Tackling Society's Grand Challenges:

GRADUATE STUDENTS ADVANCE SOLUTIONS IN HEALTH CARE AND CLEAN ENERGY

As the twenty-first century's first decade came to a close, two major engineering-driven issues moved to the forefront of the national conversation: health care and clean energy. Several graduate researchers at the College of Engineering are collaborating with faculty in advancing promising engineering solutions in both of these critical domains.

Engineer's Jason L. London recently spoke with five graduate students whose research is aimed at either improving patient care or reducing environmental impact. From developing robotic cardiac surgery techniques to producing carbon-neutral energy from the material in a plastic bottle, these students are confronting some of society's toughest challenges. Here, they describe how they are working to make a difference.

Working at Winchester Hospital in Massachusetts, Jesse Lock, MD, a doctoral candidate in Mechanical Engineering, knows firsthand the impact technology and innovation can have on patient care.

"I love being a pediatrician and the idea that technology can help physicians diagnose and heal patients. But during my residency training, I was surprised by the simplicity of medical equipment. When compared to the complexity of a modern car or mobile phone, a heart monitor is years behind.

Following my residency, I joined the College's Late Entry Acceleration Program. After two years I matriculated into the doctoral program and was fortunate to end up in Professor Pierre Dupont's BioRobotics Research Laboratory, where the focus is on medical devices. We're working on a thin, snakelike robotic device for doing intracardiac surgery.

Current cardiac repair is done in one of two ways: open-heart surgery, which provides excellent exposure but can be physically traumatic; or by using peripherally inserted catheters, which is minimally invasive but can be very difficult to control. Our approach is to combine the best of both worlds.

The robot we're developing is minimally invasive but still able to move dexterously and precisely within the heart. I know how traumatic full-scale cardiac surgery can be for children, and this could be a great solution. And with the current debate on Capitol Hill, it seems likely that there will be a national trend toward reducing health care costs with less invasive surgeries.

Our short-term goals are to improve the robot's functionality within the operating room and to demonstrate its ability to move effectively within the heart. I can also imagine where this device would be useful to access other areas of the body, such as the brain or lungs. In the longer term, my goal is to find practical applications for devices while continuing to work as a pediatrician."

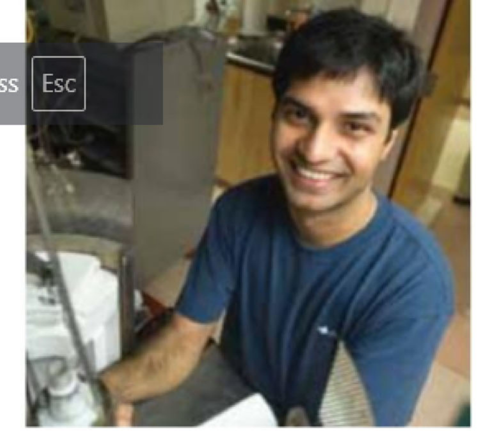
Collaborating with the College of Engineering and the School of Medicine, Center for Integration of Medicine and Innovative Technology (CIMIT) Fellow Amira Hussein is working to prevent spinal fractures before they start.

"Before joining BU I was looking for research on bone mechanics, where I could perform both mechanical testing and numerical analyses of biological tissue. I wanted to see how I could apply mechanical engineering concepts in a biological area. [Associate] Professor Elise Morgan's (ME) lab was the perfect match.

In my research I'm working to improve predictions of vertebral fractures. Spine fractures are common, especially with an aging population, and 45 percent of fractures can go undiagnosed. Our group has developed a device that incrementally compresses human cadaver spine segments to failure. After each load increment, the spine segments are imaged at high resolution using micro-computed tomography. We then use digital image correlation techniques developed in [Associate] Professor Paul Barbone's (ME) lab to determine failure patterns and regions where failure is likely to occur.

At the Medical Campus, we obtain clinical three-dimensional images of the spine segments, and estimate the bone mineral density and fracture risk of our samples. The images are used to generate three-dimensional, patient-specific models to simulate and predict vertebral fractures.

Knowing the clinical fracture risk and results from our sample simulations, we hope to show that 3-D simulations of spine fractures may provide better predictions of spine fracture risk. This type of injury can lead to further fractures that are not limited to the spine. Early discovery can improve patients' quality of life and potentially reduce medical costs."



Soobhankar Pati's research focuses on producing carbon-neutral energy and reducing pollutants. Spurred by positive results, he's not stopping after graduation.

