SPRING 2018

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Boston University College of Engineering

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VALENTINA TOLL-VILLAGRA (ME'16) CREDITS MANUFACTURING CONCENTRATION FOR PROFESSIONAL SUCCESS

BOSTON UNIVERSITY

Engineering's Gender Diversity Problem

BY DEAN KENNETH R. LUTCHEN

Gender disparity has long been an issue in the engineering profession, and many engineering schools, including ours, have established outreach programs aimed at attracting more young women.

Recently, I was invited to give a talk about the future challenges of engineering education to a group of mechanical engineering department chairs from around the Northeast. While preparing for the talk, I researched data on the number of bachelor's degrees awarded in the top six engineering disciplines for the last 10 years. The data was an epiphany (at least to me). First, of the approximately 100,000 bachelor's degrees awarded among all engineering disciplines, more students—28 percent—received mechanical engineering degrees in 2016 than any other discipline; in fact, there were more than twice as many mechanical engineering degrees as the next most popular discipline, electrical engineering at 12 percent, and the gap is growing fast. My audience was very proud that theirs had become the dominant discipline. Then, I hit them with the epiphany.

Only 13.8 percent of mechanical engineering bachelor's degrees were awarded to women, a figure barely changed from a decade ago. The national average for all of engineering—boosted by a combination of several smaller disciplines—has been around 20 percent. I told the chairs that the real epiphany in these data is that the rapid and incomparable rise and dominance in mechanical engineering enrollments might mean that no single discipline is doing more to promote gender disparity than their own. In fact, I fail to see how gender equality could occur in engineering unless their discipline, perhaps in tandem with electrical engineering with 12.7 percent women, led the solution. I also noted the irony that of the 35 chairs in the audience, only one of them (our own Alice White) was a woman.

Gender disparity has long been an issue in the engineering profession, and many engineering schools, including ours, have established outreach programs aimed at attracting more young women. The makeup of my audience prompted me to question whether those programs have been successful, so I asked whether they have designed programs to attract more women specifically to mechanical engineering. They returned blank stares.

Why does the most popular engineering discipline attract so few women? I have posed this question to my faculty, decanal colleagues and advisory board representing leaders in the corporate world. Although there is no consensus, there are some opinions that may offer us a way forward.

Some engineering deans and employers have hypothesized that women shy away from mechanical engineering because they don't have experience using power tools and machine shops, and making things in middle and high school, and they perceive mechanical as a discipline for people who have had such experiences. Yet, ironically, many of my colleagues believe that most male mechanical engineering students don't have such experience either. Another hypothesis is that women do not realize that mechanical engineering engages creative design, robotics, machine learning, artificial intelligence, 3-D printing driven by creative computer design and many other math and science skills that have nothing to do with power tools.

In our increasingly interdisciplinary profession, the skills of the mechanical engineer are essential and must be synthesized with others in fields like electrical, computer and systems engineering. Innovation to meet society's challenges must be a cooperative venture that involves creators from more than one discipline and gender working together with the essential people, skills of communication and networking. Neither gender has a skills advantage and we need both to participate equally. As a simple example, consider autonomous vehicles, which require human-centered design at the intersection of mechanical, electrical, software and systems engineering. It will impact sustainability and climate, urban efficiency and function, and quality of life, particularly for the elderly who seek ways to remain mobile, interactive members of society.

At Boston University, the proportions of women in our undergraduate mechanical, electrical and computer engineering programs are approximately double their respective national averages. I cannot say for certain why, but I suspect our foundational philosophy of "Creating the Societal Engineer," along with the inclusion of multidisciplinary concentrations that we offer, has something to do with it. As you will read in this issue's cover story, concentrations give our students the option of adding a cutting-edge, multidisciplinary field to their major. These concentrations open their minds to how they can engage with engineers from other disciplines, even others like business people and community leaders, to innovate new technologies and products.

Emphasizing the interdisciplinary, collaborative and societal nature of all engineering disciplines is an avenue worth pursuing as we seek to attract more women to the profession. Boston University has made some headway, but no one engineering school can solve the challenge. This is a national challenge and the data indicate that mechanical and electrical engineering must explicitly impact gender equity in their respective disciplines, or we as a nation will never reach gender equity in engineering. ■

PHOTOGRAPH BY KALMAN ZABARSKY

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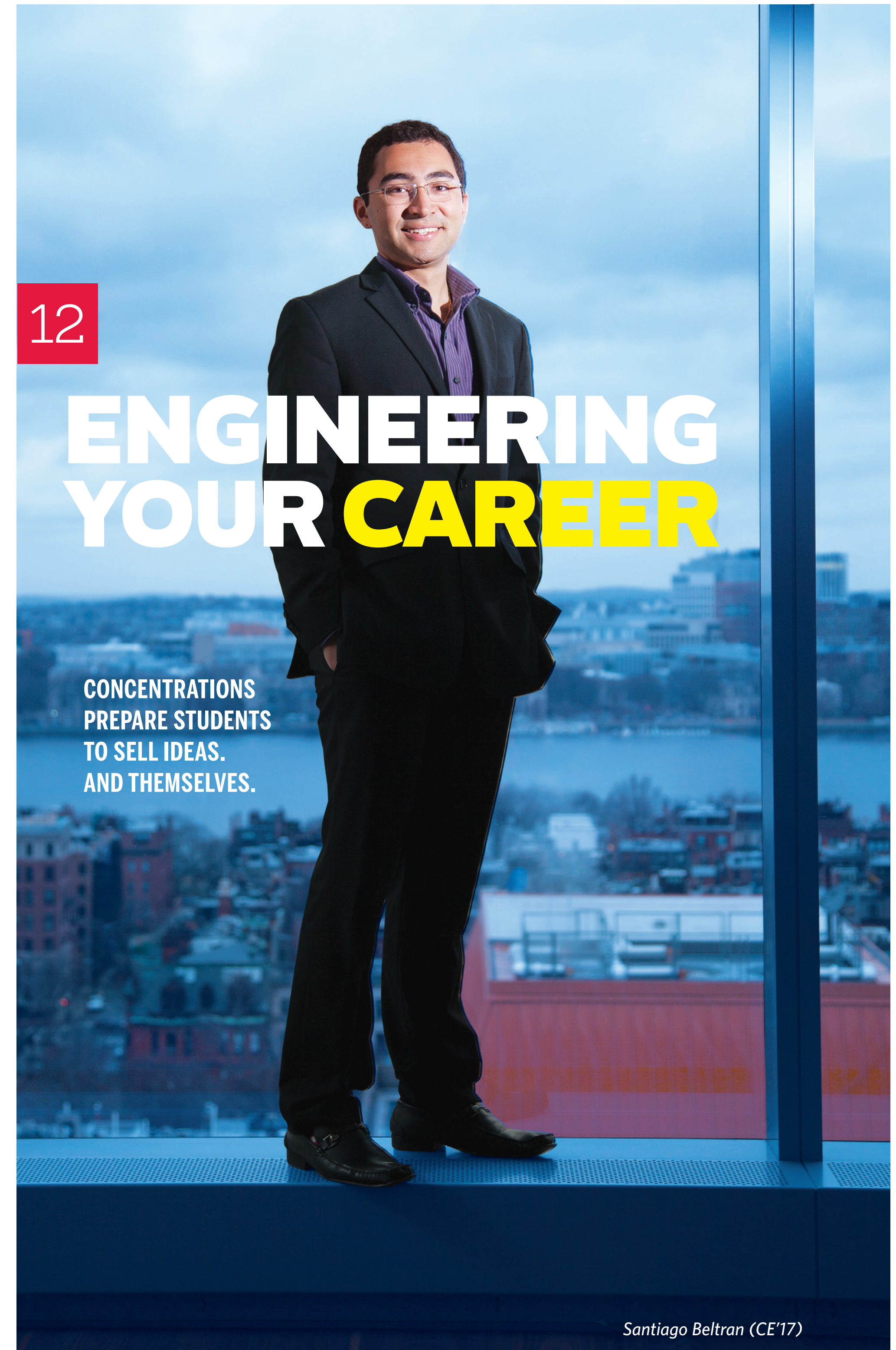

Santiago Beltran (CE'17)

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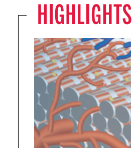

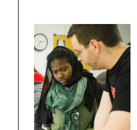

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Student Teams Recognized at iGEM Jamboree
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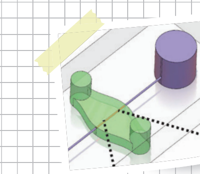

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Leadership from BU and the College of Engineering cut the ribbon celebrating the opening of the Engineering Research Center on October 2, 2017. Left to right, University Provost Jean Morrison, University President Robert A. Brown, Professor Thomas Bifano (ME, MSE), Professor Alice White (ME, MSE), Professor Christopher Chen (BME, MSE), Professor David Bishop (ECE, MSE) and Dean Kenneth R. Lutchen.

