The First Living Robots

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A team of scientists at the University of Vermont have repurposed living cells and assembled them into entirely new life-forms. The living cells were harvested from the embryos of African frogs, the species *Xenopus laevis*. Hence, the team has named these "biological machines" *xenobots*.

Programmable Organisms

This finding is truly a first. Joshua Bongard, a computer scientist and robotics expert at the University of Vermont who co-led the new research explains that "[t]hese are novel living machines. They're neither a traditional robot nor a known species of animal. It's a new class of artifact: a living, programmable organism."[1]

At about a millimeter wide, the team has identified some key capabilities of xenobots. One being the ability to move toward a target; with or without a payload. One example of a payload would be a medicine to be carried to a target area inside of a patient. The team has also made observations of the ability of xenobots to heal themselves after being cut.

While the biological material was harvested from frogs, xenobots were actually designed on a supercomputer at the University of Vermont. The assembly and testing was done by biologists at Tufts University.

Co-leader, Michael Levin, who directs the Center for Regenerative and Developmental Biology at Tufts noted that many useful applications for xenobots can be imagined; applications that cannot be done by other machines. He provided examples, "like searching out nasty compounds or radioactive contamination, gathering microplastic in the oceans, traveling in arteries to scrape out plaque."[2]

The Research

The results of this new research that, for the first time ever, "designs completely biological machines from the ground up," were published January 13 in the Proceedings of the National Academy of Sciences.

Frog stem cells were harvested, separated into single cells and left to incubate. These cells were then cut and joined under a microscope, based on the designs created on the computer.

The body forms created by the computer are not otherwise seen in nature. The cells began to work together, creating ordered motion "as guided by the computer's design, and aided by spontaneous self-organizing patterns -- allowing the robots to move on their own."[3]

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[1] University of Vermont. "Living robots built using frog cells". ScienceDaily. January 13, 2020. Available at: https://www.sciencedaily.com/releases/2020/01/200113175653.htm. Accessed on January 31, 2020.
[2] Ibid.
[3] Ibid.

Groups of xenobots were able to push pellets into a central location, while others were built with a hole through the center that doubled as a pouch capable of carrying an object. Professor Joshua Bongard explained this as "a step toward using computer-designed organisms for intelligent drug delivery."[4]

Key Themes

The article in LivingScience that summarized this research further discussed important themes surrounding the discovery, implications for the technology, and for the future.

The unique nature of this sort of 'living technology' makes it fragile as compared to so many other technologies created with materials like steel and plastic. But, xenobots are notably able to heal themselves, and they are biodegradable.

Another important theme is the potential that this discovery highlights of our ability to learn about how cells communicate and connect extends deep into both computational science and our understanding of life:

> *[Levin] and the other scientists in the UVM and Tufts team -- with support from DARPA's Lifelong Learning Machines program and the National Science Foundation -- believe that building the xenobots is a small step toward cracking what he calls the "morphogenetic code," providing a deeper view of the overall way organisms are organized -- and how they compute and store information based on their histories and environment.*[5]

Finally, there is the theme of possible unintended consequences associated with this sort of experimentation. That fear is rational, but Levin makes an interesting appeal:

> *If humanity is going to survive into the future, we need to better understand how complex properties, somehow, emerge from simple rules. Much of science is focused on controlling the low-level rules. We also need to understand the high-level rules. If you wanted an anthill with two chimneys instead of one, how do you modify the ants? We'd have no idea.*
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> *I think it's an absolute necessity for society going forward to get a better handle on systems where the outcome is very complex. A first step towards doing that is to explore: how do living systems decide what an overall behavior should be and how do we manipulate the pieces to get the behaviors we want?*

YouTube Video

A YouTube video was posted by University of Vermont: *UVM and Tufts Team Builds First Living Robots*[6]
https://www.youtube.com/watch?v=aQRBCCjaYGE&feature=youtu.be

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[4] Ibid
[5] Ibid.
[6] UVM and Tufts Team Builds First Living Robots" University of Vermont YouTube Channel. Posted January 13, 2020. Available at: https://youtu.be/aQRBCCjaYGE. Accessed on January 31, 2020.