If there's one thing an engineer knows how to do, it's construct efficient systems — whether it's a circuit board or a manufacturing process. In medicine, this skill is particularly critical to ensure that patients receive the best possible care.
A Welcoming Environment for Undergraduate Research

The faculty in the Engineering School actively encourage our undergraduates to participate in research. As educators, we understand that research helps students see the ideas and information we cover in the classroom in their full light: as powerful tools for solving problems, designing systems and making discoveries.

We also find that research gives students a firsthand sense of what it takes to be an engineer in the real world. In the course of their projects, they learn that taking the initiative, mastering new fields of knowledge, working closely with others and understanding new perspectives are all part of being an effective engineer.

In fact, we’ve found that involving undergraduates in our research projects adds an important new dimension to our relationship with students. There are many opportunities for us to mentor students when we work side by side to achieve a common goal.

In this issue of IMPACT, we focus on student research in medicine. These opportunities are available to all our students, thanks to our proximity to excellent schools of medicine and nursing at U.Va. and through our biomedical engineering program. But this is not the only research area in which our students are involved. They work closely with faculty in all our departments to make the discoveries that will enable us to engineer a better future.

P. Paxton Marshall
Associate Dean for Undergraduate Programs
U.Va. School of Engineering and Applied Science

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UNDERGRADUATE RESEARCH IN HEALTH CARE
Eliah Shamir (BME ’08) came to U.Va. because she liked what she saw. “I was looking for an interdisciplinary program in biology that focused on problem solving,” she says. “The faculty in the Department of Biomedical Engineering fit the bill. They are enthusiastic, they have a great new building and their curriculum is flexible. You have plenty of choices.”

Shamir has made the most of them. After seeing a UNESCO documentary about the trade in minority women from the hill tribes of Myanmar, Laos and China into the Thai sex industry, she and her friend, Shi-Shi Wang, a foreign affairs major, decided to travel to Thailand to research HIV education and prevention among migrant sex workers. Together they applied to a number of organizations and received funding from the Raven Society, U.Va.’s Center for Global Health, and the Pfizer Foundation.

“Initially, I felt intimidated about applying for the project, but everyone I talked to was very supportive,” she says. Assistant Professor of Biomedical Engineering Brian Helmke helped her formulate her research proposal and submit it to the University’s Institutional Review Board, which is charged with protecting the rights and the safety of human subjects participating in research.

“My training as an engineer proved very useful,” Shamir says. “I mapped out the information I wanted to learn, and I prepared lists of questions and follow-up questions that would help me get the data I needed.” Before leaving, the two students built a network of contacts in Thailand, both by e-mail and by phone. “People kept on referring me to other people,” she says.

Shamir and Wang traveled to Thailand for nine weeks last summer — and their trip provided Shamir with a critical insight: despite meticulous preparation, research sometimes takes you into new and unanticipated areas. Upon arrival, she enlarged the scope of her project. While Wang maintained her focus on sex trafficking, Shamir expanded her research to cover the issues involved in creating sustainable and healthy communities for migrants as a whole, not just sex workers. “I found that few people had looked at the political and social circumstances of these migrants,” she says.

She conducted interviews in Bangkok and in migrant camps on the country’s western border with Myanmar.

Currently, Shamir, who won a prestigious Goldwater Scholarship before leaving for Thailand, is doing research with Paul Hoffman, a professor of medicine, infectious diseases and international health, getting a head start on the capstone project required of every biomedical engineering major. Ultimately, she would like to enter an M.D./Ph.D. program, perhaps in infectious diseases or immunology.

“I don’t know precisely where I want to go,” she says. “Right now I’m interested in exploring.”
A hundred years ago, all surgery was exploratory. If you wanted to find out what was the matter with a patient, you operated. Today, physicians have a suite of noninvasive diagnostic tools at their disposal, from X-rays to ultrasound to magnetic resonance imaging.

Drew Maier (CS ’07) is part of an effort to take one of the most powerful of these diagnostic tools, the 3-D CAT scan, and make it more useful in the operating room. A CAT scan is essentially an X-ray on steroids. While a simple X-ray image shows the body in profile, a CAT scan machine rotates around the body and takes a series of very narrow X-rays that can be assembled into a cross section. A 3-D CAT scan takes this a step further, stacking these slices — in essence creating a virtual, three-dimensional reproduction that radiologists can explore as if they were moving through the body. The problem for surgeons is that reconstruction of these images can take as long as 10 minutes to complete.