PHOTOGRAPH BY DAVE GREEN

BU Wins $20M for NSF Engineering Research Center

Boston University has been awarded a $20 million, five-year grant from the National Science Foundation (NSF) to create a multi-institution Engineering Research Center (ERC). Designed to stimulate translation of research to practice by facilitating worldwide corporate, clinical and institutional partnerships, the grant accelerates an area of engineering research—in this case, bioengineering functional heart tissue, or synthesizing personalized heart tissue for clinical use—that is likely to spur societal change and economic growth within a decade. It is renewable for a total of 10 years and $40 million. The lead institution on the grant, Boston University will house the center; Professor David Bishop (ECE, MSE), head of ENG's Division of Materials Science & Engineering, will direct it.

"The goal is moving from the basic research capability to a technology that could be disruptive," Dean of the College of Engineering and Professor of Biomedical Engineering Kenneth R. Lutchen notes. "The center will transform cardiovascular care by synthesizing breakthroughs in nanotechnology and manufacturing with tissue engineering and regenerative medicine."

Of more than 200 applicants, only four—Boston University, Purdue University, the Georgia Institute of Technology and Texas A&M University—received the extremely competitive ERC grant in 2017. "The awarding of the NSF ERC is outstanding recognition of the quality and creativity of our faculty team from across the College of Engineering," says Robert A. Brown, president of BU. "Their efforts will help make the creation of personalized human tissue for cardiac applications a reality."

The award hits a "sweet spot" at the intersection of BU's strengths in biomedical engineering, photonics and nanotechnology, Lutchen says. Four leaders in specific areas—or "thrusts"—of technical expertise will work with Bishop: Photonics Center Director Professor Thomas Bifano →

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BU Wins $20M for NSF Engineering Research Center

(ME, MSE) will direct imaging; Mechanical Engineering Department Chair Professor Alice White (ME, MSE) will direct nanomechanics; Professor and Director of the Biological Design Center Christopher Chen (BME, MSE) will direct cellular engineering; and Stephen Forrest, a University of Michigan professor of materials science and engineering, will direct nanotechnology. Arvind Agarwal, a Florida International University (FIU) professor of mechanical and materials engineering, will work with White's team to advance nanomechanics methods, and will also lead FIU's involvement in the ERC, with a crucial role in education and outreach.

The ERC will also develop areas of expertise in education, diversity, administration and outreach. Research Assistant Professor of Mechanical Engineering Helen Fawcett will lead the diversity team; Assistant Professor Stormy Attaway (ME) and Professional Development & Postdoctoral Affairs Program Director Sarah Hokanson (CAS'05) will co-lead the workforce development and education team; Photonics Center Assistant Director of Operations and Financial Administration Robert Schaejbe will lead the administration team; and Photonics Center Assistant Director of Technical Programs Thomas Dudley will lead the innovation ecosystem team, a group of companies and research consortia that will serve as advisors and work with the ERC to commercialize the technologies it creates.

Partner institutions the University of Michigan and Florida International University, as well as six affiliate institutions—Harvard Medical School, Columbia University, the Wyss Institute at Harvard, Argonne National Laboratory, the École polytechnique fédérale de Lausanne in Switzerland and the Centro Atómico Bariloche/Instituto Balseiro in Argentina—will offer additional expertise in bioengineering, nanotechnology and other areas.

"We have assembled a very competitive team from world-class institutions with a compelling vision," Bishop says. "This grant gives us the opportunity to define a societal problem, and then create the industry to solve it. Heart disease is one of the biggest problems we face. This may allow us to solve it, not make incremental progress."

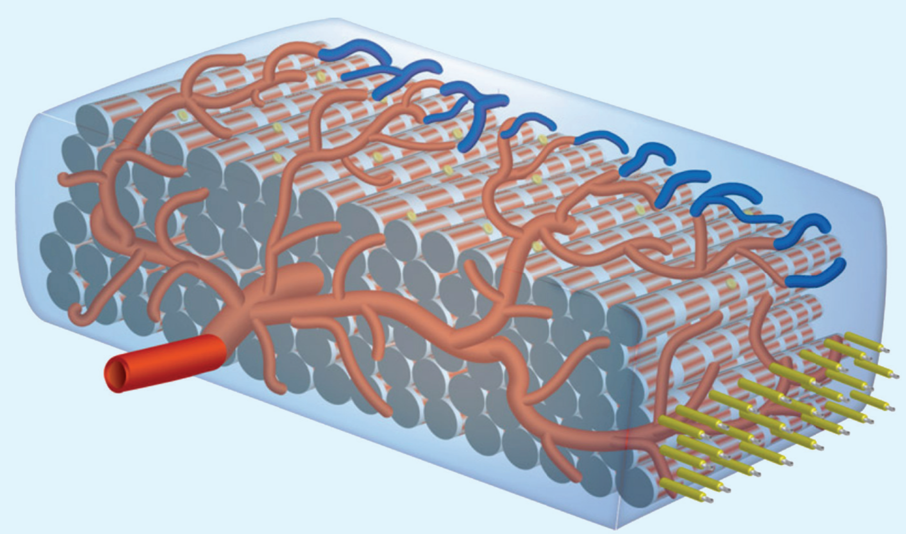
According to the American Heart Association, heart disease—including coronary heart disease, hypertension and stroke—is the leading cause of death in the United States. Approximately 790,000 people in the United States suffer heart attacks each year, roughly one every 40 seconds. Of those, about 114,000 will die. Statistics like these, and the fact that cardiovascular disease is relatively advanced in terms of regenerative medicine, led the team to target it in their ERC proposal.

Scientists and engineers have been struggling to build or grow artificial organs for decades. But aside from simple, nonmoving parts, like artificial windpipes, the field has not lived up to its early promise. This is partly because organs, with their multiple cell types, have proved difficult to synthesize, and also because researchers have learned that the body's dynamic stresses—beating hearts, stretching lungs—play a larger role in how tissues grow and perform than originally thought.

The ERC plans to accomplish four goals with the cellular metamaterials it intends to build: fabricate responsive heart tissue containing muscle cells and blood vessels; understand and control the tissue using optical technologies; scale the process up to easily create multiple copies of the tissue; and personalize the product so it can be tailored to individual patients. The first objective will be to create "functionalized heart tissue on a chip," Lutchen says—tissue that could be built with a specific patient's cells and used to test new drugs and therapies. The ultimate aim is to fabricate heart tissue that could replace diseased or damaged muscle after a heart attack.

"It's humbling to have the opportunity to work on something that could really be a game changer," Bishop says. "If we succeed, we'll save a lot of lives and add meaningful years for many people."

