RESEARCH BRIEF

Preventing the Creation of Mirror Life

A Strategy for the United States

The creation of mirror life—a hypothetical life form, such as a bacterium, built from biomolecules with the opposite molecular structure of all known life on earth—could cause fatal infections in multicellular life, including humans, animals, and plants, and upend entire ecosystems. In July 2026, RAND published *A U.S. Strategy to Prevent the Creation of Mirror Life*, which overviews two lines of effort (LOEs) that U.S. policymakers could pursue to prevent mirror life from becoming reality. This brief summarizes these LOEs, the policy levers called for by each LOE, and the principles and analysis on which they are built.

Mirror Life: What It Is and How It Could Pose Catastrophic Risk

Mirror life is a hypothetical form of life built from biomolecules with the opposite molecular structure of all known life on earth. Although mirror life does not yet exist, experts estimate that creation of the first mirror bacterium—a likely first instantiation of mirror life—could be technically feasible within the next few decades and could potentially cost as little as several hundred million dollars.

Mirror life's reverse molecular structure could enable mirror bacteria to (1) escape immune detection and cause fatal infections, (2) avoid natural predators, and (3) proliferate throughout natural ecosystems. If created and released, whether accidentally or intentionally, mirror bacteria could potentially spread widely, causing irreversible harm.

The Policy Challenge: Preventing an Irreversible Threshold

The policy challenge that mirror life presents is both urgent and unusual. Scientists have produced mirror-image biomolecules that could serve as the building blocks of mirror life. Much of the research that moves science closer to realizing mirror bacteria is not inherently dangerous, has demonstrated benefits or promises benefits, and is likely to continue for reasons unrelated to the creation of mirror life. However, mirror life itself is expected to have few plausible benefits. Despite this, some actors might still wish to pursue mirror life, such as well-intentioned researchers who overlook the risks associated with mirror life or malicious actors who seek to acquire or use mirror life as a doomsday capability.

Traditional governance approaches for emerging technologies—such as post-hoc regulation or adaptive oversight—rely on the opportunity to mitigate risks as they emerge and before they become crises. These approaches might be ill-suited to govern mirror life. This is because once a single viable mirror bacterium exists, the knowledge and methods for making riskier variants could prolifer-

ate rapidly, and even seemingly benign strains of such bacteria could be modified to be more dangerous. The first successful creation of mirror life could therefore represent an irreversible threshold: a point after which containment and control become far more difficult and perhaps even impossible.

A Global Challenge Requiring U.S. Leadership

Only a small number of scientifically advanced actors possess the capacity to pursue mirror life. For the foreseeable future, less advanced actors—including isolated or sanctioned regimes, nonstate groups, and individuals—lack the infrastructure, expertise, and access to materials that are required to create mirror life without assistance from the global scientific community. This asymmetry has an important strategic implication: **Should the few scientific powers capable of creating mirror life agree on the need to prevent it, their restraint effectively denies the means of creating it to all others.**

The United States, as one of the world's leading scientific powers and a global hub for bioscience and biotechnology, is uniquely positioned to influence the global trajectory of mirror life development and therefore should lead international efforts to prevent its creation. U.S. actions can help establish international restraint, although preventing mirror life ultimately depends on sustained cooperation among the major scientific powers—particularly China—because no country can manage the risk alone.

Four Principles for a U.S. Strategy

RAND researchers guided U.S. policymakers in developing a strategy to address the risks posed by mirror life before scientific progress or geopolitical incentives close the window for meaningful action. Rather than predicting whether mirror life will pose catastrophic risk with certainty, the authors treat the expert assessment that mirror life could pose unacceptable risks as sufficient motivation for strategic planning now.

RAND researchers identified the following four principles, which guide the development of a strategy:

- **Prevention over mitigation:** Because the first mirror bacterium could trigger irreversible consequences and enable the rapid proliferation of mirror life capabilities, governance, norms, and constraints must be established before mirror life exists—rather than governments and other actors relying on mitigation after the fact.
- **Universal restraint over partial restraint:** Even a single actor creating mirror life could pose a global risk. Prevention depends on broadly shared restraint supported by coordinated governance, transparency, and scientific norms.
- **Transparency over secrecy:** A shared understanding of mirror life's risks and confidence that others are exercising restraint are essential for preventing competitive dynamics and sustaining collective prevention efforts.
- **Cooperation over coercion:** Because no country can eliminate the risk alone, prevention requires trusted international cooperation that preserves legitimacy and encourages broad participation rather than coercive measures.

Two Lines of Effort: Reducing Incentives and Advancing Detection and Deterrence

RAND researchers identified policy levers that policymakers could consider, specifically those that **(1) reduce incentives to develop mirror life** and **(2) detect and deter early-stage development of mirror life.** Other levers—such as those that disrupt or punish advanced development or build countermeasures and resilience—are inconsistent with the four strategic principles and therefore do not factor into a U.S. preventive strategy.

