



BUILDING THE BIOWORKFORCE OF THE FUTURE

**EXPANDING EQUITABLE PATHWAYS INTO
BIOTECHNOLOGY AND BIOMANUFACTURING JOBS**

JUNE 2023



THE WHITE HOUSE
WASHINGTON

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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://coecc.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>

<p>Examples include:</p> <ul style="list-style-type: none"> - Pharmaceutical products like vaccines - Medical devices 	<p>Examples include:</p> <ul style="list-style-type: none"> - Genetically modified crops and animals - Improving plant genetics for increasing biomass - Food ingredients produced with precision fermentation 	<p>Examples include:</p> <ul style="list-style-type: none"> - Biobased chemicals - Biofuels - Biobased plastics
<p>Sample occupations include:</p> <ul style="list-style-type: none"> - Scientist - Biomedical engineer - Biomedical technician - Process engineer - Microbiologist - Medical manufacturing technician - Fermentation engineer 	<p>Sample occupations include:</p> <ul style="list-style-type: none"> - Plant and animal scientists and geneticist - Food scientist - Soil and plant scientist - Field technician - Laboratory assistant - Fermentation engineer 	<p>Sample occupations include:</p> <ul style="list-style-type: none"> - 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/PAR-23-100.html>

²⁸ <https://grants.nih.gov/grants/guide/pa-files/PAR-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?oppId=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