Modernizing Microbial Biotechnology Regulation

In its April 2025 report, the National Security Commission on Emerging Biotechnology (NSCEB) recommended creating simple pathways to market (Rec. 2.1a) and preparing regulatory agencies for novel products (Rec. 2.1b). Since the release of the report, the NSCEB conducted extensive stakeholder outreach to identify specific Congressional actions to achieve those outcomes. The NSCEB looks forward to working with Congress, federal agencies, and other stakeholders to implement these policy options, including through legislation, oversight activities, and other efforts.

Humans have relied on microorganisms for thousands of years, long before scientists understood their existence. Foods such as bread and yogurt are among the earliest examples of humans putting microorganisms to work, and scientists have used biotechnology to improve microorganisms since the 1970s.[1] Today, biotechnology is enabling the development of microorganisms with incredible potential to help the United States defend, build, nourish, and heal.

Applications of genetically engineered microorganisms (GEMs) can be broadly divided into two categories: contained use and environmental release. Acting as tiny factories, GEMs in contained biomanufacturing systems can produce products such as biofuels, chemicals, enzymes, food, and medicines. GEMs can also serve as environmental tools, performing specific functions such as mining rare elements, adding nutrients to soil, and detecting toxins. For both categories, scientists enlist a variety of microorganisms, such as bacteria, yeast, and microalgae.

GEMs in Action

Developers are applying GEMs in a wide range of current and emerging uses, such as:

Biomanufacturing enzymes that allow detergents to clean clothes better at lower water temperatures.[2]

Producing the materials, food, and medicines that astronauts need on long missions.[3]

Providing nitrogen directly to crops, reducing the need for costly imported fertilizer.[4]

Serving as biological sensors that alert military divers of potential toxins in ocean water.[5]

Recovering critical minerals from mining waste and reducing dependence on overseas mines.[6]

Opportunities to Modernize GEM Regulation

The United States divides oversight of GEMs across three primary agencies: the Animal and Plant Health Inspection Service (APHIS) within the U.S. Department of Agriculture (USDA), the Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA).[7] However, depending on the product, oversight may involve multiple offices and programs operating under different statutes, some of which are shown in the following table.

Selected Agencies and Authorities for GEM Regulation

Agency	Office or Program	Statutory Authority	Products
Animal and Plant Health Inspection Service (APHIS)	Biotechnology Regulatory Services (BRS)	Plant Protection Act (PPA)	GEMs that may pose a plant pest risk
	Veterinary Services (VS)	Animal Health Protection Act (AHPA)	GEMs that may pose an animal health risk
Food and Drug Administration (FDA)	Human Foods Program (HFP)	Federal Food, Drug, and Cosmetic Act (FFDCA)	GEMs in human food, supplements, & cosmetics
	Center for Veterinary Medicine (CVM)		GEMs in animal food
Environmental Protection Agency (EPA)	Office of Pesticide Programs (OPP)	Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	GEMs in pesticides
	Office of Pollution Prevention and Toxics (OPPT)	Toxic Substances Control Act (TSCA)	Intergeneric GEMs that are not regulated by another agency

Fragmented regulation discourages investment, development, and commercialization of GEMs in the United States. Developers often face review by more than one agency, and each agency regulates similar GEMs under different criteria.[8] Unlike the decades of precedent for plant biotechnology, GEM developers have few commercial case studies to guide them. At the same time, emerging technologies such as synthetic genomes and multi-species microbial communities do not fit neatly within existing risk assessment frameworks. Synthetic genomes involve designing and assembling genetic material at a scale beyond traditional genetic modification, while multi-species microbial communities rely on interactions among a group of multiple microorganisms rather than the behavior of a single, well-characterized strain.[9]

Developers are using new gene editing tools, high-throughput automation, and artificial intelligence (AI) to design microorganisms with unprecedented precision. The next generation of GEMs will feature advanced genetic techniques that allow fine-tuned control of microbial behaviors, including production of complex materials on demand. Developers are also exploring new microbial platforms, such as extremophilic microorganisms that can function under harsh conditions and with less water and energy. These scientific advancements underscore the need for a modern regulatory system with flexible but predictable oversight. Without Congressional action to streamline and modernize microbial biotechnology regulation, the United States risks losing global leadership to countries that are building more agile regulatory systems.

