Executive Summary
This analysis provides an overview of the federal government’s research priorities and funding opportunities related to the bioeconomy and closely related fields such as biotechnology, synthetic biology, and engineering biology. While the bioeconomy as a concept is not new and federal investments in these research areas have been ongoing for years, biotechnology has traditionally received less attention than other emerging industries such as artificial intelligence, quantum information sciences, advanced manufacturing, and advanced wireless technology. However, the COVID-19 pandemic and the ability of the scientific community to develop tests and vaccines in record time brought the societal benefits of investments in the biological sciences to the national stage. Biotechnology is now poised to remain in the spotlight in the coming months and years with new legislation on the bioeconomy moving forward in Congress and new investments proposed in the FY 2022 budget request. This analysis provides an overview of the Biden Administration’s priorities, recent and planned congressional action, and a state of play across federal agencies. This document will be updated as necessary to highlight new opportunities.
Introduction
The federal government has historically taken a decentralized approach to research and development investments in the interconnected fields of synthetic biology, engineering biology, and biotechnology, and agencies and departments use their own definitions and criteria for these and other components of the bioeconomy. This makes it challenging to capture the full breadth of the bioeconomy and the individual technology fields that contribute to it. Both the Obama and Trump Administrations recognized the need for coordinated federal efforts on the nation’s bioeconomy, and each organized activities to characterize, promote, and protect the bioeconomy through the White House Office of Science and Technology Policy (OSTP). This includes:

- In April 2012 the **Obama Administration** released the [National Bioeconomy Blueprint](https://www.whitehouse.gov), intended to guide federal agencies in collaborating with each other and with the private sector to promote economic growth, job creation, improved public health, and advance clean energy technologies. The Blueprint laid out strategic objectives for the United States to meet in order to foster a vibrant bioeconomy, emphasizing foundational research and development at the intersection of life and physical sciences, technology transfer, regulatory barriers, workforce development, and public-private partnerships.

- In October 2019 the **Trump Administration** hosted the [Summit on America’s Bioeconomy](https://www.whitehouse.gov), which brought together federal officials and bioeconomy experts from the private sector to discuss U.S. leadership in the global bioeconomy, as well as challenges and priorities ahead in fields connected to the bioeconomy. Discussion at this Summit emphasized biotechnology as an “Industry of the Future” on which the bioeconomy could be built, and noted that workforce, data and infrastructure, cross-sector collaboration, and regulatory innovation were all crucial to maintaining and strengthening the bioeconomy.

Outside of the Executive Branch, other efforts have taken shape in recent years to define the bioeconomy and coalesce research priorities in this space. In 2019 the [Engineering Biology Research Consortium (EBRC)](https://www.engineeringbiology.org) released a research strategy titled [Engineering Biology: A Research Roadmap for the Next-Generation Bioeconomy](https://www.engineeringbiology.org/roadmap), outlining technical themes (engineering DNA, biomolecular engineering, host engineering, and data science) as well as applications and impact sectors (industrial technology, health and medicine, food and agriculture, environmental biotechnology, and energy) for the bioeconomy. Later, in 2020, the [National Academies of Sciences, Engineering, and Medicine](https://www.nationalacademies.org) released a report titled [Safeguarding the Bioeconomy](https://www.nationalacademies.org), which was supported by the Office of the Director of National Intelligence. This report examined how to define, measure, and forecast the U.S. bioeconomy, as well as how to measure U.S. leadership in the global bioeconomy and what security risks are associated with activities related to the bioeconomy. This report agreed on the following consensus definition of the bioeconomy:

“The U.S. bioeconomy is economic activity that is driven by research and innovation in the life sciences and biotechnology, and that is enabled by technological advances in engineering and in computing and information sciences.”
Biden Administration Bioeconomy Priorities

From the start of his Administration, President Biden’s top priorities included addressing the ongoing COVID-19 pandemic from both health and economic perspectives, advancing racial equity, and addressing climate change. Biotechnology and synthetic/engineering biology are especially relevant for tackling the climate crisis and improving public health, and federal investments in biotechnology related to these areas are likely to increase in the coming years. The Biden Administration is also likely to apply an equity lens to advancements in biotechnology and the bioeconomy and take steps to ensure that not only are biotechnologically-derived products and services accessible to all, but that the processes of creating such products are not actively harmful to disadvantaged communities.

