in developing the state’s life sciences workforce. Only one program is brand new as of December 2021 and is still in development—the associate degree program in biotechnology manufacturing, which is a product of collaboration between the Benjamin Franklin Institute of Technology (BFIT) and Ginkgo Bioworks; the program will be hosted by the Nubian Square Life Sciences Training Center.

Life sciences workforce training in Massachusetts covers an array of industry sectors (Table 3). Identified programs prioritize providing students with a solid science foundation, as graduate certificates require a science background for students to take part in the programs. While all outlined programs train for careers in the life sciences, there emerged some distinction in the focus of these programs.

Biotechnology programs are designed to familiarize students with standard operating procedures (SOPs) in laboratories, strengthen their research skills, and teach them about the latest technologies. Most training programs (57.1 percent)—seven of which are hosted by community colleges—focus on biotechnology.

Biomanufacturing programs outlined the same foundations as biotechnology programs. In addition, biomanufacturing training includes activities that provide experience in quality control, process development, and current Good Manufacturing Practices (cGMP).¹² Overall, one-third of

¹¹ Northeastern’s A2M Program is an exception in this analysis as it is the next optional step for people who earn their credential through the program at Middlesex Community College.

¹² Mandated by the Food and Drug Administration (FDA)

identified programs focus on biomanufacturing; three of which are hosted by community colleges, two by private colleges or universities, and one by a community-based organization.

While data science accounted for one program (4.8 percent), the biomedical and general life sciences industry sectors accounted for two programs each (9.5 percent each). One of the biomedical programs, offered by Just-A-Start in partnership with Bunker Hill Community College (BHCC), provides an academic biomedical foundation that includes comprehensive laboratory skills training and leads to a variety of life sciences jobs. The data science and general life sciences programs, all offered by the Massachusetts Life Sciences Center (MLSC), are respectively geared towards data science and STEM internship opportunities in the life sciences industry.

TABLE 3. MASSACHUSETTS LIFE SCIENCES TRAINING PROGRAMS BY INDUSTRY SECTOR

Industry Sector	Number of Programs*	Percent of Programs
Biotechnology*	12	57.1%
Biomanufacturing*	7	33.3%
General Life Sciences	2	9.5%
Biomedical	2	9.5%
Data Science	1	4.8%

* BFIT's new program is expected to develop skills in biotechnology and biomanufacturing, among others; thus, it is counted for both categories. As such, the total number of programs will not equal 23 and the percentage will not sum to 100 percent.

Just over 60.0 percent (60.9 percent) of the identified in-state training programs focus on training biological technicians (Table 4). One of the fourteen programs is still in development, as mentioned above. Five of these programs—hosted by MassBay Community College (MassBay), MassBioEd, Quincy College, and Worcester Polytechnic Institute (WPI)—provide clear pathways into biomanufacturing roles. Approximately one-third (34.8 percent) of the programs train individuals for a variety of occupations within the life, physical, and social science category.¹³ Some programs include lab training while others focus on instruction broadly related to industry. One program, hosted by the Massachusetts Life Sciences Center (MLSC), develops data scientists for the life sciences industry.

TABLE 4. MASSACHUSETTS LIFE SCIENCES TRAINING PROGRAMS BY PROGRAM PROVIDER

Program Provider	Number of Programs	Percent of Programs
Community College	10	43.5%
Private College/University	5	21.7%
Community-Based/Non-Profit Organization	4	17.4%
Quasi-Public Agency	3	13.0%
Public College/University	1	4.3%

¹³ These programs outlined training opportunities for engineers, environmental scientists, chemists, biomedical professionals, and microbiologists among others.

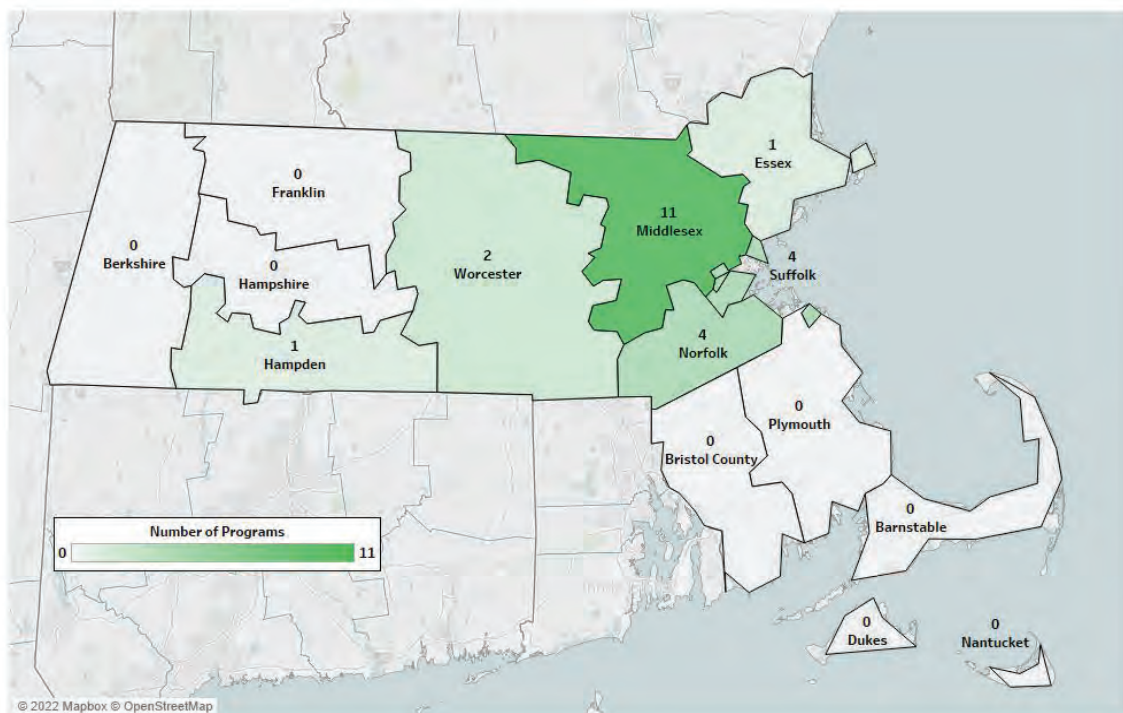
Middlesex County offers eleven training programs, accounting for 47.8 percent of programs (Table 5). Norfolk and Suffolk counties each have four programs (17.4 percent respectively). Worcester County has two programs which are offered by WPI and lead to certifications in biomanufacturing. Essex and Hampden counties each have one training program (4.3 percent each).

TABLE 5. MASSACHUSETTS LIFE SCIENCES TRAINING PROGRAMS BY COUNTY

County	Number of Programs	Percent of Programs
Middlesex	11	47.8%
Norfolk	4	17.4%
Suffolk	4	17.4%
Worcester	2	8.7%
Essex	1	4.3%
Hampden	1	4.3%

Of the eleven programs offered in Middlesex County, four are hosted by Middlesex Community College and three by MLSC; this means that six distinct institutions offer life sciences training in Middlesex County. Two institutions (MassBay Community College and Quincy College) offer training in Norfolk County and four institutions offer training in Suffolk County.

FIGURE 25. MASSACHUSETTS LIFE SCIENCES TRAINING PROGRAMS BY COUNTY



The concentration of life sciences training programs in Middlesex, Norfolk, and Suffolk counties is unsurprising given the general distribution of colleges and universities in Massachusetts.¹⁴ Given that Middlesex, Suffolk, and Norfolk also have the highest proportion of research and development (R&D) jobs¹⁵, the industry is well-poised to take advantage of the talent pipeline from schools in the area. Additionally, Middlesex County has the highest proportion of biomanufacturing jobs (45.2 percent) followed by Worcester County (20.4 percent).¹⁶ The two counties also have the highest biomanufacturing job growth of 7.9 percent for Worcester County and 4.8 percent for Middlesex County.¹⁷ However, there are only three biomanufacturing training programs between the two counties—two at WPI and one with MassBioEd.

One area of opportunity is leveraging talent from biomanufacturing programs adjacent to the county, which Middlesex and Suffolk companies are already doing with Northeastern's programs. Another area of opportunity is increasing partnerships between industry and training hosts in Middlesex and Worcester counties. Regional economic development agencies, like Grafton's Economic Development Council in Worcester County,¹⁸ are also keen to host biomanufacturing companies in their cities and towns.

The analysis shows an almost equal number of associate degrees (39.1 percent) and certificates (34.8 percent) as outcomes of life sciences training programs in Massachusetts (Table 6). While a total of five programs (21.7 percent) had no discernible outcomes, four identified the importance of internship experience gained through the program, and one hailed the eligibility to gain college credit for BHCC. MCC and Northeastern's A2M program leads to various outcomes, and individuals may get the opportunity to pursue their studies up to the associate level at MCC or continue at Northeastern to earn their bachelor's or master's degrees.

TABLE 6. MASSACHUSETTS LIFE SCIENCES TRAINING PROGRAMS BY DEGREE OR OUTCOME

Degree/Outcomes	Number of Programs*	Percent of Programs
Associate*	9	39.1%
Certificate	8	34.8%
Internship Experience	4	17.4%
Bachelor's*	1	4.3%
Master's*	1	4.3%
College Credit Eligibility	1	4.3%

* The A2M program is counted for each outcome, i.e., associate degrees from MCC and either bachelor's or master's degrees from Northeastern University. As such, the number of programs will not total 23 and the percentage will not sum to 100 percent.

¹⁴ National Center for Education Statistics (NCES), College Map.

¹⁵ Massachusetts Biotechnology Council. 2021 Industry Snapshot. August 2021. https://www.massbio.org/wp-content/uploads/2021/08/2021-INDUSTRY-SNAPSHOT_FINAL.pdf.

¹⁶ *Id.*

¹⁷ *Id.*

¹⁸ Grafton Economic Development. Biomanufacturing Brochure. 2018. <https://massecon.com/wp-content/uploads/Grafton-MA-Biomanufacturing-Brochure-2018.pdf>.

Federal & State Workforce Development Resources

INTRODUCTION

The research team assembled an extensive life sciences asset inventory using a review of publicly available listings and government websites. The inventory includes 26 programs, covering grants, tax credits, wage reimbursement, capital funding, and cost share programs. This asset inventory provides a basic understanding of the existing programs and financial resources available to life sciences businesses in Massachusetts.

OVERVIEW

Three in ten (30.8%) life sciences assets are general support programs, the largest proportion of all programs. These programs provide broad support to life sciences businesses through various tax credits, tax exemptions, cost sharing benefits, and unemployment benefits. The general support programs have targeted goals of assisting life sciences businesses with research costs, drug development costs, purchases of property, improving manufacturing process, and unemployment assistance.

Recruitment programs accounted for the second largest share (23.1%) and consists of programs that support life sciences businesses with recruitment of employees and interns. These programs provide support to life sciences businesses by sponsoring internships and apprenticeships while offering wage reimbursement of interns and employees, targeted grant programs to attract life sciences businesses not located in the state to relocate to Massachusetts, and grant programs targeted to attract data scientists to the life sciences industry.

Research and development programs accounted for 19.2% of assets and consists of programs that assist life sciences businesses with research and development expenses. These programs provide support to life sciences businesses by providing tax credits that ease the burden of research and clinical testing expenses, and funding targeted to foster the development of novel technologies and techniques of existing or innovative therapies.

Equity-focused programs accounted for 11.5% of the assets and consist of programs that support life sciences businesses in creating a diverse workforce. These programs support life sciences businesses by sponsoring internships while offering wage reimbursement for interns, and grant programs to support early-stage life sciences companies that have women leadership.

The three remaining programs each accounted for less than 10.0% of the assets and include programs that support life sciences businesses with expanding their workforce through tax credits that stimulate job creation, improve the skills of their workforce through a grant that targets workforce development, and entrepreneurial support through a convertible note targeting life sciences startups (Table 7).

TABLE 7. ASSET PROGRAMS BY PROGRAM TYPE

Program Type	Number of Programs	Percentage of Programs
General Support	8	30.8%
Recruitment	6	23.1%

Research & Development	5	19.2%
Equity	3	11.5%
Job Creation	2	7.7%
Workforce Development	1	3.8%
Entrepreneurial Support	1	3.8%

FEDERAL PROGRAMS

Just under one quarter (23.1%) of the twenty-six identified asset programs are federal programs. There are two federal general support programs. The Trade Adjustment Assistance program is not life sciences specific but assists manufacturing companies affected by import competition with a 50/50 cost sharing of up to \$75,000 to projects aimed at improving a manufacturers competitive position. For businesses to receive the trade adjustment assistance, they must be a manufacturer that is facing direct foreign competition (Table 8).

The WorkShare program is another federal general support program that is not life sciences specific. The WorkShare program aims to offer businesses who are experiencing temporary slowdowns an alternative to layoffs by allowing employers to reduce hours of employees while allowing employees to collect unemployment benefits to partially offset reduced hours. For businesses to receive the WorkShare assistance they must be covered by the unemployment insurance system.

There are two federal research and development tax credits—the Orphan Drug Tax Credit and the R&D Payroll Tax Credit. The Orphan Drug Tax Credit incentivizes pharmaceutical companies to develop treatments for rare diseases by offering a tax credit equivalent to 25.0% of qualified clinical testing expenses. The R&D Payroll Tax Credit provides a federal tax credit of 10.0% of research and development expenses up to \$250,000 to offset payroll taxes

The on-the-job training (OJT) program is a recruitment program that is not life sciences specific. The OJT program assists employers with the cost of hiring and training new employees through wage reimbursements between 50.0% to 90.0% of an employee's wages during training. The wage reimbursement is only available for up to six months of training, and employers must commit to continued employment upon completion of the training.

The Work Opportunity Tax Credit (WOTC) program aims to enable targeted employees¹⁹ who have consistently faced barriers to employment move from economic dependency into self-sufficiency by providing employers tax credits ranging from \$2,400 to \$9,600 who hire individuals from these targeted groups

¹⁹ The Internal Revenue Service define this as veterans, ex-felons, TANF recipients, designated community residents, vocational rehabilitation referrals, summer youth employees, SNAP recipients, SSI recipients, long-term family assistance recipients, and long-term unemployment recipients.

TABLE 8. FEDERAL PROGRAMS

Program type	Program Name	Goals	Funder	Financial Resource	Eligibility
General support	Trade Adjustment Assistance	Provides financial assistance to manufacturers affected by import competition	U.S Department of Commerce	Cost sharing	Must be a manufacturer that faces direct foreign competition
General support	WorkShare	Offers an alternative to layoffs for businesses experiencing temporary slowdowns, while allowing to call back furloughed workers and hire new employees	Department of Unemployment Assistance, Executive office of Labor and Workforce Development	Unemployment insurance	Must be covered by the unemployment insurance system
R&D	R&D Payroll Tax Credit	Offset up to \$250,000 in payroll taxes each year for up to five years	Federal Tax Credit	Federal tax credit	Must be a company engaged in research and development
R&D	Orphan Drug Tax Credit	Incentivize pharmaceutical companies to develop medications and treatments for rare diseases that affect small populations	Federal Tax Credit	Federal tax credit	Must be a pharmaceutical company developing a treatment for rare diseases
Recruitment	On-the-Job Training	Assist employers with the cost of hiring and training a new employee	Federal Workforce Innovation and Opportunity Act (WIOA), administered through the MassHire Career Centers	Wage reimbursement for new employees	Employer must commit to continued employment upon completion of training
Equity	Work Opportunity Tax Credit (WOTC)	Enable targeted employees to gradually move from economic dependency into self-sufficiency	US DOL	Federal Tax Credit	Employers must hire veterans and other targeted groups

STATE-RUN PROGRAMS

Just over three quarters (76.9%) of the twenty-six identified asset programs are state programs. Included into the asset inventory are two job creation programs, six general support programs, five recruitment programs, three research and development programs, two equity programs, one workforce development program, and one entrepreneurial support program (Table 9).

Massachusetts Life Sciences Tax Incentives program creates new long-term employment in the life sciences industry through six tax credits and a tax exemption. The seven asset programs include one job creation tax credit, five general support tax credits, and a general support tax

exemption. The Life Sciences Refundable Job Tax Credit provides a tax credit to life sciences businesses that commit to the creation of a minimum of fifty net new permanent full-time positions in Massachusetts. Three of the tax credits - Life Sciences Research Tax Credit, Life Sciences Refundable Investment Tax Credit, and Life Sciences Refundable FDA User Fees Tax Credit – provide life sciences businesses support by easing administrative compliance and tax burdens. The Angel Investor Tax Credit increases investment in life sciences businesses by providing a tax credit to investors. The Corporate Excise Deduction and Sales and Use Tax Exemption also aim to ease tax and administrative compliance burdens through a tax credit and tax exemption.

The state offers five recruitment programs in the form of two internships, one apprenticeship, and two grant programs. The programs aim to connect employers with prospective interns and provide opportunities to gain experience in the life sciences industry. The state offers wage reimbursement to life sciences Businesses in Massachusetts who hire interns and apprentices through the Data Science Internship Program, High School Apprenticeship Challenge/ Lab Training Program, and Internship Challenge. The Bits to Bytes Program provides a grant for capital projects that targets data analytics and or machine learning techniques to attract, train, and retain data scientists to the life sciences industry. The project teams must be comprised of not-for-profit applicants collaborating with at least one for-profit Massachusetts life sciences company to be eligible for the grant. The Massachusetts Transition and Growth Program targets out-of-state life sciences companies considering locating in Massachusetts by providing a grant on a per-job basis to companies that commit to creating more than ten but fewer than forty-nine jobs in the first twelve months of in-state operations.

There are three research and development asset programs offered by the state, including one grant program, one tax credit, and a capital funding program. The Building Breakthroughs program provides grants for capital projects that support biomanufacturing innovation in the state, the Research Credit program offers a tax credit to support employers with research related expenses, and the Novel Therapeutics Delivery program offers capital funding to foster the development of novel technologies and therapies.

The state offers two equity programs aimed at improving the diversity of the workforce in the life sciences industry through the Project OnRamp program and Massachusetts Next Generation Initiative. Project OnRamp helps underserved students start their careers in life sciences by offering employers the reimbursement of wages for interns hired through the program. The Next Generation Initiative aims to increase gender parity for the next generation of life sciences entrepreneurs by providing grants to women-led early-stage life sciences companies.

There is one workforce development program the state offers through the Workforce Training Fund Program. The program is not life sciences specific and aims to address business productivity and competitiveness by providing grants to businesses to improve the skills of new or incumbent workers.

The state also offers entrepreneurial support for life sciences firms through the Seed Fund program. The program advances innovative life sciences companies in the state by offering a convertible note of up to \$250,000 to life sciences start-up companies in Amherst, Beverly, Lowell, Mansfield, North Adams, Springfield, Pittsfield, and Worcester.

TABLE 9. STATE-RUN PROGRAMS²⁰

Program Type: Job Creation

Program Name	Goals	Funder	Type	Eligibility
Life Sciences Tax Incentives Program	Provide incentives to promote companies of all sizes to expand their efforts in creating new long-term jobs in Massachusetts	Massachusetts Life Sciences Center	Tax credit	Massachusetts life sciences business
Life Sciences Refundable Jobs Tax Credit	Foster the life sciences industry in Massachusetts by encouraging job creation and investment in the sector while easing tax and administrative compliance burdens	Massachusetts Life Sciences Center	Tax credit	Massachusetts life sciences business, must commit to the creation of a minimum of fifty net new permanent full-time positions in Massachusetts

Program Type: General Support

Program Name	Goals	Funder	Type	Eligibility
Life Sciences Research Tax Credit	Foster the life sciences industry in Massachusetts by encouraging job creation and investment in the sector while easing tax and administrative compliance burdens	Massachusetts Life Sciences Center	Tax credit	Massachusetts life sciences business
Life Sciences Refundable Investment Tax Credit	Foster the life sciences industry in Massachusetts by encouraging job creation and investment in the sector while easing tax and administrative compliance burdens	Massachusetts Life Sciences Center	Tax Credit	Massachusetts life science business
Life Sciences Refundable FDA User Fees Tax Credit	Foster the life sciences industry in Massachusetts by encouraging job creation and investment in the sector while easing tax and administrative compliance burdens	Massachusetts Life Sciences Center	Tax Credit	Massachusetts life sciences business with more than 50% of the research and development costs for the drug incurred in Massachusetts
Angel Investor Tax Credit	Foster the life sciences industry in Massachusetts by encouraging job creation and investment in the sector while easing tax and administrative compliance burdens	Massachusetts Life Sciences Center	Tax credit	**
Corporate Excise Deduction - Qualified Clinical Testing Expenses for Orphan Drugs	Foster the life sciences industry in Massachusetts by encouraging job creation and investment in the sector while easing tax and administrative compliance burdens	Massachusetts Life Sciences Center	Tax credit	Massachusetts life sciences company, engaged in the development of medications and treatments for rare diseases that affect small populations

²⁰ The resources highlighted in blue in Table 9 are all offered under one program from the Massachusetts Life Sciences Center.

Sales and Use Tax Exemption	Foster the life sciences industry in Massachusetts by encouraging job creation and investment in the sector while easing tax and administrative compliance burdens	Massachusetts Life Sciences Center	Sales and Use Tax exemption on purchases of tangible personal property made on behalf of a life sciences company	Personal property purchase must be made on behalf of a life sciences company
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Program Type: Recruitment

Program Name	Goals	Funder	Type	Eligibility
Data Science Internship Program	Connects employers with prospective interns and provide opportunities that introduce interns to applications of advanced data analytics and data science to the life sciences	Massachusetts Life Sciences Center	Internship program with subsidized/reimbursement for intern wages	Bachelor's, Master's, and Doctoral students
High School Apprenticeship Challenge/ Lab Training Program	Place underrepresented and low-income H.S students in a paid worked based setting, supplement life science education with rigorous OST training.	Massachusetts Life Sciences Center	Internship program with subsidized/reimbursement for intern wages	High school students 16+,
Internship Challenge	Provide practical experiences, increase internship opportunities & provide the opportunity to explore careers in the life sciences industry	Massachusetts Life Sciences Center	Internship program with subsidized/reimbursement for intern wages	Current/Recent (graduated within the past calendar year) college student
Bits to Bytes	Provide grants to employ data analytics and/or machine learning techniques to attract, train, and retain data scientist to the life sciences	Massachusetts Life Sciences Center	State grant	Project teams must be comprised of not-for-profit applicants collaborating with at least one for-profit MA life sciences company
Massachusetts Transition and Growth Program	Recruitment tool targeting out of state life sciences companies considering locating in Massachusetts	Massachusetts Life Sciences Center	State grant	No current presence in Massachusetts, commit to creating more than ten but fewer than forty-nine jobs in the first 12 months of Massachusetts operations

Program Type: R & D

Program Name	Goals	Funder	Type	Eligibility
Building Breakthroughs	Provides grants for capital projects that support biomanufacturing innovation	Massachusetts Life Sciences Center	State grant	**
Research Credit	Assist employer with research expenses such as wages paid to employees, a portion of wages paid to contractors, and amounts paid for supplies	State of Massachusetts	Tax credit	Services must be performed for research purposes and supplies were used to conduct research in MA
Novel Therapeutics Delivery	Foster the development of novel technologies and techniques for the delivery of existing or innovative therapies.	Massachusetts Life Sciences Center	Capital funding	Must be a Massachusetts non-profit institution

Program Type: Equity

Program Name	Goals	Funder	Type	Eligibility
Project OnRamp	Develop a diverse workforce talent pipeline for the life sciences industry	Massachusetts Life Sciences Center, MassBio, MassBioEd, Life Sciences Cares, and Bottom-Line	Internship program with subsidized/reimbursement for intern wages	College student
Massachusetts Next Generation Initiative	The program is a five year, more than \$2M commitment to ensure greater gender parity for the next generation of life sciences entrepreneurs.	Massachusetts Life Sciences Center, Takeda, King Street Properties, Sanofi, Johnson & Johnson Innovation, Mintz, Mission BioCapital	State grant program	Women led Company

Program Type: Workforce Development

Program Name	Goals	Funder	Type	Eligibility
Workforce Training Fund Program	Helps address business productivity and competitiveness by providing resources to MA businesses to fund training for current and newly hired employees	Commonwealth Corporation, State Grant	Provides grants up to \$250,000 to improve the skills of new or incumbent workers. Also, a Workforce Training Fund Express program that offers grants of up to \$30,000 for "off-the-shelf" worker training programs approved by the state	Massachusetts companies of any size

Program Type: Entrepreneurial Support

Program Name	Goals	Funder	Type	Eligibility
Seed Fund	Advanced innovative life sciences companies in MA	Massachusetts Life Sciences Center through a federal award from the Department of Commerce's Regional Innovative Strategies Program	Convertible note, investments up to \$250,000 in a convertible note to life sciences start-ups.	Start-ups in Amherst, Beverly, Lowell, Mansfield, North Adams, Springfield, Pittsfield, and Worcester

Appendix A: Survey Methodology

BW Research conducted an online employer survey of life sciences firms in Massachusetts. The survey was programmed and tested in-house by BW Research. Respondents were recruited through employer email samples and emails from MassBio to its membership.

In total, 684 emailed invites were distributed to life sciences firms in Massachusetts. Potential respondents were contacted up to 10 times via reminders. To qualify for the survey, respondents were required to be knowledgeable about hiring or staffing at their firm.

The survey was fielded between January 27th and April 15th, 2022. There were 119 respondents in total for the employer survey. The average length for the survey was 13 minutes. There is no reported margin of error for this survey as this was not a representative survey effort. The target survey population was generally MassBio membership, with some additional random outreach to other life sciences firms in Massachusetts.

Appendix B: Employer Survey Toplines

MassBio
Employer Survey
April 2022
n=121

Introduction/ Landing Page:

The following survey is being conducted on behalf of MassBio, who would value your participation in a brief survey about your firm's employment and hiring needs.

The survey is being conducted by BW Research, an independent research organization, and should take approximately 10 – 12 minutes of your time.

Your individual responses will not be published; only aggregate information will be used in the reporting of the survey results.

Section 1. Screener Questions

- A. Are you involved in staffing or hiring decisions at your firm or organization? (If not, could you please connect me to the appropriate person?) (n=129)

100.0% Yes
0.0% No
0.0% Not sure

- B. How many business locations does your company or organization have in Massachusetts? (n=129)

96.9% Record # of locations
3.1% Don't know/ Refused

Record # of locations (n=125)

63.2% 1 location
24.8% 2 to 3 locations
8.8% 4 to 5 locations
3.2% More than 5 locations

- C. What sector of the life sciences industry best describes your organization's? [ALLOW MULTIPLE RESPONSES] – *Multiple responses permitted; percentages may sum to more than 100%* (n=128)

73.4% Drug development
11.7% Research products and instrumentation
9.4% Bioinformatics
7.8% Human diagnostic development
7.0% Contract manufacturing
6.3% Medical devices
4.7% Contract research
3.9% Biotechnology
3.9% Digital health
2.3% Cell/ Gene therapy
0.0% Agricultural biotech
4.7% Other
0.0% Don't know/ Refused

Section 2. Employment & Hiring Profile

1. Including all full-time and part-time employees, how many permanent employees work at your current location? [DO NOT ACCEPT 0 AS A RESPONSE]

Average	Median
288.0	95.0

0.8%	1 to 4 employees
1.7%	5 to 9 employees
13.2%	10 to 24 employees
84.3%	25 employees or more

2. Of these [INSERT Q1#] full-time and part-time permanent employees at your current business location, how many have: (n=71-87)

16.1%	Less than a Bachelor's degree
40.8%	Bachelor's degree
20.0%	Master's degree
23.1%	Doctoral or professional degree

3. Of these [INSERT Q1#] full-time and part-time permanent employees at your current business location, how many are in: (n=85-87)

65.1%	Scientific or research roles
34.9%	Non-scientific roles, including office and administrative workers

4. Please indicate the average annual wage for entry-level positions at your firm. (n=87)

0.0%	Below \$25,000
6.9%	\$25,000 to \$49,999
51.7%	\$50,000 to \$74,999
26.4%	\$75,000 to \$99,999
2.3%	\$100,000 to \$150,000
3.4%	More than \$150,000
9.2%	Don't know/ Refused

5. Please indicate the average annual wage for non-entry-level positions at your firm. (n=87)

0.0%	Below \$25,000
0.0%	\$25,000 to \$49,999
5.7%	\$50,000 to \$74,999
11.5%	\$75,000 to \$99,999
35.6%	\$100,000 to \$150,000
32.2%	More than \$150,000

14.9% Don't know/ Refused

6. Over the last three years, has your company grown, declined, or stayed about the same in terms of total employment at your current location? (n=87)

82.8% Grown

11.5% Stayed the same

4.6% Declined

1.1% Don't know/ Refused

7. If you currently have [INSERT Q1#] full-time and part-time permanent employees at your location, how many more or fewer employees do you expect to have at your location 12 months from now? (n=77)

77.9% More (record #)

2.6% Fewer (record #)

10.4% Don't know/ Refused

9.1% Same number of employees

More (record #) (n=60)

6.7% 1 to 4 employees

11.7% 5 to 9 employees

31.7% 10 to 24 employees

50.0% 25 employees or more

Fewer (record #) (n=2)

0.0% 1 to 4 employees

50.0% 5 to 9 employees

0.0% 10 to 24 employees

50.0% 25 employees or more

Employer Projected Growth = 10.8%

[IF Q7 = "More", ASK Q8, OTHERWISE SKIP]

8. Are you expecting to hire entry-level positions, non-entry-level positions, or a mix of both over the next 12 months? (n=72)

1.4% Entry-level

16.7% Non-entry-level

81.9% Both

0.0% Don't know/ Refused

9. Thinking of the applicants for open positions over the last 12 months, please indicate your level of difficulty finding qualified entry-level applicants to fill these positions. (n=87)

- 21.8% Very difficult
- 51.7% Somewhat difficult
- 21.8% Not at all difficult
- 4.6% Don't know/ Refused

10. Thinking of the applicants for open positions over the last 12 months, please indicate your level of difficulty finding qualified non-entry-level applicants to fill these positions. (n=87)

- 47.1% Very difficult
- 47.1% Somewhat difficult
- 4.6% Not at all difficult
- 1.1% Don't know/ Refused

[IF Q9 = "Very difficult" OR "Somewhat difficult", ASK Q11 AND Q12, OTHERWISE SKIP]

11. What are the two most difficult entry-level positions to fill at your location? [PLEASE PROVIDE UP TO 2 RESPONSES] – *Multiple responses permitted; percentages may sum to more than 100%* (n=61)

- 52.5% **Research associate**
- 19.7% **Manufacturing technicians**
- 16.4% **Scientist**
- 8.2% **Specialists**
- 6.6% **Administrators**
- 6.6% **Laboratory technician**
- 6.6% **Coordinators**
- 4.9% **Accountant/ Finance**
- 4.9% **Quality control/ assurance**
- 4.9% **Clinical trial associates**
- 11.5% **Other**

12. What are the two most significant reasons for the reported hiring difficulty for entry-level positions? [DO NOT READ, ALLOW UP TO TWO RESPONSES] – *Multiple responses permitted; percentages may sum to more than 100%* (n=63)

- 66.7% Small applicant pool
- 41.3% Lack of experience/ industry-specific knowledge
- 23.8% Insufficient non-technical skills (problem-solving, critical thinking, communication, teamwork, adaptability, etc.)
- 22.2% Competition from other life sciences companies
- 7.9% Desired wages
- 1.6% Insufficient educational attainment

- 1.6% Insufficient certifications
- 3.2% Other
- 1.6% Don't know/ Refused

[IF Q10 = "Very difficult" OR "Somewhat difficult", ASK Q13 AND Q14, OTHERWISE SKIP]

13. What are the two most difficult non-entry-level positions to fill at your location? [PLEASE PROVIDE UP TO 2 RESPONSES] – *Multiple responses permitted; percentages may sum to more than 100% (n=80)*

- 34.2% Senior scientists
- 26.6% Director level and above management
- 15.2% Regulatory affairs
- 13.9% Clinical operations
- 10.1% Program management
- 6.3% Quality control/ assurance specialist
- 6.3% Process development
- 5.1% Validation specialist
- 5.1% Software developer/ engineer
- 5.1% Chemist
- 5.1% Computational sciences
- 3.8% Senior research associate
- 6.3% Don't know/ Refused
- 15.2% Other

14. What are the two most significant reasons for the reported hiring difficulty for non-entry-level positions? [DO NOT READ, ALLOW UP TO TWO RESPONSES] – *Multiple responses permitted; percentages may sum to more than 100% (n=80)*

- 76.3% Small applicant pool
- 40.0% Lack of experience/ industry-specific knowledge
- 22.5% Competition from other life sciences companies
- 11.3% Insufficient non-technical skills (problem-solving, critical thinking, communication, teamwork, adaptability, etc.)
- 3.8% Desired wages
- 1.3% Insufficient certifications
- 0.0% Insufficient educational attainment
- 3.8% Other
- 5.0% Don't know/ Refused

Section 3. Workforce Needs & Preferences

15. What is your *preferred* level of education when hiring for entry-level positions? (n=85)

- 3.5%** Certification or postsecondary nondegree award
- 7.1%** Associate's degree
- 70.6%** Bachelor's degree
- 11.8%** Master's degree
- 2.4%** Doctoral or professional degree
- 4.7%** Don't know/ Refused

16. What is your *required* level of education when hiring for entry-level positions? (n=85)

- 23.5%** High school diploma or equivalent
- 1.2%** Certification or postsecondary nondegree award
- 8.2%** Associate's degree
- 58.8%** Bachelor's degree
- 4.7%** Master's degree
- 2.4%** Doctoral or professional degree
- 1.2%** Don't know/ Refused

17. Please indicate your likelihood of hiring an applicant with less than a Bachelor's degree for an entry-level position? (n=85)

- 9.4%** Very likely
- 41.2%** Somewhat likely
- 44.7%** Not at all likely
- 4.7%** Don't know/ Refused

18. Has your firm previously hired an applicant with less than a Bachelor's degree for an entry-level position? (n=85)

- 62.4%** Yes
- 32.9%** No
- 4.7%** Don't know/ Refused

19. Please indicate your likelihood of hiring an applicant with less than a Bachelor's degree for a non-entry-level position? (n=85)

- 2.4%** Very likely
- 22.4%** Somewhat likely
- 72.9%** Not at all likely
- 2.4%** Don't know/ Refused

20. What programs or certificates would you like to see offered in your region for entry-level positions that would relate to your firm's skill requirements and hiring needs? (n=81)

- 12.3% STEM programs
- 11.1% Biotechnology manufacturing
- 11.1% Lab skills programs
- 7.4% Manufacturing certificate
- 6.2% Co-op/ internships
- 2.5% Data analytics
- 2.5% Project management training
- 2.5% Communication/ negotiation programs
- 8.6% Other
- 35.8% Don't know/ Refused

21. What programs or certificates would you like to see offered in your region for non-entry-level positions that would relate to your firm's skill requirements and hiring needs? (n=81)

- 8.6% STEM programs
- 6.2% Leadership training
- 4.9% Project management training
- 4.9% Clinical certificate
- 4.9% Manufacturing certificate
- 3.7% Biotechnology programs
- 3.7% PhDs in sciences
- 2.5% Co-op/ internship
- 2.5% Data analytics
- 8.6% Other
- 49.4% Don't know/ Refused

22. How important are each of the following credentials for entry-level applicants to possess? (n=81)

RANDOMIZE

	<u>Very important</u>	<u>Somewhat important</u>	<u>Not at all important</u>	<u>Don't know/ Refused</u>
A. Certificates in specialized topics from two-year colleges (for example, cell culture, biomanufacturing, etc.)	22.2%	46.9%	19.8%	11.1%
B. Third-party certifications (for example, RAPS, Six Sigma, etc.)	3.7%	44.4%	40.7%	11.1%
C. Badges	0.0%	6.2%	63.0%	30.9%

Section 4. Partnerships & Program Needs

23. Does your company partner with any of the following training providers to recruit talent for open positions? [SPECIFY UP TO 3 RESPONSES FOR EACH SELECTION] (n=81)

- 11.1% High schools
- 7.4% Vocational technical school
- 19.8% Community colleges
- 61.7% 4-year universities
- 12.3% Other
- 25.9% None of the above
- 6.2% Don't know/ Refused

High schools

- 16.7% Boston Public High Schools
- 16.7% Cristo Rey Boston High School
- 16.7% Watertown High School
- 16.7% Project Onramp
- 16.7% Students to Science
- 16.7% Other

Community colleges

- 33.3% Middlesex Community College
- 22.2% Out of State Community Colleges
- 11.1% Roxbury Community College
- 11.1% North Shore Community College
- 11.1% Bunker Hill Community College
- 11.1% Bristol Community College

4-year universities

- 76.2% Northeastern University
- 14.3% Harvard University
- 11.9% Massachusetts Institute of Technology
- 9.5% Worcester Polytechnic Institute
- 7.1% The University of Massachusetts Amherst
- 7.1% Worcester State University
- 4.8% HBCUs
- 4.8% Tufts University
- 2.4% The University of Massachusetts Boston
- 11.9% Other

24. Of the following potential program and service offerings, which would your company be most interested? Please select up to two responses. [MULTIPLE CHOICE – SELECT UP TO 2 RESPONSES] – *Multiple responses permitted; percentages may sum to more than 100%* (n=81)

RANDOMIZE

- 43.2%** An apprenticeship-type program for your future employees
- 32.1%** Funds to reimburse wages for the cost of training new hires
- 32.1%** Funds to train current workers to be promoted within your company
- 22.2%** A mentorship program that exposes middle and high school students to life sciences careers
- 21.0%** Career days, company tours, or classroom visits that expose middle and high school students to life sciences careers
- 14.8%** Partnerships to help develop curriculum and/or cooperative learning opportunities
- 13.6%** Sourcing and pre-screening for interns
- 3.7%** None of the above
- 2.5%** Don't know/ Refused

Appendix C: Massachusetts Life Sciences Training Inventory

The below training inventory provides an overview of life sciences-related educational programs in Massachusetts. The inventory is focused on training programs and pathways that do not require a four-year degree, though Northeastern's A2M program is included in this analysis as it begins with an associate's credential and then provides pathways for participants to move into a bachelor's or master's program following completion.

