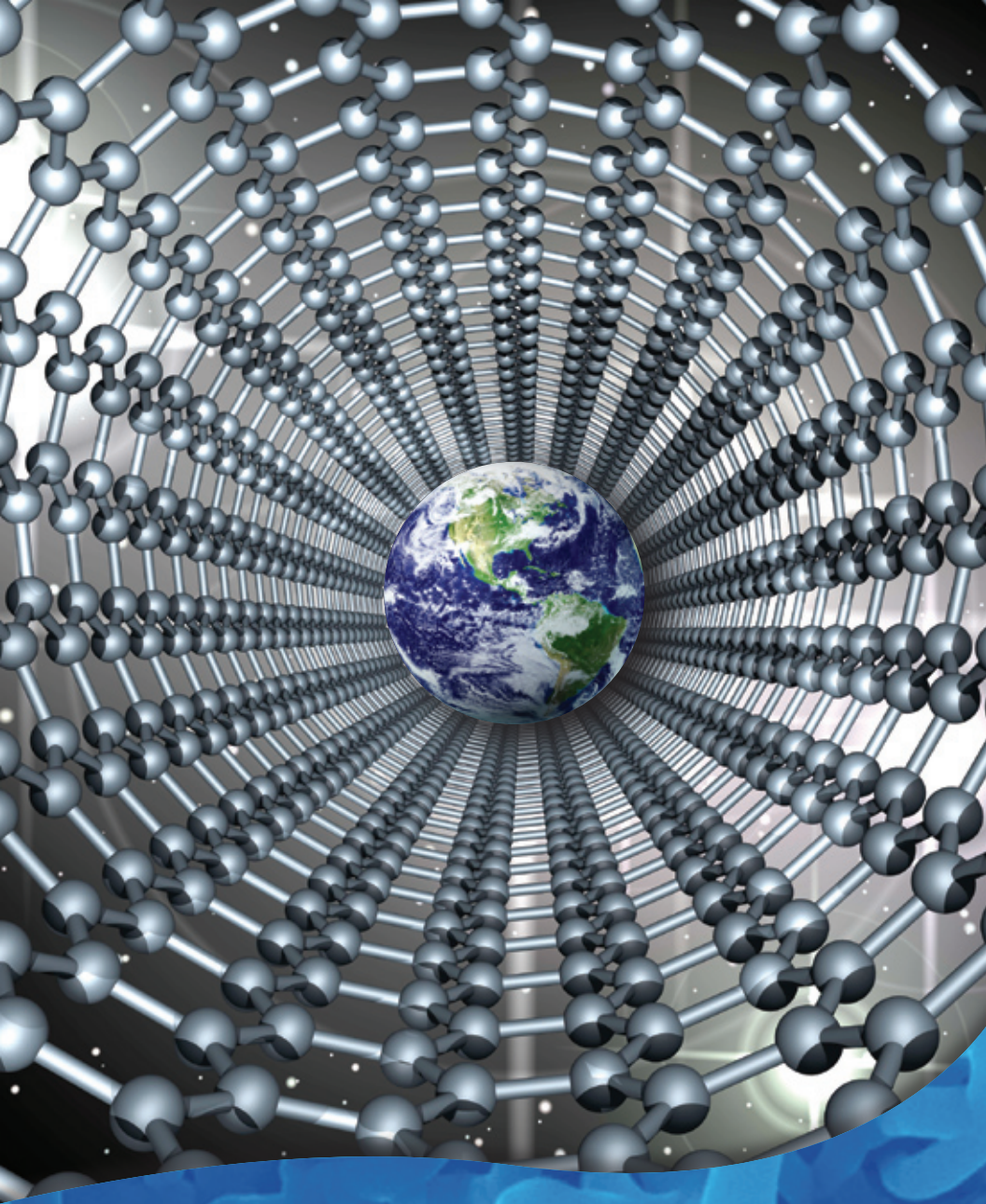
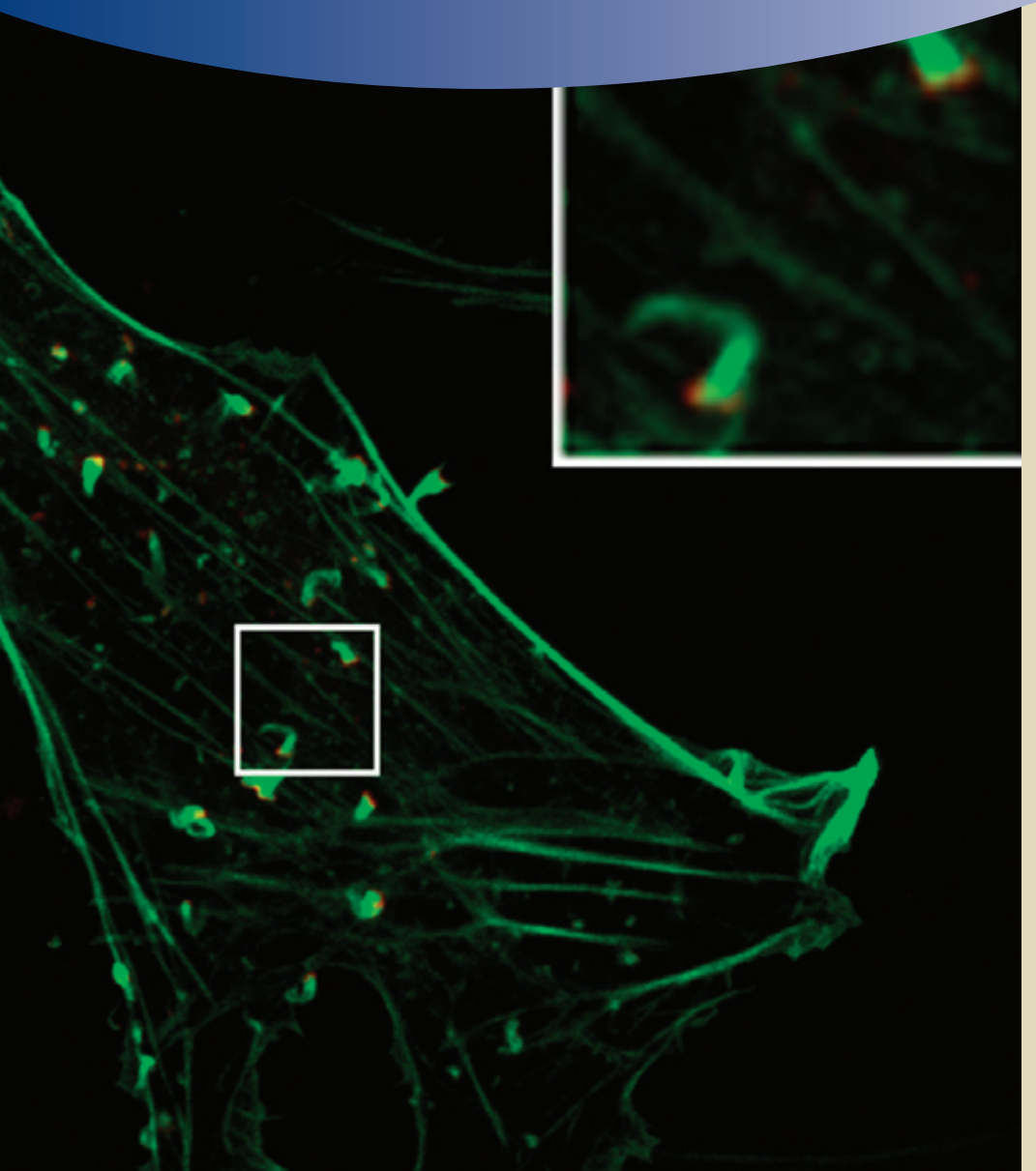