Although scientific understanding of GEMs has advanced significantly over the past fifty years, outdated laws and regulations prevent regulatory agencies from fully leveraging these developments. Congress can modernize the relevant laws and equip agencies to review GEMs more efficiently. The following policy options focus on streamlining existing pathways and establishing new ones that support innovation while protecting human health and the environment. If adopted, these policy options would strengthen U.S. leadership in microbial biotechnology and ensure that Americans benefit from new tools for defense, industry, agriculture, medicine, and beyond.

Overview

Policy Options for Modernizing GEM Regulation

Building on the NSCEB's prior recommendations and extensive stakeholder input, this paper describes 13 policy options for modernizing oversight of GEMs in containment and in the environment. These policy options should be considered alongside the NSCEB's overarching policy options for modernizing biotechnology product regulation. The NSCEB also developed detailed policy options for plants, animals, and medical products, which are presented in separate discussion papers.

Policy Options for GEMs in Containment

1. Focus EPA regulation on plausible risks of GEMs in containment.
2. Streamline EPA regulation of GEMs in containment.
3. Delineate agency responsibilities for GEMs used in animal feed.
4. Clarify FDA regulation of GEMs used in food.
5. Instruct the FDA to internally coordinate on food and feed safety review.
6. Clarify processes for importing GEMs into the United States.

Policy Options for GEMs in the Environment

7. Focus APHIS regulation on plausible risks to plant health.
8. Delineate clear pathways for GEMs in the environment.
9. Instruct EPA offices to coordinate on pesticide intermediates.
10. Streamline EPA regulation of GEMs for pest management.
11. Clarify FIFRA definitions for pesticide regulation.
12. Provide risk-proportionate permitting for GEMs.
13. Instruct APHIS programs to coordinate on GEMs for plant health.

Policy Options for GEMs in Containment

GEMs are used widely in biomanufacturing to produce a broad range of products. In biomanufacturing, biofuels production, and similar activities, GEMs are contained within closed systems, such as fermentation tanks and closed processing equipment, which are designed to prevent their release into the environment. Advances in metabolic engineering have improved production of desired substances in contained systems by integrating synthetic metabolic pathways into microorganisms. Developers have also transformed industrial enzyme production through advanced genetic techniques. These innovations support sustainable manufacturing processes by increasing the production of desired substances but can present unique regulatory challenges.

1. Focus EPA regulation on plausible risks of GEMs in containment.
Under federal policy known as the Coordinated Framework for Regulation of Biotechnology, the EPA regulates GEMs that are not regulated by other agencies under the Toxic Substances Control Act (TSCA).[10] The EPA applies its authority under TSCA to regulate certain GEMs that are intergeneric, meaning GEMs that have been engineered

with DNA from a different type of microorganism.[11] Developers noted that regulation based on whether a GEM is intergeneric is outdated and overbroad, because microorganisms naturally exchange DNA with one another.[12] Congress should instruct the EPA to regulate GEMs based on plausible risks to human health and the environment, and to reserve the highest scrutiny for novel products such as synthetic genomes. For example, well-understood strains of microorganisms with a history of safe use in biofuels production should face minimal regulation. Congress should ensure that the EPA has sufficient staffing and technical expertise to regulate GEMs based on plausible risks.

