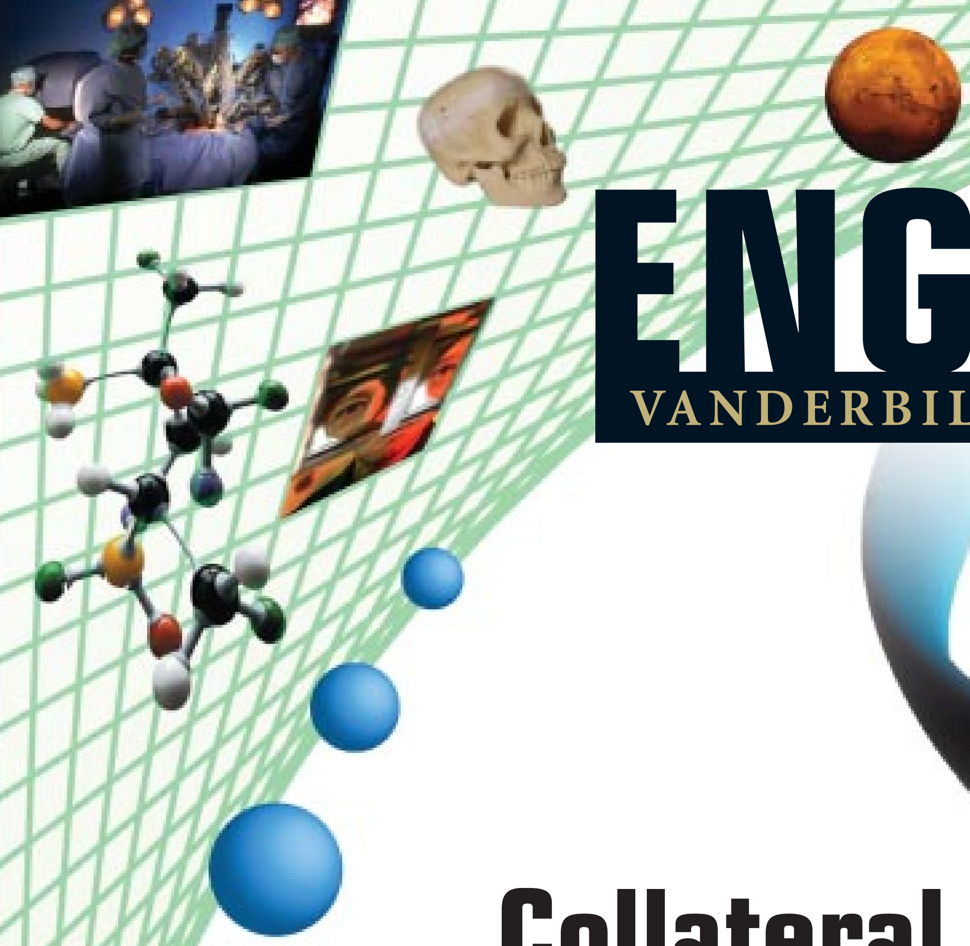

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ENGINEERING
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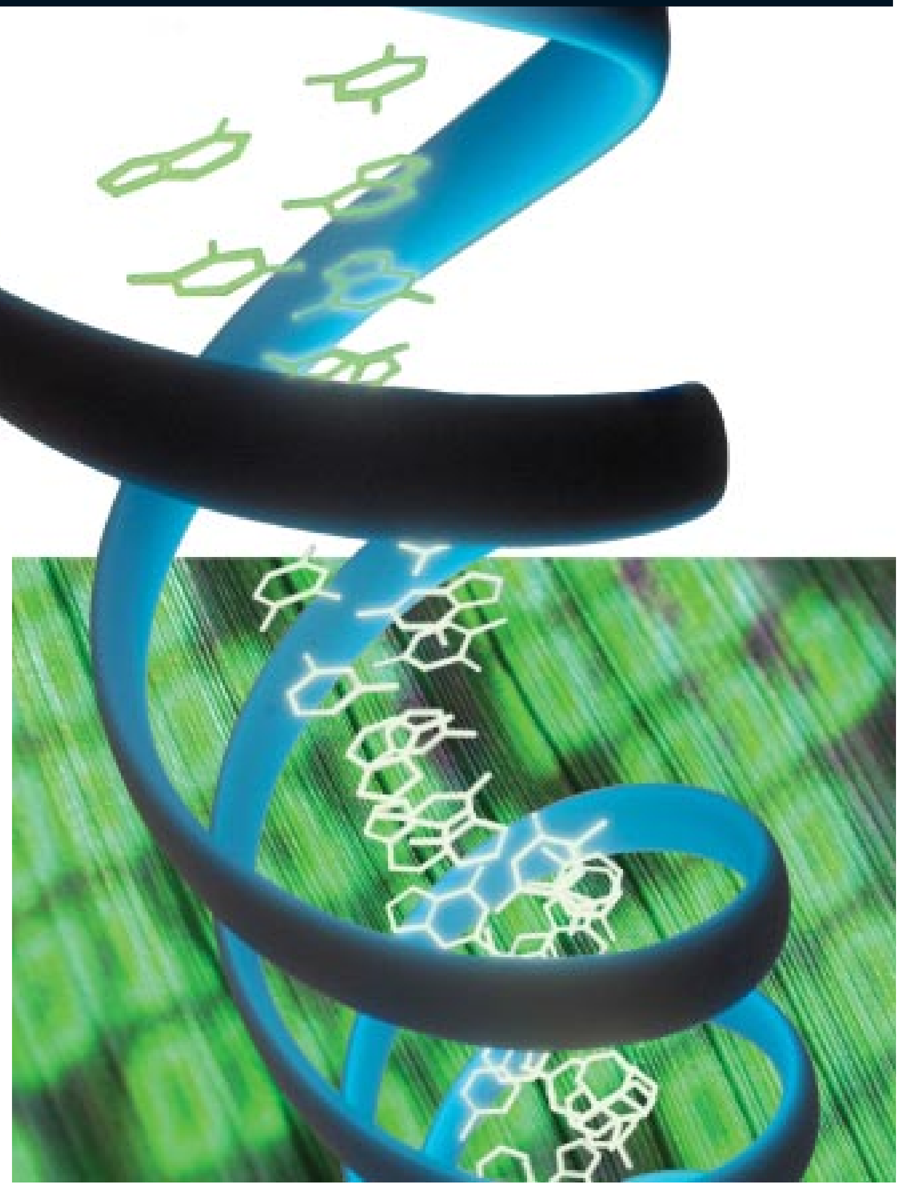
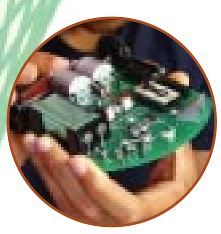


Collateral Damage

Biomedical Engineering Declares War on Medical Side Effects



IN THIS ISSUE

> "Technology-guided therapy is an outstanding example of the effectiveness of engineering in medical diagnosis and treatment."

Collateral damage—that's what the military calls it—the unfortunate, apparently inevitable, absolutely useless carnage that is part of war. In medicine, it's called side effects.

In a sense, the Department of Biomedical Engineering has declared war on collateral damage.

Think of it this way. Remember the first time a friend had arthroscopic surgery? In a few days, she was walking around, apparently with little trauma. The damage caused by the surgery itself—as opposed to the procedure performed once inside—was minimal. It seemed like a miracle. The biomedical engineering staff would like all medical procedures to be so free of side effects. It makes sense: Medical practice should affect only the diseased tissue, leaving healthy tissue and organs intact.

"Technology-guided therapy is an outstanding example of the effectiveness of engineering in medical diagnosis and treatment," says Thomas R. Harris, Orrin H. Ingram Distinguished Professor of Engineering and chair of the biomedical engineering department. "It illustrates the power of engineering ideas and technologies as a significant member of the health care team."

For example, take Robert Galloway, professor of biomedical engineering—and of surgery and neurosurgery. His optical device helps neurosurgeons "see" what they are doing. In brain surgery, a small error can cause a lot of unintended damage. CT scans reveal the blueprint of the brain, but surgeons may have difficulty locating exactly—the operative word—how the specific site in the brain relates to the scan.

"I was in the operating room and saw three board-certified neurosurgeons working with hand-held calculators, trying to locate the precise point of entry," Galloway says. "It was a clear case of people serving technology rather than the other way around." Galloway has designed a system that uses optical techniques to track the position of surgical tools on the CT scan or MRI.

On the operating room wall, a commercially available optical device "finds" the tool in space and then relates the tool to the images of the patient's brain. The brain, in turn, is located using four inserts (one more than is, strictly speaking, necessary) in the patient's skull, placed by the surgeon. Using those same four points, the software developed by Galloway's team rotates the CT scan on the screen and shows its relationship—within millimeters—to the surgeon's tool. Surgeons can guide themselves by looking on the screen, at the patient or both.