NANOTECHNOLOGY

Thinking big—on a small scale

UNIVERSITY OF CONNECTICUT 2008

What is a "nanometer"? It is a unit of measurement equal to one-millionth of a millimeter. To put this into perspective, consider the width of a single human hair, which measures in at 80,000 nanometers, or a sheet of paper, typically about 100,000 nanometers thick. These are relatively sizeable measurements in the world of nanotechnology, an emerging scientific endeavor that involves examining and manipulating materials at dimensions of a mere 1 to 100 nanometers. Engineering on a scale this minute has never before been realized—yet its future impact promises to be immense.



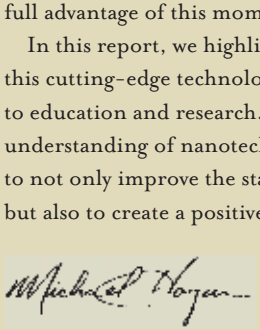
THE PRESIDENT'S REPORT ON NANOTECHNOLOGY

Picture a world in which water shortages no longer exist, where we have the capability to purify even the most polluted water. Try to imagine computers with processing speeds exponentially faster than any we have previously witnessed or buildings constructed from compounds hundreds of times more resilient than steel. This is what many researchers consider the impact of engineering of the future, all of which is considered possible through an emerging cross-disciplinary science called nanotechnology.