—BARBARA MORAN



A cardiac patch. The ERC's ultimate goal is to advance nano-bio-manufacturing methods that could lead to large-scale fabrication of functional heart tissue, which could replace diseased or damaged muscle after a heart attack. Illustration courtesy of Jeroen Eyckmans

$1M Societal Engineering Endowed Fund Supports Transformative Programs

DEDICATED FUNDING SOURCE BACKS EXPERIENTIAL ACTIVITIES

When Kenneth R. Lutchen assumed the College of Engineering deanship in 2006, he introduced the idea of creating the Societal Engineer who will use their engineering skills and training to advance society. The concept quickly took root among the college community and eventually, the phrase "Boston University Creating the Societal Engineer" was trademarked by the US Patent Office.

Now, the $1 million-and-growing Societal Engineering Endowed Fund will back, in perpetuity, curricular and extracurricular programs that support the Societal Engineer. Gifts from alumni, parents and friends of the college will ensure that existing programs—and potential new ones—will receive ongoing, consistent funding.

Because these programs go beyond what tuition alone can sustain, a dedicated funding source such as this one is critical. Indeed, to support the full range of Societal Engineering experiential activities, Dean Lutchen hopes to grow the fund to $2 million.

"These programs have become so popular with our students that I realized we need to make them a systematic part of the student experience," he says. "The Societal Engineering Endowed Fund will ensure a minimum level of support for many existing programs and allow us to think about new initiatives in the future as we grow the fund."

The Societal Engineering Endowed Fund supports programs including:

- The Technology Innovation Scholars Program (TISP), which sends carefully selected and trained undergraduates into middle and high schools around the country to inspire young people to consider engineering as a career.
- The Technology Innovation concentration, which merges engineering innovation with business skills taught by Questrom School of Business faculty.
- The Imagineering Competition, which encourages students to get creative with extracurricular engineering projects in the Singh Imagineering Lab.
- The Societal Impact Capstone Project Award, a prize for interdisciplinary Senior Design Projects that emphasize societal impact.
- Engineers in the Real World, a program that brings ENG alumni from various fields into the classroom to expound on how an engineering degree can lead to a career in many different professions.
- The BU chapter of Engineers Without Borders, which gives students the opportunity to work on real-world issues in resource-limited environments.

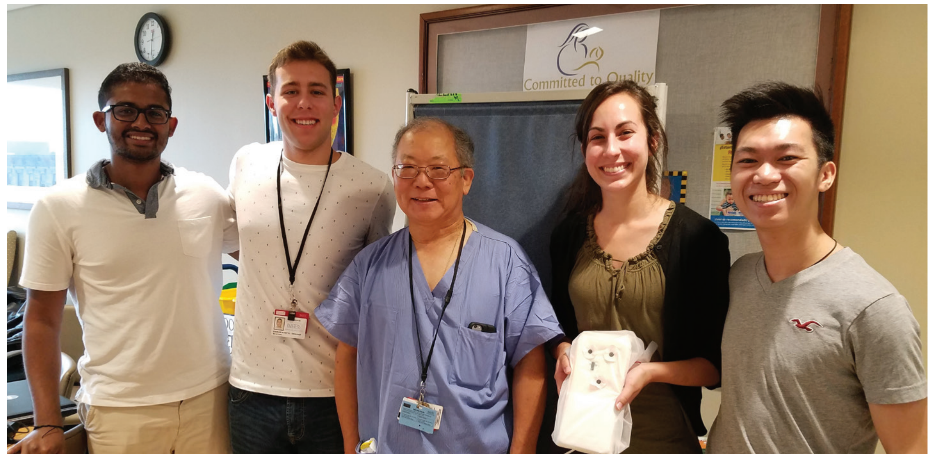
"The college is extremely grateful to the many donors and foundations who have provided support for its Societal Engineering programs, whether by contributing to the Societal Engineering Endowed Fund, establishing named endowed funds and/or providing gifts for current use or capital projects," Lutchen says. "Their generosity has helped propel the college on its successful upward trajectory over the past decade."

—MICHAEL SEELE

PHOTOGRAPH BY KALMAN ZABARSKY

High school students at a STEM outreach event learn to program and work with robots with the help of students from the Technology Innovation Scholars Program, one of the initiatives supported by the Societal Engineering Endowed Fund.

Bridge Builders: Doctors and Engineering Students Work Together to Build Innovative Devices



From left to right, Mohit Dangeti (BME'17,'19), Charles Scheftic (BME'18), Director of the Neonatal Intensive Care Unit at Boston Medical Center (BMC) Dr. Alan Fujii, Elizabeth Sridhar (BME'18) and Nicholas Leung (BME'17) gather at BMC to show off the neonatal vitals monitoring pad prototype.

PHOTOGRAPH PROVIDED BY NICHOLAS LEUNG

There's often a wide gap between the new medical devices doctors need and the ones companies decide to make, and the disconnect can cause doctors to accept surgical instruments that can create medical problems and haven't been redesigned in half a century. Now, what started out as a year-long practical course for master's students in Boston University's Biomedical Engineering Department has become a way to help close the gap.

During their one-year program, biomedical engineering master's students must design and prototype a medical device to solve a problem they pinpoint while observing doctors at Boston Medical Center (BMC). Students work in groups with medical specialists to formulate products that help patients and are feasible from engineering, manufacturing and budgetary standpoints. The drawback was the students' graduation, which brought product development to a halt.

Seeking to continue the product development process over multiple years, Master Lecturer and Adjunct Professor Jonathan Rosen (BME) established the Bridge Builders Initiative in 2016. By employing enrolled master's students who are also working on their own academic projects, program alumni and undergraduates, Rosen put together a team to work with doctors at BMC and build trial-worthy products that could become marketable medical devices.

"I was excited because I thought, 'Wow, these guys can create something that I need, but don't have,'" recalls Dr. Alan Fujii, director of the BMC Neonatal Intensive Care Unit. "Our babies are so small that there's not so much room for error when we are doing procedures, so I thought that the biomedical engineers could create stuff that would make working with neonatal babies easier and safer."

John Subasic (BME'16), along with three other graduate students, did just that by designing an electronic pad that would take the vitals, including heart rate and blood oxygen level, of a premature baby faster than the standard method. It became the first Bridge Builders project.

"When a baby comes out and is respiratorily depressed, we have to figure out how depressed they are to administer the appropriate care and to do that, we need to know the baby's heart rate," Fujii explains.

Currently, when a baby is born, doctors hold on to the umbilical cord's stump and try to count out the heart rate, which can be tricky for even seasoned doctors. But using electrodes to read blood oxygen saturation rate and heart rate can also be a tricky process with neonates because the saturation monitor must be positioned exactly right on the infant's foot to get an accurate reading. If the monitor reads zero, it can be difficult to know whether the monitor isn't attached correctly or if the baby does not have a heartbeat. The hope is that a "smart" pad would remove the need to struggle with electrode placement and cut down on the time it takes for doctors to evaluate their newborn patients and get them the care they need faster.

Michaela Trexler (BME'16,'17) was among the first master's students Rosen hired to work with Bridge Builders; she continues to work with the program as an alumna. The initiative also hired undergraduate seniors to help tweak the design of the pad over the next year. In August of 2017, the team celebrated its first success when BMC approved their proposal for a small, first-round clinical trial of the pad to evaluate its efficacy and accuracy.

During the trial, the team found that wiggling infants can make it more difficult to get fast and accurate readings. To keep the babies in better contact with the pad, the team has proposed rounding the design up slightly, said Nicholas Leung (BME'17), who was hired to coordinate current students.

The smart vitals pad is just one of four Bridge Builders projects; another is a new surgical instrument Trexler helped design that spreads a patient's rib cage during heart surgery. Standard, hand-cranked retractors exert force at an unnatural angle, sometimes cracking a patient's ribs. The new internal mammary artery retractor works with the body's physiology by moving the ribs upward in a clamshell-like fashion instead of pushing them to the side.

"Not that opening your rib cage is ever natural, but if you have to do it, you'd want something that moves with the muscles and bones rather than pulling up at an awkward, harsh angle," Trexler notes.

