Mirror Bacteria Pose Unique and Extreme Risks

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Disclosures

- *Coauthor of 2024* Science *paper and associated technical report*.
- *Unpaid Member of Advisory Committee for the* Mirror Biology Dialogues Fund, *a charitable organization*.
- *Speaking as an individual, not on behalf of any group or institution*.

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Confronting risks of mirror life

Broad discussion is needed to chart a path forward

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The New York Times

A 'Second Tree of Life' Could Wreak Havoc, Scientists Warn

Research on so-called mirror cells, which defy fundamental properties of living organisms, should be prohibited as too dangerous, biologists said.

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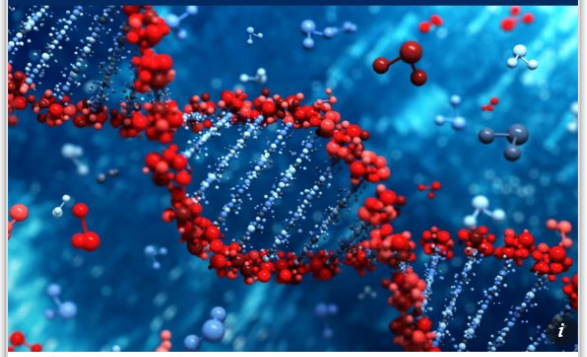

Science

'Unprecedented risk' to life on Earth: Scientists call for halt on 'mirror life' microbe research

What is “mirror” life?

- Organisms rely on molecules with **chirality** (handedness), including DNA and proteins, among others.
- Organisms use only one of the two possible configurations of these macromolecules.
- Mirror life using the opposite chirality might be constructed in the lab.
- Synthetic biologists suggest mirror bacteria could be created in the next 10-30 years.

Why create mirror bacteria?

- Technical challenges and scientific curiosity.
- Some mirror molecules might have therapeutic uses, in part because they resist degradation by usual biological pathways.
- Mirror bacteria could produce mirror molecules more efficiently than by chemical synthesis.

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- Technical challenges and scientific curiosity.
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- Mirror bacteria could produce mirror molecules more efficiently than by chemical synthesis.
- **The 2024 *Science* article does *not* advocate banning the chemical synthesis of mirror molecules. Rather, it proposes to preclude the creation of mirror bacteria.**
- This distinction rests on the fact that organisms, unlike molecules, are self-replicating. Hence, synthetic organisms with extreme and plausible risks pose a special danger.

Why ***not*** create mirror bacteria?

- **Mirror bacteria would likely evade many immune responses,** and thus they could become opportunistic pathogens of humans and other multicellular organisms.
- **Mirror bacteria would likely avoid most predators,** and thus they could spread through the environment and disrupt natural and managed ecosystems.

Mirror bacteria could evade most immune responses

- Mirror bacteria would likely evade immunity, which depends on **chiral interactions**.
- In humans and other vertebrates, infections of mirror bacteria could prove lethal, with effects similar to inherited immune deficiencies.
- (No specialized “virulence factors” would be required to initiate infections, as mucosa and skin are often leaky.)
- Many invertebrates and possibly plants would also likely be vulnerable to mirror bacteria.

Mirror bacteria could spread and disrupt ecosystems

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- Bacterial populations in nature are often kept in check by viruses and various small predators (protists, other bacteria, nematodes).
- Like the immune system, viruses and predators rely on **chiral interactions** to recognize and consume bacteria.
- Mirror bacteria would be completely resistant to viruses and likely somewhat resistant to larger predators. Even predators that killed mirror bacteria would obtain little nutritional benefit, stifling their numerical response and capacity to control mirror bacteria.
- Without these top-down controls, mirror bacteria populations could expand, spread, evolve, and invade diverse environments.
- The resulting invasion of mirror bacteria could potentially cause **massive environmental harms** through extinctions, degradation of habitats, and effects on nutrient cycling.

Wouldn’t mirror bacteria be poor competitors?

- Mirror bacteria would be unable to consume many chiral nutrients used by their natural counterparts.
- However, there are many achiral nutrients that mirror bacteria could consume, and bacteria can use, or evolve to use, some nutrients with opposite chirality.

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- Mirror bacteria would be unable to consume many chiral nutrients used by their natural counterparts.
- However, there are many achiral nutrients that mirror bacteria could consume, and bacteria can use, or evolve to use, some nutrients with opposite chirality.
- Importantly, the growth rate of a population depends on the *difference* between its birth and death rates.
- Given resistance to viruses and predators, mirror bacteria could grow and potentially reach vast numbers even if they reproduce more slowly than their natural counterparts.

What about containment and/or control measures?

- Bio-containment could be circumvented by malicious or ill-informed commercial actors by engineering more robust and dangerous mirror bacteria (e.g., one that could consume D-glucose).
- Physical containment risks human error and could also be deliberately evaded.
- A few antibiotics would likely be effective against mirror bacteria, and new antibiotics and other countermeasures could be developed.

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- Bio-containment could be circumvented by malicious or ill-informed commercial actors by engineering more robust and dangerous mirror bacteria.
- Physical containment risks human error and could also be deliberately evaded.
- A few antibiotics would likely be effective against mirror bacteria, and new antibiotics and other countermeasures could be developed.
- However, providing treatments globally and equitably during a pandemic would be extremely costly and difficult, if not impossible.
- Countermeasures could not plausibly prevent harm to other animals, plants, and ecosystems once an invasive mirror bacterium became established in the environment, where it would expand, spread, evolve, and diversify over time.