More Responsive Medical Devices

Hip replacement, open-heart surgery, organ transplants — none of the wonders of 21st-century medical care would be possible without the tools that engineers design. At U.Va., engineering students come away with a sense of the complexity that must be mastered to engineer products for the human body.

Precise Drug Delivery

Catheters are one of the marvels of medical science. They can be used to deliver radiotrace agents or stents, they can be inserted to drain urine from the bladder and they can be threaded into the coronary artery to measure pressures in the heart.

Over the last 20 years, SEAS mechanical engineering professors George Gillies and Joseph Humphrey, in partnership with Dr. William Broaddus at Virginia Commonwealth University, have developed a series of innovative catheter designs. Ali Hemyari (EE ’07) won a coveted 2006 Harrison Undergraduate Research Award from the University to work with them.

One use for catheters is to deliver a therapeutic agent through a blood vessel to a specific area of the body. The challenge is to keep the medication in place, where it can do the most good, rather than being swept away by the flowing blood. One approach is to use a balloon to block the blood flow periodically, but this poses the risk of tissue damage. U.Va. engineers are hoping that by improving the design of the catheter itself, they might keep the agent at its intended site longer.

Hemyari is working with Humphrey as his senior thesis adviser, in collaboration with George Gillies, to construct a large-scale model of this catheter. “The model will enable us to test different approaches and provide the essential data needed to produce a computer simulation,” says Hemyari.

Faster CAT Scans

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Ali Hemyari is helping to build a model catheter

“The model will . . . provide the essential data needed to produce a computer simulation.”
In an effort to slash this time, members of the Division of Interventional Radiology at the U.Va. Health System approached Associate Professor of Computer Science Kevin Skadron, who in turn enlisted Maier in the project. “We approached the problem systematically,” Maier says. “We determined that the bottleneck was not in the scanning or in the data transfer but in the reconstruction process.” Together with Professor Skadron, Maier is exploring the effect of replacing the system’s serial computer processing unit (CPU) with a powerful NVIDIA graphics card. The card can process non-graphical data in parallel, potentially shortening reconstruction time.

Maier’s task is to extract the CPU code and translate it into code that the card’s graphics processing unit can read. He meets with Skadron weekly, which keeps him on track, but adds, “When you’re doing research, you’re on your own to find the information you need.”

The average 3-D CAT scan is just too slow for Drew Maier

An Active Leg Brace

People with cerebral palsy often turn to leg braces to make their stride more efficient. Typically made of rigid materials, leg braces provide passive support and stability.

Marie Toluwani Adeyemi is working with Pradip Sheth, an associate professor of mechanical engineering, on an NSF-funded study to create an active leg brace, one that captures the excess energy that we all produce during our initial heel-strike and uses this energy to create a more efficient toe-off. She’s working with researchers at the University’s Motion Analysis and Motor Performance Laboratory at the Kluge Children’s Rehabilitation Center, one of the best-equipped centers of its kind in the United States. “Our goal is to help people with cerebral palsy walk more accurately and be more stable,” she says.

A third-year student in the School of Mechanical, Materials and Manufacturing Engineering at the University of Nottingham, Adeyemi has come to U.Va. for a year abroad. Her extensive background made her the logical choice to do a functional analysis of the prototype brace. She’s responsible for offering suggestions about materials, mechanisms and manufacturing and producing a 3-D model of an improved design.

“Before I came, Professor Sheth and I discussed a number of possible projects, but I chose this one because it combined a number of my interests,” she explains, “mechanics, innovation and a passion for working with kids.”
More Effective Treatments

The improvements in health care that we enjoy today are not simply the result of advances in medical science. They also reflect the mind-set and specialized knowledge that engineers bring to the table. As research under way at U.Va. shows, engineers are essential partners in reducing suffering around the world.

Robert Amanfu is part of a team building better bone grafts

Better Bone Grafts

For Robert Amanfu (BME '07), getting full value from his tuition means doing research. “The classroom is great,” he says, “but you cover existing knowledge. Research gives you the opportunity to have a part in discovering new knowledge.”

Amanfu is working in Edward Botchwey’s laboratory. Botchwey, an assistant professor of biomedical engineering, is studying the potential of using phospholipids to enhance the success of synthetic bone grafts. Researchers currently create bone grafts by injecting bone cells and growth-promoting proteins into a polymer scaffold. The problem is that the polymer creates an acidic environment, among other factors, that degrades the proteins. Phospholipids may prove to be an effective substitute.

