

A graduate student encounters a life-renewing machine, inspiring her to build a similar creation. Future bioengineering prospects are tantalizing, and advances in the School of Engineering are helping to make them possible, along with many other innovations stimulated by support from Pitt enthusiasts.

Making Good

Written by
Cara J. Hayden

Photographs by
Ric Evans

A young woman wearing blue scrubs pushes a patient in a wheelchair. She rolls it slowly and smoothly, doing her best to make her passenger feel comfortable. On their way down the hospital hallway, they chat about life in Pittsburgh. All the while, the woman in scrubs is monitoring the rhythms of an implanted heart device that's helping to pump life-sustaining blood throughout the patient's body.

The two women have become friendly acquaintances lately, occasionally playing card games. On this day, the pair is traveling from a heart-test clinic back to the hospital room where family has gathered. When they enter, the patient's grown daughters surround her, anxious for an update about her heart condition. Radiantly, she announces the doctor's news: *I don't need a transplant after all. My heart has healed itself.* All at once, the daughters weep, cheer, and embrace their mother and each other.

Kristie Henchir Burgess—the woman pushing the wheelchair—is a graduate student in the University of Pittsburgh's Department of Bioengineering. As she observes this emotional family moment, she feels an unexpected sensation—something like an *exclamation point!* shooting through her body. It's suddenly clear why she has spent so many hours holed up in a library studying physics, chemistry, and anatomy.

During the past few weeks, she witnessed the patient improve with the assistance of the heart device. Now, in the hospital room, as she observes the mother hugging her daughters, she truly sees the point—*bioengineering improves people's lives.* Judging by all the smiles in the room, a mechanical device has the power not only to enable a heart to heal but also to bring renewed life and a brighter future to an entire family. Burgess is hooked.



Now, several years later, she is a seasoned graduate student on the verge of completing her doctoral degree in bioengineering. Since that inspiring moment in the hospital, she has worked to construct a device that mimicks the functions of another essential organ—the lung.

Her efforts reflect the caliber of Pitt's thriving bioengineering program, which didn't even exist when Burgess began her studies at Pitt as an undergraduate engineering student. During her 10 years of immersion in engineering study and practice, she has seen a broad flourishing of progress in the School of Engineering, funded in part by generous and visionary advocates.

The school's Department of Bioengineering was founded in 1998, an academic program—with clinical ties—devoted to teaching, researching, and building medical devices that improve health care and, ultimately, society. As a regular volunteer for campus service projects like Pitt's annual fair for children with disabilities, Burgess began to see glimmers of the altruistic element of bioengineering. She joined the new department and, in 2000, was named the Outstanding Senior of the first baccalaureate class.

The department was launched with funding from the University's capital campaign, including a \$3 million grant from The Whitaker Foundation, a supporter of academic bioengineering developments nationwide.

Of all the exciting ventures the campaign has catalyzed in the school, the creation of the nationally ranked bioengineering department may be among the most impressive. In fewer than 10 years, it has expanded from a handful of students and teachers to more than 300 students, 15 full-time faculty, and 90 faculty with dual appointments in Pitt's health sciences schools. This year, the department's graduate program was ranked sixth in the nation among public institutions and 16th overall by *U.S. News and World Report*. Also, *The Chronicle of Higher Education* listed the

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The rankings affirm the prominence of Pitt faculty and students as leaders in the bioengineering field. Burgess is just one example. She was awarded a nationally coveted graduate fellowship from The Whitaker Foundation in 2001. The additional funding enabled her to pursue a PhD project—engineering the components of an artificial lung, which is beyond the scope of the usual dissertation study.

Burgess is creating a “breath module” using a microfabrication technique. The technique commonly is used to create things like computer chips, by etching tiny grooves into pieces of metal. Increasingly, it's also being used in biomedical applications. Burgess is one of the first scientists to attempt lung design with this technology.

During her project's first year, she spent a lot of time reading scientific literature on microfabrication and thinking about how she could apply it to lung development. As a woman who reads medical-mystery novels in the evenings, she was having fun investigating her own sort of mystery. In some ways, this period of desk-hunching research was similar to her undergraduate days, when she spent umpteen hours studying in the back, right corner of the engineering school's George M. Bevier Library.

The library has since been remodeled and upgraded with campaign funds. The original library was made possible by alumnus George Means Bevier (ENGR '13), the inventor of a seismograph that detects oil and gas fields. A bequest from Bevier and his wife Eva M. Bevier, valued at more than \$10 million, was the largest gift ever made to the School of Engineering. The Bevier legacy continues to support the library, as well as an endowed chair, fellowships, and programs in sustainability, engineering resources, and bioengineering.

The school's endowment has increased remarkably during the ongoing campaign. So far, endowed professorships in the school have doubled, and nine endowed chairs have been established. More than 30 endowed scholarships and fellowships have been funded, securing financial assistance for students for years to come.

During that initial research period when Burgess was reading about microfabrication, she also was updating her advisor—William Federspiel, William Kepler Whiteford Professor of Chemical Engineering, Surgery, and Bioengineering—about what she was discovering. “She really had to bootstrap the whole project,” he says. “I was learning techniques from Kristie as she learned them.”

