Medical Xpress

Heart-on-a-chip: A microfluidic marvel shaping the future of cardiovascular research

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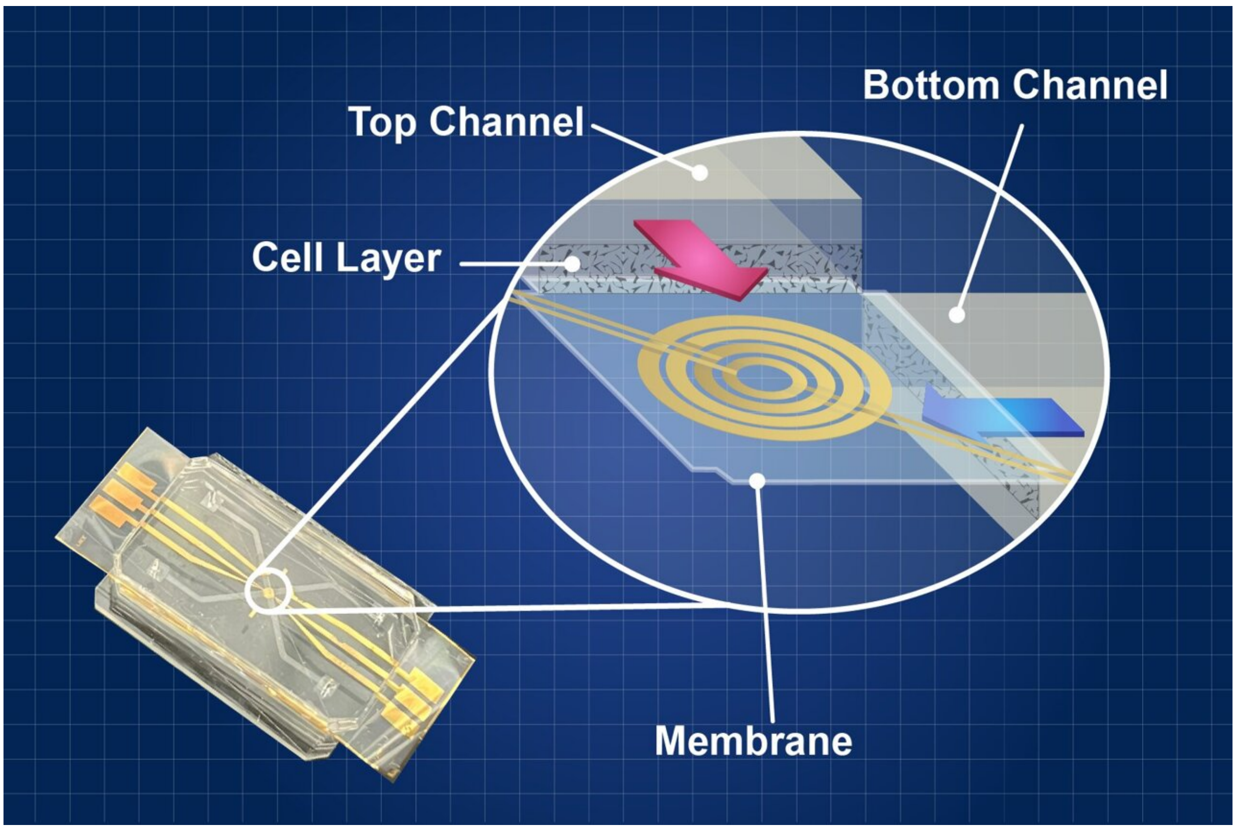

The heart-on-a-chip consists of a network of microchannels printed on a layer of polymer. Heart cells are placed within these microchannels to manipulate and observe their behavior. Credit: N. Hanacek/NIST

In a major step forward in drug development, researchers at the National

Institute of Standards and Technology (NIST) have developed a tool for building a system known as heart-on-a-chip (HoC).

This technology seeks to address the limitations of conventional cardiovascular drug development, which relies heavily on animal testing. By replicating humanlike models for studying cardiovascular diseases, the HoC system holds the promise of helping to replace animal testing, shortening drug development timelines, and reducing costs. The NIST team's results were published in *Lab on a Chip*.

