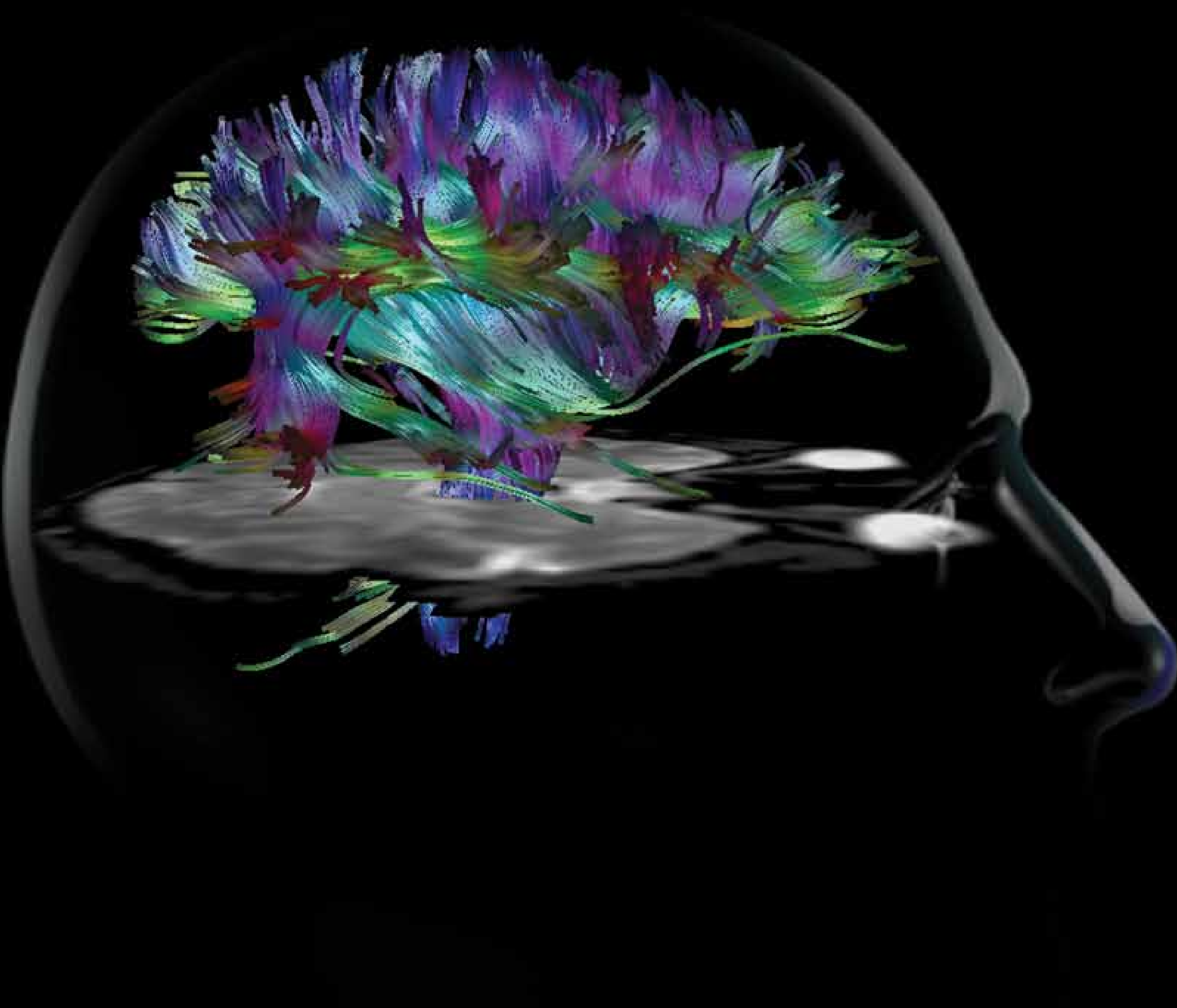
Vanderbilt engineering

Fall 2010



The Infinite to the Finite

Vanderbilt researchers imagine the future of imaging science

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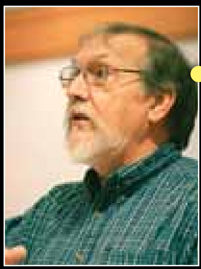
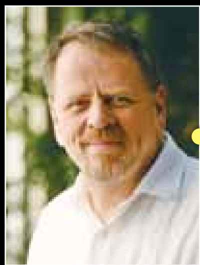
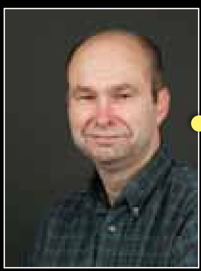
honors and awards



A.B. Bonds, professor of electrical engineering and associate chair of electrical engineering and computer science, received the Edward J. White Engineering Faculty Award for Excellence in Service for his 30 years exemplary service to the School of Engineering.



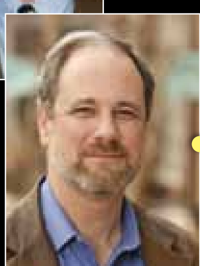
Peter Cummings, John R. Hall Professor of Chemical Engineering, is the 2010 recipient of the AIChE Founders Award, the highest honor bestowed by the American Institute of Chemical Engineers. He was honored for outstanding contributions to the field of chemical engineering and achievements that advance the profession.



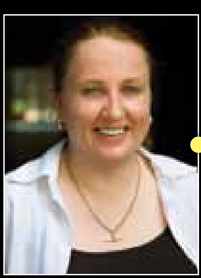
Douglas H. Fisher, associate professor of computer science and computer engineering, received a Director's Award for Program Management Excellence from the National Science Foundation. Fisher served three years as a program director at the NSF's Directorate for Computer and Information Science and Engineering before returning to VUSE this fall.

Haoxiang Luo, assistant professor of mechanical engineering, was awarded a National Science Foundation Faculty Early Career Development (CAREER) Award in the area of fluid dynamics. He will research computational modeling of insect flight and how it might inform the development of micro air vehicles.

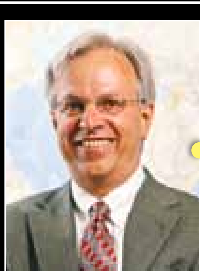
Biomedical engineering professors **E. Duco Jansen** and **Anita Mahadevan-Jansen** were named fellows of the International Photonic Science and Engineering Society (SPIE). This is only the second time in the society's history that a husband and wife have been honored as fellows simultaneously.



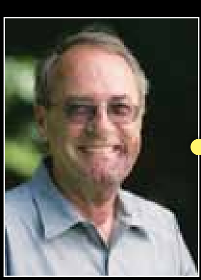
David Kosson, professor and chair of civil and environmental engineering, received Vanderbilt's Joe B. Wyatt Distinguished University Professor Award, given for the development of significant new knowledge from research or exemplary innovations in teaching. The award conveys the title for one year.



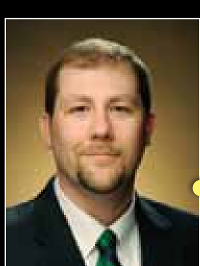
Clare McCabe, associate professor of chemical and biomolecular engineering, received the school's Excellence in Teaching Award, given to a faculty member who makes significant contributions to excellence in undergraduate or graduate instruction during the academic year.



Peter Pintauro, H. Eugene McBrayer Professor of Chemical Engineering and chair of chemical and biomolecular engineering, has been elected a fellow of the Electrochemical Society.



Janos Sztipanovits, E. Bronson Ingram Distinguished Professor of Engineering, professor of electrical engineering and computer engineering, and director of the Institute for Software Integrated Systems, was elected an external member of the Hungarian Academy of Sciences, Engineering Sciences Section. The honor is for eminent Hungarian scholars who live outside Hungary.



Jamey Young, assistant professor of chemical and biomolecular engineering, received a National Science Foundation Early Career Development (CAREER) Award. The grant will support research into the mechanisms by which saturated fatty acids induce metabolic dysfunction and cell death in liver tissues.

Vanderbilt engineering

On the cover: A diffusion tensor image illuminates white matter, hundreds of long fibers — axons — which transmit signals between different parts of the brain. The gray is an MRI slice. Such MRI images could be used to help surgeons remove brain tumors without damaging axons. Illustration by Dominic Doyle, image courtesy of VUIIS.

INSIGHT ◦ INNOVATION ◦ IMPACT℠

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Engineering Is Critical to the Country's Economic Recovery

> "The financial crisis that began in 2008 is a stark demonstration that we as a nation take great risks when we build too much of our economy on a base that does not create real value. Relying on vaporous transactions to generate wealth is no substitute for making real products and providing real services. In the 21st century, the United States and the rest of the world will face some of the greatest challenges of the modern age: feeding a growing population, generating adequate energy without destroying the environment, countering chronic and emerging infectious diseases. The first decade of the new century has shown that technological innovation is essential for the United States and other countries to meet these challenges."
>
> *Rebuilding a Real Economy — Unleashing Engineering Innovation*
>
> National Academy of Engineering, 2010

Engineers are, and will be, critical contributors to any sustainable economic upturn. They invent, they design, they turn new ideas into marketable products.

The NAE's 14 *Grand Challenges* have been broadcast across the engineering community for more than two years now. There is evidence that some of the challenges — energy, sustainability, health care and the environment — are influencing a national roadmap to economic growth and recovery. Some of these collective goals include increasing production of alternative energy, expanding broadband technology across the country, and computerizing the health care system.

