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“I tell laboratory researchers that if they can give me the details of how they make diagnoses in a full-scale lab, I can miniaturize the process for them.”

— Professor Li

Lab-on-a-chip

New Flowers Professor survives Chinese Cultural Revolution to revolutionize technology

Borrowing Li’s dream is to create a miniature, portable laboratory on size of a business card, capable of on-the-scene diagnosis of diseases and rapid detection of biochemical warfare agents. The new H. Fort Flowers Professor of Mechanical Engineering is well on his way to creating this and other revolutionary “lab-on-a-chip” technologies.

Professor Li learned the fine art of rapid response and portability long before entering his first laboratory. A youngster during the Chinese Cultural Revolution, Li was only 11 when his family was forced by the government to leave their home in Hefei, the large capital city of the Anhui province, and move some 1,000 kilometers away to the countryside. Li and his family subsisted on wheat, sweet potatoes, and apples grown in their new home.

“No, I do not like whole-wheat bread,” Li says with a smile.

Seizing Opportunities

Hardship had its advantages, Li says. It taught him to seize and appreciate opportunities and to surmount obstacles. It also taught him the value of processing a great deal of information in a short period of time.

“When the Cultural Revolution ended and we moved back to the city, I was about six weeks to prepare for an entrance exam to the newly opened university,” he says. “The exam covered all high school subjects, and I had not attended school since we moved to the countryside.”

Borrowing a review book, Li crammed for the exam. Not only was he-admitted to Zhejiang University, but he was assigned to study thermophysics. The fact that he had no choice in what he would study did not disturb Li. He was far too busy feeling lucky. “I felt like I caught the last train out,” he says. “I was already 22 years old at that point.”

After graduating in 1982, good fortune arrived again two years later in the form of government sponsorship to take graduate courses abroad. Government-mined by the Chinese government to attend a Canadian school, he was accepted by the University of Toronto. He received his Ph.D. degree in mechanical engineering in 1991 and completed a post-doctoral fellowship at Toronto the next year. He then held faculty positions in mechanical engineering at the University of Victoria and the University of Alberta, where he became a tenured professor. He returned to the University of Toronto as full professor in July 2000.

Pioneering Work

Freed at last to follow his own research interests in graduate school, Li focused on surface thermodynamics and quickly realized that he was in a good position to contribute to a better understanding of fluid flows in microchannels. These research areas became particularly important in the last few years as lab-on-a-chip technology began to emerge.

“Lab-on-a-chip” technology refers to hand-held devices that are able to quickly analyze DNA and proteins within miniature but fully integrated laboratory systems. These devices can be used directly in the field by police, emergency medical technicians, security personnel, and hazardous materials assessors.

“Dr. Li is a pioneer in the lab-on-a-chip field,” says Engineering Dean Kenneth F. Galloway. “We are very excited to have him as H. Fort Flowers Professor.”

Considered one of the world’s leading researchers in lab-on-a-chip technology, microfluidics and nanofluidics, Li had already developed many lab-on-a-chip technologies at Toronto before joining Vanderbilt last semester.

“I tell laboratory researchers that if they can give me the details of how they make diagnoses in a full-scale lab, I can miniaturize the process for them,” Li says.

It will develop more of these technologies at Vanderbilt, in addition to conducting fundamental research in fluid behavior at the micro- and nanoscale. One device he is working on will be able to detect bacteria, viruses and cancer by using fluorescence and a miniature laser multiplex system. The instrument will be able to complete tests within 30 minutes, compared with 4-6 hours required by conventional laboratory tests. Another device will be able to separate white blood cells and DNA from a single drop of blood.

A prolific writer and researcher, Li is editor in-chief of the journal Microfluidics and Nanofluidics. He has published one book and more than 155 papers in leading international journals.