Name of Organization	Name of Program	Program Type	Degree/ Outcome	General Technology Sector	County	Related SOC Code
Ben Franklin Institute of Technology	Associate Degree in Biotechnology Manufacturing	Private College/ University	Associate	Biotechnology/ Biomanufacturing	Suffolk	19-4021
Bunker Hill Community College	AS in Biological Sciences: Biotechnology	Community College	Associate	Biotechnology	Suffolk	19-1000
Gloucester Biotechnology Academy	Biotechnology Certificate Program and Summer STEM Program	Community Based/ Non-Profit Organization	Certificate	Biotechnology	Essex	19-4021
Health Resources in Action	LEAH Knox Scholars Biomedical Research	Community Based/ Non-Profit Organization	Internship Experience	Biomedical	Suffolk	19-4021
Holyoke Community College	AA in Arts and Science: Biotechnology Option	Community College	Associate	Biotechnology	Hampden	19-1000
Just A Start (in partnership with Bunker Hill Community College)	Biomedical Careers Training Program	Community Based/ Non-Profit Organization	College Credit Eligibility	Biomedical	Middlesex	19-1000
MassBay Community College	Associate in Science: Biotechnology	Community College	Associate	Biotechnology	Norfolk	19-4021
MassBay Community College	Associate in Science: Biotechnology with focus on Genomics and Biomanufacturing	Community College	Associate	Biomanufacturing	Norfolk	19-4021
Massachusetts Life Sciences Center	High School Apprenticeship Challenge	Quasi-Public Agency	Internship Experience	General Life Sciences	Middlesex	19-0000
Massachusetts Life Sciences Center	Data Science Internship Program	Quasi-Public Agency	Internship Experience	Data Science	Middlesex	15-2051
Massachusetts Life Sciences Center	Ernest E. Just Postgraduate Fellowship Program: Internship Challenge	Quasi-Public Agency	Internship Experience	General Life Sciences	Middlesex	19-0000

MassBioEd	Biomanufacturing Technician Apprenticeship Program	Community Based/ Non-Profit Organization	Certificate	Biomanufacturing	Middlesex/ Worcester	19-4021
MassBioEd	Clinical Trial Associate Apprenticeship Program	Community Based/ Non-Profit Organization	Certificate	Clinical Trials	Online	19-1000
Middlesex Community College	Associate in Science: Biotechnology Technician	Community College	Associate	Biotechnology	Middlesex	19-4021
Middlesex Community College	Biotechnology Technician Program: Learn & Earn	Community College	Associate	Biotechnology	Middlesex	19-4021
Middlesex Community College	A2M with Northeastern	Community College	Associate	Biotechnology	Middlesex	19-4021
Middlesex Community College	Biotechnology Technician Certificate	Community College	Certificate	Biotechnology	Middlesex	19-4021
MIT	Professional Certificate Program in Biotechnology & Life Sciences	Private College/ University	Certificate	Biotechnology	Middlesex	19-0000
Northeastern University	A2M with Middlesex Community College	Private College/ University	Bachelor's, Master's	Biotechnology	Suffolk	19-4021
Quincy College	Certificate in Biotechnology and Good Manufacturing Practice	Community College	Certificate	Biomanufacturing	Norfolk	19-4021
Quincy College	Associate in Biotechnology and Good Manufacturing Practice	Community College	Associate	Biomanufacturing	Norfolk	19-4021
UMass Lowell	Graduate Certificate in Biotechnology and Bioprocessing	Public College/ University	Certificate	Biotechnology	Middlesex	19-1000
Worcester Polytechnic Institute	Fundamentals of Biomanufacturing	Private College/ University	Certificate	Biomanufacturing	Worcester	19-4021
Worcester Polytechnic Institute	Graduate Certificate in Biomanufacturing	Private College/ University	Certificate	Biomanufacturing	Worcester	19-4021

Appendix D: Life Sciences NAICS Codes

NAICS	Industry	Employment Percent Contribution
325411	Medicinal and Botanical Manufacturing	100.0%
325412	Pharmaceutical Preparation Manufacturing	100.0%
325413	In-Vitro Diagnostic Substance Manufacturing	100.0%
325414	Biological Product (except Diagnostic) Manufacturing	100.0%
541380	Testing Laboratories	11.6%
541713	Research and Development in Nanotechnology	59.7%
541714	Research and Development in Biotechnology (except Nanobiotechnology)	100.0%
541715	Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)	66.0%
611310	Colleges & Universities	2.9%
621511	Medical Laboratories	100.0%
622110	General Medical and Surgical Hospitals	4.5%
622210	Psychiatric and Substance Abuse Hospitals	0.6%
622310	Specialty (except Psychiatric and Substance Abuse) Hospitals	3.8%

Appendix E: Life Sciences Regional Assets

New Jersey, California, Pennsylvania, and North Carolina are leaders in the Life Sciences industry. Their governments have all created various programs and incentives to help their life sciences businesses continue to grow. The four states have their own targeted focuses ranging from diversity, equity, and inclusion, early-stage business support, and workforce development. There is one targeted focus that the four states each had in common, access to capital, which can be a major barrier to a life sciences business' ability to grow.

New Jersey

The state of New Jersey supports their life sciences industry through various programs and incentives offered by the New Jersey Economic Development Authority (NJEDA). New Jersey has recognized that access to capital is a major barrier to life sciences business's ability to grow. The NJEDA is combating this through their angel investor tax credit program, which offers investors a tax credit of 20 percent of the qualified investment made in a New Jersey emerging technology or life sciences businesses.

The state of New Jersey is also targeting underserved communities by increasing the angel investor tax credit from 20 to 25 percent if the investment is made to a certified minority- or women-owned business enterprise or if the business is located in an opportunity zone or new markets tax credit census tract.

Another key focal point that New Jersey is supporting is early-stage companies. The NJEDA is supporting early-stage companies with seed capital programs like the NJ CoVest Fund and rent support grants through the NJ Ignite program, where bonus months of rent support are given to companies that are minority- or women-owned business enterprises or are located in an opportunity zone.²¹

California

The state of California assists their life sciences businesses through the California Life Sciences (CLS) organization. The CLS organization has targeted entrepreneurship, workforce development, and racial and social equity as principal areas of assistance for the life sciences industry. The state aims to build a pipeline of diverse talent through the racial and social equity initiative which includes the NexGeneGirls program that provides firsthand learning, leadership development and career mentoring for high school females of color, and the Racial & Social Equity Career Connections Summit that supports Black, Indigenous, and other People of Color (BIPOC) students in their career journey. The CLS supports workforce development through various skills training resources and professional development conferences held throughout the year.

The state of California also offers the employment training panel which provides funding to employers to assist in upgrading the skills of their workers through training that leads to good paying, long-term jobs.²²

²¹ New Jersey Economic Development Authority. Life Sciences Programs. <https://www.njeda.com/life-science/#:~:text=New%20Jersey%20is%20the%20medicine,therapy%20and%203D%20printed%20drug.>

²² California Life Sciences. <https://www.califesciences.org/>.

Pennsylvania

The state of Pennsylvania supports its life sciences industry through Life Sciences Pennsylvania (LSPA). LSPA has placed a focus on supporting life sciences business' access to capital and early-stage life sciences businesses support. LSPA supports access to capital and early-stage life sciences businesses with the Life Sciences Greenhouse Initiative which provides an appropriation fund to promote early-stage risk capital and catalyst development and creation of new life sciences related products and companies.

The state also offers the Keystone Innovation Program that creates innovation zones where tax credits are available for start-up life sciences firms. The state supports access to capital with the Ben Franklin Technology Development Authority Fund which provides funding to early-stage and established companies to promote an entrepreneurial business environment, advance technology innovation, and create a technology-ready workforce.²³

North Carolina

The state of North Carolina supports its life sciences industry through the North Carolina Biotechnology Center (NCBioTech). NCBioTech has placed a focus on supporting university technology development and company startup and growth. NCBioTech supports university technology development through various grants and loans including the Flash Grants, which provide up to \$20,000 to creative ideas that exhibit early indications of commercial potential, Innovation Impact Grants, which provide up to \$150,000 for the purchase of research equipment for academic or nonprofit institutions, and the Translational Research Grants that provide up to \$100,000 to fund programs that explore commercial applications or initiate the early commercial development of university-held life sciences inventions.

NCBioTech also supports company startups and growth with the Small Business Research Loan which provides a loan of up to \$250,000 for innovative early-stage life sciences companies and the Strategic Growth loan which provides a loan of up to \$500,000 to help North Carolina life sciences product companies reach milestones that will enable them to obtain further funding from investors and/or to commercialize their products.²⁴

²³ Life Sciences Pennsylvania. State Policy Priorities. <https://lifesciencespa.org/advocate-4/state-policy-priorities/>.

²⁴ North Carolina Biotechnology Center. Funding Programs. <https://www.ncbiotech.org/funding>.

Barriers to Bridges:

Addressing the Urgent Need for a
Diverse, Research-Ready Workforce
Within the Clinical Research Profession

A Call to Action

INTRODUCTION

The clinical research profession is in the midst of a serious workforce shortage, and the problem is getting worse. This was the focus of a forum sponsored by the Association of Clinical Research Professionals (ACRP), in which thought leaders from across the clinical research spectrum came together to consider the likely reasons for this deeply concerning situation and how best to turn barriers into bridges.

“The projected growth of the clinical research industry is demanding a diverse, research-ready workforce that doesn’t exist today,” Susan Landis, Executive Director of ACRP, told the gathering of Partners Advancing the Clinical Research Workforce, an industry consortium established by ACRP to confront this formidable challenge. Right now, the clinical trial workforce is not keeping up with the workload, ultimately threatening to delay delivery of innovative treatments to patients who need them. “Now is the time to spotlight the key barriers and encourage radical ideas for change,” Landis stated.

So, what exactly underpins the struggle to boost the workforce? Lack of awareness of the clinical research profession as a career option is certainly one reason. However, the Partners group unanimously highlighted a second incontrovertible barrier: the default prerequisite for a specific number of years of experience—very frequently two years—in entry-level job descriptions. In essence, it’s a one-two punch or a double whammy: even if significant efforts are made to raise awareness of the profession—and the fulfilling career it offers—many of those who have been enticed by this prospect will end up falling at the first hurdle.

Put simply, entry level is often not really entry level. The paradox of “how can I get any experience until I get a job that gives me experience?” is the ultimate Catch-22 scenario. Of course, it is not unique to the clinical research profession, as others have illustrated.¹

When a profession is crying out for more people—and the consequences of a workforce shortage are potentially dire—the onus should not be on candidates themselves or their advocates to come up with strategies to play the system. Instead, the system should be fixed.

The urgent need for a fundamental “system fix” is further highlighted by the impact on those already in the profession and the organizations that employ them. When entry restrictions are too tight, there is a tug-of-war over existing employees, with employers offering more and more competitive packages and trying to outdo one another in the race to secure human resources. The result has been an alarming rate of churn in the profession, with serious adverse effects on organizational productivity, operational continuity, team building, and morale. Clinical research sites are reportedly experiencing the greatest drain on talent, as it’s well acknowledged that these providers function as the industry’s training ground for entry-level employees. In fact, the Society for Clinical Research Sites recently published an Open Letter highlighting this predicament.²

BARRIERS: A CLOSER LOOK

Lack of Awareness of Clinical Research as a Profession

Participants in the Partners gathering, who represent pharmaceutical sponsors, contract research organizations, sites, and leaders from clinical research support industries, noted that clinical research is generally not well known as a career option, especially among younger people about to enter the workforce. Although the COVID-19 pandemic—and the global mission to develop vaccines at record speed—raised awareness of the ability of science to solve big public health problems, the role played by the clinical research industry is still under-recognized.³ “Clinical research is not part of the STEM discussion,” said Danielle Coe, Founder and CEO of Black Women in Clinical Research, who called for a “big shift” to put clinical research firmly on the career radars of students and college advisers.

Other participants echoed Coe’s concern, calling for increased community outreach, new educational materials, and an overarching campaign designed to encourage new professionals and “lateral movers” (those considering a change of profession) to consider clinical research as a stimulating, rewarding, and versatile career choice.

Alongside the imperative to grow the workforce is the equally vital need to diversify it. Recent research from the Tufts Center for the Study of Drug Development⁴ found a statistically significant relationship between staff diversity and clinical trial participant diversity but reported that only 22% of respondents to a survey believed that staff diversity is a major factor for the success of clinical research. Education is needed throughout the profession about how staff diversity builds trust with under-represented demographic sub-groups whose participation in clinical research is imperative for understanding potential safety and efficacy differences in real-world populations. For this reason, initiatives specifically designed to attract particular ethnic groups into the profession should be actively pursued.

Ultimately, both strengthening and diversifying the workforce are imperative to the sustainability, quality, and reliability of clinical research now and in the future.

“Clinical research is not part of the STEM discussion.”

— **Danielle Coe**, Founder and CEO,
Black Women in Clinical Research



The “Two Years of Experience” Entry Requirement

Turning its attention to the requirement for two years of experience (or a similar specific number), the Partners group agreed that the urgent need for new recruits, juxtaposed with routine blocking of large numbers of applicants by this “tick box” prerequisite, is nothing short of sabotage. “We have to address this disconnect,” Leslie Wolfe, MHA, Director of US-Early Talent Program & Clinical Trial Coordinator Organization for Merck, asserted.

Many indications already exist that college graduates who have taken programs of study in clinical research and/or undergone dedicated internships would be eminently suitable entry-level candidates, whose experience and training could be further enhanced “on the job.” Yet, in the current hiring culture, they are often rejected and it’s very difficult to break through.

Notably, no robust evidence exists to show that the 2-year requirement *actually* produces a more effective clinical research workforce. It appears to be based on a supposition that has been perpetuated for decades without scrutiny. That’s not an acceptable situation at the best of times but, in the midst of an escalating workforce shortfall, it becomes truly pernicious.

- Questioning the justification for the requirement, Sarah Holloway, PhD, formerly with Kelly Science and Clinical and a co-chair of the Partners gathering, asked, “What is the purpose of the 2-year rule? What are we seeking to de-risk?”
- Calling it a “rigid, exclusionary barrier,” Sharleen Traynor, PhD, MPH, Fieldwork Coordinator/Instructor with the Clinical Trials Research Associate (CTRA) Program at Durham Technical Community College, said the self-imposed requirement means “we’re seeing a lot of well-qualified candidates not being considered.” She added that the simultaneous requirement for a bachelor’s degree further excludes potentially promising people, especially those with fewer financial resources. As in many other fields, communities of color tend to be impacted most.
- Jeanne Hecht, MBA, PMP, CEO of JTH Consulting, LLC, agreed. “We are leaving out some of the most innovative minds with this arbitrary minimum requirement,” she said. “Our industry must evolve and re-examine some of its archaic practices.”

“We are leaving out some of the most innovative minds with this arbitrary minimum requirement. Our industry must evolve and re-examine some of its archaic practices.”

— **Jeanne Hecht, MBA, PMP**
CEO, JTH Consulting, LLC



The group further noted the clinical trial industry's lack of standardization and consistency with job titles, skill requirements, career paths, onboarding, and training represents yet another barrier for prospective candidates, and one that doesn't always get much easier for those who manage to enter the profession. Jessica Fritter, MACPR, ACRP-CP, Clinical Instructor of Practice at The Ohio State University (and formerly with Nationwide Children's Hospital), described the situation at entry-level as "horrendous" and Danielle Coe asked, "Can't we manage to make this profession more welcoming?"

Where to Go from Here

Participants agreed that industry leaders must address the two key barriers—lack of awareness about clinical research as a profession and the 2-year experience stipulation—simultaneously in order to move the needle as quickly and effectively as possible.



**Raise awareness
of the profession**
+ address the diversity
challenge

**Rethink the 2-year
experience
requirement**

GROW & DIVERSIFY THE WORKFORCE

Of the two barriers, rethinking the 2-year requirement is by far the more challenging. In theory, there are two choices here:

- **EITHER:** research must be undertaken to justify the 2-year requirement—and if it proves justifiable, a highly visible and accessible pathway by which candidates can gain those two years of experience should be established;
- **OR:** the unproven 2-year requirement should be replaced with a valid and credible alternative, underpinned by objective evidence.

With the workforce crisis escalating rapidly, the group was unanimous that doing neither of these is not an option. When it came to choosing which of the two routes is the better one, they were united in their view that measuring experience in purely quantitative terms is outdated. Just as the credentials of a writer are never judged simply on the number of words or pages they produce, experience should be measured qualitatively, based on a set of well-articulated standards and competencies.

To address the identified barriers, the leaders of the Partners Advancing the Clinical Research Workforce consortium proposed four key strategic imperatives:

GRASSROOTS OUTREACH TO RAISE AWARENESS

In the absence of a well-funded national workforce development campaign, pursue a grassroots outreach effort to build awareness of clinical research as a profession through educational materials and motivational messaging.

DEFINE AND EMBED A NEW MEASURE OF EXPERIENCE

Define a new composite measure of experience to replace the 2-year requirement, building on the groundbreaking efforts of the Multi-Regional Clinical Trials Center's Joint Task Force for Clinical Trial Competency.⁵ This new measure of experience should also capture transferable skills for those making a lateral move from other professions.

ESTABLISH COMPETENCY-BASED TRAINING

Build upon the existing repository of clinical research training with a proven, competency-based educational program accessible to all in the industry that will help accelerate early talent onto study teams without sacrificing the quality or integrity of clinical trials.

SUPPORT NOVEL RECRUITMENT AND RETENTION INITIATIVES

Support organizations that are implementing novel and innovative methods to recruit new and diverse talent into the industry, including professionals whose skills align with the needs of clinical research who may be seeking a new career. In addition, share best practices regarding retention, including professional development opportunities such as certification.

EXISTING INITIATIVES UPON WHICH TO BUILD

“Ready, Set, Clinical Research!™” Awareness-Raising Toolkit

To address the need for awareness-raising about the clinical research profession, ACRP has launched a new toolkit entitled “Ready, Set, Clinical Research!™” with tailored versions for entry-level and “lateral movers.” The toolkit is designed for flexible use by career advisors, recruiters, employers, and other stakeholders with a vested interest in the growth and diversification of the clinical research workforce. The toolkit content showcases the “who,” “what,” “why,” and “how” of a career in clinical research, using carefully crafted, impactful messaging intended to influence both hearts and minds. Emotive, personal stories from patients and clinical research professionals are featured to emphasize the people-centered nature of clinical research, while a bold, contemporary design aims to foster a sense of excitement, inspiration, and curiosity. The toolkit also showcases the numerous routes into the profession and the wide spectrum of potential roles.



[Learn more at acrpnet.org/rscr](https://acrpnet.org/rscr)

Establishment of Competency Domains as a Basis for Measuring Experience

The Joint Task Force for Clinical Trial Competency, an international team of investigators, educators, and clinical research professionals spearheaded by the Multi-Regional Clinical Trials Center of Brigham & Woman’s Hospital and Harvard, has developed an authoritative framework of competency domains that objectively define the knowledge, skills, and attitudes necessary for conducting safe, ethical, and high-quality clinical research. These have been adopted and assimilated by ACRP as “core competencies” and represent a robust foundation for the collaborative development of a new, composite measure of experience to replace the 2-year requirement.

Once defined and validated, it will be imperative to achieve (a) recognition and buy-in across the industry; and (b) alignment on what this measure means in practice and how to implement it when assessing candidates. To minimize discrepancies in understanding and interpretation, ACRP is well placed to develop a comprehensive guide that reframes the principles for recruitment of clinical research professionals, alongside a “playbook” and user-friendly template for talent acquisition professionals and hiring managers that simultaneously encompasses the need for inclusivity and diversity.

This will comprise a major undertaking in its own right, but it will only be the beginning. Success will depend entirely on the collective commitment of the industry to adopt and embed these new principles. “The clinical research industry is in a workforce crisis which can only be solved by an immense collaborative effort,” ACRP’s Susan Landis stressed. “We need to harness the power of all your organizations. Core principles, standards, and tools can be provided, but you are the ones who understand how things work within your own organizations, where the pain points are, and what needs have to be addressed in order to drive adoption.”

“The clinical research industry is in a workforce crisis which can only be solved by an immense collaborative effort.”

— **Susan Landis**, Executive Director, ACRP

CASE STUDIES: BUILDING BRIDGES

The following section describes a range of innovative models and approaches that are enabling and facilitating the growth and diversification of the clinical research workforce. For more details, visit acrpnet.org/mmd

Training the Next Generation of CRCs

Angela Griffiths, PhD, Education Program Manager at the UC Davis Clinical and Translational Science Center’s Clinical Trials Office, shared a successful program that piloted an innovative and scalable clinical research coordinator (CRC) training program to grow and diversify the clinical research workforce and provide a re-training opportunity to under-resourced communities. This unique program combines classroom learning with workplace exposure to clinical research in order to train next-generation CRCs.

Effective Outreach to Latin American Populations

Michaele Linden Johnson, MBA, FACHE, Senior Director of Clinical Trials and Business Development for the Medical Center of the Americas Foundation, shared details of a program that effectively reached out to traditionally underserved Latinx populations in and around El Paso, Texas. “We have an opportunity to significantly increase Latino representation in clinical trials if we can grow a competitive infrastructure for tomorrow’s trials,” she told attendees, noting that the Latinx population represents nearly 20% of the US population but accounts for only 7% of the clinical trial patient population.

“We have an opportunity to significantly increase Latino representation in clinical trials if we can grow a competitive infrastructure for tomorrow’s trials.”

— **Michaele Linden Johnson, MBA, FACHE**, Senior Director of Clinical Trials and Business Development for the Medical Center of the Americas Foundation

Welcoming New Entry-Level Workers

Merck’s Leslie Wolfe shared successes from her company’s Early Talent Rotational Program, explaining how the Global Clinical Trial Operations-US organization recruited, trained, and developed inexperienced new graduates to launch careers in clinical research, in part by creating a new entry-level position that didn’t require two years of prior experience as defined by many other organizations.

The program effectively:

- Built a strong clinical research foundation to foster rapid promotion to various pathways and functional roles (e.g., clinical research associate, data manager, clinical scientist, regulatory affairs specialist).
- Expanded candidate recruitment to include non-intern, new graduates to build a more diverse candidate pool.
- Fostered collaboration with other departments to create similar early-talent programs.

Similarly, the Clinical Development Academy team at PPD,⁶ part of Thermo Fisher Scientific, helps recruit, hire, onboard, and develop select college graduates, early career individuals, and mid-level professionals with transferable skills, but who may have limited or no clinical research experience. The program is designed to ensure that these new workforce entrants are the most efficient and effective as possible and offers extensive training and support through a cohort approach, which includes professional networking opportunities, senior leadership mentoring and resources, and cohort collaboration.

Filling Vacancies, Reducing Attrition

Sharleen Traynor shared details of her successful Durham Tech Clinical Trials Associate curriculum, which leverages partnerships with hiring managers to bypass systemic barriers and create alternate paths, enabling more accurate matching of candidates to opportunities and providing education and practical skills training for entry-level roles. In Durham, the results were clear and positive, Traynor said, noting, “Candidates come in with a passion for clinical research and our program’s precision matching of candidates to roles empowered our partners to fill vacancies faster.”

Conclusion

The current approach to recruitment and retention of the clinical research workforce needs revolutionary re-thinking. The status quo is unsustainable. A great innovator, Marie Curie, said, “It is not the practical men, but the dreamers who create new paradigms. While hard facts define today, new value is created only when the impossible becomes possible.” We can only make the impossible possible if we work together. In the interests of a thriving and vibrant workforce—ready to meet today’s high demand for clinical research and ultimately serve the medical needs of millions of people—let’s work together toward a more insight-driven, more modern, more enlightened approach to hiring people in our industry. Let’s start a movement. Let’s do it now.



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6. <https://vimeo.com/729316336/027768278a>

ACRP established the Partners Advancing the Clinical Research Workforce consortium to convene industry leaders in an unprecedented collaborative effort to identify imaginative and disruptive ways to build the clinical research workforce of the future. Learn more at acrpnet.org/pacrw



BEST PRACTICES FOR DIVERSITY AND INCLUSION IN STEM EDUCATION AND RESEARCH: A GUIDE BY AND FOR FEDERAL AGENCIES

A Report by the
INTERAGENCY WORKING GROUP ON INCLUSION IN STEM
FEDERAL COORDINATION IN STEM EDUCATION SUBCOMMITTEE
COMMITTEE ON STEM EDUCATION
of the
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

September 2021

About the National Science and Technology Council

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is to ensure science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at <http://www.whitehouse.gov/ostp/nstc>.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, the environment, and the technological recovery and use of resources, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of Federal research and development in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal Government. More information is available at <http://www.whitehouse.gov/ostp>.

About the Federal Coordination in STEM Education Subcommittee

The Federal Coordination in STEM Education (FC-STEM) is a subcommittee of the NSTC Committee on STEM Education (CoSTEM), which was established pursuant to the requirements of Section 101 of the America COMPETES Reauthorization Act of 2010 (42 U.S.C. §6621). In accordance with the Act, CoSTEM reviews science, technology, engineering, and mathematics (STEM) education programs, investments, and activities, and the respective assessments of each, in Federal agencies to ensure that they are effective; coordinates, with the Office of Management and Budget, STEM education programs, investments, and activities throughout the Federal agencies; and develops and implements through the participating agencies a Federal STEM education strategic plan, to be updated every five years. FC-STEM advises and assists CoSTEM and serves as a forum to facilitate the formulation and implementation of the strategic plan.

About the Interagency Working Group on Inclusion in STEM

Six Interagency Working Groups (IWGs) support FC-STEM as it implements the Strategic Plan and brings together members who represent the Federal government's foremost experts in STEM education. Four of the IWGs are concentrating their efforts on one of each of the four pathways outlined in the Strategic Plan. These pathways include Strategic Partnerships, Convergence, Computational Literacy, (educational pathways) and Transparency & Accountability. The National Science and Technology Council (NSTC) chartered a fifth IWG, the Interagency Working Group on Inclusion in STEM (IWGIS), in response to Section 308 of the 2017 American Innovation and Competitiveness Act and focuses on broadening participation in STEM as described in more detail below. A sixth IWG was formed in response to the 2020 Supporting Veterans in STEM Careers Act to improve veteran and military spouse equity and representation in STEM fields and careers.

BEST PRACTICES FOR DIVERSITY AND INCLUSION IN STEM EDUCATION AND RESEARCH:
A GUIDE BY AND FOR FEDERAL AGENCIES

About this Document

The purpose of the Interagency Working Group on Inclusion in STEM (IWGIS) is to advise FC-STEM on coordinating activities regarding inclusion in STEM fields across the Federal government, with a focus on identifying research, best practices, and policies on how to promote diversity and inclusion of all groups in the Federal STEM workforce, including women, people from underrepresented racial and ethnic groups, and persons with disabilities.

In October 2019, members of the IWGIS set out to accomplish the group's first strategic objective: to share among Federal agencies best practices for diversity and inclusion, both within agencies and in the programs they support. As part of achieving this objective, the group was tasked with developing a compendium on Best Practices for Diversity and Inclusion in STEM Education and Research for Federal Agencies. The group broke down the task into three parts. First, the group developed clear definitions of evidence-based, emerging, and promising practices. Second, the group conducted a literature search on evidence-based practices for diversity and inclusion in STEM. Third, the group incorporated data from a Best Practices Solicitation (information request) from FC-STEM Interagency Working Groups to FC-STEM agencies, collected in August 2020. The goal was not only to identify best practices and exemplary programs but also to establish the evidence base for the existing effective practices, including findings from robust evaluations. This report is the result of the extensive work conducted by the IWGIS. The compendium also includes recommendations for increasing diversity in Federal programs.

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**BEST PRACTICES FOR DIVERSITY AND INCLUSION IN STEM EDUCATION AND RESEARCH:
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Abbreviations and Acronyms

CoSTEM	Committee on Science, Technology, Engineering and Mathematics (STEM) Education
DOC	Department of Commerce
DoD	Department of Defense
DOE	Department of Energy
DHS	Department of Homeland Security
DOI	Department of the Interior
DOL	Department of Labor
DOS	Department of State
DOT	Department of Transportation
ED	Department of Education
EPA	Environmental Protection Agency
FC-STEM	Federal Coordination in STEM Education Subcommittee
HBCU	Historically Black Colleges and Universities
HHS	Department of Health and Human Services
IWG	Interagency Working Group
IWGIS	Interagency Working Group on Inclusion in STEM
MSI	Minority Serving Institution
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NSTC	National Science and Technology Council
OMB	Office of Management and Budget
OPM	Office of Personnel Management
OSTP	Office of Science and Technology Policy
SI	Smithsonian Institution
S&E	Science and Engineering
STEM	Science, Technology, Engineering and Mathematics
UREG	Underrepresented Racial and Ethnic Groups
USDA	U.S. Department of Agriculture

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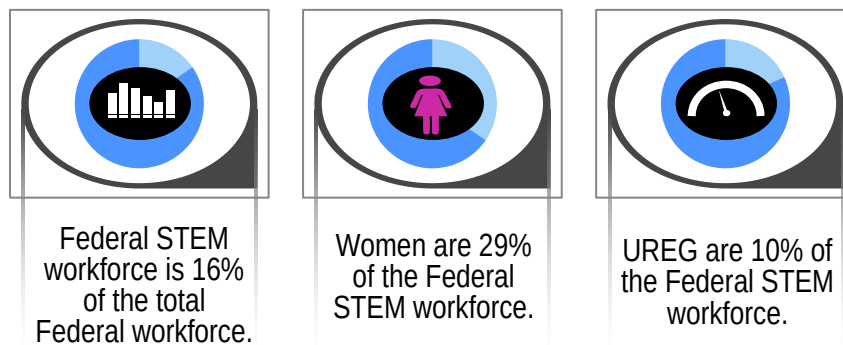
Executive Summary

This report is the result of the extensive work conducted by the Interagency Working Group on Inclusion in STEM (IWGIS). The document provides a summary of best practices that can be employed by Federal agencies as they implement strategies to promote diversity and inclusion in the Federal STEM workforce. The data in this document was derived from two sources.

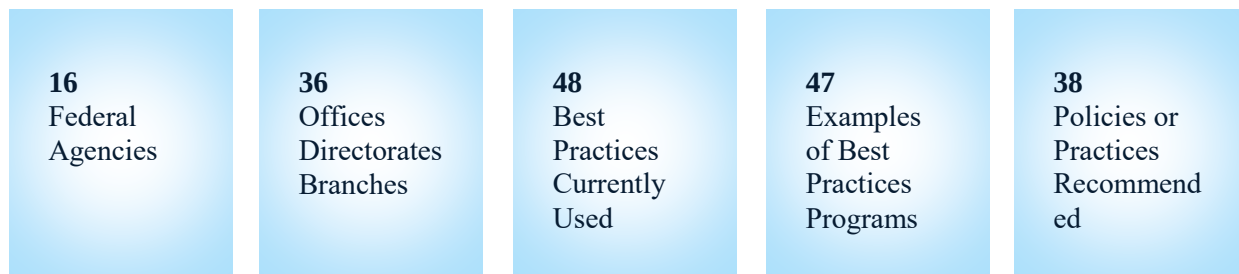
The first is a comprehensive review of the literature on best practices for broadening participation of underrepresented racial and ethnic groups (UREG) in STEM. The second is a Best Practices Solicitation (information request) from FC-STEM Interagency Working Groups to FC-STEM agencies, collected in August 2020. An overview of the data from this solicitation (see Appendix 1) including the most commonly reported best practices and recommended policies for future implementation, is provided below.

Note: The COVID-19 pandemic has exacerbated the challenges identified in this document and should be kept in mind when considering best practices.

Demographics of the Federal STEM Workforce



Best Practices for Diversity and Inclusion in STEM Solicitation Results



Barriers to Diversity and Inclusion in STEM

Policies
 Workplace climate
 Differential compensation packages
 Data systems
 Cost of education
 Peer-to-Peer interaction
 Individualized barriers the STEM workforce
 Perception of STEM programs
 Stereotypes and stereotype threat
 Biases
 Science identity
 Accessibility for individuals with disabilities

Key Areas for Diversity and Inclusion in STEM



Top 5 Best Practices for Diversity and Inclusion in STEM Currently Used by Federal Agencies as reported in the Best Practices Solicitation

- Cultivate partnerships and collaborations
- Engage Minority Serving Institutions (MSI) as equal partners with Federal agencies
- Provide authentic and culturally relevant STEM engagement and research experiences for youth and interns
- Develop and retain promising personnel through effective mentorship
- Conduct targeted outreach through clubs, conferences, and organizations

Top 5 Policies and Practices for Diversity and Inclusion in STEM Recommended by Federal Agencies as reported in the Best Practices Solicitation

- Develop a Human Capital Operating Plan that includes inclusive hiring strategies, focuses on retention, and assures equal access to advancement
- Develop explicit strategies for diversity and inclusion with measurable goals, and hold leadership and employees accountable
- Align diversity and inclusion goals with agency and organizational mission and goals
- Establish monitoring and assessment systems to measure progress toward goals
- Provide consistent and sufficient funding for diversity, equity, and inclusion initiatives, including opportunities for individuals from groups underrepresented in STEM

Key Recommendations for Diversity and Inclusion in STEM by and for Federal Agencies

- ✓ Use the definitions of evidence-based, emerging, and promising practices to help explain the levels of best practices that are adopted by each agency.
- ✓ Develop a pathways approach to STEM academic and career programs at each agency that allows for flexibility with multiple entry points and enables participants to build on academic achievement and research expertise at different levels and life stages.
- ✓ Identify barriers to access and participation in STEM programs offered by each agency and develop strategies to reduce or eliminate them by partnering with other agencies, institutions, and professional organizations.
- ✓ Expand recruitment for Federal jobs, work-based learning opportunities, scholarships and fellowships at minority-serving institutions and institutions with high levels of diversity through face-to-face and virtual outreach efforts.
- ✓ Set goals for outcomes and measurable impacts related to recruitment and retention efforts for employment to increase diversity of the STEM workforce.
- ✓ Provide opportunities for leadership training and skills development and create a plan for leadership and advancement that addresses barriers impacting groups underrepresented in STEM.
- ✓ Provide unconscious bias training for existing managers to raise awareness of how implicit bias can impact performance reviews, hiring, promotion, and access to training and leadership opportunities.
- ✓ Use existing hiring and special pay rate authorities to diversify the Federal STEM workforce at all levels.
- ✓ Develop more flexible hiring and pay authorities, particularly for entry-level positions. Create authority for Federal scholars and fellows to be hired noncompetitively into Federal service.
- ✓ Adopt or adapt promising and emerging practices to address recruitment, retention, and access challenges.
- ✓ Develop or expand work/life balance efforts.

Introduction

In 2018, the National Science and Technology Council Committee on STEM Education published [*Charting a Course for Success: America's Strategy for STEM Education \(the Strategic Plan\)*](#).¹

The Strategic Plan is a North Star, guiding investments in science, technology, engineering, and mathematics (STEM) education for five years. The Strategic Plan lays out a vision for a future where all Americans will have lifelong access to high-quality STEM education and the United States will be the global leader in STEM literacy, innovation, and employment. The components of the Strategic Plan support three overarching aspirational goals:

1. Build Strong Foundations for STEM Literacy
2. Increase Diversity, Equity, and Inclusion in STEM
3. Prepare the STEM Workforce for the Future

The Strategic Plan's second goal—increasing diversity, equity, and inclusion in STEM—is key for achieving the other two goals. When an organization's workforce is diverse in terms of gender, race, socioeconomic status, ethnicity, ability, geography, religion and other identities, and when that organization provides an inclusive environment, it better retains talent, and is more innovative and productive.^{2,3,4,5} Broadening participation is a fundamental prerequisite for making high-quality STEM education accessible to all Americans and will maximize the creative capacity of tomorrow's workforce. The National Science and Technology Council chartered the Interagency Working Group on Inclusion in STEM (IWGIS) to advise the Subcommittee on Federal Coordination in Science, Technology, Engineering, and Mathematics (STEM) Education (FC-STEM) on coordinating activities regarding inclusion in STEM fields across the Federal government, with a focus on identifying research, best practices, and policies on how to promote diversity and inclusion of all groups in the Federal STEM workforce, including underrepresented groups such as people who are Black or African American, Hispanic/Latinx, American Indian, Alaska Native, Native Hawaiian, and Pacific Islanders, women, and persons with disabilities.

This document presents a compendium on Best Practices for Diversity and Inclusion in STEM Education and Research for Federal Agencies. The IWGIS conducted a review of the literature on evidence-based approaches and strategies for effective recruitment, engagement, and retention of individuals from groups that are underrepresented and underserved in STEM. The literature review encompassed practices from private sector and academia as models for Federal Agencies. The goal is not only to identify best practices and exemplary programs but also to establish the evidence base for the existing effective practices and include recommendations for increasing diversity in Federal STEM programs, including those supported through Federal funding.