DANIEL DUBOIS

Dean Galloway

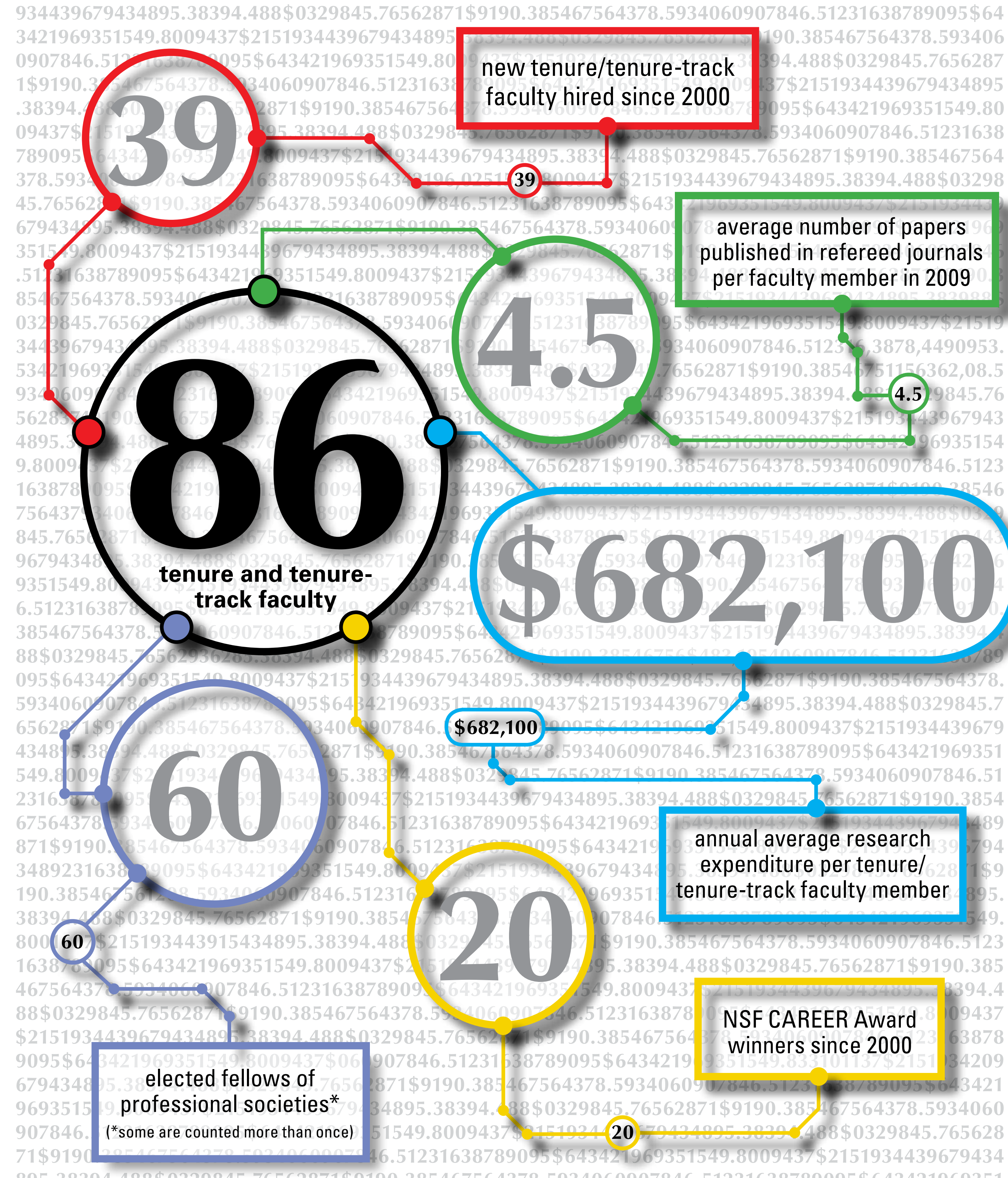
As dean of a research-extensive engineering school, I am encouraged by the role of engineers in supporting sustained economic recovery in America and globally. Our progress can be anticipated and encouraged by academic research and corporate and government R&D. As I critically examine School of Engineering research activities, I believe we are doing our part to contribute to innovative discovery while educating the next cohort of engineers. Our four strategic research areas are well-aligned with the core talents of our faculty and the requirements for a recovering economy: health care, information systems, defense and national security, and energy and the environment.

The articles in this edition of *Vanderbilt Engineering* illustrate our research culture, which has always been one of purposeful accomplishment — focused on important problems. For instance, in the cover story you will read about advances in health care by Vanderbilt's world-class imaging institute, as well as the engineers and physicians working with each other to make diagnostic technologies more accessible. Other articles feature an alumnus working in cybersecurity as it relates to national security and another alumnus leading the rebuilding of an engineering icon in the automotive industry.

You'll also learn of faculty engaging in multi-institutional research that will better secure electronic medical records, plus two of our young faculty members who have won prestigious NSF-CAREER Awards for their respective research in metabolic engineering and microfluidics. You will also read about the stellar accomplishments of our students who are consistently recipients of prestigious scholarships and national recognition for their research contributions.

The School of Engineering is working tirelessly to provide opportunities for young engineers. The number of our students participating in engineering-specific study abroad programs is double the national average, and the student interest in on-campus research is very high. We equip students with knowledge and a solid set of skills so that after they leave our classrooms, our labs and our campus, they are prepared to become contributors to a sustainable economic upturn — as engineers have throughout history.

Kenneth F. Galloway
Dean



National Center for Health Care Security Relies on Vanderbilt Team

A new national center established to secure the privacy of electronic health information will rely on experience and work from Vanderbilt engineers and medical researchers.

DANIEL DUBOIS

Janos Sztipanovits

The U.S. Department of Health and Human Services recently announced the creation of a new center for health information and privacy. The SHARPS center will focus on three specific subjects: electronic health records, health information exchanges and telemedicine. The center will be housed at the University of Illinois, and experts from universities across the country will handle different areas of research.

Vanderbilt's participation in the center shows that the university has become highly visible in the field of health care security and privacy, says **Janos Sztipanovits**, E. Bronson Ingram Distinguished Professor and director of the Institute for Software Integrated Systems (ISIS) at Vanderbilt's School of Engineering.

Sztipanovits; Mark Frisse, Accenture Professor of Biomedical Informatics at the Vanderbilt University Medical Center; and Edward Shultz, MD, director of information technology integration at VUMC; head up the joint Vanderbilt team. William Stead, VUMC's chief strategy and information officer, will serve as one of the center's two chief scientists.

One of Vanderbilt's unique contributions is the close partnership it has established between its engineers and clinical researchers. The Medical Center has a 15-year track record in the development of electronic health care records. ISIS contributes a structured approach to data security and extensive software tools that it developed to protect sensitive data for the Department of Defense.

The ability to combine engineering and medical skills and apply them to health care will assist Vanderbilt in identifying barriers to the adoption of information technology and in developing solutions for its use.

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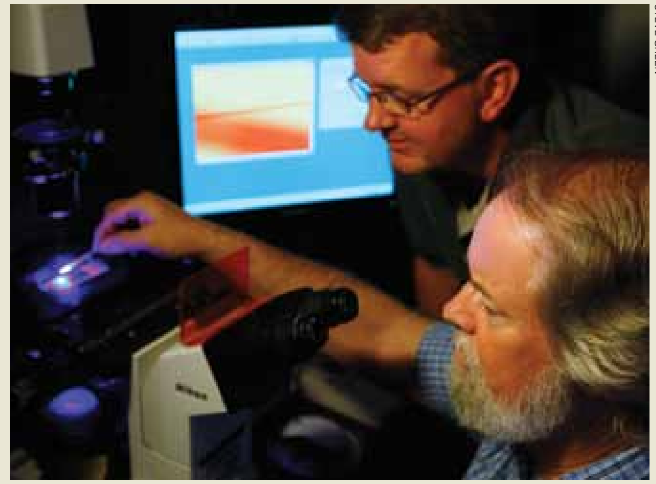
Great Research IDEAS Receive University Funds



STEVE GREEN

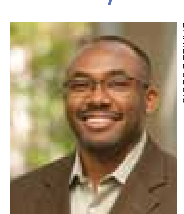
IDEAS grant recipient team of Rick Haselton, professor of biomedical engineering (right), and David Wright, associate professor of chemistry

Vanderbilt University believes its faculty produce breakthrough research that can advance society — and it's backing them with its own money. A new program, **Innovation and Discovery in Engineering And Science** (IDEAS), will provide a one-time investment of more than $3 million in institutional funds to faculty researchers, 11 of whom are from the School of Engineering.

The program is designed to seed innovative, faculty-driven research initiatives. Strikingly, each approved project with an engineering aspect involves collaborations among several faculty members, both in and out of the School of Engineering.

Engineering faculty participating in the awarded projects are **Yi Cui**, **Aniruddha Gokhale**, **Frederick Haselton**, **Clare McCabe**, **Kenneth Pence**, **Nilanjan Sarkar**, **Douglas Schmidt**, **Zhiao Shi**, **Greg Walker**, **Robert Weller** and **Jules White**.

Newly Tenured, New Year



DANIEL DUBOIS

William Robinson

Seven faculty members started the fall semester with new titles after being promoted to associate professor with tenure. They are **Julie Adams**, computer science and computer engineering; **Eric Barth**, mechanical engineering; **Franz Baudenbacher**, biomedical engineering; **Aniruddha Gokhale**, electrical engineering and computer science; **Deyu Li**, mechanical engineering; **William Robinson**, electrical engineering and computer engineering; and **Florence Sanchez**, civil and environmental engineering.

Two professors were honored with emeritus status by the Vanderbilt University Board of Trust. **Bob Roselli** is now professor of biomedical engineering, emeritus, and professor of chemical engineering, emeritus, and **Steve Schach** is now professor of computer science, emeritus, and professor of computer engineering, emeritus.

Congratulations to **L. Hall Hardaway Jr.**, BE'57, on receiving the Associated General Contractors SIR (Skill, Integrity, Responsibility) Award, the highest honor presented by the Middle Tennessee chapter of AGC. Chairman of Hardaway Construction and member emeritus of the Vanderbilt Board of Trust, Hardaway was inducted into the School of Engineering's Academy of Distinguished Alumni in 2002.

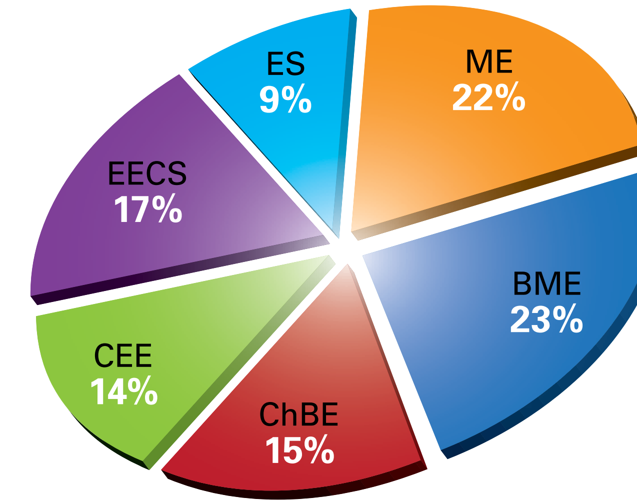
Reaction to Reactor Photo?

We're still seeking the names of those pictured in the spring 2010 "A Look Back" article. **Bob Smith**, BE'63, identified one alumnus, but we still want to know the others. Email *engineering.magazine@vanderbilt.edu* if you can help. From left, they are Lewis E. Akin (BE'59, MS'60), Professor John Dunlap (BE'53, MS'56), unknown, Professor Waverly Graham, unknown, Bill Westerman (BE'59, MS'61), unknown.

PHOTO BY HANSON CARROLL, COURTESY OF VANDERBILT UNIVERSITY SPECIAL COLLECTIONS AND UNIVERSITY ARCHIVES.

Major Emphasis

Undergraduate Enrollment by Department, Fall 2009



Legend:
BME—Biomedical Engineering; CEE—Civil and Environmental Engineering; ChBE—Chemical and Biomolecular Engineering; EECS—Electrical Engineering and Computer Science; ES—Engineering Science; ME—Mechanical Engineering.

The Infinite to the Finite

Vanderbilt researchers lead in imaging science and in putting the technology to work

by Jennifer Johnston

DANIEL DUBOIS

Adam Anderson (right, with research fellow Ha-Kyu Jeong) studies brain connectivity and development using MRI at the Vanderbilt imaging institute.

A professor from the Vanderbilt School of Engineering talks with a neurosurgeon in a hallway at Vanderbilt University Medical Center. Their discussion fine-tunes ideas that the engineer takes forward in implementation. An education researcher at the Kennedy Center meets with a biomedical engineering professor and they brainstorm ways imaging can be used to benefit children. A cancer researcher works with one of the world's leading imaging experts to characterize tumors and assess the tumors' response to chemotherapy.

These collaborations occur on a regular basis as Vanderbilt engineers, physicists, chemists, biologists, physicians and students undertake research in advanced methods of imaging and use it in creative and innovative ways to improve patient outcomes, guide surgery, test treatments and advance basic science, along with a myriad of other potential applications.

Technology is Here Now

Imaging — the ability to see inside the body through various technological advances such as computed tomography (CT), magnetic resonance imaging (MRI), spectroscopy, positron emission tomography (PET), ultrasound and even the basic X-ray — has improved dramatically in recent decades, and so have innovations that allow researchers to use multiple imaging techniques in concert. Advances also have helped meld together images taken at different times, such as before and during surgery.