Engineer, Inventor, Philanthropist

The H. Fort Flowers Chair in the School of Engineering was created through the contributions of the Flowers family to honor the late H. Fort Flowers, who received a B.E. degree in engineering from Vanderbilt in 1912 and an M.E. degree in 1913. A highly successful engineer, inventor, manufacturer and philanthropist, Flowers invented the side-dumping gondola railroad car for transporting and delivering bulk materials. He founded the Differential Steel Car Company to manufacture these cars which were widely used by railroads, mining operations and steel mills. A man of wide interests, Flowers held more than 80 patents. A former vice president of the Vanderbilt Alumni Association, he was awarded the Distinguished Engineering Alumni Award in 1973, posthumously.

— Vivian F. Cooper
Wanted: Alumni to Help Recruit Engineering Students

A on of its many efforts, the Engineering Alumni Council (EAC) is encouraging alumni engineers to become involved with Vanderbilt at their hometown national alumni chapter or regional alumni committee (ARC). These locally based ARC’s are an established joint venture of the offices of Undergraduate Alumni and Alumni Relations. Their mission is to coordinate alumni efforts and to build the best possible relations with their classmates each year, personalize the admissions process, convey the Vanderbilt story, and increase the University’s visibility to prospective students and alumni. Alumni involvement in student recruitment is an excellent match, because alumni know the Vanderbilt experience, can provide a personal element to the process, and can help bring the University to life for the prospective student.

You can become involved in several different ways:

• Participate in college fairs—Pass out information, gather inquiry cards, and share your personal experiences about your time spent at Vanderbilt with prospective students.
• Local area meetings—Contact your local alumni chapter and encourage them to make a decision to commit to Vanderbilt.

Attend the alumni student admissions interview program to further promote Vanderbilt to prospective students and help admissions to better appreciate the applicant process.

Write an alumni letter of recommendation on behalf of a prospective student.

There are ARC in more than 40 states currently helping Vanderbilt to strengthen the applicant pool and provide the admissions office with alumni who can help students make the right decision and get involved in the University.

EAC is sure that focused engineering alumni involvement can provide additional recruitment support for the School of Engineering. We hope you will join us in this effort.

—Steve Lainhart, BE’74
EAC Vice-President of Student Recruitment

Faculty Notes

Brenton Dou rant, professor of electrical engineering and computer engineering, was recently elected chair of the steering committee for the Institute of Electrical and Electronic Engineers (IEEE) Ponsorship on Medical Imaging Adding

Peter T. Cummings, John R. Hall Professor of Chemical Engineering, has been elected a fellow of the American Physical Society. Each year, no more than half of 1 percent of the APS membership becomes a fellow.

David M. Hestand, professor of electrical engineering and chair of the Department of Electrical Engineering and Computer Science, has been elected to the administrative committee of the IEEE Nuclear and Plasma Sciences Society.

Kenneth F. Galloway, dean of the School of Engineering, chaired the 2005 Engineering Dean’s Council Public Policy Colloquium, held in February in Nashville.

Thomas R. Harris, Orrin H. Ingram Distinguished Professor of Biomedical Engineering and chair of the Department of Biomedical Engineering, recently presented over the American Institute for Medical and Biological Engineering Annual Meeting in Washington, D.C. For the past year, Harris has served as president of the organization. He also has been appointed to the 2005 inaugural class of fellows and received a distinguished service award from the Biomedical Engineering Society.

Two other faculty members also were named fellows of the Biomedical Engineering Society: Paul H. King, associate professor of biomedical engineering, and Robert J. Roditi, professor of biomedical engineering.

Bridget Rogers, associate professor of chemical engineering, has been elected to the American Vacuum Society board of directors.

Richard E. Spence, Centennial Professor of Civil and Environmental Engineering, smier, received the 2005 Founders’ Award from the Association of Environmental Engineering and Science Professors (AEESP) last October. Professor Spence also delivered the named keynote address for the AEESP Water Environment Federation annual meeting.

