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ENGINEERING
VANDERBILT

Dream Team

Vanderbilt part of national center to develop new cyber-security technologies

Most of us rely on networked computer systems in our homes, cars and offices and in critical national infrastructures. According to the National Science Foundation (NSF), many of these systems are far too vulnerable to cyber attacks that can inhibit their operation, corrupt valuable data, or expose private information.

The NSF has addressed this critical problem by establishing a major new multi-institutional center to protect the nation's computer infrastructure from cyber attacks while improving its reliability. The School of Engineering will play an important role in the new, $19-million center.

The Vanderbilt Institute for Software Integrated Systems (ISIS) is one of eight university collaborators in the Team for Research in Ubiquitous Secure Technology (TRUST), the new NSF Science and Technology Center. The center's initial funding will be apportioned over five years with the possibility of a five-year, $20-million extension. Vanderbilt's portion of the initial funding is $3 million.

Preventing an Electronic Pearl Harbor

"The cyber-security community has long feared that it would take an electronic Pearl Harbor for people to realize the scale of disruptions possible from a concerted attack by terrorists," says S. Shankar Sastry, University of California, Berkeley professor of electrical engineering and computer sciences and director of the TRUST center.

Vanderbilt researchers will help develop new technologies to protect the nation's critical infrastructure from such attacks. "ISIS 'model-integrated computing' technology will play a key role in establishing a new discipline for secure system design," says Janos Sztipanovits, ISIS director and E. Bronson Ingram Distinguished Professor of Engineering.

TRUST researchers intend to transform the ability of organizations to design, build and operate trustworthy information systems that control critical infrastructure.

TRUST "will investigate key issues of computer trustworthiness in an era of increasing attacks at all levels on computer systems and information-based technologies," the NSF said in announcing the new center. TRUST will address a parallel and accelerating trend of the last decade — the integrating of computing and communication across critical infrastructures in such areas as finance, energy distribution, telecommunications and transportation.

The center will build cyber-system security through modeling and analysis, development of secure embedded ("smart") systems, and integration of reliable components and secure information-management software tools.

"Much public attention has been focused on problems with cyber security, particularly in terms of identity theft," Sztipanovits says, "but this is the first time anyone has tackled the problem at the network level. We are developing ways to protect the computer, transportation, telecommunications and power distribution networks as integrated systems."

Sztipanovits cites the Great Northeast Power Blackout of 2003 as an example of the scope of the potential problem with insecure, outdated and inadequately integrated networks. "As networks have grown, the multiplicity of parts has threatened to outgrow the coordinating management systems."

Global networks

An additional problem, he says, is the difficulty coordinating public policies from state to state when the networks serve nationwide or global publics. "There are significant issues the public must decide, but these decisions vary from state to state. How can we coordinate these issues more uniformly?"

The center will also develop education and outreach programs geared to K-12 schools, undergraduate students and institutions serving under-represented populations, who will become the future of cyber-secure systems.

"We expect that TRUST will rapidly become a national resource that will transform the way we practice and teach systems science and engineering," Sztipanovits says.

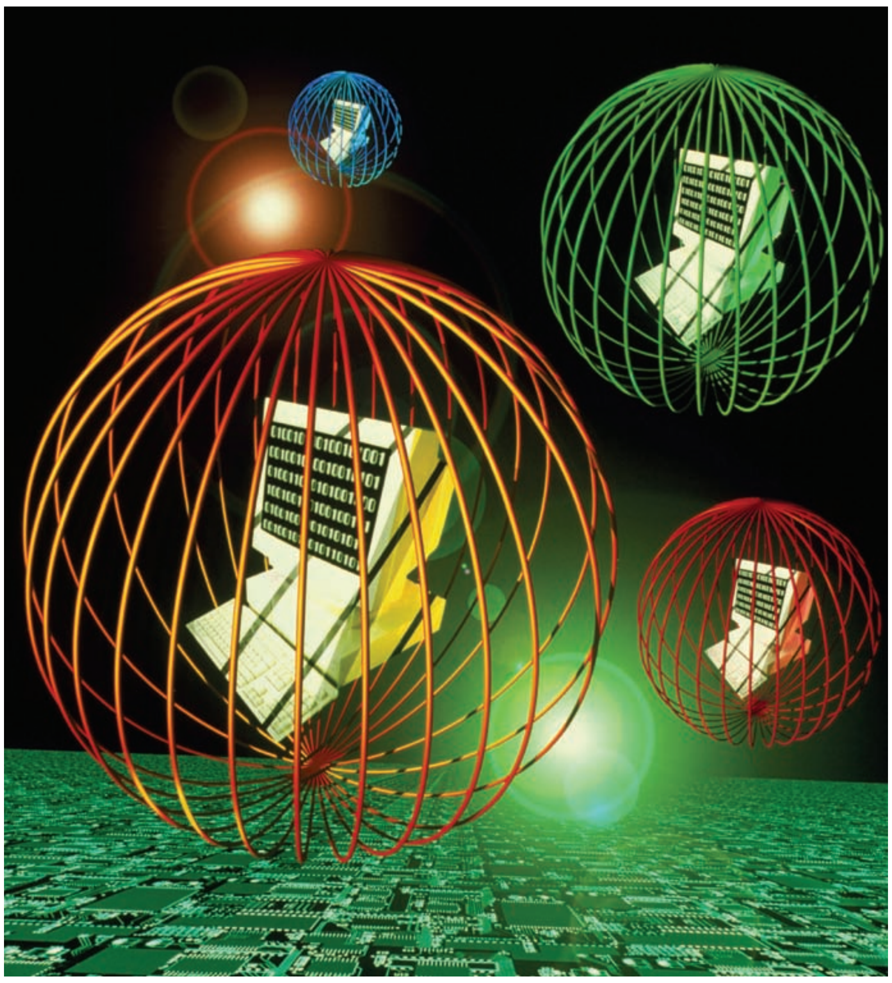
In addition to the Vanderbilt School of Engineering and UC Berkeley, TRUST academic partners include Carnegie Mellon University, Cornell University, Mills College, San Jose State University, Smith College and Stanford University. The program also brings together multiple industrial partners, including BellSouth, Cisco Systems, ESCHER (Boeing, General Motors, Raytheon), Hewlett Packard, IBM, Intel, Microsoft, Qualcom, Sun and Symantec.

TRUST "represents the 'dream team' of information assurance and complex systems research," says Rep. Sherwood Boehlert, R-N.Y., chairman of the House Science Committee. Boehlert played a critical role in reinstating funding for the NSF Science and Technology Center program when it was expected to be cut.