2. Streamline EPA regulation of GEMs in containment.
The EPA requires that developers submit a Microbial Commercial Activity Notice (MCAN) before manufacturing, importing, or commercially using certain GEMs. The EPA provides risk-based exemptions based on the organism's characteristics, genetic modifications, use conditions, and containment.[13] Tier I covers the lowest-risk activities with the least oversight, while Tier II allows somewhat broader activities with additional oversight. Together, these two tiers are intended to focus full MCAN review on higher-risk cases while enabling faster pathways for well-understood, low-risk GEMs. Some developers noted that MCANs work well and that the EPA often provides fast responses, but others expressed concerns about costly requirements for low-risk products. Congress should instruct the EPA to work with developers to make minor improvements to the MCAN process and exemptions, which would reduce burden for both developers and regulators, while maintaining safety. Specifically, the EPA should:

- Publish a standard form for MCAN submissions and update guidance with a list of recommended data to reduce the need for additional data requests;
- Establish performance-based standards for maintaining containment during transport and allow transport of GEMs under Tier I if they otherwise meet Tier I requirements;
- Update guidance to allow minor genetic changes within existing MCANs, including parameters for what constitutes a minor change and a notification process that allows developers to update an MCAN when changes meet those parameters; and
- Allow greater consolidation of similar GEMs in one MCAN and update guidance with set criteria for similarity, in recognition that modern strain development programs require testing of 20 to 30 similar strains.

3. Delineate agency responsibilities for GEMs used in animal feed.
Regulatory pathways for GEMs in animal feed depend on whether the GEM is intended to provide nutritional benefits, improve animal health, or provide environmental benefits. Developers noted that this can lead to overlapping jurisdictional issues and unnecessary delays. Congress should pass the Innovative FEED Act of 2025 (S.1906 and H.R.2203), which would create a new regulatory category for animal feed ingredients that do not improve nutrition and direct the FDA to regulate these ingredients as food additives rather than animal drugs. Congress should further clarify that the FDA should regulate GEMs intended to provide nutritional or animal health benefits under its animal food authorities and instruct the FDA to establish a notification-based pathway for well-known probiotic chassis used in animal feed. Congress should also direct the FDA, EPA, and APHIS to establish an interagency agreement outlining regulatory roles and responsibilities for GEM feed additives with claimed environmental benefits, such as reducing methane emissions or improving nutrient utilization. Together, these options would provide a non-drug pathway for animal feed additives and speed commercialization of safe products.

4. Clarify FDA regulation of GEMs used in food.
The FDA requires that food additives undergo premarket review and approval but provides a notification-based pathway for additives that are well-characterized and recognized as low risk. Developers noted that this notification pathway is not clearly defined for GEMs. Congress should clarify that the FDA has the authority to establish streamlined, risk-based review pathways for well-characterized, low-risk GEMs and the food ingredients they produce, consistent with the agency's long-standing approach for other low-risk food substances. Congress should ensure that the FDA has sufficient staffing and technical expertise to regulate GEMs under their food safety authority. The FDA should issue clear guidance defining when premarket notifications are appropriate and publish a list of ingredients for which developers submitted a notification. The FDA should also provide simplified review or exemptions for well-understood GEMs that are not eligible for notification. These actions would reduce uncertainty for developers and allow the FDA to focus resources on products that raise novel or higher-risk safety questions.

5. Instruct the FDA to internally coordinate on food and feed safety review.
Within the FDA, the Human Foods Program (HFP) oversees food for humans, while the Center for Veterinary Medicine (CVM) oversees food for animals. The FDA implements notification-based pathways differently for human and animal food, even though the risk considerations are similar. In addition, different parts of the FDA may review many food ingredients separately, including those derived from GEMs. While there are some differences in risk assessment – for example, animals typically have less varied diets than humans – there are opportunities to consolidate parts of the review. Developers noted that duplicative review can delay approvals. Congress should require a coordinated FDA approach to ensure that the right expertise is applied without duplicative review.

6. Clarify processes for importing GEMs into the United States.
Stakeholders identified inconsistent coordination between APHIS and Customs and Border Protection (CBP) on processing GEM imports into the United States, leading to inappropriate holds of GEMs and non-engineered microorganisms at U.S. ports of entry. Delays or destruction of imported samples can halt experiments, disrupt production timelines, and slow research and development. Congress should instruct APHIS to provide training to CBP to ensure that permitted and permit-exempt microorganisms are not inappropriately held at the border. By directing APHIS to provide targeted training to CBP personnel, Congress can reduce unnecessary delays at ports of entry and support American development of GEMs while maintaining biosecurity.