Because of the decentralized nature of this field, it is difficult to calculate the exact level of proposed federal investment in biotechnology and synthetic/engineering biology for fiscal year (FY) 2022 and prior years. In addition, the federal government does not provide an estimate on total annual expenditures unlike other emerging technology areas. However, many of the science and technology priorities emphasized by the Biden Administration in its FY 2022 budget request involve biotechnology or could contribute to strengthening the U.S. bioeconomy. While more details about the state of play at each agency are included later in the document, below are a few key examples:

- The Biden Administration proposes the creation of two new Advanced Research Projects Agencies, one to focus on health and biomedical science (ARPA-H) and one to focus on climate (ARPA-C). Both would invest in breakthrough technologies, very likely including those in fields like synthetic biology and engineering biology, with the potential to transform their respective focus areas.
- At the National Science Foundation (NSF), biotechnology would be a major area of emphasis in the proposed new Directorate for Technology, Innovation, and Partnerships.
- Increased investments in biotechnology are proposed for research and development activities at the Department of Defense (DOD), Department of Energy (DOE), and the National Institute of Standards and Technology (NIST).

In addition to discretionary spending to support federal agencies in annual appropriations bills, President Biden also highlighted his ongoing interest in “Industries of the Future” like biotechnology in his proposed American Jobs Plan, which would modernize America’s infrastructure, spur climate action, strengthen workforce and education, and promote U.S. global competitiveness. If passed by Congress, this plan would direct $50 billion to NSF to support collaborative, use-inspired, translational research focused on emerging technology areas, including biotechnology. The American Jobs Plan would also provide $30 billion across federal agencies for Industries of the Future, including biotechnology, especially for opportunities tied to job creation and in rural areas.

President Biden has also signaled his interest in the biological sciences and the bioeconomy through his selection of his official science advisor and Director of the White House Office of Science and Technology Policy (OSTP). In addition to elevating the OSTP Director to a Cabinet-level position for the first time, President Biden notably selected Dr. Eric Lander, a geneticist and mathematician, to fill this role. This is the first time that the OSTP Director has come from a life sciences background, which emphasizes the Administration’s commitment to elevating the life and biomedical sciences, not only
from a pandemic-preparedness perspective, but also for biotechnology and synthetic biology. In a January 2021 letter to Dr. Lander, coinciding with his nomination as White House science advisor and OSTP Director, President Biden specifically highlighted synthetic biology as one of the emerging technologies in which the United States needs to maintain leadership for our economic prosperity and national security, signaling his interest in supporting this field moving forward.

In his first 100 days, President Biden also signed a number of executive actions on a wide range of topics including COVID-19, immigration, the economy, manufacturing, national security, and equity, among others. While none of these actions have had a sole focus on biotechnology or synthetic biology, these areas could easily be incorporated into further agency actions or policies as a result of these actions. Given the challenging Congressional environment, President Biden might seek to advance other policy priorities through executive actions, and may take action specifically to bolster specific emerging technology areas like biotechnology.

Congressional Interest
The House and Senate Appropriations Committees are currently drafting and advancing FY 2022 appropriations bills that include investments in biotechnology, synthetic biology, and engineering biology. At the time of this writing, the House Appropriations Committees have advanced all 12 of their FY 2022 bills, with plans to pass the bills in the full House by September. Overall, the House bills generally support the funding proposals advanced by the Biden Administration, including increased funding for biotechnology at federal agencies such as NSF, DOE, NIST, and the National Institutes of Health (NIH). The Senate has not yet advanced any of its FY 2022 appropriations bills. While Congress continues to negotiate final FY 2022 appropriations, the outlook for fields connected to the U.S. bioeconomy remains promising, given their demonstrated and potential benefits in addressing U.S. global scientific competitiveness, public health, and climate change.

Outside of appropriations, in June 2021, the Senate passed the Bioeconomy Research and Development Act as part of the U.S. Innovation and Competition Act of 2021 (USICA). The bill was previously introduced in the last Congress along with a companion bill in the House of Representatives called the Engineering Biology Research and Development Act, but Congress was not able to pass it before the end of the legislative session. This year, the Senate attached the bioeconomy legislation to a larger package on innovation, trade, and research security. The House also reintroduced its bioeconomy bill in July 2021 and has plans to advance the bill later this year. The two bioeconomy bills are very similar and key provisions include:

- Establishing a National Engineering Biology Research and Development Initiative through OSTP to strengthen and broaden the nation’s efforts in this space, including specifically to advance research and development, advance biomanufacturing, develop the future bioeconomy workforce, and support research in ethical, legal, environmental, safety, security, and societal issues;
- Supporting the creation of databases and tools for bioeconomy-relevant research efforts;
- Expanding public-private partnerships and education and training for the next generation of researchers;
- Providing research and development direction to key federal agencies supporting bioeconomy-relevant efforts, including NSF, NIST, DOE, DOD, NIH, the National Aeronautics and Space
Administration (NASA), the U.S. Department of Agriculture (USDA), the Food and Drug Administration (FDA), and the U.S. Environmental Protection Agency (EPA); and

- Directing the National Academies to review ethical, legal, environmental, safety, security, and societal issues related to engineering biology.