The U.S. strategy organizes levers into the following LOEs (Figure 1):

- **LOE 1—Engage scientific superpowers, especially China, to build the foundation for collective restraint.** This LOE prioritizes transparent scientific collaboration, shared risk assessments, and early norm-setting to discourage major powers from viewing mirror life as a strategic advantage and to prevent mirror life research from becoming an arena for geopolitical competition. LOE 1 shapes the incentives for major scientific powers and academic institutions and has a cascading impact on other nation-states and commercial firms. Although LOE 1's direct influence on other actors is more limited, broadly stigmatizing mirror life could

FIGURE 1

Two Lines of Effort in a U.S. Strategy for Preventing Mirror Life

Line of Effort 1
Build the foundation for collective restraint

Shape early expectations by improving scientific understanding, aligning interpretations of risk among major powers, and establishing shared norms that make restraint the natural baseline.

Policy levers

- **Reduce incentives to develop mirror life**
  - Conduct additional risk assessments to address remaining uncertainties
  - Research alternatives to mirror life and the technologies that would enable its creation
  - Develop voluntary, ethical standards defining responsible scientific conduct
  - Issue early public multilateral statements and resolutions to delegitimize development
- Detect and deter early-stage development
- Disrupt or punish advanced development
- Build countermeasures and resilience

Line of Effort 2
Establish collective restraint

Translate emerging consensus into durable constraints to raise the costs and lower the incentives of pursuing mirror life while building the monitoring architecture needed for credible enforcement.

Policy levers

- **Reduce incentives to develop mirror life**
  - Establish agreements not to pursue mirror life, including commitments among major powers
- **Detect and deter early-stage development**
  - Expand monitoring of early-stage research
  - Develop verification methods for research activity uncertainties
  - Establish a global oversight committee
  - Increase direct economic barriers
  - Restrict access to enabling inputs, knowledge
  - Criminalize and prosecute development
- Disrupt or punish advanced development
- Build countermeasures and resilience

Affected actors — Does the LOE reduce actors' incentives to pursue mirror life? ✓ Yes ✓ Yes, indirectly ✗ No

Affected actors	Line of Effort 1	Line of Effort 2
Countries		
Countries with advanced biology capabilities	✓	✓
Isolated states and sanctioned regimes	✗	✓
Nonstate groups		
Private commercial enterprises	✓	✓
Academia and research institutions	✓	✓
Criminal and violent extremist organizations	✗	✓
Apocalyptic fringe groups	✗	✓
Individuals		
Well-resourced individuals	✗	✓

still create reputational and operational barriers for malign actors.
- **LOE 2—Establish collective restraint across domestic, allied, and competing scientific communities.** This LOE combines measures that reduce the incentives and increase the costs of creating mirror life. Together, these actions shift motivations and capabilities away from mirror life development for states, commercial firms, research institutions, and multilateral bodies.

In pursuing these LOEs, the United States should:

- **Commit clearly to not developing mirror life,** even if other actors are suspected of pursuing it. This commitment reflects the fact that the possession of mirror life would not provide protection, deterrence, or resilience against mirror life developed by others and would instead exacerbate global risk.
- **Take great caution with actions or statements that could foster mistrust or spur strategic competition** in the field of mirror life or its enabling technologies, particularly actions or statements that are related to disrupting mirror life development or investing in countermeasures and resilience.
- **Advance actions with longer lead times as soon as possible.** Legislation, international engagement, technology development for detection and verification, and treaty-creation groundwork require years to mature. These efforts should begin now and evolve as new information emerges.
- **Exclude coercive measures from the strategy at this time.** Actions that rely on pressure, disruption, or punishment would erode trust and cooperation among major scientific powers on which prevention depends. Such measures should be out of scope at this time. If such measures ever become appropriate, they should be pursued cooperatively and transparently, not unilaterally.
- **Treat countermeasures and resilience as later-resort measures.** These measures are unlikely to be effective against the proliferation of mirror life and the ensuing risks. Premature or unilateral investment in defensive preparations could inadvertently weaken deterrence, advance the science of mirror life, and trigger counterproductive dynamics.

By strengthening trust, transparency, and cooperative incentives, the United States can help ensure that those with the means to develop mirror life choose not to—and, in doing so, make mirror life's pursuit infeasible for everyone else.

This research brief describes work done in RAND Global and Emerging Risks and documented in *A U.S. Strategy to Prevent the Creation of Mirror Life*, by Nidhi Kalra, Forrest W. Crawford, Matthew L. Nicotra, Scott Behmer, Josh Dettman, Gerald L. Epstein, Edward Geist, David Glickstein, Graham Griffin, and Krista Langeland, RR-A4335-1, 2026 (available at www.rand.org/t/RRA4335-1). To view this research brief online, visit www.rand.org/t/RBA4335-1. RAND is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors. RAND® is a registered trademark.

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