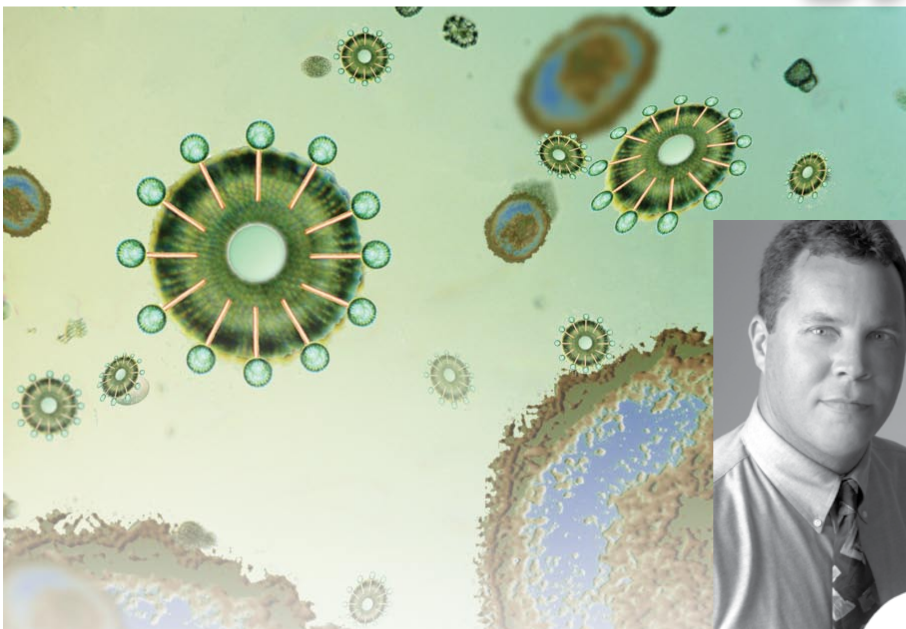
Nanotechnology



Tiny Disease Fighters

Armed with therapeutic drugs, nanoparticles injected into the body move along in the bloodstream toward their target—a cancer cell. These nearly invisible legions of stealthy, infinitesimal specks invade the target cell and deliver diagnostic or therapeutic agents.

Over the past four years, this scenario has been fine-tuned by Mike Jay (right, above) in the UK College of Pharmacy and his former colleague in the college, Russ Mumper. It's an approach that holds great promise for diagnosing and treating various cancers and fighting viruses like HIV.

An important step in the researchers' nanoparticle tinkering is their use of "recognition molecules" that are attached to the surface of the particles. With this chemical tinkering, the particles can be directed to specific parts of the body, for example, a receptor on a tumor. "Whether injected or dried and incorporated into a tablet, the particles head for the cancer cell and bind to a receptor," Mumper explains. "The cancer cell engulfs the particle and, in doing so, engulfs the drug that will leach out into the cell and kill it."

In 2000, believing strongly in the therapeutic potential of this process, Mumper and Jay founded NanoMed Pharmaceuticals Inc. In the last two years, their work has "taken off," Jay says. Initial studies have shown that their nanoparticles are safe and biocompatible, and they have been shown to overcome the resistance that tumors develop to many chemotherapeutic agents. Testing of their nanoparticles, loaded with the anti-tumor drug Idarubicin, is under way in an animal model of leukemia.

"My greatest hope," says Jay, "is that what we discovered and developed will be used to help people who have diseases that are especially hard to treat."

Nanotubes,

only a few atoms in circumference, are stronger than steel, and can conduct electricity.

Working Together on the Nanoscale

With $20 million in grant funding and industry partners including Lexmark, Cypress Semiconductor, Quanteon, the Painting Technology Consortium, and Lexel Imaging Systems, UK's Center for Nanoscale Science and Engineering (CeNSE) is the nexus for nanotechnology research at UK and for joint U of L and UK nanotechnology projects.

CeNSE research covers nanoelectronic devices, nanoscale materials, biosensors, chemical/environmental sensors, and nanotechnology education and commercialization.

Two dozen UK faculty are involved in CeNSE, including center director Vijay Singh (electrical and computer engineering), who is studying sensors and solar cells for commercial and military applications, and Ushi Graham (Center for Applied Energy Research), who is focusing on carbon nanotube docking stations for fuel catalysts and leading a Toyota/UK project on fuel cells based on nanocatalysis.

Eric Grulke (chemical and materials engineering) is studying nanocomposites for space radiation shielding and recently developed the nanoCLEAR anti-reflective lens system with Optical Dynamics in Louisville, Kentucky. This system is a new method for producing anti-reflective eyeglass lenses.

Zhi Chen and Todd Hastings (electrical and computer engineering) are developing photonic and electrochemical sensors, including, in collaboration with Parkinson's researcher Greg Gerhardt, sensors that measure in real time neurotransmitters in the brain.

Bruce Hinds (chemical and materials engineering) is studying water transport and chemical gatekeeping in carbon nanotubes and has teamed with pharmacy researcher Audra Stinchcomb to use nanotubes to improve topical and transdermal drug delivery.

In addition, Bob Yokel (pharmacy), along with several CeNSE researchers, is leading a new multidisciplinary consortium on nano-toxicology with the University of Louisville. And Leonidas Bachas (chemistry) is using nanoscience and molecular biology for environmental remediation and self-organization of nanoparticles.

Harnessing the Power of the Nanotube

A chain of nanotubes able to span the 250,000 miles between the Earth and the moon could be loosely rolled into a ball the size of a poppy seed. These hollow, cylindrical structures measure only a few atoms in circumference, are stronger than steel, and can conduct electricity.

Carbon nanotube research at UK started nearly 25 years ago when Peter Eklund (formerly in physics and astronomy, below) began to study nanotube-containing carbon materials. He developed an arc-discharge method for producing nanotubes, allowing his group to produce larger amounts of material at higher purity. Eklund and chemists Robert Haddon, Mark Meier and Jack Selegue worked together on purification technologies similar to those developed in earlier work on fullerenes (a.k.a. buckyballs—hollow spheres with 60 symmetrically arranged carbon atoms. Nanotubes differ only in that they are strands rather than spheres.)

This collaboration, with the addition of Frank Derbyshire at the Center for Applied Energy Research (CAER), eventually led to an NSF Materials Research Science and Engineering Center (MRSEC) on Advanced Carbon Materials at UK. Under the MRSEC award, CAER researchers Rodney Andrews, David Jacques and Apparao Rao began to concentrate on methods for producing larger quantities of multi-walled carbon nanotubes for applications such as high-strength composites, super-capacitors and batteries, and biological sensors.

Today, with support from the Army Research Laboratory, the CAER group produces several kilograms per day of high-purity nanotubes and supplies materials to UK nanotube researchers in biomedical engineering, chemistry, chemical and materials engineering, electrical engineering, and mechanical engineering, as well as to collaborators at other institutions and in industry.