"Working in Professor Uday Pal's (ME) lab, I'm developing a method to extract pure hydrogen from garbage that will eventually be used by fuel cells to derive energy. Our process is very unique, as it uses garbage to produce separate streams of high-purity hydrogen and synthetic gas in a single step.

To simulate garbage, we're using high-density polyethylene (HDPE), which is essentially the same material used in a plastic bottle. The HDPE is inserted in one side of our solid oxide membrane and steam enters through the other side. The steam dissociates to produce hydrogen and oxygen ions, and the membrane selectively allows only oxygen ions to migrate across. The oxygen ions react with the HDPE to produce a multipurpose synthetic gas, leaving a pure stream of hydrogen gas behind. It's an energy-positive, carbon-neutral process.

In the waste-to-energy market, the main question is, how much waste can your device consume in a day? In the next three years, our goal is to be able to consume two tons of waste a day, and it's definitely within reach.

Our group started this project from scratch, and it's amazing to see the progress we've made. I plan to graduate this year, but I'm not stopping my research; I hope to stay on as a postgraduate researcher. It's a dream for doctoral students to continue their PhD work, and I am excited about the impact that this project will make."

To see video demonstrations of each student's research, please visit **www.bu.edu/eng/magazine/research.**

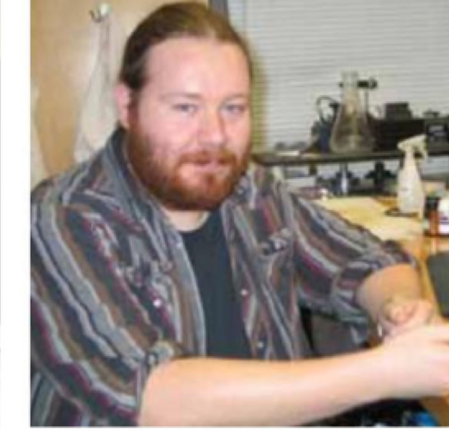
Brad Kaanta's research in micro-fabrication and micro-chromatography is helping to advance cleaner energy resource exploration.

"Before I came to the College of Engineering, I was exposed to MEMS (microelectromechanical systems) research in the U.S. Air Force. I loved micro-fabrication, and I came to the College of Engineering specifically to work in [Associate] Professor Xin Zhang's (ME) lab. I also received a Dean's Fellowship, which enabled me to find my own research project and dive right in.

One of the main areas of my research concerns cleaner resource exploration. In this discipline, our lab has developed a very successful and mutually beneficial research relationship with Schlumberger, an oil field and energy services company. In collaboration with Schlumberger, I'm now working to build detectors for gas micro-chromatography, a technique used in chemical analysis.

In the oil industry, more accurate chemical analysis can improve engineers' ability to detect different types of oil in the ground. Ideally, gas chromatography can detect gases ranging in size anywhere from 'C1'—methane—to 'C40,' which is basically sludge or wax. If you can detect what's in the output, you can generate fewer pollutants during the process. Oil well sites can cost over $100,000 per hour to run, so the more information you have before drilling, the less damage you can do, and the quicker you can get results.

Originally this project was funded only for a year, but because of our success, we're currently working on a three-year, National Science Foundation grant. Schlumberger has already transferred some of the research we've developed to their engineering centers. This shows that our research has been successful, and there are clear signs of future positive results."



Jeremy Stark is working to make desert-based solar panels dust-free, and more efficient in the process.

"Since the deposition of dust on solar panels prevents light from entering the cell, our research aims to make the panels self-cleaning to prevent dust accumulation and loss of power.

The most effective place for a large-scale solar farm is the desert, but sandstorms sometimes blanket the panels with dust and debris, which can significantly degrade operations. These installations can span as much as a quarter mile, and the cost of manually cleaning panel surfaces with water is very high.

Our lower-cost technology uses a set of transparent electrodes placed on the panel's surface. Driven by phased voltage pulses, the electrodes remove dust through electrodynamic force. Only a small fraction of solar panel power output is used to drive the electrodes for cleaning, a process that can be completed in less than two minutes. An off-site control board determines when panels need to be cleaned—either at a set time each day, or programmed for when panel efficiency drops off due to dust deposition.

I got involved in this research while doing undergraduate research in transparent electrodynamic screens and the development of an analyzer for characterizing fine particles at the University of Arkansas, Little Rock, with Malay Mazumder—who is now a research professor in the ECE Department. He's one of the main reasons I came here, along with the resources at the Photonics Center.

We are now working towards the commercialization of the self-cleaning technology within a year. We're making good progress, and hopefully our research will make solar panels efficient and cost-effective."