"Ideas that were around 20 or 30 years ago can now be made to work because the technology is here now," says John Gore, the internationally known director of the Vanderbilt University Institute of Imaging Science. VUIIS is a university-wide research center that brings together engineers and scientists with interests spanning the spectrum of imaging research — from the engineering of imaging techniques to the application of imaging tools to study the brain's inner workings.

Gore, recently named the Hertha Ramsey Cress University Professor of Radiology and Radiological Sciences and Biomedical Engineering, also holds appointments as professor of physics and professor of molecular physiology and biophysics. Those joint appointments in the schools of Engineering, Arts and Science, and Medicine reflect the imaging institute's transinstitutional scope.

Thomas Yankeelov, director of cancer imaging research for VUIIS, has a secondary appointment as assistant professor of biomedical engineering. He says Vanderbilt's university-wide collaborative culture is critical to new discovery. "In order to make progress on the basic science of imaging, we need a lot of expertise," he says. "To apply and translate those developments requires collaborating with those who are interested in using imaging to advance their own research. That research frequently informs what basic imaging science problems we should be tackling. So being inside a university that actually enables and values collaboration not only makes our jobs easier, it also makes it more fun."

JOHN RUSSELL

Mark Does' research includes studies that aim to improve specificity in MRI. The work could impact the diagnostic and prognostic capabilities of MRIs in a wide array of diseases and injuries.

What Goes on Inside the Brain

At VUIIS, Associate Professor of Biomedical Engineering Adam Anderson and other colleagues are working on imaging projects designed to map brain function. They ask questions about how the brain changes when someone thinks about a certain topic or performs a certain function, such as learning to read or do math. How does brain function change, they want to know, in someone with a psychiatric disorder, learning disability, epilepsy, dementia or Alzheimer's disease?

The white matter of the brain has bundles of many, many axons that connect the neurons together, Anderson explains. These bundles hold the key to understanding many disease processes. "We use MRI to study the state of these connecting bundles and relate any injury to the bundles to symptoms," he says.

In patients with schizophrenia, the researchers have found particular pathways where the integrity of the bundles is strongly correlated with disease symptoms, such as hallucinations.

In one study using imaging, the researchers created a model for language function that can aid not only in patients with trauma injuries but in understanding how children learn language. Preliminary data on a small number of subjects in a different study helped make predictions about how well a child might do when exposed to certain tutoring methods. Anderson, who also has appointments in radiology and radiological sciences, has also conducted studies to better understand brain function in children who struggle with math.

Quantifying and Measurement

Associate Professor of Biomedical Engineering Mark Does pursues projects regarding the nervous system. His brain imaging studies seek to find ways to quantify the amount of myelin around certain axons. Since myelin, which forms a sheath around many nerve fibers, becomes damaged from disease, the researchers are seeking quantitative data so more can be understood about disease processes.

Similarly, Does is working in muscle imaging to find ways to measure inflammation as muscles heal. A bone-density tracing project using MRIs seeks to predict which bones might be susceptible to fracture and why. "There are a number of different disease conditions that are known to relate to broken bones. We are trying to find methods to diagnose fracture probability," Does explains.

Hope for Parkinson's

Imaging plays a key role in the School of Engineering's focus on health care, one of its four strategic research areas. Faculty from several departments within the school work on research that involves imaging.

Bennett Landman, assistant professor of electrical engineering and computer science, joined the faculty in January and hit the ground running in developing technologies to study the human brain. Landman extends computer-automated techniques to analyze brain characteristics for large-scale imaging studies. This research targets development of new biomarkers to assist

JOHN RUSSELL

Adam Anderson briefs a volunteer before an MRI scan.

DANA JOHNSON

A VUIIS researcher examines a subject's brain activity.

imaging staging, prognosis and treatment guidance in neurological disease. In addition, Landman is working on developing statistical approaches to allow Internet-based collaboration for better medical imaging approaches. Within VUIIS, Landman heads up the new Center for Computational Imaging, which improves the analysis resources available to basic science and medical researchers.

Professor of Electrical Engineering Benoit Dawant uses imaging in his research into innovative deep brain stimulation surgery techniques for patients with Parkinson's disease and other tremor disorders. An electrode is implanted deep in the brain and connected to a wire on the outside of the body, functioning much like a cardiac pacemaker. The electrode creates an electric field that modifies the way neurons in the brain talk to each other.

Dawant, Research Assistant Professor in Electrical Engineering Pierre-Francois D'Haese and colleagues work with Vanderbilt neurosurgeons Dr. Peter Konrad and Dr. Joseph Neimat as well as neurologists, electrophysiologists and physical therapists in a complex process of patient selection, procedure planning, implantation and monitoring of the device.

In this procedure, the target area, called the subthalamic nucleus, is very small. Implanted in the correct spot, the electrodes suppress the symptoms of Parkinson's. Incorrectly done,

JOHN RUSSELL

People with Parkinson's disease benefit from brain stimulation research by Benoit Dawant and colleagues.

JOHN RUSSELL

J. Michael Fitzpatrick developed a three-legged platform used with imaging during cochlear implant surgery.

the procedure can create side effects for the patient, so precision is critical. The engineering aspect of the procedure involves using images to calculate precise coordinates for the targets, like creating a map or a GPS system for the brain. The implant is then placed using a stereotactic frame contraption, which is attached to the skull.

During the procedure, the patient is awake and immediate feedback can determine whether the probe is stimulating the correct area of the brain in the right way. The small probe is then removed, and the permanent one is inserted and affixed.

Although, in the long term, brain stimulation may be shown to slow the progression of the disease, it is currently used to minimize the symptoms of Parkinson's. "So far the probe is not a cure, it's palliative," Dawant says. The team has been capturing data about the procedure to create statistical models so that surgeons outside Vanderbilt might one day utilize the same methods. "We'd like to create a big central repository for deep brain stimulation cases," he says.

Innovations for Image-guided Surgery

J. Michael Fitzpatrick, professor of computer science and computer engineering, has partnered with Dawant to translate some of the same ideas to patients with severe hearing loss. Implanting a cochlear device currently requires removing a piece of bone behind the ear. It can sometimes take a month for the area to heal sufficiently for the surgeon to know whether the procedure was effective. Fitzpatrick, Dawant and colleagues, including Assistant Professor of Mechanical Engineering Robert Webster, have been working with ear surgeon Dr. Robert Labadie, associate professor of otolaryngology, on a concept to make the implantation procedure minimally invasive.

To provide the accuracy required for this delicate surgery, they devised a frame, or platform, similar to that used for deep brain surgery. A three-legged stand somewhat like a tiny table, it mounts behind the ear on bone-implanted anchors and is used with the aid of imaging to guide the surgical instrument in making a very small surgical entryway. There are critical areas to avoid during this procedure, especially the facial nerve and the chorda tympani, which regulates taste.

"Benoit finds where the cochlea is. I find out where the anchors are," Fitzpatrick says.

The instrumentation still is in the testing phase but preliminary data is encouraging. "We have developed algorithms to localize the sensitive structures. We can automatically find the trajectory, the cochlea and the structures to avoid," Dawant says, explaining that the rest of the team then designs a platform to guide the drill along that trajectory so that it makes a hole into the cochlea through which an electrode can be inserted. Other team members include Ramya Balachandran, MS'03, PhD'08, research assistant professor of otolaryngology, and research engineer and doctoral student Jason Mitchell, MS'02. Taking the research a step even further, the team is collaborating with colleagues at Leibniz University in Germany to develop a robotic arm that one day may perform parts of the ear surgery autonomously.

Fitzpatrick has been involved in implementing engineering innovations for image-guided surgery at Vanderbilt for decades. "Image-guided surgery was significantly advanced here. The systems people use day-to-day are based on what we developed," he says. "I see my role not so much as a visionary guy but as an engineer who makes the visionary person's idea work."

The Bridge to Health Care

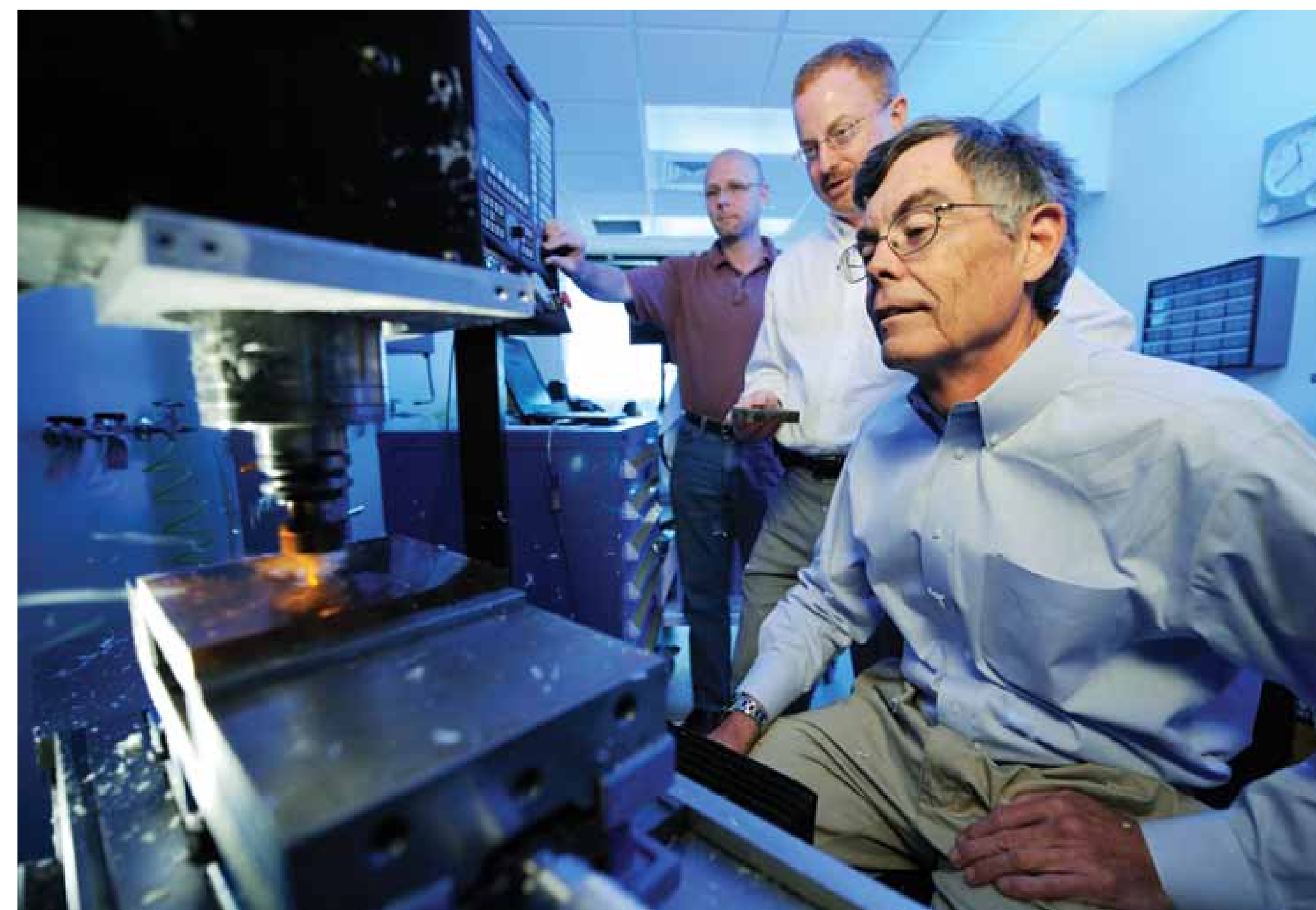
Other VUSE professors are also heavily involved in using imaging in their research. Michael Miga, associate professor of biomedical engineering, is a leading researcher in using imaging to develop compensation strategies for soft tissue deformation during image-guided surgery. Miga and Robert Galloway, professor of biomedical engineering, have conducted research to help align preoperative images with images taken during surgery. The task is difficult in organs such as the brain and liver, which tend to shift and change shape due to varying surgical presentations such as draining of cerebrospinal fluid in the case of the brain, or separation from the surrounding ligamenture with the liver. The result is a presentation of the organ that differs considerably from its anatomical orientation during preoperative scanning.

