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Food Biomanufacturing for National Security

Growing a New Segment of the U.S. Defense Industrial Base

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Executive Summary

The United States is at an inflection point in food biomanufacturing. Advances in fermentation and synthetic biology have made it possible to produce proteins, fats, and other food ingredients in enclosed bioreactors—rapidly, with diverse inputs, and virtually anywhere. These capabilities have profound implications for national security, food supply chain resilience, and the United States' position in the intensifying global competition over leadership in biotechnology.

Food biomanufacturing directly addresses critical defense challenges:

Biomanufacturing allows for simplified, streamlined, and safe food production in contested environments. Fermentation can be leveraged to produce food in austere environments with minimal inputs, reducing the supply burden of military operations and potentially saving lives.

Biomanufacturing allows for the efficient production of critical defense goods. Equipment and processes used for food biomanufacturing are fungible to other types of bioindustrial manufacturing. Building food-grade fermentation infrastructure domestically also allows the defense industrial base to surge production of other goods, such as energetics, chemicals, or fuels, as needed.

Biomanufacturing allows for safer, more diversified domestic food production. Diversifying food production can improve resilience against food supply shocks: Unlike conventional protein production, which is deeply consolidated,[1] food biomanufacturing leverages a diverse array of inputs and can be produced anywhere. This technology can be leveraged to manufacture products, such as palm oil, that cannot be produced in the continental U.S. This input and geographic diversity makes food biomanufacturing less susceptible to supply shocks. Food biomanufacturing can also scale quickly and efficiently: tons of protein can be produced in a matter of hours, and typically is less perishable than conventional protein sources, allowing the U.S. to build and increase food stores for disaster situations.

Biomanufacturing will boost U.S. technological advantage in one of the most consequential industries of the century. Other countries are actively increasing investments in food biotechnology. To stay ahead, we must invest quickly and ambitiously.

We recommend that the U.S. Department of Defense (DoD) analyze the potential to leverage its expanding innovation and industrial policy toolkit—including R&D funding, loans, loan guarantees, offtake agreements, and procurement contracts—to catalyze private investment in food biomanufacturing infrastructure. Strategic investment would pay dividends for the safety of our troops, resilience of our food supply, and leadership position in the global technology landscape.

Introduction

Fermentation is among the oldest technologies in human civilization and is simultaneously one of the most exciting frontiers of modern science and manufacturing. For thousands of years, we have harnessed microbial processes to produce bread, beer, cheese, and other foods. Today, recent advances in synthetic biology and bioprocess design have unleashed a manufacturing revolution—producing an extraordinary range of products from food to fuels, specialty chemicals, materials, plastics, and medicines.

New applications of biomanufacturing extend across virtually every major industrial sector. In the energy and chemicals industries, microbes can produce sustainable fuels and specialty chemicals with fewer resources than petroleum-derived inputs. In pharmaceuticals, fermentation underpins the production of life-saving medicines such as insulin, antibiotics, and vaccine components. Fermentation can even produce synthetic blood that can lower or eliminate refrigeration requirements for life-saving trauma treatment on battlefields and in rural communities. In advanced materials, biomanufacturing yields novel fibers, bioplastics, and performance textiles. The breadth of goods and societal benefits that can be produced through biotechnology is vast and continually expanding.

1 Zane Swanson, Caitlin Welsh, and Joseph Majkut, ***Mitigating Risk and Capturing Opportunity: The Future of Alternative Proteins*** (Washington, DC: Center for Strategic and International Studies, 2023), https://www.csis.org/analysis/mitigating-risk-and-capturing-opportunity-future-alternative-proteins.

Food Logistics in the U.S. Military Context

In food logistics, the connection between biomanufacturing and national security is especially significant. The DoD's Defense Logistics Agency (DLA), central to food distribution, provided over 315 million meals in FY 2025.[2] In contested environments, food logistics is a readiness and survivability issue: Food must be produced, packaged, stored, transported, protected, and delivered across supply chains that are vulnerable to disruption. This burden is significant even in current conflicts: Estimates suggest that supplying Ukrainian forces in the ongoing conflict with Russia may require 50 to 150 trucks of food alone per day.[3]

The challenge of how to deliver food supplies to troops would be especially acute in any future conflicts in the Pacific theater, where long distances, contested air and maritime routes, and limited forward infrastructure might make conventional resupply highly contestable.[4] For inaccessible locations such as submarines, on-site production of food could significantly expand crew endurance and improve readiness.

Food logistics is also a supply chain resiliency challenge. For conventional meal preparation, production of vitamins, amino acids, and fats is concentrated among a relatively small number of suppliers and geographies, often outside the United States.[5] Palm oil, for example, is widely used across packaged foods, consumer goods, biofuels, lubricants, and other industrial applications, magnifying the supply chain risk.[6] Specialized ingredients may be of particular importance for the production of combat rations, which must satisfy demanding requirements for nutrition, safety, palatability, shelf life, cost, weight, and volume that far exceed ordinary food standards.

The Promise of Fermentation-Derived Protein

One of the most exciting applications of modern fermentation is the production of proteins and fats for human consumption. Fermentation-derived proteins and fats offer a pathway to produce high-quality, nutrient-dense food ingredients at either massive or small scales that improve food system resilience and enable our armed forces to produce food with limited inputs in resource-constrained environments.

