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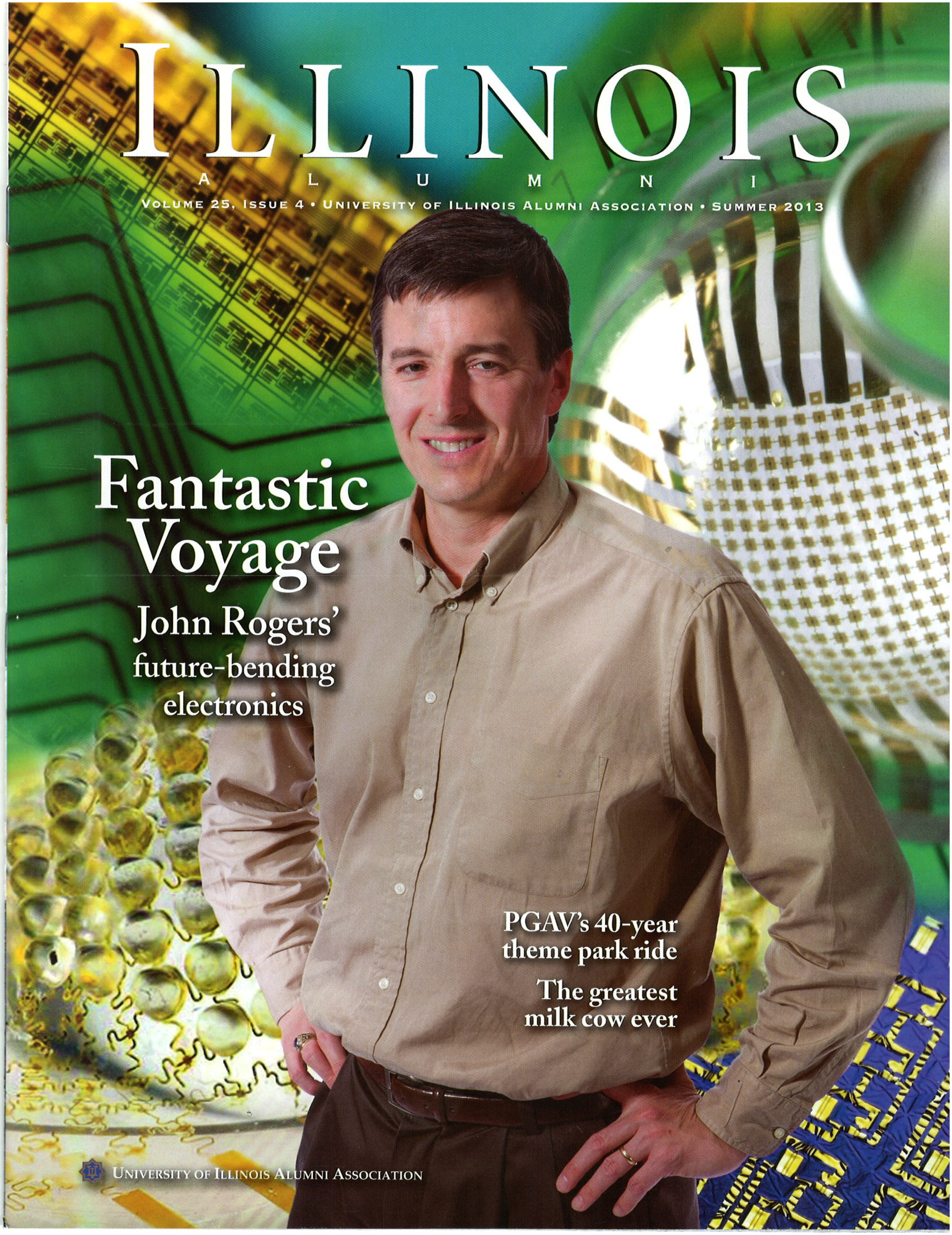