Instead of handing students a problem to solve, the master of biomedical engineering program at BU gives students the opportunity to observe physicians in practice and work with them to conceptualize and prototype a solution to a real clinical problem, hand-in-hand work that's rare for a master's-level program.

Says Leung, "If you create something that doctors find really helpful and that has a lot of potential, your idea has the possibility of becoming a full device. That's the whole goal of the Bridge Builders Initiative and why I came to BU."—**LIZ SHEELEY**

Undergraduates Recognized for Synthetic Biology Projects at 2017 iGEM Giant Jamboree

MORE THAN 3,000 PARTICIPANTS FROM 44 COUNTRIES SHOWCASED WORK

The BostonU Hardware Team (from left to right), Dinithi Samarasekera (BME'20), Dylan Samperi (BME, CE'19) and Sarah Nemsick (BME'20) display their award for Best Hardware Project at the iGEM Jamboree.

The BostonU Wet Lab Team (from left to right), Shuyi Xu (BME'19), Stephen Tucker (BME'20), Madeline Simota (BME'20), Thomas Costa (BME'18), Abigail Sasdelli (BME'18) and Saimrunali Dadigagla (BME'20), with Associate Professor Douglas Densmore (ECE, BME) at the iGEM Jamboree

PHOTOGRAPHS PROVIDED BY MARISA MENDES

In November, two BU student teams were recognized for their scientific achievements during the 2017 International Genetically Engineered Machine (iGEM) Giant Jamboree.

More than 3,000 participants from 44 countries showcased their work in Boston during the annual competition for students who wish to explore synthetic biology research, hosted by the nonprofit organization iGEM. The Jamboree is a culmination of eight months of rigorous research where teams are judged on an oral presentation, a poster, their team Wiki and a question-and-answer session with the judges. The two teams, BostonU Wet Lab and BostonU Hardware, won silver and gold medals respectively; the Hardware team also took home the prize for Best Hardware Project.

"Both teams demonstrated how synthetic biology can be used to perform computational concepts not traditionally associated with biological systems," Associate Professor Douglas Densmore (ECE, BME) says. "Their success is a testament to their hard work and the dedication and leadership of the graduate student mentors." Densmore advised the teams, along with Assistant Professor Wilson Wong (BME) and Professor Daniel Segrè (Bioinformatics).

The Hardware team's project, Microfluidic Applications for Research in Synbio (MARS), aimed to increase the accessibility and usability of devices called microfluidic chips for synthetic biologists. Among their benefits, these chips allow researchers to run smaller-scale experiments, meaning supplies go further and results are produced more reliably, but manufacturing them requires expensive equipment and highly specialized knowledge.

"In our coursework we learn about engineering principles, but iGEM is a really good opportunity to learn what really goes into engineering and developing a system for people to actually use," Hardware team member Dylan Samperi (BME, CE'19) says.

Dinithi Samarasekera (BME'20) has been interested in synthetic biology since high school and joined iGEM as a freshman without having any undergraduate research experience, but "you're held to very high standards at iGEM and in our lab especially, so it was a great opportunity to hone my research skills and to understand what the field really entails," she notes.

Hardware team members included Samperi, Samarasekera and Sarah Nemsick (BME'20); ECE graduate student Josh Lippai mentored the team.

The Wet Lab team worked to build a biological circuit that would effectively be able to determine a cell's state—and, in this case, if that state indicates the presence of cancer—by measuring the levels of certain genetic materials within the cell. When a cell becomes cancerous, the expression profile of certain strands of genetic material changes, and researchers can then detect those changes. But various cancers produce different expression paradigms, and researchers typically need to measure thousands of markers to categorize a cell. Through a series of biological switches, the new circuit would be able to streamline that process and operate in a cell-free environment, making a simple blood test to diagnose cancer a long-term possibility.

"Participating in iGEM really taught me how to problem-solve because we had to figure out what went wrong and how to control the experiment, and what the next step would be," Abigail Sasdelli (BME'18) says.

Wet Lab team members included Sasdelli, Thomas Costa (BME'18), Shuyi Xu (BME'19), Stephen Tucker (BME'20), Madeline Simota (BME'20) and Saimrunali Dadigagla (BME'20); graduate students Alan Pacheco (Bioinformatics) and Matthew Brenner (BME) mentored the team.

—**LIZ SHEELEY**

A Hidden Pathway Revealed

Blood vessels act as a transportation system, bringing and discarding molecules to and from each organ to maintain the internal stability our bodies need. But during chronic disease or even minor injury, blood vessels can be damaged enough to compromise vital organ function.

Professor Christopher Chen (BME, MSE), director of the Biological Design Center and associate faculty at the Wyss Institute at Harvard University, and his team have created a 3-D blood vessel-on-a-chip model that can be used to understand what happens to vessels during injury on a molecular scale. The model is outlined in a paper published in *Proceedings of the National Academy of Sciences*.

Team members and BME graduate students William Polacheck and Matthew Kutys were eager to use the blood vessel-on-a-chip, an ideal way for them to study the effects of the mechanical forces of blood flow on vessels in lifelike conditions. Their fruitful research uncovered a previously unknown molecular pathway that elucidates how blood vessels maintain their integrity and could explain why cancer patients experience side effects from certain therapeutic drugs.

They were trying to discover how mechanical forces affect blood vessel walls and why they leak. When blood flows through vessels, it exerts forces called shear stress onto their walls. "We knew there was a link between shear stress and barrier function," Polacheck says. The chip enabled them to identify that link by allowing them to replicate the effects of blood flow and measure vessel leakiness, which was not previously possible.

Polacheck and Kutys soon noticed that the forces activated a protein-signaling pathway called Notch that has been long known to play a major role in cellular behavior by turning genes on and off. But they also learned that Notch also has another, previously unknown, function that could explain leaky vessels.

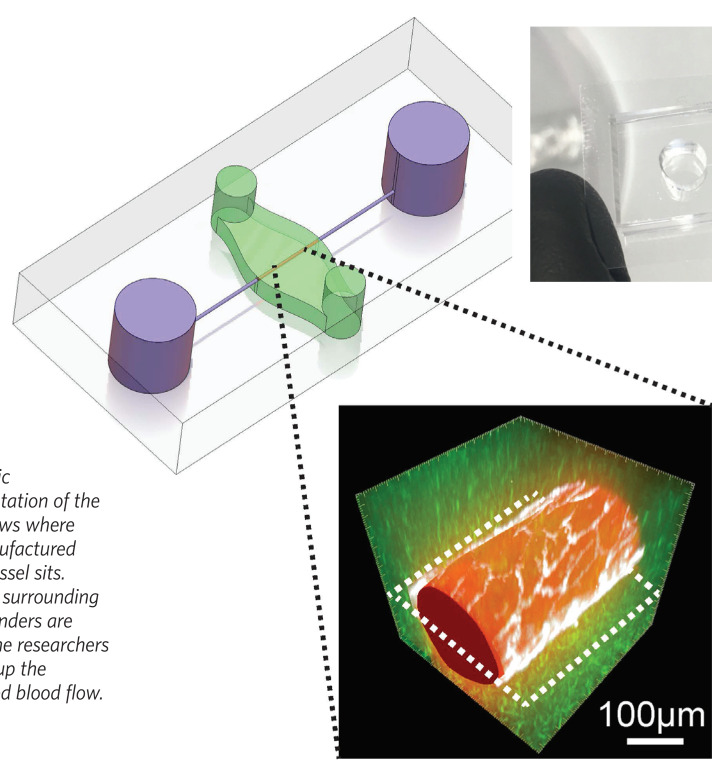
"We were seeing that Notch was activated when we simulated blood flow, so we needed to connect Notch to barrier function to close the circle," Polacheck explains.

They discovered that physical forces on the blood vessel walls cause the Notch pathway to build a complex of proteins in the cell membrane and trigger a process that holds neighboring cells together, preventing fluid from leaking between them. Their findings have been published in *Nature*.