Sanchez receives NSERC CARE Award for nanofiber concrete research

C ontinuing in concrete is not all it’s cracked up to be. Concrete structures—those composites of natural and man-made components—may be responsible for the end of nature as we know it and the start of a new era of nanotechnology.

Flavio Sanchez is looking into the fascinating world of nanofiber concrete as a means to strengthen concrete by adding nanofiber-reinforced cement-based materials to the mix. This research draws on a variety of cutting-edge techniques from nanoscience to micromechanics (a nanometer is one billionth of a meter), and may hold the key to a new world of concrete for the future.

Assistant Professor Sanchez is her research on long-term durability of nanofiber-reinforced cement-based materials. Her research is focused on understanding the strength characteristics of concrete made with nanofiber-reinforced cement-based materials and how these new materials will perform over time, in a variety of conditions because of its composition.

“For nanofiber-reinforced cement-based materials, the cement is an ancient material that has been used for centuries, but its chemistry is still not well understood,” Sanchez says. “We mix cement with aggregates to create concrete, which we often reinforce with steel rebars. The rebars corrode over time, leading to significant problems in our transportation and building infrastructure.”

Sanchez wants to explore how the new materials being developed by the nanoreinforced cement-based materials research team at MIT might contribute to solving the problem.

“Instead of being constrained to the traditional job of making cement-based materials, we are free to explore the properties of the nanoreinforced cement-based materials and how these new materials will perform over time, in a variety of conditions,” Sanchez says. “It is the first time we’ve looked at these nanofibers and seen how they can react with the mixture and reinforce the concrete.”

Sanchez will use a three-year, $391,411 CARE Award from the Natural Sciences and Engineering Research Council of Canada (NSERC) to continue her work.

Bend It Like Buckyballs?

Sc ecor rollo-shape “buckyballs” are the most famous materials ever to be explored by scientists as they examine the prospects of revolutionary medicine and the computer industry. Since their discovery, buckyballs and buckyball-like carbon-atom molecules have been exploring the properties of these materials for a range of applications and innovations.

These graphite-like molecules represent a potential environmental hazard. A new study published in December 2005 in Biophyocical Journal struck a caution note for researchers who have used traditional methods for the synthesis of buckyballs and determined their potential to be toxic to the environment and the health of future generations. This study, led by researchers at Vanderbilt, suggests that the combination of buckyballs’ dislike of water and their affinity for such carbon-based molecules might cause them to clump together and sink to the bottom of a lake, pool, lake, stream or other aquatic environment. As a result, researchers thought they should not cause a significant environmental problem.

Cummings’ team found that, depending on the form the DNA takes, the 60-carbon-atom (C60) buckyball molecule can lodge in the end of a DNA molecule and break apart important hydrogen bonds within the double helix. They can also stick to the minor groove on the outside of DNA, causing the DNA molecule to bend significantly to one side. Damage to the DNA molecule is even more pronounced when the molecule is split into two halves, as it does when the cell is dividing or when the genes are being activated to produce proteins needed by the cell.

“Damage to the DNA by buckyballs is quite strong,” Cummings says. “We found that the energy of bonding was comparable to the binding energies of a drug to receptors in cells.”

It turns out that buckyballs have a much greater affinity for DNA than they do for themselves. “This research shows that if we can design this molecule, it can bind to DNA,” Cummings says. “If the DNA is damaged, it can be inhibited from self-repairing.”

More research needed

What the researchers don’t know is whether these worrysome binding events will take place in the body. Earlier studies have shown that buckyballs can migrate into tissues, Cummings says. “We don’t know whether our experimental and theoretical studies to demonstrate whether they can actually get there. Because of the toxicity of nanomaterials like buckyball is not well known at this point, they are regarded in the laboratory as potentially very hazardous, and that is troubling.”

—Vivian F. Cooper

Brain mapping helps Parkinson’s patients

One of thousands of people who experience movement disorders associated with Parkinson’s disease and a variety of other neurological conditions stand to benefit from a new guidance system that uses computerized brain-mapping techniques to significantly improve an increasingly common surgical procedure called deep brain stimulation (DBS).