Fantastic Voyage

John Rogers' future-bending electronics

PGAV's 40-year theme park ride

The greatest milk cow ever

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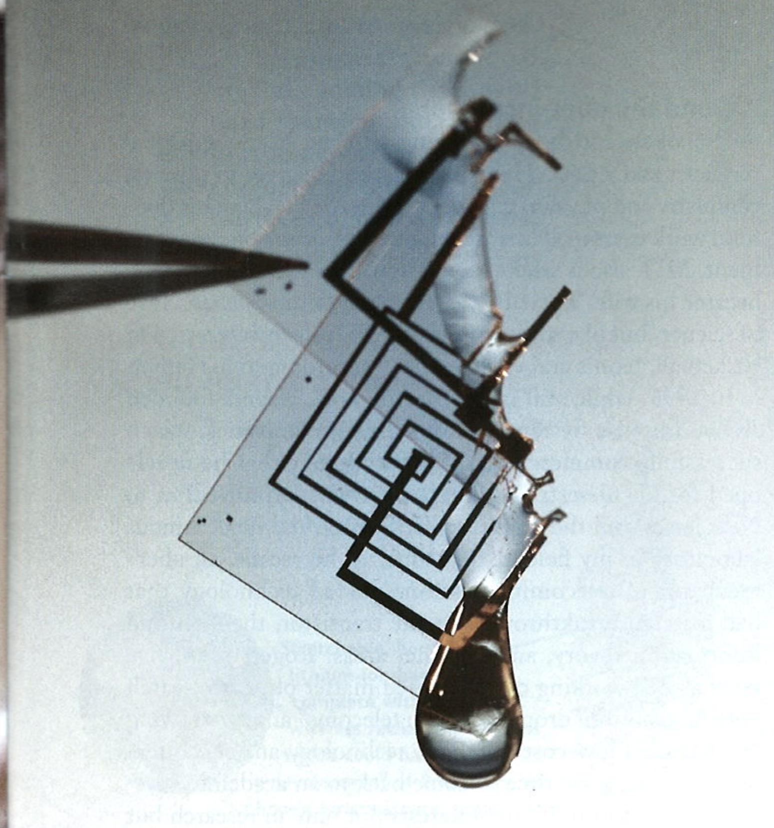


Mind-bending electronics from the lab of UI scientist **John Rogers** promise to revolutionize health care in the plugged-in world of tomorrow

Wired

by Jim McFarlin

Someday in the not-too-distant future, John Rogers will be delighted to tell you to stick a sock on it. On your heart. Or your brain. Or any other organ that may stand in need of continuous monitoring or an electronic performance boost.

Clearly, these are not the calf-length argyles that come three to a package at Target.

Rogers, a professor of materials science and engineering at the University of Illinois and director of its Frederick Seitz Materials Research Laboratory, is developing a super-flexible, micron-thin silicone rubber sheath that wraps around your ticker, where its advanced electronics and sensors will regulate and monitor the heartbeat, send data to the cardiologist and alert its owner of the need for medical attention. In time, Rogers expects the device will replace the pacemaker as a kind of "electronic pericardium."

The scientist also expects to enable surgeons to use their fingertips as instruments and to allow doctors to treat patients with implants that dissolve harmlessly in the body when no longer needed. He has designed electronic sutures that monitor surgical wounds for infection and healing. His ultra-thin electronic "tattoos," which can be placed on the forehead or elsewhere on the body, track such functions as blood flow and hydration (and, when tested by drivers on the NASCAR circuit, they worked).

Welcome to the idea cloud at the Rogers group, where science fiction becomes fact, and dreams produce data.

"We're trying to define a space where we can take electronics and marry them with the human body in ways that people haven't thought about before," Rogers says.

A 25th-century realm

The devices to accomplish this end are fabricated from materials so adaptive and sophisticated that they can act as electronic enhancements to organs. Integrated into the body as never before, such innovations will create, in Rogers' words, "human tissue whose health is enhanced by continuous low-level intervention to maintain proper functioning of the system."

John Rogers? This sounds like Buck Rogers territory, a 25th-century realm where the seamless melding of man and machine

UI professor John Rogers adjusts the vacuum system of a tool used to form conducting traces in his revolutionary electronics. Above, a tiny device, insertable into the human body, will fight infection post-surgery, then dissolve.