ISIS is an internationally recognized research organization focused on advanced technologies for intelligent systems and software. The institute developed "Model-Integrated Computing," which facilitates synthesis and management of computer systems. The technique has been used to develop a variety of different technologies and solutions for industry and government, ranging from General Motors to the Defense Advanced Research Projects Agency.

ISIS is known for its research into embedded systems, which are computer controlled equipment found in household products such as microwaves, industrial equipment such as robotic manufacturing machines, and electronics equipment such as satellites and cell phones.

—Vivian Cooper-Capps

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— S. Shankar Sastry


STEVE GREEN

Senior Associate Dean Overholser

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It's Not Your Father's Engineering Education

Ever wonder what it would be like to study engineering today? Some things haven't changed all that much — engineering is still a combination of practicality, ingenuity and hard work. But our teaching faculty are doing lots of exciting new things, and Dean Galloway and I thought you might like to hear about a couple of them.

We have an excellent new first-year course designed to help students chose their major, to give them a sense of what it is like to be an engineer, and to teach a few basic skills they'll need later. Coordinated by Chris Rowe, director of first-year programs, this "modularized" course draws on


DANIEL DUBOIS

Adrian Lauf, BE'05, center, and his team designed a missile guidance system to transform Apache helicopter missiles into computer-guided precision weapons. It was their project for the Senior Design course, part of the school's innovative curriculum.

what learning scientists now know about how people learn. For the first third of the semester or so, students gather in sections of about 30 people under the guidance of a professor and learn basic computer skills and problem-solving skills. Then for the remaining portion of the term, they elect two disciplinary modules — say, in chemical engineering and then mechanical engineering — and work on projects with professors in those areas.

These projects are what our Peabody collaborators call "challenge based." In civil engineering, for example, the freshmen design skeletons of high-rise buildings, then put their designs on a shake table in the structures lab and simulate an earthquake in order to challenge their newly won practical understanding of tension, compression and shear forces. In the biomedical engineering module, the students are challenged with a real patient case, derived from the emergency department of Vanderbilt Hospital. They must postulate a pathology based on what they are learning about medical imaging (a great application of engineering, by the way).

Designing Seniors

The senior design course has changed a lot since most of us were in school. We now assemble interdisciplinary teams of students from biomedical, computer, electrical and mechanical engineering to work on yearlong design projects often derived from industry or the hospital. The originator of the project, sometimes an alumnus/a practitioner, may be involved from start to finish. The intellectual property stays with the "donor" of the project. Projects from last year included protective devices to minimize football injuries and improvements in potato chip containers for export. Directed by Professors Paul King, Don Kinser, Andy Dozier, Joel Barnett and others, the two-semester sequence also includes presentations on licensure, ethics, patents, and other practical matters important to the practicing engineer. We think we have a "real world" design sequence. If you would like to be involved, please let me know.

Engineering education at Vanderbilt is exciting. If you continue to be interested, in future columns I hope to report to you on the results of our recent polling of alums one and four years from graduation, discuss with you some of the challenges of globalization of engineering and how that should (or should not) affect what we do, and perhaps report on recent trends in engineering enrollment of women and under-represented minorities. Contact me at *k.a.overholser@vanderbilt.edu.*

—*Art Overholser,* Senior Associate Dean

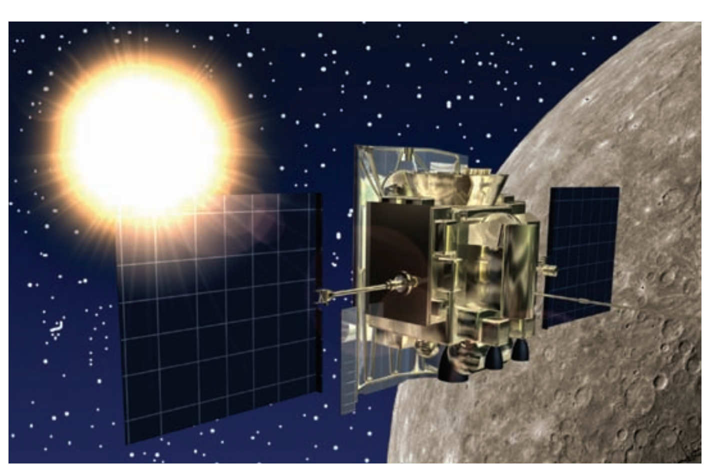
Air Force funds new research program

The School of Engineering has been selected to lead a new research program that focuses on the impact of radiation on continually shrinking electronic devices and new microelectronic materials—both in space and on the ground.

Known as the Multidisciplinary University Research Initiative (MURI) on Radiation Effects on Emerging Electronic Materials and Devices, the program includes engineers and scientists from Arizona State University, the University of Florida, the Georgia Institute of Technology, North Carolina State University and Rutgers University, in addition to Vanderbilt.

Ronald D. Schrimpf, Vanderbilt professor of electrical engineering and director of the Institute for Space and Defense Electronics (ISDE), is leading the new program. It will receive more than $1.1 million per year for three years from the Air Force Research Laboratory's Office of Scientific Research, with two additional renewal years possible.

"We have a very strong group of researchers participating in this program," says Schrimpf, "and we expect to generate fundamental research that will prove invaluable in the coming years of electronics development."



Established in 2003 by the Vanderbilt Radiation-Effects Group, ISDE is one of a few programs involved in microelectronics research for space applications.

This is the second MURI led by the School of Engineering. Vanderbilt engineers and physicists led an earlier five-year MURI program focusing on radiation-induced degradation of semiconductors.

—*Vivian Cooper-Capps*

Faculty Notes

Five engineering professors received the 2004-2005 Provost's Award for Innovation in Teaching and Learning with Technology: **Sean Brophy**, research assistant professor of biomedical engineering; **Anita Mahadevan-Jansen**, associate professor of biomedical engineering; **A.M. Mellor**, Centennial Professor of mechanical engineering, emeritus; **Christopher Rowe**, senior lecturer in engineering science, and **Greg Walker**, assistant professor of mechanical engineering.

The U.S. Nuclear Regulatory Commission has appointed **James H. Clarke**, professor of the practice of civil and environmental engineering, to its Advisory Committee on Nuclear Waste (ACNW). The ACNW advises the commission on how to regulate, manage and safely dispose of radioactive waste produced by nuclear power facilities and former nuclear weapons production facilities.

G. Kane Jennings, assistant professor of chemical engineering, received the University-wide Ellen Gregg Ingalls Award for Excellence in Classroom Teaching.

Professor of Mechanical Engineering **Alvin M. Strauss** chaired the Southeast Regional Space Grant Meeting, held in April 2005 at the Nashville Marriott Vanderbilt. The 11-state regional group is part of the National Space Grant College and Fellowship Program, supported by NASA to promote space and science education at all levels throughout the country. The Tennessee Space Grant Consortium, a member of the Southeast regional group, is based at Vanderbilt. It is directed by Strauss, who has been with the state consortium since it was founded in 1990.

