THE AUTHOR FILE

Chris Toumazou

Inspired by his son, an electrical engineer brings microchip technology and portability to biology.

Biomedicine was not initially on his radar, but a dramatic event changed that, says Imperial College engineer Christofer Toumazou. When his son was 12 years old, his kidneys "packed up," Toumazou says. At the time, Toumazou's research focus was circuit design and mobile telephony. His son is now 19, eager to leave the routine of daily dialysis, and on the waiting list for a kidney transplant. As Toumazou coped with his son's renal failure, it struck him how few inroads the computer-chip industry had made into home-care technology for the chronically ill. "I guess that's when my real inspiration began," he says.

Imperial College

Chris Toumazou

As it turned out, the boy is genetically predisposed to renal failure. For his dad, the diagnosis meant that an adequate DNA test, coupled with wireless tracking of body temperature and blood pressure, might have averted the kidney crash. Toumazou began thinking about a handheld device tuned to biology that might be able to sequence DNA and also detect specific mutations such as predisposition to kidney failure or other traits—for example, those that affect drug metabolism.

He began by building the core of such a device. He used ion-sensitive field effect transistor (ISFET)-based sensors to translate biochemistry into electrical output with a configuration that measures the fluctuations in ionic charge that accompany chemical reactions. Roche has licensed these sensors, and they have become part of the Ion Torrent genome sequencer.

In his most recent work, Toumazou and colleagues at Imperial College and at DNA Electronics, a company he founded, apply the sensors to miniaturize the DNA amplification step prior to high-throughput sequencing. The team uses integrated circuit design and fabrication techniques for this device, which is the size of a small fingernail. The device performs real-time pH sensing and is equipped with transistors, flow cells and signal processing and thermocycling capabilities. It can potentially render obsolete the optics, probes and dyes necessary for quantitative PCR.

It might be possible, Toumazou says, to integrate the new miniaturized DNA amplification approach and the DNA analysis onto a USB stick using chips that can be produced on a large, cost-efficient scale. Scalability is important when trying to get devices into a health-care setting, where they must also be portable and integrated, he says. A clinician could potentially use the device to determine the right drugs and dosage for a given patient, he says.

To foster multidisciplinary research between engineers, physicists and clinicians, Toumazou founded the Centre for Bio-Inspired Technology at Imperial. "It's great to see clinicians and engineers trying to communicate," he says. At age 33, he became Imperial's youngest professor in the college's history.

Originally, Toumazou managed to enter university without A levels, the qualifying exams in the UK. He had taken a technician's course at a local college in Cheltenham, UK, where he achieved such high marks that he was admitted to Oxford Polytechnic. And "from then on, he proceeded to be the best student we ever had," says John Lidgey, who was Toumazou's doctoral thesis advisor at Oxford Brookes University.

Together the engineers created a new approach to analog circuit design, called current mode, and the two still work together on projects. This year Toumazou was awarded a Regius professorship, which is a royal appointment from Queen Elizabeth II. "It makes my parents proud," he says.

"He is a true polymath with an academic ability matched by sound business acumen," says Lidgey. Toumazou, who has founded several companies, thinks that academics need to balance their efforts carefully: engage commercial partners early enough to seize a business opportunity, but thoroughly incubate an idea before seeking licenses or product development partnerships. When seeking commercial collaborators, scientists should keep in mind, he says, that several engineering groups at their university might also be competing with one another for attention from companies, thwarting one another's efforts.

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Most importantly, he believes that innovators should not limit their ideas to orbits around existing technologies and that they should remember to draw on multidisciplinary input.

Toumazou balances out his busy days with athletic activity. He is experienced in the Japanese martial arts kendo and sanchin, which emphasize physical and spiritual awareness. For his activities in business and academic environments, he says, "awareness is very important to what is going on around you."

Vivien Marx

Toumazou, C. *et al.* Simultaneous DNA amplification and detection using a pH-sensing semiconductor system. *Nat. Methods* **10**, 641–646 (2013).