The document is laid out as follows. The Introduction provides important context for understanding the need for best practices in diversity and inclusion in STEM, including definitions of evidence-based, emerging, and promising practices, and an overview of institutional and individual barriers that

¹ Committee on STEM Education of the National Science & Technology Council (2018) *Charting a Course for Success: America's Strategy for STEM Education* Executive Office of the President of the United States.

² Saxena, Ankita (2014) *Workforce Diversity: A Key to Improve Productivity* *Procedia Economics and Finance* 11: 76-85.

³ National Academies of Sciences, Engineering, and Medicine (2019) *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforces* The National Academies Press.

⁴ National Science Board (2019) *Science and Engineering Indicators 2020: Science and Engineering Labor Force* *Science and Engineering Indicators 2020* NSB-2019-8.

⁵ National Science Board (2020) *NSB Vision 2030* NSB

individuals from underrepresented groups confront as they progress in a STEM career. The next section provides an overview of a literature review on best practices for diversity and inclusion in STEM education and training programs, followed by a section summarizing a literature review on promising and emerging practices. The document concludes with a section that provides recommendations for Federal agencies, and with short concluding remarks.

The data in this document originated from two sources. The first is a comprehensive review of the literature on best practices for broadening participation of underrepresented racial and ethnic groups in STEM. The second is a Best Practices Solicitation (an information request) from FC-STEM Interagency Working Groups to FC-STEM agencies, collected in August 2020. An overview of the data from this solicitation, including the most commonly reported best practices and recommended policies for future implementation, can be found in Appendix 1.

Definition of Best Practices

The five Interagency Working Groups (IWGs) established under FC-STEM each have one or more deliverable in their work plan that calls for identifying best practices. The following definitions of best practices are designed to incorporate the needs of the five IWGs and to aid in the development of language to help standardize the use of the term and improve overall reporting of best practices.

The term “best practices” is ubiquitous and is used in a range of arenas such as education, research, business, industry, and public policy. The term has become so accepted that in many cases, people talk about “best practices” without identifying what exactly is meant by the expression. A generally accepted definition of a best practice is “a procedure that has been shown by research and experience to produce optimal results and that is established or proposed as a standard suitable for widespread adoption.”⁶

This document follows the example set by the US Department of Education (ED) in the Education Department General Administrative Regulations (EDGAR) Evidence Definitions,⁷ which include a *tiers of evidence* to distinguish the extent of the evidence base supporting the effectiveness of a project component in improving a relevant outcome.

This document uses three levels to distinguish among “best practices”: evidence-based practices, promising practices, and emerging practices. The first task of the IWGIS was to develop these definitions in consultation with other FC-STEM IWGs. All IWGs have adopted these definitions.

Evidence-based practices

The National Institutes of Health (NIH) developed a definition of evidence-based medicine that was designed to “*transform the way evidence on clinical effectiveness is generated and used to improve health and health care.*” It is proposed that this definition of evidence-based medicine be adapted to address STEM education more broadly: to the greatest extent possible, the decisions that shape STEM education programs and policies—by stakeholders alike—will be grounded on a reliable evidence base, will account appropriately for individual variation in stakeholders’ and programs’ needs, and will support the generation of new insights on program effectiveness. Evidence is defined here as information from

⁶ Definition: Best Practice (n.d.) *Merriam-Webster*.

⁷ Electronic Code of Federal Regulations (2021) *e-CFR*.

research and evaluation that has met some established test of validity. Processes that involve the development and use of evidence should be accessible and transparent to all stakeholders.⁸

Promising Practices

There are some cases when an agency or organization has been successfully implementing a particular practice but has not collected or generated sufficient evidence to clearly determine all the parameters associated with success of the practice. The Office of Personnel Management (OPM) and OSTP's report on *Reducing the Impact of Bias in the STEM Workforce* defines promising practices as those that are consistent with principles established by research but have not been verified by evaluation.⁹ "Promising practices" can also be used to refer to practices that are known to be "evidence-based" under a specific context, but are being applied in a different context. For example, in seeking to better understand the issues that continue to impact the underrepresentation of women in STEM disciplines, a recent National Academies of Sciences, Engineering, and Medicine report found that some evidence-based practices improved outcomes for one group but were not as effective for another group. In this different context, the evidence-based practices were therefore designated as promising practices.¹⁰

Emerging Practices

Emerging practices are considered to be interventions that are new, innovative, or exploratory in nature, and while they may be based on some level of evidence, that evidence is not sufficient for it to be considered a promising practice.¹¹

Note: These definitions are not meant to be the only way that an organization can define best practices. They are intended to be a guide to help the FC-STEM Interagency Working Groups develop best practices documents that span a range of topics. In addition, these definitions are designed to bring a level of consistency across IWGs.

Definition of Underrepresented

The IWGIS surveyed its membership about the operationalizations of the term "underrepresented" in each agency. Examples of these definitions can be found in Appendix 2. In many cases, legislation defines the scope of an agency's definition of "underrepresented," sometimes even for specific programs.

The IWGIS also held scholarly conversations to examine the use of inclusive language, specifically, the use of the phrase "underrepresented groups" to better understand how race and ethnicity are depicted in publications and the media. The summary of these conversations can be found in Appendix 3. The conversations enabled the IWGIS to better understand how scholars and laypeople use various terms to describe people of color in the U.S. and how diverse groups may be impacted by terms like

⁸ Institute of Medicine (2008) Evidence-Based Medicine and the Changing Nature of Healthcare: 2007 IOM Annual Meeting Summary - Appendix C, IOM Roundtable on Evidence-Based Medicine Roster and Background National Academies Press.

⁹ Interagency Policy Group on Increasing Diversity in the STEM Workforce by Reducing the Impact of Bias (2016) Reducing the Impact of Bias in the STEM Workforce: Strengthening Excellent and Innovation *Office of Science and Technology Policy, Office of Personnel Management*.

¹⁰ National Academies of Sciences, Engineering, and Medicine (2020) Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine: Opening Doors *The National Academies Press*.

¹¹ Interagency Policy Group on Increasing Diversity in the STEM Workforce by Reducing the Impact of Bias (2016) Reducing the Impact of Bias in the STEM Workforce: Strengthening Excellent and Innovation *Office of Science and Technology Policy, Office of Personnel Management*.

“underrepresented”, “minorities”, and “racial and ethnic minorities.” The decision to consider and examine language was based on concerns raised about inclusive language following the heightened awareness of inequities that were amplified by the pandemic.

The IWGIS and IWG Transparency and Accountability (T&A IWG) Joint Subgroup sought to define the terms “minority”, “underrepresented minority”, and “underrepresented” to provide a common definition for FC-STEM working groups and members. Both the IWGIS and T&A IWG agreed that it is important to consider how these terms can or will be operationalized to collect data around participation rates under the COMPETES Act. The scholarly discussions held by the IWGIS were not meant to duplicate this effort but simply to better understand how these terms have evolved and are used (or misused) in scholarly and lay publications. While blogs and tweets are not scholarly literature, they are a common means of communication for non-scholars and were part of the motivation to examine inclusive language. It was also the intent to provide recommendations to FC-STEM that might be applied in future publications.

The Current Status of the Federal STEM Workforce

The Federal government relies on its scientific and technical workforce to perform critical functions in an array of areas, including space exploration, national security and information technology, management and protection of the environment, and transportation. The IWGIS also compiled a study to assess the current status of the Federal STEM workforce, which would serve as a point of reference for recommendations to address practices for diversity, equity, and inclusion in STEM. The data reported here are from OPM’s [FedScope](#) database.¹² This data analysis was conducted to shed light on the demographics of the Federal STEM workforce. Highlights from the study include:

- Of the 2.1 million Federal employees, more than 330,000 people comprise the Federal STEM workforce (16%).¹³
- While women and individuals from underrepresented racial and ethnic groups comprise about 43% and 38% of the total Federal workforce, respectively; they only comprise 29% and 10% of the Federal STEM workforce.¹⁴
- The top STEM employer is the Department of Defense, which employs 47% of the STEM workforce. Other agencies are smaller and represent a range, employing between .18 - 7% of the Federal workforce.
- Overall, growth in STEM careers has been overwhelmingly positive in various fields and careers. This is a testament to the government’s broadening participation programs and recruitment efforts.
- Pay disparities among males and females remain. Women tend to make 7 cents less on the dollar than men, and a [recent report from the Government Accountability Office](#)¹⁵ supported this finding.

¹² Fedscope (2019) *Office of Personnel Management*.

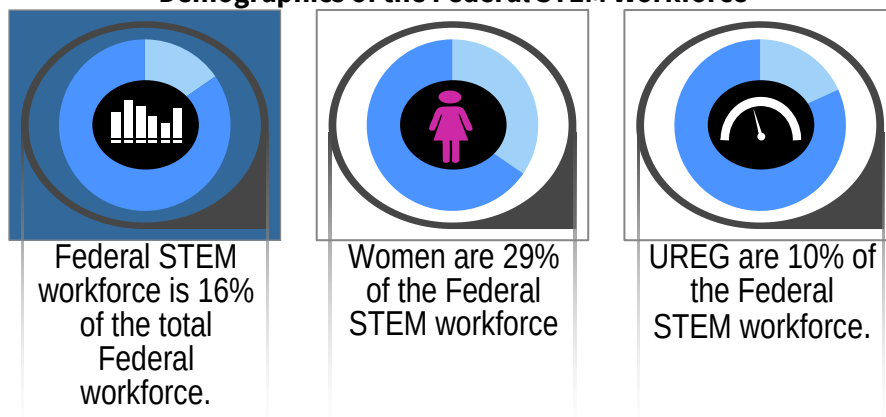
¹³ The study considered the more than 280,000 (~14%) people who occupy engineering, information technology and mathematics, physical science and natural resources and life science careers. The analysis focuses on the STEM workforce for job tracks: 04xx Natural Resources and Life Sciences, 13xx Physical Science, 08xx Engineering & Architecture, and 22xx Information Technology and 15xx Math fields. This analysis does not include STEM employees in occupations such as sociology, psychology, management analyst, etc. or STEM workers in management or administrative positions (e.g., NSF). The Health fields are also not included in this report (~196,000 employees reported in Health Occupations). Data reported here includes the pay banding systems for GS, excepted service, SES, and agency-specific systems. Approximately 25% of STEM employees are in special pay systems at DOC, DOE, NSF and other agencies.

¹⁴ Underrepresented women are counted twice in the study (as underrepresented groups and women).

¹⁵ U.S. Government Accountability Office (2020) Gender Pay Differences: The Pay Gap for Federal Workers Has Continued to Narrow, but Better Quality Data on Promotions Are Needed *GAO-21-67*

- The STEM workforce is aging – 46% of the Federal STEM workforce is over the age of 50.

Demographics of the Federal STEM Workforce



Barriers to Diversity and Inclusion in STEM

This subsection provides an overview of leading institutional and individual barriers to diversity and inclusion in STEM. Understanding and identifying barriers within Federal agencies and across STEM pathways is integral to identifying and prioritizing the development and implementation of best practices across federally sponsored STEM education and research programs. This list was assembled from an extensive STEM literature review. It is beyond the scope of this document to dive deeply into all of the barriers indicated and that is not the intent.

While improvements in the participation of underrepresented groups in STEM have been made in the United States, STEM retention and degree attainment are persistently lower for underrepresented groups. These groups can include, but are not limited to, women, Black/African American, Hispanic/Latinx, American Indian, Alaska Native, or Native Hawaiian.^{16,17} Please see Appendices 2 and 3 for further information.

There are many barriers to inclusion in STEM. Identifying and removing the institutional, social, economic, and academic barriers at play requires deliberate investigation and intervention. Federal agencies must have a strong grasp of the types of barriers that exist in order to effectively promote diversity, equity, and inclusion in Federal STEM efforts.

Policies

Institutional policies can be barriers to inclusion, often unintentionally, or they can play a significant role in both creating and preventing overcoming barriers to inclusion of underrepresented groups. Even the absence of a clear statement or mission recognizing the value of diversity can act as a “de facto”

¹⁶ Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., and Zavala, M. E. (2016) Improving underrepresented minority student persistence in stem *CBE Life Sciences Education* 15.

¹⁷ Estrada, M., Hernandez, P. R., and Schultz, P. W. (2018) A Longitudinal Study of How Quality Mentorship and Research Experience Integrate Underrepresented Minorities into STEM Careers *CBE Life Sciences Education* 17.

policy barrier to ethnically and racially diverse hires.¹⁸ A lack of relevant institutional policies may result in inequitable practices in hiring, promotions, and job placement practices based on race and gender.¹⁹

The mere presence of institutional or program policies is also not sufficient. The ineffective and inconsistent administration of diversity related policies and practices can render them ineffective.²⁰

Even with effective policies in place, data collection strategies and policies can be a barrier when organizations do not collect data (or are prevented from doing so due to legal or policy barriers) in a way that allows for accurate characterization of the variables of interest, for example, data on disability status or disaggregation of intersectional demographic data.

Workplace Climate

Workplace climate can be a significant barrier to inclusion when there are real or perceived differences in the way individuals are treated by peers and leaders based on their race, gender, disability, or other demographics that may, or may not, result from prejudice or animus and may or may not be intentional in nature.

Work-life balance disproportionately impacts female employees more than male. For example, women with children or caregiver responsibilities experience greater stress compared to men with children.²¹ This situation can become a threat to career persistence, especially when institutional support for work-life balance is poor.

The correlate to a workplace for students early in their scientific career is the college campus. Experiencing a culture with a hostile or unwelcoming racial environment is correlated with social and academic withdrawal, academic isolation, and social isolation, along with other negative consequences.²²

Regardless of the nature of the workplace, maintaining an inclusive workplace climate requires proactively employing strategies that promote inclusivity at all levels. Organizations that are most successful are also very intentional about their workplace climate actions.

Differential Compensation Packages

Similar challenges related to compensation packages are experienced in academia and in the Federal STEM workforce. In academia, compensation models and packages can incorporate hard and soft money methods of funding salaries. Hard money positions are funded by the institution for a defined period, while soft money positions depend on the successful rewarding of scientific grants.²³

¹⁸ Institute of Medicine (US) Committee on Institutional and Policy-Level Strategies for Increasing the Diversity of the U.S. Healthcare Workforce, Smedley, B.D., Stith-Butler, A., and Bristow, L.R. (Eds.) (2004) In the Nation's Compelling Interest: Ensuring Diversity in the Health-Care Workforce *National Academies Press (US)*.

¹⁹ Yang, Y. and Konrad, A.M. (2011) Understanding Diversity Management Practices: Implications of Institutional Theory and Resource-Based Theory *Group & Organization Management* 36: 6-38.

²⁰ Ibid.

²¹ López, C.M., Margherio, C., Abraham-Hilaire, L.M., and Feghali-Bostwick, C. (2018) Gender disparities in faculty rank: Factors that affect advancement of women scientists at academic medical centers *Social Sciences* 7.

²² National Academy of Engineering, Engineering National Academies of Sciences, and Medicine (2016) Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways The National Academies Press.

²³ López, C.M., Margherio, C., Abraham-Hilaire, L.M., and Feghali-Bostwick, C. (2018) Gender disparities in faculty rank: Factors that affect advancement of women scientists at academic medical centers *Social Sciences* 7.

Some Federal agencies may have positions which encounter similar challenges. For example, the Department of Homeland Security (DHS) experiences a barrier with respect to extending cyber retention pay to Schedule A for persons with disabilities. Whereas non-Schedule A candidates may begin receiving cyber retention pay once they are cleared for duty, candidates that have been brought on via Schedule A for persons with disabilities are subject to a one-year probationary period before they are eligible to receive it -- a policy scenario where there is a disparity felt by individuals of an underrepresented community.

Individuals from underrepresented groups, especially women, have been greatly impacted by the disparity between these compensation mechanisms. Gaps or lapses in funding can occur more for women, who typically have greater responsibilities than men for family care. The lack of salary funding during a lapse has a direct effect on staff retention.^{24,25}

Availability and Use of Data

A prerequisite to addressing barriers to inclusion is understanding the current situation; that requires accurate and relevant demographic data. In January 2021, President Biden issued a [*Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking*](#).²⁶ Among other things, Section 5 of the Memorandum, which focuses on evidence-based policymaking, indicates new guidance will be forthcoming from the Office of Management and Budget (OMB) to improve agencies' evidence-building plans and annual evaluation plans; scientific-integrity principles shall be incorporated into agencies' data governance and evaluation approaches; and agencies shall (as appropriate and consistent with applicable law) expand open and secure access to various Federal data.

As required by the America COMPETES Act²⁷ and its subsequent reauthorization,²⁸ Federal agencies have begun reporting on the rates of participation of different demographics in Federal programs, including by individuals from underrepresented groups, women, and people in rural areas. The absence of accurate demographic data for the workforce in systems (local, state, Federal) and job sectors (education, business, technology) results in a limited ability to determine the systemic and individual factors that impact underrepresented groups in the STEM workforce.

Cost of Education

First generation STEM undergraduates from underrepresented groups often have greater college debt than students whose parents are college graduates.²⁹ This can hinder performance and negatively affect career progression. In addition, students who must work to afford college may miss out on professional growth opportunities accessible to more affluent students, such as unpaid research experience, professional meeting attendance, and summer academic experiences. Finally, early career

²⁴ Correll, S.J., Benard, S., and Paik, I. (2007) Getting a Job: Is There a Motherhood Penalty? *American Journal of Sociology* 112: 1297-338.

²⁵ López, C.M., Margherio, C., Abraham-Hilaire, L.M., and Feghali-Bostwick, C. (2018) Gender disparities in faculty rank: Factors that affect advancement of women scientists at academic medical centers *Social Sciences* 7.

²⁶ Presidential Actions (2021) Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking *The White House*.

²⁷ America Competes Act (2007) *Congress*.

²⁸ America Competes Reauthorization Act of 2010 (2010) *Congress*.

²⁹ Cadaret, M. and Bennet, S.R. (2018) College Students' Reported Financial Stress and Its Relationship to Psychological Distress *Journal of College Counseling* 22.

positions in some STEM fields do not typically provide high salaries.³⁰ The combination of high debt and low pay can result in individuals from underrepresented groups leaving the STEM workforce to find higher paying jobs.

Workplace Interactions

Professional interactions play a large role in STEM retention of individuals from underrepresented groups. In academia, negative student-faculty interactions, such as direct discrimination by faculty members, is associated with greater attrition of women, Black, and Hispanic students (compared to their male or white and Asian-American peers). In general, any interaction related to race and ethnicity that results in a person feeling uncomfortable is negatively linked to STEM retention.³¹

Individualized Barriers to the STEM Workforce

Individuals from underrepresented groups have a greater attrition rate as they move along STEM pathways. Meeting the needs of these individuals at each of these steps requires a concerted and deliberate plan.³² An understanding of the barriers that individuals from underrepresented groups face is of paramount importance for planning a successful strategy to overcome them.

The strongest impact determining whether a secondary school student enters the STEM scientific workforce is their socioeconomic status.^{33,34} The major factor affecting the economic status of students is the income of their parents. This factor affects many facets of a student's life, including students incurring a high level of debt during college. In addition, educational centers are often located in areas with a high cost-of-living. Thus, a lower household income level necessitates living further from the source of education. The longer commute time effectively acts as a barrier.

Another significant factor that can act as a barrier for individuals is the lack of a support system, among family, friends, and peers. While these groups are commonly among the most important supports for individuals, if family and friends have no experience navigating higher education, and peers are lacking in the college setting, the lack of a support system can exacerbate isolation and make it harder to persist and succeed.

A lack of diverse mentors contributes to the dearth of a support system. Mentorship provides individuals from underrepresented groups the potential to see themselves through the eyes of an influential guide.³⁵ Without formal or even informal mentors, individuals from underrepresented groups

³⁰ Jobs for the Future (2007) The STEM Workforce Challenge: The Role of the Public Workforce System in a National Solution for a Competitive Science, Technology, Engineering, and Mathematics (STEM) Workforce *U.S. Department of Labor, Employment and Training Administration*.

³¹ Park, J. J., Kim, Y. K., Salazar, C., and Hayes, S. (2020) Student–Faculty Interaction and Discrimination from Faculty in STEM: The Link with Retention *Research in Higher Education* 61: 330-56.

³² Acosta, D. and Olsen, P. (2006) Meeting the needs of regional minority groups: the University of Washington's programs to increase the American Indian and Alaskan native physician workforce *Acad Med*, 81: 863-70.

³³ Taylor & Francis Group (2020) 'Low' socioeconomic status is the biggest barrier to STEM participation *ScienceDaily*.

³⁴ Cooper, G. and Berry, A. (2020) Demographic predictors of senior secondary participation in biology, physics, chemistry and earth/space sciences: students' access to cultural, social and science capital *International Journal of Science Education* 42: 151-66.

³⁵ National Academies of Sciences, Engineering, and Medicine (2019) The Science of Effective Mentorship in STEMM *The National Academies Press*.

may experience feelings of isolation and invisibility.^{36,37} The sum effect of a lack of a support system can manifest as a difficulty in acclimation to majority culture and, ultimately, lead to retention failure.

In addition to socioeconomic status and support systems, the educational system itself can act as a barrier. Educational models are often implicitly built with the understanding that students come through a traditional education path. The lack of culturally responsive teaching can serve as a barrier for students from underrepresented groups.

Finally, discrimination of underrepresented groups is a direct barrier to career opportunities.³⁸ Overt racism and discrimination directly act to remove individuals from the STEM workforce.

Perception of STEM Programs

The perception that STEM programs are male dominated affects not only students but teachers and parents as well. Women and individuals from underrepresented groups in STEM confront gender stereotypes at academic institutions because of socio-cultural stereotypes regarding white males and academic STEM disciplines. Parents and teachers are also influenced and are less likely to believe in the capability of a student from an underrepresented group. This can result in students deciding not to pursue STEM careers without the encouragement of their mentors.^{39,40}

Stereotypes and Stereotype Threat

Stereotype threat occurs when individuals fear that they will confirm a negative stereotype (e.g., not being expected to succeed) about a group to which they belong.^{41,42,43} The fear of confirming stereotypes sometimes results in higher levels of anxiety and stress, especially for women and individuals from underrepresented groups. An African American or Latino student, for instance, may face stereotype threat during a scientific task or an exam; they may fear confirming the stereotype that African American or Latino students “underperform” in STEM.

³⁶ Martinez, M.A., Alsandor, D.J., Cortez, L.J., Welton, A.D., and Chang, A. (2015) We are stronger together: reflective testimonios of female scholars of color in a research and writing collective *Reflective Practice* 16: 85-95.

³⁷ Comer, E.W., Medina, C.K., Negroni, L.K., and Thomas, R.L. (2017) Women Faculty of Color in a Predominantly White Institution: A Natural Support Group *Social Work with Groups* 40: 148-55.

³⁸ Small, M. L., and D. Pager (2020) Sociological perspectives on racial discrimination *Journal of Economic Perspectives* 34: 46-97.

³⁹ Blackburn, H. (2017) The Status of Women in STEM in Higher Education: A Review of the Literature 2007–2017 *Science & Technology Libraries* 36: 235-73.

⁴⁰ Saucerman, J., and Vasquez, K. (2014) Psychological Barriers to STEM Participation for Women Over the Course of Development *Adultspan Journal* 13: 46-64.

⁴¹ Steele, C.M. (1997) A threat in the air: How stereotypes shape intellectual identity and performance *American Psychologist* 52: 613–629.

⁴² Carr, P.B. and Steele, C.M. (2010) Stereotype Threat Affects Financial Decision Making *Sage* 21: 1411-1416.

⁴³ Beasley, M. A. and Fischer, M.J. (2012) Why they leave: the impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors *Social Psychology of Education* 15: 427-48.

Biases

Biases, such as sexism, can often be found in the workplace culture. Indeed, both explicit bias and implicit bias (with regard to gender, racial, and ethnic stereotypes) are prevalent in the United States and in science.^{44,45}

Implicit bias is typically associated with individual behaviors; however, an implicit bias can influence entire systems and institutional practices and structures. This can also be said for racism, which is typically associated with individual behaviors, but has a pervasive systemic and structural impact in science and in STEM.⁴⁶

Science Identity

Science identity can be described in terms of how an individual seeks to be a scientist.^{47,48} STEM persistence may be negatively affected if a person is not given an opportunity to develop their STEM identity.⁴⁹ Conversely, a person with a strong science identity would exhibit *competence* about scientific concepts, the potential for scientific *performance* (in terms of using scientific tools and navigating scientific social situations), and *recognition* as a scientist to both themselves and others in the field.⁵⁰ The concept of science identity and how individuals strive to become valued members of the STEM disciplines is an expanding area of research.^{51,52}

A strong science identity positively influences the likelihood of pursuing a career in science.^{53,54,55} Conversely, weak or underdeveloped science identity among underrepresented groups and women is a barrier to recruitment, retention and persistence in STEM careers.^{56,57,58} Strategies to expose students

⁴⁴ Pietri, E.S., Johnson, I.R., Ozgumus E., and Young, A.I. (2018) Maybe She Is Relatable: Increasing Women's Awareness of Gender Bias Encourages Their Identification With Women Scientists *Psychology of Women Quarterly* 42: 192-219.

⁴⁵ Handley, I.M., Brown, E.R., Moss-Racusin, C.A., and Smith, J. L. (2015) Quality of evidence revealing subtle gender biases in science is in the eye of the beholder *Proc Natl Acad Sci USA* 112: 13201-6.

⁴⁶ Thorp, H. H. (2020) Time to look in the mirror *Science* 368: 1161.

⁴⁷ Gee, J. P. (2000) Identity as an Analytic Lens for Research in Education *Review of Research in Education* 25: 99-125.

⁴⁸ Bucholtz, M., Barnwell, B., Skapoulli, E., & Lee, J. (2012) Itineraries of Identity in Undergraduate Science *Anthropology & Education Quarterly* 43: 157-172.

⁴⁹ Vincent-Ruz, P. and Schunn, C.D. (2018) The Nature of Science Identity and its Role as the Driver of the Student Choices *International Journal of STEM Education* 5.

⁵⁰ Carlone, H. B., and Johnson, A. (2007) Understanding the science experiences of successful women of color: Science identity as an analytic lens *Journal of Research in Science Teaching* 44: 1187-218.

⁵¹ Stryker, S., and Burke, P.J. (2000) The Past, Present, and Future of an Identity Theory *Social Psychology Quarterly* 63: 284-97.

⁵² Büyükgöze, H. and Gün, F. (2017) Building the professional identity of research assistants: a phenomenological research *Educational Sciences: Theory & Practice* 17.

⁵³ Estrada, M., Hernandez, P. R., and Schultz, P. W. (2018) A Longitudinal Study of How Quality Mentorship and Research Experience Integrate Underrepresented Minorities into STEM Careers *CBE Life Sciences Education* 17.

⁵⁴ Stets, J., Brenner, P., Burke, P., and Serpe, R. (2016) The science identity and entering a science occupation *Soc Sci Res* 64.

⁵⁵ White, A. M., DeCuir-Gunby, J.T., and Kim, S. (2019) A mixed methods exploration of the relationships between the racial identity, science identity, science self-efficacy, and science achievement of African American students at HBCUs *Contemporary Educational Psychology* 57: 54-71.

⁵⁶ National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2007) Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering The National Academies Press.

⁵⁷ Burt, B.A., Williams, K.L., and Smith, W.A. (2018) Into the Storm: Ecological and Sociological Impediments to Black Males' Persistence in Engineering Graduate Programs *American Educational Research Journal* 55: 965-1006.

⁵⁸ Villa, E., Wandermurem, L., Hampton, E., and Esquinca, A. (2016) Engineering Education through the Latina Lens *Journal of Education and Learning* 5: 113.

early to the experiences and benefits of science and to ensure that students from underrepresented groups receive mentoring throughout their career help to cultivate science identity.⁵⁹

Science identity is a dynamic factor that changes in response to societal context as well as situational factors. Thus, measuring the identity of an individual at one point in time in a situation is not a static determination. Five science identities were found from a study of 52 college students, mostly from underrepresented groups, that affected their feelings of being ready to apply to a doctoral program after their undergraduate studies.⁶⁰ These students were followed up later to show how their identities have changed as they progressed in their scientific careers.⁶¹ Through various domains of development, participants were enabled to develop their identities as graduate students and to anticipate being seen by others as highly prepared for PhD training. Supporting and nurturing science identities is crucial for recruitment and retention of a diverse scientific workforce.

Accessibility for Individuals with Disabilities

Individuals with disabilities experience lower levels of career success when compared to peers without disabilities.⁶² There are multiple barriers that individuals with disabilities face:

- Many workplaces have limited staff resources to provide employee training on accessibility issues.
- There are added costs associated with purchasing appropriate technology or resources for accommodations. One method to overcome this barrier is to create a central budget at the institute level for accommodations. This avoids requiring department budgets, which are smaller, to cover these costs. In addition, some federally funded research may use grant funds to cover the costs of accommodations.⁶³
- There is a lack of representation of employees with disabilities on advisory boards and leadership teams at institutions.
- There is a lack of data on individuals with disabilities in Federal, state, and local databases related to STEM careers and workforce. Disability is stigmatized, and often individuals do not report disabilities in surveys and other demographic reporting formats. Limited or inaccurate data fail to provide a clear depiction of the population for the purpose of tracking participation rates, changes over time, and other key information that can help program and policy.
- There is a lack of work-based learning opportunities for employees with disabilities.
- There is a lack of a common assessment tools for data collection and evaluation of individuals with disabilities.
- There is a lack of system-wide recruitment and engagement of individuals with disabilities.

The next section provides an overview of a literature review conducted by IWGIS members on best practices for diversity and inclusion in STEM.

⁵⁹ Aikens, M. L., Robertson, M. M., Sadselia, S., Watkins, K., Evans, M., Runyon, C. R., Eby, L. T., and Dolan, E. L. (2017) Race and Gender Differences in Undergraduate Research Mentoring Structures and Research Outcomes *CBE Life Sci Educ* 16.

⁶⁰ Gazley, J.L., Remich, R., Naffziger-Hirsch, M.E., Keller, J., Campbell, P.B., and McGee, R. (2014) Beyond preparation: Identity, cultural capital, and readiness for graduate school in the biomedical sciences *Journal of Research in Science Teaching* 51: 1021-48.

⁶¹ Remich, R., Naffziger-Hirsch, M. E., Gazley, J. L., and McGee, R. (2016) Scientific growth and identity development during a postbaccalaureate program: Results from a multisite qualitative study *CBE Life Sciences Education* 15.

⁶² Bellman, S., Burgstahler, S., and Chudler, E.H. (2018) Broadening Participation by Including More Individuals With Disabilities in STEM: Promising Practices from an Engineering Research Center *American Behavioral Scientist* 62: 645-56.

⁶³ Kuo, M. (2015) Science in sign language *The American Society for Biochemistry and Molecular Biology*.

Key Areas for Advancing Diversity and Inclusion in STEM

Members of the IWGIS conducted a literature review to compile **evidenced-based best practices** for promoting diversity and inclusion in STEM in the Federal and non-Federal landscape. The following Key Areas emerged as central themes for best practices: STEM Pathways, Access and Recruitment, Retention and Achievement, and Advancement.



The Key Areas below are structured as follows. Each key area contains an overview of the issue, touching on barriers from the previous section. Subsection titles under each key area are best practices that emerged from the literature search and contain brief descriptions of the best practice and provide further information and examples. The examples following each key area originate from a Best Practices Solicitation (information request) to FC-STEM agencies, collected in August 2020. These examples represent some of the many exemplars of programs implementing best practices for diversity and inclusion across the Federal government. See Appendix 1, Table 3 for further examples of programs from the Best Practices Solicitation Results.

Key Area 1: STEM Pathways

Individual journeys from education to occupation are often complex. Increasingly robust sources of data have the potential to more accurately capture the multiple entry and exit points of individuals and lead to the development of better tools to understand the nuances within individuals' trajectories in STEM.⁶⁴

A Pathways Approach

The “STEM pipeline” model suggests a straightforward, linear progression from formal STEM education to STEM occupation. This model does not reflect the full range of career opportunities available to STEM degree holders and the many factors that influence career choices over a lifetime.⁶⁵ A “STEM pathways”

⁶⁴ Lord, S.M., Ohland, M.W., Layton, R.A., Camacho, M.M. (2019) Beyond pipeline and pathways: Ecosystem metrics *Journal of Engineering Education* 108: 32-56.

⁶⁵ National Science Foundation (n.d.) STEM Education and the Workforce Pathways, Not Pipelines *National Science Board*.

model better represents the relationship between degree and jobs, in which STEM degree holders follow career paths into STEM and non-STEM jobs, or both, over the course of their working lives.⁶⁶

An emphasis on career pathways encourages a shift in the focus of questions concerning workforce competitiveness from “how many degrees/workers” do we have to “what STEM **knowledge and skills**” should all U.S. workers have.⁶⁷

Decades of data show that workers with STEM degrees follow numerous pathways leading to careers in and out of their field of study and even into non-STEM jobs. A focus on pathways highlights our collective challenge to ensure that all students have access to STEM pathways, and that roadblocks to their success are identified and removed.⁶⁸

Among college-educated U.S. workers with their highest degree in a science and engineering (S&E) field, just under half (49%) are employed in an S&E or S&E-related job. Non-S&E jobs held by S&E degree holders include management, sales, marketing, social services, and teaching in non-STEM fields.⁶⁹

Guided Pathways

Students take a variety of paths to completing a STEM program, often transferring between institutions, stopping for a period and switching into or out of STEM majors. They pursue a range of different STEM credentials, including degrees and certificates, at different types of 2-year and 4-year institutions (e.g., research university, liberal arts college, nonprofit or for-profit 2-year college). Given this variety of pathways, it is important to promote **successful navigation** into and through STEM programs of study through institutional structures, policies, and practices that provide a variety of entry/exit points and strengthen STEM readiness for entering and enrolled college students.⁷⁰ Some of these activities are funded by Federal agencies, such as:

- Guided pathways (map of courses)
- Inter-institution articulations
- Preparation support
- Developmental education approach
- Bridge programs⁷¹

Pathways for Military Veterans

Military veterans returning from deployment frequently possess technical training and have significant experience with sophisticated machinery and systems, yet they face obstacles to embarking on STEM pathways. Veterans may not readily know how to translate their experience to civilian careers. Veterans with disabilities encounter especially daunting challenges.⁷²

⁶⁶ Ibid.

⁶⁷ Ibid.

⁶⁸ National Science Foundation (2015) Revisiting the STEM Workforce: A Companion to Science and Engineering Indicators 2014 *National Science Board*.

⁶⁹ National Science Foundation (n.d.) STEM Education and the Workforce Pathways, Not Pipelines *National Science Board*.

⁷⁰ Guided Pathways (n.d.) *CCRC and the AACC Pathways Project*.

⁷¹ National Academies of Sciences, Engineering, and Medicine (2018) Indicators for Monitoring Undergraduate STEM Education *The National Academies Press*.

⁷² National Science Foundation (2015) Revisiting the STEM Workforce: A Companion to Science and Engineering Indicators 2014 *National Science Board*.

Several initiatives, focused on academic advising, internships, networking services and peer support are underway to alleviate the roadblocks that veterans, including disabled veterans, encounter.⁷³ Many of these initiatives are highlighted in the National Science Board reports on the Skilled Technical Workforce.⁷⁴ In addition, the Federal Government initiated a program to offer career development opportunities for returning veterans interested in Federal science-related jobs.⁷⁵

Appealing STEM Pathways

If essential STEM pathways are not attractive relative to other career options, too few students may undertake and persist in STEM courses of study. The state of STEM pathways also affects incumbent workers. If the condition of these pathways is poor, incumbent workers may find them less appealing and consider other careers out of their field of degree or out of STEM altogether.⁷⁶

It is important to monitor and **assess the condition** of these pathways and identify risks and challenges. Labor market indicators such as earnings and unemployment rates as well as related indicators addressing why individuals with STEM degrees work out of their field of degree help provide information about the availability and condition of STEM pathways.

Examples:

In 2017 the **Department of Labor's (DOL)** Employment and Training Administration published a research brief titled [Building Early College Pathways to STEM Careers Bridgeport Tries a New Tack to Meet Employer Demand for Skilled Workers](#). The brief describes the design and implementation of the STEM Early College Expansion Partnership in Bridgeport, Connecticut, which aims to create career **pathways** in advanced manufacturing and health care for underserved high school students. The goal is to make learning more relevant to students by matching the curriculum with the knowledge and skills they would need on the job and to promote college and career success for students from disadvantaged backgrounds. The brief also identifies four emerging lessons and challenges to meet employer demands: small costs can be significant barriers to students; attrition highlights the need for clear expectations and strong support systems; gender diversity in manufacturing is a continuing goal; and covering tuition and other costs is an ongoing challenge.

The **United States Department of Agriculture's (USDA)** [Agricultural Research Service \(ARS\)](#) has developed hiring **pathways** for interns already onboard within the agency. This allows ARS to access a wide pool of diverse candidates for any upcoming vacancies within the agency. Specific examples include internships via the [Pathways Program](#) and partnerships with third-party organizations such as the Hispanic Association of Colleges and Universities (HACU); the agency hires several dozen HACU interns each year. In addition, ARS recently hired two USDA 1890 National Scholars into entry level STEM positions in the agency. The 1890 National Scholars program supports one scholar at each of the country's nineteen 1890 land grant institutions.

The **National Aeronautics and Space Administration (NASA)** [Community College Aerospace Scholars \(NCAS\)](#) is a nationwide activity designed for post-traditional learners enrolled in an accredited 2-year institution in the U.S. who are interested in a STEM career. NCAS helps students make the connection

⁷³ Ibid.