Defining Fermentation-Derived Protein

Fermentation happens when a microbe creates or transforms a product. The microorganism eats a feedstock (typically, but not always, a source of sugar) and metabolizes it into the final product.

Precision fermentation uses microorganisms as "cell factories" to produce specific functional proteins, fats, or other molecules. Products produced through precision fermentation include whey and casein proteins, heme, collagen, and egg white proteins. Companies such as Onego Bio, The EVERY Company, and Perfect Day use precision fermentation to produce genuine animal protein.

Biomass fermentation cultivates microorganisms such as fungi, yeast, or microalgae to produce large volumes of protein. Companies such as the Fynder Group, Quorn, and Air Protein use biomass fermentation to create fiber- and protein-rich food products.

Importantly, fermentation is inherently flexible and location-independent. Fermentation processes can leverage a variety of feedstocks, including American-grown staple crops like corn and wheat, agricultural sidestreams like corn stover and soy straw, and even gases like carbon dioxide and methane. Fermentation can happen anywhere, from a mass-production facility on the plains of the American Midwest to a miniaturized bioreactor in the bed of a deployed military vehicle. This flexibility makes fermentation an efficient, safe, and resilient way to produce food—particularly given that fermentation is less vulnerable to the weather events and supply shocks that are increasingly threatening the U.S. food system.

2 Defense Logistics Agency, ***FY2025 Annual Report: The Nation's Logistics Combat Support Agency*** (Fort Belvoir, VA: Defense Logistics Agency, 2025).

3 Emerging Technologies Institute, "Rations to the Warfighter: Innovation and Vulnerabilities," ***Emerging Tech Horizons***, YouTube Video, 37 minutes, October 1, 2025, https://www.youtube.com/watch?v=46OBGssDVyg.

4 Elizabeth Specht, "Possibilities of Biomanufacturing for Defense," ***National Defense Magazine,*** October 2025 (Arlington, VA: National Defense Industrial Association, 2025).

5 Emerging Technologies Institute, "Rations to the Warfighter."

6 Emerging Technologies Institute, "Rations to the Warfighter."

Case Study: Onego Bio's Jefferson, WI Facility

Food biomanufacturing company Onego Bio is building a 130,000-square-foot precision fermentation facility in Jefferson, Wisconsin—a project that illustrates the promise of domestic food biomanufacturing. The facility, slated for commissioning in 2028, will produce over 6,000 tons per year of Bioalbumen, a protein bioidentical to chicken egg-white ovalbumin, by converting corn sugar into protein via precision fermentation. That output is equivalent to the protein produced by approximately six million laying hens. Because the product is made via fermentation rather than sourced from live poultry, it is not susceptible to avian influenza or salmonella—offering food manufacturers a safe, stable alternative during supply disruptions such as the recent wave of bird flu outbreaks that sent egg prices to record highs.

The project's economic footprint is substantial: an estimated $250–300 million in construction spending over two years, supporting roughly 2,160 construction jobs; 81 permanent positions at the facility; and 136 indirect jobs in the surrounding region. Onego Bio is also developing military applications for its protein, including use in MREs and forward-deployed rations, in collaboration with the DoD. To finance the facility, the company is pursuing federal support through DoD's Distributed Bioindustrial Manufacturing Program (DBIMP), for which it has successfully obtained a Phase I project planning award, as well as the USDA's 9003 Biorefinery Assistance Program, which can provide loan guarantees of up to $250 million for bio-based production.

Onego Bio's experience underscores a central theme of this brief: Promising U.S. food biomanufacturing ventures exist and are ready to scale, but their ability to quickly scale domestically hinges on access to federal financing tools.

Policy Context: Biomanufacturing for DoD

Biotechnology and biomanufacturing have moved squarely into the mainstream of U.S. national security policy. The DoD's expressed priorities in biomanufacturing are broad: its 2023 Biomanufacturing Strategy included food and agricultural resilience, advanced materials, fuels, energetics, medical supply chains, data infrastructure, and industrial capacity.[7] In 2025, the DoD's Chief Technology Office (the Office of the Under Secretary of Defense for Research and Engineering, or OUSD(R&E)) reinforced this trend by designating biomanufacturing as one of its six Critical Technology Areas, the Department's method for indicating its technology priorities.[8]

Currently, the Pentagon's biomanufacturing efforts are concentrated within the defense innovation enterprise. The Distributed Bioindustrial Manufacturing Program (DBIMP) has spent over $120 million to commercialize techniques for biomanufacturing products of national security significance, particularly in "food, fuel, fitness [advanced materials], firepower [e.g., energetics], and fabrication."[9] Under the Tri-Service Biotechnology for a Resilient Supply Chain (T-BRSC) program, DoD has invested over $280 million across 30 projects to modernize biomanufacturing infrastructure.[10] Additionally, the President's Fiscal Year 2027 budget request includes over $50 million for Pilot-Scale Production of Bioindustrial Products, as well as funding for a number of S&T programs focused on improving combat rations and developing innovative feeding technologies to reduce resupply requirements and enhance operational independence, including at DLA and the Army.

7 Office of the Under Secretary of Defense for Research and Engineering, ***Biomanufacturing Strategy*** (Washington, DC: U.S. Department of Defense, March 21, 2023).

8 Chief Technology Office, "Critical Technology Areas," U.S. Department of Defense, accessed May 21, 2026, https://www.cto.mil/cta/.

