Micro-Credentials for a Thriving And Secure American Bioeconomy

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Executive Summary: The United States is at a pivotal moment, expanding its bioeconomy - economic activity derived from life sciences, biotechnology, and biomanufacturing. This sector holds enormous potential for innovation, sustainability, and economic growth. However, the current workforce lacks the interdisciplinary skills needed to keep pace with rising demand. Key areas such as synthetic biology, circular product design, and biosafety face significant talent shortages. Given the dual-use nature of emerging biotechnologies and the growing importance of data protection, the talent gap hinders industrial growth and raises concerns about security and ethics. U.S. federal agencies, along with international partners (such as those formed through the OECD, the Quad, and bilateral agreements with the United Kingdom, India, and other countries) have directed substantial investments into bio-based innovation. Yet without corresponding strategies to expand and adapt the workforce, the United States risks falling behind in global leadership. Micro-credentials offer a practical and scalable solution. These short, industry-focused training programs can prepare both new and transitioning workers with relevant skills, from commercial-scale fermentation to bioethics and data analytics. A T-shaped approach, integrating deep technical expertise with broad awareness of ethical, regulatory, and sustainability issues, will best serve the evolving needs of the American bioeconomy. To coordinate interagency actions on biotechnology regulation, the National Security Commission on Emerging Biotechnology has recommended establishing a National Biotechnology Coordination Office (NBCO). Housed within the Executive Office of the President, the NBCO would align federal, academic, and industry needs to define standardised learning outcomes and competency benchmarks for micro-credentials. More importantly, micro-credentials can also create “bridge programs”, enabling individuals from entirely unrelated fields– such as finance, automotive manufacturing, or design– to transition into the bioeconomy. Complemented by public-private partnerships, co-developed curricula, and expanded training through community biolabs and colleges, these initiatives can build a diverse, future-ready workforce, positioning the United States as a global leader in a secure, ethical, and innovation-driven bioeconomy.

I. Background

The United States stands at a critical juncture in shaping the future of its bioeconomy—an emerging sector with the potential to drive sustainable manufacturing, improve health outcomes, strengthen national security, and create high-quality jobs. At the same time, the U.S. risks falling behind global competitors if it fails to address foundational workforce and training gaps. We define bioeconomy as “economic activity derived from the life sciences, particularly in the areas of biotechnology and biomanufacturing, and includes industries, products, services, and the workforce” (NIST 2022; The White House 2022). Current training mechanisms are inadequate or unevenly distributed to support the projected growth of the American bioeconomy, despite initiatives like the USDA's B3 Programs, undergraduate and apprenticeship programs, and emerging efforts in community and technical colleges (New America n.d.; Prochaska and Schiller 2024; Oldach and Neote 2021; National Institute of Food and Agriculture n.d.) Academic institutions lack specialized bioeconomy-focused programs, resulting in significant workforce skill gaps that fail to align with industry needs, while regional variations in training quality create disparate preparedness across the country (Liang et al. 2023; Prochaska and Schiller 2024). Recognising these challenges, the United States has historically pursued international partnerships to strengthen bioeconomy capabilities.

Through multilateral forums like the Organization for Economic Cooperation and Development (OECD) Working Party on Biotechnology, Nanotechnology, and Converging Technologies, the U.S. helps shape international standards and best practices for responsible biotechnology development (OECD 2022). The Atlantic Declaration between the U.S. and the UK has established biomanufacturing as a cornerstone of economic cooperation (The White House 2023c). In the Indo-Pacific region, the Quad Partnership established between the US, Japan, Australia, and India focuses on developing bio-innovation strategies, while the US-India Initiative on Critical and Emerging Technology deepens bilateral cooperation (National Academies of Sciences, Engineering, and Medicine n.d.).