Professors receive NSF awards

Two engineering professors recently won the prestigious National Science Foundation CAREER Awards, given to exceptional junior faculty to support their promising research.

T. John Koo, assistant professor of computer engineering, and **Mark D. Does**, assistant professor of biomedical engineering, will each receive $400,000 over five years.

Koo will use the award to support his efforts to pioneer a new science that will help engineers do a better job of designing the wide array of "smart devices" containing microchips that are spreading rapidly throughout modern society.

The marriage of digital processors and sensors with mechanical systems—what engineers call "embedded hybrid systems"—produces devices that are much more complex than the mechanical and electrical systems that they are replacing. In addition, hybrid systems interact with their environment and each other, adding yet another level of complexity. The net result is that more things can go wrong. As a consequence, hybrid systems are significantly more difficult to design and test.

That's where Koo comes in. To help provide a basis for this new science, Koo is combining two mathematical methods—"multiresolution analysis" and "level set methods"—to improve the design of hybrid systems. When combined, the two techniques should have the capability to predict how a hybrid system will perform under a wide variety of conditions.


DANIEL DUBOIS

John Koo works on a new science to help engineers produce better "smart devices" containing microchips that are spreading rapidly throughout modern society. He also is designing miniature, unmanned helicopters for use by the military.

Current simulation techniques can predict how a cell phone design, for example, will perform under specific combinations of important factors, such as heat, humidity, battery charge, signal strength and distortion. Koo's approach, by contrast, holds the promise of predicting how a design will work in all combinations of important variables, making it much easier to pinpoint situations where the design is most likely to fail.

"My hope is that the tools [I'm developing] will help us finally to realize the dream of safe and reliable autonomous control systems for cars and other vehicles, smart structures that can respond dynamically to earthquakes and severe storms and advanced biomedical devices."


DANIEL DUBOIS

Mark Does is working on improving MRI technology.

Does' research will help advance the application of MRI technology to more precisely analyze bodily tissues at the cellular level, particularly in the brain, spinal cord and heart. His work will help researchers get a better understanding of diseases such as multiple sclerosis.

MRI has proven to be one of the most effective non-invasive ways to see what is happening within the body.

"MRI was devised only 30 years ago," Does says, "and while it has become a mainstay in clinical radiology, it is rich in capabilities, and we are far from utilizing it to its full potential."

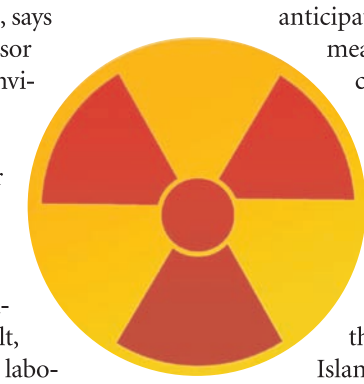
Does is one of the core members of the Vanderbilt University Institute of Imaging Science (VUIIS) and directs its Center for Small Animal Imaging.

According to the National Science Foundation, CAREER awards support exceptionally promising college and university junior faculty who are committed to the integration of research and education and are most likely to become the academic leaders of the 21st century.

Radiation experts investigate seafood safety

Some 40 years ago the United States conducted underground nuclear tests at Amchitka, one of the Aleutian Islands in Alaska. Now a study by researchers from seven universities has found that radioactive materials from those tests are not threatening seafood from that area.

Their finding is important for U.S. consumers because about one-third of fish sold commercially in this country comes from that region, says David S. Kosson, professor and chair of civil and environmental engineering.



Kosson directed the geophysical research for the independent study. He and Michael Stabin, assistant professor of radiology and radiological sciences at Vanderbilt, conducted much of the laboratory analysis. They found that the levels of radionuclides in the area are presently far below any human health food safety standard. Radionuclides are atoms that emit radiation and can accumulate in muscle tissue and bones.

"The results are very reassuring," says Kosson, "not only because approximately one-third of the fish sold commercially in the U.S. comes from the broader marine region affected by the area we studied, but because our evidence showed no indications of damage to the ecosystem in the area."

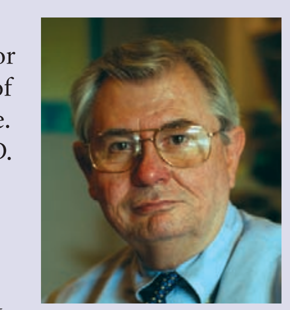
At the same time, Kosson cautions that the situation requires continued monitoring.

"Our remote sensing studies of the island's rock substructure show that any nuclear material from the nuclear test will actually take longer to travel through the substructure than we anticipated," Kosson says. "That means that the area should continue to be monitored well into the future."

The study was commissioned by the U.S. Department of Energy, along with the State of Alaska, the U.S. Fish and Wildlife Service and the Aleutian/Pribilof Islands Association. The research was planned and conducted by The Consortium for Risk Evaluation with Stakeholder Participation (CRESP), an independent university consortium. Their goal was to find out whether three tests of nuclear bombs exploded in Amchitka Island between 1965 and 1971 have resulted in dangerous levels of radioactivity in the fish and wildlife of the area.

—*Vivian Cooper-Capps*

Ask the Faculty



Thomas R. Harris is the Orrin Henry Ingram Distinguished Professor of Engineering, professor and chair of biomedical engineering, professor of chemical engineering, and professor of medicine. He received an M.D. from Vanderbilt and a Ph.D. in chemical engineering from Tulane University. He joined the Vanderbilt faculty in 1964.

Vanderbilt has made a commitment to "personalized medicine" as a research focus. What does that term mean, and how will it affect patients?

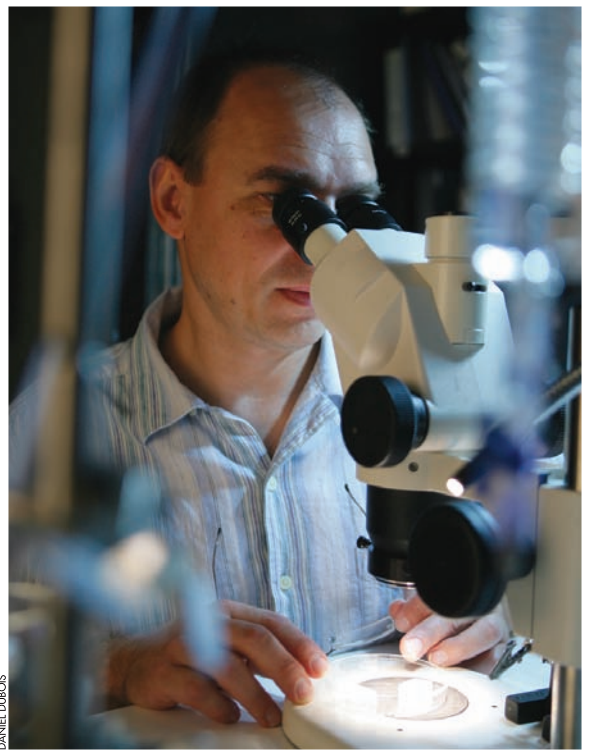
Personalized medicine refers to the potential that exists to use genetic information and other "biomarkers" to tailor therapy for a particular individual based on their biochemical and physiological state. It is hoped that the proliferation of information stemming from genetic analysis will allow the development of more effective and specific therapies, mainly, but not exclusively, pharmacological.

