EBRC Engineering Biology Research Consortium

Response to NSF TIP's Workforce Development Roadmap

The Engineering Biology Research Consortium (EBRC) is a nonprofit, public-private partnership that brings together scientists, engineers, and industry leaders to advance the field of engineering biology to address national and global needs. EBRC's members include experts from over 90 universities and research institutes, alongside leaders from more than 20 companies, philanthropies, and other organizations. Working closely with partners across the engineering biology ecosystem, EBRC focuses on four key areas: Research Roadmapping, Policy & International Engagement, Education, and Security. Below we provide specific recommendations to the National Science Foundation for Technology, Innovation, and Partnerships (NSF TIP), responding to each of its 6 questions on how to guide future investments to strengthen the American workforce in critical and emerging technologies.

(i) How might NSF TIP collaborate with critical and emerging technologies industries to best prepare future workers and reskill current workers?

Biotechnology capacity and a skilled bioeconomy workforce are crucial to U.S. competitiveness and leadership. In order to align the bioeconomy workforce development with emerging industry needs to advance and expand biotechnology capacity nationwide through upskilling and reskilling workers, NSF TIP should act as a coordinated leadership to:

- Target funding towards **collaborative programs between education/training programs and private industry that co-develop and co-deliver training for current professionals at all career stages**, including structured opportunities (e.g., internships, externships, and apprenticeships) that directly feed into emerging biotechnology workforce and accessible credentialing and certification pathways to support career transitions, labor mobility, and continuous learning opportunities for evolving industry needs in the bioeconomy;
- Fund programs that **train educators in current synthetic biology and engineering biology practices**, including industry research experiences, and shadowing opportunities, and collaborative curricula development, to strengthen industry-educator networking and enable them to better incorporate real-world applications into their teaching, demonstrating the value of industry-educator engagement; and
- **Support (nonprofit) organizations to establish, collect, and report metrics** from industry, universities, and workforce programs to track bioliteracy and bioeconomy capacity, monitor workforce trends, skills gaps, emerging skills, STEM educational and career outcomes, and regularly update data to inform future funding priorities and program design.

(ii) How might NSF TIP leverage local, state, and tribal, including regional, efforts in workforce development to help provide all Americans with the skillset(s) required for careers in critical and emerging technologies or closely aligned fields?

With the U.S. bioeconomy workforce currently concentrated largely on the coasts, despite resources and opportunities existing throughout the nation, ensuring all Americans are adequately educated and equipped with the required knowledge and skills to enter the bioeconomy workforce is critical. To address this, NSF TIP should:

- **Convene regional, state, and tribal leaders and stakeholders** participating in local bioeconomy workforce efforts to ensure NSF TIP programs complement workforce development plans and provide training relevant to community and cultural needs for emerging tech careers, fostering regional partnerships to support underrepresented communities and rural areas facing potential workforce shortages;

- **Invest in and strengthen local infrastructure and training centers** already in place, particularly non-traditional academic institutions, such as community biolabs, makerspaces, public libraries, museums, and zoos that are geographically accessible, culturally responsive, and trusted within their communities. These organizations meet individuals where they are and provide flexible pathways into the workforce beyond traditional higher STEM education systems through hands-on laboratory experiences, project-based learning, and peer mentorship, lowering barriers to entry into bioeconomy fields. NSF TIP should recognize them as essential partners in Potential Investment #1 and incentivize collaboration with nearby academic institutions, research centers, and companies to co-develop curricula, apprenticeships, and internship programs, and to donate and repurpose old equipment to align training with current bioeconomy workforce needs; and

- **Create targeted funding pathways for programs that increase access to workforce development programs**, including offering flexible training formats (times, platform, language) to accommodate workers across different geographies and cultures and provide additional support for childcare or transportation assistance during training periods.

(iii) Beyond questions 1 and 2 above, are there specific sectors, organizations, or groups that NSF TIP must especially engage to fully address the goals articulated in the workforce roadmap and this RFI? If so, which ones, why, and how?

To build a robust, sustainable bioeconomy workforce capable of meeting current demands and future needs, NSF TIP must strategically engage with stakeholders beyond the traditional academic and industry partners, including:

- **Scientific societies,** such as Society of Biological Engineers, American Society for Microbiology, American Institute of Chemical Engineers, Society for Industrial Microbiology and Biotechnology, American Physical Society, and National Society of Professional Engineers. These societies are robust networks of experts, practitioners, and trainees across critical biotechnology fields, functioning at the interface of innovative research and the workforce. They convene cross-sector

stakeholders, establish industry-recognized skills, and reach diverse audiences across education- and career-stages and geographic regions. To support "Potential Investment #2," NSF TIP should partner with scientific societies to co-create professional development and upskilling programs with stackable credentials for educators and students in emerging biotechnology fields;

- **Science policy organizations**. These organizations bridge research, workforce, and policy development, providing expertise and recommendations that enable sustained cross-agency coordination and evidence-based decision-making. Unlike discipline-specific societies focused on technical competencies, these organizations have the capacity to analyze the bioeconomy workforce holistically, identifying challenges and opportunities across different agencies and sectors. To align with "Potential Investment #1, NSF TIP should partner with science policy organizations to map and evaluate existing federal initiatives across other federal agencies and departments, ensuring TIP initiatives fill gaps rather than duplicate existing efforts. NSF TIP should additionally allocate dedicated funding for science policy fellowship programs that connect bioeconomy industry professionals, academic faculty, and researchers with federal agencies. Fellows develop the competencies to translate complex science for policy audiences and better understand how the regulatory landscape affects workforce pathways, creating a talent pool of individuals who can create, implement, and assess TIP workforce initiatives to address the current shortage of professionals; and

- **Professional labor associations and unions**, such as manufacturing unions, electrical workers, process engineers, and technical professional associations, that would support emerging industry sectors, such as bioprocessing and biomanufacturing. These organizations are often underutilized and underrecognized stakeholders for biotechnology workforce development, as there is the opportunity to create connections with these groups leading to the retraining of workers from sunsetting industries. NSF TIP should encourage NSF Engine partnerships with professional labor associations and unions to ensure (re)training aligns with actual availability of bioeconomy jobs and develop more effective entry and retention strategies to support a more sustainable workforce.