For surgeons, it's a big help, because a cancerous tumor, in real life, looks very similar to brain tissue, so the scan is used to define the edges of the tumor. Also, many cerebral procedures require great precision, like the current treatment for Parkinson's disease, in which a neurostimulator is placed at a specific node in the brain.

"The human eye can see in maybe 2 ¼ dimensions," says Galloway, "length, width, and a little bit of depth. But it can't see [through tissue to] the back of someone's head, and brain tissue is opaque. This device lets the surgeon know what's underneath."

The surgical guidance task is one of seven dimensions: three positional, three attitudinal and time. Galloway uses the analogy of a pilot bringing in a plane to land. "A pilot can be over the runway, but if he's upside down or flying backwards, it's not going to be a good landing." Yaw, pitch and roll are important in flying, and the angle of attack is important in surgery. Plus, there's the all-important issue of time.

Galloway compares his work to the "You are here" arrow on a shopping mall sign. "The sign has a map and a yellow arrow, showing where you are in relation to the map. Neither the map nor the arrow is good enough alone. You need the two together before it's helpful."

He is very generous in attributing the success of his work to his many coworkers on the faculty, both in his department and other engineering departments. Even more, he is especially kind to his graduate students: "They are the engine that drives this enterprise," he says.

According to Galloway, Vanderbilt's progress in this area is also due to a willingness of faculty and staff to forgo territorialism and cross departmental and school boundaries, with everybody adding their own particular expertise. As a result, it's not surprising that he, along with many of his engineering colleagues, is also listed on the faculty of the surgery department. Cooperation with the School of Medicine is at the very heart of this work.

To further the cross-departmental synergy, Galloway has formed the Technology Guided Surgery Office, which formalizes the unofficial collegiality that makes innovations possible. Because of such interdepartmental cooperation, Galloway says, "the patent portfolio developed at Vanderbilt in Technology Guided Surgery is unmatched in this country."

Instant Biopsies

Another engineering faculty member, Anita Mahadevan-Jansen, is also advancing the tools available to aid cancer surgery. She has developed a probe that will perform a tissue biopsy on the fly.

(continued on page 4)

DANIEL DUBOIS

Associate Dean David Bass

Campaign Gifts Shape the Future of VUSE

Every day, hundreds of people on the Vanderbilt campus are inventing what's next. Their innovations will help us better explore the vastness of the universe or the smallest dimensions of human cells, create engines that run better than anything we've ever seen while keeping the environment cleaner, let us live in outer space, and enable robots to perform critical tasks that once seemed impossible.

This work is all being done at the Vanderbilt School of Engineering. As alumni and friends, you know that the School of Engineering is unique. It is one of the nation's leading engineering programs in the midst of a great liberal arts and professional school environment. This unique community provides enormous opportunities for students to thrive and research to soar. Indeed, the school has galloped up the rankings in many areas over the past few years, and more and more students—undergraduate and graduate—vie for a chance to study with our talented faculty.

DAVID CRENSHAW

Bill Featheringill, BE'64

Last spring, Vanderbilt publicly launched its ambitious "Shape the Future" Campaign with a goal of $1.25 billion in new giving. This is the biggest philanthropic effort in the history of Vanderbilt, and it will enable the University to leap to the very highest levels of American higher education institutions. It is a campaign undertaken with the people of Vanderbilt who, indeed, do "shape the future."

The School of Engineering's goal for "Shape the Future" is $60 million. Reaching this goal will help provide the financial resources and endowment needed to compete with the nation's top tier engineering schools to bring together the most promising undergraduates, the best graduate students, and the most creative faculty. VUSE's Campaign Chairman William Featheringill, BE'64, and his campaign committee are working with Dean Ken Galloway, the faculty and staff to give every alumnus and friend of the school a chance to help. Already, committee members and others have made the renovation of Jacobs Hall and the construction of Featheringill Hall possible through early leadership gifts to the campaign.

All of the priorities of the "Shape the Future" Campaign are crucial to the School of Engineering's ultimate success. Most critical, however, is scholarship endowment. The cost of attending a private university of Vanderbilt's caliber is substantial, and the college choices of many talented young people are often balanced by the financial aid offered. If the School of Engineering is to continue attracting the best and brightest students, it must be able to offer more scholarship assistance. This need is true for attracting graduate students, as well as undergraduates. Fellowships for men and women who want to continue their engineering education are necessary for the school's continued growth as a community known for its innovation and ingenuity.

The School of Engineering's other vital need is faculty support, particularly endowed chairs. Our faculty is already dynamic and extraordinary. In the last five years alone, for example, they have produced a 70 percent increase in research activity. But, the school faces increased competition for both retaining and recruiting the best faculty from other institutions as well as from industry. Succeeding in this marketplace requires not only competitive salaries, but also the recognition and distinction that comes with endowed chairs.

Vanderbilt is a great place to get an engineering education, a place where faculty and students work and learn in an environment of innovation, technical excellence, and collaborative research. But, we face an increasingly tough field of competitors for the best students and faculty. Your generosity will help ensure that the School of Engineering continues its enormous progress. Every alumnus and friend of the School of Engineering will have an opportunity to participate in the "Shape the Future" Campaign. When you do so, your giving will help shape the future of a great school and its extraordinary people.

—David Bass,
Associate Dean for Development and Alumni Relations

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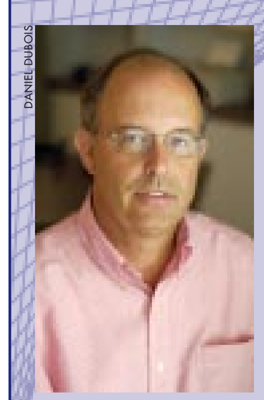
Ask the Faculty



DANIEL DUBOIS

Professor LeVan

From time to time, Vanderbilt Engineering will query faculty members on timely subjects. We welcome reader suggestions for future topics. We recently asked M. Douglas LeVan, Centennial Professor of Chemical Engineering and chair of the department, about the job market for Ch.E. graduates:

Q: How has the job market been for chemical engineering graduates during the past two or three years?

A: Because of the downturn in the economy, I'd say that it has been fair. Last May, about 75 percent of our students had job offers or had been accepted to graduate school by graduation. The year before, about 90 percent knew what they were going to be doing by Commencement. It's still a lot easier to find a job with an engineering degree than with another bachelor's degree, but the students have to work at it.

Q: Where are they working?

A: During the past three years, most of our graduates have gone to work for oil and energy-related companies, microelectronic companies, pharmaceutical companies and consulting firms. Another large group goes to graduate school at a number of good universities, including Vanderbilt, Georgia Tech, and the universities of Virginia, Michigan and Texas. A couple enrolled in law school at Harvard and American universities. A few have gone into the U.S. Navy, and several foreign students have returned to the Middle East to work for oil companies there. Our students have high expectations for their careers. They're looking for technical or managerial leadership opportunities.

Q: How do they go about finding jobs?

A: The best way is for them to work for a company in the summer after their sophomore and/or junior years. We work with the University placement office, and firms often contact me directly. Many of our alumni actively recruit Vanderbilt engineering students for summer internships and permanent jobs, and we appreciate their help very much.

Shape the Future: A Campaign for Vanderbilt

Campaign Priorities for the School of Engineering

Attracting the Best Students: Scholarships and Fellowships—$18 million

More resources for scholarships and fellowships will help ensure that the School of Engineering continues to attract exceptional students.

Recruiting and Retaining Top Faculty: Faculty Chairs and Support—$10 million

More faculty chairs and related support will allow the school to continue recruiting and retaining exceptional scholars, teachers and researchers.

Discovery Without Boundaries: Transinstitutional Initiatives—$8 million

The School of Engineering is essential to many of Vanderbilt's innovative transinstitutional endeavors that cross the traditional boundaries between schools and academic disciplines.

New Foundations: Facilities and Technology—$20 million

Leadership gifts to the campaign have already provided support for the renovation of Jacobs Hall and construction of Featheringill Hall with its more than 50 new teaching and research laboratories.

Growing Support: Annual Giving—$4 million

Annual gifts are vital to bridge the gap between expenses and revenues from tuition, research, endowment and other sources. These gifts help develop new programs and initiatives that would otherwise be impossible.

Bequests

There is no better way for alumni and friends to see that their commitment to the School of Engineering continues far into the future than by creating a legacy through a bequest.

Shape the Future

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Minority interns have fun while they learn during SIPHER

"Look! It has green lights that we can use to track it," says Bina Shah excitedly, pointing to the toy flying saucer that Edwin Vargas is attempting to pilot with a controller attached by a long black cord.