What role does engineering play in personalized medicine?

Biomedical engineering plays several roles in these developments. First, engineering methods and technologies have been and are continuing to improve the efficiency of analysis of basic biomarkers so that rapid characterization of an individual patient can occur. In particular, microarray technologies have significant promise for this application. Second, personalized medicine implies much more specific applications of therapeutic intervention and quantitative monitoring of response than has been needed before. The general area of biomedical engineering known as "technology-guided therapy" represents efforts to look at these issues and devise improved therapies and monitoring technologies based on imaging, lasers and other methods. Finally, the underlying premise of personalized medicine is that biomarkers will provide information that can be assimilated into a systems model of a particular patient. This requires significant knowledge of systems biology from the molecular level to the whole organism level. Biomedical engineering brings methods from complex systems analysis to help develop such an understanding of biological integration.

Vanderbilt Engineers Design Microscopic Laboratories for Cells

Picture yourself taking a micro-engineered needle and extracting immunity-protecting T-cells from your own body. Next imagine depositing them for a brief stay in a little cell spa, where drugs and toxins are waiting to give them a real workout. Now imagine injecting those boosted cells back into your body, where they can turn the tide in your personal battle against disease.



Franz Baudenbacher, assistant professor of biomedical engineering, is also co-director of VIIBRE.

You've just glimpsed the future of immunology.

It's a scenario that Vanderbilt engineers are working to create today through projects funded by the Vanderbilt Institute for Integrative Biosystems Research and Education (VIIBRE). One of Vanderbilt's transinstitutional initiatives, VIIBRE is home for a cluster of research projects being conducted by faculty and students from the School of Engineering working with biologists, chemists and others in the College of Arts and Science, Peabody College and the Medical Center.

The multidisciplinary teams are developing microscopic devices for monitoring cell behavior in situations such as cancer, blood vessel development, wound healing, and diseases that attack the immune system, says VIIBRE Director John Wikswo, Gordon A. Cain University Professor and professor of biomedical engineering. Wikswo's other titles suggest the breadth of VIIBRE research: A.B. Learned Professor of Living State Physics, professor of molecular physiology and biophysics, and professor of physics.

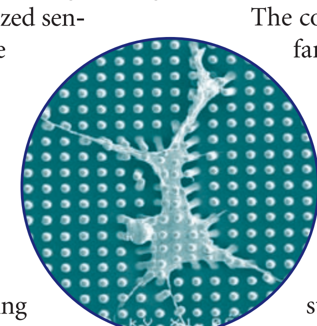
Cell sensors destined for labs and home use

Many of the devices the engineers are working on will likely be used by physicians to help determine suitable therapeutic drug regimens or by researchers studying how cells respond to new drug compounds that are still under investigation.

They are designing the smaller sensors, however, for at-home use by individuals, just as pregnancy kits and diabetes monitors are now commonly employed. Although smaller than 100 microns (a micron is 1/25,000 of an inch and a human hair is 70 microns), the devices can hold many cells extracted from the body. They're ideal for studying cells, safely removed from the human body, as they react to drugs and toxic substances and interact with other cells.

These microfluidic containers are based on an instrument called a "multianalyate microphysiometer," developed under the direction of David Cliffel, assistant professor of chemistry. This instrument contains sensors that can simultaneously measure concentrations of key chemicals that cells consume and excrete—oxygen, glucose and lactic acid—and monitor the health of thousands of cells confined in a small volume.

Vanderbilt engineering researchers, led by Franz Baudenbacher, assistant professor of biomedical engineering, developed miniaturized sensors so they could be incorporated into microfluidic devices and record rapid changes in the metabolism and signaling of a small number of cells. They did it by devising a method for molding micro-channels and valves in a silicone polymer similar to the kind used for soft contact lenses.



The sensors being designed by the Vanderbilt engineers will give scientists the capability to capture, manipulate, grow and study single living cells in tiny containers that are barely larger than the cells themselves.

VIIBRE researchers conduct nanoscale experiments in this "clean room."

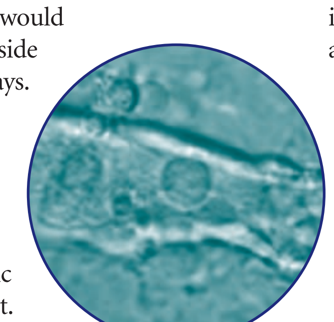
Last December, VIIBRE began collaborating with Pria Diagnostics LLC, a company that specializes in miniature medical diagnostic instruments. The company's best-known product so far is a handheld male fertility detector.

The company learned of the university's involvement in developing microfluidic devices when David Schaffer, MS'03, BE'00—then a Vanderbilt engineering graduate student—applied for a position with the California-based firm. Schaffer didn't go to work for Pria. Instead, as a VIIBRE project engineer, he now oversees a Vanderbilt-Pria partnership that aims to develop inexpensive devices that can rapidly detect the presence of infectious diseases.

Labs-on-chips simulate body's environment

In Baudenbacher's lab, faculty and graduate students are designing microfluidic devices to measure how cardiac myocytes (the muscle cells in the heart) release calcium from their internal stores and cause the cells to contract. These cells, marked with a fluorescent dye that signals changes in the amount of calcium they release, would be placed in a cell-sized, miniature detection system that circulates tiny amounts of a saline solution through microscopic channels, pumps and valves. The valves, formed of silicone and rubber, are fused to glass slides equipped with microelectrodes.

By replicating the cells' natural micro-environment, these labs on-a-chip will allow researchers to stimulate and study cells in a way that would be otherwise impossible to do outside the human body, Baudenbacher says.



In the case of a cancer, which may have different mutations, physicians could extract cancer cells from the patient's body and apply many different drug combinations to them in the microfluidic devices, at no danger to the patient. "You'd be able to customize therapy to a particular patient because you've understood how his or her cells respond," Baudenbacher says.