Congress is likely to pass a bioeconomy bill before the end of the year that would establish a 10-year initiative to help maintain U.S. leadership similar to prior legislation in quantum science and technology and artificial intelligence.

**State of Play Across Federal Agencies**

Below is an overview of research priorities, funding opportunities, and other major actions related to the bioeconomy of key federal agencies. Lewis-Burke will continue to monitor these opportunities and provide updates as appropriate.

**Department of Defense (DOD)**

DOD’s Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) notes biotechnology as one of the Department’s modernization priorities. DOD seeks new capabilities enabled by biotechnology that include advances in material and systems engineering, military medicine, warfighter performance, chemical and biological defense, as well as sensing/communication/controls. Over the past year, OUSD(R&E) released multiple funding opportunities to support biotechnology efforts at the Department:

- In December 2020, DOD released a two-step funding opportunity announcement (FOA) for the National Defense Education Program (NDEP) seeking innovative applications on mechanisms to implement Science, Technology, Engineering, and Mathematics (STEM), Biotechnology, and Civics Education efforts. One of the three focus areas included biotechnology outreach and workforce development.

- In March 2021, DOD released two requests for proposals (RFPs) to establish respective Centers of Excellence on Materials Science and Biotechnology at Historically Black Colleges and Universities (HBCUs) or Minority-Serving Institutions (MSIs).

- In FY 2022, the Army is requesting \(^1\) $20 million in applied research (6.2) and $50 million in advanced technology development for a new Tri-Service Biotechnology for a Resilient Supply Chain (T-BRSC) program. This program will explore and demonstrate how novel biotechnology processes and materials can address the military’s supply chain vulnerabilities and needs.

**Manufacturing**

In 2020, DOD announced an $87 million, seven-year award to the **BioIndustrial Manufacturing and Design Ecosystem (BioMADE)**, a nonprofit created by EBRC for a new manufacturing institute to advance

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sustainable and reliable bioindustrial manufacturing technologies. DOD also sponsors the Advanced Regenerative Manufacturing Institute (ARMI), whose mission is to “make practical the large-scale manufacturing of engineered tissues and tissue-related technologies, to benefit existing industries and grow new ones.”

DARPA

The Biological Technologies Office (BTO) within the Defense Advanced Research Projects Agency (DARPA) aims to “develop new technologies and approaches that ensure biosafety, biosecurity, biological cybersecurity of biological hardware, data, and information, and protection of the bioeconomy.” BTO has a standing Broad Agency Announcement that accepts proposals on a rolling basis, seeking research that includes (but is not limited to) “combating pandemic disease, innovative physiological interventions, human performance and warfighter readiness, and deep exploration of changing ecologies and environments for improving U.S. capabilities and resilience.” The rolling BTO BAA can be found here.

In FY 2022, DARPA has requested approximately $47 million for five new biotechnology relevant programs including the Environmental Microbes as a Bioengineering Resource (EMBER), Bio-Inspired Coastal Defense, Bio Cyber Security (BCS), Next-Generation Combat Casualty Care, and Distributed Access to Critical Biotherapeutics for Warfighters programs.

Other Opportunities:
The following organizations also support the Department’s biotechnology/synthetic biology portfolios:

- **Office of Naval Research Warfighter Performance Department**
  This department “enhances warfighter effectiveness and efficiency through bioengineered and biorobotic systems, medical technologies, improved manpower, personnel, training and system design.”

- **Human and Engineered Systems Division**
  The Division’s mission is to “direct, plan, foster and encourage science and technology in cognitive science, computational neuroscience, bioscience and bio-mimetic technology, physiology and biophysics, immunology, social/organizational science, training, human factors, and decision making as related to Naval needs.”

- **Warfighter Protection and Applications Division**
  The Division’s mission is to “conduct research and technology demonstration programs directed at maintaining the survival, health and performance of Navy and Marine Corps personnel during training, routine operations, special operations and in times of war.”

- **Air Force Office of Scientific Research - Chemistry and Biological Sciences**
  “The Chemistry and Biological Sciences Team is responsible for research activities in chemistry and biological sciences. A wide range of fundamental chemistry, biology, mechanics, and biophysics research is supported to provide the Air Force with novel options to increase performance and operational flexibility.”