⁷⁴ National Science Board (2019) The Skilled Technical Workforce: Crafting America's Science & Engineering Enterprise *National Science Foundation*.

⁷⁵ Feds Hire Vets (n.d.) *U.S. Office of Personnel Management*.

⁷⁶ National Science Foundation (2015) Revisiting the STEM Workforce: A Companion to Science and Engineering Indicators 2014 *National Science Board*.

between a STEM degree and NASA career opportunities and realize that working in STEM is an attainable goal. Additionally, NCAS prepares and motivates students to participate in other competitive NASA projects, programs, and internships, and encourages community college students to finish their 2-year degree and pursue a 4-year degree or career in a STEM field. To increase the efficiency and effectiveness of NCAS, new infrastructure was put into place in Fiscal Year 2019 as NCAS piloted the 'NASA on Campus' expansion model. NASA on Campus takes the successful evidence based NCAS model implemented at NASA centers and trains community college faculty to achieve the same positive student outcomes on their local campus. The pilot allowed NCAS to add six onsite events and helped refine a model for full implementation. The campuses produced an 18% increase in the number of students completing the full NCAS experience from the previous year.

The [Human Exploitation Rescue Operative \(HERO\) Child-Rescue Corps](#) is a program developed by U.S. Immigration and Customs Enforcement's Homeland Security Investigations, and in conjunction with the Department of Defense and the National Association to Protect Children. The HERO Child-Rescue Corps Program provides training in high-tech computer forensics and law enforcement skills to wounded, injured and ill Special Operations Forces. Trainees assist Federal agents in the fight against online child sexual exploitation. With successful completion of the program, HERO interns have the knowledge, skills, and experience to apply for careers with Federal, state, and local police agencies, and other organizations, in the field of computer forensics.

Key Area 2: Access and Recruitment

In addressing diversity and inclusion in STEM, access and recruitment are two distinct but related issues.^{77,78,79,80} Because individuals' journeys in STEM are complex, broad access and intentional recruitment is critical for building an inclusive workforce.

Partnerships in Support of Individuals from Underrepresented Groups

Changing demographics will have a direct impact on the STEM talent pool.^{81, 82}

- Create initiatives to increase diversity and inclusion in student populations. Initiatives should focus on reducing barriers and supporting individuals from underrepresented groups, including providing financial support for internships.⁸³

⁷⁷ Definition: Access (n.d.) *Merriam Webster*.

⁷⁸ Definition: Recruitment (n.d.) *Smart Recruiters*.

⁷⁹ Definition: Recruitment (n.d.) *Business Dictionary*.

⁸⁰ Access is defined as a way or means of approaching or entering a place; permission, liberty, or ability to enter, approach, or pass to and from a place or to approach or communicate with a person or thing.

Recruitment refers to the process of identifying, attracting, interviewing, selecting, hiring, and onboarding employees. In other words, it involves everything from the identification of a staffing need to filling it. A second definition of recruitment is the process of finding and hiring the best-qualified candidate (from within or outside of an organization) for a job opening, in a timely and cost-effective manner. The recruitment process includes analyzing the requirements of a job, attracting employees to that job, screening and selecting applicants, hiring, and integrating the new employee to the organization.

⁸¹ National Academies of Sciences, Engineering, and Medicine (2019) *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce* *The National Academies Press*.

⁸² "A clear takeaway from these population estimates is that the educational outcomes and STEM readiness of students of color will have direct implications on the nation's economic growth, national security, and global prosperity."

⁸³ Henneberry, S.R. and Radmehr, R.,(2020) Quantifying impacts of internships in an international agriculture degree program *PLOS ONE* 15(8).

BEST PRACTICES FOR DIVERSITY AND INCLUSION IN STEM EDUCATION AND RESEARCH:
A GUIDE BY AND FOR FEDERAL AGENCIES

- Recognize that Minority Serving Institutions⁸⁴ are an underutilized resource for strengthening the STEM workforce.⁸⁵ Efforts should be made to actively engage with MSIs and scientific societies that serve persons from underrepresented groups.^{86,87}
- The National Science Foundation’s NSF INCLUDES program documents several strategies that have demonstrated success in increasing access for individuals from underrepresented groups.⁸⁸ These evidence-based strategies include culturally responsive pedagogical practices, summer bridge programs, research experiences, and mentoring, among others.

Leverage Human Resources Departments

It is important to recognize the role of Human Resources Departments in addressing the issues of diversity and inclusion in recruitment.^{89,90}

- Identify and change recruitment and hiring practices that fail to be inclusive.⁹¹ Consider marketing materials, recruitment sources, qualifying questions and candidate scoring rubrics, make-up of hiring committees, and the interview processes.
- Address unconscious bias. For example, rather than viewing hiring persons with disabilities as just being “the right thing to do,” it must be viewed as part of a talent strategy that will benefit the organization and outweigh what they see as the potential expenses and risk.⁹²
- Use appropriate data for comparison when assessing diversity and inclusion internal to your agency. For example, only 13% of companies in the U.S. have reached the Department of Labor’s target of having 7% disability representation in their workforce.⁹³

Examples:

The **National Oceanic and Atmospheric Administration’s (NOAA)** [José E. Serrano Educational Partnership Program with Minority Serving Institutions](#) (EPP/MSI) has demonstrated its ability to increase inclusion, retention, and achievement of supported scholars through financial support,

⁸⁴ Minority Serving Institutions (MSIs) are traditionally defined by one of two overarching categories: historically defined or enrollment-defined institutions. Historically defined MSIs were established with the express purpose of providing access to higher education for a specific minority group and include Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities (TCUs). Enrollment-defined MSIs are Federally designated based on student enrollment and institutional expenditures and include Hispanic Serving Institutions (HSIs), Alaska Native-Serving and Native Hawaiian-Serving Institutions (ANNHIs), Asian American and Native American Pacific Islander-Serving Institutions (AANAPISIs), Predominantly Black Institutions (PBIs), and Native American-Serving Nontribal Institutions (NASNTIs).

⁸⁵ National Academies of Sciences, Engineering, and Medicine (2019) Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce *The National Academies Press*.

⁸⁶ Wolfe, B.A. and Riggs, E.M. (2017) Macrosystem Analysis of Programs and Strategies to Increase Underrepresented Populations in the Geosciences *Journal of Geoscience Education* 65: 577-593.

⁸⁷ Bruno, B.C., Wren, J.L.K., Noa, K., Wood-Charlson, E.M., Ayau, J., Leon Soon, S., Needham, H., and Choy, C.A. (2016) Summer bridge program establishes nascent pipeline to expand and diversify Hawai'i's undergraduate geoscience enrollment *Oceanography* 29(2):286–292.

⁸⁸ National Science Foundation INCLUDES Coordination Hub, Research Brief (2020) Evidence-based Strategies for Improving Equity and Inclusion of Individuals in Underrepresented Racial and Ethnic Groups National Science Foundation.

⁸⁹ Waite, A.M., & McDonald, K.S. (2019) Exploring Challenges and Solutions Facing STEM Careers in the 21st Century: A Human Resource Development Perspective *Advances in Developing Human Resources* 21(1), 3–15.

⁹⁰ “Human resource development (HRD) has largely been absent from the discussion on potential contributions it may provide to address recruitment, development, and retention issues that threaten a diverse, sustained supply of career ready STEM workers. Considering the changing nature of knowledge-intensive jobs and continuing growth in STEM occupations, HRD’s role to advance STEM careers in the 21st century is significant”

⁹¹ Kennedy, T.J., Jerdee, C., and Henneborn, L. (2019) 4 Ways to Improve Your Company’s Disability-Inclusion Practices. *Harvard Business Review*.

⁹² 2019 Employment Tracker Results (2019) *National Organization on Disability*.

⁹³ Ibid.

internships, and professional engagement. This investment has resulted in a significant increase in the education and graduation of students from underrepresented communities in STEM fields that support NOAA's mission. With performance metrics as a program requirement, EPP/MSI has developed a database that contains student data and other information used to track and assess program performance. An [article](#) published in the *Journal of Geoscience Education* highlighted the best practices of the EPP/MSI program and describe how NOAA and its academic partners have supported the program's objectives. Collaborative planning and program design with key partners, collaborations with NOAA scientists, having the partnerships led and impacts realized mostly by MSIs, using cooperative agreements rather than grants, and a commitment from NOAA leadership to support the program have been important components of the success of EPP/MSI.

The **Department of Transportation (DOT)** is currently developing a Recruitment Plan to eliminate the underrepresentation of minorities, females, and persons with disabilities. Recruitment activities include the Fall Historically Black College and University (HBCU) Recruitment Conference; the Department of Transportation Mentoring Program; Department of Transportation Youth Employee STEM Mentoring Program; Employee Resource Groups like Federally Employed Women – Women on the Move Chapter; Summer Transportation Internship Program for Diverse Groups; and the Federal Aviation Administration's Minority Internship Program.

The **Veterans Benefits Administration's (VBA)** [Edith Nourse Rogers Science Technology Engineering Math \(STEM\) Scholarship](#) allows eligible veterans and dependents in high-demand STEM fields to extend their Post-9/11 GI Bill or Fry Scholarship benefits. In launching the Rogers STEM Scholarship, the VBA has been transparent with students and schools in promoting the availability of the scholarship and encouraging its use. In addition, the method by which the scholarships are reviewed is a blind system thereby removing demographic characteristics as well.

The **Department of Education's (ED)** [Gaining Early Awareness and Readiness for Undergraduate Program \(GEAR UP\)](#) is a discretionary grant program for states and for partnerships designed to increase the number of low-income students who are prepared to enter and succeed in postsecondary education. GEAR UP funds are also used to provide college scholarships to low-income students. GEAR UP provides six-year grants to states and partnerships to provide services at high-poverty middle and high schools. GEAR UP grantees serve an entire cohort of students beginning no later than the seventh grade and follow the cohort through high school. GEAR UP funds are also used to provide college scholarships to low-income students. The program supports fellowships to students pursuing terminal degrees in academic disciplines designated as areas of national need.

In 2019, the **U.S Patent and Trademark Office (USPTO)** in response to the Study of Underrepresented Classes Chasing Engineering and Science Success ([SUCCESS Act](#)) was required by Congress to identify publicly available data on women, minorities, and veterans and to provide legislative recommendations on how to encourage and increase participation by these groups as inventor-patentees and entrepreneurs. As part of this effort, the USPTO organized a National Council to help in the development of a national strategy to increase American Innovation. Innovation is inherent in STEM and in who becomes an inventor in America. The USPTO is striving to make the vital connection between STEM and innovation. For example; its annual [National Summer Teacher Institute](#) offers transdisciplinary professional development opportunities to support K-12 educators in fostering innovation and STEM through intellectual property creation and protection. USPTO builds innovation capacity through strategic partnerships: AAAS/NSF HBCU Making & Innovation Showcase training on intellectual property and invention education for students and faculty at Howard University, University

of Puerto Rico, and University of Houston/Texas Southern University, YMCA, FIRST Robotics, Center for Science and the Public, among others. In the recent past, USPTO joined forces with youth development and employment programs such as the Urban Alliance, to provide workforce training for underserved high school seniors. USPTO works with various affinity groups such as the Society for Hispanic Professional Engineers and the National Society of Black Engineers among others to build intellectual property literacy and make the connection between STEM, innovation, and its importance to building future innovators and entrepreneurs.

Key Area 3: Retention

Retention is a key issue for maintaining diversity and inclusion in STEM. Many factors can affect retention, including: a hostile institutional climate that is not aligned with policies that support diversity and inclusion; a lack of institutional commitment and accountability; and aggregation of categories of data, which can distort or impede understanding of critical factors that affect retention for different populations. Evidence-based practices to mitigate these factors are outlined below.

Alignment of Institutional Culture and Climate

Federal agencies can learn from practices and policies that academic institutions have implemented to create mutually supportive communities that foster a strong sense of belonging to increase retention.^{94,95,96,97,98,99,100}

- Implement confidential, third-party climate-assessment surveys and create an equity office that offers a ‘safe space’ for employees. Build critical mass to ensure employees do not feel isolated.^{101,102}
- Support the establishment of employee resource groups, new employee initiatives, virtual resource centers, and programs and policies that support career-life balance.¹⁰³

⁹⁴ Allen-Ramdial, S.A., and Campbell, A.G. (2014) Reimagining the Pipeline: Advancing STEM Diversity, Persistence, and Success *Bioscience* 64: 612–618.

⁹⁵ Charvat, L.J. (2009) Exemplary Practices in Equity and Diversity Programming *University of British Columbia – Vancouver*.

⁹⁶ Dewsbury, B. M. (2017) On faculty development of STEM inclusive teaching practices *FEMS Microbiology Letters* 364.

⁹⁷ Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., and Zavala, M. E. (2016) Improving underrepresented minority student persistence in STEM *CBE Life Sciences Education* 15.

⁹⁸ Killpack T. L. and Melón L.C. (2016) Toward inclusive STEM classrooms: what personal role do faculty play? *CBE Life Sciences Education* 15.

⁹⁹ National Research Council (2013) Seeking Solutions: Maximizing American Talent by Advancing Women of Color in Academia: Summary of a Conference *The National Academies Press*.

¹⁰⁰ Redding, C. (2019) A teacher like me: A review of the effect of student-teacher racial/ethnic matching on teacher perceptions of students and student academic and behavioral outcomes *Review of Educational Research* 89: 499-535.

¹⁰¹ Allen-Ramdial, S.A., and Campbell, A.G. (2014) Reimagining the Pipeline: Advancing STEM Diversity, Persistence, and Success *Bioscience* 64: 612–618.

¹⁰² Charvat, L.J. (2009) Exemplary Practices in Equity and Diversity Programming *University of British Columbia – Vancouver*.

¹⁰³ Turk-Bicakci, L. and Berger, A. (2014) Leaving STEM: STEM Ph.D. Holders in Non-STEM Careers *American Institutes for Research*.

- Implement diversity and equity training for professional development. Enable effective mentoring and coaching opportunities and develop specialized assistance for groups at risk for leaving the organization.^{104,105,106,107}
- Support programs that develop students' science efficacy, motivation, identity, and values, such as internships, fellowships, and undergraduate research experiences.¹⁰⁸

Institutional Commitment and Accountability

Incorporate “inclusion” in the institutional mission, core values, and strategies and coordinate strategic investments for inclusivity efforts and increase institutional accountability through data.¹⁰⁹

- Ensure that leadership consists of a diverse group of individuals with a range of experiences and thinking.^{110,111}
- Ideally, institutions should track hiring actions and separations with a number of demographic markers and monitor trends.^{112,113}
- Federal agencies should monitor the status and quality of STEM education programs to insure their efficacy. Improved federal data systems might allow tracking students' engagement across federal programs.¹¹⁴

Data Disaggregation and Intersectionality

To adequately understand the issues that impact retention, institutions must look at differences by population and STEM discipline as an important factor in implementing effective strategies for change.

- Data disaggregated by populations, geographical regions, and race/ethnicities is critical to STEM participation, identifying target populations, and capturing their unique characteristics.¹¹⁵

¹⁰⁴ Dewsbury, B. M. (2017) On faculty development of STEM inclusive teaching practices *FEMS Microbiology Letters* 364.

¹⁰⁵ Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., and Zavala, M. E. (2016) Improving underrepresented minority student persistence in stem *CBE Life Sciences Education* 15.

¹⁰⁶ National Research Council (2013) Seeking Solutions: Maximizing American Talent by Advancing Women of Color in Academia: Summary of a Conference *The National Academies Press*.

¹⁰⁷ Redding, C. (2019) A teacher like me: A review of the effect of student-teacher racial/ethnic matching on teacher perceptions of students and student academic and behavioral outcomes *Review of Educational Research* 89: 499-535.

¹⁰⁸ Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., and Zavala, M. E. (2016) Improving underrepresented minority student persistence in stem *CBE Life Sciences Education* 15.

¹⁰⁹ National Research Council (2013) Seeking Solutions: Maximizing American Talent by Advancing Women of Color in Academia: Summary of a Conference *The National Academies Press*.

¹¹⁰ Charvat, L.J. (2009) Exemplary Practices in Equity and Diversity Programming *University of British Columbia – Vancouver*.

¹¹¹ Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., and Zavala, M. E. (2016) Improving underrepresented minority student persistence in STEM *CBE Life Sciences Education* 15.

¹¹² National Academies of Sciences, Engineering, and Medicine (2018) Indicators for Monitoring Undergraduate STEM Education *The National Academies Press*.

¹¹³ Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., and Zavala, M. E. (2016) Improving underrepresented minority student persistence in stem *CBE Life Sciences Education* 15.

¹¹⁴ National Academies of Sciences, Engineering, and Medicine (2018) Indicators for Monitoring Undergraduate STEM Education *The National Academies Press*.

¹¹⁵ National Academy of Engineering (2012) Colloquy on Minority Males in Science, Technology, Engineering, and Mathematics *The National Academies Press*.

- Furthermore, data must be disaggregated by sex within race/ethnicity, disability, citizenship, and STEM discipline to understand the experiences at the intersection of different identities. Using disaggregated data should be a part of regular management practices at the organizational level; it should not be viewed as added work.¹¹⁶
- Evaluation studies with disaggregated data can help leaders set goals related to their duties and responsibilities and be more reflective about their decision-making processes.¹¹⁷

Examples:

In an effort to increase institutional commitment and accountability, all **NIH** [institutional research training grant](#) applications are required to address (a) plans for the recruitment of individuals from groups underrepresented in STEM and (b) the retention of appointed trainees. The Recruitment Plan to Enhance Diversity and Trainee Retention Plans in the application should provide a detailed plan for recruitment to enhance diversity and a plan to sustain the scientific interests as well as monitor the academic and research progress (i.e., retention) of trainees from all backgrounds within a program. Applicants may use the Program Plan section to expand upon the Trainee Retention Plan and to provide evidence of the program's commitment to ensuring the well-being and success of all trainees throughout their graduate training. Institutions submitting renewal applications are also required to report on their records in recruiting prospective participants from underrepresented groups and retaining appointed trainees.

The **Department of Defense's (DOD)** [LEGACY Program](#) is under the Wright-Patterson Air Force Base (WPAFB) Educational Outreach Office, which has a multitude of programs that support local schools. The program specifically focuses on students from underrepresented groups and in underserved schools and areas around all four AF installations. As students progress through the program, LEGACY staff keep in communication with families to check in and see if they need any support. The WPAFB Educational Outreach Office provides support through tutoring, mentoring, and resources to assist students with their coursework or project. One-on-one mentoring and support throughout the school year demonstrate to families that the Air Force is interested in and invested in students' well-being. The Wright-Patterson LEGACY also provides apprenticeship opportunities for students, where they can work on base with mentors and receive hands-on research experiences.

The **Department of Transportation (DOT)** has a [Human Capital Operating Plan](#) designed to improve, streamline, and enhance the effectiveness of the department's processes and maximize employee and organizational performance. Metrics are used to track onboarding for women, Latinos, persons with disabilities, and persons with targeted disabilities.

Key Area 4: Achievement and Advancement

In addressing diversity and inclusion in STEM, achievement and advancement are two distinct but related issues. The best practices for these issues, outlined below, create opportunity, support, and growth of an individual in their career. An important distinction is that while achievement can be related to individuals, the *opportunity for achievement* is systemic. There are systems that support, enable, encourage, and help people reach their career goals and systems that provide barriers and discourage individuals from reaching their career goals.

¹¹⁶ George, Y. S., and Malcolm, S. M. (2011) Measuring diversity: An evaluation guide for STEM graduate school leaders *American Association for the Advancement of Science*.

¹¹⁷ Ibid.

- **Achievement:** Achievements encompass accomplishments in a given field, project, or task, and can also include successful completion of academic coursework or degrees. The [National Assessment of Educational Progress](#) and the [Trends in International Mathematics and Science Study](#) equate achievement with performance.^{118,119}
- **Career Advancement:** “The upward progression of one’s career. An individual can advance by moving from an entry-level job to a management position within the same field, for instance, or from one occupation to another.” (<https://www.thebalancecareers.com/advancement-525653>).¹²⁰ Advancement includes promotion, as well as tenure for academic positions.

Establish clear guidelines for employee evaluation and promotion

Implicit bias can greatly influence workplace culture and impede opportunities for achievement or advancement.^{121,122,123}

- Ensure guidelines/criteria for employee evaluation and promotion are clearly established and reviewed before the review process (various sources, including Canada Research Board Chairs and McKinsey & Co Report).^{124,125}
- Consider the promotion of equity, diversity, and inclusion principles in an individual’s work as criteria for recognition, awards, etc. For example, provide credit to individuals who mentor and participate in service-related activities.¹²⁶
- Provide unconscious bias training to all employees, including those that participate in entry-level performance reviews (not just those that participate in senior-level reviews).¹²⁷

Develop robust systems of support

A lack of systems of support can negatively affect motivation, morale, and persistence, thus hindering achievement and advancement in the workplace (e.g., inexperienced leadership; lack of diverse mentors and colleagues; lack of professional development opportunities; workplace inflexibilities; and lack of open environments that foster communication or opportunities for giving and receiving feedback, etc.)

¹¹⁸ The National Assessment of Educational Progress (n.d.) A Common Measure of Student Achievement *IES NCES*.

¹¹⁹ Martin, Michael, Mullis, I.V.S, and Foy, P. (2017) TIMMS 2019 Assessment Frameworks *TIMSS & PIRLS International Study Center*.

¹²⁰ National Academies of Sciences, Engineering, and Medicine (2018) Engineering Societies' Activities in Promoting Diversity and Inclusion: Proceedings of a Workshop in Brief *The National Academies Press*.

¹²¹ Ibid.

¹²² “Barriers to advancement are no longer primarily a result of ‘bad apples’ who resist the inclusion of underrepresented minorities, said Cech. Instead, subtle beliefs and practices, such as microaggressions, cognitive biases, and cultural processes, create disadvantages that progressively accumulate. Furthermore, she reported that a plateauing in the percentage of women receiving bachelor’s degrees in science and engineering over the past two decades suggests that these beliefs and practices do not necessarily improve over time.”

¹²³ “The sociologist Lauren Rivera’s examination of interviews for elite positions, such as those in professional services firms, indicates that hobbies, particularly those associated with the rich, feature prominently as a selection criterion.” [Your Approach to Hiring is All Wrong](#) *Harvard Business Review*

¹²⁴ Booth, S. and Boudreau, M. (2018) Equity, Diversity and Inclusion Practices *Canada Research Chairs*.

¹²⁵ Huang, J., Krivkovich, A., Starikova, I., Yee, L., & Zanoschi, D. (2019) Women in the Workplace 2019 *McKinsey & Company*.

¹²⁶ Booth, S. and Boudreau, M. (2018) Equity, Diversity and Inclusion Practices *Canada Research Chairs*.

¹²⁷ Huang, J., Krivkovich, A., Starikova, I., Yee, L., & Zanoschi, D. (2019) Women in the Workplace 2019 *McKinsey & Company*.

- Develop a mentorship program where senior employees can serve as mentors to early career employees. Establish institution-wide rewards for effective mentorship, mentorship education, and a review system as part of the program.¹²⁸
- Intentionally encourage and establish sponsorship programs within the organization.¹²⁹
- Work with professional societies and employee resource groups and networks to advance individuals from underrepresented groups.^{130,131,132,133}
- Offer greater flexibility in the workplace (e.g., flexible hours) to support work/life balance and accommodate transitions.¹³⁴
- Conduct research on work/life balance, salary equity, and other conditions with employees who have left or are considering leaving.¹³⁵
- Create initiatives to support individuals from underrepresented groups, such as employee resource groups and professional development training.^{136,137,138}
- Recognize and reward individuals or institutions for their achievements and excellent work. Consider the promotion of equity, diversity, and inclusion principles in an individual's work as criteria for recognition, awards, etc.¹³⁹

Create ample opportunities and pathways for growth

Issues with hiring and limited opportunity pathways hinder professional growth.

- Create and offer opportunities for leadership and overall professional achievement, such as high-profile assignments, leadership training, sponsorship, and mentorship.^{140,141}
- Consistently use targets to guide hiring and promotions processes. Set a goal for getting more women and individuals from underrepresented groups into first-level management.¹⁴²

¹²⁸ National Academies of Sciences, Engineering, and Medicine (2019) *The Science of Effective Mentorship in STEM* *The National Academies Press*.

¹²⁹ Huang, J., Krivkovich, A., Starikova, I., Yee, L., & Zanoschi, D. (2019) *Women in the Workplace 2019* *McKinsey & Company*.

¹³⁰ Haydon, I., Herpoldt, K.-L., Hosseinzadeh, P., Kang, C., Kang, L.J., Montoni, N.P., & Tatum, W.K. (2018). Workforce diversity: Strategies for cultivating inclusion in research *eLife Sciences Magazine*.

¹³¹ National Academy of Engineering (2014) *Advancing Diversity in the US Industrial Science and Engineering Workforce: Summary of a Workshop* *The National Academies Press*.

¹³² National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2011) *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* *The National Academies Press*.

¹³³ National Academies of Sciences, Engineering, and Medicine (2019) *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce* *The National Academies Press*.

¹³⁴ National Academy of Engineering (2014) *Advancing Diversity in the US Industrial Science and Engineering Workforce: Summary of a Workshop* *The National Academies Press*.

¹³⁵ Huang, J., Krivkovich, A., Starikova, I., Yee, L., & Zanoschi, D. (2019) *Women in the Workplace 2019* *McKinsey & Company*.

¹³⁶ National Academy of Engineering (2014) *Advancing Diversity in the US Industrial Science and Engineering Workforce: Summary of a Workshop* *The National Academies Press*.

¹³⁷ National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2011) *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* *The National Academies Press*.

¹³⁸ National Academies of Sciences, Engineering, and Medicine (2019) *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce* *The National Academies Press*.

¹³⁹ Booth, S. and Boudreau, M. (2018) *Equity, Diversity and Inclusion Practices* *Canada Research Chairs*.

¹⁴⁰ Balakrishnan, A., Zuckerman, B.L., Acheson-Field, H., and Simon, I.D. (2018) *STEM Campus Climate: A Webinar of the Broadening Participation Interagency Working Group (BP IWG)* *IDA Science & Technology Policy Institute*.

¹⁴¹ Haydon, I., Herpoldt, K.-L., Hosseinzadeh, P., Kang, C., Kang, L.J., Montoni, N.P., & Tatum, W.K. (2018). Workforce diversity: Strategies for cultivating inclusion in research *eLife Sciences Magazine*.

¹⁴² Huang, J., Krivkovich, A., Starikova, I., Yee, L., & Zanoschi, D. (2019) *Women in the Workplace 2019* *McKinsey & Company*.

- Require a diverse pool/slate of candidates for hiring and promotions.¹⁴³

Examples:

National Institute of Standards and Technology (NIST) International and Academic Affairs Office (IAAO) implements several of the best practices outlined above to support inclusion in STEM through achievement and advancement, as well as retention. IAAO utilizes affinity groups and employee resource groups to raise awareness and expand networks for diversity and inclusion in STEM. For instance, the mission of the [Steering Group for Equity in Career Advancement](#) is to identify the causes of apparent inequities in **promotions at NIST for women and minority researchers** and make recommendations. The agency is also forming a diversity council to provide recommendations on retention, inclusion, achievement, and advancement. Likewise, in an effort to provide accountability and support for ongoing diversity and inclusion initiatives, NIST is in the process of hiring a Chief Diversity and Inclusion Officer.

The **NSF ADVANCE Program** focuses on addressing systemic barriers that impact the diversity, equity, and inclusion of diverse STEM faculty in academic teaching, research, and administrative positions in institutions of higher education. Systemic (or organizational) inequities may exist in areas such as policy and practice as well as in organizational culture and climate. For example, practices in academic departments that result in the inequitable allocation of service or teaching assignments may impede research productivity, delay advancement, and create a culture of differential treatment and rewards. Similarly, policies and procedures that do not mitigate implicit bias in hiring, tenure, and promotion decisions could lead to women and racial and ethnic minorities being evaluated less favorably, perpetuating historical under-participation in STEM academic careers, and contributing to an academic climate that is not inclusive. Further resources and research can be found through the [ADVANCE Resource and Coordination \(ARC\) Network](#), which seeks to achieve gender equity for faculty in higher education STEM disciplines.

Promising and Emerging Practices

In addition to evidence-based practices highlighted in the four key areas above, the group conducted a literature search to identify promising and emerging practices. While there were many sources for evidence-based practices, few sources highlighted promising and emerging practices. The issues addressed in this section include emerging hiring practices at agencies, promising interventions for closing the equal opportunity gaps in the Federal workforce, and suggestions for consistency in STEM leadership development programs across agencies.

Continuing efforts to improve employment outcomes for workers with disabilities

Key areas addressed: Access & Recruitment; Retention

Promising and emerging practices to increase the inclusion of individuals with disabilities in the workforce include:

- Reframing the challenge of recruitment and retention of individuals with disabilities as a marketing case, and using a strategic and tactical marketing framework, beginning with a segmentation of the employer based on their readiness to support diversity and inclusion. Findings show three distinct market segments in the private employer base—Choir, the Inclusive,

¹⁴³ Ibid.

and the Uninitiated. Choir is defined as “Companies with existing programs and a culture that supports the hiring and advancement of people with disabilities.” Inclusive companies are “companies that support a diverse workforce, but do not explicitly include people with disabilities in their initiatives.” Finally, uninitiated companies have not introduced any programs or initiatives to include people with disabilities.¹⁴⁴

- o Consider collaborating with the Small Business Administration to develop resources to encourage companies below the Fortune 1000 level to apply tactical strategies identified in the Employer Engagement Strategy Marketing Framework.
- o Marketing framework strategies may include: Adjusting Communications (e.g., Use visual communication, when appropriate, to signal cultural change); Engaging the Organization (e.g., Recognize and reward vendors that support advancement of people with disabilities); and Creating a Roadmap
- Forming strategic partnerships and working with offices/institutions that serve people with disabilities. Consider reaching out to potential veteran participants and contributors through veteran organizations.¹⁴⁵
 - **Example:** In 2019 the **National Science Foundation (NSF)** funded [traineeships](#) to support the re-entry of women and women veterans into the STEM workforce through NSF INCLUDES. These traineeships were partially funded by The Boeing Company as part of its Women Make Us Better and Women in Leadership Initiatives. The traineeships focus on providing training and professional development—including mentorship and leadership development—and offering internships and research experiences. Fields of study include applied sciences, skilled trades, and modern technologies and subject areas such as advanced manufacturing, agriculture, computer and information science, energy, engineering, geospatial sciences, micro- and nanotechnology, and safety and security. The women supported through these traineeships are pursuing their STEM dreams at different points in their careers and several have been featured in the NSF INCLUDES National Network [blog](#).
 - **Example:** The **U.S. Geological Survey (USGS)** developed a job-training program for young adults with cognitive disabilities in partnership with school districts and public programs that train disabled adults. The result has been experience, job growth, and employment for the participants and the advancement of USGS science for the bureau.
 - **Example:** In December 2020, the **National Geospatial-Intelligence Agency** under the **Department of Defense** launched the [Neurodiverse Federal Workforce pilot program](#) to increase opportunities for neurodiverse individuals in geospatial and imagery analysis roles. The pilot – a collaborative effort with MITRE, a non-profit R&D company – is a six-month internship program that also provides an intensive one-week training and interview workshop. The pilot originated as a result of the Office of Management and Budget and General Service Administration’s Government Effectiveness Advanced Research Center Challenge - a competition to solicit proposals to solve the Federal government’s toughest management problems while collaborating with the private sector, academia, and the public.
- Recruiting individuals with disabilities onto advisory boards and leadership teams.¹⁴⁶

¹⁴⁴ EMPLOYER ENGAGEMENT STRATEGY’s Office of Disability Employment Policy Contract Number: DOLU139434942 Period of Performance: September 30, 2013 – September 29, 2014 FINAL REPORT (2015) *Department of Labor*.

¹⁴⁵ Bellman, S., Burgstahler, S., & Chudler, E. H. (2018). Broadening Participation by Including More Individuals With Disabilities in STEM: Promising Practices from an Engineering Research Center. *American Behavioral Scientist* 62: 645–656.

¹⁴⁶ Ibid.

- Sending staff to disability-related conferences.¹⁴⁷
- Applying universal design strategies in all areas of work (products and environments) to increase accessibility.¹⁴⁸
 - **Example:** Consider utilizing any of the following resources: The DO-IT (Disabilities, Opportunities, Internetworking, and Technology) Center has developed numerous resources to promote universal design in science and engineering, including the [Center for Universal Design in Education](#), [Equal Access: Universal Design of Engineering Departments](#), and [Equal Access: Universal Design of Engineering Labs](#).

Establishing consistency in use of telework authority across the Federal agencies

Key areas addressed: Access & Recruitment; Retention

Prior to the COVID-19 pandemic, there was a lack of consistency in the use of telework authority across Federal agencies. Federal telework programs are established primarily to meet agency mission and operational needs. Telework saves financial resources by helping Federal agencies reduce real estate and energy costs and promote management efficiencies and makes agencies more resilient in severe weather and other emergencies. It is a promising and emerging practice for inclusion, as telework can improve the quality of employee work-life balance and increase employment opportunities for persons with disabilities.¹⁴⁹

- **Example:** Feedback from Federal agencies on successful use of maximum telework during COVID-19 stay at home orders.

Expanding and Reevaluating Traditional Recruitment and Retention Efforts

Key areas addressed: Access & Recruitment; Retention

Hiring the right talent to advance the mission of the organization is the number one priority for employers. According to the Census and Bureau of Labor Statistics, 95% of hiring is done to fill existing positions. Most vacancies are a result of turnover due to a lack of opportunities for advancement internally and results in external hiring (retention as a key issue).¹⁵⁰

Barriers to hiring into the Federal workforce are well documented, most recently in the final report of the National Commission on Military, National and Public Service.^{151,152} The Commission reported that Federal agencies have over 100 different hiring authorities. Only 25 percent of positions are filled using the competitive Civil Service system and more than 50 percent of job announcements do not result in a hiring action. As reported in the FY2020 President's Budget request, new hires of student interns fell from 35,000 in 2010 to 4,000 in 2018 (2010 is the year the Pathways program replaced other more flexible student authorities). To address barriers to Federal jobs: reform the hiring process by providing

¹⁴⁷ Ibid.

¹⁴⁸ Ibid.

¹⁴⁹ Guide to Telework in the Federal Government (2011) *United States Office of Personnel Management*.

¹⁵⁰ Cappelli, P. (2019) Hiring-Recruiting: Your Approach to Hiring is All Wrong *Harvard Business Review*

¹⁵¹ National Commission on Military, National, and Public Service (2020) Inspired to Serve: The Final Report of the National Commission on Military, National, and Public Service *National Commission on Military, National, and Public Service*.

¹⁵² Edwards, K.A., McColleston, M., Phillips, B., Acheson-Field, ., Leamon, I., Johnson, N., and Lytell, M.C. (2021) Compensation and Benefits for Science, Technology, Engineering, and Mathematics (STEM) Workers: A Comparison of the Federal Government and the Private Sector *Rand*.

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agencies greater flexibility to recruit and select candidates; and expand noncompetitive hiring, especially for Federal scholarship and fellowship recipients.

Innovative and inclusive hiring practices for STEM employers to consider include:

- Requiring that all postings be posted internally and track the percentage of hires from within
- Designing jobs with realistic requirements. Consider whether a job truly requires “10 years of experience.” Unrealistic requirements can deter potential hires from applying.
- Using a diverse team to evaluate job announcements for potentially unconscious biased language that would dissuade females or other underrepresented groups to apply.¹⁵³
- Updating the recruitment and interview process. Implicit and explicit biases most often play a role during the interview process. Consider the ways in which interviewing protocols can lend themselves to biases and can be changed to be more inclusive (see the “Access & Recruitment” section above for further examples).
- Developing more flexible hiring authorities to remove barriers to Federal hiring, particularly for students participating in Federal scholarship and fellowship programs.
- Providing assistance in the job application process

Examples:

[NASA’s HBCU/MSI Technology Infusion Road Tour](#) is an example of a **promising practice** to support broadening participation in STEM. Led by NASA’s Office of STEM Engagement, the NASA Technology Infusion Road Tour is a multi-day forum allowing Minority Serving Institutions the opportunity to collaborate with members of NASA’s Offices Small Business Programs, STEM Engagement, the Space Technology Mission Directorate, and NASA’s prime contractors, including Boeing and Lockheed Martin. In addition, leaders from NASA mission directorates share opportunities available in respective organizations. Hosted on an MSI campus, representatives from various MSIs showcase their research capabilities with the long-term goal of gaining access to funding through more lucrative Federal contracts. Networking activities include tours of the host MSI research facilities and a match-making session, allowing for direct interaction between MSIs and representatives from NASA, prime contractors, and other invited Federal agencies. NASA is the only Federal agency with a 1% goal for contracts with MSIs. In calendar year 2019, NASA Technology Infusion Road Tour events were held at Tuskegee University, New Mexico State University, and the University of Puerto Rico, Rio Piedras.

The **Food and Drug Administration (FDA)** is actively working to [recruit](#) and retain underrepresented minorities in STEM positions. The agency is accomplishing this through:

- Evaluating and revamping the Diversity and Inclusion Strategic Plan, specifically outreach and recruitment efforts
- Expanding outreach and recruitment by actively seeking out partnerships with organizations that target individuals from underrepresented racial and ethnic groups in STEM
- Participating in specific events with Historically Black Colleges and Universities and other Minority Serving Institutions, including conferences

Additionally, the FDA supports potential candidates by providing information about the work that FDA is accomplishing and assisting with navigating employment opportunities.