Amanfu began his research career during his first year working in the corrosion laboratory in the Department of Materials Science and Engineering. “It was a great experience,” he recalls, “but I wanted a project closer to my own area of interest.” Amanfu met with Thomas Skalak, the chair of the Department of Biomedical Engineering, and secured a place in his laboratory. Botchwey approached him in spring 2006 and recruited him for his project.

“It’s not difficult finding a research opportunity in the Engineering School if you’re enthusiastic,” Amanfu says. “Faculty members are very receptive to undergraduates. They are sympathetic to the student perspective, and they understand why students want to do research.”

The Healing Power of Fat

Peter Stapor (BME ’08) approached his work in Shayn Peirce-Cottler’s laboratory as an apprenticeship. Over the course of a year, he moved from sterilizing Petri dishes to serving as a full-fledged lab technician. He learned how to harvest tissue from rats and stain it as part of an experiment to track the ability of adipose stromal cells (ASCs) from fat tissue to generate blood vessel growth.

Last summer, he took part in a study to develop a way to spray ASCs on chronic wounds, like bedsores, to promote healing. “I was trying to figure...”
In October, the World Health Organization issued yet another call for better and cheaper tuberculosis (TB) tests for developing countries. Tuberculosis kills an estimated 1.7 million people each year, but many of these deaths are due to wrong or late diagnoses. Courtney Paulding (BME ’07) is part of an effort at U.Va. to develop a practical test that produces results more quickly.

The acid-fast test, commonly used to detect tuberculosis, takes between six and eight weeks. Working with Michael Lawrence, an associate professor of biomedical engineering, and Dr. Eric Houpt, a professor in U.Va.’s Center for Global Health, Paulding is helping to improve a protocol for TB testing based on the polymerase chain reaction (PCR), a technique used to identify DNA. For the last five years, Houpt has collaborated with researchers at the Kilimanjaro Christian Medical Centre in Moshi, Tanzania, to develop more effective treatments for opportunistic infections associated with AIDS.

“With PCR, you can get results the same day,” Paulding says. “The problem is to make it more selective for TB.” Because of the difficulty in using infected sputum (or mucus) samples collected in Tanzania, Houpt takes TB-negative sputum and contaminates it with TB bacteria. Paulding’s job is to make sure that this synthetic sample is realistic, that it responds to acid-fast screening the way clinical samples do and that it matches samples used in the literature.

The project is one of several research experiences that Paulding has had as an undergraduate. “Doing research has given me the confidence to ask for help when I need it,” she reports. “That’s critical because there’s always information you need to learn.”
More Consistent Systems

If there’s one thing an engineer knows how to do, it’s construct efficient systems — whether it’s a circuit board or a manufacturing process. In medicine, this skill is particularly critical to ensure that patients receive the best possible care.

Online Screening for New Mothers

Joanne Weisberger’s experience illustrates how easy it is to find a research project at the Engineering School. Looking for a topic for her senior thesis, Weisberger (CpE ‘07) simply talked to her technical adviser, Associate Professor of Electrical and Computer Engineering Ron Williams. He handed her a list of requests for undergraduate researchers compiled by the Engineering School’s Department of Science, Technology and Society.

She was attracted by a notice from Emily Drake, a professor in the School of Nursing, looking for assistance in designing, developing and testing an interactive Web site to screen women for postpartum depression. “In just a week, we had all gotten together, and I started on my project,” Weisberger says.

Weisberger’s first task was to find out more about postpartum depression, which affects 10–15 percent of women any time from one month to one year after childbirth. Women with postpartum depression may feel restless, anxious, sad or depressed.

“Doctors do not always screen new mothers for postpartum depression,” Weisberger says. “Professor Drake wants to create a screening tool that provides confidential results and supports new mothers in the privacy of their homes.”

The project gave Weisberger, a computer engineering major, the opportunity to add to her programming skills. To create the site, she’s using PHP, a dynamic programming language, in conjunction with MySQL, a database management system.

“On a project like this, you have the responsibility to learn whatever it takes to complete it,” Weisberger says.

Weisberger has already created a preliminary site that Drake is testing on focus groups of new mothers. “It felt good to see it up and running,” she says.