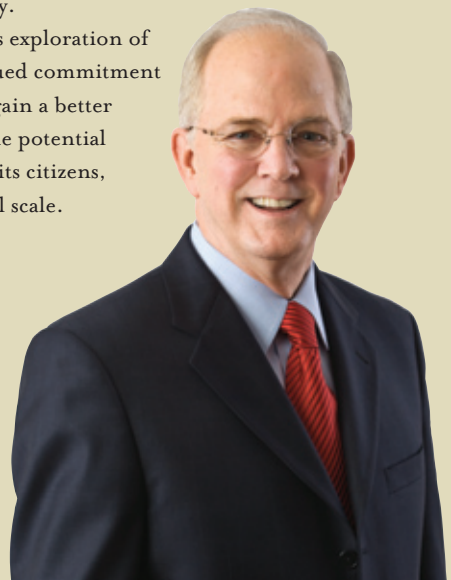
The University's investment in this branch of science is significant, with more than 60 faculty members and numerous graduate students—along with more than $20 million in research grants and contracts—currently engaged in nanotechnology research spanning our academic disciplines, including potentially life-altering work taking place at the UConn Health Center.

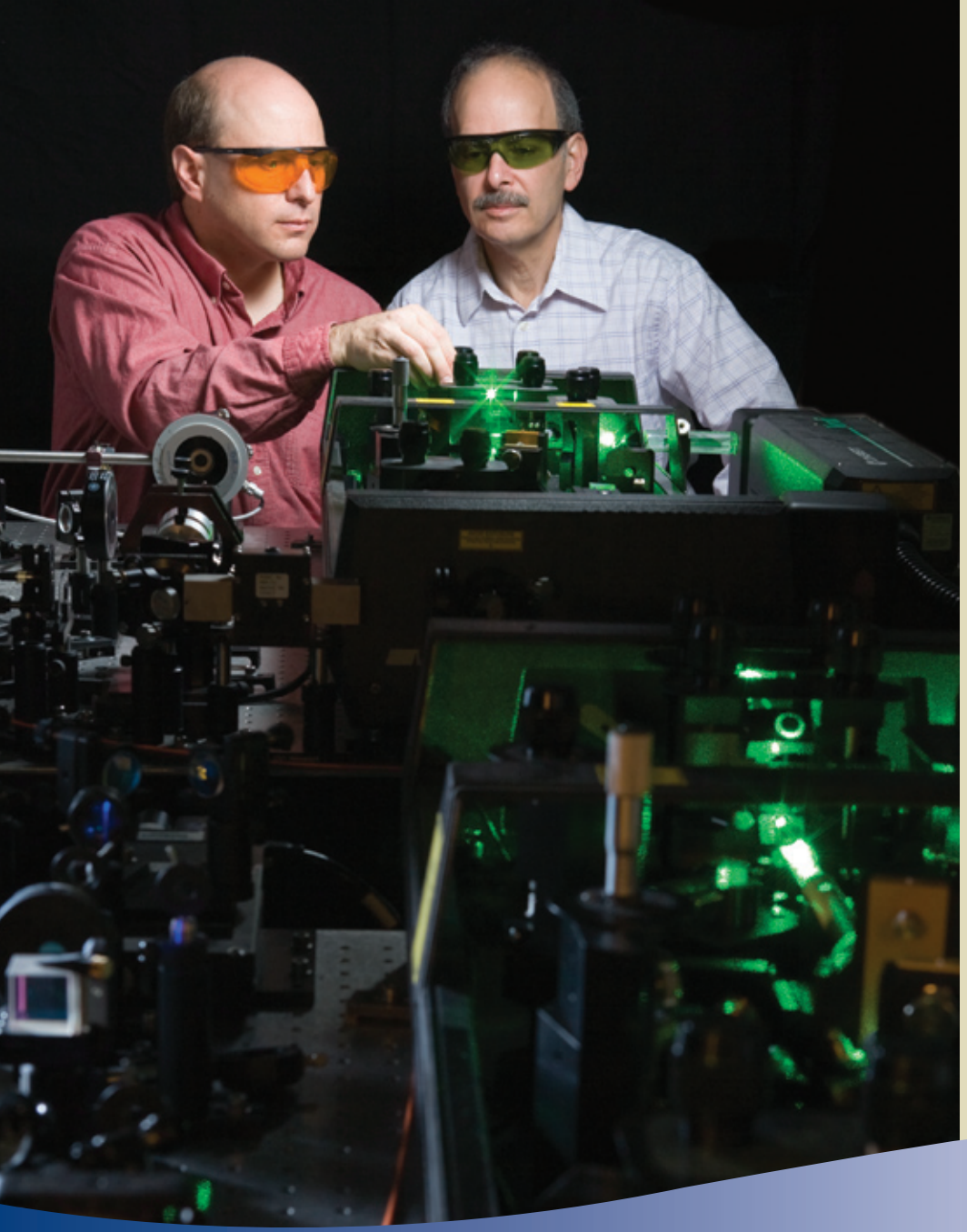
The future applications of nanotechnology are just beginning to take shape, and yet the stakes have already hit at an all-time high, with intense competition for financial support. Committing to fundamental nanotechnology research initiatives and building an infrastructure today are essential to our pioneering the development of novel nanotechnology products and programs in the years ahead. At UConn, we are taking full advantage of this momentous opportunity.

