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LIVING ROBOTS: XENOBOTS AND ANTHROBOTS

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Annotation: Recent advances in bioengineering have demonstrated that living cells can self-organise into functional biological structures under laboratory conditions. This has led to the creation of xenobots in 2020 – microscale living constructs derived from frog cells and assembled without conventional programming. In 2023, anthrobots were also developed. This article outlines key achievements and current scientific limitations.

Keywords: xenobots, anthrobots, Xenopus laevis, neurons regeneration, tissue regeneration.

Introduction. The robots we create from metal and plastic do not work well inside a living organism: they often cause inflammation, do not know how to adapt to soft tissues, and at the same time they rust. Almost every living organism contains stem cells that thrive in the body, but we cannot yet precisely and specifically control them. Xenobots combine the features of both approaches: they are alive, like cells, but created for a specific purpose, like robots. In 2023, researchers extended this approach to human cells, and it became obvious that this was not just a wonderful experiment, but a potential tool in medicine.

Main part. In 2017, researchers took cells from the African clawed frog, Xenopus laevis embryos, namely heart muscle and skin cells. First, they decided to carefully separate them, then placed them in a special nutrient solution and simply began to observe what would happen. After this, the cells began to stick together. After about a day or two, they formed balls approximately one millimetre in diameter. As a result of this experiment, the researchers demonstrated that genetic modification was not required to create them – just nutrients and time. To give these balls the desired shape, scientists used artificial intelligence: the program went through millions of configuration options, then selected the best cells that best suited the conditions of the required task. Often, to get the version they wanted, they had to modify these beads by hand under a microscope.

2020 – First Generation: These were created using a new evolutionary algorithm. It automatically designed new biological structures, and then, based on their simulation, selected the best of them and assembled them from frog heart and epidermal cells. The peculiarity of these bots was their movement in a swarm, while they covered a distance of up to 39 mm in 12 hours and independently collected small particles into heaps [1].

2021 – Reproduction: Xenobots, which resembled the video game character Pac-Man, learned to capture free cells, and then assembled new working copies from them – they could assemble up to four generations in a row, without copying DNA and cell division [2].

2023 – Anthrobots: A little later, researchers decided to apply the same methods to human tracheal cells. And we got new structures. They were approximately 30-500 µm in size and lived for 45-60 days [4]. An interesting feature was the ability of the anthrobots in the group to help damaged neurons regenerate – nerve cells began to grow within three days [3]. But all these experiments were carried out in a laboratory bowl.

2025 – Memory: after new experiments, in 2025, researchers identified 537 uniquely activated genes in xenobots. These genes responded to sound of 100-500 Hz and their ability to “remember” light stimuli using introduced RNA molecules [4].

2025 – Cell Rejuvenation: The essence of rejuvenation is that when anthrobots self-assemble, adult cells become biologically younger by approximately 25% based on certain epigenetic markers – again, without genetic intervention [5]. Their key features: they move using tiny hairs on the surface, called cilia.

When the nutrients run out, the biorobots begin to decompose without leaving any toxic residues or traces in the environment.

Medicine. The main property of anthrobots, which increases their importance for medicine, unlike ordinary xenobots, is that they can be created from the cells of a patient. This feature means that the immune system will not reject them as a foreign body [3]. In theory, they could deliver drugs directly to tumours, clear clogged arteries, or even help the body recover from spinal cord injuries.

But, unfortunately, so far all this only works in a laboratory bowl. Until now, no one has ever introduced anthrobots into a living organism, and we do not know how they will behave in the bloodstream, the immune system, and three-dimensional tissues. They also have a limitation in their creation. In one production cycle, only a few hundred biorobots are produced, but this is not enough because millions are needed for therapy.

The ability of xenobots to collect small particles up to one millimeter in size prompted researchers to use them as small microplastic cleaners; they collected particles into piles that a filter could collect; the filters themselves do not cope well with microplastics [1].

After completion of the work, xenobots simply decompose without polluting the environment. But this method has its own problems: xenobots can reproduce only in environments containing free stem cells, and they are not found in the natural rivers and seas we are accustomed to. We also still don't know how xenobots might begin to behave when temperature, salinity, and water pollution change, since no one has yet conducted the necessary experiments.

Xenobots and anthrobots raise many questions. If you look from the outside, they are also living beings: they exhibit metabolic activity, move, react to the world around them and can reproduce [2]. But on the other hand, they are created for a specific purpose, that is, intentionally, like an ordinary tool.

As for the risks. Uncontrolled reproduction of xenobots is actually very unlikely: this requires free stem cells in the environment, and in nature, as it was already mentioned, such cells are not naturally present [2]. But at the same time, international standards for working with xenobots and anthrobots have not yet been implemented.

Conclusion. To summarize, in just five years, xenobots and anthrobots have gone from a simple idea to real laboratory results. Researchers have been able to prove that it is possible to create structures from cells without the use of genetic modifications, but using their ability to independently unite [1, 6], the ability to reproduce in completely new ways [2], the ability to respond to various sounds and remember light stimuli [4] and even help nerve cells recover [3]. It has also been found that adult cells become biologically younger after a process of self-assembly, a key feature that could help in the development of new treatments or other fields of science [5].

However, these findings remain largely preliminary. Not a single experiment has yet been carried out inside a living organism. To date, we cannot explain the key effects. We do not have the ability to produce biorobots in the quantities required for all our needs. Therefore, current evidence suggests that, anthrobots will most likely remain a research tool for the next few years, but the possibility of their further application in various fields is very high.

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