Using light to detect the first shadows of cancer

For years it has been the goal of Vadim Backman, professor of biomedical engineering, to see a simple, noninvasive test for the most common cancers become widely available in physicians’ offices. In his lab in the basement of Silverman Hall, Backman and his group—in partnership with Hemant K. Roy, director of gastroenterology research at NorthShore University HealthSystem—have tested, optimized, and perfected two biophotonic technologies that rely on what is called the “field effect”: a biological phenomenon of the earliest stage of cancer in which cells undergo nanoscale genetic and epigenetic changes across a range of tissues. Now these technologies can detect early changes in small, easily accessible tissue samples—from the cheek for lung cancer and from the base of the rectum for colon cancer. It’s an elegant solution that, having done well in clinical trials, could soon become part of a routine checkup.

The first technology uses a technique called low-coherence enhanced backscattering spectroscopy, in which a fiber-optic probe measures how light bounces back from tissue to search for cancer’s fingerprint in the nanoarchitecture of its cells. Physicians can use the small probe to test tissue in the base of the rectum for colon cancer or during a standard upper endoscopy for pancreatic cancer, which has been historically extremely difficult to detect in its early stages. After successful clinical trials, the technology has been licensed to a company and could be in use in Europe as early as 2013 and in the United States following FDA approval.

Backman’s other technology, nanocytology, also makes use of field effect, but instead of a probe, a physician swabs a small sample from the patient, and researchers use a specialized partial-wave spectroscopy microscope to examine the cellular nanoarchitecture of the sample. The research group under Backman and research associate Hariharan Subramanian has conducted clinical trials using this technique for lung, colon, pancreatic, esophageal, and ovarian cancer—all with cells gathered noninvasively, and all with promising results. “It’s truly a platform technology,” Backman says.

What might be most interesting about nanocytology is that it detects the same cellular changes in all of these cancers. “These five organs are drastically different,” Backman says, “yet this change is the same. What can we learn about cancer’s process from this?”

Backman has teamed with Allen Taflove, a professor of electrical engineering and computer science and the Bette and Neison Harris Professor of Teaching Excellence, and Igal Szleifer, the Christina Enroth-Cugell Professor in biomedical engineering, to mathematically model this effect in order to understand the biology behind it. “We had no way to look at these changes before,” Backman says. “Now we can combine engineering, physics, micromolecular processes, and biology in an attempt to truly understand cancer.”
Rehabilitation robotics

Ed Colgate (left) and Michael Peshkin (right) want robots to work for us—especially when we’re most vulnerable. Colgate, the Allen K. and Johnnie Cordell Breed Senior Professor of Design and professor of mechanical engineering, and Peshkin, professor of mechanical engineering, conduct research in human-robot interaction. With close ties to the Rehabilitation Institute of Chicago (RIC), they’ve developed several robotic devices for rehabilitation, including the KineAssist, which helps stroke patients regain the ability to balance and walk.

Working with Todd Kuiken, professor of biomedical engineering at McCormick and of physical medicine and rehabilitation at the Feinberg School of Medicine, as well as director of RIC’s Neural Engineering Center for Artificial Limbs, they helped develop a new kind of prosthetic arm that works with the amputee’s own nerves. They used their research in haptics—tactile feedback technology that uses touch as an interface—to give the arm “touch feedback” capabilities.

“With our strong robotics group and our connections with the Rehabilitation Institute, we really have a rich set of research opportunities that hopefully will result in better prosthetics for everyone,” Colgate says. ■

Modeling complex reactions

Linda Broadbelt (right), an expert in the computer generation of complex reaction mechanisms, is known for modeling chemical reactions that have implications for everything from recycling to tropospheric ozone formation. Now Broadbelt, chair and professor of chemical and biological engineering, is making her move in medicine: She is partnering with Keith Tyo, assistant professor of chemical and biological engineering, to develop new biosynthetic processes that use inexpensive materials like sugar to make more affordable drugs for the developing world.

She’s also working with Lonnie Shea, professor of chemical and biological engineering, to identify active pathways in the cell array technology developed by Shea that could be used to investigate the progression of diseases or to promote the development of functional tissue replacements. “Partnering with other professors allows us to tackle these complex problems from both computational and experimental standpoints,” she says. ■

Left: Glycosidic cleavage of methyl-cellobiosan: Using quantum mechanics, the Broadbelt lab has discovered a mechanism for the decomposition of cellulose, the dominant component of plant biomass, which has eluded researchers for more than 90 years. This understanding will advance efforts to produce renewable energy from cellulosic biomass.