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XENOBOTS: AI-DESIGNED LIVING MACHINES (Report)

In our presentation, we discussed the fascinating topic of Xenobots, a groundbreaking innovation at the intersection of artificial intelligence, biology, and robotics. First introduced in a 2020 study by Kriegman, Blackiston, Levin, and Bongard, Xenobots are living, programmable organisms made from the stem cells of *Xenopus laevis* (African clawed frog) embryos. What makes them unique is not only their biological makeup but the fact that they are designed entirely using computer algorithms. This project forces us to reconsider what counts as a living being and whether life can be treated as a material to be engineered.

The process of creating Xenobots starts with extracting stem cells from frog embryos. These cells are then sculpted into specific shapes, guided by designs generated from evolutionary algorithms. The AI runs thousands of simulations, testing different cell configurations for how well they can perform desired tasks, such as movement or object manipulation. Once a successful design is found, the corresponding structure is manually assembled in the lab. Remarkably, the cells naturally self-organize into functional organisms, often exhibiting behaviors that were never explicitly programmed, such as spontaneous movement or self-repair.

We also explored the capabilities that make Xenobots especially noteworthy. Unlike traditional machines, Xenobots are biodegradable, capable of self-healing, and can even work collectively in swarms to carry out simple tasks, such as pushing particles into piles. These features open the door to a wide range of applications. For example, in medicine, Xenobots might one day be used for targeted drug delivery or minimally invasive surgeries. In environmental science, they could help collect microplastics from oceans or break down toxic waste. Their small size and biological nature make them well-suited for delicate environments where traditional machinery would be impractical or harmful.

However, the emergence of AI-designed life forms raises significant ethical and philosophical questions. If a living organism is created by a machine, should it have legal or moral protections? What are the risks of accidental release into the environment? Can such organisms evolve in unforeseen ways once released outside controlled settings? During our presentation, we emphasized that while scientific progress is impressive, it also demands serious ethical reflection and regulatory frameworks to ensure responsible development and use.

Current research is focused on expanding the complexity and functionality of Xenobots. Scientists are experimenting with adding neural-like circuits to allow decision-making, extending the organisms' lifespans, and automating their construction. While they remain in the experimental stage, it is likely that practical applications will emerge within the next decade, particularly in fields requiring highly targeted and temporary biological interventions.

Personally, I (Surya Gona) found presenting this topic both exciting and challenging. The concept of Xenobots is so novel that it naturally sparks curiosity, but it also requires clear explanation to convey the underlying science and its broader implications. One challenge I faced was simplifying the technical language without losing important details. In the future, I would aim to incorporate more visuals or real-world examples to help the audience grasp the potential and risks more intuitively.

Works Cited

Kriegman, S., Blackiston, D., Levin, M., & Bongard, J. (2020). A scalable pipeline for designing reconfigurable organisms. *Proceedings of the National Academy of Sciences*, 117(4), 1853–1859.

Blackiston, D., Kriegman, S., Bongard, J., & Levin, M. (2021). A cellular platform for the development of synthetic living machines. *Science Robotics*, 6(52), eaaz1707.