Shah is a senior from the University of Alabama at Birmingham majoring in computer science. Originally from Bogota, Columbia, Vargas is a senior at Middle Tennessee State University, where he is a double major in computer science and mathematics. They are among 11 undergraduate engineering and computer science majors from schools in the Southeastern United States who spent 10 weeks this summer at Vanderbilt as interns in the Summer Internship Program in Hybrid and Embedded Software Research (SIPHER).

"This was my first research experience, and I didn't know what to expect," says Shah. "It's turned out to be a lot more fun and a lot more useful than I expected. You can see possible uses for what we have done."

This was the inaugural year of SIPHER. The internship was organized by the School of Engineering's Institute for Software-Integrated Systems (ISIS) as part of a major five-year research grant from the National Science Foundation (NSF) that ISIS received along with partners at UC Berkeley and the University of Memphis.

DANIEL DUBOIS

Michael Rivera-Jackson with the parallax robot he programmed to detect upcoming collisions and avoid them.

The grant involves the development of "hybrid and embedded systems." These are the kinds of systems proliferating madly throughout modern society that integrate computers with other devices. They are found in cell phones, computers that control automobile engines, "smart" appliances and a variety of new medical instruments. The purpose of the internship is to expose members of under-represented minorities like Shah and Vargas to this important new technology.

"Despite the fact that we had a late start in sending out the announcements for the internship, we received 22 applications in only two weeks," says program coordinator Robert P. Boxie III, a recent Vanderbilt graduate with a double major in chemical engineering and music. The NSF grant supported seven of the interns who were selected. The other four were funded through a variety of other programs.

Two of the interns are seniors at Vanderbilt School of Engineering: Shantel Higgins, who is majoring in electrical engineering, and David Garcia, a computer science and mathematics major. Two others, Trione Vincent and Efosa Ojomo, are participants in the Fisk/Vanderbilt 3:2 engineering program. When the interns arrived early in June, they were divided into five teams and each was given a different project. Shah and Vargas teamed up with Vincent, a double major in computer science and computer engineering whose home is New Orleans. The three had the assignment of developing a video system that can track moving objects: first, a slow-moving toy blimp made of aluminized Mylar and second, a fast-moving flying saucer.

The other four teams were assigned similar projects:

- Garcia, Daniel Balasubramanian, and Rachel Dennison were tasked with programming Lego Mindstorm robots to travel from a known position to a known destination while avoiding objects placed in its path. Once they mastered this, they were given the additional task of programming the robot to find a second "lost" robot.
- Higgins and Ojomo teamed up to develop a "smart structure"—a beam equipped with sensors and actuators designed to keep it from vibrating.
- John Kirby took on the challenge of automating the old saying, "Teaching is the best way to learn." His challenge was to develop "teachable agents": Computer routines designed to act like students, which actual students then must instruct on a given subject so that the agents can pass a test.
- Nickolia Coombs and Michael Rivera-Jackson were given a small parallax robot. First they programmed it to detect upcoming collisions and avoid them. Second, they built a complicated maze out of cardboard and programmed the robot to find its way through the maze. Finally, they reprogrammed the robot to find a nearby light source.

Each of the teams was assigned a graduate student adviser. Tivadar Szemethy, a Ph.D. student in electrical engineering, worked with Shah, Vargas and Vincent. "It's very interesting to see how quickly the students began applying theory to real-life problems," says the Hungarian grad student. "The classroom problems that they are used to always have one right solution. But that isn't the case in real life. So they had to come to terms with the fact that there isn't one right solution, but a number of solutions, each with different pros and cons."

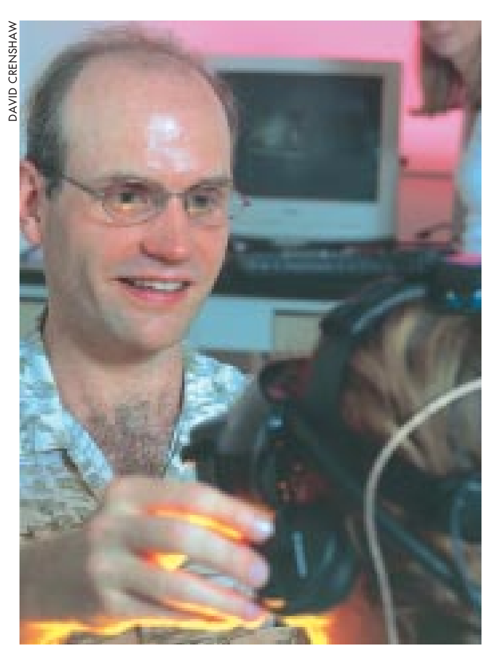
Szemethy's observation is echoed by Gabor Karsai, the associate professor of electrical engineering and computer science who directs the internship with the aid of Janos Sztipanovits, E. Bronson Ingram Distinguished Professor of Engineering and director of ISIS; Ken Frampton, assistant professor of mechanical engineering; and Gautam Biswas, associate professor of computer science.

"I have been impressed by the quality of the students. It's a very nice feeling to see them progress as far as they have," Karsai says.

"We're a really diverse group. We have people from Nigeria, India, Colombia, Hungary and Puerto Rico," Vincent says proudly. "We've learned a whole lot about each other's cultures."

—David F. Salisbury

Bodenheimer receives NSF award



DAVID CRENSHAW

Professor Bodenheimer adjusts a motion-sensing device on a student.

A Vanderbilt engineering professor has been recognized with one of the National Science Foundation's most prestigious awards for his high-tech exploration of an old maxim: The best way to learn a subject is to teach it.

Robert E. Bodenheimer, assistant professor of computer science, has received the NSF's Faculty Early CAREER Development Award to develop a program that reinforces and tests what a student has just learned by requiring the student to teach an animated character.

The national award, given to selected junior faculty for exceptionally promising research, includes $425,000 over five years to assist recipients in getting established and making major contributions in their field.

Bodenheimer's research involves developing animated characters called "teachable agents" to aid children in understanding and applying scientific and mathematical concepts. After children learn new scientific and mathematical concepts, they are asked to teach them to the animated agent. The character then attempts to apply what the student has taught it to solve some problems. If the character fails, the student delves further into the material, "teaches" the agent more facts and concepts and then puts the character through the challenge simulation again.

"People become active learners when they are teaching and instructing," Bodenheimer says. "Our job is to make the character as engaging and compelling as possible, to help motivate children of different ages to 'teach' the character to be successful in solving problems."

His research involves developing and assessing computer animation techniques that generate interactive movements and facial expressions that are lifelike. The project also will help teach Vanderbilt engineering students to understand better the mathematics of good animation.

Bodenheimer joined the Vanderbilt faculty in 2000, after a postdoctoral fellowship with the Animation Lab of the Georgia Institute of Technology in Atlanta. He received his bachelor's and master's degrees from the University of Tennessee and his doctoral degree from the California Institute of Technology.