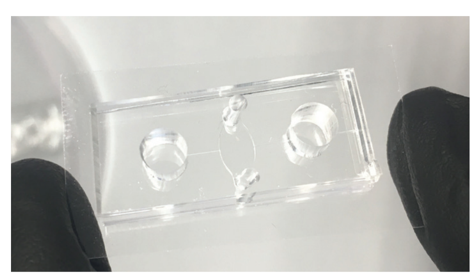
Leaky vessels alone can lead to major health problems, and this new pathway may offer insight into how this condition occurs. In addition, some newer cancer therapeutics target the Notch pathway in an effort to block the overgrowth of cells. By blocking the entire Notch pathway, these drugs may also be inhibiting the heretofore-unknown function of sealing blood vessel walls, causing them to leak. Indeed, these drugs have reported such side effects and, until now, clinicians have been at a loss to explain why this occurs. Polacheck and Kutys may have found the answer.

"Going forward, we hope to establish a better understanding of where and when this pathway contributes to health and disease," Chen says. "We also will continue our efforts to build new cell culture platforms that can be used to mimic and study important disease processes."

—LIZ SHEELEY



A graphic representation of the chip shows where the manufactured blood vessel sits. The two surrounding blue cylinders are where the researchers hooked up the simulated blood flow.



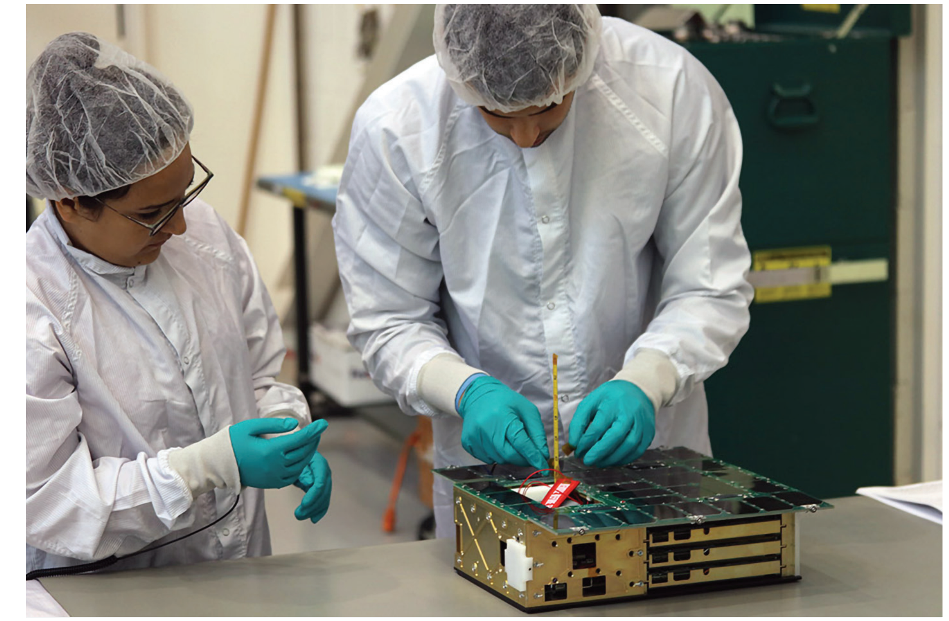
William Polacheck holds the blood vessel-on-a-chip he and Matthew Kutys developed to study how blood flow affects vessel integrity.

IMAGES COURTESY OF WILLIAM POLACHECK

PHOTOGRAPH COURTESY OF AIR FORCE RESEARCH LABORATORY

NASA to Launch BU Student–Built Microsatellites

ANDESITE WILL GET CLOSE-UP LOOK AT THE AURORA



Maria Kromis (ENG'17) and David Einhorn (ENG'17) inspect ANDESITE.

If MacGyver were on a mission to study the aurora, this is the satellite he might build: A grid of scrap solar cells pasted onto an iPad-sized green rectangle of circuit board; a six-inch cut of stainless steel tape measure soldered in one corner as a makeshift antenna; and inside, a suite of smartphone-class sensors that anyone can buy on the internet. But despite its crude looks, this microsatellite, a piece of a BU student–built experiment called ANDESITE, is actually on the leading edge of a new trend: studying space using "swarms" of inexpensive, lightweight mini-satellites that are cheap to build and launch.

ANDESITE is on track to launch in 2018 as part of a satellite "rideshare" coordinated by NASA's Educational Launch of Nanosatellites (ELaNa) Project. It's a teaching mission first: roughly 15 students, including Project Manager J. Brent Parham (ENG'18) and Project Engineer Maria Kromis (ENG'17), are working on the project at any given time, gaining the kind of hands-on satellite-building experience that aspiring space engineers usually have to wait years for.

But ANDESITE is not just for practice. It will examine how charged particles spilling out from the Sun buffet the Earth's magnetic field. Called the solar wind, this stream of particles can be a gentle breeze or a sudden, potentially hazardous gust that makes the Earth's magnetic field flap like a windsock in a hurricane.

"It was very important for us to have a true science mission. When it's launched into space, we're doing fundamentally new research," says Assistant Professor Brian Walsh (ME), who heads up the project with Professor Joshua Semeter (ECE).

When solar wind particles hit the Earth's magnetic field, they cram together and funnel through lanes marked off by the Earth's magnetic field lines, like commuters squeezing through a bank of subway turnstiles. Then, they drop down on the atmosphere, generating electrical currents that make the glowing, multicolored aurora—but can also wreak havoc on radio communications and electrical systems below. By measuring the strength and direction of the magnetic field some five hundred kilometers above Earth, ANDESITE will help reveal how those electrical currents move energy into the atmosphere, which could help researchers provide better predictions about potentially dangerous solar storms and understand how the aurora gets its peculiar ripples and whirls.

Until now, space physicists have studied these questions using single, high-precision spacecraft. But solo satellites have limitations even when they are outfitted with top-of-the-line sensors, says Parham, who presented a mission update at the American Geophysical Union's Fall Meeting on December 13.

"If you're flying one sensor through something really fast on a satellite, you're just getting a time series of data," Parham says. But because the aurora is always changing, it's impossible to tell the difference between changes over time and changes over space: they are all mixed up together.

The satellites will take positions a few kilometers apart, circling the Earth every 90 minutes. Combining readings from all eight spacecraft, space physicists will be able to piece together a full picture of the aurora, even without exquisitely sensitive—and exquisitely expensive—parts. "We don't need a finely tuned Ferrari: we advance our science with eight Camrys," Walsh notes.

Inside each of ANDESITE's eight circuit-board satellites is a smart compass, made up of a magnetometer that reads out the strength of the magnetic field in three directions, plus a GPS device and a gyroscope, that tell where the satellite is and which way it's pointed. Also on board: a "baby microprocessor," popular with electronics hobbyists, a battery to store up energy from the solar cells, and the tape-measure antenna, which will send data back to the mothership. The total cost of parts for one mini-satellite: about $500.

The deployer also slashes the cost of launch to pennies on the dollar: the face value of a rideshare "ticket" for a mission like ANDESITE is about $200,000, compared to at least $20 million to fly solo, says Parham. ANDESITE's spot is sponsored by NASA's ELaNa program.