Photography courtesy of John Rogers; opposite page, photography by Evan Sears

Photo courtesy of John Rogers

A wrist "tattoo" the size of a postage stamp monitors the heartbeat. Designed to replace bulky equipment and provide continuous information, such devices can also measure hydration, oxygen levels and blood pressure.

is possible, where electronics and biotics expand each other's capabilities beyond previously limiting conceptions about what can be manufactured and how the body may react. What John Rogers is pursuing over the long term is nothing less than a radical vision of what humans can become.

This is the vision that drives work and life in the Rogers group in the basement of Seitz Lab, where an idea factory of 100 graduate, postgraduate and undergraduate students – supported by a phalanx of 25 Ph.D.-bearing scientists – has cranked out hundreds of papers in peer-reviewed journals and secured patents at a remarkable rate – nearly 100 to date.

Engineering their space-age materials at the nanoscale, these researchers literally manipulate atoms to assemble the desired properties. Rogers and his team create ultra-small, ultra-efficient silicon components and combine them with such "soft" materials as polymers, liquid crystals and biological tissue. The end result: functional systems that, just a few years ago, couldn't have been conceived, much less produced.

"He is the most creative and innovative researcher I have ever met," marvels longtime collaborator Yonggang Huang, a distinguished engineering professor at Northwestern. "He is outstanding in fundamental science, engineering applications and technology innovation.

"Everything he touches becomes gold."

Beyond the uber-incubator

Soft-spoken and boyish-looking, Rogers is the son of a physicist and a poet. He holds advanced degrees in physics, chemistry and physical chemistry from MIT, where his doctoral work examined laser techniques for precision measurement. MIT also is where he met researcher Lisa Dhar, who became his wife. Their 10-year-old son, John, also has a love of science, but like most boys his age, is "mostly interested in basketball, tennis and video games," according to his father.

In 1995, while still in the Boston area, Rogers founded Active Impulse Systems, the first of his companies, which successfully commercialized the technology that he developed for his dissertation. After two years he moved on to New Jersey and the legendary Bell Labs, "the most famous laboratory in my field at that time" as he recalls, an uber-incubator of telecommunications-related technology that had fostered breakthroughs in the transistor, the laser and information theory, among other areas. Rogers spent five years at Bell working on condensed matter physics research until "the bottom dropped out on telecoms" amid a growing revolution of low-cost cellphone technology and the Internet. "It was a good time to come back to an academic environment and to fulfill my interests not only in research but also teaching and mentorship," Rogers says.

And so he found Illinois – and Illinois found him. His former boss at Bell Labs, who had become director of the Beckman Institute for Advanced Science and Technology on campus, recruited Rogers to the faculty in 2002 with appointments in both chemistry and engineering. Today Rogers holds a Swanlund chair, the highest endowed position on campus. He has also gleaned honors from, among others, the National Science Foundation, the American Chemical Society and the U.S. Department of Defense, as well as a MacArthur Fellowship and the Lemelson-MIT Prize, each carrying a $500,000 award. He has made a radio that fits on a grain of sand – just to show it could be done – and designed a camera modeled on an insect's eye. A few of his more recent innovations include LEDs that inject into – and illuminate – the brain, and stretchable, rechargeable lithium-ion batteries.

Rogers' cross-disciplinary prowess in physical chemistry, materials science and device engineering has enabled a new style of creative research, particularly notable in this age of unparalleled academic specialization. At 45, Rogers is the scientific world's equivalent of a rock star.

Not that he acts like one.

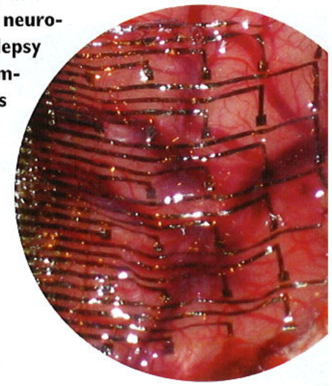
"The students are doing everything. I just take credit for it," quips the researcher. With signature modesty, he also lauds his collaborators and praises the University. "I've found the campus to be very open and full of talented people who are also very easy to work with, so we collaborate a lot," Rogers says. "Not only in my department – materials science and engineering – but also in mechanical and electrical engineering, chemistry, chemical engineering, physics. All of this expertise has to be brought to bear."