- **Army Research Office (ARO) – Physical Sciences**
  “Research in the Physical Sciences is focused on basic research to discover, understand, and exploit physical, chemical, and biological phenomena. This research is of a fundamental nature; however, in the long term, discoveries in this area are expected to lead to revolutionary capabilities in sensing, communications, protection, wound healing, power/energy storage and
generation, and materials that extend the performance of Army systems well beyond current limits.”

- **ARO Life Sciences Division**
  Foundational research competencies include “Biological related disciplines, including synthetic biology, biological materials, biological/abiological interfaces, and biological effect.”

**Department of Energy (DOE)**

In FY 2021, DOE spent $700 million to support biotechnology research and development to meet decarbonization efforts for transportation, industry, and agriculture. DOE investments are primarily in fundamental science and tool development in bioengineering and bioprocessing technologies to optimize microbes and plants for production of biofuels and bioproducts, as well as enhancing the ability of bioenergy crops and residue to help sequester carbon in soils. Major DOE programs that support biotechnology include:

- **Biological Systems Science within the Biological and Environmental Research (BER) program:**
  This $400 million program supports biotechnology approaches, such as genome sequencing, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, and integration of information into computational models, to advance a predictive understanding of biological systems for DOE mission goals. A key element is biosystems design research to explore genomic pathway design and new secure gene-editing and multi-gene stacking techniques for designing new functions into plants and microbes. BER also supports research in the microbiome. Specifically, DOE support efforts to improve understanding of genomic mechanisms in the functioning of plants and soil microbial communities in the environment. This information leads to understanding how plants and microbes impact the cycling and fate of carbon, nutrients, and contaminants in the environment and contribute to more sustainable ecosystems. BER also invests in artificial intelligence and machine learning techniques to aid in the discovery of novel processes and key insights into the functioning of biological systems by examining large datasets with powerful analytics. BER currently support four Bioenergy Research Centers ($100 million a year) focused on multidisciplinary genome-enabled biotechnology research to sustainably produce a range of bioenergy and bioproducts from renewable plant biomass. BER has also invested in new quantum-enabled instrumentation for imaging biological processes and for visualizing cellular metabolism non-destructively.

- **Biosciences within Basic Energy Sciences (BES):**
  This $228 million program supports research in biochemistry, chemistry, and biophysics of energy capture, conversion, and storage in plants and microbes. Research priorities include mechanisms for light harvesting and creation and transport of energy carriers in natural photosynthesis, molecular-level understanding of redox and active site protein chemistry controlling energy and molecular conversions, and biochemical and biophysical principles that determine the synthetic pathways to produce biomolecules and structures with specific architectures. BES also supports research in biomolecular materials to create robust, scalable, energy-relevant materials as well as catalysis science and solar photochemistry to establish a foundation for bio-inspired, biohybrid and biomimetic systems.

- **Advanced Research Projects Agency-Energy (ARPA-E):**
  In the last few years, ARPA-E has spent $47 million supporting three biotechnology programs—Biotechnologies to Ensure a Robust
Supply of Critical Materials for Clean Energy, Systems for Monitoring and Analytics for Renewable Transportation Fuels from Agricultural Resources and Management (SMARTFARM), and Energy and Carbon Optimized Synthesis for the Bioeconomy (ECOSynBio).

- **Bioenergy Technologies Office within the Office of Energy Efficiency and Renewable Energy (EERE):** This $57 million program focuses on developing bioengineering techniques to optimize production of fuels, chemicals, and materials in microbes. This program supports the Agile BioFoundry, a consortium of seven DOE national laboratories that use a Design-Build-Test-Learn cycle with a goal of a 50 percent reduction in the time and cost to bring new bio-derived molecules to market. This program also supports biological engineering including enzymatic hydrolysis, fermentation, downstream separations, and catalysis to demonstrate transformation of bio-based feedstocks into jet fuels and chemicals. This program also supports biological methods for plastic deconstruction and upcycling including optimization of novel enzymes and organisms.