In this report, we highlight the University's exploration of this cutting-edge technology and our continued commitment to education and research. We trust you will gain a better understanding of nanotechnology's incredible potential to not only improve the state and the lives of its citizens, but also to create a positive impact on a global scale.



Michael J. Hogan
President, University of Connecticut





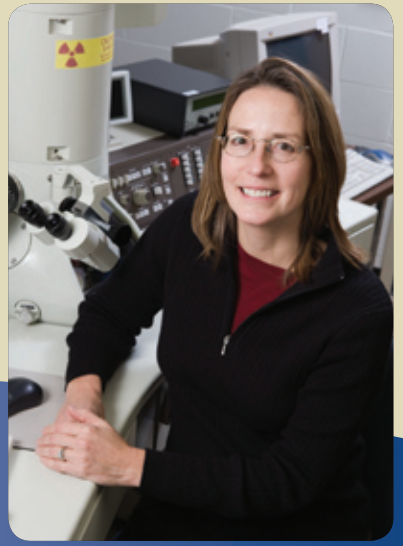
LIFE-ALTERING POTENTIAL

The possibilities of nanotechnology are innumerable, with the potential to touch virtually every facet of applied science—from high-tech manufacturing to advanced military technology and beyond—and, in turn, many aspects of our lives. On the medical front, doctors may one day be able to diagnose diseases at much earlier stages; repair damaged hearts with lab-grown tissue; precisely target cancer cells with chemotherapy drugs; and modify viruses, permanently preventing them from infecting humans.

◀ At the UConn Health Center's R.D. Berlin Center for Cell Analysis and Modeling (CCAM), faculty members are carrying out a range of special research projects in nanomedicine. Among these projects is CCAM director Leslie Loew's work. Loew, a professor of cell biology, computer science and engineering, is using fluorescent dyes that he helped develop to record the passage of ions across cell membranes. This work will provide insight into how cells, genes, and proteins in the body communicate and, in turn, the possible causes of certain diseases.

• Paul Campagnola, assistant professor of cell biology at the UConn Health Center, uses lasers to build complex, 3-D structures of organ tissues, such as skin and ovaries, with details down to the nanometer. This work could lead to a better understanding of how cancer invades and metastasizes within the body and, ultimately, may aid in future diagnostic and therapeutic efforts.

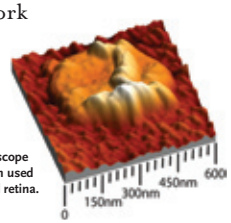
▶ Liisa Kuhn, assistant professor of oral rehabilitation, biomaterials and skeletal development at the Health Center, is investigating the possibility of using nanotechnology to help fight cancer. Her studies into the use of calcium phosphate nanoparticles to deliver anti-cancer drugs directly into tumors and the draining lymph nodes would allow doctors to provide effective treatment with unparalleled precision.



THE NEXT GENERATION OF NANOTECHNOLOGY

Understanding and controlling materials on the nanoscale is swiftly bringing about innovations in industries as diverse as data storage, disease prevention, and agriculture. At UConn, numerous studies currently being conducted by faculty and graduate students offer a glimpse into just a few of the many incredible prospective applications of nanotechnology.