DBS has proven to be highly effective in the treatment of movement disorders such as Parkinson’s. However, it is limited to people with such severe neurological issues that they cannot receive standard drug therapies. The new system can do a better job for patients in one of the first insertions two out of three times, compared with one out of five times without it. According to Konrad, this innovation has reduced the length of the operation from two days down to five hours.

The computer-aided guidance system consists of a three-dimensional brain atlas that you can use by combining the brain scans of 21 postoperative DBS patients into one another using sophisticated computer-mapping methods. To predict the location of the target area in a new patient, the researchers map the reference atlas onto the patient’s brain structure. When the neurosurgeons have used this prediction in collaboration with Professor Konrad, associate professor of neurological surgery and biomedical engineering.

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“Leaching” is the action of a liquid passed over and through a solid. Kosson likes to use drip coffee as an example of a leaching process.

Kosson and Sanchez have reason to be proud. The leaching protocol they developed, along with VanderbiIt col- leagues Andrea Gazzaroba and H.A. van der Sloot of the Netherlands Energy Research Foundation, is a powerful, highly adaptable tool for power engi- neers and environmental engineers. "The protocol considers the range of known coal combustion residue chem- istry and management conditions," Kos- son says. The method also permits develop- ment of data that are compar- able across U.S. and other types of coal.

The approach has also been demon- strated to be applicable for evaluating potential environmental impacts from a wide range of solid materials for benefi- cial use and disposal.

Published in Environmental Engi- neering Science 2002, the protocol has its beginnings in the 1980s, when Kos- son was on the faculty at Rutgers and was trying to help the state of New Jersey figure out what to do with solid waste residue after incineration. Kos- son happened to meet van der Sloot during a conference in Europe, and the two discovered they had similar frustra- tions with the existing frameworks for assessing leaching. Kosson and van der Sloot put their heads together to design a more compre- hensive and adaptable protocol based on the traditional method. "A lot of the ini- tial design work was detailed out on napkins while riding the train to and from Washington, D.C.," Kosson says. The researchers "tried to determine the intrinsic leaching properties of contami- nants of interest and to develop com- puter simulation models that use the intrinsic properties to predict contamina- tion under various conditions in the field. The traditional protocol attempted to mimic conditions in the field, which basically required "re- inventing the wheel" for each facility. The new protocol is based on input data and known dynamics, and varia- tions from site to site are accounted for using the simulation modeling." "The leaching protocol we developed, and continue to refine, is based on characterizing fundamental param- eters of leaching dynamics of contami- nants and then modeling them to predict outcomes in different field sce- narios," Kosson says.

As part of this project, Kosson and Sanchez ran tests to check the validity of their protocol in producing actual results in the field. "The Leaching Framework was able to fully satisfy our quality assurance and quality control requirements," Sanchez says.

Mercury rising

The protocol, which is being adopted in Europe and is being used by the EPA in several situations, can be employed in a variety of industrial and public utility situations. Kosson and his associates have been working with the agency to replace the traditional contaminants the agency currently uses in tests. What we found was that mercury concentration levels below the mercury detection limit maximum contaminant level, but the arsenic and selenium concentrations present the potential for adverse environmental impacts with and without the new method," he says.

The good news is that Kosson and Sanchez also found, much to their sur- prise, that the testing series and interpretation software they have developed to evaluate and predict how contaminants will behave under various environmental and waste-management sce- narios is as valid as they had hoped it would be. "The protocol is very solid," Kosson says with a smile.

Napkins and Coffee Grounds

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Survive and Thrive in Engineering School

E ach fall, the School of Engineering co-sponsored with the Babcock Johnson Black Cultural Center a Distinguished Black Alumni Talk by Tamara Rayburn, senior research scientist with Gannett Fleming. In her talk, “Survive and Thrive in Engineering School: Success Through Community,” Rayburn discussed what faculty, alumni and minority students can do to ensure their success in obtaining an engineering education. She encouraged students to take advantage of undergraduate research opportunities and urged minority alumni to participate in an mentoring program with current students.