"Each organ has its own unique challenges based on the organ's anatomy, physiological nature, and that impacts the approach that a surgeon takes," Miga says. His research employs computational modeling techniques that mimic the behaviors of the organ and then modify the presurgical images to reflect deformations that occur during surgery. That allows a surgeon to accurately track the location and behavior of the organ despite soft tissue deformation. (See fall 2009 *Vanderbilt Engineering.*)

Galloway also works on research that involves finding ways to use imaging to help guide surgeons behind the eyeball while avoiding muscles and other important structures.

"What we are doing started out as image-guided surgery. Now it's much bigger than that," Galloway says. He sees surgeons as evolutionary, he explains, following a pathway and seeking to constantly improve their craft and patient outcomes. Engineers working with doctors are the revolutionaries, taking basic ideas and applying them to different problems in an attempt to transform and revolutionize the process.

"Vanderbilt is extraordinarily good as an institution with all kinds of imaging," Galloway says. "It's very difficult to find a place that does it as well, and yet we've been sort of under the radar. Coupled with the imaging institute, we're the bridge that takes these therapeutic findings into health care."



JOHN RUSSELL

From left, doctoral student Jason Mitchell, Dr. Robert Labadie and J. Michael Fitzpatrick use image-guided programs to fabricate a unique patient-specific drill guiding platform for use during surgery.

Imaging Visionaries

On the corner of Vanderbilt's Medical Center Drive and 21st Avenue is a research institute that houses what is likely the single largest, most comprehensive imaging center in the country. The Vanderbilt University Institute of Imaging Science puts the most advanced imaging techniques literally at the doorstep of Vanderbilt University Medical Center physicians who want to find new ways of advancing medicine, education specialists at Peabody College looking to improve learning methods, and engineers researching new technologies.

"We get support from all parts of the university, and the thing that distinguishes us from others is that we're transinstitutional," says institute director John Gore, Hertha Ramsey Cress University Professor of Radiology and Radiological Sciences and Biomedical Engineering. At other universities, imaging research would be headquartered in either radiology or engineering, but VUIIS transcends the usual compartments. "This setting allows us the best of both worlds."

The imaging institute explores virtually every aspect of imaging science, from the underlying physics of imaging to applications of imaging techniques to detect, diagnose and treat disease.

The institute already houses seven powerful magnets including a 7 Tesla human scanner, one of only 13 in the world being used in human studies. Built in 2006, the building includes four floors of research, classroom and office space. Great care and planning went into every facet of the $19.7 million facility, including creating a mock MRI scanner so human research subjects can adjust to the feeling of lying prone in the cylindrical tube. The center also houses other advanced imaging devices, including a 3-T whole body scanner, X-ray, ultrasound, PET, optical and CT scanners.

The state-of-the-art center provides ready access to the latest equipment while facilitating constant communication among potential collaborators.

"We're not a lab living in a bubble," says Mark Does, associate professor of biomedical engineering. "(Interaction is) how we identify the relevant questions. We were built from day one for greater collaboration."

Currently, 24 faculty members and 50 graduate students, mostly engineering majors, are associated with the institute. In addition to addressing questions brought by "visionaries," institute faculty conduct their own research, much of it designed to improve imaging technologies and methods and to use them in new applications.

DANA JOHNSON

John Gore

One of the most highly regarded research groups in the world in biomedical imaging, the imaging institute explores virtually every aspect of imaging science, from the underlying physics of imaging to applications of imaging techniques to detect, diagnose and treat disease.

"We have the tools that provide the right information and we don't have the constraints of being spread around," Gore says. "We were fortunate that the administration had a vision for how everything should be knit together."

That vision was implemented by Gore, the renowned imaging expert who came to Vanderbilt from Yale in 2002 to set up the institute. Gore assembled a team of the best imaging scientists to develop advanced research using the latest, most powerful imaging equipment available.

In summer 2010, the center received a $3.45 million federal stimulus grant to purchase a new magnetic resonance imaging (MRI) scanner to study small animals. The 15 Tesla scanner (one Tesla is roughly 20,000 times the strength of the magnetic field of the Earth) can produce detailed images of the brain and body, as well as measure minute levels of key compounds. It will be used in noninvasive studies of genetically engineered mice and other small animal models, creating opportunities for breakthrough research in basic understandings of cancer, diabetes and brain disorders, along with other possibilities.

"We've got the hammer and we're often looking around for the right nail," says Adam Anderson, associate professor of biomedical engineering. "We rely on the rest of the university to bring us novel questions. We develop methods, and use them to provide new knowledge, but there are many physicians or educational researchers who study problems with which imaging can help. We rely on them to describe what they need."

Among the research projects ongoing at VUIIS are studies furthering understanding of the human brain and how it functions, including asking why gray matter is gray and white matter is white, and building tools for understanding how the brain is organized. Other work involves better understanding blood flow in tumors, how the brain changes when a psychiatric disorder is present, and the impact of certain medicines on brain function.

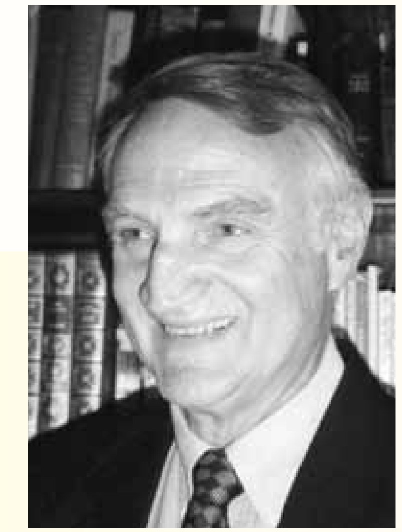
"A lot of projects here draw heavily on engineering and the applied sciences to make them work," Anderson says. "There are a lot of algorithms being developed to help the interpretation of information from different modalities."

—Jennifer Johnston

Unforgettable

Peter G. Hoadley

Professor of Civil and Environmental Engineering, Emeritus



Peter Hoadley

by James A. Johnson, BE'63, PhD'72

I grew up surrounded by engineers. My father and one uncle were civil engineers. Another uncle was a mining engineer, and another was a road builder. It wasn't much of a surprise in 1959 when I enrolled as an engineering student at Vanderbilt.

I still remember when then-Assistant Professor of Civil Engineering Peter G. Hoadley arrived at the School of Engineering. It was my junior year, and he represented a new wave of faculty with outstanding talent. Professor Hoadley was well-liked and respected for his academic credentials and ability.

It was not only a privilege, but also a delight to have someone as highly regarded as Pete as my instructor. I took structural engineering courses under him. He was a superbly talented teacher, and I found his lectures engaging. Pete's teaching turned the light bulb on for me and ignited my interest in structural engineering.

Knowledgeable, insightful, accomplished and athletic, Pete continually amazed me with his technical background and teaching. He was very approachable and helpful with explanations when we had difficulty understanding a particular concept. It wasn't unusual to find him on campus playing a pickup game of basketball at Memorial Gym. We were practically contemporaries and at times, he seemed more like an older brother than a faculty member.

Through his encouragement, I went to graduate school and earned my master of science degree in civil engineering from the University of Illinois in 1965. After spending three years in the Army, I returned to Vanderbilt to earn my Ph.D. Pete was on my dissertation committee.

In 1970, I began my professional engineering career in Houston where many of my projects involved the planning and design of highways, bridges, airports and aviation facilities. Not surprisingly, I was able to apply techniques learned from Pete Hoadley. His teaching enabled me to thoroughly understand design challenges and solve them with structural analysis. I may have inherited a passion for engineering, but Pete provided me with a solid, technical background that I still use today.

Pete was a cross-generational teacher, and my connection with him evolved when my sister, Ann Johnson Nielson, BE'68, and later, my nephew, Blake Jones, BE'96, took courses under him. With much affection, they would recall their positive experiences with Professor Hoadley to me. He was described as the same wonderful teacher and mentor that I remembered. I have received the same comments from other younger engineering students from Houston who studied under Professor Hoadley.

At one time or the other, we meet individuals whose relationship with us positively impacts our lives. I believe that if one has had an opportunity, there is also an obligation to pay it forward. Pete Hoadley was one of the best teachers I had during my engineering education, and he continued to meet this high standard of teaching for succeeding generations of Vanderbilt civil engineers.

Recently, I've had the opportunity to establish a graduate award at the School of Engineering. I decided to name my graduate award in Pete Hoadley's honor because he represents the best of faculty at the Vanderbilt School of Engineering. This award is a tribute to him and his contribution to engineering education. It helps me repay the School of Engineering for the value that I received from my Vanderbilt engineering education. The Peter G. Hoadley Graduate Award is also a way to provide a deserving graduate student in civil engineering with the same opportunity that I had. In Pete's honor, I'm paying it forward.

James A. Johnson, BE'63, PhD'72, is a director at Kellogg Brown and Root Services in Houston, where he helped develop the firm's civil engineering business. He is a member of the School of Engineering Committee of Visitors and the Advisory Board for the Department of Civil and Environmental Engineering, and a former member of the school's alumni council. Jim was inducted into the VUSE's Academy of Distinguished Alumni in 2006.

