EBRC Engineering Biology Research Consortium

Translational Research for Breakthrough Technologies: Advancing Engineering Biology to Address Societal Needs at NSF

A Policy Paper by the Engineering Biology Research Consortium[†]

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The National Science Foundation has long been an enabler of engineering biology research, supporting some of the earliest scientific discoveries in synthetic biology, and considers biotechnology to be a key element of its investment strategy and leadership among U.S. research agencies.[1] Advancements in engineering biology will help solve open problems relevant to major societal challenges and economic competitiveness, spurring progress in industrial biotechnology, in materials synthesis, processing, and performance, in global health and well-being, in food and agriculture, environmental biotechnology and sustainability, and in clean energy production, storage, and utilization.[2] As NSF establishes its new Directorate for Technology, Innovation and Partnerships to translate research into practical applications,[3] the agency has abundant opportunity to boldly support engineering biology research towards transformational, use-inspired technologies to grow and expand the U.S. bioeconomy.[4]

Key recommendations:

- Establish programs and initiatives to translate fundamental engineering biology research results from other NSF directorates into innovative, use-inspired technologies, catalyzing the societal and economic potential of engineered biology;
- Establish broadly accessible infrastructure, including geographically-distributed open biotechnology research spaces and testbed facilities, to transform engineering biology tools and concepts into application-inspired technologies;
- Enable cross-disciplinary research and training and entrepreneurial education to accelerate transformative engineering biology advancement and innovation, for a robust and equitable bioeconomy.

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[1] National Science Foundation. Advanced Biotechnology and Bioeconomy Research at NSF. https://nsf.gov/bio/bioeconomy.jsp

[2] See EBRC roadmaps at https://roadmap.ebrc.org for more about potential advancements and technical milestones in these areas.

[3] Referred to as the Science and Technology Directorate in H.R.2471 - Consolidated Appropriations Act, 2022 (PL 117-103). https://www.congress.gov/bill/117th-congress/house-bill/2471/

[4] National Academies of Sciences, Engineering, and Medicine. 2020. *Safeguarding the Bioeconomy*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25525.

Opportunity for Impact

Today, much of the engineering biology research community is funded through NSF research awards,[5] primarily through the Biological Sciences and Engineering Directorates.[6] These awards have generated a vast number of the fundamental capabilities and tools that underpin engineering biology research, including high-throughput gene assembly, sequencing, and screening, data-driven design and integration of macromolecules and circuits, and contextual transformation and characterization of host cells.[7] Continued support of this basic research is essential, but new programs and opportunities can catalyze and accelerate the early-stage translation of tools and discoveries from the established directorates.

The TIP Directorate should support programs to transform fundamental research results into innovative, use-inspired technologies, catalyzing the societal and economic potential of engineered biology.

Engineering biology researchers need the ability to rapidly design, test, and learn from their fundamental discoveries in settings dedicated to the translation of ideas. The TIP can support the initial transition of a fundamental engineering biology tool or platform to technology by providing opportunities for researchers to explore potential real-world environments and determine utilization and constraints across many application sectors *prior to scale-up*. Such investigations will go beyond the novelty or basic understanding of a system, pathway, or tool to explore and better understand the potential applications, real-world behaviors, and system-level impacts of engineered biology, in advance of establishing feasibility for market or commercial potential.

The TIP Directorate should invest in broadly accessible infrastructure, including geographically-distributed open biotechnology research spaces and testbed facilities.

Sites and facilities that allow independent researchers to access tools and testbeds, and provide platforms to share the data generated, will not only enable researchers to more efficiently and effectively progress technologies, but will also catalyze greater collaboration. Facilities should leverage partnerships between academic institutions, industry, non-profits, and government to create ecosystems with shared resources and knowledge. Such open research spaces can enable engineering biologists to access platforms and technologies that might otherwise be inaccessible or unfeasible. Notably, application-inspired testbeds and instrumentation must integrate digital infrastructure and computational capabilities, such as complex modeling and machine learning, to better understand and analyze engineering biology solutions. By establishing these facilities beyond traditional biotechnology hubs (notably the Boston and the San Francisco Bay areas), not only would NSF diversify research and development opportunities, but also better support education and workforce equity across the U.S. and capitalize on local resources and communities.

The TIP Directorate should enable cross-disciplinary research and training and entrepreneurial education to accelerate transformative engineering biology advancement and innovation.

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[5] Based on data collected from an informal survey of EBRC members.

[6] Data collected from https://www.nsf.gov/awardsearch/advancedSearch.jsp on 10 Jan 2022.

[7] Engineering Biology Research Consortium (2019). *Engineering Biology: A Research Roadmap for the Next-Generation Bioeconomy*. DOI: 10.25498/E4159B. http://roadmap.ebrc.org/2019-roadmap

Building a stronger workforce and bioeconomy requires fostering a greater understanding and appreciation of the impacts and societal contexts of research, technologies, and products — crucial for understanding and strengthening the public good of such technologies, contributing to building public confidence, and reducing economic risk. The TIP should provide opportunities for cross-disciplinary collaborations to enable engineering biology researchers to partner and engage with economists, environmental scientists, social scientists and other nontechnical experts to explore the impacts of their technology development, particularly early-on as research project ideas are being generated. Diversity of research teams also fosters the diversity of individuals contributing to discovery and innovation, a necessity for building a robust, equitable bioeconomy. This can be complemented by entrepreneurial education for all researchers, to build stronger foundations for transforming research towards application.

Transforming the Future

Providing support for translational research with potential applications in critical areas of the bioeconomy is needed to keep the U.S. at the forefront of engineering biology. Investing in broadly accessible testbeds and research infrastructure and networks can not only accelerate translation of biotechnologies but also build strong collaborations and a more inclusive research community. The TIP Directorate can establish and enable programs that more effectively support cross-disciplinary research that leverages a wide array of disciplines, including the social sciences, catalyzing opportunities that expand the translational capacity of projects. With the standup of the TIP Directorate, NSF has the opportunity to transform engineering biology technologies toward breakthrough solutions, strengthening our global economic competitiveness and building a robust and equitable workforce.

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