¹⁵³ Gaucher, D., Friesen, J., and Kay, A.C. (2011) Job advertisements that use masculine wording are less appealing to women. *Journal of Personality and Social Psychology* 101:109-128.

Developing Leadership in the STEM Workforce

Key areas addressed: Retention; Achievement & Advancement

Retention of an inclusive Federal workforce is dependent upon the opportunities provided for advancement. There is a **need** for effective and diverse leadership at all levels of the Federal STEM workforce. Federal leadership development programs provide employees with opportunities for development.¹⁵⁴ Federal employers should consider career-long training that enlightens employees and strengthens their skills to enable high performance, retention, and effective leadership.¹⁵⁵

- **Example:** The Excellence in Government Fellows Program, for instance, is a year-long program that strengthens the leadership skills of GS-14 and GS-15 Federal career employees through a proven combination of innovative coursework, best practices benchmarking, challenging action-learning projects, executive coaching, and government-wide networking.

Continuing to increase the representation of women in STEM

Key areas addressed: Access & Recruitment; Retention; Achievement & Advancement

The Interagency Policy Group on Increasing Diversity in the STEM Workforce identified several promising practices, such as developing and utilizing diversity toolkits, and emerging practices, such as unconscious bias training for search committees and hiring and promotions safeguards. A key recommendation from that group is that each Federal agency should exercise leadership at all levels in increasing representation of women.^{156,157}

- **Example:** To address gender equity within the agency, NIH implemented evidence-based interventions as well as promising practices. Evidence-based interventions include providing resources on mentoring, retention, and career advancement; leadership development; training opportunities; work-life integration; and helping to connect students and career professionals with professional societies that promote their interests.¹⁵⁸ In 2019, NIH also published the “[NIH Scientific Diversity Toolkit](#),” which institutions and agencies can use to help advance their own diversity and inclusion practices.

¹⁵⁴ Services for Agencies: Federal Leadership Development Programs (n.d.) *United States Office of Personnel Management*.

¹⁵⁵ Policy, Data, Oversight (n.d.) Training and Development *Office of Personnel Management*.

¹⁵⁶ National Academies of Sciences, Engineering, and Medicine (2020) Evidence-Based Interventions for Addressing the Underrepresentation of Women in Science, Engineering, Mathematics, and Medicine: Proceedings of a Symposium—in Brief *The National Academies Press*.

¹⁵⁷ Interagency Policy Group on Increasing Diversity in the STEM Workforce by Reducing the Impact of Bias (2016) Reducing the Impact of Bias in the STEM Workforce: Strengthening Excellent and Innovation *Office of Science and Technology Policy, Office of Personnel Management*.

¹⁵⁸ National Academies of Sciences, Engineering, and Medicine (2020) Evidence-Based Interventions for Addressing the Underrepresentation of Women in Science, Engineering, Mathematics, and Medicine: Proceedings of a Symposium—in Brief *The National Academies Press*.

Best Practices Solicitation Results Overview

The data reported on in this section was derived from a Best Practices Solicitation (information request) from FC-STEM Interagency Working Groups to FC-STEM agencies, collected in August 2020. Data was provided by 16 FC-STEM agencies. Some agencies provided more than one response, on behalf of a different office, branch, or directorate within the agency.

The IWGIS request was phrased as follows:

The Interagency Working Group on Inclusion in STEM (IWGIS) would like for you to address the following two questions:

- a. What are the best practices utilized by your organization to increase the retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? Please provide specific examples or evidence that supports this best practice.
- b. If you could implement one policy or practice that would drive positive change for diversity and inclusion in STEM, what would it be?

All responses from the solicitation are documented in Appendix 1. Below are the top 5 best practices for diversity and inclusion in STEM currently used by Federal agencies, as well as the top 5 policies and practices recommended by Federal agencies to drive positive change for diversity and inclusion in STEM.

Top 5 Best Practices for Diversity and Inclusion in STEM Currently Used by Federal Agencies

- Cultivate partnerships and collaborations
- Engage Minority Serving Institutions as equal partners with Federal agencies
- Provide authentic and culturally relevant STEM engagement and research experiences for youth and interns
- Develop and retain promising personnel through effective mentorship
- Conduct targeted outreach through clubs, conferences, and organizations

Top 5 Policies and Practices for Diversity and Inclusion in STEM Recommended by Federal Agencies

- Develop a Human Capital Operating Plan that includes inclusive hiring strategies, focuses on retention, and assures equal access to advancement
- Develop explicit strategies for diversity and inclusion with measurable goals and hold leadership and employees accountable
- Align diversity and inclusion goals with agency and organizational mission and goals
- Establish monitoring and assessment systems to measure progress toward goals
- Provide consistent and sufficient funding for diversity, equity, and inclusion initiatives, including opportunities for individuals from groups underrepresented in STEM

Recommendations

Based on the compendium of practices in this document, the Interagency Working Group on Inclusion in STEM developed the following policy recommendations to help increase the recruitment, retention, achievement, and advancement of individuals from groups that are underrepresented in the Federal STEM workforce and STEM programs in institutions of higher education that receive Federal funding.

Definitions

- ✓ Use the definitions of evidence-based, emerging, and promising practices to help explain the levels of best practices that are adopted by each agency. These definitions will clarify what works and why a practice is adopted for a specific group, while also substantiating expectations of effectiveness.

Barriers to Participation in STEM Programs and Pathways

- ✓ Identify barriers to access and participation in STEM programs offered by each agency and develop strategies to reduce or eliminate them by partnering with other agencies, institutions, and professional organizations. Create a comprehensive plan to highlight and address, by providing incentives for participants and grantees to demonstrate progress.
- ✓ Focus on one or more institutional barriers to STEM such as policies, workplace climate, differential compensation package, data, and peer-to-peer interactions. Require program participants and grant recipients to spell out how they will reduce or eliminate institutional barriers to diversity in STEM.
- ✓ Focus on one or more individualized barriers to participation in STEM such as mentoring, support systems, discrimination, perception of STEM programs, stereotypes and stereotype threat, bias, and STEM identity. Design programs to address these elements and constructs that impact students' participation and retention in STEM.
- ✓ Focus on one or more barrier impacting STEM participation for individuals with disabilities. Develop policies and practices to ensure representation of individuals with disabilities in leadership and decision-making bodies to ensure that accessibility, recruitment and retention issues are addressed.

Key Areas for Diversity and Inclusion

- ✓ Develop a pathways approach to STEM academic and career programs at each agency. Allow for flexibility with multiple entry points that enable participants to build on academic achievement and research expertise at different levels and life stages.
- ✓ Identify barriers to access and participation in STEM programs offered by each agency and develop strategies to reduce or eliminate them by partnering with other agencies, institutions, and professional organizations.
- ✓ Expand recruitment for Federal jobs, work-based learning opportunities, scholarships and fellowships at Minority-Serving Institutions and institutions with high levels of diversity through face-to-face and virtual outreach efforts. Create authority for Federal scholars and fellows to be hired noncompetitively into Federal service.
- ✓ Set goals for outcomes and measurable impacts related to recruitment and retention efforts for employment to increase diversity of the STEM workforce.
- ✓ Provide opportunities for leadership training and skills development that will support professional advancement. Create a plan for leadership and advancement that addresses barriers impacting groups underrepresented in STEM. Take advantage of existing Federal programs or create leadership development efforts at each agency to support diversity efforts.

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- ✓ Provide unconscious bias training for existing managers to raise awareness of how implicit bias can impact performance reviews, hiring, promotion, and access to training and leadership opportunities.
- ✓ Use existing hiring authorities to diversify the Federal STEM workforce at all levels.
- ✓ Develop more flexible hiring pay authorities, particularly for entry level positions.
- ✓ Create authority for Federal scholars and fellows to be hired noncompetitively into Federal service.

Promising and Emerging Practices

- ✓ Adopt or adapt promising and emerging practices to address recruitment, retention, and access challenges.
- ✓ Develop or expand work/life balance efforts.
- ✓ Create a plan for leadership and advancement that addresses barriers impacting groups underrepresented in STEM.

Conclusion

The full benefits of the Nation's STEM enterprise will not be realized until all Americans have lifelong access to high-quality STEM education. While improvements in the participation of individuals in underrepresented racial and ethnic groups in STEM have been made, the STEM enterprise continues to face the same diversity, equity, and inclusion challenges that are present in society. This document provides a summary of best practices for Federal agencies as they implement strategies to promote diversity and inclusion in the STEM workforce.

Appendix 1: Best Practices Solicitation Results

The data in this section was derived from a Best Practices Solicitation (information request) from FC-STEM Interagency Working Groups to FC-STEM agencies, collected in August 2020. Data was provided by 16 FC-STEM agencies. Some agencies provided more than one response, on behalf of a different office, branch, or directorate within the agency.

The IWGIS request was phrased as follows:

The Interagency Working Group on Inclusion in STEM (IWGIS) would like for you to address the following two questions:

- a. What are the best practices utilized by your organization to increase the retention, inclusion, achievement, or advancement of individuals from groups that are underrepresented and underserved in STEM? Please provide specific examples or evidence that supports this best practice.
- b. If you could implement one policy or practice that would drive positive change for diversity and inclusion in STEM, what would it be?

Tables 1 and 2 below capture agency responses to questions a and b above, respectively. The numbers for each line denote the number of total mentions of any given best practice. Please note that one agency may have provided more than one best practice. Agencies used different terms when submitting their responses. To the extent possible, the tables below capture original wording in responses to ensure accuracy of interpretation.

Table 3 below captures the specific best practice program names provided by agencies in response to question a above.

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Table 1. Best Practices currently utilized by Agencies to Increase Retention, Inclusion, Achievement, and Advancement of Individuals from Groups Historically Underrepresented in STEM

Partnerships / Collaborations	15
Minority Serving Institutions (involvement and outreach)	14
Authentic STEM Engagement / Research	9
Alignment of Diversity and Inclusion Goals with Organization Mission and Goals	8
Targeted Outreach (clubs, conferences, organizations)	8
Targeted Recruitment	7
Mentoring (including early career and peer-to-peer)	7
Model Adaptability (including transfer and articulation)	7
Internships	6
Technical Assistance (including in applications and employment)	6
Pathways to STEM Careers (including bridge and dual-credit programs)	6
Professional Engagement / Development	6
Scholarships	5
Affinity / Employee Resource Groups and Engagement	5
Apprenticeships / Traineeships	5
Targeted Funding Opportunities for Underrepresented Groups	5
Program Monitoring and Assessment	5
Explicit Goal for Participation of Underrepresented Groups	5
Data-driven Evaluation Research	4
Community Colleges	3
Industry / Small Business Involvement	3
Required Reporting (accountability)	3
Human Capital Operating Plan / Hiring Strategies (including hiring authorities)	3
Leverage Resources	3
Cooperative Agreements (accountability)	3
Solicitation-specific Review Criteria	3
Financial Assistance	2
Fellowships	2
Work-based Learning Programs	2
Academic Support	2
Community Colleges	2
Training Grants	2
Tracking Student Progress (including performance metrics)	2
Explicit Strategy to Hold Leadership and Employees Accountable	2
Integration of Social and Academic Environments and Development of Self-efficacy	1
Additional Development Opportunities	1
Blind Review of Applications	1
Relationships	1
Training and Onboarding of Partner Campuses	1
Direct Investment to Minority Serving Institutions	1
Steering Group for Equity in Career Advancement	1
Databases	1
Onboarding Metrics	1
Defining Key Terms (underrepresented, underserved, diversity, inclusion)	1
Quality Curriculum Aligned with STEM 5-Year Strategic Plan	1
Provide Support to Change Institutional Practices and Culture	1
Explicit Goal for Contracts with Minority Serving Institutions	1
Leadership Commitment	1

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Table 2. Policies or Practices Recommended by Agencies to Drive Positive Change for Diversity and Inclusion in STEM

Human Capital Operating Plan / Hiring Strategies (including hiring authorities)	6
Explicit Strategy to Hold Leadership and Employees Accountable	5
Alignment of Diversity and Inclusion goals with Organization Mission and Goals	4
Program Monitoring and Assessment	4
Targeted Recruitment Professionally and Academically for Underrepresented Groups	3
Awareness and Access for Underserved Communities	3
Partnerships / Collaborations	3
Consistent Targeted Funding Opportunities for Persons of Underrepresented Groups	3
Data-driven Evaluation Research	3
K-12 Emphasis	2
Community (including belonging and connection)	2
Pathways to STEM Careers (including jobs, bridge, and dual-credit programs)	2
Mentoring (including early career and peer-to-peer)	2
Leadership Development for Professionals from Underrepresented Groups at the Executive Level	2
Unconscious Bias and Racism Training	2
Transparent Processes	2
Representation of Diverse Workforce at all Levels	2
Explicit Goal for Participation of Underrepresented Groups	2
Leadership Commitment and Buy-in	2
Create Programs that Identify and Address Systemic Barriers within STEM Teaching and Research Organizations and other STEM Workplaces	2
Scholarships	1
Financial Assistance	1
Accessibility to Educational Resources (including computer and internet)	1
Break-down the Barriers between K-12 and Postsecondary Education	1
Incorporate Student Voice in Development and Implementation of Federal Broadening Participation Initiatives	1
De-stigmatize Career and Technical Education	1
Minority Serving Institutions (involvement and outreach)	1
Targeted Outreach (clubs, conferences, organizations)	1
Professional Engagement / Development	1
Career Advocacy / Sponsorship	1
Learning Agenda	1
Create a Student-centered Data Collection Effort	1
Diversity Metric Goals	1
Diversity and Inclusion Office or POC in all Professional Workforce Organizations	1
Re-prioritize the focus on “economic success” or “economic independence”	1
Leverage Resources	1
Create a report card for Equity, Diversity, and Inclusion where Agencies Demonstrate Improvements toward Benchmarks	1
Authentic STEM Engagement / Research	1

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Table 3. Examples of Best Practice Programs Provided by Agencies

Agency	Office/Directorate/Branch	Program Name
VA		Edith Nourse Rogers STEM Scholarship
NOAA	Office of Education	Jose E. Serrano Educational Partnership Program
NASA	Office of STEM Engagement	NASA Minority University Research and Education Project (MUREP)
		NASA Community College Aerospace Scholars (NCAS)
		NASA National Space Grant College and Fellowship Project
		NASA Technology Infusion Road Tour
DOL	Employment and Training Administration	Industry Intermediaries to Expand Registered Apprenticeship Programs
		TechHire Partnership Grants
		STEM Early College Expansion Partnerships
		Trade Adjustment Assistance Community College and Career Training (TAACCCT) Grant
ED	OPEPD	TRIO Program
		Upward Bound Math and Science Program
		Hispanic-Serving Institutions STEM (HSI STEM) and Articulation Program
		Minority Science & Engineering Improvement Program (MSEIP)
		GEAR-UP Program
		STEM Innovation for Inclusion in Early Education (STEMIE) Center
DOD	OASD/M&RA (RI)	DOD STARBASE
DOD	OSD SMART Program	DOD SMART Program
DOD	Air Force AFRL/EN	DOD LEGACY Program
NSF	EHR (HRD)	LSAMP
NSF	EHR (HRD)	CREST
NSF	EHR (HRD)	HBCU-UP
NSF	EHR (HRD)	TCUP
NSF	EHR (HRD)	ADVANCE
NSF	GEO	Significant Opportunities in Atmospheric Research and Science (SOARS)
		REU Program in Geoscience
		U.S. Academic Research Fleet (ARF)
NSF	EHR (DUE)	S-STEM Program
NSF	EHR (HRD)/AGEP Program)	AGEP
NSF	EHR (DGE)	National Science Foundation Research Trainee (NRT) Program
		Innovations in Graduate Education (IGE) Program
		CyberCorps Scholarships for Service (CyberCorps SFS)
NSF	CISE	CSfor All Program
		BPC Alliances
		STARS Leadership Corps Program
USDA	Chief Scientist	USDA Pathways Programs
		Forest Service Resource Assistants Program (RAP)
		U.S. Youth Conservation Corps (YCC)
		21st Century Conservation Service Corps (21CSC)
DOE	Oak Ridge Institute for Science and Education	Historically Black Colleges/Universities/Minority Serving Institution Council
DOE	Pacific Northwest National Laboratory	Bridging Opportunities for Leadership and Training in STEM (BOLTS) Program
		Young Women in Science (YWIS) Program
		Student Research Apprenticeship Program (SRAP)
		Diversity Internship for DTRA (DID) Program
		Department of Energy Office of Environmental Management (DOE-EM) Minority
		Serving Institutions Partnership Program (MSIPP)
DOE	Thomas Jefferson National Accelerator Facility	Becoming Enthusiastic About Math and Science (BEAMS)

Appendix 2: Examples of Agency Operationalizations of the Terms “Underrepresented” and “Underserved”***Department of the Interior (DOI)***

The agency does not have an operationalized definition of “underrepresented” “diversity” or “inclusion.” However, in common usage in DOI programs, “underrepresented” is used for personnel to refer almost exclusively to gender, ethnicity, or race, and to mean at a level lower than the US population. “Diversity” is largely undefined. At USGS, our Diversity and Equal Opportunity Office defines diversity as underrepresented groups, women, and persons with disabilities. Inclusion is just beginning to be discussed, mostly in the context of workplace culture. DOI is implementing bystander training and generational sensitivity training to begin to tackle inclusion.

Department of Education (ED)

The Department of Education does not have a specific way it operationalizes the term “underrepresented” and it would generally be up to the individual programs or authorizing legislation to indicate what this means in a specific context. The Department often uses terms like underrepresented minorities as an informal term to include African Americans, Hispanics/Latinos, Native Americans, and Asian/Pacific Islanders. Underrepresented might also reference children with disabilities, special education students, low-income children or families (sometimes this becomes students who qualify for free/reduced price lunch), women, or English language learners. Increasingly, there are attempts to ensure the representation of rural students and schools as well.

The Department also uses the term somewhat interchangeably with references to disadvantaged (which could mean low-performing or economically disadvantaged), underserved, “high need” students, or students “at risk.”

The Every Student Succeeds Act (ESSA) requires states to collect and report data on student “subgroups” including: economically disadvantaged students; students from each major racial/ethnic group; children with disabilities as defined under IDEA; and English learners.

Language from ED’s Institute of Education Sciences (IES) Training Programs: IES encourages recruitment of fellows from groups underrepresented in education research (for example, racial/ethnic minorities, first in their families to graduate college, veterans, individuals from low-income backgrounds, and individuals with disabilities). IES usage of underrepresented/underserved: English learners, free or reduced lunch recipients (low-income families), and Hispanic and Black students.

Food and Drug Administration (FDA)

FDA operationalizes “underrepresented” as the NIH does at <https://www.edi.nih.gov/data/demographics>

National Aeronautics and Space Administration (NASA)

NASA Office of STEM Engagement (OSTEM) assessed its “diversity” Performance Goal (PG) and Annual Performance Indicator (API) highlighted below which included:

- Analysis of historical performance data to determine overall performance of NASA’s OSTEM Higher Education investments (internships, fellowships and other student engagement opportunities) in achieving the PG and API
- Literature Review and Benchmarking other Federal Agencies
- Convened experts to review assessment findings and develop recommendations for future diversity metrics (Expert Panel Review - ERP)

The assessment noted that although NASA OSTEM has achieved this goal historically, the trend analysis indicated no significant change in closing the gap of any diversity category (flat). Additionally, the Expert Review Panel recommended keeping this PG and API but to further explore this topic. In FY2020, NASA OSTEM is conducting a “Diversity Deep Dive” study to evaluate “How have NASA STEM Engagement investments broadened participation of historically underrepresented and underserved groups in STEM fields in NASA STEM Engagement activities?” and annually we assess NASA OSTEM performance in achieving PGs and APIs and determine if they need to be enhanced or retired.

Performance Goal (PG) 3.3.3: Provide opportunities for students, especially those underrepresented in STEM fields to engage with NASA’s aeronautics, space, and science people, content, and facilities in support of a diverse future NASA and aerospace industry workforce.	Annual Performance Indicator (API)/Success Criteria: Meet or exceed the national average in two of the four categories of student diversity for NASA STEM enrollees in internships, fellowships, or other student engagement opportunities. Diversity Categories: (1) students across all institutional categories and levels (as defined by the U.S. Department of Education), (2) racially or ethnically underrepresented students (Hispanics and Latinos, African Americans, American Indians, Alaska Native, Native Hawaiians and Pacific Islanders), (3) women, and (4) persons with disabilities at percentages that meet or exceed national averages for science and engineering enrollees, as determined by the most recent, publicly available data from the U.S. Department of Education’s National Center for Education Statistics.
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National Institutes of Health (NIH)

NIH encourages institutions to diversify their student and faculty populations to enhance the participation of individuals from groups identified as underrepresented in the biomedical, clinical, behavioral, and social sciences, such as:

- Individuals from racial and ethnic groups that have been shown by the National Science Foundation to be underrepresented in health-related sciences on a national basis (visit [nsf.gov](https://www.nsf.gov) to see [data](#) and the report “[Women, Minorities, and Persons with Disabilities in Science and Engineering](#)”). The following racial and ethnic groups have been shown to be underrepresented in biomedical research: Blacks or African Americans, Hispanics or Latinos, American Indians or Alaska Natives, Native Hawaiians, and other Pacific Islanders. In addition, it is recognized that underrepresentation can vary from setting to setting; individuals from racial or ethnic groups that can be demonstrated convincingly to be underrepresented by the

grantee institution should be encouraged to participate in NIH programs to enhance diversity. For more information on racial and ethnic categories and definitions, see the [OMB Revisions to the Standards for Classification of Federal Data on Race and Ethnicity](#).

- Individuals with disabilities, who are defined as those with a physical or mental impairment that substantially limits one or more major life activities, as described in the [Americans with Disabilities Act of 1990, as amended](#). See NSF data [here](#).

Individuals from disadvantaged backgrounds, defined as those who meet two or more of the following criteria:

- Were or currently are homeless, as defined by the McKinney-Vento Homeless Assistance Act (Definition: <https://nche.ed.gov/mckinney-vento/>);
- Were or currently are in the foster care system, as defined by the Administration for Children and Families (Definition: <https://www.acf.hhs.gov/cb/focus-areas/foster-care/>);
- Were eligible for the Federal Free and Reduced Lunch Program for two or more years (Definition: <https://www.fns.usda.gov/school-meals/income-eligibility-guidelines/>);
- Have/had no parents or legal guardians who completed a bachelor's degree (see <https://nces.ed.gov/pubs2018/2018009.pdf>);
- Were or currently are eligible for Federal Pell grants (Definition: <https://www2.ed.gov/programs/fpg/eligibility.html>);
- Received support from the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) as a parent or child (Definition: <https://www.fns.usda.gov/wic/wic-eligibility-requirements/>).
- Grew up in one of the following areas: a) a U.S. rural area, as designated by the Health Resources and Services Administration (HRSA) [Rural Health Grants Eligibility Analyzer](#), or b) a [Centers for Medicare and Medicaid Services-designated Low-Income and Health Professional Shortage Areas](#) (qualifying zip codes are included in the file). Only one of the two possibilities listed can be used as a criterion for the disadvantaged background definition.

Students from low socioeconomic status (SES) backgrounds have been shown to obtain bachelor's and advanced degrees at significantly lower rates than students from middle and high SES groups (see https://nces.ed.gov/programs/coe/indicator_tva.asp), and are subsequently less likely to be represented in biomedical research. For background see Department of Education data at, <https://nces.ed.gov/>; https://nces.ed.gov/programs/coe/indicator_tva.asp; <https://www2.ed.gov/r schstat/research/pubs/advancing-diversity-inclusion.pdf>.

Literature shows that women from the above backgrounds face particular challenges at the graduate level and beyond in scientific fields. (See, e.g., "[From the NIH: A Systems Approach to Increasing the Diversity of Biomedical Research Workforce](#)")

Appendix 3: IWGIS Academic Discussion on Language and Use of the Term “Underrepresented Groups”

The IWGIS also held scholarly conversations to examine the use of inclusive language, specifically, the use of the phrase “underrepresented groups” to better understand how race and ethnicity are depicted in publications and the media. Below is a brief summary of our findings and some general recommendations that will be incorporated into IWGIS documents.

Summary of Findings

- The STEM education community has attempted to move away from deficit language in education (*economically disadvantaged, at-risk, vulnerable, high crime, urban*)
- Language referring to groups that are underrepresented is also evolving.¹⁵⁹
- Consequently, there is no uniform agreement about what terms to use
 - o Scholarly literature uses *underrepresented groups* to refer to numbers related to the representation in the STEM workforce; it not intended to be derogatory. This term is used in international literature as well.¹⁶⁰
 - o *Underrepresented groups* is preferable to “underrepresented minorities” or “historically underrepresented”¹⁶¹; the latter infers that that parity has been achieved when it has not
 - o Scholarly literature does not typically use “people of color”; the US Commission on Civil Rights also refrains from using umbrella terms like this because they hide individual groups; instead, they promote a people-first approach
 - o Government reports use the term *racial and ethnic minorities*
 - o The term *minority* or *minorities* places a value judgment and infers that those labeled as minority are ‘less than’.¹⁶²
 - o The term “*underrepresented*” is primarily interpreted to refer to African Americans and Hispanics and therefore overlooks or reduces the importance of the other racial and ethnic groups that are underrepresented in STEM
 - o Professional organizations use underrepresented as well: NOBCCHE.org, [APS](http://APS.org), National Academies of Science, Engineering and Medicine ([Diversity, Equity and Inclusion](http://DiversityEquityandInclusion.org) reports; although recent reports refer to the “underrepresentation of” specific groups).

Options/Possible Recommendations

- Be more sensitive when referring to underrepresentation in STEM
- Underrepresented is a relative term and the context should be clearly defined – underrepresented with respect to what?

¹⁵⁹ Castania, K. (2003) *The Evolving Language of Diversity Cornell Cooperative Extension*.

¹⁶⁰ Pearson, W. and Fechter, W. (1994) *Who will do science? Educating the next generation Johns Hopkins University Press*.

¹⁶¹ Mukherji, B.R., Neuwirth, L.S., & Limonic, L. (2017) *Making the Case for Real Diversity: Redefining Underrepresented Minority Students in Public Universities SAGE 7*.

¹⁶² Castania, K. (2003) *The Evolving Language of Diversity Cornell Cooperative Extension*.

- Recognize that there are differences between language used in lay publications versus scholarly/peer reviewed publications
- Communicate that “underrepresented groups” is an acceptable term in scholarly literature
- Use the term *underrepresentation* to refer to what is occurring in fields of science or the participation of specific racial and ethnic groups in STEM fields
- Spell out the racial and ethnic groups being discussed; perhaps avoid the use of the acronym “URM”

Appendix 4: Demographics of the Federal STEM Workforce Infographic

Demographics of the Federal STEM Workforce

The federal government relies on its scientific and technical workforce to perform critical functions in an array of areas, including space exploration, national security and information technology, management and protection of the environment, and transportation. Of the 2.1 million federal employees, more than 330,000 (16%) people comprise the federal STEM workforce. This study considered the more than 280,000 (~14%) people who occupy engineering, information technology and mathematics, physical science and natural resources and life science careers. While women and traditionally underrepresented racial and ethnic groups (UREG*) comprise about 43% and 38% of the total federal workforce, respectively; they only comprise 29% and 10% of the federal STEM workforce. This data analysis was conducted to shed light on the demographics of the federal STEM workforce.



ABOUT THIS STUDY

Two of the goals of the Federal five-year strategic plan were to "Increase diversity, equity and inclusion in STEM" and to "Prepare the STEM workforce for the future". As a result, this study was compiled to assess the current status of the federal STEM workforce and serve as a point of reference for recommendations to address the Plan's goals. The data reported here are from OPM FedScope (fedscope.opm.gov; June 2019). This analysis focuses on the STEM workforce for job tracks: 04xx Natural Resources and Life Sciences, 13xx Physical Science, 08xx Engineering & Architecture, and 22xx Information Technology, 15xx Math, and 12xx Patent Examiner fields. This analysis does not include STEM employees in occupations such as sociology, psychology, management analyst, etc. or STEM workers in management or administrative positions (e.g. NSF). The Health fields are also not included in this report (~196,000 employees reported in Health Occupations). Data reported here includes the pay banding systems for GS, excepted service, SES, and agency-specific systems. Approximately 25% of STEM employees are in special pay systems at DOC, DOE, NSF and other agencies.

TOP STEM EMPLOYERS



The Department of Defense (DOD) is the largest employer in the federal government and its employees make up 47% of the federal STEM workforce. Individually, the other federal agencies represent smaller fractions (0.18-7%) of the total federal STEM workforce, however when specific career fields are considered their contribution to accomplishing the federal government's mission as it relates to STEM is evident.

Racial and ethnic diversity demographics and employment of women by the top STEM employers varies by agency and career field. VA, EPA, HHS and DOD have the highest representation of UREG in their total STEM workforce. HHS, EPA, NSF, and VA have the highest percentages of women in their total STEM workforce.

Department of Agriculture (USDA), Department of Commerce (DOC), Department of Defense (DOD), Department of Energy (DOE), Department of Homeland Security (DHS), Department of Interior (DOI), Department of Transportation (DOT), Environmental Protection Agency (EPA), Health and Human Services (HHS), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), Smithsonian Institution (SI), Veterans Affairs (VA).

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280,000+

Federal STEM employees in career fields assessed in this study. Cumulatively, engineering, information technology and mathematics careers are the largest career fields in the federal STEM workforce. The Department of Defense, as the largest STEM employer, drives this trend. Natural resources and physical science careers represent a smaller share of the federal STEM workforce, however women are more highly represented in those career fields. UREG are largely underrepresented in each of the career fields at all agencies assessed.

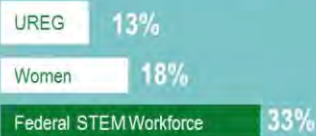
Information Technology and Mathematics



UREG and women comprise 24% and 28%, respectively, of employees in information technology and mathematics career fields. IT and mathematics represents 32% of federal STEM workforce careers.

DOD, VA, and DOC are the top employers of IT and mathematics careers. More than 30% of the DOD STEM workforce is IT and mathematics and within these career fields, women and UREG represent 23% and 21% of the workforce, respectively. IT and mathematics careers are 37% and 28% of the VA and DOC STEM workforce, respectively.

Engineering and Architecture



Engineering and architecture represent the largest STEM career field in the federal workforce. Among the federal agencies assessed, UREG and women had the lowest representation in these career fields.

NASA, DOD, and DOC are the top employers of engineering and architecture careers. These career fields represent 85% of NASA's workforce. Women and UREG represent 23% and 15% of the employees in these career fields. For DOD and DOC, engineering and architecture represent 48% and 33% of the STEM workforce, respectively.

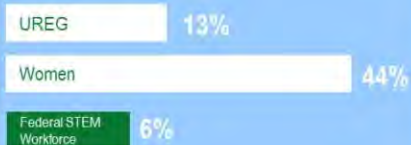
Natural Resources & Life Sciences



Natural Resources and Life Sciences represent a smaller share of the federal STEM workforce, however women are strongly represented in this career field.

USDA, DOI and HHS are the top employers of natural resources and life sciences careers. More than 65% of the USDA STEM workforce are natural resources and life sciences careers. Women comprise 36% and UREG are 13% of USDA careers in these fields. For DOI and HHS, these career fields are 45% and 37% of their STEM workforce, respectively.

Physical Sciences

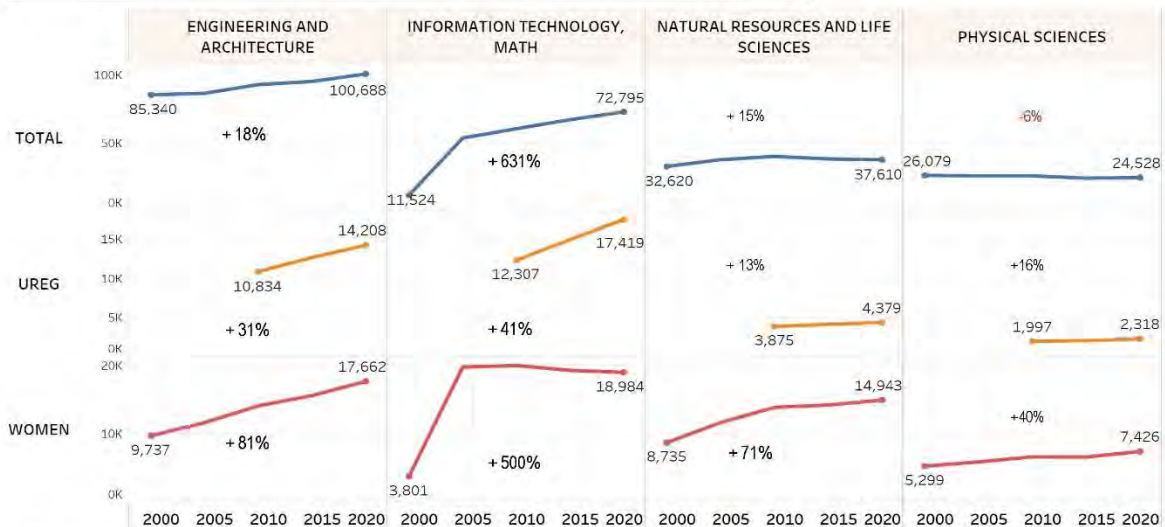


Physical sciences represents the smallest of the STEM career fields assessed. Women comprise a large share of this career field, compared to UREG.

DOC, DOD and DOI are the top employers in the physical science career field. This career field constitutes 25% of the DOC STEM workforce, with women and UREG representing 25% and 11%, respectively. Physical science careers are only 3% of the DOD STEM workforce and represent 18% of the DOI STEM workforce.

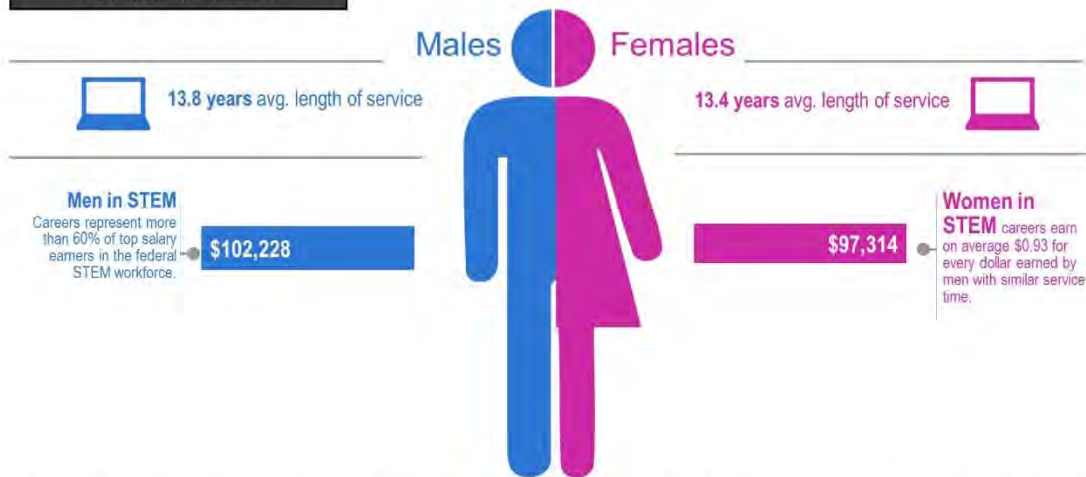
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GROWTH IN STEM CAREER FIELDS



Growth in STEM careers has been consistently positive in engineering and technology career fields over the past 20 years. Both women and UREG have had overwhelmingly positive growth in engineering and technology, likely due to increased dependence on technology and increased investments in education by federal agencies to increase representation in these areas. Growth in natural resources and life sciences was positive, particularly for women; while an overall decrease in physical sciences was observed. Data on race and ethnicity was not collected by FedScope prior to 2009.

SALARIES



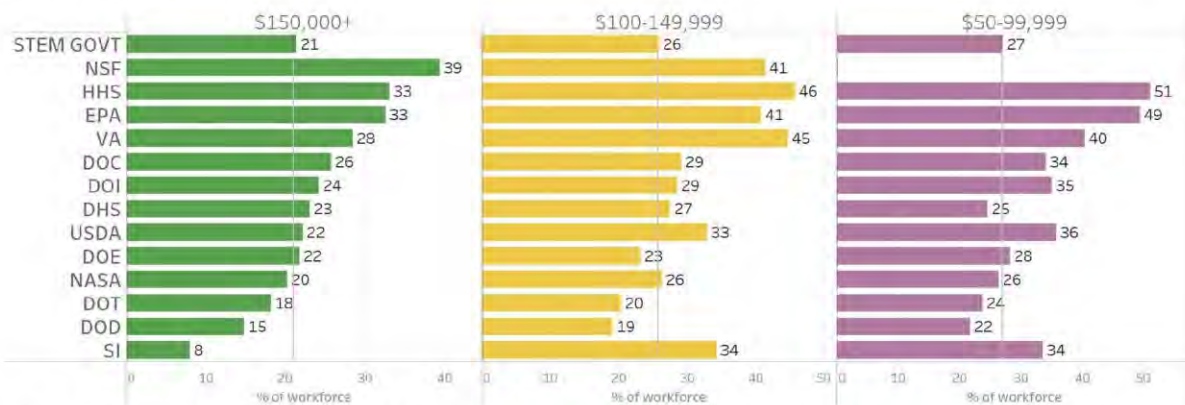
A recent report by the US Government Accountability Office revealed that the gender pay gap among federal employees decreased by 12 cents on the dollar from 1999 to 2017 (GAO-21-67, 2020). Though varied, pay disparities also existed among women from different racial and ethnic groups with the widest gaps (9-12 cents) existing for Hispanic and Latina, Black, American Indian and Alaska Native women. An assessment of salary data in the current study aligned with that reported by GAO, showing that women earned 93 cents for every dollar earned by men.