In FY 2022, DOE plans additional funding solicitations in biotechnology, including:

- $10 million to support advanced manufacturing for novel polymer upcycling approaches. Specifically, BER is interested in novel extensions of biodesign and synthetic biology approaches for the design of new plant- and microbially-derived polymers that can advance new biotechnology applications in resource recovery and recycling.
- $10 million in biosystems design for carbon sequestration in terrestrial systems. Specifically, this would support programmable production and/or deconstruction of organic/inorganic/hybrid materials in modified plants and microorganisms. The goal would be to understand the key molecular processes governing soil-microbe-plant interactions with the environment that control carbon turnover.
- $10 million for programmable biomaterials and biocatalysts, including advancing biochemical processes and structures to serve as a foundation for bio-inspired, biohybrid, and biomimetic systems with desired functions and properties.
- ARPA-E has not yet developed FY 2022 funding solicitations, but is exploring new funding opportunities focused on sensing, analytics, and phenomics for biofuels; synthetic biology to extract critical materials; and new technologies to improve the carbon efficiency of bioconversion platforms.

**National Science Foundation (NSF)**

According to the budget request document, NSF plans to invest $382.26 million in FY 2022 for Biotechnology activities including data, tools, research infrastructure, workforce capacity, and innovation. This would be a 25% increase over FY 2021 funding levels. NSF plans to invest in a wide range of biotechnology areas across various directorates, including “genomics, proteomics, synthetic biology, chemical biology, bioinformatics, computational biology, data analytics, structural biology, biophysics, tissue engineering, and development of new types of biomaterials, bio-probes, bio-based microelectronics, and biomanufacturing.” NSF will also support education and training activities and

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research to ensure socially responsible adoption of new and emerging biotechnologies. While not specifically dedicated to biotechnology, NSF has a number of large funding opportunities that could support center-level awards in biotechnology. There are also a range of standing funding opportunities across NSF in biotechnology including Science and Technology Centers (STCs) and Biology Integration Institutes (BIIs).

Across NSF, the Directorates for Biological Sciences (BIO), Engineering (ENG), and Mathematical and Physical Sciences (MPS) have invested the most in biotechnology in the last couple of years and have facilitated community engagement related to biotechnology at their advisory committee meetings. The MPS advisory committee has also established a Subcommittee on Synthetic Biology to advise on future activities in this field.

- BIO has a summary of activities in biotechnology at [https://www.nsf.gov/bio/bioeconomy.jsp](https://www.nsf.gov/bio/bioeconomy.jsp). The existing and future Biology Integration Institutes as well as projects supported under the Rules of Life Big Idea will also play a significant role in advancing NSF’s biotechnology activities.
- MPS supports a range of programs, including: Molecular Foundations for Biotechnology (MFB), Biomaterials (BMAT), Semiconductor Synthetic Biology for Information Storage and Retrieval (SemiSynBio-II), Mathematical Biology, Joint NSF/NIH Initiative to Support Research at the Interface of the Biological and Mathematical Sciences (DMS/NIGMS), NSF-Simons Research Centers for Mathematics of Complex Biological Systems (MathBioSys), and Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science (SCH).
- ENG supports biotechnology activities through the Engineering Biology and Health Cluster within the Chemical, Bioengineering, Environmental and Transport Systems (CBET) Division. Additional biotechnology programs supported through ENG include: Designing Synthetic Cells Beyond the Bounds of Evolution (Designer Cells); Environmental Convergence Opportunities in Chemical, Bioengineering, Environmental, and Transport Systems (ECO-CBET); and Reproducible Cells and Organoids via Directed-Differentiation Encoding (RECODE).

For FY 2022, NSF plans to make new investments in foundational research (including in the programs highlighted above); computing and physical infrastructure, including AI and machine learning and mid-scale facilities; proof-of-concept development; and education and workforce development. Biotechnology will be one of the focus areas for the FY 2022 NSF Research Traineeship (NRT) program. The new Translation, Innovation, and Partnerships (TIP) directorate, which will support “use-inspired, solution-oriented research and innovation,” will include biotechnology as one of its priority areas. Within TIP, NSF is expected to release a new solicitation in September 2021 for Regional Innovation Accelerators (RIAs). As proposed in the FY 2022 budget request, RIAs would provide funding of $100 million over 10-years to cultivate new innovation ecosystems. NSF has also recently awarded “Innovation in the Bioeconomy: Workshops to catalyze translation and partnerships” that will include five biotechnology related themes to help define future priorities for NSF: (i) Feeding the Planet Sustainably, (ii) World Without Waste: a circular bioeconomy, (iii) Towards a Healthier Planet: from molecules to ecosystems, (iv) Biological Mitigation of Climate Change, and (v) Bioeconomy Ecosystem and Society.
National Institute of Standards and Technology (NIST)

NIST’s role in the bioeconomy supports measurement science, validated data, and standards development leadership for emerging biotechnologies. In line with OSTP recommendations, NIST is tasked with advancing “R&D that enables biotechnology, ‘omics, scientific collections, biosecurity, and data analytics to drive economic growth across multiple sectors including healthcare pharmaceuticals, manufacturing, and agriculture.” NIST is also home to the National Metrological Institute, which provides measurements and reference materials for international measurement standards that supports the biotechnology supply chain both domestically and internationally.