—as told to Becky Green

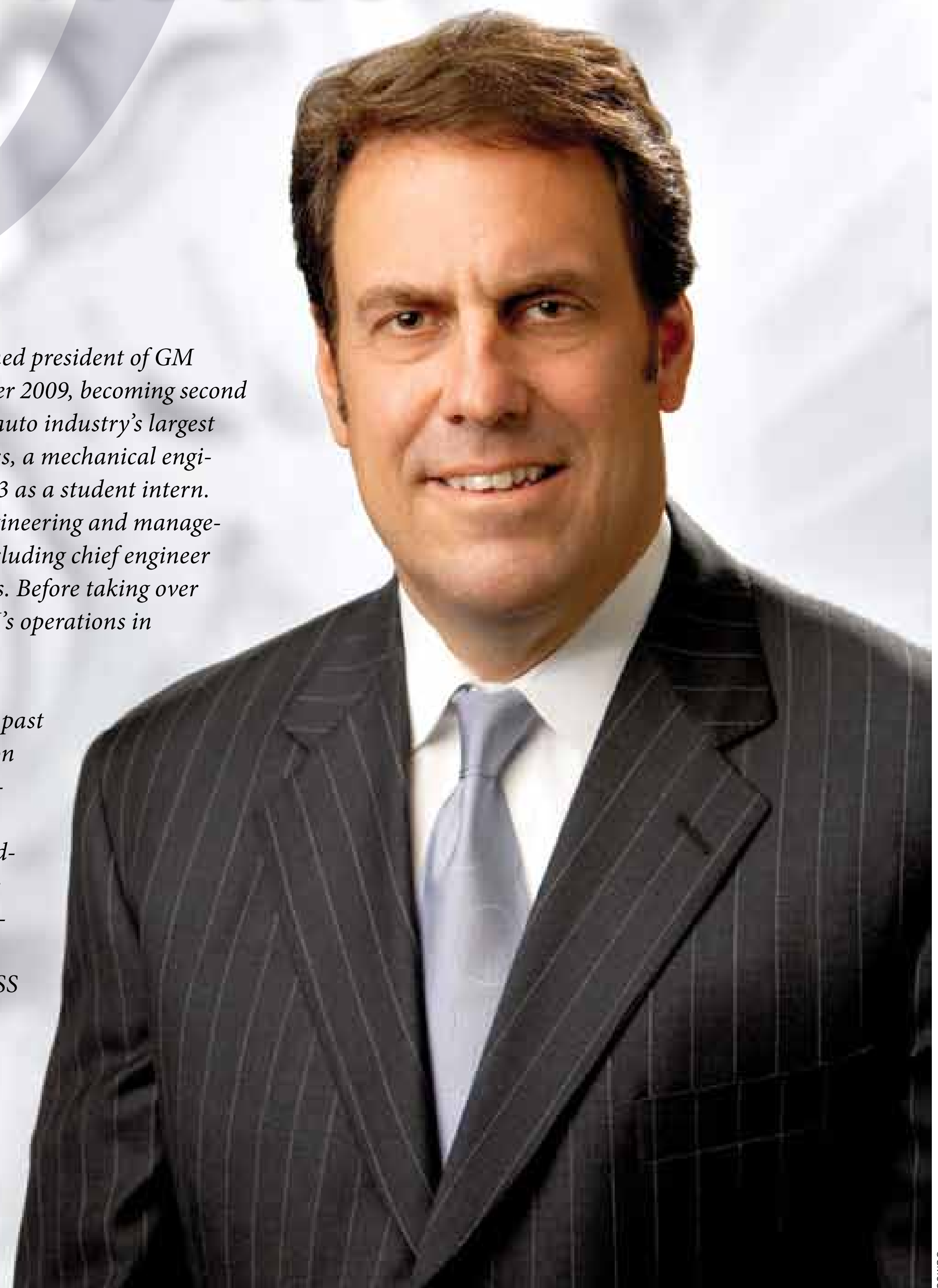
9 Questions for GM President Mark Reuss

by Jan Read

Mark Reuss, BE'86, was named president of GM North America in December 2009, becoming second in command of one of the auto industry's largest and most prominent companies. Reuss, a mechanical engineering grad, started with GM in 1983 as a student intern. Since then, he has held numerous engineering and management positions across GM brands, including chief engineer roles in GM's large luxury car vehicles. Before taking over GM North America, he managed GM's operations in Australia and New Zealand.

Reuss has a love for cars that extends past business. He is a certified test driver on the famed Nürburgring course in Germany and has earned his license for Grand American Road Racing (Grand-Am). He started the GM Performance Division in 2001 and launched associated production and racing vehicles including the V-Series Cadillacs and SS Chevrolets.

Reuss spoke with Vanderbilt Engineering *about his new role, how his studies at the School of Engineering helped him in the automotive business, and the soul of the car.*



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Why did you choose Vanderbilt?

Vanderbilt's engineering school recruited at Cranbrook, my high school in Michigan. I really wanted to live in a different place and not just go to another big Midwest school.

I had an excellent experience at Vanderbilt. I met people that I never would have met. My relationship with Vanderbilt is still good, by the way. I was just at Vanderbilt for an Engineering Committee of Visitors meeting. There are still people there who taught me.

How did your Vanderbilt education help you start your career?

At Vanderbilt I had the opportunity to work hands-on with engines, which was an experience that was quite different from what my counterparts were doing at other schools. We were learning about fuel systems and thermodynamics, and I'm not sure other places had that.

Also, Vanderbilt was unique (and still is) in that I had a full course load that included ethics, the business of engineering and product development. That was very progressive back then, and I still benefit from that business curriculum that's enmeshed in the engineering school.

How did that benefit you?

Once I started at GM, I immediately knew that my Vanderbilt experience and the way I had learned to do business were very different. From the start, I wasn't looked at as "just another GM engineer from the same pattern," and that's helped me a lot.

Because of my classes, I was attuned to think about where the competition was going next and how we could beat that. That's a totally different way of thinking than benchmarking, which was what everyone else was doing. My VUSE education made me think about what people would want next — and that's a pretty powerful thought. You won't always be right, but you can anticipate people's wants and needs. If you're focused on benchmarking, you're always going to be following.

Can you map your GM career?

I've worked in almost every part of the company — manufacturing, engineering, vehicle development, body shop tooling. I had the chance to put it all together when I was managing GM's operations in Australia and New Zealand. It was the culmination of all I've learned: the general management piece, engine plants, vehicle plants, dealerships, sales and marketing. It was great preparation for what I'm doing now.

My background as an engineer is key to my career. This is still very much a product-based business. You have to anticipate and decide the portfolio of vehicles to produce and market. To do that, you have to know the car and understand its soul.

What is the soul of the car?

It's kind of a mystical art — the soul of a car, how the vehicle actually drives. You have to integrate all the areas. Is it quieter than the competition? How is the engine and drive quality? You have to think about noise and vibration, ride and handling. Who is your customer? What are the three or four main things that are important to that customer, that will make them walk out of the car they're in and into yours? That is the soul of the car.

How has the audience of car buyers changed from years ago?

People are much less brand-loyal than they used to be. It certainly makes it interesting, because you can't rely on the "once a GM, always a GM" concept. Dan Lovinger [BA'87], who is also a Vanderbilt graduate, is a friend of mine who works at MTV. He brought our folks together with some of their folks, and we got a good peek under the curtain about what the millennium generation is, what they like, and what they want next.

Can you tell us about the Volt?

The Volt is a very exciting vehicle. It's an extended-range electric vehicle. Think about it as a car that is electrically driven with a battery and a little generator on the back. It's not a traditional hybrid. The Volt runs on electricity that it generates itself. It frees the consumer from being dependent on charging stations — no range anxiety.

The battery is the key to the Volt. It's a liquid-cooled stack battery cell that's T-shaped. The battery is actually part of the car. We developed it all inside GM. The mindset in the battery lab is very much science-oriented. There are a lot of young engineers on that project.

What kind of person do you want on your leadership team? Do you look for other engineers?

I want people who love cars. I want people who are passionate about getting the company to win. They have to be willing to leave behind the way that we operated in the past. I believe that if you drive the change of behavior, you change the way we get results.

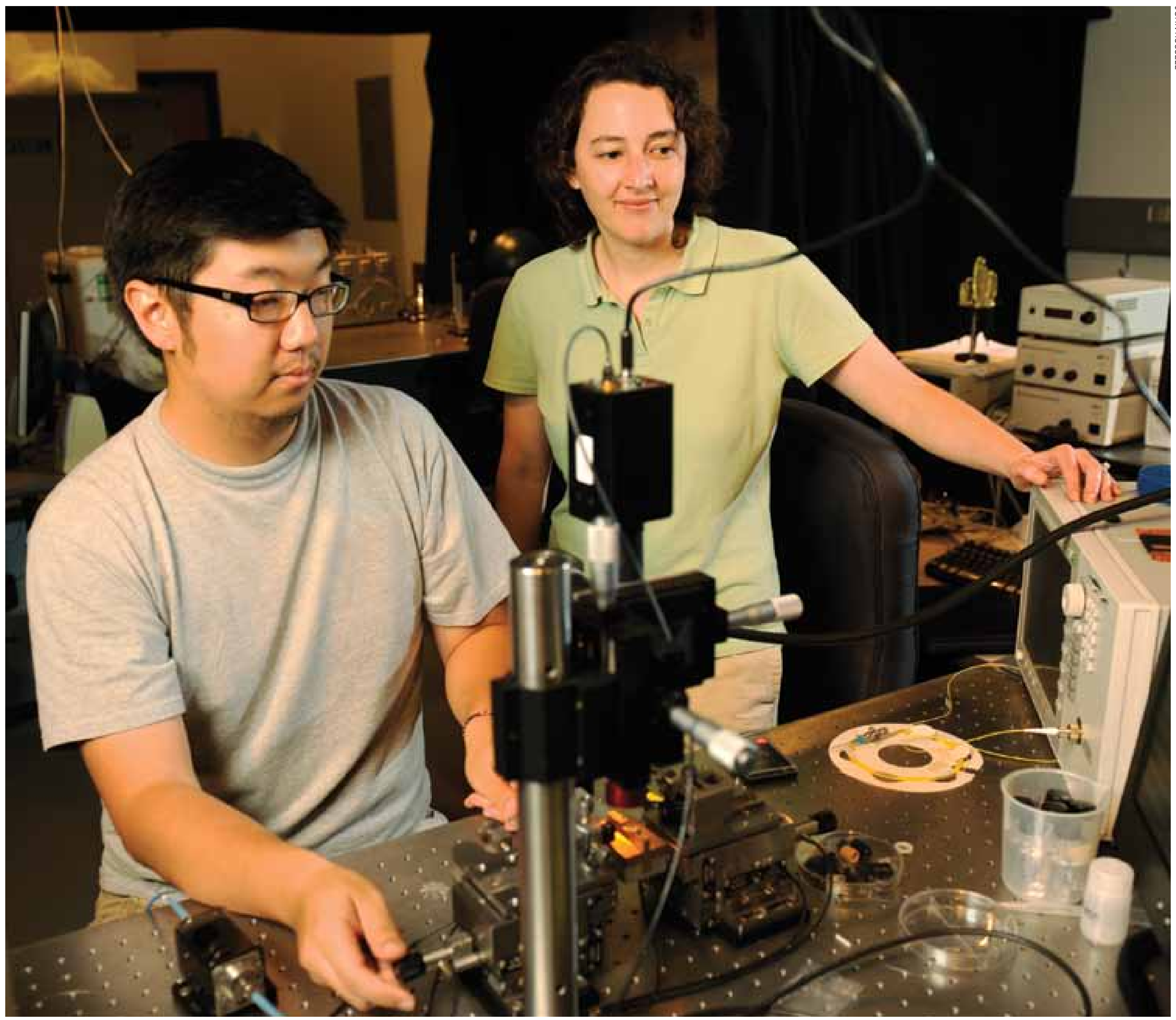
What's making you passionate these days?

The new Buick Regal — I really like that car. I also had the opportunity to drive the new V Series Cadillac coupe. That car is about as close to perfect as possible. It's a rolling piece of sculpture, one of the most dramatic cars I've ever seen. When I was driving the car around, I kept finding people taking pictures of themselves with the car. My wife drives a Cadillac Escalade hybrid. We have three kids, and she loves that car.