(iv) As technology impacts nearly all economic sectors, a full range of technology-enabled roles will require a wide range of skills. Where should NSF TIP emphasize its investments in workforce development in the near and long term?

NSF TIP should prioritize workforce development investments that align with the emphasis on critical and emerging biotechnologies, particularly in the rapidly expanding bioeconomy. Such investments are essential to U.S. competitiveness and supporting the administration's priorities for innovation, including:

- **Artificial intelligence (AI) and machine learning tools for biological applications.** NSF TIP should integrate computational tools with synthetic biology, including bioinformatics, AI-protein and drug discovery, modeling for biomanufacturing, and machine learning. This should support the development of novel predictive models and computational frameworks to optimize biological design and improve scalability,

accelerating discovery. Opportunities for interdisciplinary training and collaboration will foster stronger workforce development and broaden participation in the emerging field of AI and biology;

- **Vocational, junior college, and community-based training programs.** The bioeconomy workforce will not be solely composed of Ph.D. trained scientists, but will also include technicians and operators across many different critical systems. NSF TIP should develop funding opportunities to support training programs within less-resourced institutions, like vocational/trade schools, junior colleges, or other community-based organizations. These training programs could also be tied to employment opportunities within federal test beds or scale up facilities;

- **Biosafety and biosecurity.** Workforce development must include training for responsible use, including, risk management and mitigation strategies, and lab safety for synthetic biology, such as ethical frameworks for dual-use research and data governance and standards; and

- **A recurring national biotechnology workforce development event** (e.g., workshop or symposium) to bring together academic institutions (including community colleges and technical schools), small and mid-sized companies, nonprofit training organizations, and regional economic development entities, to identify emerging skill requirements, establish industry-validated competency benchmarks, scale successful workforce initiatives to local and regional needs, and align training and curricula to real-world jobs, expanding a more interoperable, stable workforce that supports natural labor mobility and healthy competition for skilled talent.

(v) Which of the critical and emerging technologies specified in Section 10387 of the CHIPS and Science Act of 2022 (Public Law 117-167) (p. 215-217) will have the greatest workforce needs in the next five years? The next decade?

Failing to invest in the bioeconomy workforce will leave industries vulnerable to emerging biological threats, as biotechnology, medical technology, genomics, and synthetic biology face urgent workforce needs over the next five years and the coming decade. Advancing predictable synthetic/engineering biology for bioeconomy applications requires NSF TIP to encourage the shift of the physical manufacturing paradigm to a biomanufacturing paradigm that accounts for higher-order input and output parameters. Currently, expertise remains concentrated at advanced degree levels, creating a critical gap in mid-skill roles for high-volume, low-value bioproducts, such as the space between crop harvesting and human drug manufacturing, including food ingredients, agricultural feedstocks, and vaccines.

To meet the accelerating demands of the bioeconomy, such as sustainable energy innovation, identification and treatment of emerging pathogens, and elimination of human diseases, NSF TIP should invest in building a more robust workforce capable of leveraging advanced computing, automation, and evidence-based approaches to solve complex biological problems. This includes fostering cross-sector partnerships to ensure equitable access to industry-informed education and training, experiential learning opportunities, and coordinating with other federal agencies to align workforce development with local and national needs.

(vi) What may be the most effective strategies to address workforce gaps as critical and emerging technologies are introduced into a range of industries?

To address workforce gaps in the rapidly expanding U.S. bioeconomy, NSF TIP must implement strategies that expand awareness of the promise of engineering biology and create accessible pathways into the bioeconomy workforce by:

- **Creating robust networks that strengthen cross-sector partnerships**, including academia, industry, government, labor organizations, and community-science institutions to enable collaboration and knowledge sharing about emerging skills and career opportunities in synthetic biology/engineering biology;
- **Strengthening industry partnerships through co-development of curricula and skills development** where industry leaders proactively define professional skills and competencies, ensuring STEM education stays up to date. NSF TIP should fund paid experiential learning opportunities, such as apprenticeships, internships, and externships for trainees to apply classroom skills to real world applications while building their professional networks;
- **Aligning private-public initiatives through shared digital platforms** where companies, universities, labor organizations, and workforce training organizations have access to current data on available jobs, required skills, and predicted salary ranges in critical biotechnology industries;
- **Creating specific funding mechanisms for K-12 schools to expose students early on to biotechnology and engineering biology,** normalizing such careers as everyday options, something they can imagine themselves doing. Funds could also go towards programs, such as field trips, after school, or summer programs that immerse students in their local bioeconomies, connecting them to professionals, researchers, and labs in their communities; and
- **Investing in public engagement and outreach**, such as partnerships with media and science influencers, open science calls, and Hackathons, and public demonstrations that showcase diverse professionals in emerging biotechnology careers, making these topics more accessible, tangible, and exciting.