If a patient's immune system has been compromised by HIV/AIDS or an unknown biological agent, physicians could extract a small number of that person's T-cells and perform experiments on them in the microfluidic devices to determine which drug works best.

"A lot of external agents suppress the immune system," explains Shannon Faley, a biomedical engineering graduate student in Wikswo's lab. She's in a group that is studying how T-cells, the body's generals in the fight against threats, respond—and fail to respond. "Understanding how T-cells react to toxins gives us an idea of how they're designed, a method of toxin discrimination, and potentially how to adjust their responses," she says.

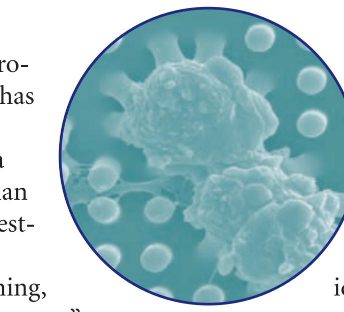
The challenge for engineers is to design ever-smaller containers that perform more tests on cells, without costing a fortune.

A biohazard detector in your pocket

Mark Stremler, assistant professor of mechanical engineering, is working with VIIBRE on a Department of Defense and NIH-funded project to develop a sensor system that could detect and identify the presence of dozens of dangerous substances in the environment. Soldiers in battle or first responders to a terrorist attack would use it to identify agents such as anthrax and ricin, or, more important, ones that were previously unknown. It could also help identify dangerous industrial chemicals released into the air following an accident or fire.

Stremler is working with Cliffel's lab to characterize how cultured cells respond to certain toxic substances in the microphysiometer. The researchers' aim is to identify the type of dangerous agent depending on how the cells respond to the substance.

With Baudenbacher's group, Stremler's team is also working to further miniaturize the microphysiometer, which has a testing chamber much smaller than a dime and thinner than a human hair. The testing chamber of the device they're designing, called a "nanophysiometer," would measure only 20 by 50 microns, with electrodes inside. A single cell's diameter is 10 microns.



"We could trap about two cells in each chamber and put a large number of chambers in the device," Stremler says. The group is also hoping to reduce the time it takes the sensor to read cell responses—from 50 seconds to less than one second.

An engineering approach to biological problems

The engineers conducting research for VIIBRE bring to the effort their analytical approach in tackling problems and their ease in crossing the boundaries of different specialties.

"The engineering approach is to break down the problem into well-defined segments linked to each other through a single variable, and then analyze and resolve each segment in a controlled manner," says Prasad Shastri, assistant professor of biomedical engineering and a polymer science specialist who is working on the microfluidic devices. "This analytical approach offers superior outcomes, as endpoints are well defined and we are able to elucidate the problem in a logical manner."

Shastri is developing strategies that combine materials engineering with knowledge gained from single-cell systems to drive large-scale organizations of cells into complex tissues, such as blood vessels, bone and nerves (please see related article on page 4). "By applying findings in a single-cell system, gained through microfluidics, to materials design, researchers can arrive at solutions such as a drug-delivery strategy to a diseased tissue," he says.

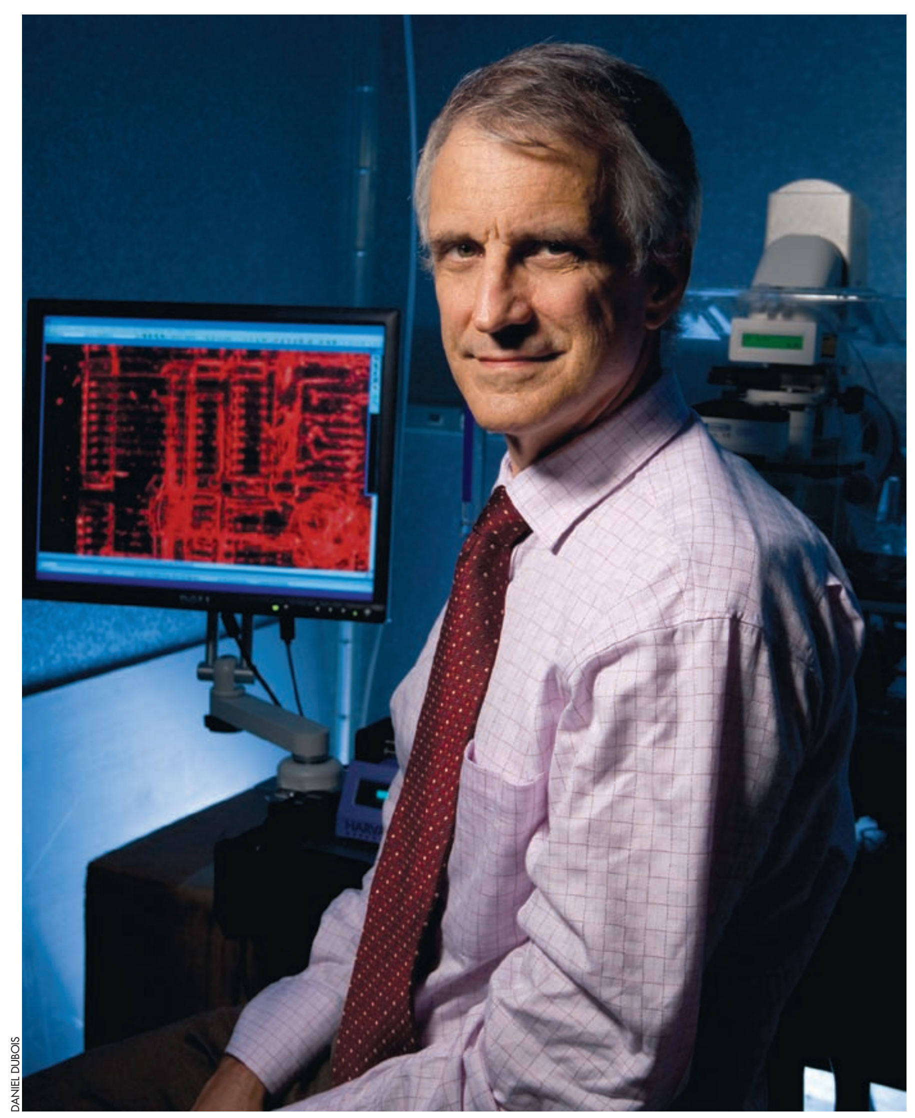
"A good scientist can also break down a problem," Faley says, "but the understanding that we engineers have of basic physical laws and engineering principles gives us a special insight when developing technology for biological applications. As biomedical engineers, we have a wide base of knowledge, which makes us flexible."

The VIIBRE engineers all bring a practical viewpoint to the tools they are helping to develop. "We're a very diverse group, working on many problems and leveraging one project off the others," Baudenbacher says. "You want to use the technologies you develop in multiple areas, because it takes so much time to develop them."