Explorer of Light

Like the optics she studies, Sharon Weiss carries energy and information with power and potential

by Sandy Smith



JOHN RUSSELL

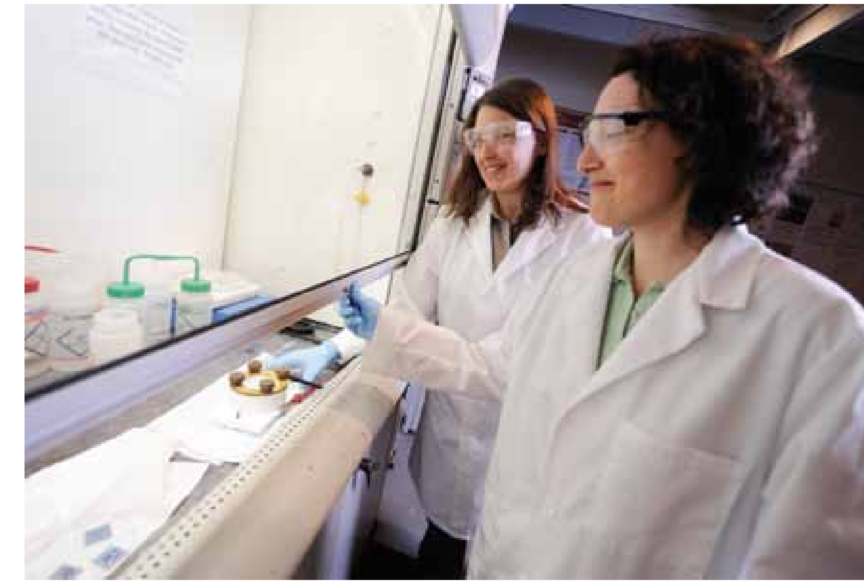
In the VU Photonics lab, doctoral student Chris Kang measures the intensity of light passing through a silicon waveguide sample. He's one of eight graduate and four undergraduate students who work with Sharon Weiss (right) in the Weiss Group.

When people discover that Sharon Weiss works in optics, they often ask if she can fix their glasses.

"I say, 'No, but I can tell you how they work,'" says Weiss of her field of optics — the study of light, not eyewear. "Light can carry energy and information, something as simple as voice or music or as complicated as video." Yet the research into optics conducted by Weiss, assistant professor of electrical engineering, is anything but simple.

In fact, research conducted in her Vanderbilt University School of Engineering labs — as well as in collaborations across campus — has the potential to revolutionize the next generation of computers, military safety, health care and even museum lighting. The Weiss Group focuses on research involving photonics, optoelectronics, nanoscience and technology, and optical properties of materials. Its research initiatives are supported in part by the National Science Foundation and several Department of Defense agencies.

Photonics concerns the controlled flow of photons, or light particles, and is the optical equivalent of electronics. The field covers a huge range of science and technology applications, including optical computing, laser manufacturing, biological and chemical sensing, display technology and medical diagnostics and therapy. Weiss' expertise in photonics has made her a frequent research collaborator across the university.



JOHN RUSSELL

Doctoral student Jenifer Lawrie (with Weiss, right), sets up an electrochemical etching cell used to fabricate porous silicon samples for biosensing experiments.

> "Her science fills a niche that complements other efforts under way at Vanderbilt."
>
> —Sandra Rosenthal
>
> *Director, Vanderbilt Institute of Nanoscale Science and Engineering*

Sharing Optics Expertise

"Sharon contributes to the collaborative atmosphere in two ways," says Sandra Rosenthal, director of Vanderbilt Institute of Nanoscale Science and Engineering. "First, her science fills a niche that complements other efforts under way at Vanderbilt. For example, her expertise in optics can be utilized to develop biosensors and logic components for photonic communications, or to enhance absorption in a novel solar cell. She has core expertise that benefits many programs.

"Secondly, she has a personality well-suited to collaboration. Not everybody is a good collaboration partner," says Rosenthal, who is also professor of chemistry, physics, pharmacology and chemical and biomolecular engineering. "Sharon can work just as well as a member of a team as she works individually. She's engaged, prompt, responsible and does her fair share."

Their collaboration began shortly after Weiss came to Vanderbilt, when Rosenthal was doing research with solid-state lighting devices, which use light-emitting diodes (LEDs) instead of electric filaments for illumination. "It turned out that Sharon had covered this material in a course she had at the Institute of Optics while she was a graduate student," Rosenthal says. "I asked her if she wanted to form a partnership in the research going forward and was delighted when she said yes."

Weiss and Rosenthal explore LED lighting improvements using ultrasmall cadmium selenide nanocrystals. Their research has focused on the development of white LEDs, which have the potential for higher efficiency and longer lifetimes compared to other current lighting technologies. The ultrasmall nanocrystals emit pure white light with superior color quality, which is especially important for applications like museum lighting.

Computing at the Speed of Light

Weiss and Richard Haglund, professor of physics, recently launched a project exploring the uses of light in computing.

"The demand for faster computational speed is no longer being met by faster processors," Weiss explains. "Computers have been getting faster and faster, but now you will often find dual core or quad core processors to accomplish that. The processing speed of each core is no longer getting much faster. There has to be some revolution in computing, and one of the viable options is to do it with light."

Currently, computer cores include chips made from silicon, but there are scaling limits with the present approach of increasing speed by shrinking the size of silicon transistors. "The industry wants to stay with silicon as long as possible," she explains. "Billions of dollars have been invested in capital equipment."

Weiss and Haglund's research explores whether integrating vanadium dioxide with silicon might deliver increases in speed without the costly move away from the silicon infrastructure. "The path is set; it's just a matter of time," Weiss says. "I would not be surprised within 10 years to see a significant number of optical components in computers."

JOHN RUSSELL

This high-precision optical measurement system allows light to couple from an optical fiber into a silicon waveguide sample located under the red microscope objective lens.

Building on the Foundation

Silicon and its derivatives were the foundation of Weiss' doctoral thesis at the University of Rochester and remain central to her research. Silicon is traditionally known as the material of choice for electronic applications. The integrated circuits that control computers and cell phones, for example, are primarily made out of silicon. "Silicon is a relatively abundant material and it is the backbone of most modern technology," she explains. "My Ph.D. adviser used to say, 'If it can be done in silicon, it must be done in silicon.'" Many of Weiss' research initiatives examine the potential of silicon for applications that involve light instead of electricity.

In her lab, Weiss and her team of eight graduate and four undergraduate students work on optical research initiatives. Several projects take advantage of the large surface area that can be obtained by introducing nanoscale holes into silicon, forming a material called porous silicon. When coated with appropriate chemicals, the tiny holes — more than ten million times smaller than one meter — can be used to selectively capture specific biological molecules of interest. Light interaction with the molecules in the holes enables identification and quantification of the molecules. The research opens up the possibility of performing cost-effective environmental monitoring or medical diagnostics in real time on a very small scale.

> "Vanderbilt is the kind of place where you don't just pay lip service to collaborative research."
>
> —Sharon Weiss

"Combining new innovations in nanotechnology with existing knowledge about how to capture molecules on microscope slides has already enabled significant breakthroughs in disease detection and treatment," Weiss says.

Weiss is also collaborating with Paul Laibinis, professor of chemical and biomolecular engineering, to synthesize DNA inside porous silicon. "You can think about DNA as your genetic makeup. What we are doing is putting a particular sequence of DNA inside our porous silicon biosensors," she says. "If geneticists know that the presence of a particular DNA sequence in one section of a person's genetic code means that person is more likely to develop cancer or heart disease, then we can identify if that sequence is present by comparing it to the complementary DNA sequence that we can synthesize in our porous silicon sensors."

OFFICIAL WHITE HOUSE PHOTO: LAWRENCE JACKSON

President Obama chats with recipients of the Presidential Early Career Awards for Scientists and Engineers (PECASE) before a group photo in the East Room of the White House. Weiss is in the third row on the far left.

Why Vanderbilt School of Engineering

When it came time to apply for her first faculty position after getting her doctorate, the New York state native initially did not consider moving too far south. Her ties to Rochester were strong; she had grown up there and had been recruited by the University of Rochester to play soccer for four years. She attended the university and its Institute of Optics from freshman year through earning her doctorate.

Dennis Hall, former director of Rochester's Institute of Optics, had become Vanderbilt's vice provost for research and dean of the Graduate School. He suggested Weiss take a look at Vanderbilt. Drawn by the "engaging interdisciplinary climate," she joined the Vanderbilt School of Engineering in 2005.

"The research that I do is not traditional engineering. Vanderbilt is the kind of place where you don't just pay lip service to collaborative research," she says. "I also sensed Vanderbilt had an upward slope. ... it was going somewhere fast."

Honored by the President

Weiss also is going somewhere fast. In 2009, she was one of 100 young researchers recognized by President Barack Obama with a Presidential Early Career Award for Scientists and Engineers (PECASE). The award is the highest honor bestowed by the federal government on young engineers. That led to an invitation to attend the German-American Frontiers in Science symposium this summer. Only 70 researchers under the age of 45 were invited. "They have speakers who talk about timely research topics that span multiple disciplines, followed by lots of time for discussion," Weiss says. "Bringing people together who individually have great ideas and asking them to think about current challenges in crosscutting fields suggests that more ideas will be generated and potential solutions found." Weiss has also been selected to attend the National Academy of Engineering-sponsored U.S. Frontiers of Engineering symposium this fall.

She's still as enthusiastic about the field of optics as when she was a college freshman taking an introduction to optics class, and readily elicits the same passion in engineering students. In teaching a course on signal processing and communication, she adapted the syllabus to include a section on fiber optics, which allows students to understand how sound, pictures and data can be transferred for phones, television and Internet usage.

Weiss often includes laboratory exercises in each course curriculum to reinforce concepts with hands-on activities. "If you talk in abstract equations, students often just memorize what they need to and forget it soon after the exam," she says. Weiss is also active in community outreach as she participates in a number of programs such as TWISTER (Tennessee Women in Science, Technology, Engineering and Research) at Nashville's Adventure Science Center.

Knowledge is something she believes in giving not just to her students but also using to stretch herself. "Research and teaching are a rewarding balance. With research, you can put in a lot of time and sometimes you get few tangible rewards. Other times you put in a little effort and get a lot out," she says. "With the classroom, it's almost immediate impact. It's immediate gratification that you're making a difference."

National Defender

Philip Reitinger goes from Microsoft to Homeland Security to protect American cybersecurity

by Sandy Smith

Like other engineers, Philip Reitinger, BE'84, has made a career of building bridges. But the divide that he has spanned is between corporations and government and between technology and policy.

Reitinger is the Department of Homeland Security's deputy under secretary of the National Protection and Programs Directorate and director of the National Cyber Security Center.

Those are big titles and increasingly important roles to both the American public and to the government. In Homeland Security's quadrennial review of the nation's security, cybersecurity joined weapons of mass destruction, violent extremists and terrorism, transnational crime and natural disasters as the most pressing issues threatening homeland security.

Security in the Connected Age

"We're putting computers into everything now," says Reitinger, who earned a bachelor's degree in electrical engineering and computer science at Vanderbilt School of Engineering. "We're building a broad array of highly complex devices. Most of these things are connected in deep ways to one another and to the Internet. These computers can reach from anywhere to anywhere, which is great. We no longer just say, 'I use my computer to type documents.' Now we watch TV, listen to music, send emails, all using computers. Increasingly we're using computers to keep our food cold and do banking. So this network of computers is moving toward greater complexity, greater connectivity and greater criticality."

Despite the importance of computers to everything from power plants to

HILARY SCHWAB

Philip Reitinger, BE'84, leads the charge to protect the nation's computer security.

. . . cybersecurity [has] joined weapons of mass destruction, violent extremists and terrorism, transnational crime and natural disasters as the most pressing issues threatening homeland security.

home refrigerators, "there are huge, grand challenges," he says. "How do we actually make security easier for people?" Reitinger believes that even as people and companies try to keep their computers secure, there are others trying to undermine that security. "We're in an environment now where if someone devotes the time and resources, they'll find a way," he says. "That's not a sustainable place to be."