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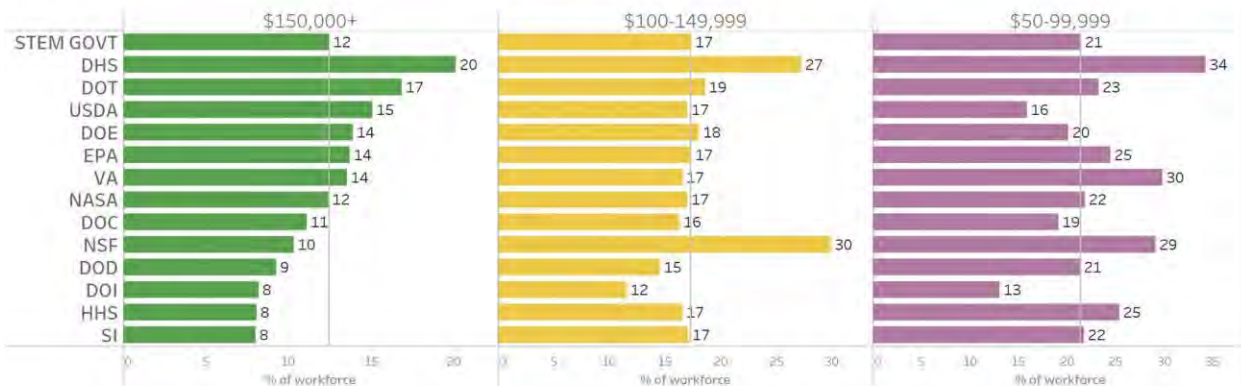
Salary as a Proxy for GS Level

Due to variances in pay scales (i.e. GS vs. pay banding) this study considers salary as a proxy for GS level. The figures below show the percentage of earnings by STEM employees for each federal agency compared to the total STEM workforce (STEM GOVT). Salaries were classified as entry-level (\$50-99,999), mid-career (\$100-149,999) and late career (\$150,000+).

In general, women earned more than the average STEM salary at most of the STEM agencies analyzed for this study. Most women are at entry to mid-level salaries in STEM fields with roughly a third of the women in the STEM workforce earning high-level salaries. UREG salaries vary widely across STEM agencies at entry level salaries and are at average with all STEM employees at mid-level salaries. About half of the STEM agencies UREG employees meet the average high-salary levels in STEM.



Women's salaries in STEM career fields. Data points represent percentages of women's earnings and are not meant to equal 100% when all salary categories are added together. The percentage of women earning less than \$150K were generally lower for most agencies, however earnings were consistently equal to or greater than the average for the federal STEM workforce.

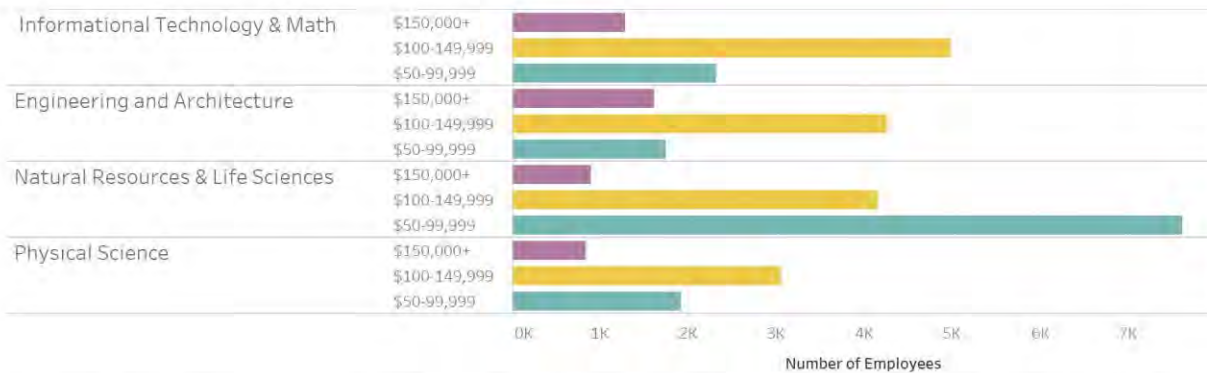


UREG salaries in STEM career fields. Data points represent percentages of earnings by UREG and are not meant to equal 100% when all salary categories are added together.

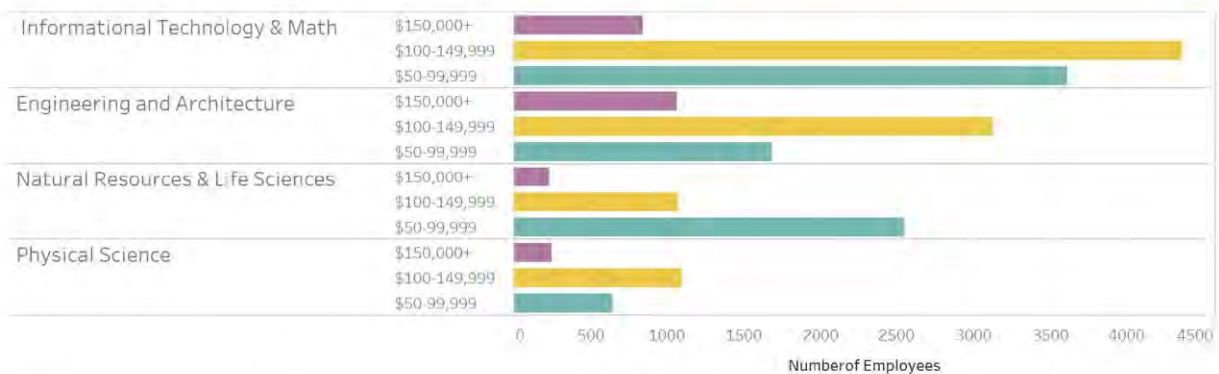
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Salary by STEM Career

The greatest number of women by salary occur in the Natural Resources & Life Sciences (~12,976) where the majority of employees are at entry level salaries (\$50-99,999). In the other STEM fields the majority of women earn mid-level salaries (\$100-149,999), in particular in the fields of Information Technology and Math. The greatest number of UREG are employed in Information Technology & Math fields where most employees earn mid-level salaries (\$100-149,999), STEM fields in the Natural Resources & Life Sciences report the majority of UREG employees at entry level salaries (\$50-99,999).



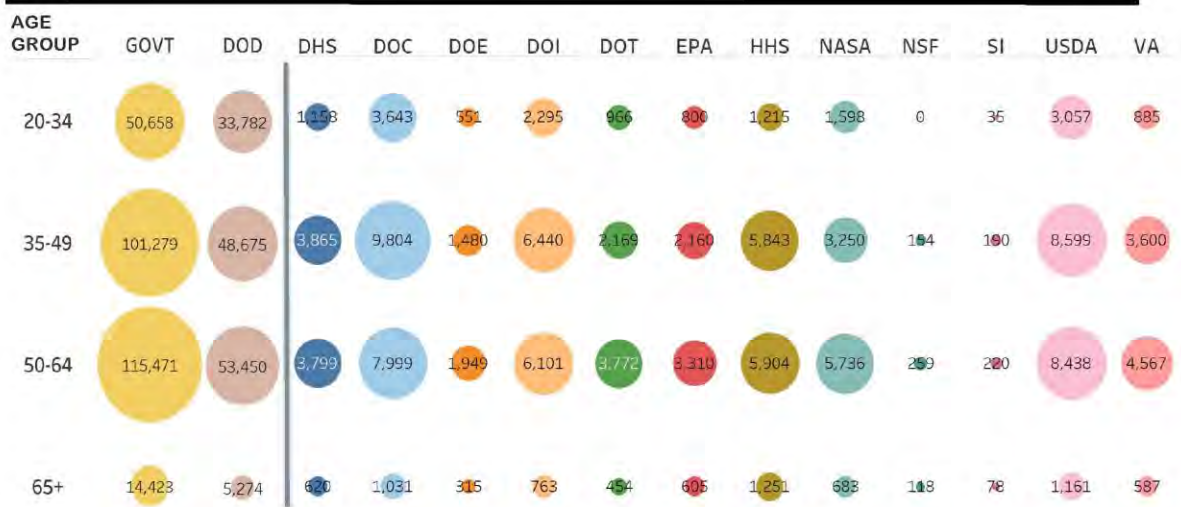
Women's salaries by STEM career category. Data points represent the number of women earning entry-, mid-, and high-level salaries.



UREG salaries by STEM career category. Data points represent the number of individuals from UREG earning entry-, mid-, and high-level salaries.

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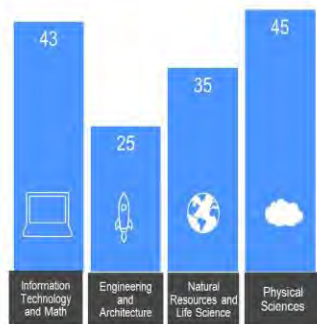
AGING STEM WORKFORCE



Employees aged 50+ account for 46% of the federal STEM workforce, while those less than 35 account for only 18%. The 35-49 year old age group accounts for 36% of the federal STEM workforce. Trends for all federal agencies included in this study consistently revealed that the federal STEM workforce, much like the federal workforce in general, is aging. If current hiring trends persist, the federal workforce may face a deficit in qualified STEM employees.

47.5%

Average percent of individuals over age 50 for top STEM employers in the 4 federal career tracks.



Of the career categories considered in this study, physical sciences and IT and Math have the highest percentage of employees over age 50. This analysis includes the entire population of employees in those career areas.

Resources:

Data Sources: Unless otherwise noted below, all data are from FedScope (fedscope.opm.gov) from the Office of Personnel Management, for all full-time, non-seasonal, permanent employees (June 2019)

GAO, Gender pay differences: The pay gap for federal workers has continued to narrow, but better quality data on promotions are needed, GAO-21-67 (Washington, DC: December 2020).

This study was compiled by the Interagency Working Group for Inclusion in STEM Workforce Subcommittee, December 2020. Authors: Natasha White (NOAA), Sheree Watson (USGS), Avital Percher (NSF), and Marlene Kaplan (OSTP)

TUFTS CENTER FOR THE STUDY OF DRUG
DEVELOPMENT | JUNE 2020

DRUG DEVELOPMENT WORKFORCE IN THE AGE OF DIGITAL TRANSFORMATION



The Fourth Industrial Revolutionⁱ is here, and it is transforming the drug development enterprise. The unprecedented and simultaneous maturing of a wide variety of data-management solutions and breakthrough technologiesⁱⁱ has increased the biopharmaceutical industry's ability to collect and store large, ever-growing quantities of clinicalⁱⁱⁱ and patient-generated health data (PGHD)^{iv}. These data, when paired with powerful analytics, hold great promise in better informing and supporting stakeholders throughout the drug development process, in advancing public health, and in delivering new treatments and cures to waiting patients around the world.

On December 4, 2019, the Tufts Center for the Study of Drug Development (Tufts CSDD), with support by a grant from Pfizer, Inc., facilitated a first-of-its-kind Senior Leadership Roundtable in New York City to discuss the current state of the drug development workforce as it enters the digital era. Sixty executives from pharmaceutical and biotechnology companies, technology-solutions companies, professional trade organizations, and academia participated in the roundtable. Participant functional expertise included clinical, clinical operations, data management, regulatory affairs, human resources, digital technology, and R&D strategy.

Experts discussed the current state and preparedness of the drug development workforce, challenges and opportunities presented by the digital transformation era, new and emerging critical skills and competencies required, changes in talent recruitment and retention practices, and the reshaping of corporate mindsets and cultures to become digitally proficient organizations.

This White Paper, which provides key findings from the roundtable, is intended to inform and stimulate discussion, as the various components of the drug development pipeline lead the vanguard in the Fourth Industrial Revolution.

Executive Summary

The Tufts Center for the Study of Drug Development (Tufts CSDD) convened a roundtable on December 4, 2019 with sixty executives from pharmaceutical and biotechnology companies, technology-solutions companies, professional trade organizations, and academic institutions to discuss the current state of the drug development workforce as it enters the digital era. Insights were generated and shared through discussion on the following topics:

- **Challenges the drug development industry is expected to face as it adapts to the digital era**
- **Key trends shaping the industry's future workforce**
- **Skills and competencies that will be most valued by the industry**
- **Changing and new roles expected to emerge during this digital era**
- **What industry can do to meet human resource needs**
- **Practical steps organizations can take to advance existing staff and attract new talent**
- **What Human Resource functions can do to support digital transformation**
- **What organizations can do to shape corporate mindset, behavior, and culture**

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1. The Evolution of Data Sources and Usage Supporting the Drug Development Process

Over the past forty years, the sources and usage of data supporting the drug development process have evolved substantially. Between 1980 and 2000, industry focused primarily on gathering scientific data which used retrospective, insular data sets that were small and had limited accessibility and utility. Since the turn of the millennium, industry has embraced gathering scientific and operating data to inform scientific questions and executional feasibility. This approach relies on more accessible and comparative data permitting interim review and adjustment. The enterprise continues to evolve toward patient-centered data that requires open, flexible operating models supported by a high volume of structured and unstructured data, as well as powerful prospective and predictive analytics including those supported by machine learning and artificial intelligence. In the coming years, clinical development is expected to become increasingly decentralized, customized, and predictive. [Figure 1](#) maps this transformation.

Figure 1: Speed of transformation of data and analytics usage in drug development



	1980–2000	2000–2025?	Post-2025?
Primary mission	Great science	Feasible and great science	Patient-engaged science
Clinical trial orientation	Key Opinion Leadership (KOL)	Investigative site	Patients and patient data
Operating focus	Insular	Comparative and competitive	Open
Operating approach	Reactive	Responsive	Customized and predictive
Decision support	Basic and lagging	Risk-based, root cause and benchmarking oriented	Advanced analytics, leading
Data accessibility	Limited accessibility	Improving accessibility	High cross-platform accessibility
Data value	Retrospective, appraisal-based	Anticipatory, pre-approved, adaptive	Continuous, flexible learning

As biopharmaceutical research transforms into a more data-rich operating environment, drug development professionals need to be equipped with the skills to distill actionable knowledge from vast clinical and patient-generated health data sets. It is in the industry's immediate interest to take the steps necessary to transform infrastructure and operating models, and to develop workforce data-science capabilities.

Digital transformation is moving at a rapid pace, and has shifted from adopting specific technologies to the broader project of rapidly establishing and embracing new operating models and adopting new solutions that take full advantage of what data can offer. Drug development stands to benefit greatly from increased exchange of knowledge and improved best practices for collecting, organizing, storing, sharing, exchanging, analyzing, interpreting, and communicating data. Such a transformation requires a high degree of adaptability at the levels of individuals, organizations, and the entire industry.

2. What Challenges Will the Industry Face as It Adapts to the Digital Era?

The need for overarching data strategies and governance frameworks

The volume of diverse scientific and operating data requires organizations to prioritize, clarify, and coordinate strategies for how data will be used to support development decisions. Biopharmaceutical companies are also seeking clarity from regulatory agencies to ensure the validity and regulatory compliance of data sources and to determine what constitutes meaningful and useful evidence to support agency decisions. Guidelines for data ownership, data privacy and security, data integration, data sourcing, and use of real-world data remain unclear.

Competition with technology sector for workforce talent

The emergence of hybrid roles will drive competition between drug development companies and technology companies in recruiting top data-science and artificial-intelligence talent. The biopharmaceutical industry must tap into the technology sector to recruit cohorts of data scientists and others with expertise in areas such as project management, systems engineering, and computer science. As competition for talent intensifies, biopharmaceutical companies must factor the expectations of digital natives who demand flexibility, opportunity, upward mobility, and the opportunity to do work they find meaningful.

Increasing cost of data management

Managing and coordinating sources of data and containing the growing costs of data management are driving the adoption of unified data platforms. Employees will require constant retraining to ensure up-to-the-minute proficiency in the rapidly changing features of such unified data platforms and skills. Such upskilling in technological updates will increase workforce training and development costs. New features and upgrades in a platform, as well as the development and adoption of new platforms that offer enhanced functions, mean that what was not possible six months ago has now become both possible and

a competitive advantage; and if companies are not agile in systems deployment and training, the development lifecycle will remain long, become obsolete, and as a result considerably delay the industry's progress along the transformation continuum.

3. What Are the Key Trends Shaping the Industry's Future Workforce?

Rapid changes in the job market

Dramatic job destruction and job creation will characterize the job market of the near future, and digital innovation is expected to have a sweeping impact on all involved in healthcare, including patients, payers, and drug developers. Technological developments, most especially the automation of repetitive and rote tasks, are expected to allow individuals to focus on meaningful work. Wages are expected to increase for STEM occupations, and these jobs will have high employment multiplier effects.

Growing demand for individuals with blended backgrounds and expanded skill sets

Drug development organizations must find individuals not only with depth of experience and expertise, but also with breadth. Science and engineering skills, for example, are most highly valued when complemented by a background in business management. Similarly, expertise in computer and data science is becoming more attractive to biopharmaceutical companies, particularly when paired with hands-on engineering experience. Regardless of the combination, however, strong communication, management skills, strategic thinking, agility, and an ability to work in diverse teams will continue to be indispensable characteristics for the drug development professional of today and tomorrow. In traditional legacy operating models, such combinations of skill sets have not always been prioritized in the hiring process and therefore are the exception rather than the rule. New human-resource planning, strategy, and execution are required to foster the right environment for new cadres of hires with breadth and depth of talent and skill sets to flourish.

Increasing need for clinical-research and clinical-care convergence

As drug development seeks access to patients and patient data, existing infrastructure within clinical care represents a viable and sustainable source for data. Health and lifestyle data drawn from patients' personal and mobile devices will also become increasingly common. Partnerships between drug developers, health-data aggregators, health systems, and online health communities will become far more commonplace. To succeed, the workforce will need to become more adept at integrating, managing and analyzing data from these historically unused and under-leveraged sources.

4. What Skills and Competencies Will Be Valued by the Industry?

The industry's nascent patient-centric approach is requiring a different type of professional: one who can easily adapt to the conditions described above. [Figure 2](#) details the desired competencies in drug development professionals.

Figure 2: Competencies of digital-era drug development professionals

Complex reasoning, critical thinking, and data-driven decision-making	Skill at understanding big data and acquiring secondhand knowledge. This requires an understanding of interfaces, infrastructure, and algorithms.
Curiosity	Genuine interest in mining, cleaning, and analyzing data, and skill at quickly discerning patterns and questioning assumptions.
Communication and emotional intelligence	Ability to share, connect, and build relationships with peers and collaborators in different cultural and functional settings, oftentimes using digital communities.
Agility	Willingness to quickly learn new software packages, tools, and methodologies through self-training and group training with the goal of using technology to aid in improving individual and team workflow efficiencies.
Novel and adaptive thinking	Capacity to continuously adapt to and foresee changes in the way drug development is conducted.
Transdisciplinarity	Ability to understand concepts across multiple disciplines and work across the various workflow functions that make up the bench-to-bedside process.

5. What Roles Are Expected to Emerge?

In the near term, as the impact of digital transformation becomes evident, drug development organizations must retain flexibility to act nimbly and redeploy or reconfigure the workforce. The following roles are expected to gain greater currency in coming years:

- **Data scientists** will mine, clean, and analyze and find patterns in large data settings using advanced analytics.
- **AI systems trainers** will be responsible for training colleagues in the use and inner workings of complex AI algorithms.
- **Sustainers** will be responsible for ensuring that AI systems operate as designed and in the way in which they are intended to operate.
- **Translators** will convert data into findings and AI algorithms into actionable items.

- **Patient and provider navigators** will work with providers and patients in granting them a more active role in drug development.
- **Technology navigators** will provide technology support to clinical-research associates and the staff involved in the execution of clinical trials.

6. What Can the Industry Do to Meet Human-Resource Needs?

Develop a set of digital-thinking principles for drug development

Developing a set of digital-thinking principles for drug development is urgent. These principles must have a particular focus on workflow, understood as the sequence of research, development, manufacturing, and administrative processes that constitute the drug development pipeline from initiation to completion. Additionally, a harmonized understanding of the concept of “digital drug development professional” must be developed. To achieve this, a thorough industry-wide “Comprehensive Needs Assessment” must take place.

Develop dynamic corporate cultures

At the organizational level, senior management must continue to focus on building dynamic cultures and developing feedback loops within and across teams. Intra-company community building is perceived as an important part of digital transformation.

Motivate with higher purpose

It is also of great importance to focus on attracting and motivating today’s workforce with higher-purpose objectives, emphasizing the industry’s mission to save lives and benefit society. A higher purpose that staff members find personally meaningful will encourage outsiders to join the industry and galvanize employees to develop new skills and adapt to changing conditions.

Proactively train and develop its workforce

Taking a proactive approach in the training of existing staff and incoming recruits is encouraged. Specifically, offering individualized mentorships and training programs geared to individual needs are proven to deliver value, particularly when they address deploying and implementing new technologies, methodologies, or applications. Staff can be trained through both bottom-up and top-down training methodologies. These include in-house experiential training, simulation programs, hackathons, coding camps, and other off-campus training programs. Creating an environment that fosters and rewards constant self-learning is of paramount importance.

Workforce training should not end here, however. A continuous learning environment in which progress and small wins are measured and communicated must be developed. Teams can achieve great success by innovatively capturing progress and routinely celebrating success stories within their teams and throughout the organization. Examples of key performance indicators to champion include the number of new data-science–related training programs deployed by an organization, participation in and outcomes

from the deployment of such programs, number of data-science fellows and/or interns recruited, number of training programs aimed at increasing quantitative and computational skills, trainee-reported self-efficacy in quantitative and computational skills, degree attainment, and disciplinary diversity of staff.

7. What Practical Steps Can Organizations Take to Advance Existing Staff and Attract New Talent?

First, **industry leadership must model desired behaviors**. It is important that staff are able to take calculated risks and operate outside comfort zones, but this behavior must first be modeled by managers in order to develop high levels of psychological safety.^v

Second, **organizations must be agile**. Digital transformation will likely exacerbate already-high employee turnover rates. To thrive, the industry must integrate recruitment processes more tightly with corporate cultures to accelerate decision-making. This approach will allow for shorter timelines and ensure the ramp-up period for new recruits, which will, in turn, facilitate faster recruitment and onboarding. Such an approach will require ongoing colleague development to retain staff.

Third, **organizations must develop experiential and individualized training programs**, as well as community engagement programs such as innovation challenges, contests, hackathons, and crowdsourcing. Organizations benefit greatly when employees are provided with spaces to come together to develop solutions to problems in which they and their peers are most personally invested.

Fourth, biopharmaceutical **leaders must visit and engage with companies outside of the industry** to understand how other sectors (such as financial services, telecommunications, or computing) are approaching workforce development and consumers, as well as hire and engage with consultants with experience in digital transformation.

Fifth, **organizations must factor the “extended workforce” into their growth and training strategies** and make a habit of the following practices: (1) understanding the role and capabilities of the CRO; (2) understanding the needs of users (that is, the hands-on implementers of protocols); (3) defining the roles of the CRAs, etc., as well as the roles of those involved in the digital transformation process (e.g. trainers, translators, sustainers, navigators); (4) developing materials to train healthcare providers in data science-related clinical applications; and (5) attending conferences outside the drug development industry to gain insight into how other industries are adapting to technological change.

Finally, biopharmaceutical organizations should **develop partnerships with universities** in the form of data-science training programs, rotational internship programs, and fellowships. These programs are effective in providing introductions to the industry and organization, as students are a gateway to their peers when they return to their respective institutions.

8. What Can Human Resources Do to Support Digital Transformation?

Human-resources departments play a crucial role in supporting the industry's digital transformation. Therefore, it is recommended that HR staff take the following actions:

1. **Develop guidelines for hiring** by identifying the competencies and educational requirements of each new position. To narrow down the ideal characteristics of a prospective recruit, the process should be part of a partnership between HR and the manager hiring a new employee, and it should include a conversation focused around values, behaviors, and cultural fit.
2. **Develop simplified high-level job descriptions focused equally on behavioral characteristics and on specific job roles.** Because roles are likely to change dramatically and frequently in coming years, high flexibility and dynamism are in high demand. Accordingly, job descriptions can be modeled after those for technology companies, and should also communicate the industry's and organization's greater purpose to prospective hires.
3. HR functions at biopharmaceutical companies must **develop recruitment campaigns that highlight what prospective talent most cares about.** Millennials will soon make up the majority of the workforce and the competencies desired by the biopharma industry are most likely to be found in this group. Accordingly, the factors that matter most to potential recruits as they evaluate companies to work for generally include purpose, fun, agility and the potential for rapid professional advancement.
4. **Develop interactive digital media** that engage the public, experts, and non-experts while creating online and offline communities, as these groups can attract talent and better establish these organizations within the digital and real-world spheres.
5. **Develop communication campaigns that make use of consistent messaging** targeting colleges, high schools, and middle schools to increase awareness of career opportunities in the industry.
6. HR functions will need **to expand sources for identifying talent.** They must be more resourceful and broader in scope to find talent excluded by traditional recruitment pools such as agencies and universities. Human Resource functions play a crucial role in supporting the industry's digital transformation.

9. What Can Organizations Do to Shape Corporate Mindset, Behavior, and Culture?

Measure and communicate outcomes

It is imperative to measure and communicate outcomes associated with implementing digital transformation initiatives. Companies must become accustomed to assessing the state of their processes before and after rolling out such initiatives. Tangible achievements can be shown by periodically assessing the process of collecting, cleaning, and analyzing data across departments within the organization. This can be done with benchmarking tools and operational excellence metrics such as cycle-time reductions. Organizations must be able to **demonstrate the positive impact of those initiatives on revenue** and customize the communication of these achievements to different internal audiences.

Hire individuals aligned with the mission and culture of the organization

To guarantee that new hires are well aligned with company culture and values, organizations must focus on developing and expanding unconventional hiring arrangements. Tiered approaches are a type of unconventional hiring arrangement that yields positive results for biopharmaceutical organizations. In these arrangements, individuals work contractually for a “trial period,” and then, if they are found to be a good fit, are brought in as full-time employees.

Shift behaviors and develop a collaborative corporate culture

Collaborative work cultures are those in which transparency, seamless communication, agility, and calculated risk-taking are encouraged and supported, and can facilitate the successful deployment of digital transformation initiatives. For this reason, leaders and managers must prioritize communication with staff at every level of the organization and share best practices across functional departments. Leaders and managers must also communicate openly with their staff about the pace of implementation of strategic initiatives and the possibility that some initiatives might fail. Teams and individuals must be provided with the space and leadership support to take calculated risks and employ breakthrough thinking. Agility develops when individuals feel empowered to learn, take action, and communicate their impact to others. For this reason, digital transformation initiatives that focus on implementing incremental changes are found to be most effective. Incremental changes facilitate the use of recognition and reward systems, which encourage individuals to self-train, train others, and deliver results. Individuals are motivated by their ability to communicate about a problem they have solved and their impact on the bottom line. In sum, when individuals feel psychologically safe and teams focus on smaller goals, realize quick wins, and communicate seamlessly, they achieve greater cycle-time reductions.

Adjust to the global nature of drug development

Organizational cultures are an essential factor in business transformation processes, and critical to the success of any digital transformation strategy. As the world has become more interconnected, and as biopharmaceutical development is global in nature, companies are encouraged to recognize the value of maintaining a diverse workforce. Having an understanding of the cultural nuances surrounding the management of data across world regions will determine the success of biopharma companies and the

industry as a whole. People react differently to various data-management protocols and regulations, and privacy needs vary from region to region; companies must be prepared to address that. A diverse workforce that brings a wide variety of experiences, talents, thinking styles, and approaches to problem solving will be ideally positioned to develop creative solutions resulting from cultural challenges inherent in a company's global presence.

10. Conclusions

In this roundtable, pharmaceutical, biopharmaceutical, and technology company senior executives discussed digital transformation and the ways in which the drug development enterprise must adapt to meet the rapidly changing digital landscape and ensure that the life sciences sector continues to thrive. The discussion was candid, thoughtful, timely and critical. The shared learnings from this roundtable are invaluable and represent just the beginning of an ongoing conversation.

The rapid pace and broad scope of digital transformation requires individual companies, and the industry as a whole, to be adaptable, resourceful, curious, agile and open. Senior leadership and HR will be instrumental in guiding organizations through this transformation and in establishing and executing strategies, policies, and procedures.

11. Next Steps

This White Paper is intended to stimulate discussion and help spur new strategies and responses. It is the authors' hope that the biopharmaceutical industry will continue to convene roundtables and discussion forums to guide the enterprise as it navigates this challenging digital transformation.

12. Endnotes

ⁱ The Brookings Institution defines the Fourth Industrial Revolution as one that is “characterized by the fusion of the digital, biological, and physical worlds, as well as the growing utilization of new technologies, such as artificial intelligence, cloud computing, robotics, 3D printing, the Internet of Things, and advanced wireless technologies.”

ⁱⁱ Recent breakthrough technologies include genomics, smartphones, nanotechnology, robotics, and wearable sensors.

ⁱⁱⁱ The University of Washington Health Sciences Library defines clinical data as “information that is collected during the course of ongoing patient care or as part of a formal clinical trial program.” It lists six major types of clinical data: electronic health records, administrative data, claims data, patient/disease registries, health surveys, and clinical-trials data.

^{iv} The United States National Coordinator for Healthcare Information Technology defines patient-generated health data (PGHD) as “health-related data created, recorded, or gathered by or from patients (or family members or other caregivers) to help address a health concern. PGHD include, but are not limited to, health history, treatment history, biometric data, symptoms, [and] lifestyle choices.”

^v In the book “Trust and Distrust in Organizations” (Kramer and Cook, 2004, p. 241), psychological safety is defined as describing “individuals’ perceptions about the consequences of interpersonal risks in their work environment. It consists of taken-for-granted beliefs about how others will respond when one puts oneself on the line, such as by asking a question, seeking feedback, reporting a mistake, or proposing a new idea.”

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The Rockefeller Team Science Leadership training program: Curriculum, standardized assessment of competencies, and impact of returning assessments

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Abstract

The ability to effectively lead an interdisciplinary translational team is a crucial component of team science success. Most KL2 Clinical Scholars have been members of scientific teams, but few have been team science leaders. There is a dearth of literature and outcome measures of effective Team Science Leadership in clinical and translational research. We focused our curriculum to emphasize Team Science Leadership, developed a list of Team Science Leadership competencies for translational investigators using a modified Delphi method, and incorporated the competencies into a quantitative evaluation survey. The survey is completed on entry and annually thereafter by the Scholar; the Scholar's primary mentor and senior staff who educate and interact with the Scholar rate the Scholar at the end of each year. The program leaders and mentor review the results with each Scholar. The survey scales had high internal consistency and good factor structure. Overall ratings by mentors and senior staff were generally high, but ratings by Scholars tended to be lower, offering opportunities for discussion and career planning. Scholars rated the process favorably. A Team Science Leadership curriculum and periodic survey of attained competencies can inform individual career development and guide team science curriculum development.

Introduction

The overall vision of the Rockefeller University Center for Clinical and Translational Science (CCTS), supported by the National Institutes of Health Clinical and Translational Science Award (CTSA) program, is to develop, demonstrate, evaluate, and disseminate innovative programs to achieve translational success and to integrate these into a seamless "Learning Clinical Research Enterprise" that uses outcome data to drive quality improvement for the benefit of human health. The Rockefeller University 3-year Masters' degree KL2 Clinical Scholars Program, which began in 2006 and is supported by both CTSA and University resources, is a key component of the CCTS, and its goal is to prepare translational team science leaders who are able to use their skills to improve human health [1]. It is designed to provide an optimal environment for junior translational investigators to develop team science and leadership skills by designing, conducting, analyzing, and reporting a human participant protocol under the supervision of an expert senior scientific mentor and a multidisciplinary group of Team Science Educators/Evaluators (TSE/Es) who comprise the Senior Staff of the CCTS. We have approximately 15–20 Scholars in the program at any time.

Our motivation to focus on Team Science Leadership is rooted in our belief that the ability to effectively lead an interdisciplinary translational team is a crucial component of team science success, supported by feedback from prior graduates who expressed insecurity about their Team Science Leadership skills immediately after graduation, and by our observation that despite our Scholars having extensive experience participating as team science members, they have little experience as team science leaders. While there is universal recognition of the importance of team science and team leadership in the conduct of clinical and translational science (CTS) [1–3], and an enormous literature from industry on team leadership and organization [2,4], there is a remarkable dearth of outcome measures of effective team leadership in CTS.

Table 1. Elements of the Team Science Leadership curriculum

1.	Distribution of Team Science Leadership Self-Assessment Survey and Team Science Leadership Evaluation Survey to incoming Scholars. Self-assessments conducted using both instruments.
2.	A series of tutorials focused on Team Science Leadership, including topics related to :why leadership is important; what makes for effective leadership; different styles of leadership; case-based analysis of leadership responses to a series of typical academic leadership challenges; adages reflecting principle of leadership; leadership literature; and the importance of team diversity.
3.	Trainings in preparation for leading a human participant protocol as the responsible Principal Investigator (PI): Good Clinical Practice; Protection of Human Subjects; Responsible Conduct of Research; 15-hour structured course and one-on-one tutorials on research methods and biostatistics that stress the importance of leading and managing research and analytic teams; 10-session seminar series on Rigor, Reproducibility and Reporting that stresses the importance and value of multidisciplinary teams; and regulatory requirements for clinical investigation, including registration in ClinicalTrials.gov.
4.	Constitution of a multidisciplinary team by Scholar PI, including, depending on protocol, biostatistician, bioinformatician, research nurse, research coordinator, information technology expert, participant recruitment expert, laboratory technician, and research pharmacist.
5.	Preparation of a Pilot Grant application requesting funding for the protocol.
6.	Preparation of human participant protocol with one-on-one training under the Rockefeller University Center for Clinical and Translational Science (CCTS) Navigation [13] and the Community-Engaged Navigation [14] programs, the Centralized Research Participant Recruitment [15] program, Research Hospitalist [16] initiative, and Informed Consent for Next-Generation Sequencing [17] initiative.
7.	Oral presentation of the human participant protocol to the Rockefeller University Institutional Review Board.
8.	Training by senior Nurse Practitioner Research Coordinator in conduct of team science meetings, along with constructive feedback after senior Coordinator observes meetings.
9.	One-on-one review by senior Coordinator of Scholar's response to challenging hypothetical scenarios, e.g., nurse administration of incorrect dose of study drug to two participants (Is this your responsibility? How will you determine exactly how the error occurred? What is your action plan to prevent this from happening again? To whom will you report this error? How will you communicate what you have found, and plan to do, to each of your team members?).
10.	Management training skills.
11.	Early audits of Scholar protocols after the first few participants are enrolled to ensure compliance with all protocol, regulatory, and IRB requirements.

Moreover, while the business literature on corporate leadership is robust, in our literature review, we could not identify any team leadership competencies that are specific for serving as a team leader of clinical and translational research. Specifically, PubMed searches in July 2021 for papers with the terms “team science outcome” or “team science competencies” in their titles yielded no papers. The 2011 CTSA Core Competencies in Clinical and Translational Research touched on Translational Teamwork and Leadership [5] but were very general and did not provide a mechanism to assess outcomes. Even a search of the NCI Team Science Toolkit [6] did not identify tools for outcome assessment of Team Science Leadership. To address these gaps, we enhanced our curriculum to emphasize Team Science Leadership, developed a list of team science leadership competencies specific for translational investigator team leaders, and implemented a Team Science Leadership quantitative evaluation survey to be completed annually by the Scholar, the Scholar's primary mentor, and the TSE/Es. We also implemented a process to review the results with the Scholars to ensure that they receive feedback on their progress at a time when they can plan a course of action to ensure that they master the competencies before graduating. Analyzing the results of the survey has also provided crucial additional information that has enhanced our ability to: 1) teach team leadership skills, 2) provide opportunities for trainees to develop their skills via experiential learning, 3) evaluate trainees' competencies, 4) provide feedback to trainees about their performance, 5) assess whether providing feedback results in improved performance, and 6) identify opportunities to strengthen individual components of team science training. This paper describes our Team Science Leadership curriculum, presents the process we followed to create the Rockefeller Team Science Leadership competencies

and survey, and provides early results on psychometrics, means and variability of items, and lessons learned on the utility of the survey.

Methods

Team Science Leadership Curriculum

The Team Science Leadership curriculum is outlined in Table 1 and discussed in more detail in Supplementary Materials.