9 U.S. Government Accountability Office (GAO), ***Defense Industrial Base: DOD Efforts to Develop Domestic Biomanufacturing***, GAO-26-107797 (Washington, DC: U.S. Government Accountability Office, February 26, 2026).

10 GAO, Defense Industrial Base.

Through the Bioindustrial Manufacturing and Design Ecosystem (BioMADE), a Manufacturing Innovation Institute supported by DoD, nearly $600 million has been committed to biomanufacturing innovation.[11] DARPA has also been active through programs such as Living Foundries, Switch, Cornucopia, and Ag x BTO.[12] At DEVCOM, the Army has explored food biomanufacturing for contested supply-chain resilience and is building internal biomanufacturing pilot capacity.[13] Despite these investments, biomanufactured materials have yet to become a mainstay of defense procurement priorities.

Congress has likewise shown growing interest in DoD's biomanufacturing efforts. The 2026 National Defense Authorization Act (NDAA) contained several significant biomanufacturing provisions:

- A dedicated management office reporting to the Deputy Secretary of Defense, with responsibility for coordinating DoD's biomanufacturing activities across the acquisition lifecycle, from research through procurement and sustainment[14]
- Authorities that provide added budget flexibility to the DBIMP program and enable a new biomanufacturing capacity program to fund activities such as establishing, retooling or upgrading commercial biomanufacturing facilities that can meet the demands of "the next generation of warfighters"[15]
- A "biotechnology supply chain resiliency program" with scope for chemicals, materials, and fuels.[16] Significantly, metrics for the program could include "operational integration and transition to programs of record," suggesting that Congress hopes biomanufactured products can traverse the "valley of death," finding markets in DoD procurement or operations and maintenance (O&M) programs with buying power
- DoD was directed to develop a strategy for expanding these efforts in future years, including through a network of commercial biomanufacturing facilities accessible to DoD, updates to military specifications for bio-based products, and demand signaling tools such as advance market commitments or offtake agreements[17]

Why Fermentation-Derived Protein Production Matters for Defense

The U.S. food system, while enormously productive, is characterized by consolidation and geographic concentration that create significant vulnerabilities. Our food supply is vulnerable to multiple categories of potential sudden shock, as documented by the Center for Strategic and International Studies,[18] respected defense analysts,[19] and food security researchers.[20] These include trade disruptions; disease outbreaks that decimate livestock populations or contaminate crops; and direct disruptions caused by geopolitical conflict, including damage to production infrastructure, trade embargoes, or the weaponization of food access.

Fermentation-derived proteins directly mitigate these vulnerabilities. Because they are produced in enclosed, controlled environments and with diverse and flexible inputs, they are less susceptible to animal diseases, crop failures, long or complex supply chains, or weather disruptions.

Diversifying food production through biomanufacturing also improves systemic resilience against supply shocks

Unlike conventional protein production, which is deeply consolidated with a small number of large facilities processing the majority of the nation's meat supply,[21] food biomanufacturing leverages a diverse array of feedstocks and can be sited virtually anywhere with access to basic industrial infrastructure. This input and geographic diversity make fermentation-derived food production far less susceptible to a variety of localized disruptions. The broad array of firms (115 companies involved in

11 GAO, Defense Industrial Base.

12 Defense Advanced Research Projects Agency (DARPA), "Cornucopia," U.S. Department of Defense, accessed May 21, 2026, https://www.darpa.mil/research/programs/cornucopia.

13 U.S. Army, "DEVCOM CBC Cuts Ribbon on Expanded Biomanufacturing Facility," June 12, 2024, https://www.army.mil/article/277195/devcom_cbc_cuts_ribbon_on_expanded_biomanufacturing_facility.

14 National Defense Authorization Act for Fiscal Year 2026, Pub. L. No. 119-60, § 242 (2025) [hereinafter FY2026 NDAA].

15 FY2026 NDAA §§ 241, 243.

16 FY2026 NDAA § 244.

17 FY2026 NDAA § 246.

18 Zane Swanson, Caitlin Welsh, and Joseph Majkut, ***Mitigating Risk and Capturing Opportunity: The Future of Alternative Proteins*** (Washington, DC: Center for Strategic and International Studies, 2023), https://www.csis.org/analysis/mitigating-risk-and-capturing-opportunity-future-alternative-proteins.

19 Sarah Danon, Saro Naomi Gakusi, Ivette Povis Landa, Jane Pan, and Claire Reichle, ***Food Trade Chokepoints & U.S. National Security in 2040*** (Washington, DC: Council on Strategic Risks, 2025), https://councilonstrategicrisks.org/2025/12/16/food-trade-chokepoints-us-national-security-in-2040/.

20 Noah J. Wescombe et al., "It's Time to Consider Global Catastrophic Food Failures," ***Global Food Security*** 46 (September 2025): 100880, https://allfed.info/research/publications-and-reports/peer-reviewed/its-time-to-consider-global-catastrophic-food-failures/.

21 Kailee A. Schaefer, Ryan A. Williams, and Glynn T. Tonsor, ***Consolidation and Concentration in U.S. Meat Processing: Updated Measures and Implications*** (Washington, DC: U.S. Department of Agriculture, 2023), https://www.usda.gov/sites/default/files/documents/schaefer-et-al-2023.pdf.

fermentation-derived protein production in the U.S.)[22] can grow the defense industrial base and diversify the U.S. food supply.