The potential harm has grown along with the sophistication of the hackers Reitinger has seen throughout his career. "When I first got involved in working on cybersecurity, we were at the tail end of the 'hacker and cracker' [phase] of somebody seeking a reputation," he says. "They'd attack a webpage and scrawl across it. That's not where we are anymore. Cybercrime is about getting access to real money or information of value and there are individual hackers and groups. It runs the gamut and some elements are highly organized."

Though cybersecurity is his main focus, as deputy under secretary he's also concerned about the full range of dangers to the nation, including protecting federal facilities, infrastructure, risk management and analysis, and US-VISIT, the biometric program that identifies people entering the United States.

En Garde

Reitinger has had a front-row seat as cybercrime has shifted, but it was never a seat he intended to take when he graduated from the School of Engineering. The self-described computer geek came to Vanderbilt with a straightforward career path in computers in mind — though an extracurricular activity might have been a clue to his future. He was a member of the fencing team, a "broad group of people who were all quirky in some way," he says. "It may be a sport that draws quirky people."

(Though he gave up fencing — a sport he admits he wasn't very good at — his future wife was a member of a national championship women's team. "I make sure that I don't make her angry," he says.)

Late in his senior year, he took the LSAT just to see how well he would do. He did well enough to be accepted to Yale, and that led his thoughts to a future in patent law.

Reitinger quickly found another path, one that would allow him to bridge technology and policy: He entered government service. Jobs followed at the Department of Justice, where he was deputy chief of the Computer Crime and Intellectual Property division, and executive director of the Department of Defense's Cyber Crime Center. He also spent six years at Microsoft, becoming chief trustworthy infrastructure strategist before returning to the federal government in 2009.

Experience with both government and corporations has helped Reitinger understand the critical role that each plays in cybersecurity. "You learn different things in government and industry, and both of them have their advantage," Reitinger says. "The pace of change in this space far exceeds most areas with which government or industry has to deal."

Helping Defend Your Country

He sees the importance of cross-pollination between government and industry. "The biggest piece of getting the job done is having the right people. Making sure that we can keep bringing in the right people, people from the private sector, is also a significant challenge since we don't pay what the private sector does," he says. "But it's a way of helping to defend your country. You'll get responsibilities that you'd never get in the private sector."

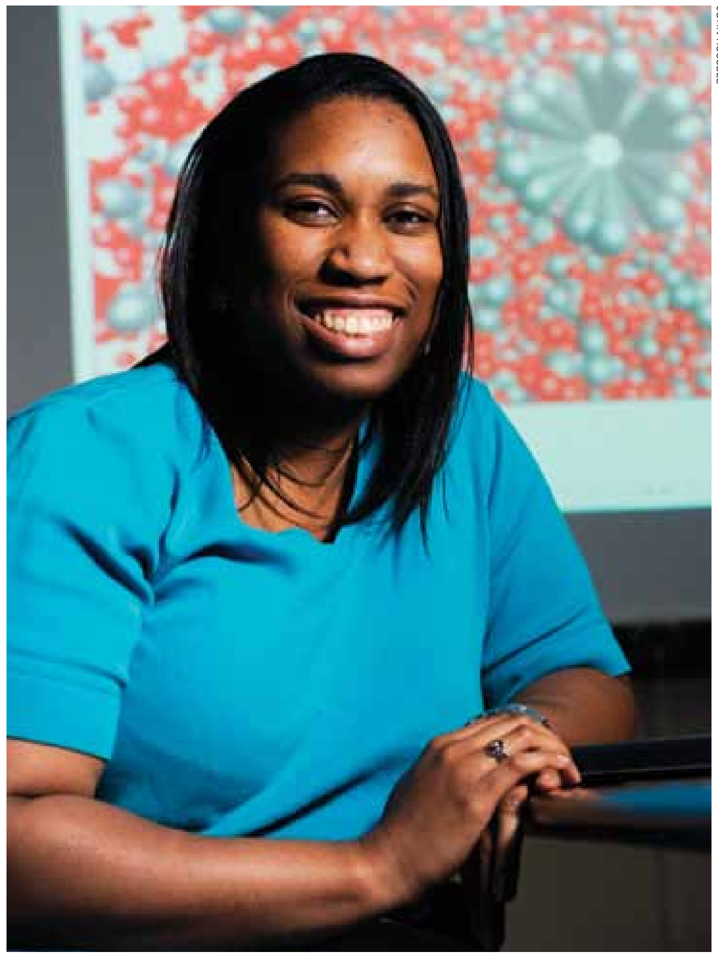
His ability to understand the technology, via his engineering degree, and policy, aided by law school, has made Reitinger a rarity in Washington. That position is familiar to the Jacksonville, Fla., native, who still builds the occasional computer at home as a hobby.

"I have tried to be somewhat interdisciplinary in my career. Though I have a technical degree from Vanderbilt, it is a university that, even for people who are deeply mired in the technical side, gives experiences that are much broader. It is a liberal arts university for engineers as well," he says, noting his VUSE education gave him a much broader educational experience to bring to law school.

"I've done things that involve both technology and policy," Reitinger says. "If you find things that you're passionate about, you'll have a great career no matter what."

Six Awards in Three Years are SMART

by Brenda Ellis



JOHN RUSSELL

Ebonee Walker's molecular dynamics simulations (on screen) relate to research into missile materials. They're supported by the U.S. Army Aviation and Missile Research, Development and Engineering Center.

"Even before I learned which lab picked me up, I was excited. But when I learned I would be working on military robots in San Diego, it was unbelievable."

—Brian Okorn

A U.S. Department of Defense program has top engineering and science students all over the country competing for a select few scholarships — and Vanderbilt Engineering students have claimed six of them in three years.

The Science, Mathematics and Research for Transformation (SMART) Scholarship for Service Program provides full tuition, book fees, health benefits, paid summer internships, an annual cash stipend of $25,000 to $41,000, and employment at a DoD lab after graduation.

The DoD established the SMART program five years ago to support undergraduate and graduate students in science, technology, engineering and mathematics disciplines. The program aims to add civilian researchers at defense department laboratories, which employ more than 200,000 engineers, scientists and mathematicians working on some of the world's most interesting research projects.

Zach Smith, a junior in mechanical engineering, and Catie Gay, a doctoral student in civil and environmental engineering, are 2010 recipients. In 2009, three students received SMART scholarships: Brian Okorn, BE'10, computer engineering; doctoral student Ebonee Walker, interdisciplinary materials science; and senior Thiago Olson, electrical engineering. Jeff Pierce, PhD'10 (engineering systems), received the award in 2007 and then served as a resource for other VUSE applicants.

Hands-on-the-Bench Researchers

The SMART program focuses on supporting students who demonstrate interest in conducting applied research. The highly selective program has grown from 27 awards in 2005 to 251 awards in 2009. In 2010 only 298 awards were granted out of 3,400 applications, resulting in an acceptance rate of slightly more than 8 percent.

"The process begins when students engage in research projects with faculty," says Julie A. Adams, associate professor of computer science and computer engineering. "The scholarship . . . augments their research and academic opportunities with a real-world experience via the required summer internship with the associated DoD sponsor."

Now a graduate student at VUSE, Okorn began undergraduate research on human-robot interfaces in Adams' lab after completing his freshman year. He works in the field of simultaneous localization and mapping in 3D (3D SLAM) for the automated mapping of smuggling tunnels, his master's thesis topic. Okorn completed his summer internship at the Navy's Space and Naval Warfare Systems Center in San Diego; his post-graduation job will be in its unmanned systems lab.

"The scholarship provides an income far greater than any internship or student job ever could and it allowed me to remove the loans I had," says Okorn, who credits Adams for extensive help as a mentor. "Professors like her are the reason I selected Vanderbilt, and I don't believe I would have achieved as much as I have without her."

He applied for the scholarship primarily for the job opportunity. "I work in mobile robotics, and when it comes to robots, the government has the best technology and is doing the most advanced research," Okorn says. "Even before I learned which lab picked me up, I was excited. But when I learned I would be working on military robots in San Diego, it was unbelievable."

Freedom to Pursue Research

Doctoral student Ebonee Walker says SMART spells freedom. "The stipend and the job after graduation mean I don't have to worry about questions like 'Do I have funding?' and 'What am I going to do after this?' I have the freedom to pursue research I find interesting, and I can avoid some issues that may become a distraction to the process," she says.

Walker interned at the U.S. Army Aviation and Missile Research, Development and Engineering Center at Redstone Arsenal in Huntsville, Ala., and will work there after graduation. Her research involves using carbon nanotubes in missile composite materials to enhance thermal properties.

JOHN RUSSELL

Adsorbed in His Work

Doug LeVan seeks to improve air quality both on Earth and in space

by Joanne Lamphere Beckham, BA'62

Can the world burn fossil fuels for energy in a way that doesn't contribute to global warming? What can be done to protect people from the release of toxic chemicals? How would NASA care for a sick astronaut during long-duration space explorations like a manned mission to Mars?

These are some of the problems that drive M. Douglas LeVan, J. Lawrence Wilson Professor of Engineering and professor of chemical and biomolecular engineering at the Vanderbilt University School of Engineering.

A leader in the field of adsorption, LeVan seeks to improve air quality both on Earth and in space. Working at the interface between pure research and its applications, he and his team of researchers are developing new materials and striving to understand old ones better.

Adsorption involves the use of solids to filter substances from either gases or liquids. It differs from *absorption*, in which a fluid permeates or is dissolved by a liquid or solid.

"My research has focused almost entirely on gas phase adsorption onto different materials," he says. The results have implications for the environment, space exploration and the military.

New Developments for Greenhouse Gases

Currently, his research group studies adsorption of gases on nanoporous materials. Such materials contain pores smaller than a nanometer (one billionth of a meter). In addition to applying theory, the team uses models and experiments in air separation, gas storage, the removal of trace contaminants and other applications.

For example, the researchers are working on developing new metal organic framework adsorbents to remove carbon dioxide from the flue gases of coal-fired power plants. Funded by the U.S. Department of Energy, this research may help reduce the greenhouse gases that contribute to climate change.

"The object is to capture carbon dioxide and concentrate it enough to store in old wells or use it to drive oil and natural gas to producing wells for enhanced recovery," he explains.

LeVan has received continuous research support from the U.S. Army for more than 20 years. Currently, his group is working with the Army to develop new adsorbent materials and to study equilibrium and rate properties of new and existing adsorbents.

Into Space and Back

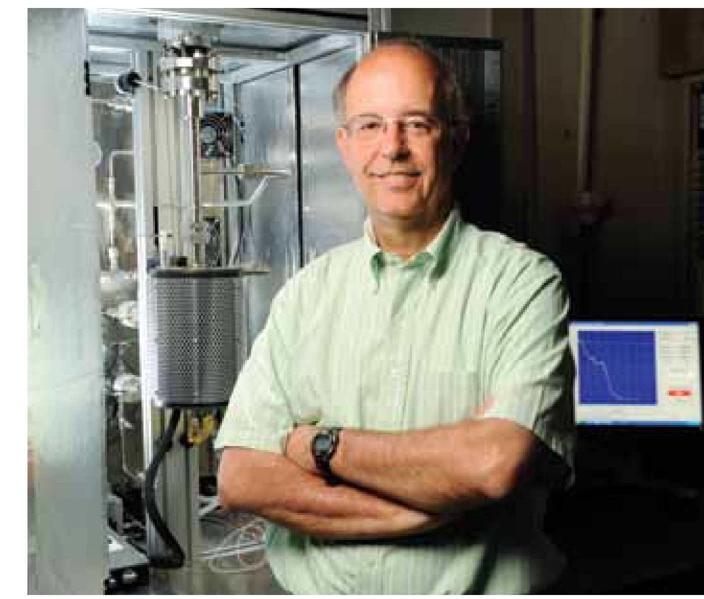
During the past 15 years, LeVan's NASA research has involved many aspects of advanced life support and *in situ* resource utilization. Current collaborations include the development of small medical oxygen concentrators that will help keep astronauts healthy during long-duration space missions.