A native of Charlotte, N.C., Rayburn earned a B.E. degree from Vanderbilt in 1995, with a double major in biomedical and electrical engineering. She went on to earn M.S. and Ph.D. degrees in biomedical engineering from the University of Alabama, Birmingham, in 1997 and 2003, respectively.

Upon returning to Gannett Fleming, Rayburn was a postdoctoral fellow at the University of Georgia. She has held faculty positions at Georgia and SUNY Downstate Medical Center in Brooklyn, N.Y.

She has held positions at Georgia and SUNY Downstate Medical Center in Brooklyn, N.Y. The author of several peer-reviewed articles in biomedical research journals and a chapter in Quantitative Cardiovascular Electrophysiology, Rayburn also has six patents pending in the area of cardiovascular device therapies.

E ntrepreneurial engineering student Andrew Zachar started down the road to becoming a test pilot when he received his first remote-control airplane at age nine. At 17 he signed up for flying lessons near his Chicago home, earning his pilot’s license before his 18th birthday.

While at Vanderbilt, Zachar took courses in aerospace propulsion and airplane aerodynamics taught by Professor Amiran Ankanar as part of his mechanical engineering curriculum. Last summer, Zachar obtained an internship with Boeing, working in the flight test engineering department on the company’s new, very flight business jet, the Cessna Citation Mustang. After graduation in May, Zachar will join the company as a flight test engineer, on track to become a test pilot in a couple of years.

“Test flight engineers design, oversee and analyze the tests needed for development and certification of the aircraft,” Zachar says. He advises to young engineering students “Find something you’re passionate about, that makes you thrive. If you have the opportunity, go after it.”

Michael Irvine Mott, a member of the School of Engineering’s Committee of Visitors, passed away on November 19, 2005, following a battle with cancer. A Marine aviator, test pilot and Boeing aerospace executive, he received a bachelor’s degree in engineering science from Vanderbilt in 1971 and an M.S. from the University of Southern California in 1981.

A winner of the Distinguished Eagle Scout Award, he was a graduate of Battle Command Academy in Franklin, Tenn. He served in the U.S. Marine Corps for 20 years, retiring in 1991. After graduating from the Naval Test Pilot School, he flew or participated in 89 major test projects. Following his military career, he became associate director for NASA. He then served as vice president and general manager of NASA systems for Boeing Aerospace and was responsible for the strategic direction of Boeing’s civil space programs.

He is survived by his wife, Kathy; son, Michael Irvine Mott Jr., a 2003 graduate of the School of Engineering; daughter, Ashley; mother, Edith W. Mott, Ph.D.; and brother, William E. Mott, MLA ’78, Ph.D. ’80.

Valued COV Member Dies

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Michael Mott, BE’71

Mott, 55, of Saddle Brook, N.J., was a graduate of the University of South Carolina in 1971 and an M.S. from the University of Southern California in 1981.

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He is survived by his wife, Kathy; son, Michael Irvine Mott Jr., a 2003 graduate of the School of Engineering; daughter, Ashley; mother, Edith W. Mott, Ph.D.; and brother, William E. Mott, MLA ’78, Ph.D. ’80.
International chess champion Dan Fleetwood sees parallels between his serious hobby and his profession.

"In chess, as in science and engineering, you need to be able to break problems down into parts and look for patterns," says the professor of electrical engineering and chair of the Department of Electrical Engineering and Computer Science (EECS). "Chess provides good training in critical thinking, logic, strategy and tactics."

Fleetwood recently finished eighth in the 18th World Correspondence Chess Championship, and first place on board three of the 14th World Correspondence Chess Olympics. The latter takes him halfway to a coveted grandmaster title; there are only six correspondence chess grandmasters in the U.S. Since he plays by email in the evenings and on weekends, "An average game usually lasts one to two years," he says.