Food biomanufacturing offers critical advantages in speed and shelf stability

Protein can be produced via fermentation in a matter of hours rather than the months or years required for conventional animal agriculture. Fermentation-derived ingredients are typically less perishable than conventional protein sources, enabling the United States to build and maintain strategic food reserves for disaster response and military sustainment.[23, 24]

Strategic investment in food biomanufacturing infrastructure will boost our ability to compete in other biotechnology sectors

Food biomanufacturing uses equipment and inputs that can be fungible to other types of bioindustrial manufacturing. Yet, virtually no other bioproduct has the volume requirements of food. Building high-volume, food-grade capacity is the best way to build a "supply chain of supply chains" to ensure our defense industrial base is equipped for any as-needed surge production of industrial biotech products such as fuels, chemicals, or energetics.

Furthermore, food biotechnology provides unique opportunities to valorize and transform sidestreams to efficiently meet critical supply needs, like specialty chemicals, critical minerals, or fuel. One example is a biological minerals recovery project funded by ARPA-E: a seaweed company able to extract rare earth elements from red seaweed via its protein processing.[25] Another example is Savor, which produces alternatives to tropical oils like palm oil and cocoa butter —inputs critical to many consumer products and not produceable within the continental U.S. Savor's platform converts CO2 or methane directly into these fats and can co-produce aviation fuel at the same facility. Savor won a DoD Distributed Bioindustrial Manufacturing Program Phase I grant[26] to design an integrated facility for co-production of food and fuel, illustrating how a single domestic plant can address both commercial supply chain resilience and military aviation fuel demand.

Biomanufacturing can leverage a diverse range of upcycled inputs, such as corn stover or soy straw, as sources of sugar for feedstocks. This has the potential to create new income streams for American farmers across the country. Most food manufacturing companies looking toward building commercial-scale facilities are planning to site them in rural areas, co-located with the agricultural inputs that serve as feedstocks, bringing quality jobs to rural communities.

Food biomanufacturing will provide a logistical edge in contested environments

Food biomanufacturing allows the production of nutrient-dense food on-site with minimal inputs and a small footprint, improving the safety and reducing the burden of military operations. The DoD is currently exploring low-resource food biomanufacturing for austere environments via the U.S. Army Combat Capabilities Development Command—Soldier Center (DEVCOM)[27] and DARPA's Cornucopia program,[28] but continued investment is needed to fully integrate these technologies into military operations.

22 Good Food Institute, "Alternative Protein Company Database," accessed May 21, 2026, https://gfi.org/resource/alternative-protein-company-database/.

23 Chief Technology Office, U.S. Department of Defense, "DoD Releases Five Awards for Distributed Bioindustrial Manufacturing Program," July 30, 2024, https://www.cto.mil/dod-releases-five-awards-for-distributed-bioindustrial-manufacturing-program/.

24 Good Food Institute, "Deep Dive: Fermentation Protein Ingredients and Food Functionality," accessed May 21, 2026, https://gfi.org/science/the-science-of-fermentation/deep-dive-fermentation-protein-ingredients-and-food-functionality/.

25 Advanced Research Projects Agency–Energy, "Umaro Foods: Marine Bio-Ore Mining of Rare Earth Elements," U.S. Department of Energy, accessed May 21, 2026, https://arpa-e.energy.gov/programs-and-initiatives/search-all-projects/marine-bio-ore-mining-rare-earth-elements.

26 U.S. Department of Defense, "DOD Releases 12 Awards for Distributed Bioindustrial Manufacturing Program," September 13, 2024, https://www.war.gov/News/Releases/Release/Article/3904890/dod-releases-12-awards-for-distributed-bioindustrial-manufacturing-program/.

27 U.S. General Services Administration, System for Award Management (SAM.gov), "Alternative Protein Technologies for Military Field Feeding," SAM.gov contract opportunity, Notice ID W911QY26_ALTERNATIVE_PROTEINS, published April 16, 2026, https://sam.gov/workspace/contract/opp/f0c7648b33da49cab00b545fc503b612/view.

28 DARPA, "Cornucopia."

The Urgency of American Leadership

Fermentation-derived protein production not only offers a way to improve food system resilience but also has implications for the wider biotechnology industrial ecosystem.

The United States faces a rapidly narrowing window to secure its position as the global leader in biotechnology. More than 40 countries have now adopted formal strategies for developing their bioeconomies.[29] The National Security Commission on Emerging Biotechnology (NSCEB), a bipartisan congressionally mandated body created by Congress to analyze the global biotechnology landscape and provide recommendations to ensure American leadership, has issued a series of progressively more urgent assessments of global biotechnology competition.[30] The NSCEB noted that "…emerging biotechnology could enable the on-demand production of essential resources such as fuel, food, and medicine, reducing the military's reliance on vulnerable supply chains."