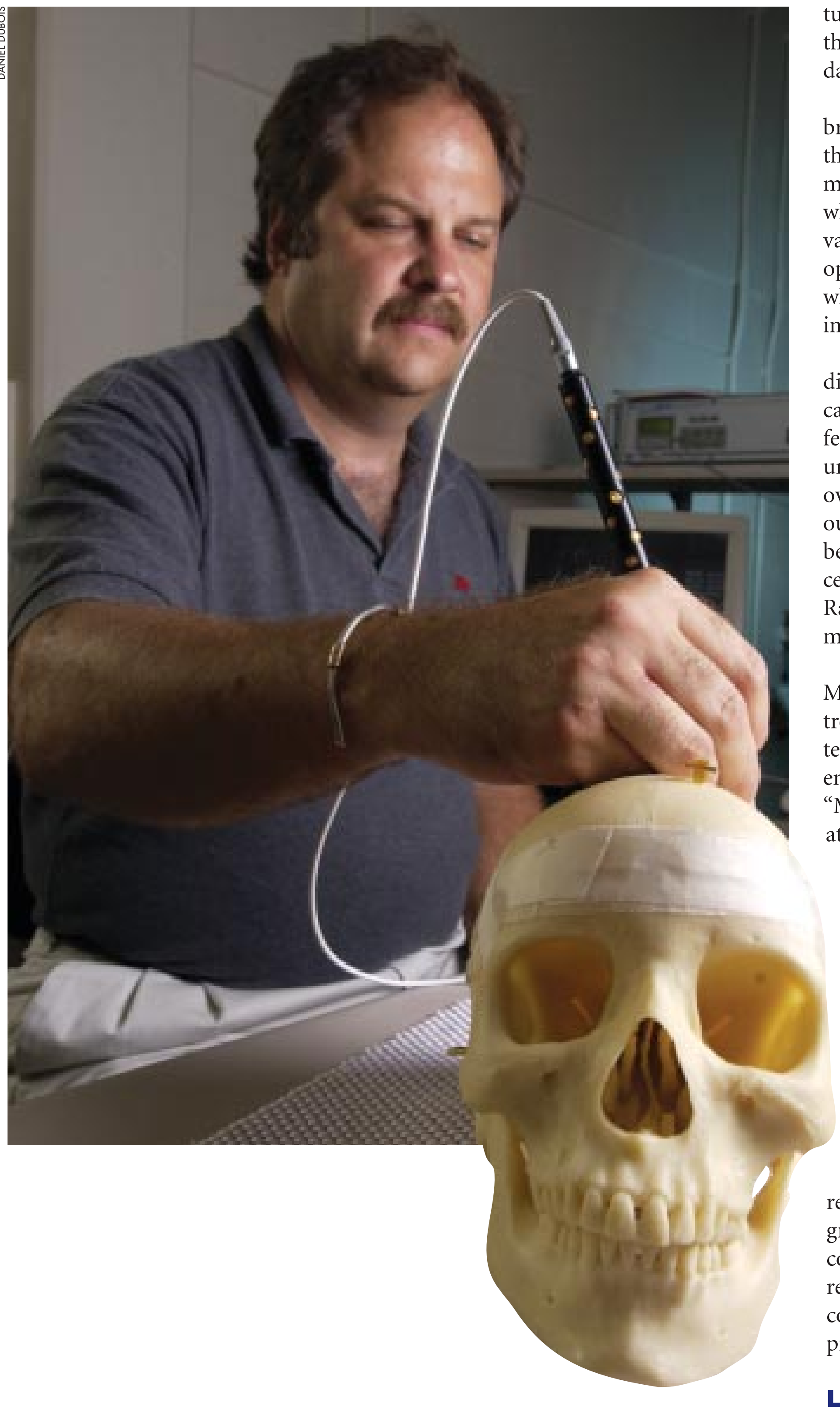
— From the Vanderbilt Register

Collateral Damage *(continued from page 1)*

Her device uses two light sources, each one delivered to the area under study by a slender fiber optic probe. The first uses broadband white light that is reflected out of the tissue in a scatter pattern that is read by an optical device. The second uses a nitrogen laser, which causes certain molecules in the body to fluoresce. "We use the reflectance data from the white light to account for blood and the fluorescence data to give us a sense of the biochemistry and morphology of the tissue," she says.

(below) Professor Galloway has designed a system that uses optical techniques to track the position of surgical tools used in brain surgery with CT or MRI scans.

DANIEL DUBOIS



The tissues are analyzed by comparing the reflection/scattering pattern of a given tissue with the known patterns of normal and cancerous tissue.

"Our brain research so far is very promising," says Mahadevan-Jansen, assistant professor of biomedical engineering. "The optical surgical guidance system we've developed has achieved nearly 100 percent accuracy in identifying the margins of brain tumors."

The system also has proven superior to even the experienced eye. "Several times our techniques indicated that the surgeon had not quite gotten the entire tumor, and the histological results of the laboratory proved that the optical data was correct," she notes.

Mahadevan-Jansen points out that brain matter has a mushy texture, so that opening a skull will cause a deformation in the shape of the tumor, which makes her device even more valuable. Her device is still in trials, operating behind a kind of "wall" in which the operator and surgeon make independent assessments.

Professor Mahadevan-Jansen uses a different optical technique to diagnose cancers of the ovaries and cervix. A different method is necessary because, unlike brain tumors, the cervix and ovaries may have healthy tissue, cancerous tissue, and tissue that is in-between. "We found that using fluorescence was not as accurate as using Raman Scattering; it produced too many false positives," she says.

To make the determination, Mahadevan-Jansen uses a form of spectroscopy called Raman Scattering. The technique measures the vibrational energies of the tissue's molecules. "Most photons enter and exit material at the same wavelength or energy level," she says. "But a small fraction of light emerges in directions other than the incoming beam, with greater or lesser energy than the initial light. We measure those frequency shifts and produce a pattern that is characteristic of particular molecular species."

Like the equipment used in the brain research, Raman Scattering equipment uses a laser light source, fiber to deliver the light and return data through a probe, a spectrograph to measure the data, a charge-coupled device camera to digitally record the data, and a computer to control the process and graphically present the results.

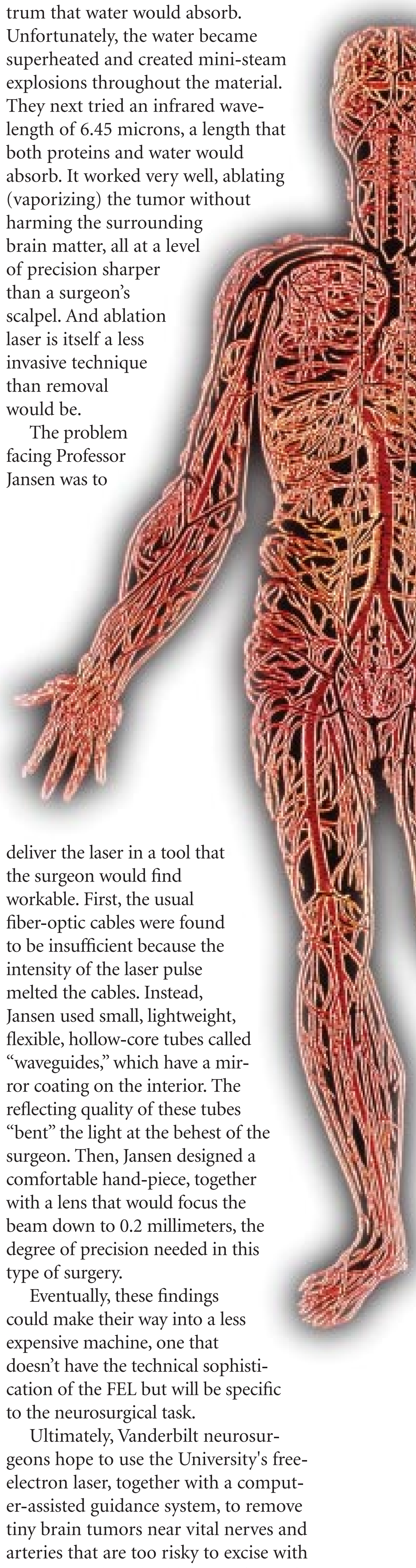
> "The optical surgical guidance system we've developed has achieved nearly 100 percent accuracy inidentifying the margins of brain tumors."

Lasers for Brain Surgery

For E. Duco Jansen, an assistant professor of biomedical engineering with a special interest in the relationship between lasers and human tissue, the Keck Free Electron Laser (FEL) was the principal draw to Vanderbilt. Unlike most lasers, the FEL is tunable—its wavelength can be adjusted, as can the duration of the pulses and their intensity. Plus, the Keck center, alone among the four FEL centers in the nation, has an in-house surgical suite, allowing the practice of surgical techniques—once they are deemed safe.

Of course, not just any laser light will do. Conventional lasers are finding growing applications in medical practice. Researchers have tried to use them for brain surgery in the past, but they largely abandoned the effort because the amount of collateral damage to surrounding tissue is too great. In neurosurgery a fraction of a millimeter can spell the difference between success and failure.

The point is to get a wavelength that will destroy a tumor without harming the rest of the brain. Using non-human brain material, Vanderbilt researchers first tried a part of the infrared spectrum that water would absorb. Unfortunately, the water became superheated and created mini-steam explosions throughout the material. They next tried an infrared wavelength of 6.45 microns, a length that both proteins and water would absorb. It worked very well, ablating (vaporizing) the tumor without harming the surrounding brain matter, all at a level of precision sharper than a surgeon's scalpel. And ablation laser is itself a less invasive technique than removal would be.



The problem facing Professor Jansen was to deliver the laser in a tool that the surgeon would find workable. First, the usual fiber-optic cables were found to be insufficient because the intensity of the laser pulse melted the cables. Instead, Jansen used small, lightweight, flexible, hollow-core tubes called "waveguides," which have a mirror coating on the interior. The reflecting quality of these tubes "bent" the light at the behest of the surgeon. Then, Jansen designed a comfortable hand-piece, together with a lens that would focus the beam down to 0.2 millimeters, the degree of precision needed in this type of surgery.

Eventually, these findings could make their way into a less expensive machine, one that doesn't have the technical sophistication of the FEL but will be specific to the neurosurgical task.