Working in "soft" materials such as polymers and liquid crystals, joining them with "hard" semiconductors like silicon, and exploring how they can conform to the curvilinear surfaces of human tissues,

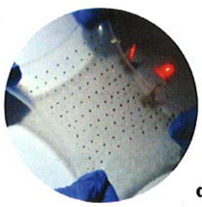
Professor John Rogers and his research group have been creating innovative, next-generation devices

like they were rolling off a production line. In the past 18 months alone, they have conceived:

Cellular-scale LEDs that inject into the depth of the brain, with ability for wireless control over complex behavioral responses in freely moving animals



Flexible, bio-integrated sheets of sensors designed for high-resolution mapping of electrical activity in the brain, potentially allowing neurosurgeons to treat epilepsy by detecting and eliminating seizures seconds before they occur



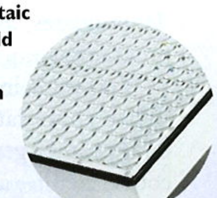
Stretchable, bendable lithium-ion batteries, complete with integrated wireless recharging systems, which could hasten the development of flexible smartphones, wristwatches, tablets and other electronic devices

Digital cameras, with designs inspired by insects, to achieve unmatched fields of view and imaging properties

A new type of biodegradable, "transient" electronics technology made of materials like silicon, magnesium and silk, which could be implanted in the body, perform vital diagnostic tasks, then dissolve completely in bodily fluids

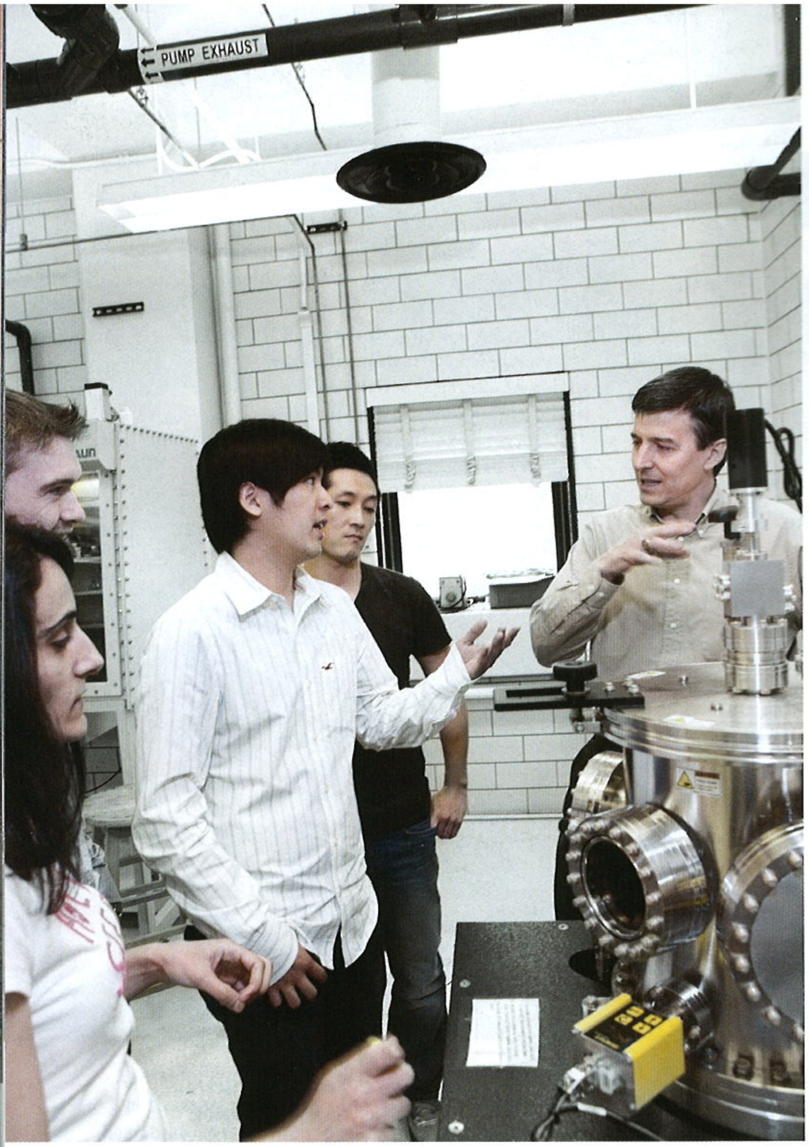
"Smart" wearable electronics, which place flexible semiconductors in fingertip wraps and gloves to dramatically enhance the sense of touch, or apply them to the skin in a tattoo-like patch to monitor vital functions on a continuous basis