Policy Options for GEMs in the Environment

Current regulations are poorly suited for GEMs intended for environmental release, creating regulatory dead-ends in which no agency provides a viable pathway to commercialization. Both APHIS and the EPA have authority over some GEMs intended for environmental release, but their oversight relies on outdated frameworks. To date, the only GEMs EPA has approved for environmental release are microbial pesticides. APHIS lacks a commercialization pathway for environmental release altogether. As a result, developers confine work indoors or move projects offshore. Solutions to these regulatory gaps are increasingly important as developers pursue beneficial products such as GEMs that capture rare earth metals from mining waste or that pull pollutants from water and soil.[14]

7. Focus APHIS regulation on plausible risks to plant health.
APHIS oversight of GEMs hinges on "plant pest risk," an outdated interpretation of its authority in the Plant Protection Act (PPA) to protect against plant pests, which are organisms that can damage or cause disease in plants.[15] APHIS's regulatory approach depends on whether a GEM itself is a plant pest, or if it is engineered with DNA from a plant pest, rather than any actual risks. Congress should instruct APHIS to regulate GEMs based on plausible risks to plant health or the environment, and to reserve the highest scrutiny for novel products, such as synthetic genomes or multi-species groups of GEMs that are intended for release into the environment together. Congress should ensure that APHIS has sufficient staffing and technical expertise to regulate GEMs under their plant health authority. Congress should also direct APHIS to use exemptions or fast-track review for well-understood or low-risk GEMs, such as microorganisms that do not replicate in the environment or that are closely related to well-characterized strains. Replacing the outdated plant pest framework with tiered, risk-based review would allow APHIS to bypass full reviews for products that pose minimal risk to plant health or the environment, while maintaining oversight of novel products.

8. Delineate clear pathways for GEMs in the environment.
As mentioned above, the EPA regulates intergeneric GEMs that are not regulated by other agencies under TSCA. Specifically, the EPA regulates GEMs that are intended for uses other than food, food additives, drugs, cosmetics, medical devices, tobacco, nuclear material, firearms, or pesticides. Developers emphasized that chemical risk assessment frameworks can be poorly suited to microorganisms, which replicate, evolve, and interact with ecosystems in ways that chemicals do not. As APHIS establishes a clear pathway for GEMs through the policy option described above, some GEMs could fall under both APHIS and EPA oversight. In addition to instructing the EPA and APHIS to regulate GEMs based on plausible risks, Congress should direct the agencies to collaboratively determine which GEMs would be regulated by each agency, and to avoid duplicative oversight. Congress should also direct APHIS and the EPA to collaboratively develop clear guidance for developers and to share information as appropriate to ensure a harmonized approach.

9. Instruct EPA offices to coordinate on pesticide intermediates.
The EPA regulates pesticides, including those produced by GEMs, under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). However, the EPA regulates pesticide intermediates under TSCA. Developers expressed concern that GEMs used for pest management consequently often face regulation under both FIFRA and TSCA. Although chemical pesticides and intermediates can also face regulation under both statutes, developers emphasized that applying both FIFRA and TSCA to pesticidal GEMs results in greater complexity and burden than is warranted by their risk profile. Congress should instruct the EPA's Office of Pesticide Programs (OPP) and Office of Pollution Prevention and Toxics (OPPT) to provide coordinated review for products that are regulated by both offices. Congress should also direct the OPP and OPPT to collaboratively develop clear guidance for developers, and to share information as appropriate to ensure a harmonized approach.

10. Streamline EPA regulation of GEMs for pest management.
Microorganisms provide innovative opportunities for pest management, such as GEMs engineered to target specific plant diseases.[16] Congress should instruct the EPA to establish a streamlined regulatory pathway for microbial pesticides that do not replicate in the environment, use well-characterized, low-risk strains, or use well-understood modes of action. Streamlining the review of low-risk microbial pesticides would accelerate access to safer, more sustainable pest control options and align with the EPA's ongoing efforts to modernize regulation of microbial pesticides.