In January 2024, the NSCEB identified that the United States maintained a clear but at-risk global leadership position in biotechnology, having pioneered foundational advances since the 1970s.[31] By April 2025, the Commission revised its assessment,[32] stating that China was quickly ascending toward global leadership after making biotechnology a strategic national priority for two decades. The Commission stated that the United States must take swift action within three years to remain competitive. Just eight months later, in December 2025, the NSCEB released an even more sobering finding: new evidence indicated that the window for decisive action was closing far faster than anticipated, underscoring the urgency for an accelerated U.S. policy response.[33] The 2025 Report to Congress of the U.S.-China Economic and Security Review Commission warned that "the United States currently faces a future in which it depends on China for access to the most cutting-edge biotechnology innovations, sophisticated biomanufacturing equipment, and advanced biomaterials."[34]

Falling behind in biotechnology would compromise the resilience of the U.S. defense industrial base and technological advantage in war, erode the nation's ability to retain world-class scientific talent, and forfeit economic opportunities in one of the 21st century's most consequential industrial sectors. The stakes of this global competition are enormous.

A new report by Systemiq[35] focuses specifically on the strategic action China is taking to scale biomanufactured food production. Historically a net importer of food, China is now taking decisive steps to grow its domestic production of high-value fermentation-derived protein ingredients. China's 15th Five-Year Plan, released in March 2026, includes synthetic biology and novel proteins as part of the country's strategy to increase domestic food production and diversify protein sources. The national government has recognized in various policy documents (including the Five-Year Plan, No. 1 Central Document, and Outline for Accelerating the Construction of an Agricultural Powerhouse) that food security is imperative to national security. Accordingly, China is growing investments in fermentation-derived protein infrastructure at multiple levels of government. For example, the new Tianjin Biomanufacturing Innovation Academy, funded by the State Development & Investment Corporation, has a focus on scaling fermentation infrastructure, and Beijing's municipal government recently co-funded a protein innovation R&D center.[36]

The United States has an urgent opportunity to invest in fermentation-derived food production and anchor the rapidly growing bioeconomy within our borders. As it confronts a growing agricultural trade deficit, the U.S. investment in emerging sectors like fermentation-derived ingredients represents an opportunity to create new export categories while anchoring innovative food production domestically.[37]

29 National Academies of Sciences, Engineering, and Medicine, "The Ecosystem of the U.S. Bioeconomy," in ***Safeguarding the Bioeconomy***, chap. 5 (Washington, DC: National Academies Press, 2020), https://doi.org/10.17226/25525.

30 National Security Commission on Emerging Biotechnology (NSCEB), "Homepage," accessed May 21, 2026, https://www.biotech.senate.gov/.

31 NSCEB, "Interim Report," January 10, 2024, https://www.biotech.senate.gov/press-releases/interim-report/.

32 NSCEB, "Homepage."

33 NSCEB, ***Charting the Future of Biotechnology: An Action Plan for American Security and Prosperity*** (Washington, DC: National Security Commission on Emerging Biotechnology, 2025), https://www.biotech.senate.gov/2025_report/the-future-of-biotechnology/.

34 U.S.-China Economic and Security Review Commission, ***2025 Annual Report to Congress*** (Washington, DC: U.S.-China Economic and Security Review Commission, 2025), https://www.uscc.gov/annual-report/2025-annual-report-congress.

35 Samantha Landsman, Alex Andreoli, Anna Morser, and Christine Delivanis, ***China's Food Future*** (London: Systemiq, 2026), https://www.systemiq.earth/chinas-food-future/.

36 Landsman et al., ***China's Food Future***.

37 U.S. Department of Agriculture, Economic Research Service, "Foreign Agricultural Trade of the United States (FATUS): U.S. Agricultural Trade Data Update," accessed May 21, 2026, https://www.ers.usda.gov/data-products/foreign-agricultural-trade-of-the-united-states-fatus/us-agricultural-trade-data-update.

China's Biomanufacturing and Protein Security Playbook

China's activity in biomanufacturing is robust and accelerating. Biomanufacturing is the only sector identified as both a "future industry" and a "core technology" in China's 2021 Five-Year Plan—signaling the Chinese Communist Party's view of biotechnology as increasingly central to manufacturing dominance.[38]

In November 2025, China released a list of 43 companies tasked with building pilot-scale biotechnology facilities by 2027.[39] The majority of these companies are in the food sector—a critical indicator of where China is directing its biomanufacturing ambitions. China has also established robust incentive structures for biotech firms, ranging from national industrial policy directives to local government subsidies and spanning each step of the value chain from research through commercialization.[40]

Independent assessments speak to the impact of China's ambitious investments in biotechnology. The Belfer Center's Critical and Emerging Technology Report found that China has the most immediate opportunity to overtake the United States in biotechnology, relative to other critical sectors including artificial intelligence, semiconductors, and space technology.[41] The Director of National Intelligence's Annual Threat Assessment identified that China sees biotechnology as "critical to becoming a dominant economic power" and seeks to grow its domestic bioeconomy to $3.3 trillion.[42]

In the specific domain of fermentation-derived protein research, China appears to be maintaining a significant and growing lead. For most years for which data is available, China has published more primary research articles in the field than the United States.[43] While the U.S. retains advantages in commercialization and venture capital formation, China's dominance in foundational research—combined with its industrial policy apparatus—positions it to rapidly translate scientific advances into commercial-scale production.

The Current Moment: Evidence of Rising Interest and Research Activity

The global fermentation-derived protein industry is in a period of rapid growth and early commercialization. Investment, company formation, and research activity have all accelerated markedly over the past several years, reflecting growing recognition of the technology's commercial and strategic potential.