In the past, the U.S. has maintained extensive research partnerships through the National Academies and the National Institutes of Health's international programs, fostering joint ventures in synthetic biology, biomanufacturing, and biomedical research with a global network of partners. These international collaborations complemented significant domestic strides to elevate the U.S. bioeconomy. Public and private investments worth $64 billion in biomanufacturing, during the Biden administration alone, showcased interest in the growing domestic bioeconomy (The White House 2023b). Federal agencies such as the U.S. Department of Agriculture (USDA), the Department of Energy (DOE), and the National Science Foundation (NSF) previously increased funding and strategic initiatives to expand domestic manufacturing and reduce carbon emissions (The White House 2023a). These efforts were complemented by the creation of programs such as BioMADE, InnovATEBIO, and NIIMBL, which focus on workforce development and translational research (InnovATEBIO 2024; BioMADE n.d.; NIIMBL 2023).

Recent shifts in federal policies halting initiatives aimed at fostering sustained innovation, preparing a diverse workforce, and clarifying industry regulations pose a threat to American competitiveness in the global bioeconomy (The White House 2025; Malakoff 2025). Chief among these concerns is workforce development, as the country faces increasing global competition while struggling to meet growing demands for interdisciplinary skills in biotechnology, synthetic biology, feedstock management, and circular product design. In the long term, the shortage of skilled workers with broad expertise will be a severe impediment to the sustained growth of the U.S. bioeconomy. Without strategic intervention, the U.S. risks missing opportunities to build a sustainable, resilient bioeconomy workforce.

II. Creating standardised micro-credentials to upskill the future workforce

Micro-credentials—short, targeted learning units that validate specific skill sets—offer a promising avenue for bridging skills gaps. In contrast to traditional degree programs that may take years to complete, micro-credentials focus on the immediate competencies demanded by industry (Tamoliune et al. 2023). This is particularly salient in a field as expansive as the bioeconomy, which spans life sciences, chemical engineering, data analytics, supply chain management, and sustainability science. Short, modular programs and certificates can help current professionals and new entrants alike keep pace with emerging technology and market demands, while also providing more equitable, lower-cost routes for underrepresented groups to access and thrive in the sector (McGreal and Olcott 2022; Varadarajan, Koh, and Daniel 2023; Johns Hopkins AAP 2019; NOCTI 2020).

Training should adopt an interdisciplinary, T-shaped approach encompassing broad contextual awareness and deep specialised expertise to ensure that micro-credential programs remain relevant and forward-looking. For instance, a project manager who gains foundational knowledge in synthetic biology can more effectively apply their expertise in planning, coordination, and regulatory innovation to support the development and commercialisation of bio-based innovations. These interdisciplinary skills foster better cross-functional collaboration, manage complex supply chains, and comply with evolving legal frameworks (Paris et al. 2023). Courses might focus on specialized skills such as commercial-scale fermentation, novel bio-based materials, waste valorization, or project management for circular supply chains, supplemented by broader knowledge of sustainable development principles, circular bioeconomy, and knowledge of bio-based markets and techno-economic analysis (Carus and Dammer 2018).

Rapid biotechnological innovation can pose dual-use risks, where discoveries in fields like synthetic biology or genomics may be misapplied with harmful intent. Moreover, as large-scale biomanufacturing grows, so does the need to safeguard sensitive data, particularly genomic and personal health information, against unauthorized access. Addressing these issues requires a comprehensive workforce strategy incorporating mandatory bioethics training, best practices for handling proprietary data, and ongoing oversight to prevent intellectual property theft. Micro-credentials offer a pivotal opportunity to embed ethical and security considerations into the fabric of bioeconomy workforce development. Mandatory micro-credentials in biosafety, data governance, and dual-use risk mitigation can help professionals acquire specialized in-demand skills without neglecting critical compliance standards.

III. Micro-credentials support the transition of cross-disciplinary workforce

The U.S. can expand its bioeconomy workforce by strategically repurposing professionals from adjacent fields, tapping into a wealth of transferable skills in data analytics, automation, supply chain management, and more (Hudson Valley Community College n.d.; Roach 2019; Arizona State University n.d.). For example, data scientists accustomed to modeling in finance or retail can pivot to bioprocess analysis, while automation engineers from automotive or semiconductor manufacturing can streamline robotics in bioproduction lines. Workers from declining industries such as traditional manufacturing, coal mining, and certain segments of the automotive sector could benefit from targeted reskilling through bioeconomy micro-credentials (Riley 2018; Bureau of Labor Statistics n.d.; Ortiz-Ospina n.d.). These cross-sector transitions are supported by emerging “bridge programs” that validate new competencies in bioreactor operations, biomanufacturing, and regulatory affairs (Bradford, Beier, and Oswald 2021; Black 1996). These initiatives not only mitigate job displacement but also support workforce adaptation to emerging high-growth sectors.