Ultimately, Vanderbilt neurosurgeons hope to use the University's free-electron laser, together with a computer-assisted guidance system, to remove tiny brain tumors near vital nerves and arteries that are too risky to excise with conventional medical lasers or by traditional brain surgery. Some of these applications will be based on the clean cutting of soft tissue. Other uses may include welding tissue to assist in wound healing, repairing nerves, reattaching retinas or monitoring neurological activity—applications where infrared light proves superior to other wavelengths.

Genetic Engineering

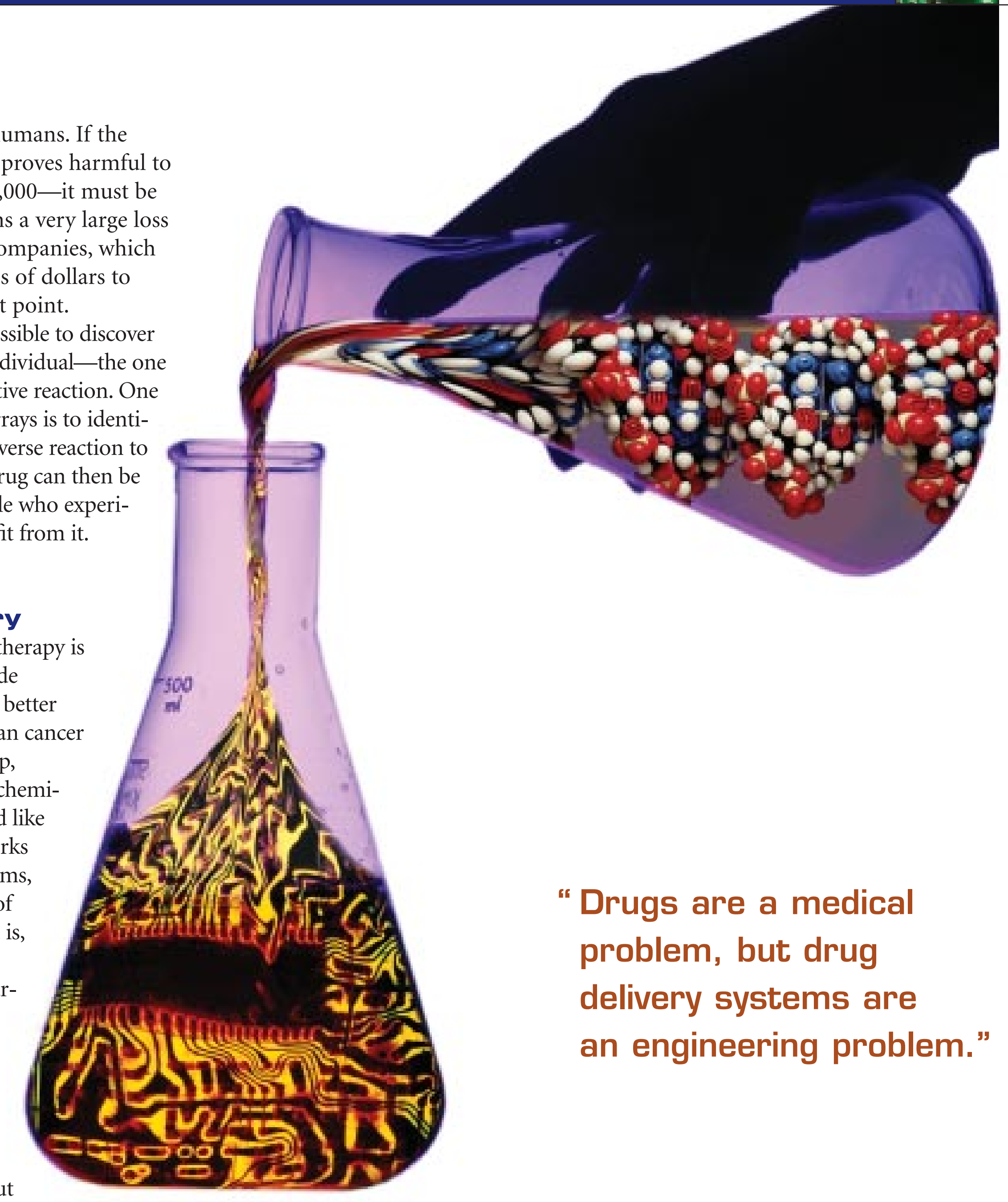
Perhaps the holy grail of non-invasive medical therapy will be better utilization of an individual's genetic pattern. Frederick R. Haselton, associate professor of biomedical engineering, is involved in one technology which might make that happen—DNA microarrays. This novel biotechnology is built around DNA "chips." Haselton, along with his graduate students and Vanderbilt colleagues, has developed several patented technologies for the production and application of these chips. With the assistance of Vanderbilt's Office of Technology Transfer and Enterprise Development, Haselton's group also started a biotechnology company, Microarrays, Inc., which is in the business of printing microarrays.

Cancer research is one of the many uses of DNA microarrays—Haselton's initial work was done in conjunction with collaborators from the Vanderbilt-Ingram Comprehensive Cancer Center.

Many scientists suspect that certain genes in an individual's DNA may be responsible for a particular cancer. Before the use of microarrays, researchers had to separately check each of 30,000 candidate genes to see if it might be involved. Now they can make discoveries investigating many more genes simultaneously. As a result, disease research can now be discovery driven—looking to see which genetic pathways are involved without knowing what they are in advance.

Microarrays may also revolutionize the way drugs are approved and used in the United States. As it now stands, a potential drug must go through extensive testing to prove that it is effective and not harmful to humans. If the drug fails—even if it proves harmful to only one patient in 1,000—it must be discarded. That means a very large loss for pharmaceutical companies, which have invested millions of dollars to bring the drug to that point.

Soon, it may be possible to discover why that particular individual—the one in 1,000—had a negative reaction. One of the uses of microarrays is to identify patients with an adverse reaction to a specific drug. The drug can then be given to the 999 people who experienced a positive benefit from it.



Nanotech Drug Delivery

Probably no medical therapy is more notorious for side effects—and riper for better therapeutic tools—than cancer treatment. Ales Prokop, research professor of chemical engineering, would like to change that. He works on drug delivery systems, using the techniques of nanotechnology. That is, he designs a molecule that will perform a particular function.

"Drugs are a medical problem," he says, "but drug delivery systems are an engineering problem." A drug exists that will cut off the growth of blood capillaries in a cancerous tumor, effectively killing it. The problem is to deliver the drug without affecting the rest of the body. Prokop constructs protein molecules specifically designed to bind to the tumor, molecules that are large enough to carry the drug, which was developed elsewhere. Because the drug is being delivered directly to the site of the tumor, it can be stronger than currently used chemotherapy potions, which course more or less randomly through the bloodstream causing the catastrophic side effects that we associate with chemotherapy today. The most difficult part of the process is keeping the molecules separate while building them. For this, Prokop uses his own proprietary technique, which he has patented.

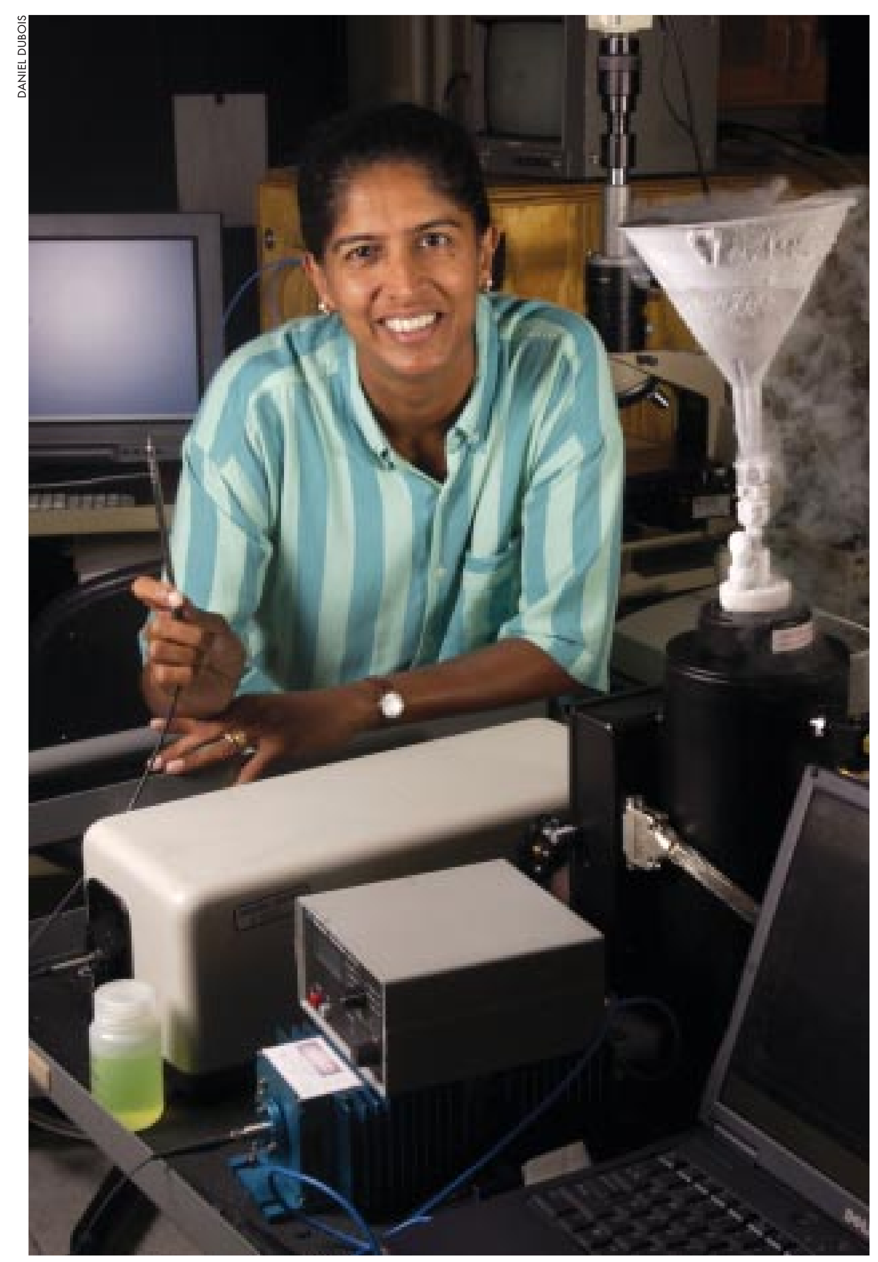
> "Drugs are a medical problem, but drug delivery systems are an engineering problem."