We introduced the Team Science Leadership initiative to the Clinical Scholars by providing them with a Team Science Leadership Self-Assessment document with a series of questions about

Team Science Leadership for self-assessment (Table 2), and if they chose, discussion with their primary mentor and/or the leaders of the Clinical Scholars program. The document covers the Scholar's experiences and/or views of current and past experience in participating in teams, developing and articulating a vision for a team, delegation of tasks, oversight of team members, decision-making, conflict resolution, models of leadership and role modeling, and self-reflection on the Scholars' current strengths and weaknesses as a team leader. In addition, Scholars rate themselves on their Team Science Leadership Competencies (see below) on entry into the program and yearly using the same survey used by the TSE/Es. To broaden the Scholars' scope in contemplating their roles as leaders, we searched for other leadership models that might be instructive for comparison. We selected a program on leadership, *The Art of Teams: Achieving Excellence as Equals*, that uses the relationship among the members of a string quartet as a paradigm of shared and shifting team leadership, reflecting the

Table 2. Rockefeller University Clinical Scholars Team Science Leadership self-assessment survey

1. Current and past team experience
• How many different teams do you participate in or lead?
• What are your positive and negative reflections on your experience as a member of a medical care team during your medical training?
• Have you ever received training in team leadership?
• How do you tailor your leadership style when leading a basic science team versus a clinical research team versus a team that includes industry members?
• How do you see yourself as a leader in your current role?
2. Current and past team experience
• How many different teams do you participate in or lead?
• What are your positive and negative reflections on your experience as a member of a medical care team during your medical training?
• Have you ever received training in team leadership?
• How do you tailor your leadership style when leading a basic science team versus a clinical research team versus a team that includes industry members?
• How do you see yourself as a leader in your current role?
3. Developing and articulating a vision
• Do you have a clear vision for your team, and if so, how do you articulate it and engage team members in sharing your vision? Did you engage team members in developing or refining the vision?
• How do you make certain everyone on your team understands the goals and desired outcomes?
4. Delegation of tasks and oversight of team members
• Under what circumstances do you delegate authority to team members? How do you maintain quality control over the tasks that you delegate?
• How do you determine the degree of independence granted to individual team members?
• How do you make certain that the person you delegate a task too feels able to accomplish the task?
• Under what circumstances do you share team leadership and how do you signal that to other team members?
5. Decision-making
• Which methods of communication do you use (e.g., phone, email, text, in person, group meetings) and how do you decide which method to use?
• How do you solicit advice from more senior people who are either on your team or who you know and respect?
• How do you resolve intra-team conflict?
6. Leader role modeling
• How do you demonstrate that you take ultimate responsibility for all actions of the team?
• How do you insure that you are recognizing the contributions of team members equitably?
• How do you mentor team members in developing their leadership skills?
• What do you do to establish trust among team members and demonstrate your own accountability?
• How do you consult with other team members before making decisions and do you share your thought process with other team members?
• How do you support your team members?
• How do you lead collaborations between your team and other teams?
7. Self-reflection
• What do you enjoy the most about leading your team?
• What do you do well as leader?
• How do you think you could improve as a leader?

relative roles of the instruments as dictated by the music and the overall team structure of the quartet [7].

Team Science Leadership Competencies and Teams Science Leadership Survey

As TSE/Es, we collectively recognized the need to define the competencies for effective Team Science Leadership for translational research studies. By combining our domain-specific expertise

and experience, we created a list of competencies that we assessed to be essential for an outstanding translational scientist to lead a multidisciplinary team in conducting a human participant research protocol (Supplemental Figure 1). All 15 Senior Staff members participated in a modified Delphi method [1,8,9] for generating and reviewing both the major domains and the items within domains. Over the course of 6 months of weekly meetings, the domains were first agreed upon, and then the items within domain were created, deleted, and revised until neither new items nor major revisions were suggested. These draft items were then shared with all of the current Scholars for feedback and revision. They were also shared with colleagues from Yale University and the University of Pennsylvania in a series of face-to-face meetings at each site. The list of competencies was finalized to begin the project, but with agreement that the competencies would need to be reviewed and modified periodically.

The final list converged on five domains: 1. *Foundational Leadership Competencies* containing nine items centered on creating and leading teams, creating and communicating a vision, building trust among team members, mentoring team members, and establishing lines of open communication; 2. *Professionalism Competencies* containing five items that describe aspects of responsibility and modeling ethical and supportive behavior; 3. *Team Building and Team Sustainability* containing 12 items that describe more granular level aspects of team communications, recognition of team member achievements, conflict resolution, seeking advice, and taking responsibility; 4. *Appropriate Use of Resources and Execution of Study* containing six items that describe elements of appropriate budgeting, staffing, overcoming obstacles, organizing continual quality improvement, and delegating responsibility appropriately; 5. *Regulatory Accountability* containing five items describing issues relating to compliance with Good Clinical Practice (GCP), federal and state laws and regulations, and issues related to data management, security, and sharing.

Prior to the Team Science Leadership initiative, we periodically reviewed our perceptions of the progress of individual Scholars during our weekly TSE/Es meetings. During these discussions, we appreciated the value of sharing our perceptions since we each observed the Scholars in different roles, interacting with different people, and performing different tasks. We thus recognized that by summing our individual observations we had a much more comprehensive assessment of the Scholars' progress. We therefore set a goal of systemizing the information from all TSE/Es and combining it with the Scholars' mentors' evaluations and integrating it into a comprehensive plan for competency evaluation, feedback, and improvement. To achieve this goal, we developed a research protocol describing the evaluation of Scholars' Team Science Leadership competencies and received approval from the Rockefeller Institutional Review Board prior to implementing the study. To evaluate the Team Science Leadership competencies of the Scholars, we converted the competencies into a survey in which each competency is rated based on a six-point Likert scale score (0–5), with additional space for free text comments (Table 3). We then implemented the survey in a REDCap [10] format to facilitate data collection and preserve the confidentiality of the reviews. Each Scholar evaluates herself or himself, each mentor evaluates her or his Scholar, and each TSE/E evaluates each Scholar across as many items and dimensions as are appropriate, based on content area and exposure to the Scholar's activities in that area (Supplemental Figure 2). The evaluations by the TSE/Es, mentor, and Scholars are combined into a written report that includes 1. the aggregated evaluations by the mentor and

Table 3. Team science competencies

Item	TSE/E + Mentor Mean (SD)	Scholar Mean (SD)	Average Difference (SD) (TSE/E – Scholar)
<i>A. Foundational leadership competencies for Team Science Educators/Evaluators (TSE/E) + Mentors, and Scholars, and Mean Differences</i>			
Establishes a compelling vision and sets appropriate goals	4.77 (.48)	3.33 (0.89)	1.42 (.98)
Creates a culture that values and supports diversity	4.83 (.44)	3.86 (1.17)	1.09 (1.20)
Fosters an environment of mutual trust	4.79 (.49)	3.80 (1.08)	0.96 (1.24)
Develops and nurtures collaborations and external relationships	4.90 (.30)	3.86 (0.83)	0.99 (1.06)
Explores opportunities for growth and development on a continuous basis	4.71 (.68)	2.93 (1.48)	1.55 (1.26)
Anticipates obstacles and devises strategies to overcome them	4.54 (.79)	3.0 (1.18)	1.35 (1.26)
Supports and mentors all members of the team	4.78 (.55)	3.27 (1.38)	1.47 (1.46)
Anticipates the need for resources to carry out initiatives and obtains them in a timely manner	4.57 (.84)	3.31 (1.25)	0.67 (1.15)
Establishes and oversees a communication structure and processes that insure that both oral and written communication with and among all team members and other stakeholders is timely and effective	4.70 (.72)	3.07 (1.25)	1.99 (1.58)
Foundational leadership competencies scale ($\alpha = 0.81$)	4.80 (.31)	3.35 (0.75)	
<i>B. Professionalism competencies for Team Science Educators/Evaluators (TSE/E) + Mentors, and Scholars, and Mean Differences</i>			
Accepts responsibility as PI for the conduct of all aspects of the study	4.77 (.73)	4.07 (0.79)	0.61 (1.0)
Serves as a model of the highest professional and ethical standards	4.90 (.29)	4.08 (0.79)	0.88 (0.81)
Commits to continuing education	4.71 (.59)	3.64 (1.28)	1.17 (1.34)
Commits to transparency, invites feedback from all team members, and implements ideas that garner broad support	4.88 (.33)	4.0 (0.85)	0.94 (0.94)
Recognizes and rewards contributions of all team members	4.80 (.72)	3.93 (0.88)	0.97 (0.98)
Professionalism Scale Mean ($\alpha = 0.71$)	4.81 (.20)	3.94 (0.76)	
<i>C. Team building and team sustainability for Team Science Educators/Evaluators (TSE/E) + Mentors, and Scholars, and Mean Differences</i>			
Invites participation in building vision	4.65 (0.65)	3.36 (1.15)	1.45 (1.06)
Articulates vision and goals clearly and unambiguously	4.81 (0.39)	3.0 (1.31)	1.72 (1.31)
Effectively identifies, selects, and recruits talented team members	4.56 (0.74)	3.13 (1.06)	1.58 (1.06)
Insures timely and effective bidirectional communication with all team members and among team members	4.92 (0.26)	3.80 (1.26)	0.94 (1.07)
Demonstrates respect for team members via active listening and rapid follow-up, and sensitivity to both verbal and nonverbal communication	4.91 (0.41)	3.0 (1.56)	1.37 (1.18)
Leads team meetings effectively, with defined agenda, adequate time for discussion, and adherence to starting and stopping times. Summarizes meeting and creates action plan with clear assignment of responsibility and expected completion dates	4.68 (0.54)	3.0 (1.57)	1.47 (1.4)
Celebrates milestones and accomplishments	4.88 (0.32)	3.57 (0.85)	1.39 (1.02)
Recognizes and acknowledges strengths of team members	4.77 (0.51)	3.38 (0.96)	1.42 (0.67)
Takes responsibility for all team errors and immediately develops corrective action plan based on detailed analysis of system failures leading to error	4.58 (0.90)	3.41 (0.66)	1.19 (1.11)
Intervenes as rapidly as possible to resolve conflicts, listening carefully and in confidence to all parties, and mediating resolution via building out fairly and equitably from shared values and goals	4.69 (0.92)	3.67 (0.89)	1.06 (1.46)
Seeks assistance from more senior investigator(s) and administrators when unable to successfully address problems	4.70 (0.74)	4.15 (0.68)	0.48 (0.77)
Communicates with, and is available to, clinical staff in labs and Hospital participating in the study	4.81 (0.51)	2.86 (1.29)	1.71 (1.03)
Team building and team sustainability scale ($\alpha = 0.93$)	4.79 (0.31)	3.31 (0.84)	
<i>D. Appropriate use of resources and execution of study for Team Science Educators/Evaluators (TSE/E) + Mentors, and Scholars, and Mean Differences</i>			
Budgets effectively and insures that there are adequate financial resources to support projects	4.67 (0.61)	4.0 (0.73)	0.65 (0.78)

(Continued)

Table 3. (Continued)

Item	TSE/E + Mentor Mean (SD)	Scholar Mean (SD)	Average Difference (SD) (TSE/E – Scholar)
Takes initiative in planning for appropriate staffing and identifying appropriate space, equipment, and other resources needed to conduct study	4.70 (0.51)	4.10 (0.67)	0.71 (0.75)
Formulates with the help of others effective and innovative strategies to achieve goals and reformulates strategy as appropriate to address unexpected obstacles and/or new opportunities	4.82 (0.45)	3.71 (0.61)	1.10 (0.65)
Monitors results and team function continuously and makes adjustments when necessary as rapidly as possible	4.79 (0.41)	3.59 (0.79)	1.25 (0.92)
Delegates responsibilities appropriately while still maintaining oversight and performing systematic review of actions taken by others	4.65 (0.56)	2.71 (1.43)	2.01 (1.3)
Provides constructive critical feedback to members of the team discretely and at appropriate intervals	4.74 (0.68)	3.15 (1.21)	1.40 (0.82)
Appropriate use of resources and execution of study scale ($\alpha = 0.83$)	4.76 (0.42)	3.49 (0.66)	
<i>E. Regulatory accountability for Team Science Educators/Evaluators (TSE/E) + Mentors, and Scholars, and Mean Differences</i>			
Knows, understands, and transmits to team members' information about applicable regulations related to hospital accreditation, protection of human subjects, Good Clinical Practice (GCP), research sponsor requirements, FDA, New York State Department of Health, and Rockefeller University policies, as well as local, state, and federal laws	4.70 (.61)	2.81 (0.98)	2.02 (1.10)
Knows acceptable methods of data analysis and proper methods of transmission of data to regulatory agencies and to appropriate databases to comply with data-sharing responsibilities	4.87 (0.43)	3.29 (1.07)	1.62 (1.10)
Monitors results and team function continuously and makes adjustments when necessary as rapidly as possible	4.83 (0.38)	3.41 (1.08)	1.14 (0.90)
Creates financial plan in accord with University and sponsor requirements and oversees budget and payments	4.66 (0.54)	3.41 (0.79)	1.26 (0.98)
Understands responsibilities in protecting intellectual property and complies with University and sponsor requirements for invention disclosures	4.93 (0.27)	3.75 (0.96)	0.83 (0.98)
Regulatory accountability ($\alpha = 0.97$)	4.89 (0.32)	3.28 (0.93)	

Note: Scholar ratings less than or equal to 3.0 and TSE/E versus Scholar ratings greater than 1.0 are in **bold**.

TSE/Es, presented as the mean $\pm$ SD score for each competency, 2. an adjacent column with the Scholars' self-evaluation scores, 3. an adjacent column listing the difference in the aggregated score and the Scholar's score for each competency, and 4. free text, anonymized comments by the TSE/Es and mentor. After field testing the survey with one Scholar, we made minor revisions to the survey and to the REDCap administration platform.

The Return of Results process consists of the CTSA PI and the Director of the Clinical Scholars Program prereviewing the report to make sure that any negative comments are framed constructively. They then meet with the Scholar and the Scholars' mentor to review the findings and focus on identifying areas where the Scholar thinks she or he needs additional training or opportunities to develop the competencies. The review also focuses on comparing the Scholars' self-evaluation on each competency to the aggregate evaluation by the Scholar's primary mentor and all of the TSE/Es. Where appropriate, the group identifies additional resources or programs that may help the Scholar develop the competency. After the meeting, Scholars are asked to complete a short anonymous survey (Table 4) providing feedback on the value of participating in the survey and the Return of Results process.

The first administration of the competency survey was in the Fall of 2019, followed by a second administration in the Fall of 2020, which included the incoming scholars of the 2020 cohort.

Statistical Analysis

Means and standard deviations were calculated for each item using the 0–5 scale, which spanned from “Not At All Well” to “Extremely Well,” respectively, so that a higher score indicated a greater sense of competence of the item. If the TSE/E or mentor evaluators did not have a basis for making a judgment, they selected “Not Applicable” and the result was set to missing. Equal weighted scales for each domain were calculated if greater than 50% of the items in the scale were non-missing. Data from Scholars and TSE/Es were then merged to calculate item differences as the mean of the combined scores of the TSE/Es and mentor minus the Scholar score so that a positive difference indicated that the TSE/E and mentor scores were higher than the Scholar's score.

A Cronbach's alpha was computed for each subscale to assess the internal consistency and inform reliability. To help better understand the scale structure, a factor analysis with principal component dimension extraction followed by orthogonal rotation was employed within each domain. Subsequent scree plots of the eigenvalues were examined to assess the dimensionality of the subscales. All analyses were conducted in SAS Studio V94.

Results

A total of 31 Team Science Raters (which included TSE/Es and mentors) made a total of 115 ratings across 15 scholars (11 unique,

Table 4. Survey for clinical scholars to report the value of receiving results from the team science competency survey

1) Did you find the information of value in thinking about your Team Science Leadership skills?					
1 – Not at all	2	3	4	5	6 – Very valuable
2) Taking the evaluations as a whole, were you surprised by the evaluations?					
1 – Not at all	2	3	4	5	6 – Very surprised
3) Do you think that you will change any of the things you do as a team science leader based on the evaluation?					
1 – Definitely will not	2	3	4	5	6 – Definitely will
4) What do you think is the best way to return the evaluations to Clinical Scholars?					
A. In person by:					
1 – Program Director(s)					
2 – Mentor					
3 – Program Director(s) + Mentor					
B. Electronically by:					
1 – Program Director(s)					
2 – Mentor					
3 – Program Director(s) + Mentor					

4 rated twice). The number of TE/Es and mentors rating of the Scholars ranged from 2 to 11. All of the mentors evaluated their Scholars. The mentors' ratings were incorporated into the aggregated TSE/Es ratings to preserve anonymity. The average Cronbach's alpha coefficient was 0.85 (range 0.71–0.97), where cells with fewer items had predictably lower coefficients. Visual assessment of the scree plots from the exploratory factor analysis supports a single-factor solution within each domain, where the first eigenvalue of each scale accounted for greater than 50% of the variance and the second typically less than 15%.

Table 3A presents the nine items that comprise the Foundational Leadership Competency scale, along with the average ratings by TSE/Es–mentors and Scholars, and the average difference between the ratings. In general, the TSE/Es mentors scored the Scholars higher than the Scholars scored themselves; TSE/Es mentors thought Scholars excelled at “Developing and nurturing collaborations and external collaborations” and had the most room to improve in “Anticipating obstacles and devising strategies to overcome them”, while Scholars in general thought they excelled at “Creating a culture that values and supports diversity”, and in “Developing and nurturing collaborations and external relationships”, while they felt least competent in “Exploring opportunities for growth and development”. The largest disparity in ratings between TSE/Es–mentors and Scholars in this scale was in communication. The internal consistency of the scale as measured by Cronbach's alpha was 0.81.

Similarly, Table 3B presents the five items describing Professional Competencies. TSE/Es–mentor scores were uniformly high, and they uniformly rated the Scholars higher on these constructs than did the Scholars themselves, where the largest disparity was for the items describing the Scholars' commitment to staff education. The internal consistency of the scale as measured by Cronbach's alpha was 0.71.

Table 3C describes the characteristics for the 12 items comprising the Team Building and Team Sustainability scales. Here too,

TSE/Es–mentor scores were higher, with the highest positive discrepancy for two items describing communication skills, one for the articulation of vision and goals and the second for communicating with clinical teammates. The internal consistency of the scale as measured by Cronbach's alpha was 0.93.

Table 3D presents item characteristics for the six items representing the Appropriate Use of Resources and Execution of Study scale. The largest discrepancy between scores of TSE/Es mentors and Scholars was the item about delegation of responsibility. The internal consistency of the scale as measured by Cronbach's alpha was 0.81.

Table 3E describes the five items comprising the Regulatory Accountability Scale. TSE/Es–mentors believed scholars were much stronger on hospital regulations and policy than did the scholars. The internal consistency of the scale as measured by Cronbach's alpha was 0.97.

Table 5 presents the comments provided by scholars who completed the survey about their experiences in having the meeting with their mentor team and receiving the results of the evaluation. Overall, the comments reflected an appreciation for being exposed to these constructs in addition to the traditional clinical and research skills, and a recognition that these skills are key to a successful translational science career.

Discussion

Effective Team Science Leadership is vital to success of translational research, but few programs focus specifically on developing leadership skills in this area [3,11]. This paper describes our Team Science Leadership curriculum; the development of Team Science Leadership competencies for translational investigators leading multidisciplinary teams that develop and conduct human participant protocols; the value of having the Scholar, the Scholar's mentor, and a diverse group of TSE/Es evaluate the Scholar's progress in mastering the competencies; and the value of sharing the information with the Scholar for future career development planning. By having the Scholars rating themselves on entry and yearly thereafter and having the mentors and TSE/Es rating the Scholars at the end of each year in the program, we provide feedback in a timely way that allows the Scholars, mentors, and program leaders to individualize paths to attain the competencies by the time the Scholar graduates.

We converted the competencies into a semi-quantitative survey format and evaluated the psychometric characteristics of the survey responses. In general, the five resulting scales had high internal consistency and factor structure. Of note, evaluators tended to rate Scholars as being more competent across the range of leadership characteristics than the Scholars rated themselves. In reviewing the survey results with the Scholars, the leaders used these discrepancies to initiate conversations with the Scholars to better understand their perceptions and why they felt less confident about their competence than did the mentor and TSE/Es. This feedback was especially important in helping the Scholars develop self-confidence in their abilities. Overall, Scholars rated their participation favorably, commenting that it helped them appreciate better that Team Science Leadership skills are important in becoming successful translational scientists.

Our study has several limitations. First, while the survey was developed by people experienced in translational research, with input from and collaboration with experts from two other institutions, important competencies may be missing from the list or not optimally described. Moreover, our competencies focused on the

Table 5. Clinical scholar feedback after return of results

Item	Response
Did you find the information of value in thinking about your Team Science Leadership skills?	I felt this was a good exercise in self-evaluation. It made me reflect on my successes and failings with regard to Team Science Leadership. I had never thought about science leadership as a concept before. It helped me to understand the importance if this concept as scientific project becomes more complex and teams are growing larger. Additionally, it was valuable to identify my own strengths and weaknesses.
Taking the evaluations as a whole, were you surprised by the evaluations?	The comments were much more positive than expected. Parts of it likely come from differences in culture. I tend to underestimate my abilities and was surprised by the evaluation. The results also helped me to identify areas that I can work on with the goal to improve my science leadership abilities. I feel very appreciated in my daily work, but the results boosted my confidence and determination about being able to achieve my goals.
Do you think that you will change any of the things you do as a team science leader based on the evaluation?	I already changed some of my behavior. I will try to place more emphasize on Team Science Leadership in my projects. I appreciate that a scientific project requires a vision and leadership. The results highlighted that I under evaluated my skills, and I hope that they will result in me being able to present myself, my science, and my abilities with more confidence when looking for my next position.

leadership skills required to lead a clinical research protocol team, the central component of our training program, and thus may not address competencies required for research in other areas of the translational spectrum or at different points in a translational career. In addition, the survey was implemented at only our relatively small, basic science- focused institution. Therefore, both the results and Scholar experiences may be different at other institutions with a larger number of Scholars, with different Scholar recruitment and selection priorities, and different educational programs. In particular, some other KL-2 Scholar programs focus on junior faculty who are further along in their careers than our Scholars and so are already serving as team science leaders. To gain a broader perspective, we are currently collaborating with other academic institutions to gain additional experience on the generalizability of our findings. In addition, the factor structure, which supported single dimensions within scales, and the Cronbach's alphas, which describe fairly high-scale reliability, will need to be replicated with a larger and more heterogeneous sample before drawing generalizable conclusions. For statistical and psychometric purposes, it would be optimal to have all evaluators score all Scholars on all dimensions. However, as expected, not all TSE/Es had sufficient exposure or knowledge of the Scholars to rate them on all dimensions (e.g., a TSE/E who interacted with a Scholar only on regulatory issues or budgets may not be able to evaluate the Scholar's ability to express a vision), and so "missing" responses were common. Fourth, some TSE/Es did not complete all items on the survey, so it was not possible to discern whether this was due to an inability to rate or a failure to complete the survey. Finally, we consider the competencies a living document and so anticipate modifying the lists as we learn from our own experience and from collaborators at other institutions.

With these limitations in mind, the development, deployment, and results of the survey provide interesting information. First, the survey provides a starting point for discussing Team Science Leadership competencies for translational investigators who aspire to lead their own multidisciplinary groups. Second, the results of the survey provide information to Scholars based on

the perceptions of their mentor and an experienced group of TSE/Es, nearly all of whom have interacted with numerous Scholars during their careers, and who observe the Scholars in a wide range of roles required for translational success. Third, the results of the survey inform the elements we include in our training program on a yearly basis. One ancillary benefit is that by participating in the process, and reviewing the competencies, the Scholars' mentors undergo training in mentoring in Team Science Leadership.

Despite Scholars' abundant experience in being members of clinical and scientific teams, few have formally thought of themselves as Team Science Leaders. That is why we have integrated the survey into a much fuller curriculum in Team Science Leadership to ensure that Scholars develop these competencies.

We try to emphasize that we do not expect Scholars to master all of the team science competencies rapidly, but rather want to help them identify the key skills and attributes needed and intentionally plot a multi-year path to achieve the goal that can be incorporated into the Scholar's Individual Development Plan. We previously developed a Graduate Tracking Survey System (GTSS) [1,12] to assess the progress of our Scholars after graduation and it provides outcome data on our Scholars' success as translational science team leaders. Over time, by merging the process-based assessments generated by the survey with the outcome data from the GTSS, we hope to gain a better understanding of the factors that are associated with Team Science Leadership success. That information will help us craft curricula and assessments to optimize our program. We are eager to share our survey with other institutions as we continue to refine and modify the competencies, survey, and curriculum.

Conclusion

Our Team Science Leadership initiative highlights the importance of defining Team Science Leadership competencies. Training Scholars in those competencies by embedding them in an experiential and didactic curriculum focused on clinical and translational

science, measuring Scholars' attainment of the competencies over time using a quantitative survey, and providing periodic feedback to Scholars with the focus on ensuring that the Scholar masters the competencies by the end of the program. We are eager to share our materials with educators at other institutions to help refine the competencies and to enhance external validity and continuous improvement, as well as to help systematize Team Science Leadership skills measurement and training in translational science across the CTSA network.

Supplementary material. To view supplementary material for this article, please visit <https://doi.org/10.1017/cts.2021.838>.

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Disclosures. The authors have no conflicts of interest to declare.

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Envisioning a Transformed Clinical Trials Enterprise: Establishing an Agenda for 2030

A Virtual Workshop

January 26, February 9, March 24, and May 11, 2021

Clinical trials research has changed dramatically over the last decade. The biological, physical, and digital spheres are merging; clinical research and health care are at a critical juncture; new approaches enable the collection of data in real-world settings; and new modalities, such as digital health technologies and artificial intelligence applications, are changing possibilities for the conduct of clinical research. These opportunities hold great promise for advancing our understanding of health maintenance and prevention, disease progression, and developing new therapies for patients. At the same time, the clinical research enterprise is strained by rising costs, an evolving regulatory and economic landscape, increasing clinical trial complexity, difficulties in the recruitment and retention of research participants, and a clinical research workforce that is under tremendous stress. Some, but not all, of these challenges and opportunities were predicted in the 2011 National Academies workshop, *Envisioning a Transformed Clinical Trials Enterprise in the United States: Establishing an Agenda for 2020*. There is now a need for stakeholders from across the clinical research lifecycle to consider lessons learned from progress and setbacks over the past 10 years and broadly consider goals and key priorities for advancing a clinical trials enterprise that is more efficient, effective, person-centered, inclusive, and integrated into the health delivery system of 2030.

A planning committee of the National Academies of Sciences, Engineering, and Medicine will plan and conduct a virtual public workshop designed to consider a transformed clinical trial enterprise for 2030, featuring invited presentations and discussions on:

- Lessons learned from progress and setbacks over the past 10 years.
- How an envisioned 2030 clinical trials enterprise might differ from the current system.
- The following core themes in framing a 2030 agenda:
 - Diversity and inclusion of clinical trial participants
 - Convergence of clinical research and clinical practice
 - Clinical trial data sharing
 - Incorporation of new technologies into drug research and development
 - Workforce and career development
 - Public engagement and partnership
 - Regulatory Environment
 - Cultural and Financial Incentives
- Key priority challenges and opportunities when it comes to the 2030 clinical trials enterprise.
- Practical short- and long-term goals for improving the efficiency, effectiveness, person-centeredness, inclusivity, and integration with healthcare of the clinical trials enterprise.

The planning committee will organize the workshop, develop the agenda, select and invite speakers and discussants, and moderate or identify moderators for the discussions. A proceedings of the presentations and discussions at the workshop will be prepared by a designated rapporteur in accordance with institutional guidelines.

Planning Committee

Steven Galson (co-chair), Amgen

Esther Krofah (co-chair), FasterCures, Milken Institute

Amy Abernethy, (Formerly) Office of the Commissioner,
FDA

Anita LaFrance Allen, University of Pennsylvania

Christopher P. Austin, Flagship Pioneering

Howard A. Burris, Sarah Cannon

Luther T. Clark, Merck & Co., Inc.

Giselle Corbie-Smith, The University of North Carolina
at Chapel Hill

M. Khair ElZarrad, Center for Drug Evaluation and
Research, FDA

Jennifer Goldsack, Digital Medicine Society

Richard A. Moscicki, PhRMA

Amy Patterson, National Heart, Lung, and Blood
Institute, NIH

Joseph Scheeren, Critical Path Institute (*retired*)

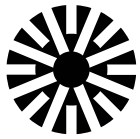
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REPORT | APRIL 7, 2022



Black Americans' Views of and Engagement With Science

Black Americans have largely positive views of medical researchers' competence; majority concerned about the potential for misconduct

BY **CARY FUNK**



(Getty Images)

How we did this ⊕

Science offers the promise to aid society in tackling its most pressing problems, lifting living standards, health and life expectancies. Learning about science can enrich people's lives in and outside of the classroom, and advances in scientific developments can spark amazement while transforming the ways we live and work.

A new Pew Research Center survey takes a wide-ranging look at Black Americans' views and experiences with science, spanning medical and health care settings, educational settings, and as consumers of science-related news and information in daily life.

The [COVID-19 pandemic](#) is a prominent reminder of the disparate health impacts Black Americans face, and of long-standing concerns about levels of trust or mistrust between scientists and Black communities.

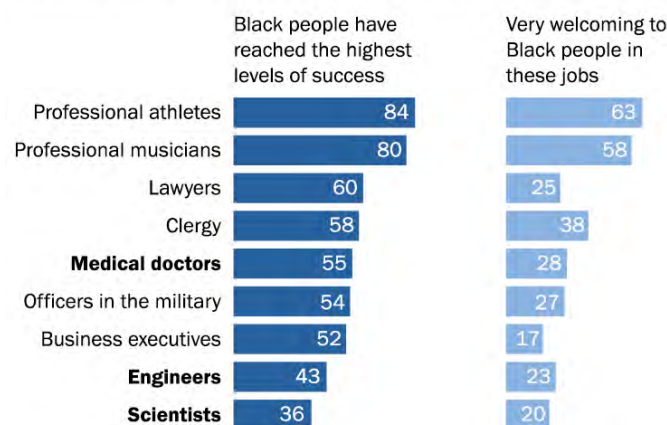
Against this backdrop, there are ongoing concerns that the segments of the public most engaged with science – people who attend science-related events, participate in medical research studies, and fill science, technology, engineering and math classrooms and the professional ranks of these fields – do not adequately reflect the racial and ethnic diversity of the nation.

The new survey, along with a series of focus groups, highlight the multifaceted views Black Americans hold when it comes to trust in medical research scientists. The findings speak to how contemporary experiences with the health care system, as well as past injustices, inform the range of attitudes Black adults express. In this and other topics addressed in the survey, there are important differences in how Black Americans see these issues depending on their education, age, gender and other characteristics.

The importance of representation for Black Americans is a through-line seen across the topics covered in the survey. A majority of Black Americans say more examples of Black high achievers in science, technology, engineering and math (STEM) would encourage more young Black people to pursue training in these fields. And issues around representation are at the center of doubts some focus group participants expressed about the openness of science-related professions to Black people.

Comparatively small shares of Black adults see science, engineering jobs as 'open' to Black people

% of Black adults who say the following about each professional group



Note: Respondents who gave other responses or who did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

"Black Americans' Views of and Engagement With Science"

PEW RESEARCH CENTER

Among the most telling findings are the limits Black adults perceive regarding the openness of scientists, engineers and medical doctors to Black people in these professions.

Relatively few Black adults believe that Black people have reached the highest levels of success as scientists (36%) or engineers (43%); a 55% majority say Black people have reached this level of success as medical doctors.

By contrast, large majorities of Black adults say Black people have reached the highest levels of success as professional athletes (84%) and musicians (80%). Six-in-ten say they have done this as lawyers and 58% say they have done this in the clergy.

Asked more directly to evaluate how welcoming these groups are to Black people in these jobs, just 20% of Black Americans say that scientists as a professional group are very welcoming of Black people. About four-in-ten (42%) say they are somewhat welcoming while 36% of Black Americans view scientists as not too or not at all welcoming to Black people in these jobs.

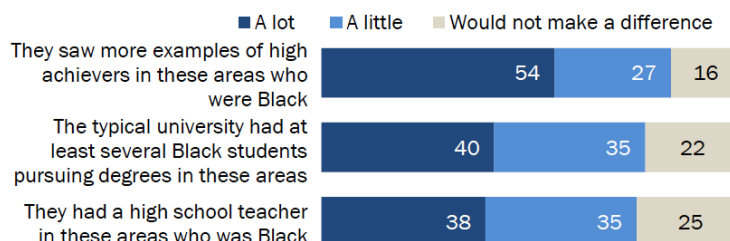
Perceptions of engineers are quite similar, with 23% saying this group is very welcoming to Black people in these jobs. Medical doctors fare only slightly better; 28% see them as very welcoming to Black people in their field.

STEM professions are not alone in this sense of being seen as no more than "somewhat" welcoming to Black professionals. Still, scientists and engineers received among the lowest ratings for openness to Black people across the nine professional groups included in the survey.

The survey findings also call attention to how ²⁵⁸visible Black achievement in STEM professional roles could potentially attract more young Black people to training programs in these fields.

54% of Black adults see a spur to more young Black people in STEM from more role models, high achievers

% of Black adults who say young Black people would be ____ more likely to pursue college degrees in STEM if ...



Note: Respondents who did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

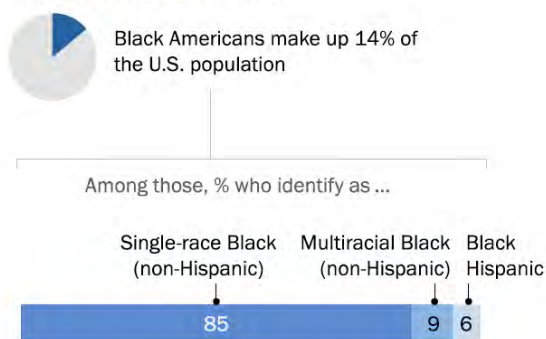
"Black Americans' Views of and Engagement With Science"

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A 54% majority says young Black people would be a lot more likely to pursue college degrees in STEM if there were more examples of high achievers in these areas who were Black; another 27% say this would help a little.

Black adults with a postgraduate (75%) or a college degree (73%) are especially likely to think that more examples of Black achievement in STEM would make young Black people a lot more likely to pursue degrees in these fields.

Smaller shares see other potential factors considered in the survey as critical. Although, majorities of Black Americans say that having a cohort of Black students pursuing degrees in these subjects at the typical university would help at least a little to attract more young Black people to these programs. A similar share say the same about having a Black high school teacher in STEM subjects. Views on this factor were about the same among the roughly half of Black Americans who report having this experience and the half who did not.

U.S. Black population

Note: Population figures include children and adults.
 Source: Pew Research Center analysis of 2020 American Community Survey (IPUMS).
 "Black Americans' Views of and Engagement With Science"

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Analysis of the survey focuses on Black Americans, including those who identify as single-race Black, multiracial Black, and Black Hispanic.¹

The survey was conducted Nov. 30 to Dec. 12, 2021, and included 3,546 Black adults; findings based on all Black adults surveyed have a margin of error of plus or minus 2.8 percentage points.

Previous Center findings highlight instances where views about science and scientists among Black adults are less positive than those of other racial and ethnic groups. A separate survey conducted in November 2021 finds about half of Black Americans (52%) say that science has had a mostly positive effect on society, compared with greater shares among White (68%) and Hispanic (62%) Americans. Among Black adults, 43% say that science has had an equal mix of positive and negative effects, and just 5% say the effect of science has been mostly negative.

This study aimed to better understand such differences. The survey casts a wide net across the key ways in which people experience and connect with science. The approach was informed by a panel of advisers with expertise on Black and Hispanic views and experiences in American society broadly, and in connection with science, health and STEM education.

The questions asked in the survey were also informed by a set of six focus groups conducted virtually in July 2021 among Black adults that elicited views about the COVID-19 pandemic and experiences and beliefs about the health and medical care systems, as well as people's interests in science topics and their past experiences with STEM schooling.

Subsequent reports will provide an in-depth look at the views and experiences of Hispanic Americans and a broader look at public opinion among the general U.S. population.

Many Black Americans express trust in ²⁶⁰scientists and medical scientists; majorities also see potential for research misconduct, have concerns about researcher accountability

Most Black adults say they have either a great deal (28%) or a fair amount (50%) of confidence in medical scientists to act in the public's best interests. About two-in-ten (21%) say they have not too much or no confidence in medical scientists.

Black Americans' trust in medical scientists, as well as that for scientists, fell over the past year, as it also did among the [general public](#). Even so, Black Americans' trust in medical scientists is greater than that for other major groups and institutions including the military, K-12 public school principals and religious leaders.

As people think about different facets of trustworthiness, a majority of Black Americans lean toward trusting medical researchers' competence, their care for the public's interests, and the information they provide about their research. A third of Black Americans say that medical researchers do a good job all or most of the time and another 46% say this occurs some of the time. Roughly two-in-ten (18%) say this happens only a little or none of the time.

At the same time, notable shares of Black adults express doubt about how often medical researchers admit and take responsibility for their mistakes. Just one-in-ten Black adults say that medical research scientists do this all or most of the time; 47% say this occurs at least some of the time. Half say this happens only a little or none of the time. Over the last few years, Black adults have become less confident that medical researchers admit mistakes and take responsibility for them; the share who say this happens at least some of the time is down 19 points since 2019.²

In the new Center survey, 55% of Black adults describe misconduct by medical research scientists as a moderate or very big problem – a share that continues to be a bit higher than that of U.S. adults overall.

The legacy of egregious medical misconduct in the [U.S. Public Health Service Syphilis Study at Tuskegee](#), commonly known as the Tuskegee syphilis study, continues to resonate widely among Black Americans. Three-quarters of Black Americans say they have heard a lot (49%) or a little (26%) about the federal government's study on syphilis, which withheld treatment from Black men, leading to preventable deaths and a worsening of symptoms among those study participants.