IV. Conclusion

i. Policy options

To maximize the impact of micro-credentials, the U.S. could pursue two main policy options. One option is to designate a centralized national body, such as the proposed NBCO, to align credentialing efforts across federal agencies, industry associations, and academic partners (National Security Commission on Emerging Biotechnology 2025). This office would define standardized learning outcomes, assessment criteria, and competency benchmarks, ensuring that micro-credentials are recognized across sectors and geographic regions. Standardization would reduce inconsistencies in quality and improve credential portability, allowing workers to more easily transition between roles and locations. It would also give employees confidence that credentials reflect high-quality, job-relevant training. However, central coordination may be slower to adjust to regional workforce needs and would require sustained administrative resources to remain adaptive over time.

An alternative or complementary option is to scale micro-credentialing by leveraging federally-funded public-private partnerships that are specifically designed to co-develop training curricula and expand delivery capacity in collaboration with academic and industry partners. Programs like BioMADE, InnovATEBIO, and NIIMBL’s eXperience initiative could serve as anchors for credential delivery, offering scalable, industry-aligned training. These programs could collaborate with universities, community colleges, community bio labs, and industry associations to co-develop specialized courses that meet national standards while addressing local workforce needs (The White House 2023a; New York City Economic Development Corporation n.d.). Community colleges are well-positioned to integrate micro-credentials into existing certificate and associate degree programs, offering flexible pathways for learners from various backgrounds to enter and excel in the bioeconomy (OERTX n.d.; Biotility 2018). This decentralized approach allows credential offerings to reflect regional industry needs and lower implementation costs by leveraging existing established channels. Yet, without coordination and targeted investment, it risks creating uneven access and fragmented standards across states. For example, industry engagement may vary, as larger corporations likely have more resources to participate in micro-credential development, while smaller businesses may struggle to engage.

ii. Implementation

Regardless of the approach, successful adoption of micro-credentials will depend on thoughtful implementation strategies that ensure quality, responsiveness, and broad-based participation. Tax credits for companies investing in worker retraining, grants for workers pursuing micro-credentials, subsidized micro-credentials for high-demand skills, or retention bonuses for successful transitions, such as those implemented by state workforce agencies and federal and state programs in industries—including retail, transportation, and healthcare—are potential strategies to incentivize repurposing workforce for the American bioeconomy (U.S. Department of Labor n.d.; Office of Apprenticeship n.d.). Federal grants and matching funds could incentivize industry actors to help design and validate micro-credential curricula, guaranteeing that content remains relevant to evolving workforce demands. Programs could promote collaboration among employers, academic institutions, trade associations, and state workforce boards to develop industry-recognized credentials in biomanufacturing, synthetic biology, and regulatory affairs. Involving employers directly in the credentialing process ensures that credentials reflect real-world job requirements, increasing their acceptance among hiring managers. Additionally, companies could commit to skill-based hiring practices, instead of relying solely on traditional university degrees, helping employers tap into a wider and more diverse pool of qualified candidates (The White House 2022).

Micro-credentials offer a powerful avenue for upskilling both new and existing professionals in the bioeconomy by providing targeted, rapid training that aligns with emerging industry needs. Their strength lies in their adaptability: short-course formats can be regularly updated to reflect breakthroughs in synthetic biology, advanced biomanufacturing, and other high-growth areas. By standardizing learning outcomes through a national council and integrating ethical and security modules, these credentials bolster technical competencies and address concerns around dual-use risks and data integrity. Workforce repurposing initiatives, which transition professionals from adjacent sectors like data analytics or automation, can be accelerated by embedding micro-credential pathways that validate new competencies.

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