Thursday, 12 August, 2010

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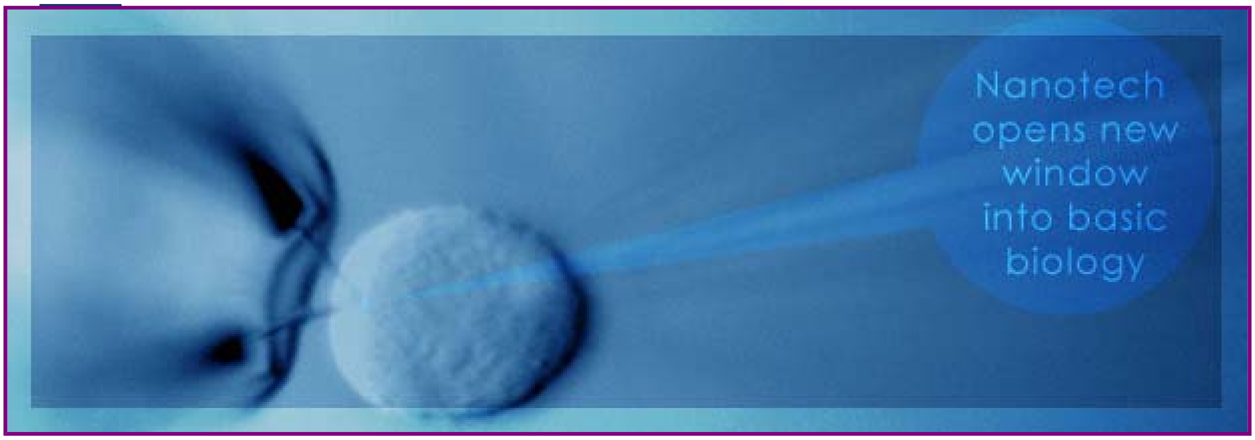

Posted August 12th, 2010

New peephole into animal cells!

Cells are the basic unit of biology: the site where energy is transformed. It is the locale where DNA, RNA and proteins perform the timeless dance of cellular reproduction.

But cells are small (a mammalian cell is about 10,000 nanometers in diameter, which sounds large until you remember that one million nanometers equals one millimeter).

Photo: © Science/AAAS
That angled piece of ultra-slender wire at the end carries a transistor, and is about to slip inside one of the cells just above it. The two legs allow current to flow through the transistor.

Tracking events inside individual cells may get a lot easier, courtesy of a new transistor that is engineered to slip easily inside a cell and is just 50 nanometers wide.

This transistor, mounted on a much-thinner-than-a-hair wire, can detect and amplify faint electrical signals inside cells.

Several innovations from chemistry and material science were needed to construct ultra-mini transistors on a hairpin-shaped piece of wire, says Charles Lieber, a professor of chemical biology at Harvard University.

The nanowire itself is silicon, the basic material of solid-state electronics. To give the wire its hairpin shape, the researchers created two 120-degree bends, which had never been done before with nanowire, says Lieber.

To form a tiny transistor at the bend, Lieber, Bozhi Tian, who's now a post-doctoral fellow at MIT, and colleagues "doped" the silicon wire with precise dollops of elements.

Small is indeed beautiful

The invention has advantages over the "patch clamp," which was developed more than 25 years ago to measure voltage at ion channels on the cell surface, says Lieber.

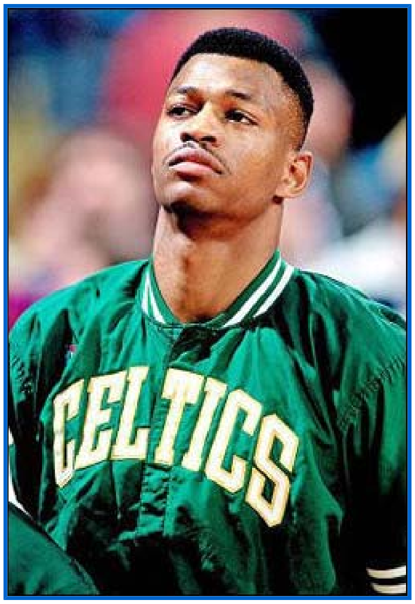

Photo: The Athlete's Heart Blog

Because the transistor "is an active device that amplifies the signal," it can be much smaller than the patch clamp, Lieber says. The new probe is so small, he adds, that "you could envision putting several of these into the same cell to measure things on a scale that's never been measured."

The fabrication techniques impressed Xudong Wang, an expert in nanowire at the University of Wisconsin-Madison. "In making nanowires, it's most difficult to grow a certain shape, and to put a specific function at a specific location."

Although most early nanoelectronics are planar, Wang adds, "They made this part that is three-dimensional, so you can study something in 3D space."

Using nanowires to measure electrical conditions inside heart muscle cells could provide a better picture of arrhythmias. These common defects in heart rhythm are a major cause of heart attacks that afflict old people, and also young athletes like Boston Celtics player Reggie Lewis, who died after an arrhythmia.

A matter of the heart

Because heart muscle cells exhibit an electrical rhythm that causes spontaneous contractions, Lieber's research group used the probe to examine chicken heart cells in the lab. Inserting the nanowire did not seem to affect the cells, Lieber says. "The cell is beating, and as the device goes in, there is no change in the beat frequency or in the electrical potential."

In contrast, harpooning a cell with a pipette — the slender glass tube used in the patch clamp — often disturbs it, Lieber says. And because that pipette also contains a liquid, "You will always have an exchange of medium from the measurement tool and the cell." The new probe uses no fluids.