The HoC is a device that mimics the intricate interactions of cells within the heart on a small chip and is part of the larger organ-on-a-chip (OoC) suite. The actual design of the heart-on-a-chip varies, but it is typically a small, transparent, or semi-transparent chip consisting of a network of microchannels printed on a layer of polymer.

These microchannels are intricately designed to imitate the blood vessels found in the human heart. Researchers place human heart cells within these microchannels to manipulate and observe their behavior. Researchers can independently stimulate them or observe their behavior under different conditions, such as the introduction of a drug.

"The heart-on-a-chip is designed to mimic the conditions of a real heart," said NIST researcher Darwin Reyes, who led the development of this HoC system. "We can manipulate the environment to change stem cells into heart cells and make them contract and relax, as they do in a body to produce a heartbeat."

The "heart" of the organ-on-a-chip system lies in something called microfluidics, which is essentially a miniature plumbing system in which researchers can precisely control and manipulate tiny amounts of liquids. Researchers use microfluidics to create advanced models of organs and tissues on small chips in the lab.

"The chip itself can be used with many different cell types," said Reyes. "In this project in particular, we're using heart cells, but you can use a customized version of the system with other cells to monitor their behavior visually and electronically."

The concept of "organ-on-a-chip" extends beyond just the heart. Researchers can create chips that mimic the conditions of various organs, which can even be interconnected to form a multi-organ system. For example, you could have a heart-on-a-chip connected to a liver-on-a-chip to simulate how the heart and liver interact in response to certain drugs or medical conditions. This approach provides a more comprehensive understanding of how different organs function together in the human body.

Rethinking animal testing

In traditional drug development, animals are often used as test subjects. However, animal physiology does not perfectly match human physiology. A drug may pass a test on an animal subject but may then fail in human testing. This not only delays the drug testing process but also puts human test subjects at risk of adverse effects from the drug. Additionally, there is ongoing debate about the ethical considerations of animal testing.

"The ultimate goal is to, if possible, be able to skip the animal testing altogether," said Reyes. "This would also shorten the time it takes to test drugs, hopefully making the medications cost less."

In 2022, President Joe Biden signed into law the FDA Modernization Act 2.0. The bill essentially revises the Federal Food, Drug, and Cosmetics Act of 1938, which mandated animal testing for every new drug development protocol.

While for the past century, the mandate was intended to ensure certain quality and safety standards for drugs and medical devices, recent advancements in science have begun to offer increasingly viable alternatives to animal testing, including organ-on-a-chip systems.

Global collaboration for standardizing organ-on-a-chip technology

Developing this new technology is not done in a vacuum. Researchers worldwide are working on similar microfluidic devices to usher in a new era of drug development. However, to make this a reality, there's a need for standardization—establishing consistent guidelines and rules for these technologies.

This not only helps in gaining regulatory approvals but also ensures better acceptance in the scientific, industrial, and medical communities. NIST is an active participant, along with scientific organizations across the globe, in developing standards for this technology.

"The more collaborative research there is outside of what is currently being done and where we're heading, the better this technology is going to be," said Reyes.

Expanding horizons beyond cardiovascular focus

While HoC is focused on cardiovascular drug development, the OoC capabilities extend beyond a specific organ. The system can be applied to various cell types relevant to cancer research.

"We are in the test phase of understanding how we can track the movement and aggressiveness of cancer cells in real-time," said Reyes. "Our hope is, in the future, with more testing, the system may be able to provide measurements of cancer cell aggressiveness that could help with diagnosis."

This new technology, underpinned by rigorous standards, marks an essential step toward a future where drug development is characterized by precision, efficiency and heightened ethical considerations.

More information: Derrick Butler et al, Heart-on-a-chip systems: disease modeling and drug screening applications, *Lab on a Chip* (2024). DOI: 10.1039/D3LC00829K

This story is republished courtesy of NIST. Read the original story here.

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