Industry landscape and investment

The United States currently maintains an early lead in the number of fermentation-derived protein companies and in the total volume of private investment directed to the sector. American firms have attracted a significant share of global venture capital in food biotechnology, and the U.S. is home to the largest concentration of precision fermentation and biomass fermentation startups.[44]

It is important to note, however, that existing industry data is primarily compiled in the United States and is therefore likely more comprehensive for North American companies and investment flows than for those in the Asia-Pacific region. China's fermentation-derived protein ecosystem, in particular, is almost certainly undercounted in available datasets, which may understate the true competitive challenge.[45]

38 Dirk van der Kley, "Biomanufacturing Is Central to China's Next Five Year Plan," ***Bio Brawl***, Substack, 2025, https://dirkvanderkley.substack.com/p/biomanufacturing-is-central-to-chinas.

39 Dirk van der Kley, "China Releases List of 43 Companies to Build Biomanufacturing Pilot Plants," ***Bio Brawl***, Substack, 2026, https://dirkvanderkley.substack.com/p/china-releases-list-of-43-companies.

40 Dirk van der Kley, "What Do Chinese Biotech Subsidies Cover?," ***Bio Brawl***, Substack, February 27, 2026, https://dirkvanderkley.substack.com/p/what-do-chinese-biotech-subsidies.

41 Eric Rosenbach, Lea Baltussen, Eleanor Crane, Ethan Kessler, Łukasz Kołodziej, Ethan Lee, Alexandre Meyer, Cynthia Tong, Britney Tran, and Delaney Wehn, ***Critical and Emerging Technologies Index***, interactive dashboard and reports (Cambridge, MA: Belfer Center for Science and International Affairs, Harvard Kennedy School, 2025), https://www.belfercenter.org/critical-emerging-tech-index.

42 Office of the Director of National Intelligence, ***2025 Annual Threat Assessment of the U.S. Intelligence Community*** (Washington, DC: Office of the Director of National Intelligence, 2025), https://www.dni.gov/files/ODNI/documents/assessments/ATA-2025-Unclassified-Report.pdf.

43 Based on unpublished analysis of publication records from Dimensions, accessed May 21, 2026, https://www.dimensions.ai.

44 Mackenzie Battle et al., ***2026 State of the Industry Report: Fermentation for Meat, Seafood, Eggs, Dairy, and Ingredients*** (Washington, DC: Good Food Institute, 2026), https://gfi.org/wp-content/uploads/2026/04/GFI-2026-State-of-the-Industry-report-Fermentation-for-meat-seafood-eggs-dairy-and-ingredients.pdf.

45 U.S. Senate Committee on Homeland Security and Governmental Affairs, "New Analysis: Urgent Policy Action Needed to Maintain U.S. Global Leadership over China in Biotech Innovation," September 11, 2024, https://www.biotech.senate.gov/press-releases/new-analysis-urgent-policy-action-needed-to-maintain-u-s-global-leadership-over-china-in-biotech-innovation/.

The Scaling Imperative

Early-stage activity in the sector is robust, and the industry is now actively working to scale up from pilot and demonstration phases to commercial production. However, where industry ultimately locates production infrastructure will depend heavily on where governments have instituted financing and supportive policy frameworks.

Financing fermentation-derived protein commercialization requires meaningful capital expenditure sourced across a range of capital types. Capital requirements for pilot and demonstration-scale facilities range from approximately $1 million to $20 million, while commercial-scale facilities can require investment of $100 million to $250 million or more, depending on the specific technology and production capacity.[46]

While venture capital has largely funded early-stage pilot and demonstration facilities, the industry faces a significant financing challenge to reach the next level of commercial scale. Venture capital, while well-suited to early research and development, is generally insufficient to fund the construction of large-scale manufacturing infrastructure. The common financing gap between early-stage R&D and manufacturing scale-up is known as the "commercialization valley of death," and it is especially pronounced in manufacturing sectors.[47] The willingness of U.S. leadership to close this financing gap for fermentation will be a decisive factor in determining whether we retain our current leadership position or cede the advanced food manufacturing industry to our strategic competitors.

In light of the significant funding constraints facing U.S. commercial production facilities, some American fermentation-derived protein companies have begun pursuing opportunities to expand commercial production overseas—particularly in the Middle East.[48, 49] These regions offer access to sovereign wealth funds or policy programs with an appetite to finance large-scale biomanufacturing facilities in their home countries, often with favorable terms that are currently unavailable in the United States.

This trend carries significant strategic implications. Technologies developed with U.S. research funding and intellectual capital may ultimately be commercialized and scaled abroad, with other nations accruing associated revenue, production jobs, manufacturing expertise, and supply chain control. If the United States fails to provide adequate financing mechanisms for domestic scale-up, it risks repeating the pattern observed in other advanced manufacturing sectors—pioneering the technology but ceding the economic and strategic benefits of commercial-scale production to competitors.

Policy Challenges and Opportunities

Most government support for food biomanufacturing is concentrated in research, science, and technology programs, instead of procurement and sustainment activities. As a result, food biomanufacturing may struggle to cross the "valley of death" and receive contracts to deliver useful materiel at scale to the Pentagon. To address this challenge, the industry will need to work with the Pentagon to identify the requirements, programs, and procurement activities that could be addressed by biomanufactured products. This could include data-based analysis of requirements and gaps, demonstrations of food technologies in operational contexts, and the creation of a feedback loop between users and the science and technology communities.