Throughout the stories of these breakthroughs, the theme is cooperation—between departments, with graduate students, and with the medical faculty. In fact, according to Chris McKinney, director of Technology Transfer and Enterprise Development, that is why the Vanderbilt School of Engineering list of patents stacks up so well against those of other schools.

It makes sense that engineering and medicine would be on the same page, because the two disciplines share the mission of making practical use of pure research. And in both fields, the goal is to cure the problem without creating new ones. No more collateral damage.

—Richard Daverman

DANIEL DUBOIS



(right) Professor Anita Mahadevan-Jansen has developed diagnostic and surgical probes that can distinguish healthy from cancerous tissue using laser techniques.

ALUMNI

Erika Brown Wagner Helps Lead "Mission Possible"

Erika Brown Wagner is a woman with a mission. Specifically, she's set her sights on Mars.

Wagner, who earned her B.E. in biomedical engineering at Vanderbilt in 2000, is now working on the Mars Gravity Biosatellite, an initiative being conducted by students from the Massachusetts Institute of Technology (MIT), the University of Washington and the University of Queensland in Australia. A Ph.D. candidate in the MIT/Harvard Joint Program in Health Sciences and Technology, she is also serving as science director for the biosatellite project, which is studying the effects of Martian gravity levels on the physiology of mammals.

Understanding about bone and muscle loss in environments with less gravity than Earth is one of the puzzles that currently occupies Wagner and her teammates.

"An 80-year-old woman with osteoporosis loses about 1 percent to 2 percent of her bone mass a year," she explains. "Astronauts floating in a space station lose that much every month. We want to understand how these bone-loss patterns may change during a mission to Mars." So the satellite, which the students are designing and hope to launch in 2005 or 2006, will carry a payload of mice into a low-earth orbit aboard a spacecraft with an artificial gravity identical to that on Mars (one-third the gravitational pull of Earth).

LAURA WULF

Erika Brown Wagner is studying the effects of Martian gravity levels on the physiology of mammals. The space-loving Vanderbilt graduate serves as science director of a project involved in a mission to Mars.

Wagner, a "die-hard" Vandy fan, also serves on the Engineering Alumni Council. As a member of the Commodore Career Connection, she drew two Vanderbilt engineering undergraduates into the space project last spring when she invited sophomore Brittany Guy and senior Payal Sehgal to extern with her in the MIT research laboratory during their spring break.

Born in Colorado and reared in Marietta, Ga., Wagner has always loved space and space travel. She got her first telescope at age five, and it wasn't many years before she was attending summer space camps at the Huntsville Space Center in Alabama.

Calling her college experience "fabulous," Wagner says, "I came to Vanderbilt with the idea that I would be an electrical engineer helping to build the rockets that would get people to Mars. I soon realized that I needed a little bit more of a human touch than that," says the avowed extrovert. Biomedical engineering was a way to do that, but "my real passion was space flight," she says.

While at Vanderbilt, she worked one summer with the aerospace industry in Huntsville and another summer at the Johnson Space Center in Houston. "To see an astronaut walk through the cafeteria just made my day," she recalls.

After beginning the master's program at MIT, she was chosen to spend a summer studying at the International Space University in Bremen, Germany, along with students from 30 other countries. It was there that she learned of the Mars project.

An independent thinker, Wagner is the kind of woman who might just wear her line-dancing boots beneath her white wedding gown—as indeed she did when she married VUSE alumnus Andy Wagner, BS'98, at a ceremony in the Canadian Rockies this past summer. The couple met while playing in Vandy's Spirit of Gold Marching Band; she played French horn, and he played the trumpet.

Now while her new husband builds airplane engines for General Electric, Erika Wagner explores space flight. "We have a lot of fun when we go to the Air and Space Museum on vacation," she says with a laugh. "He tells me stories in one half [of the museum], and I tell him stories in the other." These music-lovers also play in Boston's Beantown Brass Quintet.

To learn more about the Mars Gravity Project, visit www.marsgravity.org

— Judith DeMoss Campbell

Engineering's Best and Brightest of '03

Several engineering students have won national awards recently:

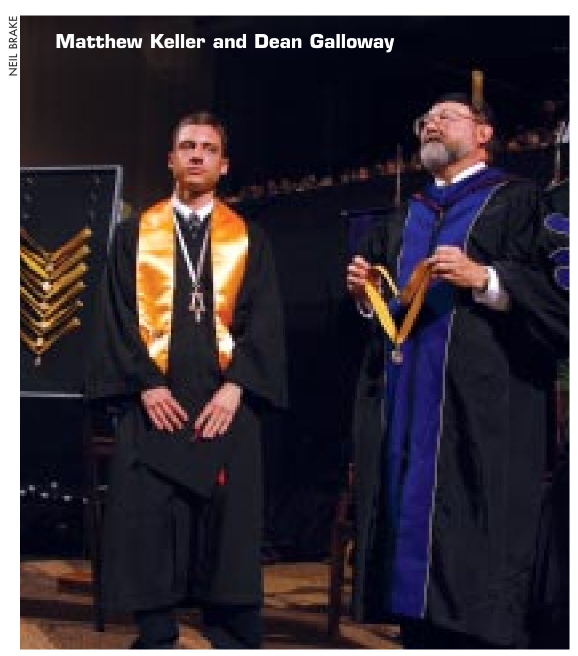
• Senior *Melanie R. Bernard* has been named one of only 38 national Tau Beta Pi scholars for the 2003-2004 academic year. Bernard, from Grand Rapids, Mich., is double-majoring in biomedical engineering and electrical engineering and will graduate next May. "I hope to enter the Vanderbilt Ph.D. program in biomedical engineering in the fall of 2004," she says. Dean Kenneth Galloway called Bernard "an exemplary engineering student who also possesses great strength of character."

• *Christina (Payne) Smith*, a graduate student in chemical engineering, has been awarded an extremely competitive U.S. Department of Energy fellowship. The Computational Science Graduate Fellowship, worth $28,000 a year, will enable Smith to study computer simulation of molecular activity in a variety of materials and fluids under the direction of Peter T. Cummings, John R. Hall Professor of Chemical Engineering at Vanderbilt. Cummings is considered one of the leading experts in the world in molecular simulation and computational nanoscience. Smith is from Ames, Iowa, and received her bachelor's degree from Tennessee Tech University.

• *Katherine Smothermon*, BE'03, of Dallas, Texas, was selected as the Chi Epsilon Cumberland District scholarship winner for 2002-2003. Smothermon was graduated summa cum laude in civil engineering in May.

• *Matthew David Keller*, BE'03, (right) received the School of Engineering Founder's Medal from Dean Galloway during Commencement exercises in May. The Bettendorf, Iowa, native is pursuing advanced studies at Vanderbilt in biomedical engineering, specifically biomedical optics, supported by a Howard Hughes Medical Institute pre-doctoral fellowship.