◀ Robert Birge, the Harold S. Schwenk Distinguished Professor of Chemistry, and his research team have several projects in progress that are heavily dependent on nanotechnology. Among them is Birge's ground-breaking attempt to develop an artificial retina that would restore vision for people who have lost it. Constructing such a device relies in part on being able to manipulate specific proteins as well as the nerve cells of the eye—work that involves carrying out procedures on the nanoscale.



A scanning-tunneling microscope image of a patch of protein used to make the artificial retina.

▶ Chemistry professor Fotios Papadimitrakopoulos, the associate director of UConn's Institute of Materials Science, is working alongside several other UConn scientists in both the Schools of Engineering and Pharmacy on assembling tiny wireless sensors—so small they could ultimately be implanted in humans—to monitor, in real time, a person's various metabolic processes, such as blood glucose level. The potential for an implantable glucose sensor, such as the one under development at the University, may become indispensable for anyone with diabetes. According to the American Diabetes Association, more than 20 million adults and children in the United States suffer from diabetes today.

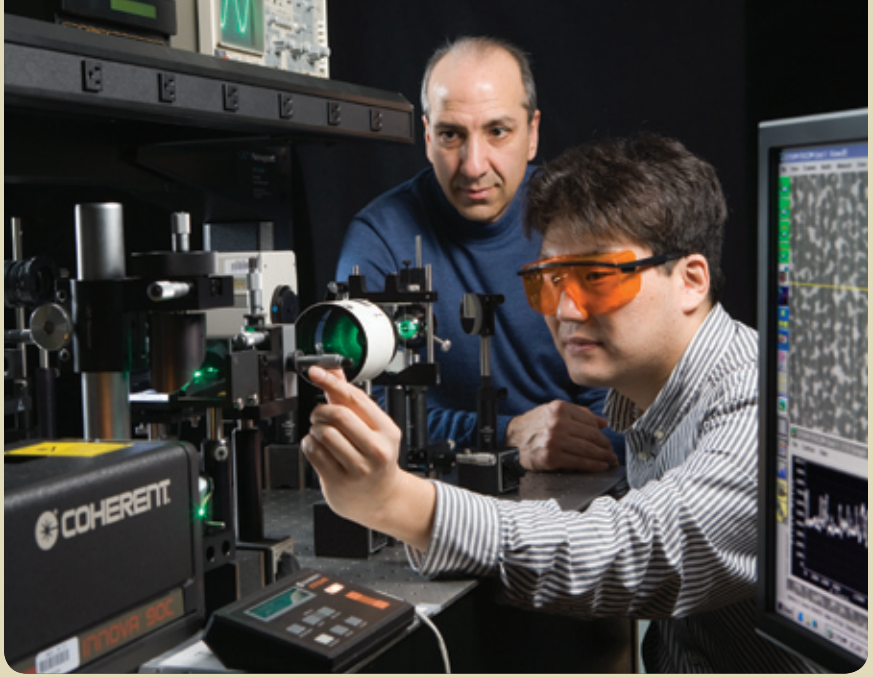
"The greatest innovations of nanotechnology have yet to be made."

—Robert Birge, the Harold S. Schwenk Distinguished Professor of Chemistry
College of Liberal Arts and Sciences