Another opportunity to speed transition lies in the new DoD Biotech Management Office, institutionalized in the FY2026 NDAA.[50] This office, along with DoD's biomanufacturing leadership in OUSD(R&E), should help buyers in DoD understand the potential of biomanufacturing, and share relevant demand signals with industry.

Key to advancing capabilities in biotechnology broadly and food biomanufacturing specifically is continued stable support for basic and applied research activities executed in universities, small businesses, governmental labs, and industry. The Pentagon's identification of Biomanufacturing as a Critical Technology Area should be matched by support in Pentagon budget requests and Congressional appropriations. This activity is the seed corn that will feed the private sector innovation of the future, including to meet future military mission requirements. This includes support for the activities of the Army Research Office, U.S. Army Natick Soldier Systems Center, Defense Logistics Agency, Manufacturing Technologies Program, and DARPA's Biological Technologies Office, among others. These activities fund use-inspired research focused on military operational needs and create the intellectual property and workforce that drives the future.

Government financing programs may be well-positioned to catalyze major private investment in biomanufacturing capacity.

46 Good Food Institute, ***Fermentation: Building End-to-End U.S. Infrastructure for Alternative Protein Production*** (Washington, DC: Good Food Institute, 2024), https://gfi.org/resource/fermentation-manufacturing-capacity-analysis/.

47 David Adler, "Financing Advanced Manufacturing: Why VCs Aren't the Answer," ***American Affairs*** 3, no. 2 (Summer 2019), https://americanaffairsjournal.org/2019/05/financing-advanced-manufacturing-why-vcs-arent-the-answer/.

48 Elaine Watson, "Liberation Labs Heads to Saudi Arabia as NEOM Investment Fund Ventures into Biomanufacturing," ***AgFunderNews,*** April 16, 2025, https://agfundernews.com/liberation-labs-heads-to-saudi-arabia-as-neom-investment-fund-ventures-into-biomanufacturing.

49 Change Foods, "Change Foods Is Making Big Moves in the UAE," ***PR Newswire***, October 20, 2022, https://www.prnewswire.com/ae/news-releases/change-foods-is-making-big-moves-in-the-uae-301655282.html.

50 FY2026 NDAA § 242.

Because biomanufacturing facilities are capital-intensive to build, financing challenges often present a key barrier. Private debt markets often struggle to underwrite against first-of-a-kind facility builds, even when those projects are evaluated to be profitable after adjusting for risk. At the same time, equity markets can struggle to finance large investments.[51] The food biomanufacturing industry has many of the features that block otherwise financeable companies from receiving investment, such as the prevalence of short-term purchase orders as opposed to long-term offtake agreements. Food biomanufacturing production facilities may therefore be especially strong candidates for this kind of industrial policy.

Recent legislation has dramatically expanded the Pentagon's industrial policy toolkit for catalyzing private capital investment, through tools such as loans, loan guarantees, offtake agreements, and even equity securities.[52] To date, these tools have been deployed primarily in the mining and refining industries, consistent with administration priorities in 2026. Going forward, DoD should evaluate and advance the applicability of such tools to scaling up food biomanufacturing, especially promising "first-of-a-kind" facilities that could significantly expand America's biomanufacturing capacity.

Such industrial policy tools are especially powerful when used in concert. For instance, loans or guarantees from the DoD's Office of Strategic Capital could be used to catalyze private investment into commercial fermentation facility capital expenditures (which can range from $15 million to up to $250 million or more, depending on the technology). Private capital is much more likely to flow into such a transaction if strong demand signals are provided. In the DoD context, either procurement contracts (e.g., food production contracts) or offtake agreements (currently authorized under DoD's Industrial Base Fund) could provide that buying power.

DoD can provide debt instruments by leveraging existing authorities under Title III of the Defense Production Act (DPA),[53] or the Office of Strategic Capital,[54] or under authorities available to the Industrial Base Fund.[55] The government could evaluate options for expanding eligibility to pre-revenue companies to receive loans or loan guarantees, and DoD should accept commercial letters of intent for revenue forecasting.

Opportunity: Contract Manufacturing

The role of contract manufacturers in scaling biomanufacturing

Contract manufacturing organizations (CMOs) and contract development and manufacturing organizations (CDMOs) play a critical role in enabling biotechnology companies to scale production without bearing the full cost and risk of building their own facilities. In simple terms, CMOs and CDMOs are third-party manufacturers that provide production capacity and technical expertise to companies on a fee-for-service basis. A CDMO additionally offers process development and optimization services, helping companies refine and test their production methods.

For fermentation-derived protein companies—many of which are early-stage startups—access to contract manufacturing capacity is essential. Building a dedicated commercial-scale fermentation facility requires tens to hundreds of millions of dollars in capital expenditure and years of construction and commissioning time. Contract manufacturers allow companies to produce commercial volumes of product while deferring or avoiding the capital burden of constructing their own plants, accelerating time to market and reducing financial risk.

Current capacity: a critical shortage

Despite the strategic importance of contract manufacturing, available capacity in the United States and globally remains severely constrained relative to demand.