— Robert Ross

Teams are developing microscopic devices for monitoring cell behavior.

— Professor John Wikswo



Professor John Wikswo, VIIBRE director

Growing bone for grafts

An international team of biomedical engineers led by V. Prasad Shastri, assistant professor of biomedical engineering, has devised a new method of growing healthy new bone in one part of the body to repair damaged bone at a different location. The research, which is based on a dramatic departure from the current practice in tissue engineering, is described in a paper published online in July by the *Proceedings of the National Academy of Sciences.*

Assistant Professor V. Prasad Shastri and a team of researchers have developed a new method for growing bone for grafts.

"We have shown that we can grow predictable volumes of bone on demand," says Shastri, "and we did so by persuading the body to do what it already knows how to do."

"This research has important implications not only for engineering bone, but for engineering tissues of any kind," adds co-author Robert S. Langer, Institute Professor at the Massachusetts Institute of Technology and a pioneer in the field of tissue engineering.

The approach currently used by orthopedic surgeons to repair serious bone breaks is to remove small pieces of bone from a patient's rib or hip and fuse them to the broken bone. They use the same method to fuse spinal vertebrae to treat serious spinal injuries and back pain. Although this works well at the repair site, the removal operation is extremely painful and can produce serious complications.

The new method has been tested in animals. If it is confirmed in clinical studies with humans, it will be possible to grow new bone for all types of repairs instead of removing it from existing bones. For people with serious bone disease, it may even be possible to grow replacement bone at an early stage and freeze it so it can be used when it is needed, says Shastri.

For an interactive story about this ground-breaking research, please visit *Exploration*, Vanderbilt's online research journal, at *http://exploration.vanderbilt.edu.*

—David Salisbury

VIIBRE Engineering Faculty Fellows

A number of engineering faculty members are affiliated with the Vanderbilt Institute for Integrative Biosystems Research and Education (VIIBRE). They are listed below with their titles and research interests:

Ted Bapty, research assistant professor of electrical engineering and computer science; software integrated systems

Franz Baudenbacher, assistant professor of biomedical engineering and physics and VIIBRE co-director; biosensors, cellular electrophysiology, micro electrical mechanical systems (bioMEMS), and micro-biocalorimetry

Peter Cummings, John R. Hall Professor of Chemical Engineering; computational nanoscience

Ken Debelak, associate professor of chemical engineering; chemical reaction modeling

Todd Giorgio, associate professor of biomedical engineering and chemical engineering; intracellular regulation

John Gore, Chancellor's University Professor of radiology and radiological sciences, professor of biomedical engineering, molecular physiology and biophysics, and physics; MRI, CT, and PET imaging

Thomas R. Harris, Orrin Henry Ingram Distinguished Professor of Engineering, professor and chair of biomedical engineering; mass transport and bioengineering education

Rick Haselton, associate professor of biomedical engineering, microarray hybridization

Duco Jansen, associate professor of biomedical engineering; optical measurement of gene expression

Kane Jennings, assistant professor of chemical engineering; surface chemical engineering, on-chip photosynthesis

David Kosson, professor and chair of civil and environmental engineering; environmental remediation

Gene LeBoeuf, associate professor of civil and environmental engineering; transport/kinetics of pollutants, toxins

Deyu Li, assistant professor of mechanical engineering; self-assembled nanofilters

Michael Miga, assistant professor of biomedical engineering; computational modeling

Ales Prokop, research professor of chemical engineering; nanobiological devices

Robert J. Roselli, professor of biomedical engineering; biotransport and modeling

V. Prasad Shastri, assistant professor of biomedical engineering; biomaterials, tissue engineering, drug delivery and cellular targeting

Veniamin Sidorov, research assistant professor of biomedical engineering; cardiac biophysics and electrophysiology

Mark Stremler, assistant professor of mechanical engineering; microfluidic devices

John Wikswo, Gordon A. Cain University Professor, A.B. Learned Professor of Living State Physics, professor of biomedical engineering, molecular physiology and biophysics, and physics, and VIIBRE director; devices and models for instrumenting and controlling the single cell, cardiac electrophysiology

Students present marketing plans to corporate 'clients'

According to many employers, one of the most serious challenges they face when hiring graduating seniors from any college is the time it takes for the new employees to get up to speed before they can truly contribute to the business. As a frequent employer of Vanderbilt graduates put it, "The one-year traineeship is history. Starting employees must contribute from Day One."

On the other hand, when companies seek to launch new products or attack new markets, they may be in the dark on key questions, such as how strongly the market needs the product, how big the demand is, how much customers will pay for it, the best way to reach and persuade them, who the competitors are likely to be, and how they will react.

To address those twin challenges, John A. Bers, associate professor of the practice of management of technology, enlisted Nashville technology corporations as "clients" for teams of students in his "Technology Marketing" class.

The students worked on market analyses, value propositions for new product lines, pricing strategies, marketing communications and selling strategies for their companies. While learning the fundamentals of marketing in class, the students could also draw upon electronic resources of the Vanderbilt library system, which contain information otherwise not available to the companies, to learn about the clients' market environments.

The experience gave students a taste of "real world" application of textbook principles, Bers says. At the same time, the experience helped the students develop persistence, diplomacy and confidence.

The eight participating companies included two medical device manufacturers, four software developers, and two information technology services firms.

Most of the clients reported that the teams validated their initial marketing strategies or provided an extra measure of independent support that gave them greater confidence in the direction they were moving. But in three circumstances, the teams provided a strong case that a market the client had originally targeted would likely be a poor fit.

David Mottram, BE'05, explains his team's project strategy recommendations to Dallas Wilt, Axis Accounting CEO, while Daniel George. BE'05, looks on.

"By redirecting their clients toward more attractive, profitable markets, the teams potentially saved them thousands of dollars and months of misplaced effort," Bers says.

—Vivian Cooper-Capps

Imagine Cup *Vanderbilt students among top eight U.S. teams*

Two Vanderbilt engineering students finished among the top eight teams in the United States in Microsoft's Imagine Cup international competition last summer.

Nathan Alderson, a junior majoring in computer science, and John "Phil" Hunt, a senior in computer engineering, adapted a Microsoft computer game called "Project Hoshimi" as an project in distributed artificial intelligence for a computer science course.

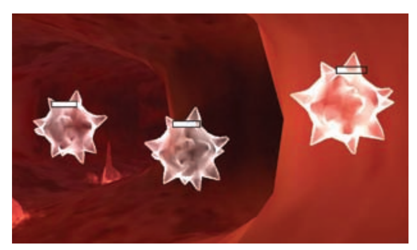
The Imagine Cup pits college teams from across the world in a head-to-head competition that tests their skills in software design and artificial intelligence. The top six international teams received cash awards and a trip to Yokohama, Japan.