"Our goal is to take air from the spaceship cabin and enrich part of it in oxygen for astronauts who might become ill during the mission," LeVan says.

Opposite page: LeVan and doctoral student Amanda Furtado examine nanoporous carbon adsorbents.

Another project involves compressing oxygen to very high pressures using adsorption technology. The oxygen could then be used by astronauts on extravehicular activity expeditions from the International Space Station and on future manned missions to Mars, where resupply is impossible. The pressurized oxygen could also be used in propulsion to burn fuel.

LeVan is also investigating the improvement of systems for the removal of trace contaminants and carbon dioxide from spacecraft cabins. This research could help prevent situations like that experienced by the Apollo 13 crew in 1970 (and depicted in the movie *Apollo 13*), in which CO_2 levels became too high in the space capsule, threatening the astronauts' lives. LeVan says that by using adsorption and hydrogen, the CO_2 could produce water and methane. The water, in turn, could be converted into oxygen for breathing and hydrogen for fuel.



JOHN RUSSELL

Doug LeVan

Teaching and Research

Formerly a member of the engineering faculty at the University of Virginia, LeVan came to Vanderbilt as Centennial Professor and chair of the Department of Chemical Engineering in 1997. He has been a Fulbright Scholar to Portugal and France and a visiting professor at Perpignan University in France and the University of Queensland in Australia. Considered one of the top experts on adsorption processes, he also has edited and authored numerous books and articles and consulted with international clients, including fuel cell innovator Bloom Energy. In 2008, he stepped down from department chair to devote more time to teaching and research.

It is in those arenas that LeVan prefers to be. When he speaks of research, the world-renowned leader in chemical engineering sounds like an artist, using phrases like "beautiful structures" and "exquisite frameworks." When he speaks of teaching, he admits, "I'd much rather work with students on these types of projects for the joy of it."

A Maxim to Live By

by Becky Green

Learn, earn, return. Civil engineer Sam McCleskey, BE'51, has made that phrase his philosophy for every stage of his adult life. That dictum, combined with McCleskey's success, has in turn made an enduring difference in the lives of students in the School of Engineering.

McCleskey began the learn phase of his adult life when he arrived at Vanderbilt's campus in 1947 from Memphis, Tenn. McCleskey and 2,499 other recipients nationwide had been selected out of 50,000 applicants to receive Naval ROTC scholarships. "It was an immense honor," McCleskey says. He would not have been able to attend the School of Engineering without the aid, he says.

The scholarship paid for his tuition and books, and allotted him $50 in spending money each month. "My scholarship required that I take 15 hours each semester as well as three hours of naval courses," McCleskey says. "It was a challenging four years, but well worth it."

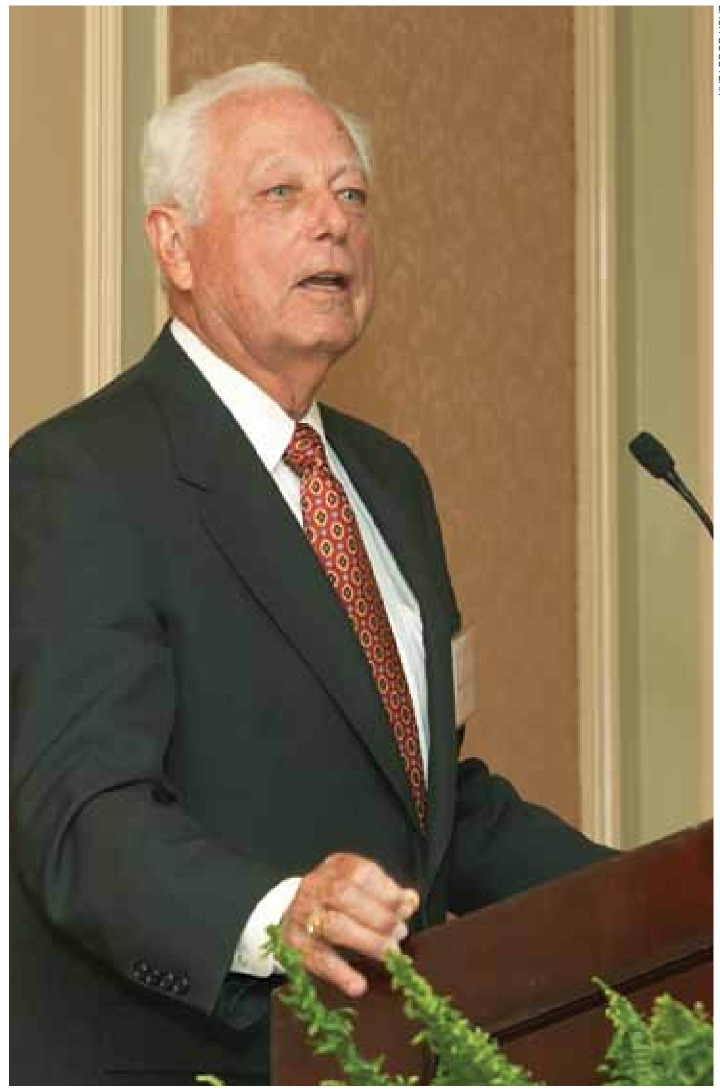
Earn

Within two days of graduating with a bachelor's degree in civil engineering, McCleskey obtained his naval commission and married Arden Keillor. McCleskey served in the Navy for three years and with the Army Corps of Engineers before returning to Memphis to follow in his father's footsteps by working as a surveyor.

In 1956 he went to work for Gulf Oil Co. as a construction engineer in Louisiana. A few years later, he was hired as vice president of construction for J.C. Milne Co., an Oregon-based company that specialized in building mausoleums.

"After learning the industry of mausoleum construction and the principles of business, I started the McCleskey Construction Company in 1961," McCleskey says. He simultaneously opened an architectural engineering division, MCF Architects.

Over the next decades, McCleskey built a business that combined engineering, design and customer service. Applying engineering know-how to considerations for structural design, environmental and climatic conditions, local development codes and material durability and maintenance, McCleskey Construction soon served clients from coast to coast. Sam McCleskey served on the boards of directors of the Georgia Cemetery Association, the Southern Cemetery Association and the National Association of Cemeteries. Today, he is one of only six people inducted into the Suppliers Hall of Fame for the cemetery and funeral industry, and his Atlanta-based mausoleum and memorialization company is now celebrating its 50th year in business. In 2007, he was named a member of the Vanderbilt University School of Engineering's Academy of Distinguished Alumni.



ZACH GOODYEAR

Sam McCleskey, BE'51, lives by the motto, "Learn, earn, return."

Return

Twelve years ago, Sam and his wife, Arden, established the McCleskey Honor Scholarship to support exceptional undergraduate engineering students who otherwise might not have the means to attend VUSE. "The scholarship benefits well-rounded individuals who demonstrate broad-based interests. This was created to help students in much the same position I was in when I entered Vanderbilt," McCleskey says. "I am appreciative of my opportunity and felt an obligation to return it."

One of the first recipients was Jordan Winston, BE'02. "The scholarship served as motivation, as I knew I had to maintain a high GPA to keep the scholarship. I ended up graduating summa cum laude with a double major in biomedical and electrical engineering," Winston says. That high GPA and his engineering background helped Winston get into medical school.

The scholarship also pushes students to reach their full potential and receive a quality education. "The McCleskey Honor Scholarship was a huge blessing for me," says Lauren Shepherd, BE'05. "Not only was I appreciative of the recognition for my hard work and commitment to academic excellence, but also the financial aid from the scholarship meant that I could focus my attention more fully on my education. The financial burden eased by the scholarship directly impacted the freedom I felt to devote myself completely to my studies."

> "The next generation of engineers will inherit a unique set of problems. . . . It will be up to you to solve these problems."
>
> —Samuel McCleskey, BE'51

Scholars' Turn to Learn, Earn and Return

McCleskey believes that now, more than ever, a Vanderbilt education is crucial. "With the global population expanding, the next generation of engineers will inherit a unique set of problems," the veteran entrepreneur says. He advises current students to learn as much as they can. "It will be up to you to solve these problems."

McCleskey's former scholars are doing their parts. Physician Winston is finishing up his training as a hospitalist. Derek Detring, BE'05, has started an energy advisory firm in Houston.

"When I received the McCleskey scholarship, it reinforced that a good work ethic and a good attitude are not only appreciated, but also rewarded in the 'real world' away from home," Detring says. "This continues to cultivate an environment of solid work ethic in my life, which is especially important now as I am a new small business owner."

ZACH GOODYEAR

McCleskey with former scholar JoAnn Todd Anderson, BE'05

Shepherd is currently in graduate school at the University of Washington in bioengineering. Her research focus is in the development of cheap, rapid and portable diagnostic devices for global health applications.

"As a graduate student, I now realize just how rare and valuable my experiences were as an undergraduate at Vanderbilt," she says, noting that she feels the School of Engineering's reputation continues to help and support her. "I feel like my acceptance to graduate school, as well as my success in securing a NSF Graduate Research Fellowship to help fund my work, was definitely aided by the quality and reputation of the education I obtained at Vanderbilt."

Vanderbilt University School of Engineering

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The Lewis Society plays an integral role in the success of the Vanderbilt University School of Engineering. The financial support of alumni, parents and friends helps deserving students receive an exemplary engineering education as well as a wonderful overall academic experience. That support makes a positive difference in the lives of students and faculty, and ensures continued growth of the school.

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ZACH GOODYEAR

From left, Beverly Smith, Academy of Distinguished Alumni member Bob Smith, BE'51, and retired Cmdr. Robert L. Brown, BE'50

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Class of 1977
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Class of 1978
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Alumni gifts directly affect that ranking. The percentage of alumni who give back to their schools is a factor in the magazine's ranking methodology. Currently, less than 15 percent of VUSE alumni make a gift each year to the school. You can help us achieve new levels of prominence with a gift of any size. To support your school and send the message that a Vanderbilt engineering education matters, contact the Vanderbilt Fund Office at 1-866-882-FUND, or give online.

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ZACH GOODYEAR

From left, Sandy Thomas, BE'64, Terry Thomas and Hibbett Neel, BE'63

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Robert S. Boswell (BE'71)
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Richard L. Johnson (BE'71)
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A Look Back

When the Boys Came Home

Returning World War II veterans swelled enrollment at Vanderbilt, particularly in the School of Engineering. VUSE's enrollment went from a wartime low of 158 in 1943-44 to 574 students in 1945-46. It reached a then-record high of 821 undergraduates in 1948-1949.

A report to the Board of Trust stated, "Naturally, classrooms and laboratories have been crowded, and the need for larger quarters has been keenly felt." The influx prompted the administration to move ahead with construction of a new 72,000 square-foot engineering building (shown right, under construction). Designed by Hart Freeland & Roberts (with two alumni co-founders, F. Eugene Freeland, BE 1906 and Martin Roberts, ME 1905), the building opened in September 1950. For once, all engineering classes were under one roof.

The growth, while challenging, did have other positive results. "There is no doubt the crowded conditions of the last several years have actually enabled us to improve the quality of the students enrolled," noted Chancellor Harvie Branscomb.

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