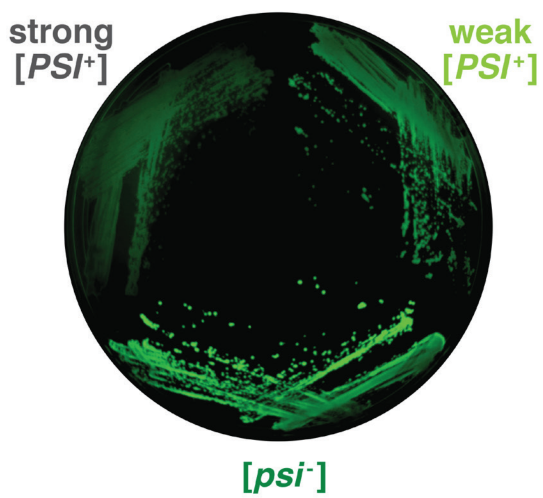
These pocket-sized satellites are not about to replace the full-sized, bespoke flagships for every application, but Parham says that he's eager for ANDESITE to help prove that little satellites can do big science. "There's something to be done with the cheap stuff," he explains. "You just have to realize that it's not either/or."**—KATE BECKER**

Shedding Light on a Puzzling Protein Process

A NEW TOOL MEASURES AND CONTROLS PROTEIN AGGREGATION, A KEY FACTOR IN SEVERAL DISEASES

Seemingly unlinked disorders like Alzheimer's disease and type 2 diabetes actually share a molecular commonality—protein aggregation, which is when proteins clump together and form large complexes or aggregates. Although protein aggregates are a hallmark of many diseases, they have recently been linked to beneficial functions as well.

Even though protein aggregation is widespread in biology, many of its causes and consequences are unknown largely because no simple, standardized research tool exists to study the phenomenon in live cells. Now, Assistant Professor Ahmad 'Mo' Khalil (BME) and colleagues from institutions including MIT and the Whitehead Institute for Biomedical Research have built a synthetic genetic tool called yTRAP (yeast Transcriptional Reporting of Aggregating Proteins) that quantitatively senses, measures and manipulates protein aggregation in live cells. The work, published in a *Cell* cover story, details how the team developed yTRAP and then used it to study a variety of protein aggregates, including disease-relevant proteins, RNA-binding proteins and prions.



yTRAP can be used to create cellular sensors for protein aggregation. The sensor produces fluorescent signals that depend on the protein aggregation state in the cell. In this experiment, three cell types were tested that produce varying signal strength depending on the aggregation of a prion protein: the brightest green for no prion aggregation (bottom), a slightly dimmer green to show a weak presence of prion aggregation (top right) and an even dimmer green signal for a strong prion presence (top left).

Prions are a special, heritable form of aggregation most famous for transmitting neurodegenerative diseases in mammals, but they are also used by organisms to execute a diverse set of positive functions that are just starting to be identified. Using the new tool, Khalil and the team created sensors to track aggregation of prions and other proteins, manipulated prions to engineer synthetic memories in cells, identified genes that can cure cells of prions and enabled high-throughput studies to learn what can influence protein aggregation and its consequences. Although developed and tested in yeast, yTRAP could allow scientists to test and develop treatments for currently incurable diseases and potentially turn on new, beneficial functions in other types of cells.

The tool is composed of two parts—one piece couples to the protein of interest and the other produces a fluorescent signal to measure the amount of aggregation in a cell. Each piece can be customized to study different proteins or express different genes and signals; for example, they were able to measure how one prion influenced another by developing a dual sensor that produced either a red or green fluorescent signal depending on the abundance of each prion.

In addition to tracking prion states, yTRAP can also control those states. Because prions are heritable, once they are triggered in a cell, all of the cells in later generations will inherit the same prion state. "Prions are a biological equivalent of a toggle light switch—you don't have to keep your finger on the switch to keep the light on," Khalil explains.

The team used this light switch-like property to build a synthetic memory device. Heat activated the prion to aggregate in a batch of cells; the hotter it got, the more aggregates formed. Inserting this synthetic memory into cells essentially installs a dimmer switch onto the light switch—the brighter the light gets, more aggregates will form in the cell population. Ten generations later, cells that were never exposed to heat maintained the same level of aggregation as their predecessors. The researchers also used yTRAP as part of a method to identify genes that could be used to essentially turn prions off, allowing researchers to toggle that light switch in the other direction.

Khalil's team also demonstrated how the tool can be used to study other proteins, including RNA-binding ones. Many of these proteins in yeast and humans have similarities to prions; mutations of those similarities have been linked to neurodegenerative diseases like ALS. With the tool's help, they uncovered aggregation-prone RNA-binding proteins, monitored the consequences of their aggregation and performed high-throughput screens to see how the aggregation of one protein influences another.

"Protein aggregates can cause a cell to gain or lose a function," Khalil notes. "It could be beneficial or harmful. For example, it could allow a cell to survive stressful conditions or change its metabolic function to digest a different type of sugar. And the discovery of these beneficial functions has often been serendipitous."

All of yTRAP's functions will allow researchers to discover new protein aggregates, track their complicated behaviors and look for factors and drugs that alter protein aggregation as potential treatments for currently incurable neurodegenerative diseases, or—on the flip side—figure out how to turn on an aggregate's beneficial function.

—LIZ SHEELEY

IMAGE PROVIDED BY ASSISTANT PROFESSOR AHMAD 'MO' KHALIL

New Understanding of Graphene Nanochannels Could Revolutionize Energy-Efficient Technologies

ASSISTANT PROFESSOR DUAN'S TEAM IS FIRST TO QUANTIFY WATER SLIPPAGES

Since scientists were first able to manufacture graphene, a flexible, single-layer sheet of carbon atoms, its unique properties have made it a highly sought-after and attractive material—it's strong, conducts heat and electricity extremely well and some research shows that it's almost frictionless. But researchers are not reporting consistent data on just how slippery graphene is, especially on the nanoscale level. In a recent paper in *Nature Nanotechnology*, Assistant Professor Chuanhua Duan (ME, MSE) and his team quantified water slippages in single graphene nanochannels for the first time, and detailed why those data are inconsistent.

Earlier this year, Duan was awarded a National Science Foundation Faculty Early Career Development grant to study the underlying mechanisms that lead to fast mass transport in graphitic nanoconduits like graphene nanochannels and carbon nanotubes; this is one of the few projects currently supported by the award. "With the new understanding learned from this paper, scientists can manufacture better graphitic nanoconduits and their membrane forms for revolutionary, energy-efficient technologies in water desalination or purification, chemical separation and energy harvesting," Duan says. "Better graphitic nanoconduits will also have major implications for lab-on-a-chip, which are a cheap, efficient and accurate mini-platforms for biochemical analysis and disease diagnostics."

How fast water flows over a surface depends on that surface's properties. To the naked eye, water flowing through a channel appears to simply glide through it, but water molecules are reacting with the channel's molecules, and that reaction slows down the water's flow. Graphene should not react with water, which would make it an ideal material for water transport—the easier water can flow through a channel, the less power it takes to push it through.

But when researchers across many labs measured how well membranes made of graphitic nanoconduits were able to transport water, they got inconsistent results without being able to pinpoint why.

Duan and his team detail a new method that can accurately measure water flow rates and the corresponding pressure in individual graphene nanochannels, and show how surface charge is the biggest factor when determining how well a particular graphene channel transports water.

When a solid has a surface charge, its molecules can react with the molecules of another substance. Theoretically, graphene should not have a surface charge and the water molecules should not react with it; this research showed that the reason behind the inconsistent data is the differing amount of surface charge that these graphene channels develop during production.

—LIZ SHEELEY

Single-Dose Drug Delivery System Creates Hope for Streamlined Cancer Treatment

SUSTAINED-RELEASE METHOD CAN ELIMINATE MORE INVASIVE TECHNIQUES

Chemotherapy patients experience both visible and invisible side effects from treatment. Most common chemotherapy drugs must be dissolved in toxic chemicals to be administered intravenously and not only cause hair loss but can also wreak havoc on the body, potentially harming major organs and weakening the immune system. These drugs must also be administered over multiple sessions in order to allow the patient to rebound from toxicity, and often require patients to get long-term catheters and return to the hospital multiple times.