The United States possesses some pilot-scale biomanufacturing facilities, including capabilities at the Department of Energy's National Laboratories,[56] and we are developing additional capacity through initiatives like BioMADE[57] and the Integrated Bioprocessing Research Laboratory (IBRL) at the University of Illinois, a public-private partnership that has received a combination of federal, state, and private funding to provide bioprocessing scale-up and research services to companies and researchers.[58] However, the critical gap is at commercial scale—we must invest in infrastructure to reach the level of production required

51 Sam Moyer, "A Strategic Investor: Federal Equity Investing Approaches to Advance National Security," in ***Proceedings of the 23rd Annual Acquisition Research Symposium and Innovation Summit***, Naval Postgraduate School, Monterey, CA, May 6–7, 2026.

52 Sam Moyer, ***Mobilizing Private Capital: Trends and Recommendations*** (Arlington, VA: Emerging Technologies Institute, 2026), https://www.emergingtechnologiesinstitute.org/publications/research-papers/mobilizing-capital-for-defense.

53 Defense Production Act of 1950, 50 U.S.C. § 4532(a).

54 10 U.S.C. § 149(e)(3)

55 FY2026 NDAA § 867.

56 Good Food Institute, "Guide to Working with U.S. National Laboratories for Alternative Protein Companies," accessed May 21, 2026, https://gfi.org/resource/guide-to-working-with-us-national-labs/.

57 BioMADE, "Pilot Plant Network," accessed May 21, 2026, https://www.biomade.org/pilot-plant-network.

58 University of Illinois Urbana-Champaign, Integrated Bioprocessing Research Laboratory (IBRL), "Welcome to IBRL," accessed May 21, 2026, https://ibrl.aces.illinois.edu/.

to manufacture fermentation-derived ingredients at volumes and costs sufficient to realize food resilience, economic, and national security benefits.

Across all biotechnology verticals, the global contract manufacturing landscape remains limited. Data collected by Synonym Biotechnologies (now Roebling) indicates that there are approximately 246 contract biomanufacturing facilities in over 40 countries.[59] Europe currently hosts the majority of global fermentation capacity at approximately 34.2 million liters, followed by the Americas at approximately 14.3 million liters, while the Asia-Pacific region accounts for approximately 1.8 million liters of documented capacity—though actual capacity in the Asia-Pacific region is likely much higher due to limitations in data collection.

Research opportunity: global contract manufacturing capacity analysis

The actual volume of biomanufacturing contract manufacturing capacity across regions is opaque. We are unaware of a single source accurately comparing global biotechnology contract manufacturing capacity across regions and industries, and have spoken with a number of experts in the field of biomanufacturing to confirm that no complete source exists. We know that capacity is a critical limiting factor for fermentation-derived protein production due to robust surveys and interviews with industry stakeholders.

There is an opportunity to research in-depth global contract manufacturing capacity across different regions, which will likely be a labor-intensive research process involving detailed supply chain analysis and stakeholder interviews. If you are interested in funding or partnering on such research, please contact ETI and GFI.

The scarcity of commercial-scale contract manufacturing capacity represents a bottleneck for the entire fermentation-derived protein industry. Without access to affordable, large-scale capital to build production capacity, even companies with promising technologies and demonstrated demand cannot bring products to market at competitive prices.

Case study: Liberation Bioindustries' contract manufacturing facility

Liberation Bioindustries (formerly Liberation Labs) is nearing completion of a first-of-its-kind facility in Richmond, Indiana: a 600,000-liter, purpose-built precision fermentation plant designed from the ground up as a contract manufacturer. Expected to begin production in 2027, the facility represents approximately $115 million in investment and will serve as a shared-capacity platform—allowing multiple biotech companies to produce food ingredients, pharmaceutical inputs, specialty chemicals, and other bio-based products at commercial scale without each having to build its own plant. Initial operations will support approximately 45 manufacturing jobs.

Liberation Bioindustries is directly addressing the contract manufacturing bottleneck. This facility will onshore crucial biomanufacturing capacity, but it represents a small fraction of what is needed to truly scale fermentation-derived protein products. Liberation has also received a Distributed Bioindustrial Manufacturing Program Phase I grant to plan a second domestic biomanufacturing facility. Follow-on federal funding would allow the domestic construction of much-needed capacity, with benefits for supply chain resilience and job creation.

59 Synonym Biotechnologies, ***State of Global Fermentation*** (New York: Synonym Biotechnologies, 2023), https://synonym.bio/insights/state-of-global-fermentation.

Conclusion

Food biomanufacturing has reached a critical juncture. Analysts predict that biomanufactured products will represent an increasingly significant share of both private and public sector consumption in the U.S. and globally. Food biomanufacturing will be a critical subsector, with a large, dual-use fleet of productive biomanufacturing capacity.

The U.S. is well-positioned to dominate this emerging supply chain, with its unmatched supply of feedstocks, vibrant capital markets, and globally competitive biotechnology workforce and innovation base. However, global competitors increasingly seek to outpace U.S. technology leadership.

Because food biomanufacturing holds promise for manufacturing large volumes of complex products at the edge, the national security, food security, and economic implications of this technology are substantial. We must continue to invest in science, technology, and innovative research to drive the future of food biomanufacturing. As companies scale up, we must invest in production infrastructure. We are already seeing companies move production overseas due to financing challenges at home. Taking note of this, DoD and Congress have begun to focus on maturing and growing the biomanufacturing supply chain. By harnessing the substantial buying power of its large procurement budgets, supporting continued innovation, and using its increasingly sophisticated industrial policy toolkit, DoD can help sustain America's edge in food biomanufacturing.

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