As of February 2020, NIST investments in support for the bioeconomy totaled $30.5 million. These investments include research efforts in engineering biology, biomanufacturing, and regenerative medicine. Additionally, NIST’s Material Measurement Laboratories support bioeconomy efforts through the Biosystems and Biomaterials Division and the Biomolecular Measurement Division.

NIST also supports the bioeconomy through its manufacturing innovation institutes, known as Manufacturing USA, which includes over a dozen institutes that across the nation to promote advanced manufacturing through public-private collaboration on technology, supply chain, and workforce development. The following institutes contribute to NIST’s role in the bioeconomy:

- **National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL)**
  NIIMBL, sponsored directly by NIST, is located in Newark, Delaware and aims to “accelerate biopharmaceutical innovation, support the development of standards that enable more efficient and rapid manufacturing capabilities, and educate and train a world-leading biopharmaceutical manufacturing workforce, fundamentally advancing U.S. competitiveness in this industry.” More information can be found at [https://niimbl.force.com/s/about-niimbl](https://niimbl.force.com/s/about-niimbl).

- **BioFabUSA/Advanced Regenerative Manufacturing Institute (ARMI)**
  BioFabUSA, also known as the Department of Defense’s (DOD) Advanced Regenerative manufacturing institute (ARMI), is headquartered in Edison, New Jersey and aims to support the “large-scale manufacturing of engineered tissues and tissue-related technologies, to benefit existing industries and grow new ones.” More information can be found at [https://www.armiusa.org/](https://www.armiusa.org/).

- **Bioindustrial Manufacturing and Design Ecosystem (BioMADE)**
  BioMADE, a DOD-sponsored institute, is headquartered at the University of Minnesota in St. Paul and focuses on advancing sustainable and reliable bioindustrial manufacturing technologies. Institute efforts include bioindustrial manufacturing applications such as: chemicals, solvents, detergents, reagents, plastics, electronic films, fabrics, polymers, agricultural products (e.g., feedstock), crop protection solutions, food additives, fragrances, and flavors. More information can be found at [https://biomade.org/](https://biomade.org/).

In the FY 2022 President’s budget request, funding for NIST to support the bioeconomy would increase from $14 million to $34 million. According to NIST, funding would mainly go toward “developing capabilities for engineering biology, advancing biomanufacturing processes and technologies, and merging artificial intelligence with biological data to create new measurement technologies.” NIST also
states that increased engineering biology investments would help develop “rapid detection methods for infectious diseases and evaluation of vaccines and therapeutics that may reduce viral spread,” as well as “mitigate increased biosecurity risks posed by dual-use and emerging biotechnologies.” In the FY 2022 House Commerce, Justice, Science, and Related Agencies bill, NIST would receive an increase of $8.5 million to support the “American Bioeconomy.”

National Institutes of Health (NIH)

While much of the research supported by NIH could be categorized as connected to the bioeconomy in some form, the agency’s most directly relevant area of interest is synthetic biology. The National Institute of Biomedical Imaging and Bioengineering (NIBIB) is the lead Institute funding and coordinating research in synthetic biology, beginning with a Funding Opportunity Announcement first issued in 2017 jointly with the National Cancer Institute (NCI) and the National Center for Complementary and Integrative Health (NCCIH). That announcement solicited proposals for research on “1) the development of innovative tools and technologies in synthetic biology and 2) their application in biomedical research and human health.” NIH has funded just under $10 million worth of awards through this solicitation from its publication through its expiration in early 2021.

Interest in synthetic biology grew across NIH as the field itself expanded, and when a new Notice of Special Interest in Synthetic Biology for Biomedical Applications was issued in fall 2020, five new Institutes and Centers had joined NIBIB, NCI, and NCCIH to support this portfolio of work: National Human Genome Research Institute (NHGRI), National Institute on Aging (NIA), National Institute of Allergy and Infectious Diseases (NIAID), Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD), and National Institute of General Medical Sciences (NIGMS). The overarching goals of this Notice of Special Interest have expanded since the 2017 solicitation and aim to:

1. “Develop tools and technologies to control and reprogram biological systems;
2. Apply synthetic biology approaches for the development of biomedical technologies;
3. Increase the fundamental understanding of synthetic biology concepts as they relate to human health; and
4. Gain fundamental biological knowledge through the application of synthetic biology approaches.”