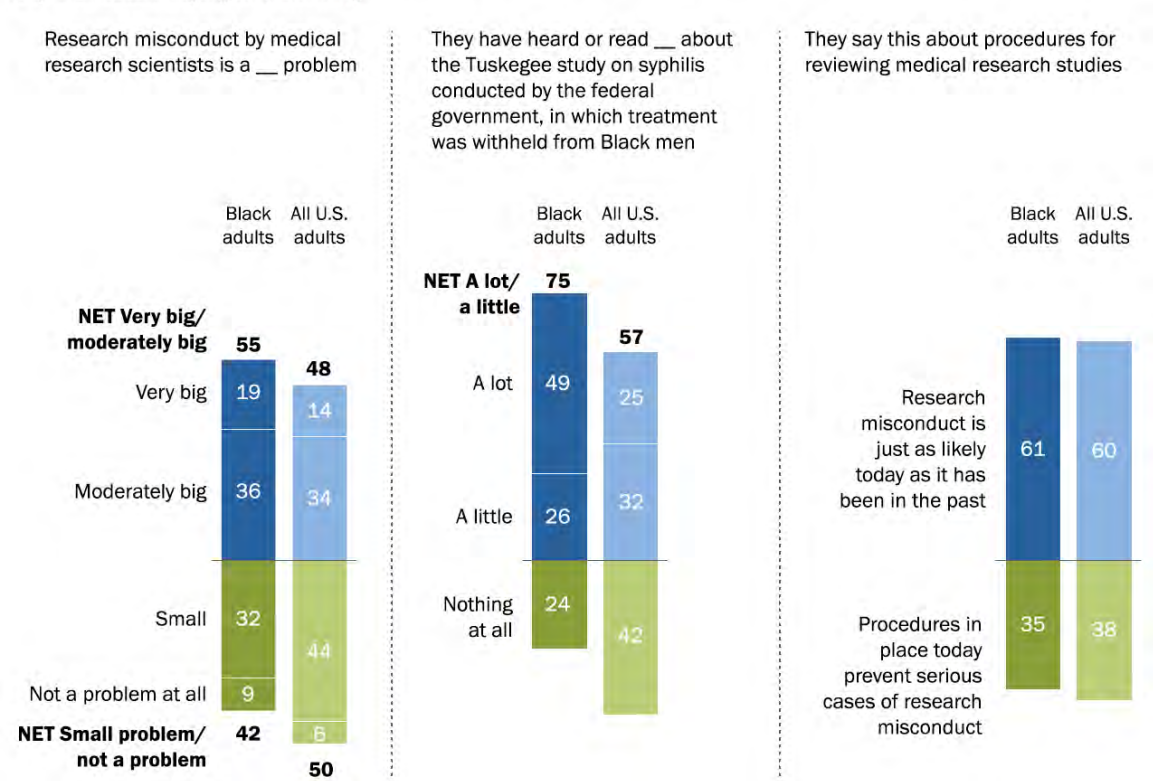
Older Black adults have the highest level of familiarity the Tuskegee syphilis study, but a majority of those under age 30 say they know at least a little about the study.

Awareness of the Tuskegee study is far lower among U.S. adults overall: A quarter say they know a lot about the study, while another 32% say they know at least a little about this

study.

Majorities of Black Americans are familiar with misconduct in the Tuskegee study, have concerns about ongoing potential for serious cases of research misconduct

% of U.S. adults saying the following



Note: Respondents who did not give an answer are not shown.
Source: Survey conducted Nov. 30-Dec. 12, 2021.
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Black Americans have a cautious outlook toward medical research going forward. About six-in-ten (61%) believe that serious cases of misconduct in medical research are just as likely today as they have been in the past. A smaller share (35%) says there are procedures in place today to prevent serious cases of research misconduct. Black Americans' views on these issues are virtually identical to those of the general population.

The Center survey was conducted more than two years into a pandemic which had disproportionate health effects on Black Americans. As stark evidence, the most recent estimates from the [U.S. Census Bureau](#) projects life expectancy at 71.8 years for Black Americans, the lowest since 2000 and below the estimates for other racial and ethnic groups.

When asked to consider potential factors responsible for differences in health outcomes for Black people, 63% of Black adults view less access to quality medical care in the area they live to be a major reason why Black people in the U.S. generally have worse health outcomes than other adults.

Majorities also view a range of other factors²⁶² as playing at least a minor role, including more environmental problems in communities where Black people live, a greater likelihood of preexisting health conditions among Black people, and health care providers being less likely to give Black people the most advanced care.

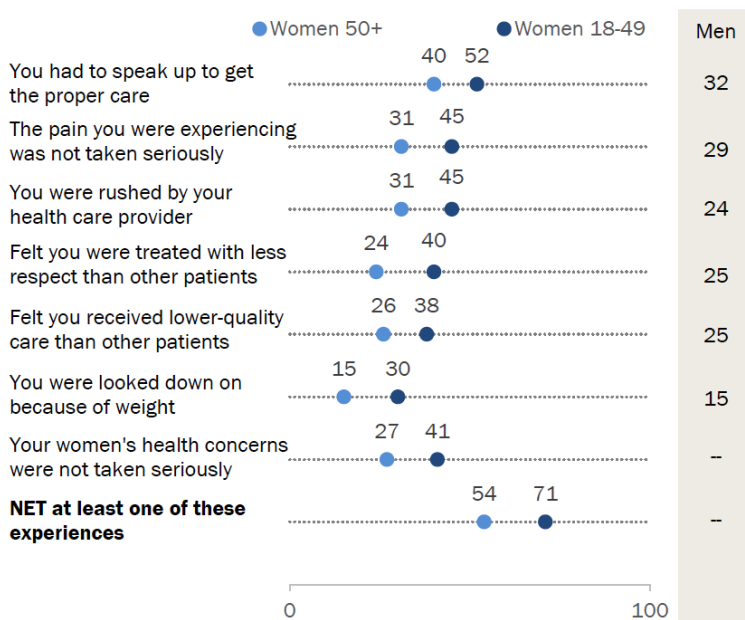
In their own clinical care experiences, 61% of Black adults give their health care provider positive marks – either excellent or very good – for the care they’ve received most recently.

Still, 55% of Black adults say they’ve had at least one of several negative experiences with health care providers in the past, such as feeling they had to speak up to get the proper care or that the pain they were experiencing was not being taken seriously.

In this regard, Black Americans’ experiences with medical care are similar to those of all U.S. adults, 58% of whom say they have had at least one of these negative experiences with health care providers in the past.

Younger Black women more likely to have had a range of negative health care experiences

% of Black adults who say they have ever experienced the following problems when dealing with doctors or other health care providers



–Indicates data not applicable.

Note: Respondents who gave other responses or did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

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The views and experiences of younger Black women, ages 18 to 49, stand out in a number of ways. This group is particularly likely to report having at least one of seven kinds of negative experiences with routine health care in the past (71% say this).

They are also more likely than other Black adults²⁶³ to say they would prefer to see a Black health care provider for routine care: 45% say this, while 50% say it makes no difference to them.

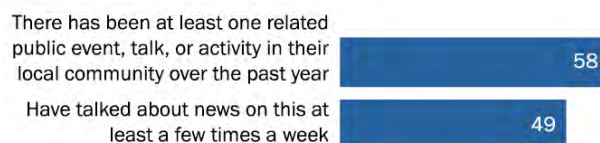
And larger shares of younger Black women say that Black health care providers are generally better than others at looking out for their best interests (41%), taking their symptoms seriously (40%) and treating them with respect (39%).

Majorities of older Black women and Black men across age groups say it makes no difference whether they see a Black doctor for routine care. No more than three-in-ten in each of these groups consider Black health care providers better than other providers at looking out for their interests, taking their symptoms seriously or treating them with respect. Majorities view Black healthcare professionals as about the same as others at providing key aspects of medical care.

The coronavirus outbreak and COVID-19 vaccine news has engaged many Black adults; a majority saw or heard about events related to the outbreak in their local area

Majorities of Black Americans have engaged with COVID-19 information

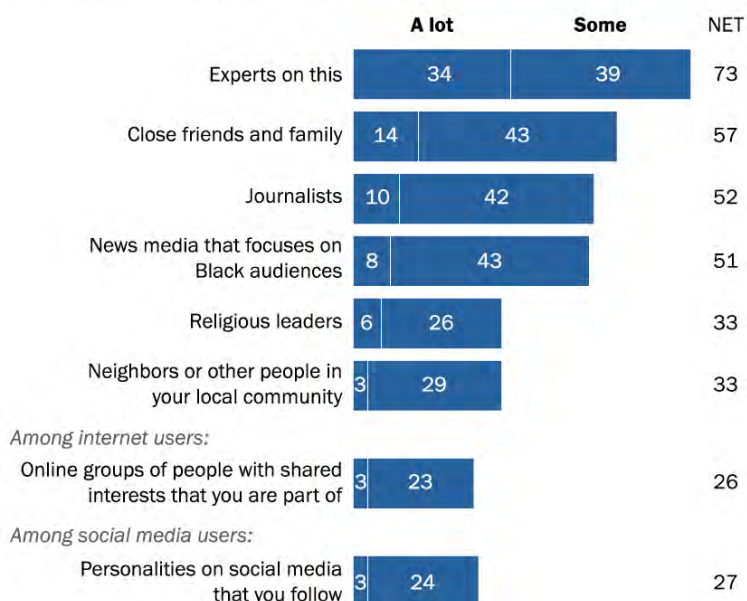
% of Black adults who say the following about the coronavirus outbreak and COVID-19 vaccines



Among social media users:



% of Black adults who say they can rely ____ on information from each source about the coronavirus outbreak and COVID-19 vaccines



Note: Respondents who gave other responses or who did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

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Amid the coronavirus pandemic and concerns about the omicron variant, a majority of Black Americans (58%) said in December 2021 that they heard about at least one public event or activity related to the outbreak or COVID-19 vaccines in their local community. Roughly half (49%) said they talked about related news at least a few times a week. Among those on social media, 57% said they had seen coronavirus-related content in the past few weeks.

The findings suggest a relatively engaged Black American public. Figures among all U.S. adults are roughly similar, although an even larger share of all U.S. adults on social media said they had seen coronavirus-related content in the past few weeks (68% compared with 57% of Black social media users).

About seven-in-ten Black Americans say they²⁶⁵ can rely on information from experts on the coronavirus outbreak and vaccines either a lot (34%) or some (39%).

A majority (57%) also say they can rely on information from close family and friends about this at least some. About half of Black adults say this about information from journalists (52%) or news media that focus on Black audiences (51%).

Fewer say they can rely at least some on information about the coronavirus from other groups. Among Black internet users, roughly a quarter say they can rely at least some on information related to the outbreak and COVID-19 vaccines from online groups with shared interests that they are part of, and just 3% say they can rely on information from such groups a lot.

Black adults' recollections of their own experiences in STEM education present a mixed picture of encouragement and acceptance, especially for those in STEM jobs today

Black adults remain [underrepresented in the STEM workforce](#), with little sign that the educational pipeline will offer near-term improvements.

The survey asked those with a high school diploma or more education to consider their most recent experiences with classwork in a science, technology, engineering or math subject as one way to gauge the degree to which people encounter potential encouragements or discouragements in the educational system. Across the set of six questions, larger shares of Black Americans recalled at least one of three positive experiences than any of three negative ones.

Looking at Black adults working in STEM jobs today with a college or postgraduate degree – a group that is more likely to have taken high-level classes in STEM – 81% say they recall at least one of three positive experiences in their classes. About seven-in-ten (69%) say someone made them feel excited about their abilities in these areas, 68% say someone helped them see ways that these subjects could be useful in their job or career and 59% say someone specifically encouraged them to keep taking classes in these subjects.

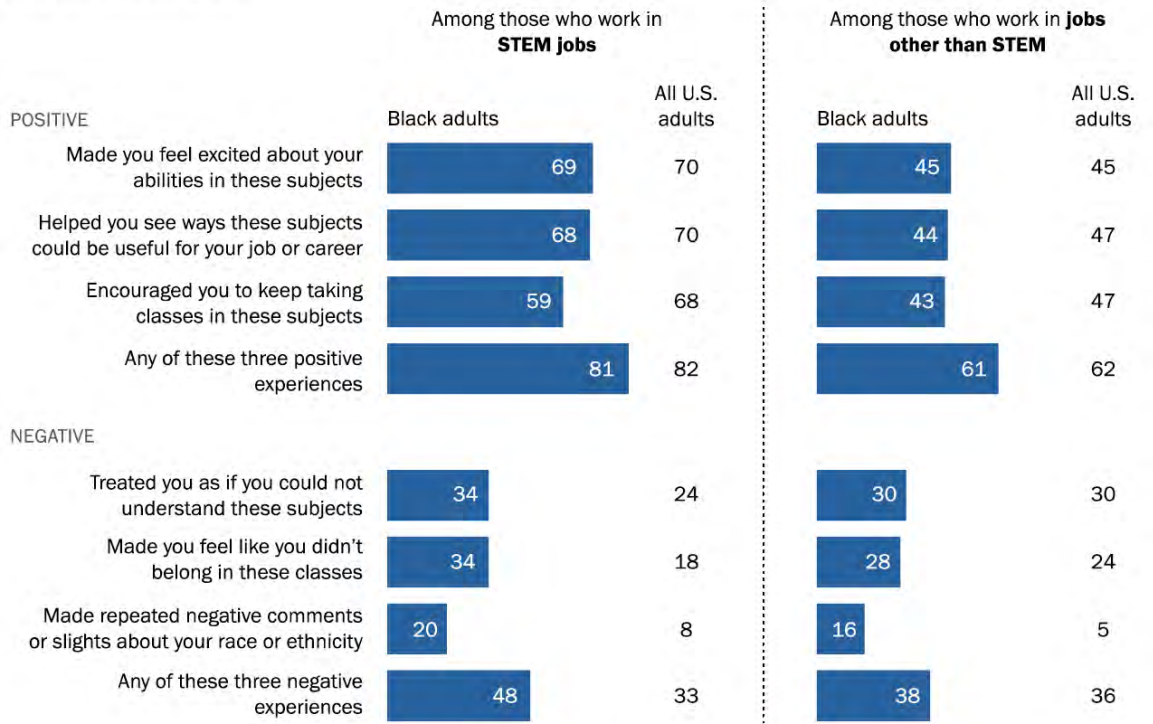
A smaller majority of Black college graduates working in non-STEM jobs (61%) recall at least one of these three positive experiences.

Among all U.S. adults with a college degree or more education, those working in STEM jobs are about equally likely to say they have had at least one of these three positive experiences. This group is somewhat more likely to say that someone encouraged them to keep taking STEM classes, however (68% vs. 59% among Black college graduates working in STEM).

Black college graduates working in STEM are ²⁶⁶more likely than all STEM workers – regardless of their racial or ethnic background – to recall some kind of mistreatment in their most recent STEM schooling (48% vs. 33%). Roughly a third of Black college graduates in a STEM job say that someone treated them as if they could not understand these subjects or made them feel as if they didn’t belong in these classes (34% each). Two-in-ten say that someone made repeated negative comments or slights about their race or ethnicity. The survey cannot speak to whether such experiences originated from interactions with teachers, counselors, students or other contextual aspects of these experiences.

Large majority of Black college graduates working in STEM jobs can recall a positive experience in STEM classes from their most recent school experience

Among employed adults with a college degree or more education, % who say in their most recent STEM schooling, they had someone who ...



Note: Based on employed adults with a college degree or more education. Respondents who gave other responses or did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.
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These findings are in line with a [2017 Center survey](#) which found 62% of Black STEM workers saying they had experienced at least one of eight forms of racial or ethnic discrimination in the workplace. This was greater than the shares of Black workers in non-STEM jobs (50%) and greater than the shares of Asian (44%), Hispanic (42%) and White STEM workers (13%) who said the same.

Next: 1. Black Americans’ views of education and professional opportunities in science, technology,

-
1. For more on the demographics of the U.S. Black population, see “[The Growing Diversity of Black America](#).” The number of immigrants to the U.S. who are Black has been [growing in recent years](#) (10% of the total Black population, including children and adults, as of 2019). ↩
 2. Findings in 2019 are based on Black adults who identify as a single race. The decline in Black Americans’ trust that medical researchers admit and take responsibility for their mistakes remains statistically significant when based on single-race Black adults. More details are provided [in the Topline](#). ↩
-



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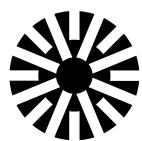
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REPORT | JUNE 14, 2022



Hispanic Americans' Trust in and Engagement With Science

Increasing representation in science seen as important for attracting more Hispanic people to science

BY [CARY FUNK](#) AND [MARK HUGO LOPEZ](#)



(Getty Images)

How we did this ⊕**Terminology** ⊕

Hispanic Americans are one of the [fastest growing](#) groups in the nation, a trend that now extends far beyond historic Hispanic population centers to every region and state across the nation. Hispanic Americans are a diverse population, tracing their roots to the island of Puerto Rico, Mexico and more than 20 other nations across Central and South America, with experiences and views about American society often differing widely depending on whether they were born in the United States or immigrated to the country.

A new Pew Research Center survey, accompanied by a series of focus groups, takes an in-depth look at Hispanic Americans' views and experiences with science spanning interactions with health care providers and STEM schooling, their levels of trust in scientists and medical scientists, and engagement with science-related news and information in daily life.

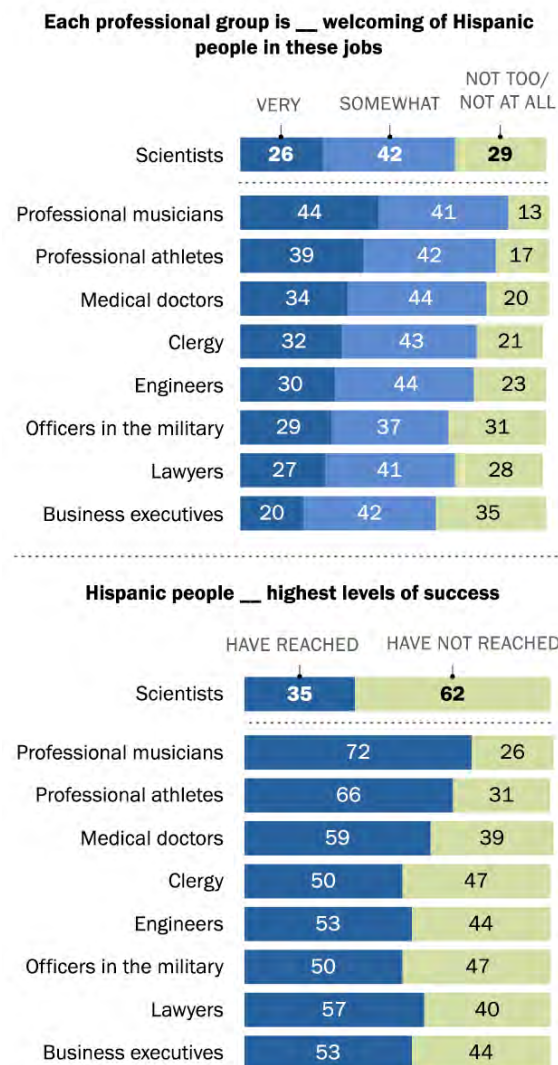
Hispanic adults hold largely trusting views of both medical scientists and scientists to act in the public's interests. Hispanic adults' encounters with the health and medical care system are varied, reflecting the diverse nature of the U.S. Hispanic population across characteristics such as nativity, language proficiency, gender, age and education.

Representation is a theme seen across issue areas in the new survey and the data underscores some of the challenges Hispanic adults view – and report experiencing – when it comes to increasing Hispanic representation and engagement with science and allied fields.

Hispanic Americans are glaringly underrepresented among the ranks of scientists and those in allied professions. Hispanic adults make up [17% of the U.S. workforce](#) but just 8% of those working in a science, technology, engineering or math (STEM) job. Since 2010, there has been an increasing share of Hispanic students attending and graduating from college as well as a rise in the share earning a bachelor's degree in a STEM field. Even so, Hispanic students remain underrepresented among college graduates and among master's and doctoral degree-earners in STEM.

Relatively few Hispanic adults see scientists as welcoming to Hispanic professionals in these jobs

% of Hispanic adults who say ...



Note: Respondents who did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

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The survey findings suggest that most Latinos see scientific professions as potentially “unwelcoming” to Latino people. For example, just 26% of Latinos feel that scientists as a professional group are very welcoming of Latinos in these jobs; another 42% say they are somewhat welcoming. About three-in-ten (29%) view scientists as not too or not at all welcoming of Latinos in their ranks.

Perceptions of medical doctors’ openness toward Latino colleagues are slightly better: roughly a third describe medical doctors as very welcoming of Latinos in these jobs (34%). While scientists are not the only professional group that Latinos view as less than very welcoming, perceptions of scientists are among the lowest measured across the nine groups included in the survey.

Hispanic adults also express a sense that ²⁷³Hispanic people are not visible at the highest levels of success in science careers. About six-in-ten say that Hispanic people *have not* reached the highest levels of success as scientists; fewer (35%) believe that they have.

Perceptions of Hispanic achievement as engineers and medical doctors are relatively more positive: 53% and 59%, respectively, think Hispanic people have reached the highest levels of success in these professions.

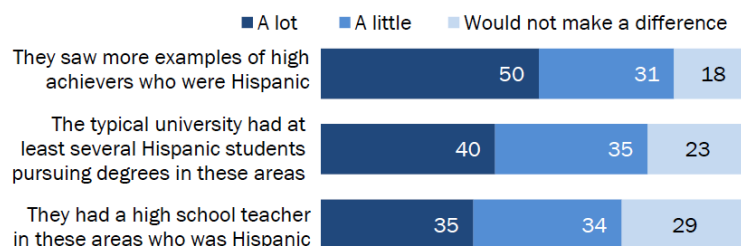
One focus group participant put the connection between representation and trust this way:

“I think we need to know more Latino scientists. I think ... well, actually, I don’t know any Latino scientists that I would say, “Oh yes. That’s that scientist ... So maybe if we knew some scientists that made a discovery that was Latino we would trust science more.” – Latina, age 25-39

The survey highlights greater visible achievement among Hispanic Americans as a potential driver of STEM engagement among Hispanic Americans, including the pursuit of college degrees in these fields.

Half of Hispanic adults think having more Hispanic high achievers in STEM would help a lot to attract more to these degree programs

% of Hispanic adults who say young Hispanic people would be ___ more likely to pursue college degrees in STEM if ...



Note: Respondents who did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

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A large majority of Hispanic adults say that seeing more examples of high achievers in STEM who are Hispanic would help a lot (50%) or a little (31%) to encourage more young Hispanic people to pursue college degrees in STEM fields.

Majorities also say young Hispanic people would be at least a little more likely to pursue college degrees in STEM if the typical university had at least several Hispanic students in STEM degree programs and if Hispanic students had a high school STEM teacher who was Hispanic.

A sizable share of Hispanic college students are the ²⁷⁴ [first in their immediate family to attend college](#). The survey finds first-generation Hispanic college students are especially likely to view representation in the form of more examples of high-achieving Hispanic people in STEM as a catalyst for greater engagement: 60% think this would make young Hispanic people a lot more likely to pursue STEM degree programs.

When thinking about ways to increase engagement with science among Hispanic Americans, focus group participants frequently raised the issue of representation.

“More of us. We need to see more of our people.” – Latino, age 25-39

“Just that, incorporate more Latino people in it, starting with school, involve kids in technology and science, and develop more projects about strategies, those type of things, for the kids to get more interested and see it more like a game and therefore begin to have a love for science.” – Latina, age 40-65

Past experiences with STEM schooling can play a pivotal role in whether or not people engage with science or pursue further training or a job in STEM. The survey paints a mixed picture when it comes to Latinos' past experiences in the classroom.

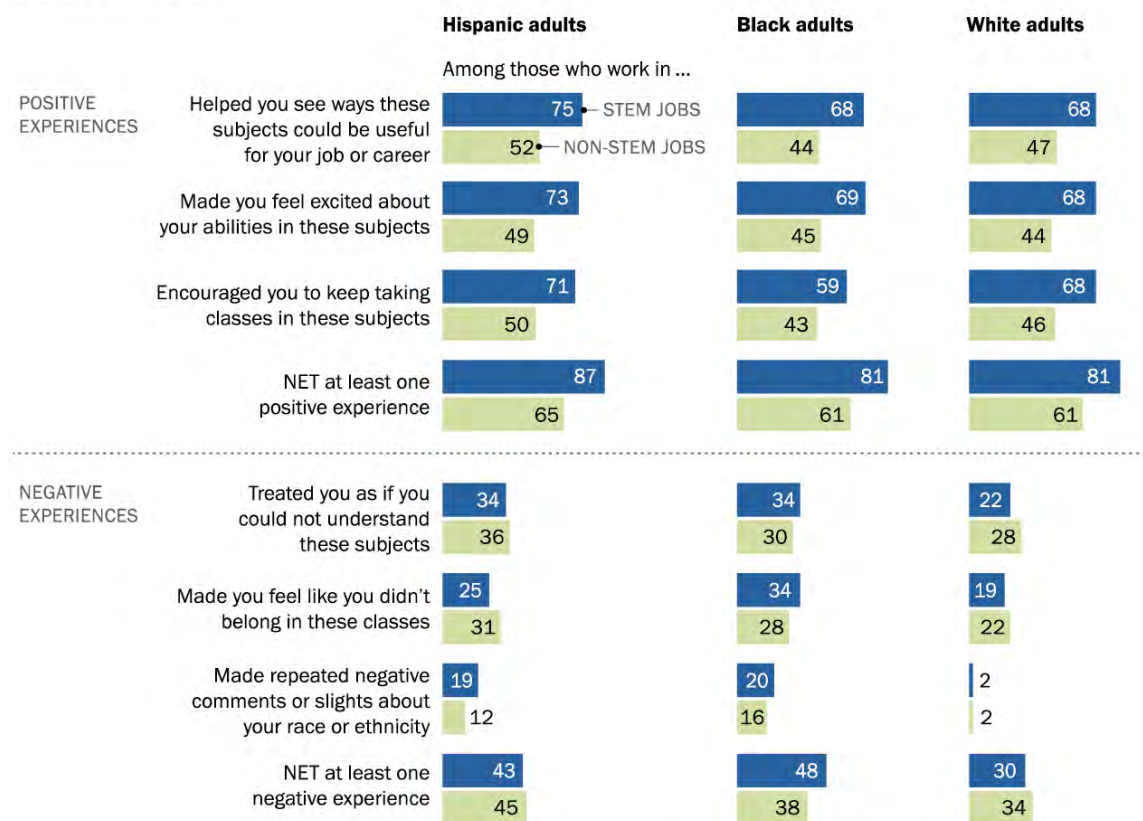
Most Hispanic college graduates working in STEM fields can recall positive experiences from their most recent educational experiences in science, technology, engineering and math – such as someone who encouraged them to keep taking classes in these subjects.

However, Hispanic college graduates working in STEM jobs are significantly more likely than non-Hispanic White college graduates in these positions to say they faced mistreatment in their most recent STEM schooling. For instance, 34% say they can recall someone treating them as if they could not understand the subject matter – significantly higher than the share of non-Hispanic White adults working in STEM who say this (22%).

In all, 43% of college-educated Hispanic STEM workers say they had at least one of the three negative experiences asked about in the survey. The experiences of Hispanic college graduates in this regard are similar to those of Black college graduates, who are also far more likely than non-Hispanic White college graduates to recall any of these three negative experiences in their STEM schooling.

Hispanic college graduates working in STEM are more likely than their non-Hispanic White counterparts to recall mistreatment in STEM schooling

Among employed adults with a college degree or more education, % who say in their most recent STEM schooling, they had someone who ...



Note: Respondents who gave other responses or did not give an answer are not shown. Hispanic adults includes those of any race. Black adults refers to all those who self-identify as Black (inclusive of those who identify as single-race, multiracial and Black Hispanic). Those who self-identify as both Hispanic and Black are included among both Hispanic adults and Black adults. White adults refers to those with a single-race identity as White and non-Hispanic.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

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The survey, conducted Nov. 30 to Dec. 12, 2021, includes 3,716 Hispanic adults; findings based on all Hispanic adults surveyed have a margin of error of plus or minus 2.6 percentage points.

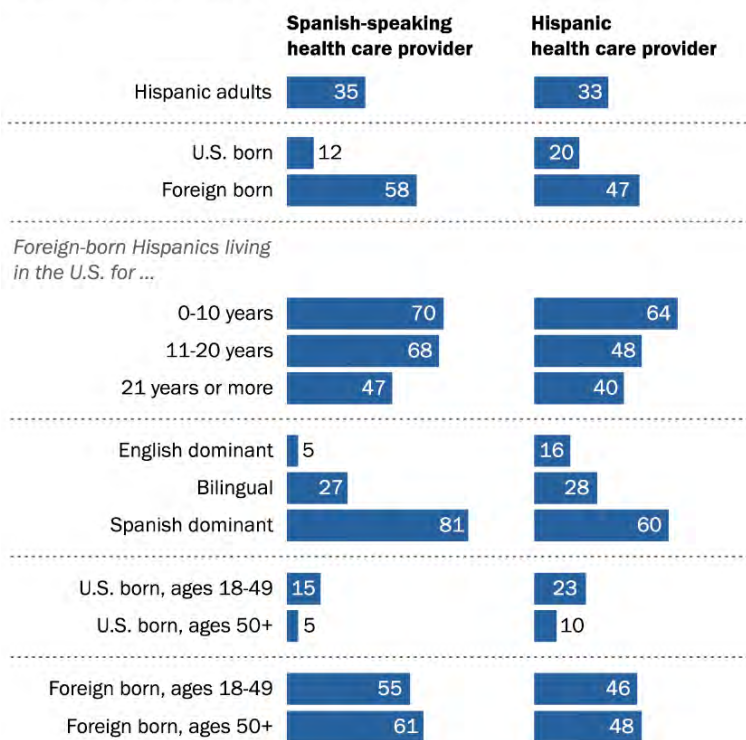
The questions asked in the survey were informed by a set of six focus groups among Hispanic adults, conducted virtually in July 2021, that elicited views about the COVID-19 pandemic, experiences and beliefs about the health and medical care systems, as well as people's interests in science topics and their thoughts about ways to increase trust and engagement with science in Hispanic communities. The study also drew guidance from a panel of advisers with expertise on Hispanic and Black Americans' views and experiences in American society broadly and in connection with science, health and STEM education.

A common theme recurring in both focus group discussions and conversations with the expert advisory panel was how the diversity of the U.S. Hispanic population is central to experiences with science across all aspects of society.

The survey data reveal these differences by characteristics such as nativity and language proficiency across science topics, but they appear especially central to Hispanic Americans' interactions with and views about medical care.

About a third of Hispanic adults say they would prefer a health care provider who speaks Spanish

% of Hispanic adults who say they would strongly or somewhat prefer a health care provider for routine care who is a ...



Note: Respondents who gave other responses or did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

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For instance, while the share of Latinos with health insurance is up over the last decade, Latino immigrants remain less likely than those born in the U.S. to have health insurance. Latino immigrants (especially those who have been in the country for 20 years or less) also are less likely than other Latinos to say they have seen a health care provider in the past year or that they have a primary care provider who they usually turn to when they are sick or need health care.

The interconnected characteristics of nativity and language proficiency are major factors shaping preferences in seeking out health care. Foreign-born Hispanic adults – a group that is much more likely to be Spanish-language dominant – are far more likely than those born in the U.S. to say they prefer to see a Spanish-speaking health care provider (58% to 12%) and to prefer a Hispanic provider (47% to 20%).

Underscoring issues of representation in the medical profession, just 7% of all physicians and surgeons are Hispanic, [according to a Center analysis of federal government data](https://www.pewresearch.org/science/2022/06/14/hispanic-americans-trust-in-and-engagement-with-science/), far

lower than the share of Hispanics in the overall²⁷⁷ workforce.

When it comes to negative experiences with health care, 52% of Latino adults say they've had at least one of six negative experiences with health care providers in the past – such as having to speak up to get the proper care. In this, experiences of Latino adults are more similar than different to those of all U.S. adults.

However, the relatively small share of Hispanic Americans who identify their race as Black (3%) are much more likely than Hispanic Americans who identify as White or as some other race to report negative health care interactions. A large majority of Black Hispanic adults (69%) say they've faced one of six negative experiences with health care providers, such as feeling that the pain they were experiencing was not being taken seriously. By contrast, a smaller share of White Hispanic adults (50%) say they've had one of these six negative experiences with doctors or other health care providers.

Trust in medical scientists and engagement with COVID-19 news and information

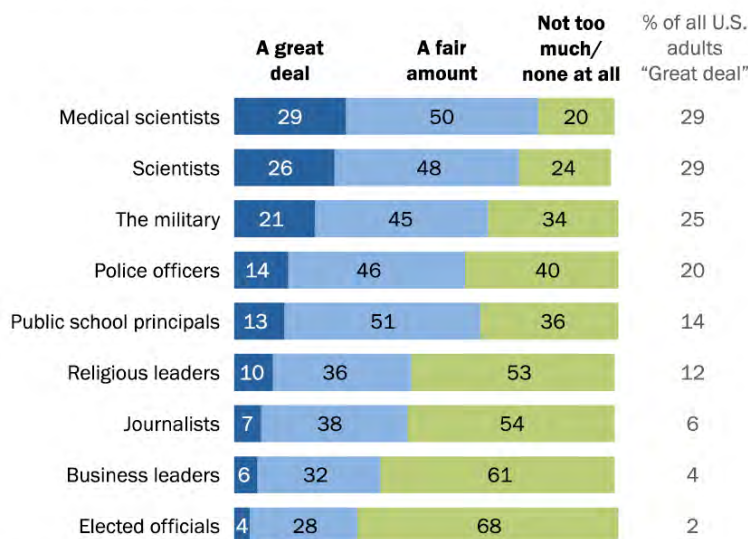
The coronavirus pandemic and the development of COVID-19 vaccines has put renewed focus on public levels of trust in medical scientists and scientists, especially in the Hispanic population that has faced [disparate health impacts](#) from COVID-19.

Hispanic adults hold largely trusting views of both medical scientists and scientists to act in the public's interests. About three-in-ten Hispanic adults (29%) hold a strong level of trust in medical scientists, saying they have a great deal of confidence in them to act in the public's best interests. Half say they have a fair amount of confidence in medical scientists, while 20% express more negative views, saying they have not too much or no confidence in medical scientists.

Trust in scientists is similarly positive. A large majority of Hispanic Americans have either a great deal (26%) or a fair amount (48%) of confidence in scientists to act in the public's best interests. (Half of the survey respondents were asked for their views of medical scientists and half were asked for their views of scientists, generally.)

About three-in-ten Hispanic adults have a great deal of confidence in medical scientists

% of Hispanic adults who have ___ of confidence in the following groups to act in the best interests of the public



Note: Respondents who did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

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Hispanic Americans' trust in medical scientists and scientists is higher than it is for other groups and institutions, including the military, police officers and K-12 public school principals.

Still, as with the [general population](#), Hispanic Americans' confidence in medical scientists is down from earlier in the coronavirus pandemic. In April 2020, 45% of Hispanic adults had a great deal of confidence in medical scientists. That figure was 30% in November 2020 and is roughly the same (29%) in the current survey. Similarly, confidence in scientists has also fallen since the early stages of the coronavirus outbreak.

As with views of scientists in the general population, Hispanic adults with a college degree or more education are generally more trusting of medical scientists and scientists than those with less education. Hispanic Democrats tend to hold more trusting views of these groups than do Hispanic Republicans – in line with partisanship patterns seen among all U.S. adults.

Hispanic Americans' broadly positive views of scientists are consistent with the reliance they report on experts to make sense of news about the coronavirus and COVID-19 vaccines.

Hispanic adults express broad engagement with coronavirus news and information; the survey was fielded in December 2021, amid a surge of coronavirus cases stemming from the omicron variant. About half of Hispanic adults (47%) say they talked about

coronavirus-related news nearly every day or ²⁷⁹a few times a week. Among social media users, 73% of Hispanics report having seen coronavirus content in the past few weeks. These levels of engagement with coronavirus news and information among Hispanic adults are similar to those seen among all U.S. adults.

Most Hispanic Americans say they can rely on experts for COVID-19 news and information

% of Hispanic adults who say they can rely on each of the following sources for information about the coronavirus outbreak and vaccines

	A lot	Some	NET
Experts	38	36	74
Close friends and family	16	41	58
News media focusing on Hispanic audiences	15	36	51
Journalists	11	40	51
Religious leaders	7	31	38
Neighbors or other people in their local community	7	27	34
<i>Among internet users:</i>			
Online groups of people with shared interests that you are part of	7	24	31
<i>Among social media users:</i>			
Personalities on social media that you follow	6	24	31

Note: Respondents who gave other responses or did not give an answer are not shown.

Source: Survey conducted Nov. 30-Dec. 12, 2021.

"Hispanic Americans' Trust in and Engagement With Science"

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Changes to public health guidance and information about the coronavirus outbreak and vaccines have proven [confusing to many Americans](#). When asked about potential sources of coronavirus information, Hispanic Americans are more likely to say they can rely on information from experts than any of seven other sources considered in the survey.

Roughly three-quarters of Hispanic adults (74%) say they can rely on information from experts in this area either a lot or some; 21% say they can rely on experts not too much or at all.

Close friends and family also play a prominent role when it comes to information about the COVID-19 outbreak and vaccines: 58% of Latinos say they can rely on close friends and family a lot or some.

About half of Latinos say the same about information on this topic from journalists and from news media focused on Latino audiences. Smaller shares say they can rely on other sources for information about the coronavirus outbreak and vaccines, including religious leaders and neighbors.

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