BIOMEDICAL ENGINEERING

A Circuit in Every Cell

Progress for tiny biocomputers

Researchers in nanomedicine have long dreamed of an age when molecular-scale computing devices could be embedded in our bodies to monitor health and treat diseases before they progress. The advantage of such computers, which would be made of biological materials, would lie in their ability to speak the biochemical language of life.

Several research groups have recently reported progress in this field. A team at the California Institute of Technology, writing in the journal *Science,* made use of DNA nanostructures called seesaw gates to construct logic circuits analogous to those used in microprocessors. Just as silicon-based components use electric current to represent 1's and 0's, bio-based circuits use concentrations of DNA molecules in a test tube. When new DNA strands are added to the test tube as "input," the solution undergoes a cascade of chemical interactions to release different DNA strands as "output." In theory, the input could be a molecular indicator of a disease, and the output could be an appropriate therapeutic molecule. A common problem in constructing a computer in a test tube is that it is hard to control which interactions among molecules occur. The brilliance of the seesaw gate is that a particular gate responds only to particular input DNA strands.

In a subsequent *Nature* paper, the Caltech researchers showed off the power of their technique by building a DNA-based circuit that could play a simple memory game. A circuit with memory could, if integrated into living cells, recognize and treat complex diseases based on a series of biological clues.

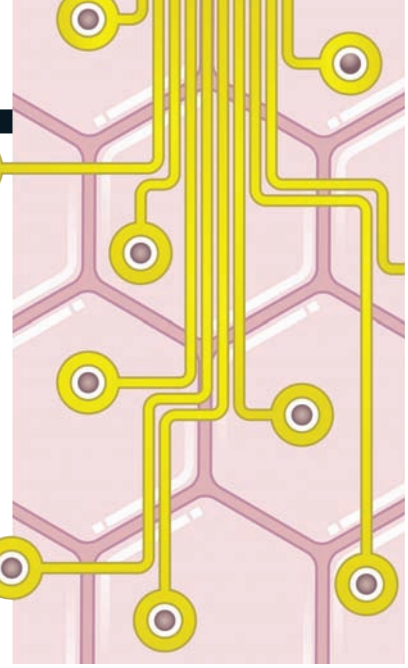

ILLUSTRATION BY THOMAS FUCHS

This circuitry has not been integrated into living tissue, however, in part because its ability to communicate with cells is limited. Zhen Xie of the Massachusetts Institute of Technology and his collaborators have recently made progress on this front. As they reported in *Science,* they designed an RNA-based circuit that was simpler but could still distinguish modified cancer cells from noncancerous cells and, more important, trigger the cancer cells to self-destruct.

Both techniques have been used only in artificial scenarios. Yet the advances in DNA-based circuits offer a new, powerful platform to potentially realize researchers' long-held biocomputing dreams.

—*Tim Requarth and Greg Wayne*