Caltech engineers build smart petri dish

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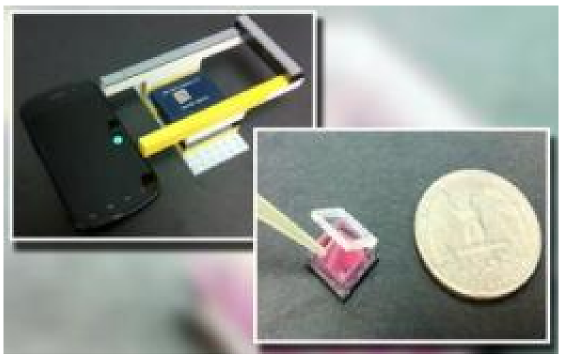

The ePetri platform is built from Lego blocks and uses a smartphone as a light source. The imaging chip is seen in detail on the right. Credit: Image courtesy of Guoan Zheng, California Institute of Technology

The cameras in our cell phones have dramatically changed the way we share the special moments in our lives, making photographs instantly available to friends and family. Now, the imaging sensor chips that form the heart of these built-in cameras are helping engineers at the California Institute of Technology (Caltech) transform the way cell cultures are imaged by serving as the platform for a "smart" petri dish.

Dubbed ePetri, the device is described in a paper that appears online this week in the Proceedings of the National Academy of Sciences (*PNAS*).

Since the late 1800s, biologists have used petri dishes primarily to grow cells. In the medical field, they are used to identify bacterial infections, such as tuberculosis. Conventional use of a petri dish requires that the cells being cultured be placed in an incubator to grow. As the sample grows, it is removed -- often numerous times -- from the incubator to be studied under a microscope.

Not so with the ePetri, whose platform does away with the need for bulky microscopes and significantly reduces human labor time, while improving the way in which the culture growth can be recorded.

"Our ePetri dish is a compact, small, lens-free microscopy imaging platform. We can directly track the cell culture or bacteria culture within the incubator," explains Guoan Zheng, lead author of the study and a graduate student in electrical engineering at Caltech. "The data from the ePetri dish automatically transfers to a computer outside the incubator by a cable connection. Therefore, this technology can significantly streamline and improve cell culture experiments by cutting down on human labor and contamination risks."

The team built the platform prototype using a Google smart phone, a commercially available cell-phone image sensor, and Lego building blocks. The culture is placed on the image-sensor chip, while the phone's LED screen is used as a scanning light source. The device is placed in an incubator with a wire running from the chip to a laptop outside the incubator. As the image sensor takes pictures of the culture, that information is sent out to the laptop, enabling the researchers to acquire and save images of the cells as they are growing in real time. The technology is particularly adept at imaging confluent cells -- those that grow very close to one another and typically cover the entire petri dish.

"Until now, imaging of confluent cell cultures has been a highly labor-intensive process in which the traditional microscope has to serve as an expensive and suboptimal workhorse," says Changhuei Yang, senior author of the study and professor of electrical engineering and bioengineering at Caltech. "What this technology allows us to do is create a system in which you can do wide field-of-view microscopy imaging of confluent cell samples. It capitalizes on the use of readily available image-sensor technology, which is found in all cell-phone cameras."

In addition to simplifying medical diagnostic tests, the ePetri platform may be useful in various other areas, such as drug screening and the detection of toxic compounds. It has also proved to be practical for use in basic research.

Caltech biologist Michael Elowitz, a coauthor on the study, has put the ePetri system to the test, using it to observe embryonic stem cells. Stem cells in different parts of a petri dish often behave differently, changing into various types of other, more specialized cells. Using a conventional microscope with its lens's limitations, a researcher effectively wears blinders and is only able to focus on one region of the petri dish at a time, says Elowitz. But by using the ePetri platform, Elowitz was able to follow the stem-cell changes over the entire surface of the device.

"It radically reconceives the whole idea of what a light microscope is," says Elowitz, a professor of biology and bioengineering at Caltech and a Howard Hughes Medical Institute investigator. "Instead of a large, heavy instrument full of delicate lenses, Yang and his team have invented a compact lightweight microscope with no lens at all, yet one that can still produce high-resolution images of living cells. Not only that, it can do so dynamically, following events over time in live cells, and across a wide range of spatial scales from the subcellular to the macroscopic."

Elowitz says the technology can capture things that would otherwise be difficult or impossible -- even with state-of-the-art light microscopes that are both much more complicated and much more expensive.

"With ePetri, you can survey the entire field at once, but still maintain the ability to 'zoom in' to any cells of interest," he says. "In this regard, perhaps it's a bit like an episode of CSI where they zoom in on what would otherwise be unresolvable details in a photograph."

Yang and his team believe the ePetri system is likely to open up a whole range of new approaches to many other biological systems as well. Since it is a platform technology, it can be applied to other devices. For example, ePetri could provide microscopy-imaging capabilities for other portable diagnostic lab-on-a-chip tools. The team is also working to build a self-contained system that would include its own small incubator. This advance would make the system more useful as a desktop diagnostic tool that could be housed in a doctor's office, reducing the need to send bacteria samples out to a lab for testing.

Provided by California Institute of Technology

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