The table below summarizes the participating Institutes and Centers’ interests in synthetic biology, and additional details and program contacts can be found in the solicitation linked above.

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<th>Institute or Center</th>
<th>Examples of Research Interests in Synthetic Biology</th>
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| NIBIB              | • Engineered biological circuits for implementing regulation and decision-making strategies in biological and biomimetic systems  
                    | • Engineered cells and tissues for therapeutic and diagnostic applications  
                    | • Sensors, processors, actuators, and other modules for biological control  
                    | • Biosensor assays for analyte detection and contrast agents and probes for imaging |
| NCI                | • Developing novel synthetic biology methods and tools relevant to cancer research and cancer management |
| NCCIH | • Using synthetic biology methods to develop novel cell, tissue, and animal-based model systems to study the fundamental mechanism of cancer development, progression, and/or response to treatment  
• Using synthetic biology methods to develop and evaluate novel diagnostic, preventive, and therapeutic approaches relevant to human cancer |
| NCIH | • Use of synthetic biology tools to identify biosynthetic gene clusters or pathways responsible for the biosynthesis of plant based natural products  
• Use of synthetic biology tools to improve production of plant based natural products from their native sources  
• Use of synthetic biology tools to assemble biosynthetic machinery and optimize yield for plant based natural products into heterologous hosts  
• Synthetic microbiome and probiotics to sense host-gut microbiome interactions and improve human health |
| NHGRI | • Synthetic genomic tools and approaches for genome-wide study of genome organization and function.  
• High-throughput approaches utilizing synthetic tools and devices for functional genomic analysis.  
• Novel methods and tools for the design and synthesis of nucleic acid molecules with defined sequences. |
| NIA | • Develop biosynthetic reporters of the hallmarks of aging for laboratory animals or for lab animal and human-derived organoid and cell culture systems.  
• Develop tools and technologies to control and reprogram aging systems for accelerated or delayed aging.  
• Apply synthetic biology approaches for the development of biomedical technologies to track geroscience-based interventions in preclinical studies.  
• Develop synthetic biology tools and technologies applicable to multiple morbidities in aging populations.  
• Apply synthetic biology approaches for re-programming and re-wiring the aging and/or diseased neural systems. |
| NIAID | • Basic research including novel cell, tissue, and animal-based model systems to better understand the complexities of infectious disease and immune disorders, and/ or immune responses in such diseases/disorders  
• Tools and technologies to facilitate design and development of novel sensors, therapeutics, antibodies, or vaccine approaches to overcome roadblocks in infectious disease diagnosis, prevention, treatment and eradication/cure  
• Translational and clinical studies for precise detection, targeting and treatment of a wide range of infectious and immunological diseases, including remodeling of the disease microenvironment |
| NICHD | • Construction and utilization of transgenic synthetic biology tools and approaches in animal model systems for the systematic and quantitative study of embryonic developmental processes  
• Engineered animal and human pluripotent cells and organoids to advance birth defects research  
• Synthetic biology tools for in vivo measurement of biophysical parameters critical for embryonic morphogenesis  
• Synthetic biology tools to advance research on endogenous tissue regeneration  
• Utilization of synthetic biology approaches and tools to develop diagnostic, prognostic, predictive, or therapeutic synthetic biomarkers for use in populations and conditions of interest to the NICHD  
• Generation of synthetic biology constructs to deliver therapeutic payloads to targeted tissue niches or cell types for the treatment of a condition of interest to the NICHD |
In addition to funding research grants through this broad Notice of Special Interest, NIH occasionally publishes more specific Funding Opportunity Announcements relevant to synthetic biology topics. Most recently, NIBIB and NCI jointly issued a solicitation for Collaborative Approaches to Engineer Biology for Cancer Applications. This program, which will fund projects through the U01 cooperative agreement mechanism beginning in October 2021, will “develop and apply novel synthetic biology approaches to address challenges across the spectrum of cancer research. Projects must define an important cancer research question and then approach that question with a synthetic biology technology, based on an adapted biological system that can sense an input, apply logic to determine a response to the input, and initiate a response.”

NIBIB hosts an annual Synthetic Biology Consortium Meeting for members of the extramural NIH community to present their work, meet others working in the field, and engage with program officers managing portfolios in synthetic biology across NIH. After the cancellation of the 2020 meeting, the Synthetic Biology Consortium Meeting for 2021 is scheduled for November 4 and 5. More details will be posted on the Synthetic Biology Consortium website.