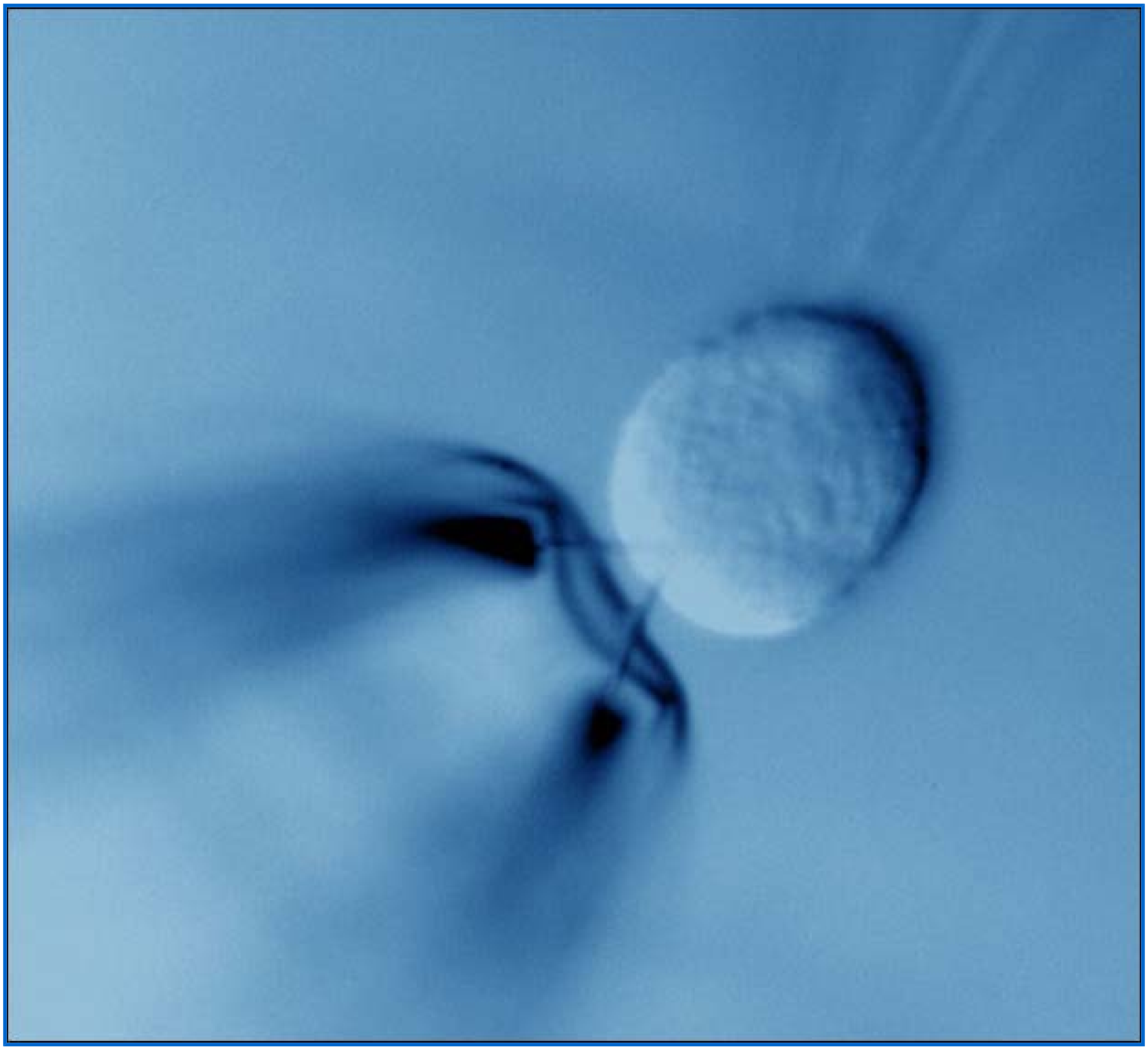

Photo: © Science/AAAS
Inside a single cell, this nanowire probe can measure electricity and may eventually be able to detect proteins and RNA.

King of nano-camo?

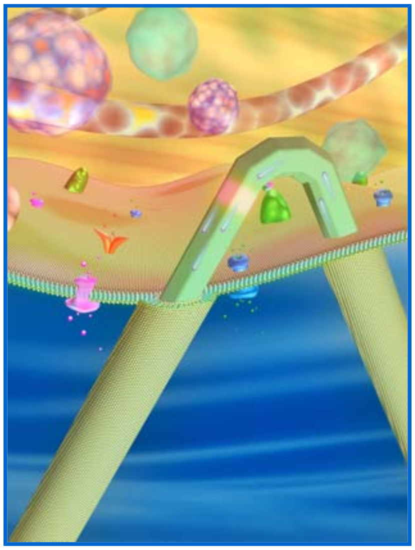

Photo: © Science/AAAS

To help the ultra-small probe enter cells, the researchers coated it with a layer that resembles a cell membrane, which causes the probe to be pulled into the cell. Cells use a similar process to devour viruses and bacteria.

A schematic of a kinked electronic sensor probe inside a cell. The coating on the wire resembles a cell membrane and enables the wire to slip inside the cell with minimal disturbance.

Beyond measuring voltage inside a cell, Lieber suggests that the transistor could carry receptors for proteins or RNA, enabling it to measure chemistry in real time inside cells. That, in turn, would open a window on many basic biological mechanisms.

“It’s almost like a dream to be able to wire up a transistor, which is the fundamental unit in digital electronics, with a cell, which is the basic unit of information processing in biology,” says Lieber. “It does not take a lot of imagination to think there will be a lot of wild things that one can do with this technology.”

– David J. Tenenbaum

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Three-Dimensional, Flexible Nanoscale Field-Effect Transistors as Localized Bioprobes," by Bozhi Tian et al, Science, 13 August 2010.

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