Ideas on the Edge

Honey, I Shrunk the Lab

THE REVOLUTION THAT REDUCED ROOM-SIZED COMPUTERS TO TINY CHIPS IS BEING REPEATED IN BIOLOGY. IN THE HANDS OF RESEARCHERS LIKE RICHARD OLESCHUK AT QUEEN'S UNIVERSITY, MICROFLUIDICS PROMISES TO TRANSFORM MEDICINE AND MEDICAL RESEARCH.

In the late 1950s, scientists developed a new way to build computers that replaced a room full of vacuum tubes with a device that could fit on a finger tip. The secret was to "print" all the necessary information-processing components and connections onto chips of silicon known as integrated circuits.

RESEARCH THAT MATTERS
REAL-WORLD BENEFITS FOR ONTARIANS:
- development of new devices that provide fast, on-the-spot diagnoses of illness
- supporting technology for much more rapid and efficient medical research, leading to new treatments

Fifty years later, a parallel revolution is taking place in the life sciences. But instead of building tiny computers, researchers like Richard Oleschuk at Queen's University are attempting to reduce biology labs to chip-size.

The new technology still depends on imprinting layers of miniscule components onto glass, plastic or silicon. But while the maze of an integrated circuit consists of tiny electronic devices that move electrical charges around, a "lab-on-a chip" is a microscopic labyrinth of channels, pumps, valves, filters and reservoirs that transport and process liquid. The emerging science of designing such systems is known as "microfluidics."

"What we're doing," explains Dr. Oleschuk, "is to put a number of sample preparation methods all on one tiny device. For example, if you have some cells you're interested in analysing for their contents. you could put some of them into one these chips." The channels in the chip would move the liquid containing the cells around to different components, which would perform the work normally done in a full-size lab: break open the cells, separate their contents into various components, and then expose those components to test substances that reveal the presence, for example, of a particular disease.

The advantage of microfluidic technology is that it requires very tiny samples. And because the samples are so small, and the chips can combine many steps, the results are available much more quickly.

An obvious application is in the quick diagnosis of illness. Lab-on-a-chip devices are already being tested for bedside use in hospitals, and in a few years or so, similar devices will enable doctors to perform tests in their own offices—and offer a diagnosis in five or six minutes. Microfluidic chips, attached to the skin or even implanted in the body, may also one day provide a way to continuously monitor a variety of vital signs and even control the release of medication.

But as big as the clinical impact of microfluidics may be, its potential in medical research is even greater.

One pressing application is in the field of proteomics, the study of the structure and function of human protein. Proteomics is a key discipline in understanding human illness and developing new treatments, but the painstaking processes of isolating and identifying individual proteins and preparing samples for analysis in devices like mass spectrometers are creating a bottleneck in protein research.

Dr. Oleschuk and his colleagues are attacking from two angles: by developing microfluidic chips that can separate proteins much more quickly; and by creating an interface that can spray the minute samples directly from the chip into a mass spectrometer. "If you can separate and purify things on a tiny chip at a much faster rate, and you can supply those to the mass spec at a faster rate, you can basically eliminate the bottleneck.

"The goal," says Dr. Oleschuk, of his research and microfluidics in gerneral, "is to have things happen quickly, on smaller amounts, much more efficiently."

It's the familiar quest for better, smaller, faster. And just as the integrated circuit led to a revolution in the way we learn and communicate, so the lab-on-a-chip may help transform the ways we deal with illness—and understand it.

Project: Development of a Microfluidic Research Facility
Institution: Queen's University
Principal Investigator: Dr. Richard Oleschuk
Trust Investment: $130,000
CFI Investment: $130,000
Total research investment from all sources: $325,000

The CMC Connection

Richard Oleschuk's research is supported in part by the Ontario Innovation Trust and the Canada Foundation for Innovation. But his work has also been aided by Canadian Microelectronics Corporation, a not-for-profit corporation that enables world-class research and commercial microsystem development. Dr. Oleschuk has used CMC fabrication services for his prototypes.

Many cutting-edge research programs in Ontario depend on this kind of access to industrial-grade microsystems technologies, and that's why the Ontario Innovation Trust and the CFI have invested $38.4 million in programs managed by CMC—programs that support over 1,400 researchers in 15 Ontario institutions.

The resulting microsystem capacity is leading to the creation of cutting-edge products as diverse as three dimensional hearing aids and miniature scanners for detecting cancer.

Ontario Innovation Trust

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Infrastructure for Innovation
About the Ontario Innovation Trust

The Ontario Innovation Trust was created in 1999 by the Government of Ontario to invest in research equipment and facilities at Ontario's universities, colleges, hospitals and other non-profit research institutions. The Trust is governed by a volunteer Board of Directors, according to the terms of a Trust agreement established by the Ontario government. A small permanent staff looks after day-to-day operations.

Since its inception, the Trust has committed almost $843 million to strengthen Ontario's position in the global marketplace of ideas. This represents more than a third of the $2.44 billion in total funding that has been invested in Trust-supported projects.