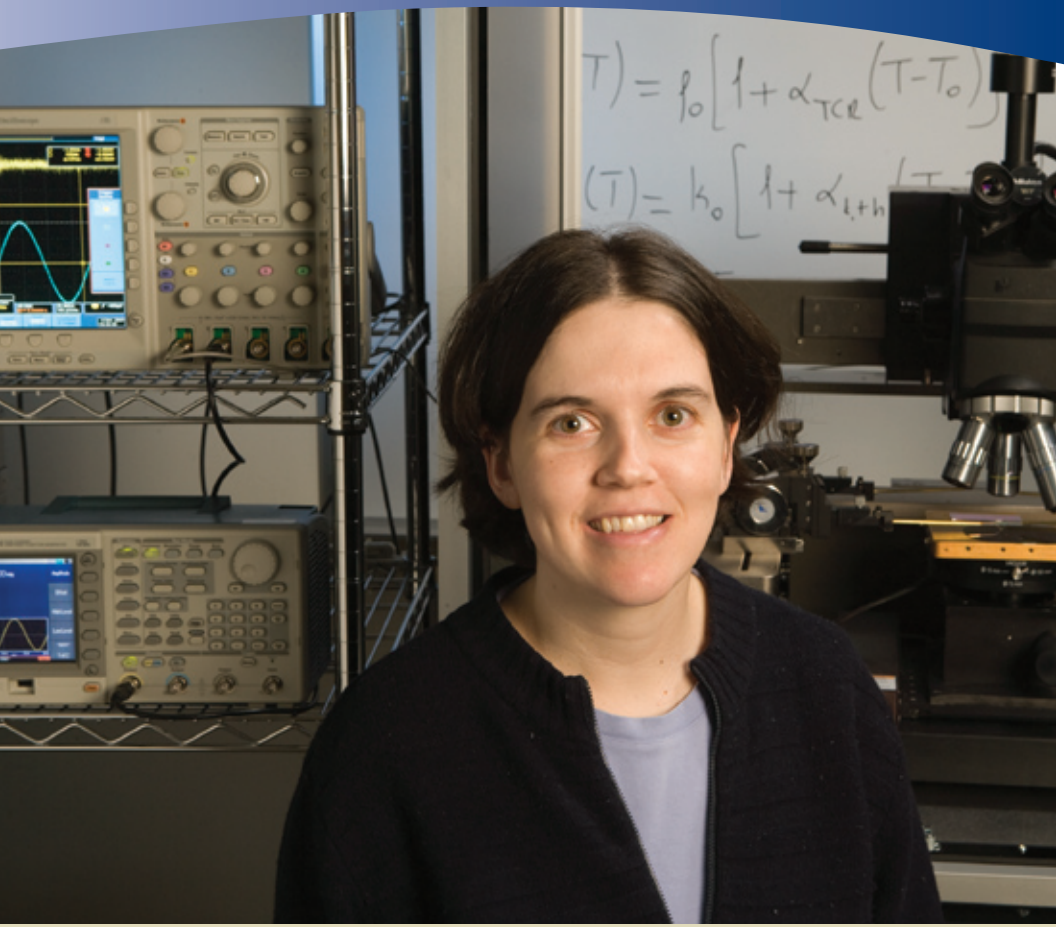
"Nanotechnology will make a fundamental change in the way we live and work."

—Challa Vijaya Kumar, professor of chemistry
College of Liberal Arts and Sciences

▼ Nejat Olgaç, professor of mechanical engineering and head of UConn's Advanced Laboratory for Automation, Robotics and Manufacturing (ALARM) Lab, has developed with his team a microscopic device that can transfer genetic material into cells with greater accuracy and effectiveness than ever before achieved. This breakthrough microinjection method—which is made possible through nanotechnology—has enormous implications for the future of many medical fields, including stem cell research and in vitro fertilization.



▲ Compelling research led by Bahram Javidi, Board of Trustees Distinguished Professor of electrical and computer engineering, makes recognition of different species of bacteria possible, using a special technique that measures how nanoorganisms interact with light. Having the ability to distinguish various microorganisms using this method could allow scientists to identify, detect, and track pandemics, such as avian flu, far more quickly and accurately than previously possible.



"With current technology—developed largely for ultra-small electronics—we can now make devices that are small enough to interact with individual molecules, proteins, or viruses. As a result, nanotechnology can have significant contributions to many fields other than conventional electronics, such as health, sustainable energy, and the environment. UConn is playing an important role in this growth."

—Helena Silva, assistant professor of electrical and computer engineering UConn School of Engineering

At the University's School of Engineering, nanotechnology applications are being developed in diverse areas, including military defense, information security, electronics, and alternative energy.

◀ In the Nanoelectronics Laboratory of UConn's Electrical and Computer Engineering Department, research being carried out by assistant professor Helena Silva involves fashioning special silicon nanowires. These tiny wires could make possible the development of superior large-area electronics, such as high-efficiency solar panels, advanced X-ray detectors for medical imaging, and flexible, lightweight electronic displays.

• Mechanical engineering professor Eric Jordan's multidisciplinary team has developed an innovative process for making ceramic coatings that could be applied to surfaces such as metal in order to defend against corrosion. Jordan's work could save both the public and private sectors billions of dollars in constructing aircraft engines, naval ships, and submarines. In fact, Jordan's team joined leading defense company Raytheon last year in a $1.47 million subcontract to aid in developing state-of-the-art ceramics using nanotechnology.

"Nanotechnology really is the future. If minds meet together, if we can find a niche and be prominent in that area ahead of time, I think that is critical."