"In late fall 2004, Nate and Phil asked if they could work on the competition for the computer science 'Projects in Artificial Intelligence' course," says Julie Adams, assistant professor of computer science. "It requires a semester-long project related to distributed artificial intelligence. The Imagine Cup required them to build a team of agents to solve the problem. It was a perfect fit."

The Vanderbilt team finished among the top eight teams in the U.S. They went on to compete against the best teams from each country in the third-round international competition, where they were eliminated.

"Needless to say, I had told them that if they made it to the third round they would receive an automatic A+ for that course," Adams says. "Of course, they would have received that grade anyway because they have done such good work on this project."

Hunt wrote the software for the team's project, while Alderson planned the strategy. Hunt has been a Microsoft Certified Professional software developer since he was 17. When he graduates in December, he plans to continue to work for Datavision Corporation, an information management company based in Columbia, Tenn. Alderson, who will graduate in May 2006, interned last summer with National Instruments in Austin, Texas.



Screen shot from the Vanderbilt team's Imagine Cup entry

Eggs Mark the Spot

In June, the School of Engineering hosted the Tennessee Louis Stokes Alliance for Minority Participation (TLSAMP) Summer Bridge Program, which helps prepare upcoming freshmen for their college careers.

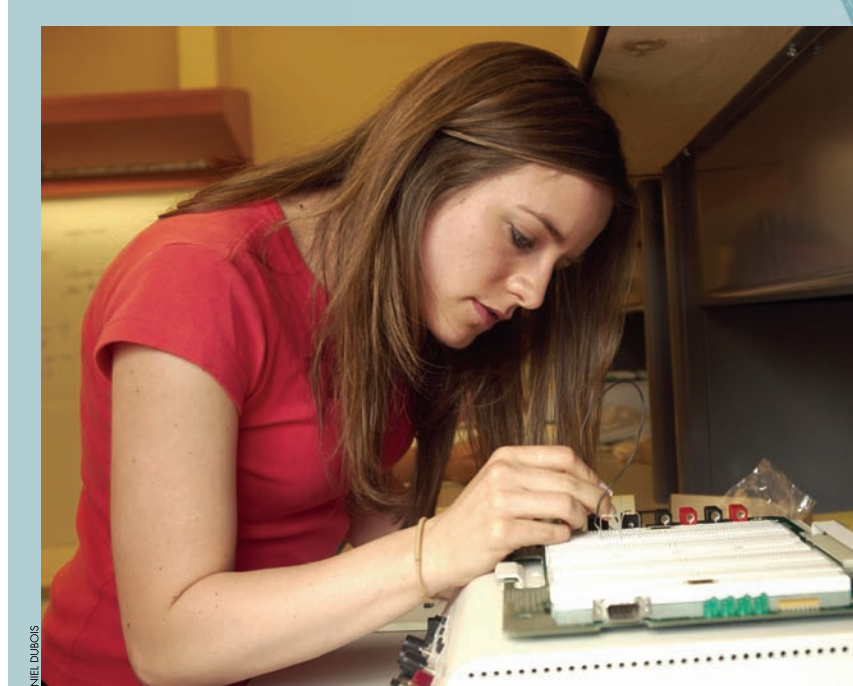
Some two-dozen entering students from Tennessee State University, Middle Tennessee State University, University of Memphis, University of Tennessee at Knoxville, and Vanderbilt participated in the bridge program.

In one of their activities, the students designed and tested egg-protecting packages by dropping them from a third-floor balcony in the Vanderbilt Stevenson Math building onto a bull's eye target in the courtyard below.

Funded by the National Science Foundation, TLSAMP was created to increase the number of underrepresented students in science, technology, engineering and mathematics.

Virtual Lab

Electrical engineering junior Vanessa Luckman tests her knowledge of circuit behavior with a National Instruments "virtual laboratory" system. Lason L. Watai, lecturer in E.E., combined this computer-supported instrumentation system with the Internet and learning methods developed by Peabody College to produce a "challenge-based" learning environment that replicates the engineering project/product development process.



Coming Full Circle

You might not find many engineering graduates among university presidents, says Harvill Eaton, but you should.

According to this university president, technology is driving the challenges facing higher education today.

"The students in this fall's entering class were born after the introduction of PCs," says Eaton, president of Cumberland University. "But 50 percent of the faculty are pre-PC. Changing the cultural climate in higher education to reflect the technological changes that have taken place in the world is a major challenge."

Founded in 1842 in Lebanon, Tenn., Cumberland is the oldest university in the Central South. "It is also the first college campus in the state to become fully wireless," says Eaton with pride.

A native of Nashville, Eaton received his B.S. and M.S. degrees in engineering science from Tennessee Technological University in Cookeville in 1970 and 1972. He then went on to earn his Ph.D. in materials science from Vanderbilt in 1976.

"It was the 'heyday' of materials science," recalls Eaton. "It was a wonderful department. Jim Wert was chair, a real mentor and leader. My advisor was Bob Bayuzick, and Bill Flanagan and Barry Lichter were my professors. The Vanderbilt faculty was exceptional. Their dedication and quality taught me what a faculty ought to be.

"I remember thinking, 'I am the luckiest guy in the world; this school has opened my eyes.'"

Eaton went on to distinction in the wider world. First, at Louisiana State University (LSU) where he rose from assistant professor of engineering to full professor. His 21-year career at LSU also included being associate dean for research and graduate studies in the College of Engineering, associate vice chancellor for research, and finally vice chancellor for research.

A desk that once belonged to Cordell Hull stands in the office of Cumberland University President Harvill Eaton, PhD'76. Hull—called the "Father of the United Nations"—was secretary of state in Franklin Roosevelt's administration and a Cumberland alumnus.

"I learned a lot at LSU," he says. "I learned to interact with the business world and with politicians at the state and federal level. My engineering education prepared me in ways no other education could have."

In 1997, Eaton left LSU to become vice president for research at Drexel University in Philadelphia. He was promoted to senior vice president for research and eventually to provost, the university's chief academic officer. He quadrupled the school's research funding and was involved in Drexel's merger with MCP Hahnemann University, which included the nation's fourth largest medical school.

Eaton came full circle in 2004, when he became president of Cumberland University. "I would not have believed it possible to return to Middle Tennessee," he says. "I'm truly blessed."

The father of two and grandfather of one, Eaton has been married for 36 years to Lois Acuff, whom he met during his freshman year at Tennessee Tech. "It was love at first sight," he says with a smile.

A ham radio operator and five-string banjo player in his spare time, Eaton also writes short stories and reads history for fun. He credits Vanderbilt with "allowing me to be a 'techie' in context, something a lot of engineering schools fail to do."