11. Clarify FIFRA definitions for pesticide regulation.
The EPA broadly interprets the definition of "pesticide" to include products such as biostimulants – biological substances that can stimulate natural processes in plants, such as faster growth or defense mechanisms against pests and disease.[17] Developers emphasized that this creates unnecessary regulatory burden for GEMs that are not intended to function as pesticides. Congress should update definitions in FIFRA, building on the Plant Biostimulant Act of 2025 (S.1907 and H.R.3783), which the NSCEB previously endorsed in its December 2024 interim report. Congress should also instruct the EPA to clarify exemptions and remove ambiguity around which products are subject to pesticide regulation. In addition, the EPA and APHIS should work collaboratively to shift non-pesticidal products to more appropriate regulatory pathways. Products that are exempt from pesticide regulation should also be exempt from requirements for pesticide residues, known as "tolerances," or should be covered by broad tolerance categories.

12. Provide risk-proportionate permitting processes for GEMs.
APHIS and the EPA collectively regulate outdoor field trials of GEMs under three statutes: APHIS regulates GEM field trials under the PPA, the EPA regulates small-scale trials of GEMs under TSCA, and the EPA regulates larger field trials of pesticidal GEMs under FIFRA. Developers stressed that it is often unclear which agency should regulate GEMs with multiple uses or at different stages of development. Developers also noted that containment requirements often do not reflect actual environmental risk. Congress should instruct APHIS and the EPA to adopt performance-based permit standards that focus on plausible risk pathways, while reducing requirements for well-understood products. Congress should also direct APHIS and the EPA to collaboratively develop clear guidance for developers and to share information as appropriate to ensure a harmonized approach. Guidance should outline a stepwise approach, with smaller trials under an APHIS permit or an EPA TSCA Environmental Release Application (TERA), transitioning to an EPA Experimental Use Permit (EUP) under FIFRA for large-scale pesticidal uses. These improvements would streamline permits and appropriately focus APHIS and EPA resources, without imposing unnecessary barriers to innovation.

13. Instruct APHIS programs to coordinate on GEMs for plant health.
Within APHIS, two programs have overlapping oversight for microorganisms used in agricultural products. The Biotechnology Regulatory Service (BRS) regulates GEMs that may pose a plant pest risk while Plant Protection and Quarantine (PPQ) regulates unmodified microorganisms. However, developers noted that BRS and PPQ maintain separate plant pest lists to determine which pests call for increased regulatory scrutiny. In addition, developers noted that BRS and PPQ have inconsistent processes for assessing whether a product is exempt from regulation, causing duplication and delays. Congress should require a coordinated APHIS approach to ensure that the right expertise is applied without duplicative review.

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Acronyms

- AHPA: Animal Health Protection Act
- AI: artificial intelligence
- APHIS: Animal and Plant Health Inspection Service
- BRS: Biotechnology Regulatory Services
- CBP: Customs and Border Protection
- CVM: Center for Veterinary Medicine
- EPA: Environmental Protection Agency
- EUP: Experimental Use Permit
- FDA: Food and Drug Administration
- FFDCA: Federal Food, Drug, and Cosmetic Act
- FIFRA: Federal Insecticide, Fungicide, and Rodenticide Act
- GEMs: genetically engineered microorganisms
- HFP: Human Foods Program
- MCAN: Microbial Commercial Activity Notice
- NSCEB: National Security Commission on Emerging Biotechnology
- OPP: Office of Pesticide Programs
- OPPT: Office of Pollution Prevention and Toxics
- PPA: Plant Protection Act
- PPQ: Plant Protection and Quarantine
- TERA: TSCA Environmental Release Application
- TSCA: Toxic Substances Control Act
- USDA: U.S. Department of Agriculture
- VS: Veterinary Services

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