—Eric Donkor, associate professor of electrical and computer engineering UConn School of Engineering

• Eric Donkor, associate professor of electrical and computer engineering, is conducting research on information security. "If, for example, someone's medical information must be transmitted from one doctor to another," Donkor explains, "we want that information to be as secure as we can make it." Donkor is attempting to build tiny semiconductor particles—with dimensions of only 10 to 20 nanometers—into networks of special fibers, similar to fiber optic cable. If Donkor succeeds in his mission, these fibers would be able to transmit and process information using light—remarkably, a single photon at a time. Transmitting sensitive medical, governmental, or business information utilizing this fundamental, indivisible particle of light would guarantee the utmost level of security.

"With nanotechnology, we will be able to make more effective vaccines for less cost."

—Newton Wahome, Ph.D. candidate
College of Liberal Arts and Sciences

DEVELOPING LEADERS

UConn graduate students in chemistry and engineering alike are working under some of the University's most accomplished faculty members on a variety of high-profile nanotechnology research projects, receiving the kind of intensive training and hands-on experience that promises to aid in earning UConn a reputation of excellence in nanotechnology research for the coming years.

These graduate students are nanotechnology's leaders of tomorrow. Our investment in students here at the University of Connecticut is helping to build a future workforce dedicated to advancing nanotechnology.

An Eye-Opening Experience

UConn graduate student Naftali Opembe, for instance, who has been working with Board of Trustees Distinguished Professor and Chemistry Department head Steven Suib, has "always been fascinated with how nanomaterials are synthesized as well as their applications on the industrial scale." At UConn, he saw an opportunity to pursue these interests and is now focused on producing nanomaterials as well as applying them as catalysts in various chemical reactions.

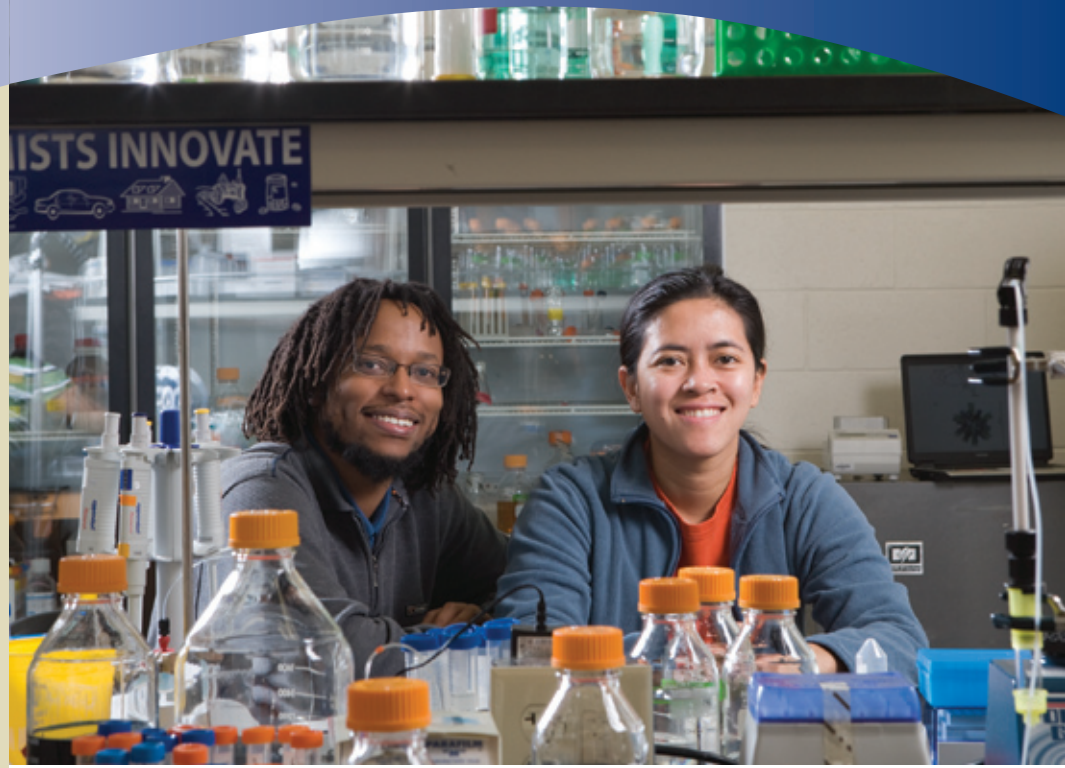
As Suib states, his research group's work in this area has "possible future practical applications in reforming of fuels, ceramic composites, in membranes, as sensors, and as novel catalysts, battery materials, and in magnetic devices."