### U.S. Department of Agriculture (USDA)

USDA’s research enterprise aims to support the agricultural sector and thus the role agriculture plays in the bioeconomy. USDA’s extramural research arm, the National Institute of Food and Agriculture (NIFA), provides numerous opportunities in this space, most notably through the competitive Agriculture and Food Research Initiative (AFRI). The FY 2022 budget request for AFRI is $700 million, the highest ever requested by an Administration, and AFRI’s authorized level. While there is strong bipartisan support for AFRI and AFRI has continue to grow over time, it is likely to receive a much lower funding level due to many other competing congressional priorities. However, AFRI’s two research solicitations (Requests for Applications, or RFAs) are expected within the next six months:

- **Sustainable Agricultural Systems (SAS):** RFA for $10 million awards with opportunities for smaller mid-size awards is expected in December 2021, and will include the following program areas of emphasis:
  - Climate-smart agriculture
  - Sources of clean energy and other high-value biobased products
  - Nutrition security

- **Foundational and Applied Science:** FY 2022 & FY 2023 RFA expected to be released in January 2022, highlighting the following areas of focus:
Mitigation and adaptation to climate change
Application of AI and climate-smart agriculture
Robotics, unmanned aerial systems, cyberphysical systems, big data
Increased investments in plant and animal breeding
Emerging technologies—gene editing, machine learning, production of new products
Biosecurity, microbiome, antimicrobial resistance

In addition to AFRI, the Agriculture Advanced Research and Development Authority (AgARDA) may see its first funding in FY 2022 to support strategic planning efforts. The program, authorized in the 2018 Farm Bill, would likely support precision and digital agriculture and climate-related research projects if given funding in future years.

**National Aeronautics and Space Administration (NASA)**

NASA’s Science Mission Directorate, Biological and Physical Sciences (BPS) Division conducts studies on biological systems under extreme conditions, such as altered gravity and radiation. Scientists use this data to contribute to important scientific discoveries and technology advancements that not only enable space exploration but benefit life on earth. NASA’s FY 2022 Budget Request proposes $109.1 million for BPS to conduct “competitively awarded grants to scientists at NASA centers, universities, and research institutions across the country. BPS develops critical equipment and processes to support new experiments and shares research results with academia, commercial industry, and other government agencies.”

BPS releases annual funding [opportunities](#) in the first quarter of the year through the Research Opportunities in Space and Earth Sciences (ROSES) omnibus solicitation. In FY 2022, NASA requested a $30 million increase for BPS to accelerate transformative science including accelerating development of the [Lunar Exploration for Space Biology Applications](#), which will “conduct biological research on the Moon to contribute to advancing technologies on Earth and transfer technologies to the commercial space sector.”

NASA’s Advanced Exploration Systems (AES) is pioneering new approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit including utilizing synthetic biology applications. The Space Synthetic Biology (SynBio) project, located at NASA’s Ames Research Center in California’s Silicon Valley, is developing technologies to biomanufacture valuable products on-demand such as vitamins and medicines. The [BioNutrients](#) experiment is part of NASA’s SynBio project and will test an in-space nutrient production method that uses genetically-engineered baker’s yeast and an extended shelf-life growth substrate to produce specific antioxidants, such as beta carotene and zeaxanthin, typically found in carrots, bell peppers, and other vegetables. Other NASA synthetic biology activities include:

- The SynBio project team is developing a technology that chemically converts carbon dioxide (CO₂) and water to organic compounds that can “feed” microbial biomanufacturing systems to make a wide range of products such as food, medicines, and plastics. This same method could be widely applied to sustainably create these products on Earth. To further advance these
efforts, NASA’s Space Technology Mission Directorate asked scientists and engineers across the country to convert CO2 to molecules to enable biomanufacturing in space.

- The myco-architecture project out of NASA’s Ames Research Center in California's Silicon Valley is prototyping technologies that could "grow" habitats on the Moon, Mars and beyond out of life – specifically, fungi and the unseen underground threads that make up the main part of the fungus, known as mycelia. This research is supported through the NASA Innovative Advanced Concepts program.

NASA also conducts biotechnology research through the International Space Station National Lab (ISSNL) for the primary benefit of everyone on earth. Spaceflight studies have demonstrated that microgravity can enable better understanding of fundamental biology and plant science and accelerate advancements in healthcare and medical technologies. Examples of recent biotechnology investigations include protein crystallization studies by several pharmaceutical companies seeking to improve drug design, using the unique effects of spaceflight on fluid dynamics to advance precision medicine through improved diagnostics and drug delivery systems, and utilizing the microgravity environment to 3D print human tissue. New ISSNL funding opportunities are posted here.