An interdisciplinary team of biomedical engineers, chemists and clinicians led by Professor Mark Grinstaff (BME) has developed a novel sustained-release, biodegradable nanoparticle system that delivers a therapeutic dose of a common cancer drug with the same curative effect as the standard multi-dose. Essentially, this system could offer an alternative that is both safer for the patient and also improves quality of life by reducing adverse effects and eliminating multiple drug administrations. Their work, done in collaboration with Brigham and Women's Hospital and the University of North Carolina at Greensboro, has been published in *Chemical Science*, a Royal Society of Chemistry journal.

The drug used in this research, paclitaxel (PTX), is commonly used to treat lung, breast and abdominal cancers. To be used for treatment, PTX must be dissolved in a specific chemical variation of castor oil, which is known to cause severe allergic reactions and neural toxicity; it is also difficult to administer high quantities due to a fine line between a therapeutic and toxic dose. To overcome these obstacles, doctors have tried to treat abdominal cancers locally, but unfortunately patients commonly experience catheter-related complications and toxicities that ultimately limit the total number of doses a patient receives.

By encapsulating the drug in a large molecule known as a polymer, scientists can vary the type of drug, polymer and chemical bond used in the system and safely give their patients a single, higher dose, eliminating the need to use the toxic carrier or more invasive administration techniques.

Iriny Ekladious, a BME graduate student in Grinstaff's lab, says their team decided to use a novel polymer developed in the Grinstaff lab in 2015, and employ a chemical bond that breaks apart in the presence of water to link the drug to the polymer. The degradable and safe polymer used in this research is hydrophobic, or water repelling, which causes the bonds between the polymer and the drug to slowly break and creates a sustained, slow release.

Since confirming that the single-dose delivery system is just as effective as the traditional multi-dose delivery, researchers can now tweak the system and try new ways to bond the drug to the polymer, or develop a chemical that could trigger the drug's release.

—LIZ SHEELEY

ENGINEERING YOUR CAREER

CONCENTRATIONS PREPARE STUDENTS TO SELL IDEAS. AND THEMSELVES.

BY LIZ SHEELEY

Joshua Liebowitz (BME'16)
PHOTOGRAPH BY JEFF WOJTASZEK

Even when an engineer crafts an elegant solution to a problem, it doesn't always get put into practice or made into a consumer product. Companies must craft solutions that are both business savvy and budget friendly, and sometimes products (or processes) don't see the light of day because they are too difficult to produce or implement. But when engineering students learn early how to design a solution—whether it's a new medical device or a streamlined warehouse design—and take into account factors like sustainability and commercialization, solutions can become innovations.

The drive to expose students to how engineering innovations improve society—a key to shaping the Societal Engineer—led to establishing undergraduate concentrations in 2009. By focusing on fields where engineers have significant impact, these concentrations go beyond engineering majors to show students the path successful technologies take, from design to the marketplace. They also complement minors, which focus on traditional academic disciplines outside of a student's College of Engineering or BU major. Nearly half the Class of 2017 graduated with a concentration or minor added to their degree.

With courses like strategy for technology-based firms, students can develop insight that helps them see the bigger picture, such as the timing of a product's development and why it's made of a particular material; they also study important business concepts like intellectual property and product management. And because the content is grounded in how actual companies operate, these courses make students very appealing to employers.

"What I've found with engineers in general is that most of us have this gift to really dive into the nitty-gritty of a certain topic, but some of the best engineers are bad at selling a product or a service," says **Neeraj Basu (EE'16)**, who graduated with a concentration in technology innovation. "If you look through the patent books at a lot of colleges, there are some amazing technologies, but the reason they've never surfaced to the market is because people don't know how to properly apply them or penetrate a market where they can add value. They're creating these really cool things, but they don't know what to do with them or how to sell them. That's why I decided to take the Technology Innovation concentration, so I could get the business savvy behind the technology."

Concentrations in technology innovation (the most popular), nanotechnology, manufacturing engineering and energy technologies are available to all undergraduates. An additional concentration, aerospace engineering, is available to mechanical engineering majors. In each concentration, students select four courses from a suite of offerings and complete a related experiential component, such as a research project or internship.

Joshua Liebowitz (BME'16) chose to add the Technology Innovation concentration—which offers courses geared toward the business and commercial space within technology development—when he developed an interest in product development.

"When I first came to BU I wasn't sure exactly what I wanted to do for a career, but I've always been interested in business," he says. "After I took the Business of Technology Innovation course, I soon realized that I wanted to be a part of research that could actually improve a patient's life, and through other classes I discovered medical device development."

Following his sophomore year, Liebowitz took an internship with the medical device company Medtronic. "That was my first engineering experience where I worked on surgical tools as a quality engineer," he recalls. "After my internship with Medtronic, I realized that every class I take should be giving me a skill that is tangible for industry, and a lot of the classes in the Technology Innovation concentration gave me those skills that I could use in interviews and especially on the job in terms of strategy, analytical thinking and solving complex problems that an employer would give me."

"My favorite class was Product Development with Professor [of the Practice] Gerry Fine," he goes on. "The class really gave me an in-depth view on what the best product development practices are for companies overall. Then through analyzing case studies and prototype development projects that we had in class, I was able to learn about product development theory and apply those learnings to the medical device industry."

Prior to earning a master's degree at Georgia Institute of Technology, Liebowitz got an internship at DePuy Synthes, the orthopaedics business division of Johnson & Johnson, working on plate and screw technologies for trauma injuries, which led to his current position as a research and development leadership program engineer at the company's Philadelphia location. There, he puts the knowledge gained in his concentration to use by working with physicians to finalize design concepts while also analyzing the supply chain to define the product's manufacturability and marketing.

Eventually, Liebowitz wants to work at the intersection of new product leadership development and commercialization. "I would love to define strategy, identify opportunities for innovation and quantify the value that innovation and development would provide for both the healthcare system and a company like Johnson & Johnson," he says.

Employers also see tremendous value in potential employees who can tackle real-world problems. **Valentina Toll-Villagra (ME'16)** credits the Manufacturing Strategy course she took in her Manufacturing Engineering concentration with exposing her to case studies that detailed how businesses solve problems they encounter.

"You get a broader perspective about real-life experiences when you go through cases and imagine yourself in that role and think about what you would do in that situation," she says. "I don't get perfectly crafted problems in my job where there is one solution, but instead more open-ended ones where there may be more than one right answer, so knowing how to analyze a situation and come up with a solution is valuable."

Toll-Villagra is based out of Austin, Tex., as a start-up project manager for Amazon in the operations engineering department,

Valentina Toll-Villagra (ME'16)

PHOTOGRAPH BY JEFF WILSON

Valentina Toll-Villagra (ME'16) credits the Manufacturing Strategy course she took in her Manufacturing Engineering concentration with exposing her to case studies that detailed how businesses solve problems they encounter.

where she oversees the build-out of new warehouses for last-mile delivery—the final step of a product's delivery journey to the customer. But it's not just about choosing a location and constructing a warehouse; she manages everything from the installation of the material-handling equipment to designing a layout that will optimize workflow. Each warehouse is different, which means each project requires a unique plan.

"I work for a very dynamic company so most likely would not be using the same technology over several years. It's always improving and changing over time, to make processes faster and more efficient. Reduce waste and optimize layout," Toll-Villagra says.

Automated Manufacturing, which she took as a junior, gave her a realistic perspective about what working in industry was actually like. "We learned about why certain processes are called what they are, or why they are currently used in industrial settings," she explains. "That class introduced me to the automated conveyer belt that is used in actual warehouses."

Two recent electrical and computer engineering alumni credit the Technology Innovation concentration with showing them how to integrate technical knowledge and business practices.

As a security consulting senior analyst for Accenture in Boston, **Santiago Beltran (CE'17)** works with clients to develop a personalized security operations platform to monitor for hacks and stop any potential system breaches before they happen.