Federspiel directs the Medical Devices Laboratory: Biotransport, Pulmonary, and Cardiovascular in Pitt's McGowan Institute for Regenerative Medicine. He has engineered several artificial lung devices, some of which are being developed commercially through ALung Technologies, a company he cofounded in Pittsburgh. He'd noted the increasing use of microfabrication in biomedical applications and thought, *Someone should design a lung this way.*

Then Burgess arrived in his lab. Federspiel was her doctoral advisor. He knew she was an A-plus student and someone who wouldn't be “shy about exploring all the available resources.” Though she'd never even heard the word *microfabrication*, she didn't hesitate to accept the challenge. Focusing her research on artificial lung development had the potential to improve the lives of people suffering from cystic fibrosis or emphysema. About 400 patients nationwide die each year while awaiting lung transplantation, and thousands of others suffer from incapacitating lung diseases.

Today, Burgess' product looks like a suction cup with straws branching from

its edges. It does what the lung does best—provides a space for oxygen to pass into blood and for carbon dioxide to travel out. Basically, the “suction cup” is a stack of polymer sheets. Each sheet has microgrooves that serve as passageways for blood or air. When the sheets are stacked, the grooves crisscross to allow for the vital exchange of oxygen and carbon dioxide. The “straws” popping out of the device are plastic tubes that pump air and blood through it. Compared to other lung devices that currently are used in hospitals, Burgess' model increases the ratio of surface area to blood flow much closer to that of natural lungs.

To create the sheets, Burgess used the microfabrication technique she had read so much about. First, she used a machine to etch tiny grooves—each narrower than a hair—into a silicon wafer that would serve as a mold. Then she operated another machine to spread a thin layer of a gooey substance—a polydimethylsiloxane polymer—onto the wafer. When the polymer dried, she peeled it off like a sticker. This was a single sheet.

The first time she created the sheets, Burgess had to use equipment at another institution because Pitt didn't have the necessary technology. Soon though the John A. Swanson Micro-Electro-Mechanical Systems (MEMS) Laboratory opened in Benedum Hall. It contains the latest microfabrication equipment. Throughout the rest of her project, she regularly used the MEMS machines alongside researchers from across the University.

The laboratory was made possible with funding from Pitt Trustee John A. Swanson (ENGR '66), who also supports a number of other initiatives that are expanding opportunities for students and faculty in the engineering school. For instance, the Swanson Institute for Technical Excellence contains the Swanson Center for Product Innovation, the Swanson Center for Micro and Nano Systems, and the RFID (Radio Frequency Identification) Center of Excellence.

After Burgess used the MEMS machines and peeled the sheets off the wafers, she stacked the sheets on top of each other. To maximize the blood-air

exchange ratio, she created very slim sheets, but their thinness made them more prone to collapse. Time after time, she prepared to run tests on her product only to discover the sheets had caved in. This was the project's greatest obstacle, but, little by little, with undaunted persistence, she improved the stacking method.

These days, most of the labwork is finished, and Burgess is writing her final dissertation thesis. Next, she will work to attach together several breath modules to create a complete artificial lung. Her invention will likely be a cylinder about the size of a plastic cup—an external device that remains unnoticed among flowers and cards at patients' bedsides. Throughout the project, she has looked back to that family moment in the hospital for inspiration.

Burgess had that experience while working for the University of Pittsburgh Medical Center Artificial Heart Program. She joined the program as an undergraduate and continued participating during graduate school. As an engineer, she found herself working with doctors, nurses, physical therapists, and other hospital staff. Her favorite part was the interaction with patients. “It was just so rewarding to see how bioengineering impacts lives,” she says.

The opportunity to work with biomedical devices in a clinical setting influenced Burgess' decision to pursue graduate work at the University, as it does for many Pitt bioengineering students.

“Pittsburgh has a long history of leadership in artificial organ development,” says another one of Burgess' advisors, William Wagner, professor of surgery, bioengineering, and chemical engineering. “Tom Starzl put us on the map in organ transplantation. When you have patients dying while waiting for organs, you become acutely aware of the need to support patients when organs aren't available.” Thomas Starzl, Distinguished Service Professor of Surgery and director emeritus of Pitt's Thomas E. Starzl Transplantation Institute, performed the



Burgess holds elements of her breath module.

world's first liver transplant and turned Pittsburgh into a worldwide hub for organ transplantation.

The engineering school has become a hub during the past decade, too. Gerald Holder, the school's dean, says the best change during the capital campaign has been the fostering of a positive, forward-driven environment where people get a sense that *things are really happening here.*

Holder is the U.S. Steel Dean of Engineering, an endowed chair created by a joint gift from Pitt Trustee Thomas J. Usher (ENGR '71G, '66G, '64) and the U.S. Steel Corporation. “The chair has been very important to us in starting a number of programs, enhancing faculty recruitment, and expanding enrollment,” says Holder. “Beyond that, scores of new initiatives continue to be possible through the ongoing generosity of the school's supporters.”

He envisions numerous ways for the school's energy to continue. Beginning next year, capital campaign funds will be used to upgrade Benedum Hall. The building will be completely remodeled, creating 40,000 square feet of space for leading-edge classrooms and labs.

Soon, plenty of students—at the graduate and undergraduate levels—will have new opportunities to find inspiration and their own *exclamation point!* moments. Like Burgess, they'll be relying on the school's equipment, resources, and mentors to improve the lives of others through engineering innovations. 