"Participating in this research," Opembe says of his work at UConn, "has been an eye opener to the potential that exists—in the industry as well as in academia—in nanotechnology. In lots of ways, my involvement in nanotechnology research under Professor Suib's supervision has put me right on the track that I envisioned."

Breakthroughs in Renewable Resources

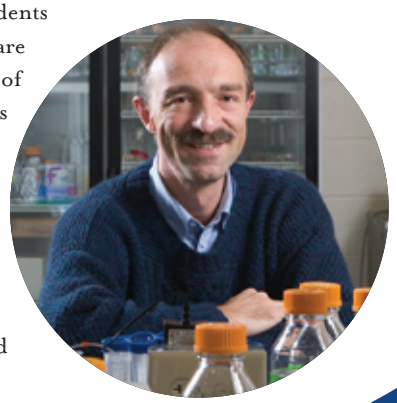
Graduate student Michael Duff is working with Challa Vijaya Kumar, professor of chemistry, to study how macromolecules, such as DNA and proteins, interact with nanomaterials. Ultimately, their research could give scientists the ability to convert harmful carbon dioxide emissions into raw materials that can be used to make products such as renewable fuels or pharmaceuticals.

"I've really enjoyed working on the novel, cutting-edge research afforded me in the nanomaterials projects I am working on," Duff says. "It's very exciting to know that you are one of the few people in the entire world who has ever done, or seen, what you've experienced in your research."



Designing Vaccines

In the Institute of Materials Science, graduate students such as Newton Wahome and Pauline Gay Padilla are working under Peter Burkhard, associate professor of molecular and cell biology, to explore how proteins on the nanoscale may be utilized in designing advanced vaccines for HIV.



For Wahome, a citizen of Kenya with a background in epidemiology and public health, UConn is the place to be. His search for Ph.D. programs in biophysics led him to Burkhard, whose ongoing research in nanomedicine presented an opportunity Wahome could not pass up.

COLLABORATIVE EFFORTS AND ECONOMIC IMPACT

Recognizing UConn as an emerging leader in Connecticut's pursuit of nanotechnology research, businesses across the state have joined forces with the University to foster a culture of collaboration. Today, for example, the University's Institute of Materials Science—which houses a number of laboratories and state-of-the-art equipment dedicated to studying nanotechnology—regularly coordinates with about 40 companies that share in the use of the lab's facilities.

Harris Marcus, a professor of materials science and engineering and the Institute's director since 1995, has been a driving force in educating students and others to "take advantage of what nanotechnology will offer." He cites the importance of the ongoing collaboration between UConn and representatives from industries, universities, and state government that currently partner within the Connecticut Nanotechnology Initiative, an ad hoc group that works to help propel the state of Connecticut forward as a leader in nanotechnology research, product development, and commercialization.

The Institute of Materials Science's mission is twofold, with a focus on working collaboratively with industries while furthering nanotechnology research. In fact, 30 UConn faculty members from a wide variety of departments are currently conducting interdisciplinary research in nanotechnology at the Institute. These faculty members include professor of materials science and engineering Leon Shaw, who is working to create nanomaterials that can store hydrogen in novel ways and, ultimately, make hydrogen-powered vehicles a reality. Meanwhile, associate professor of chemistry Greg Sotzing in the Institute's Polymer Science Graduate program is exploring the development of special nanofibers that could be used to produce advanced flexible electronic displays, including fabric capable of changing color.

Nanotechnology presents a remarkable opportunity not only for scientific discovery, but also for economic growth. It is estimated, for instance, that by the year 2014 more than 25,000 workers in the state of Connecticut may be engaged in producing nanotechnology-enabled applications and products. Additionally, worldwide sales of products that incorporate nanotechnology are predicted to amount to $2.9 trillion in revenue by 2014. UConn is prepared—through ongoing partnerships and a commitment to research—to make these possibilities a reality.

"There's a real buzz about nanotechnology. And while the buzz may fade away, the research is going to grow."

—Harris Marcus, professor, School of Engineering, and director of the Institute of Materials Science

Led by Harris Marcus, the Institute of Materials Science offers high-tech support to an array of small and large businesses. The Institute collaborates on an ongoing basis with several dozen industrial firms throughout Connecticut and neighboring states, providing access to instrumentation housed within the Institute's labs, current research studies, and the expertise of more than 100 UConn scientists involved in ongoing research efforts at the Institute.

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