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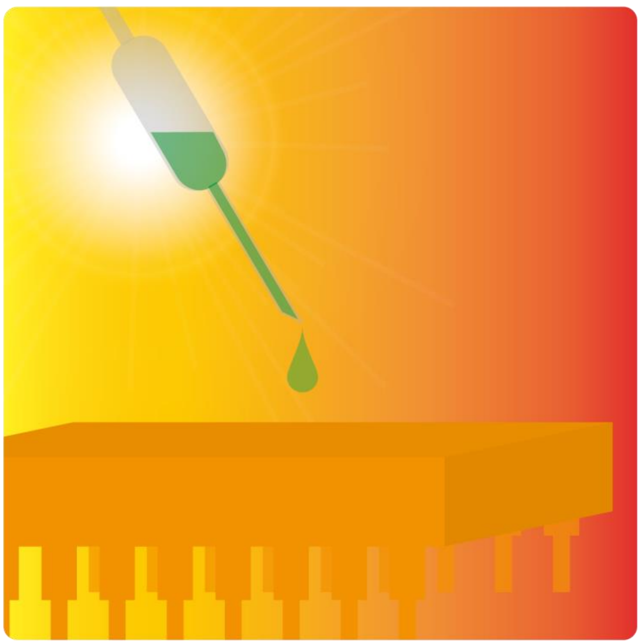
By Dr Nayef Al-Rodhan on June 23, 2016



Credit: World Economic Forum

Editor's Note: This article is part of a special report on the Top 10 Emerging Technologies of 2016 produced by the World Economic Forum. The list, compiled by the Forum's Meta-Council on Emerging Technologies, highlights technological advances its members, including Scientific American Editor in Chief Mariette DiChristina, believe have the power to improve lives, transform industries and safeguard the planet. It also provides an opportunity to debate any human, societal, economic or environmental risks and concerns that the technologies may pose prior to widespread adoption.

Outside of Hollywood special effects shops, you won't find living human organs floating in biology labs. Set aside all the technical difficulties with sustaining an organ outside the body, full organs are too precious as transplants to use in experiments. But many important biological studies and practical drug tests can be done only by studying an organ as it operates. A new technology could fill this need by growing functional pieces of human organs in miniature, on microchips.

In 2010, Donald Ingber from the Wyss Institute developed a lung-on-a-chip, the first of its kind. The private sector quickly jumped in, with companies such as Emulate, headed by Ingber and others from the Wyss Institute, forming partnerships with researchers in industry and government, including DARPA, the U.S. Defense Advanced Research Projects Agency. So far, various groups have reported success making miniature models of the lung, liver, kidney, heart, bone marrow and cornea. Others will certainly follow.

Each organ-on-a-chip is roughly the size of a USB memory stick. It is made from a flexible, translucent polymer. Microfluidic tubes, each less than a millimeter in diameter and lined with human cells taken from the organ of interest, run in complex patterns within the chip. When nutrients, blood and test-compounds such as experimental drugs are pumped through the tubes, the cells replicate some of the key functions of a living organ.

The chambers inside the chip can be arranged to simulate the particular structure of an organ tissue, such as a tiny air sac in a lung. Air running through a channel, for example, can then very accurately simulate human breathing. Meanwhile, blood laced with bacteria can be pumped through other tubes, and scientists can then observe how the cells respond to the infection, all without any risk to a person. The technology allows scientists to see biological mechanisms and physiological behaviors never before seen.

Organ microchips will also give a boost to companies developing new medicines. Their ability to emulate human organs allows for more realistic and accurate tests of drug candidates. Last year, for example, one group used a chip to mimic the way that endocrine cells secrete hormones into the blood stream and used this to perform crucial tests on a diabetes drug.

Other groups are exploring the use of organs-on-chips in personalized medicine. In principle, these microchips could be constructed using stems cells derived from the patients themselves, and then tests could be run to identify individualized therapies that are more likely to succeed.

There is reason to hope that miniature organs could greatly reduce the pharmaceutical industry's reliance on animal testing of experimental compounds. Millions of animals are sacrificed each year in such tests, and the practice provokes heated controversy. Ethical considerations aside, it has proven to be immensely wasteful—animal trials rarely provide reliable insights into how humans will react to the same drug. Tests done on miniaturized human organs might do better.

Military and biodefence researchers see the potential for organs-on-chips to save lives in a different way. The simulated lung, and other devices like it, could be the next big step in testing responses to biological, chemical or radiological weapons. It isn't possible to do this today, for obvious ethical reasons.

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