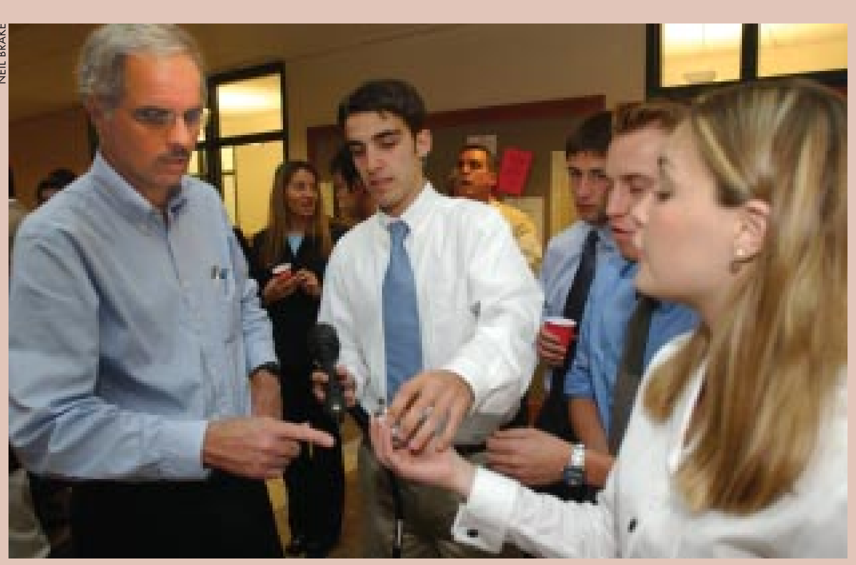
NEIL BRAKE



Matthew Keller and Dean Galloway

Designing Seniors

NEIL BRAKE



Students Travis Geisler and Rebecca Krefft show their metal coating applicator to Mechanical Engineering department chair, Professor Robert W. Pitz. Their prototype design improves the ergonomics, temperature control, and technical capacity of the original applicator used by their client, Carbinite Metal Coatings. The seniors, who graduated in May, participated in the Senior Design Project, showcased in Featheringill Hall this spring, that included seniors in the biomedical, electrical engineering and computer science, and mechanical engineering departments.

ALUMNI

Surgical Arts

Vanderbilt alumnus develops minimally invasive surgical system named after the original Renaissance man

Mike Tierney, BE'75, has played a major role in developing a new robotically-assisted surgical system that is so minimally invasive it has been likened to an auto mechanic fixing an engine without ever opening the hood.

The da Vinci® Surgical System has been cleared to perform complex heart, lung and urological procedures. The $1-million-per-unit da Vinci system allows the surgeon to sit at a console about 10 feet away from the patient and view an enhanced three-dimensional image of the surgical field provided by a camera. The camera can make a tiny 1.5 millimeter blood vessel look as big as a garden hose on the monitor.

The surgeon's fingers are placed into Velcro rings connected to two master controllers. As the surgeon's wrists and fingers move, the system's robotic arms move. The technology seamlessly translates the surgeon's movements into precise, real-time movements of the robotic arms, which are actually operating on the patient. The robotic system virtually eliminates natural hand tremors and improves dexterity to enable surgeons to do ever-finer surgery.

In conventional open-heart surgery, surgeons use a saw to cut through the sternum to create a foot-long incision. By contrast, the da Vinci system enables surgeons to perform closed-chest, open-heart surgery with robotic arms that are inserted into the chest via four holes about the width of a pencil. The instruments, only eight-tenths of a centimeter in diameter, slide easily between the ribs.

"My initial role was helping to define how such a system could meet so many challenging constraints—foremost of which was how to make the system safe to operate on humans. I later designed much of the electronics that control the movement of the arms," says Tierney, who stresses that the finished da Vinci system was the collaborative effort of a small engineering team and a physician.

Vanderbilt Medical Center surgeons are successfully using the system to perform prostate surgery. Joseph A. Smith Jr., William L. Bray Professor and chair of urologic surgery, performed the first robotic radical prostatectomy with the da Vinci system at Vanderbilt in May 2003. More than 50 men have undergone robotic prostatectomies here.

"The surgery is less painful and [results in] a shorter stay in the hospital," Smith says. "There's less bleeding, and patients are back to their normal activities more quickly.

Mike Tierney records data relating to a logic circuit he has designed in his lab notebook at Intuitive Surgical, Inc., where he played a key role in the development of the da Vinci Surgical System. He says the photo might send a useful message to engineering students that, "Yes, lab notebooks are important." At right, the daVinci viewer and controls for the robotic arms. Photos on this page taken from Intuitive Surgical, Inc., Web site.

"All of that is important, but most important is whether we will be able to improve on continence and potency," he continues. Impotence after prostate surgery is one of the major reasons men opt out of surgery for other means of treatment.

Courtesy of Uncle Sam

Tierney arrived at the School of Engineering after spending a tour of duty in Vietnam during the height of the war in 1969-70. Unable to afford college, he enlisted in the Marine Corps two weeks after his high school graduation in Brandywine, Md.

"I was stationed with the First Marine Air Wing on a forward air base at Quang Tri," he recalls. "The biggest scares were where the Vietcong would actually penetrate our perimeter and blow up aircraft and electronics with satchel charges. They would also lob 155 millimeter rockets from the hills into the air base…It wasn't very pleasant."

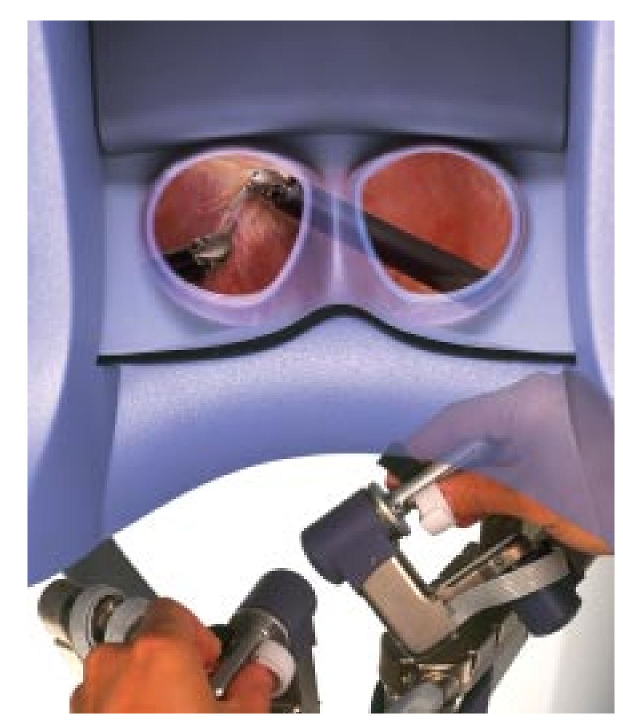
After his tour in Vietnam, Tierney was selected for a highly competitive Navy-Marine Corps scientific program for enlisted men designed to lead to an engineering degree. He won the mathematics award and had his choice of 21 universities to attend. He picked Vanderbilt because of its high academic credentials and its relatively high faculty-to-student ratio.

Tierney, who graduated summa cum laude in electrical engineering in three years, recalls Vanderbilt fondly. "I thoroughly enjoyed my time at Vanderbilt," he said. "Some of my professors were Ensign Johnson, Art Broderson and Dillard Jacobs."