Growing up, Fleetwood was used to long days of hard work at his parents’ small grocery and 265-acre farm near Seymour, Indiana — a place that inspired John Mellencamp’s song, “Small Town.” Today, Fleetwood’s name graces his high school’s Wall of Fame along with fellow alumnus Mellencamp.

Fleetwood says he took up serious chess “relatively late” during his senior year in high school, “when I hung up my spikes.” A baseball pitcher with a perfect game to his credit, he idolized Hank Aaron and still pulls for the Atlanta Braves.

After receiving his Ph.D. from Purdue University in 1984, Fleetwood joined Sandia National Laboratories in Albuquerque, New Mexico. While there, he worked for 15 years on radiation effects on microelectronics for space and defense applications.

In 1999, Fleetwood joined the Vanderbilt faculty as professor of electrical engineering. He served as associate dean for research from 2001-2003, and became chair of EECS in 2003.

When speaking of his research, he notes that "Vanderbilt has the top academic research program on radiation effects on microelectronics in the United States and probably in the world." Fleetwood is the author of nearly 300 journal articles in this area and has received numerous research awards during his career.

He and his wife, Betsy, a past president of the Vanderbilt Woman’s Club, have three sons — one a sophomore in the College of Arts and Science. Fleetwood says his greatest challenge is "balancing department chair duties with the demands of our research programs, teaching and having a real life."

“EECS is a big department, relative to others at Vanderbilt,” he says. “We have 55 tenure-track faculty, two large research institutes — ISIS (the Institute for Software Integrated Systems) and ISDE (the Institute for Space and Defense Electronics) — and the largest graduate program at Vanderbilt, with 175 students. We have about as much sponsored research as physics and chemistry combined. Keeping on top of everything is a challenge.”

When it comes to meeting challenges, this chess champion is a master.

— Joanne Beckham
Today, an ever-increasing number of eager, bright young men and women who are considering an engineering degree can now consider Vanderbilt. Our alumni, parents and friends have all played a vital role in this positive development, many of the School of Engineering’s most dedicated supporters are members of the Fred J. Lewis Society. Established 30 years ago, the Lewis Society honors the legacy of Dean Fred J. Lewis. Under his leadership from 1933 to 1959 the school enjoyed a great upsurge in enrollment, an expansion of facilities and, of paramount importance, a strengthening of academic programs. Membership in the Lewis Society is a gesture of affirmation of all that Dean Lewis accomplished and an investment in the School of Engineering’s continued success.

In the fiscal year 2004-2005, Lewis Society members’ generosity to the School of Engineering exceeded $4,291,000. A portion of this largesse is earmarked for financial aid and scholarship support funds that will make a Vanderbilt engineering degree a reality for many well-deserving students. With further support, we will continue the good work started so many years ago by Dean Lewis. I am grateful to all of those who have chosen to invest in the future of the School of Engineering, our students, and our faculty.

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2004-2005
Introducing the Academy of Distinguished Alumni

At the School of Engineering, we’ve always believed in recognizing our most accomplished alumni. When our alumni succeed, the School of Engineering and Vanderbilt succeed. In the past, we’ve recognized an outstanding graduate each year with our Distinguished Alumni Award. Now, to give these alumni—past and future—ever greater recognition, we’re inaugurating the School of Engineering Academy of Distinguished Alumni.

All past recipients of the Distinguished Alumni Award will now be recognized as founding members of the Academy. They will be joined by new inductions every year. Future honorees will be selected by a committee comprised of representatives from the Executive Committee of the Engineering Alumni Council, the faculty of the School of Engineering and the Office of Development and Alumni Relations.

Save the Date

This year’s awards banquet will coincide with Reunion/Homecoming activities. Mark your calendars for Thursday, October 19, 2006, to learn about the newest members of our Academy of Distinguished Alumni.