Surgical sutures, coated with micron-thin silicon sensors that precisely measure temperatures at the point of incision to warn against infection and provide electrical stimulation to heal wounds faster or deliver drugs in a preprogrammed regime



High-concentration, photovoltaic solar modules that set a world record for efficiency at 33.9 percent – meaning more than one-third of the energy coming into the device was converted into usable electricity

Technology photos courtesy of John Rogers / Photography by Evan Sears



Photography by Evan Sears

Committed to mentorship, Rogers meets here with Ph.D. students in Seitz Lab, where they carry out much of their research. Pictured, from left, are Canan Dagdeverin, Chad Webb, Howard Liu and Sukwon Hwang.

Hardware is critical. "To do any of this stuff in a realistic way you have to have very sophisticated, high-end tools: characterization tools, microscopy systems, electrical property measurement instruments for various classes of tiny devices that we build," Rogers explains. "And we [at the U of I] have access to the absolute best facilities, I think, in the world." He regards Seitz and Beckman, where much of his group's research is carried out, as "crown jewels for a lot of the physical science research that happens on campus," not only because of the facilities and lab space but also because of the large scientific staff and enthusiastic complement of students.

Rogers takes particular pride in the participation by undergraduates, as well as graduate students, in his research programs.

"You want in, you're in," he says of the undergraduates. "They appreciate that something exciting might be going on here; they get engaged and work like crazy." In return for course credit – and, later, letters of recommendation, which Rogers writes by the hundreds – "the undergraduates make a huge contribution to our ability to get things done.

"This is a fantastic opportunity for everyone, and we've had very good success with it."

The payoff doesn't always come via straight-line scientific methods. Several years ago one young researcher stretched a piece of rubber beneath an electronic circuit during an experiment, then accidently let it slip, causing the circuit to become, as Rogers recalls, "an accordion made of silicon." The mishap yielded a stunning breakthrough. If rigid silicon semiconductors could bend, flex and stretch, the possibilities become boundless. That fortuitous gaffe provided the basis for the soft, conformal electronics described above – electronics with which Rogers expects to transform health care and "the way that we think about the interface between biotic and abiotic systems."

And brilliance in business

Hardly a month goes by without the national and international media carrying news of yet another innovation by Rogers, who is also disseminating his technology through startup companies.

"I must say, I was very surprised by John as a businessperson," observes Jiong Ma, a venture capitalist who has helped support mc10, one of Rogers' companies. A former colleague of Rogers at Bell Labs, Ma notes that the scientist is "extremely sharp and very creative on the research side, continually looking for areas in which he can innovate."

"I have been impressed by his discussions on the business side, challenging the team to focus on the right topics and to keep pushing the envelope."

Located in Cambridge, Mass., mc10 is pioneering a range of medical monitoring technologies. The company has partnered with Reebok to produce an indicator worn by hockey players and other at-risk athletes that can identify impacts to the head during play. Rogers' North Carolina company, Semprius, deploys a revolutionary microprinting process to produce tiny, highly efficient, cost-effective cells for solar power. Other of his companies are devoted to futuristic LED lighting systems and to transient electronics, which include medical devices engineered to dissolve in the body.

And in the boundless realm that Rogers has defined – of opportunity realized by creativity and unleashed by technology – the inspiration just keeps coming.

"I see probably a dozen things that we'll do over the next couple of years, and there's no shortage of ideas," he concludes. "Who knows how long that will last? Maybe we'll get hot and cool off, or maybe we'll hit a sweet spot and mine that out, then have to determine what's next.

"But I would say that for the next two years we know the major themes and directions. We think that it's important stuff, and we're just doing it.

"It's pretty simple."

Sure.

Simple as putting a sock on it. ❖

McFarlin is a freelance writer in Urbana.