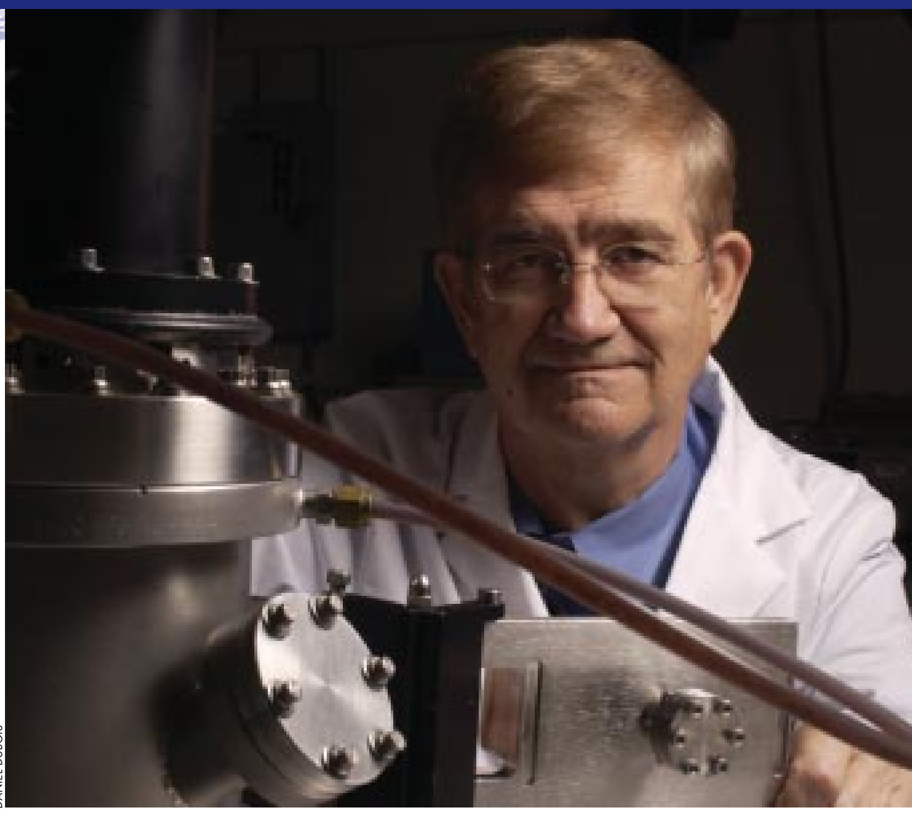
After graduation, Tierney spent five years as the engineering officer in charge of the electronic divisions aboard the *USS Seawolf* nuclear submarine. He resigned his commission in order to work in engineering design in the private sector. After earning his master's degree from Santa Clara University, Tierney spent the next 10 years in the design of medical ultrasound. In 1996, he became only the sixth employee hired by Intuitive Surgical, Inc., the company that developed the da Vinci system.

Looking back at his successful career, Tierney says he owes much of his success to both the Marines and his three years at Vanderbilt. "It was the best duty I ever had," he says of the time when his only military obligation was to attend school.

—Lew Harris



TOOL TIME



DANIEL DUBOIS

Layers of diamond are formed in this high-pressure microwave plasma-enhanced chemical vapor deposition machine. Professor Jim Davidson of the Department of Electrical Engineering and Computer Science places a process wafer in the reaction chamber. A carbon gas such as methane will be converted to diamond on the wafer's surface. The diamond film that grows will be used to make sensors or electronic devices that operate much better at more extreme conditions than current technology.

The Music Man

A Hindu professor and his Presbyterian wife bring classical Indian song and dance to Music City.

Officials from the armed forces and NASA, who fund Professor Sankaran Mahadevan's research in assessing the reliability of their rockets, ships and planes, might be surprised to learn that he has an artistic side as well.

A classical singer in the Carnatic (South Indian) tradition, Mahadevan is also a teacher and composer who has produced two albums of devotional music for the Sri Ganesha Hindu Temple in Nashville and its 1,000 families.

Professor "Maha," as he is called by his students, comes from a musical family: His father was a singer, as are his brothers and sisters. Although he grew up with devotional music in India, he lost interest in singing while a teenager. "I was hooked on cricket," he laughingly recalls.

After coming to the United States for graduate study, he became interested in traditional singing once again. While studying for his Ph.D. at Georgia Tech, he attended a lecture on Eastern spirituality in Atlanta, where he met Monica Cooley, the daughter of a Presbyterian missionary who was studying traditional Hindu dance. Their mutual interest in the Hindu arts grew into romance and marriage in 1991.

Mahadevan moved to Nashville in 1988, when he joined the civil and environmental engineering faculty. "It has been a very happy association," he says of his 15 years at Vanderbilt.

In 1992, Mahadevan and Cooley started the Kala Nivedanam School of South Indian Dance and Music in their home with four dance students. Today, they have 80 dance and 40 music students, the latter ranging in age from six to 60, half of them adults.

His students have performed in various venues, including singing with the Nashville Chamber Orchestra at the famed Ryman Auditorium. Recently, one of his vocal students, Padma Chunduru, BE'03, danced in the Nashville premiere at Langford Auditorium of the dance-drama "Megha Sandesha, the Cloud Messenger of Kalidasa," which Cooley produced. Two other dancers in the production also have ties to the School of Engineering: Meena Putatunda, a senior biomedical engineering student, and Snidgha Rathor, BE'98.

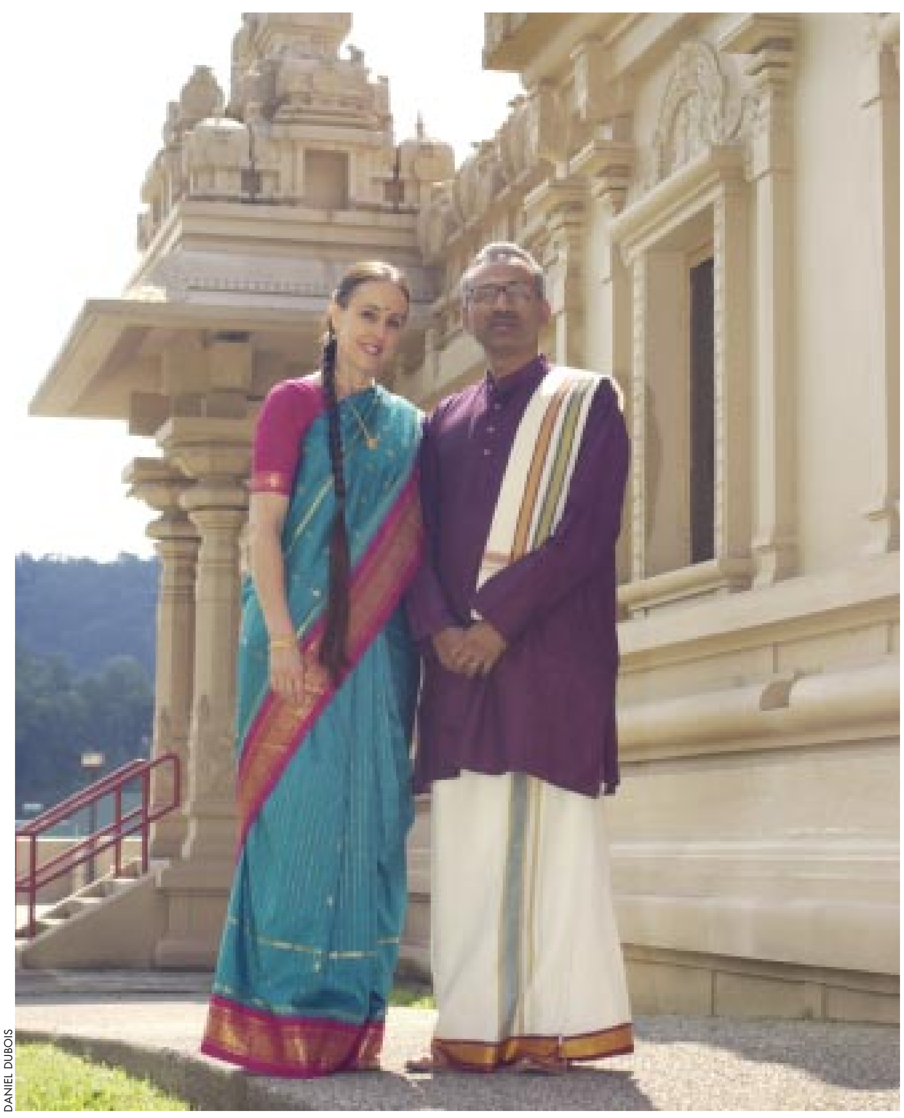
As the first engineer in his family, Mahadevan has long been interested in mathematics, specifically "how it impacts our everyday life and the equipment we use." After receiving his B.S. degree in civil and environmental engineering from the Indian Institute of Technology, he worked in India for several years. During that time, he says, "I realized that what I really enjoyed was research and teaching."

He decided to pursue graduate study in the United States, "because of its cutting-edge education and research." While earning an M.S. degree from Rensselaer Polytechnic Institute in Troy, N.Y., an interest in building structures that could withstand earthquakes led him to the study of risk and reliability of complicated systems.

As director of the Integrative Graduate Education, Research, and Training Program (IGERT), a National Science Foundation-funded, multidisciplinary program at Vanderbilt, Mahadevan applies reliability concepts early in the design of large, complex systems like the next-generation space shuttle and its solid rocket boosters. He and his students are working on projects for government agencies such as the U.S. Air Force, U.S. Department of Energy, Federal Highway Administration and NASA, and companies such as General Motors, DaimlerChrysler, Federal Express and Union Pacific Railroad.

Last year, Professor Mahadevan's work was recognized by the Society of Automotive Engineers, who presented him with the international 2002 Distinguished Probabilistic Methods Educator Award, the youngest person ever to be so honored.

—Joanne Beckham



DANIEL DUBOIS

Professor Sankaran Mahadevan and his wife, Monica Cooley, outside Nashville's Hindu Temple. They teach classical Indian music and dance to 120 students throughout the Mid-South.

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