"Vanderbilt allowed me to experience the joy of learning, the excitement of discovery, and to appreciate the priceless value of a great university," he says. "My goal for Cumberland University is to shape lifetimes of opportunity for our students just as Vanderbilt did for me."

"I love Vanderbilt," he says with genuine feeling. "It is a national treasure."

— Joanne Beckham

Doing What Matters

It took an interview with the Big Man himself before Joe Linn finally said yes to Microsoft.

The company had been trying to hire him and his wife, Cathy Jo, for years, but they always found a reason to decline.

They said no in Dallas, where they had joined the faculty at Southern Methodist University after receiving their doctorates in computer science from Vanderbilt in 1980.

They said no five years later in Virginia, where they had moved to work for the Institute for Defense Analysis, a prestigious defense contractor.

"Virginia was good for raising kids, and we had two by then," Cathy Jo says. "We lived 15 minutes from work, and it was an eight-to-five kind of job with no 'administrivia.' Plus, we had just signed up for karate classes."

That's what they told Microsoft when they visited the company's Redmond, Wash., headquarters. Microsoft said fulfilling their needs would be no problem and even lined up a karate instructor for them.

So Joe flew back again, meeting first with Dave Cutler, the father of Windows NT, and then with the company's founder and CEO, Bill Gates.

"He made clear to me the benefit of coming to Microsoft," Joe says. "I would be working on technology that matters to everyone right now." It was an offer he couldn't refuse.

Doing something that matters is important to Joe Linn, the son of two physicians and Vanderbilt alumni, Robert and Joanne Linn, who saved lives and, as Vanderbilt faculty, taught others to do the same.

As software designers at Microsoft, he and Cathy Jo helped create two of the company's most important products—the CE handheld and Windows NT.

The need to be on the cutting edge comes naturally to the Linns, both BS'74, who met as undergraduates majoring in the fledgling field of computer science. Cathy Jo remembers long hours in the computer lab and Joe helping her with a bug in an interpreter, an alternative to a language translator. "I think he was more interested in the bug than me," she says with a laugh.

Their courtship continued over games of foosball in the Graduate Pub, which was open to them because Tennessee had just lowered the drinking age to 18 and their professors invited them in.

"Like the industry itself, the CS department was very small," Joe says. "The faculty showered attention on us and treated us like graduate students."

Later, when they taught at SMU and then at the University of Southwest Louisiana, they tried to replicate their experience, but the moment had vanished.

Years later, though, Microsoft offered them the next best thing—an exciting place where smart, intensely passionate people were shaping a new world. Sixteen-hour workdays came and went without notice.

After eight years of giving his "heart and soul" to the company, Joe retired in 1998, two years after Cathy Jo had. Both were still in their mid-40s.

In retirement, the Linns' days are as full as ever before. They run marathons, play soccer, take dancing lessons, and travel. Joe is trying to get good enough on his fiddle that they'll let him play at the Tractor Tavern in nearby Ballard, Wash.

Last November at their 30th class reunion, the couple found another way to do something that matters. They made a pledge to endow the Joe C. Thompson Scholarship in honor of Cathy Jo's father. The scholarship will attract students who might not otherwise be able to afford to go to Vanderbilt.

"It seemed like a natural way to show our appreciation for what Vanderbilt did for us and our children," Cathy Jo says. Their son, Garrett, earned a BS in biology and music in 2003, and daughter Katy will receive a bachelor's degree in computer science and math in 2007.

—Robert Ross

The Linn family band: Katy on drums, Cathy Jo on harmonica, Joe on fiddle, and Garrett at the piano.

CLASS ACT

Virtually Real

Music lover Clare McCabe might be one of the few people with Apple iTune accounts in two different countries.

Besides an interest in digital music, the U.K. native loves to read, likes to travel (she tries to get home to Bridlington, England, twice a year), and spends much of her free time working on the house she bought when she joined the Vanderbilt engineering faculty last year.

McCabe's professional passion is bringing the virtual world of molecular modeling into tighter register with the actual nano-world of real-life molecules. She's interested in how molecules operate at the nanoscale, because that's an area where neither classical theory nor quantum mechanics are sufficiently predictive.

"Theory is not always the same as reality," McCabe points out. "We're improving the theory to account for the discrepancy between theory and reality."

The assistant professor of chemical engineering received her Ph.D. from the University of Sheffield in England in 1999. She is particularly interested in accurately depicting the behavior of organic molecules whether they're in their fluid or vapor states of matter. And in the process of pinning these slippery states down, she's come up with new mathematical theories for other engineers and chemists to use in designing chemical processes that use hydrocarbons.

(As in "oil" and "polymers." Pretty significant players in the industrial world, not to mention being the building blocks for other organic compounds.)

McCabe is a key player herself, leading a team of researchers in refining computational molecular modeling techniques. She and others are working to understand molecular behavior better and to predict more accurately how large numbers of molecules will react to each other.

Computer simulation uses accurate approximations to make the interactions between the molecules simple enough to work with, and is one of the major driving forces behind the nanotechnology explosion. Without these techniques, new materials and devices may not be economical or feasible to produce, because in some cases the testing costs alone would be prohibitive.

"Experimental measurements can be very costly and time consuming," McCabe says. "Computer modeling and simulation are proving to be attractive and valuable means with which to fill in the gaps in experimental literature and obtain important information."

These techniques are particularly useful in determining how materials will behave at extreme conditions, such as very high pressures and temperatures. Understanding the microscopic basis for various properties is very valuable to engineers, because they can use this understanding to streamline the design of chemical processes and make these processes more manageable.

McCabe's National Science Foundation-funded research promises to make important contributions to the effort to understand fluid properties and dynamics, which are involved in everything from blood circulation and microfluidic channels in biosensors to computer chip production.

—Vivian Cooper-Capps

DANIEL DUBOIS

Digital music fan and Assistant Professor of Chemical Engineering Clare McCabe is working on new mathematical theories for other engineers and chemists to use in designing chemical processes that use hydrocarbons.

TECH TIME

Brad Jaeger prepares to test the student Formula racecar that he and fellow mechanical engineering majors designed and built from the ground up. The students, assisted by adviser Phil Davis, spent about 4,000 hours to complete the single-seat, open-wheel racecar. Built from lightweight chromoly tubing, aluminum and composites, it has a four-cycle, 610 cc engine and is specifically designed to protect the driver in a crash.

Vanderbilt students built their first Formula racecar in 2000, designing it with pencil and paper. Today they use Pro/ENGINEER design software. About a dozen students participating in this extracurricular activity design, fabricate, test, and enter the car in the demanding student Formula racecar competition each year. They also raise money to support the project. The next competition will be held in England in 2006.

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