"I was able to fulfill both my desires to be able to learn engineering concepts and also learn how to actually make a product, sell it and return value through the technology innovation courses," Beltran says. Interested in entrepreneurship, Beltran participated in Questrom School of Business' start-up accelerator BUzz Lab and, during sophomore year, began developing a start-up with other students. "I was able to take the skills that I was learning through the Technology Innovation concentration and apply them immediately because we were trying to build a company and I thought that was really valuable," he says. He recommended even non-engineering students in his start-up take the introductory course.

Beltran has since left the start-up, but the accelerator is now integrated into a new $20 million initiative called Innovate@BU. "Seeing that BU is actually investing heavily in an incubator space and promoting student-run ideas makes me happy," he says. "I think the combination of a space where students can make their ideas happen and a curriculum that can support that process—that's big."

Beltran was also able to use his skills during job interviews and in his role at Accenture. "In an interview when a company asks me how I would go about a certain task, I can respond with the technical answers, but businesses also want to know if they could profit off of this or if they could actually return value; if they are solving the client's question," he notes. "And the technology innovation courses I took helped me understand those business aspects and made it much easier for me to answer those questions."

As a consultant working with clients, Beltran finds one class within the Technology Innovation concentration provided a skill he constantly uses on the job: design-based thinking. "Design-based thinking is an approach where, based on the problems we are observing, we try to come up with solutions, so we put ourselves in the shoes of the client in different perspectives, and then brain-storm a wide array of possible ideas and try to change our approach to come up with a valid solution," he explains. "In that case you are talking to a client and figuring out if our solution is the right fit for them, or in my position, how we can secure a client's enterprise. We have the concept for a solution, but then being able to brainstorm and interact with the client can be key. Through talking about what kind of attacks they face and what their vulnerabilities are, you can create interactive workshops and get them to think about security not just in a technical sense, but also about how it impacts their business or the bottom line, and that all comes down to design-based thinking."

Basu, too, sees the value of the Technology Innovation concentration in interweaving a technical degree with knowledge about where industry places value: "When you can show a company that you not only understand the technology, but that you also understand the business and customer base enough to cater your work to add value to the consumer—that really helps with the interview process."

Basu works in West Virginia at the Tabler Station start-up site for Procter & Gamble as a power, controls and information systems engineer. He notes that when you can understand the technology behind the entire system and pinpoint an area that can be optimized, companies see the value in you as an engineer. The site manufactures all hair care products for Procter & Gamble; he works to optimize the production process. If an employee can look at the production line, see that the shampoo bottling/filling process is an area for improvement, develop a solution to speed that process up, and present it to the company showing that it is not only innovative but also saving time and money, value is added.

The minors and concentrations within the College of Engineering allow students to develop expertise that complements their major. **Jesse Batson (ME'17)**, who graduated with a concentration in aerospace engineering and a minor in astronomy, says that being able to understand both the engineering and research sides allows for smoother communication and product development. Aerospace is rooted in engineering; space technology in scientific and technical research.

Explains Batson, who is working on a master's degree in mechanical engineering, "A lot of the space industry, whether it's industry or government, focuses not only on aerospace engineering, which is all within the atmosphere, but also space technology, which is more about developing satellites. Having both the minor and concentration becomes really helpful if I'm on an engineering team and we have to talk to the scientific research team—it's always beneficial if the engineers know about the research side and vice versa. I would be good at communicating effectively between the two teams because of my knowledge in both areas."

"Mechanical engineering is a broad degree and you can do many things with it after graduation," Toll-Villagra agrees. "That's probably why I picked manufacturing engineering as a concentration, because we learned about topics like efficiency and supply chains, which are highly used in manufacturing but also apply to any industry."

"At the job interview level, the technology innovation concentration is a good way of building a business-focused dialogue so that you can talk technically, but then also talk about what companies ultimately run on, or the business side," Beltran concludes. "Then on the job, being able to have those skills can definitely impress managers and company leadership because you are more versed in some of the issues that they're thinking about." ■

By focusing on fields where engineers have significant impact, these concentrations go beyond engineering majors to show students the path successful technologies take, from design to the marketplace.

DEGREES OF POSSIBILITY

The College of Engineering offers many ways for undergraduates to enhance their degrees in a foundational engineering discipline. They can add a minor in any discipline outside of their major: Biomedical, Computer, Electrical, Mechanical or Systems Engineering or Materials Science & Engineering. Or, they can choose to add a concentration in a broader field to complement their degree.

In 2009 the college launched concentrations that rapidly caught on with students, who choose four courses from a menu of options. Each concentration includes a related experiential component that can be satisfied with a research project, a senior design project, an internship or a directed study. Minors and concentrations are noted on official graduate transcripts.

Currently, the following concentrations are available to undergraduates:

AEROSPACE ENGINEERING

Designed for undergraduate mechanical engineering majors and minors, Aerospace Engineering covers the design, construction and science of aircraft and spacecraft. Students are exposed to aerospace fundamentals, including aerodynamics, control and propulsion. The concentration prepares students for careers in aircraft and engine design, avionics, aircraft and spacecraft materials and safety systems.

ENERGY TECHNOLOGIES

The Energy Technologies concentration gives students a fundamental understanding of the environmental impacts of various energy technologies and puts them in a position to pursue a career in the burgeoning field of green energy. The diverse course options include the electro-chemistry of fuel and battery cells; environmental policy; the planning, operation and marketing of sustainable power systems; and the emergence of sustainable energy as the defining environmental challenge of our time.

MANUFACTURING ENGINEERING

Manufacturing Engineering is a cross-cutting field that covers the main aspects of computer-based design, the conversion of research ideas into product development, cost control and optimization, company start-ups, cost proposal preparation, operating plan development and supply chain management. Students are prepared for careers in green manufacturing, materials and systems, MEMS and computer-aided design.

Each concentration includes a related experiential component that can be satisfied with a research project, a senior design project, an internship or a directed study.

NANOTECHNOLOGY

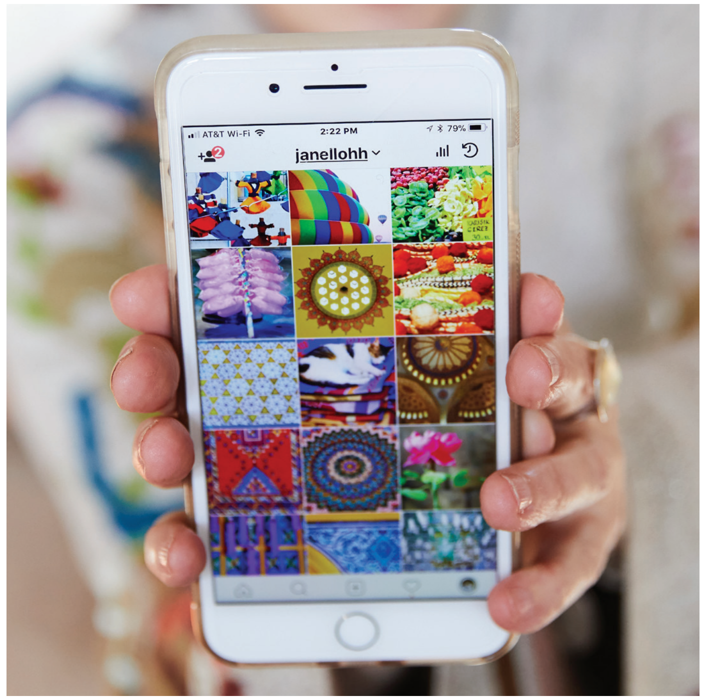
The Nanotechnology concentration offers students foundational knowledge of the effects and applications of nanotechnology, positioning them for future careers in the expanding nanotechnology field. Courses examine how engineering works on scales as small as millionths of a millimeter while students explore the foundations of quantum mechanics, atomic structure and the physics of molecules and solids.

TECHNOLOGY INNOVATION

The Technology Innovation concentration instills an entrepreneurial mindset in and prepares engineering students to recognize and utilize opportunities for technical innovation that can lead to viable commercial products and profitable businesses. The concentration focuses on understanding the innovation and entrepreneurial process from start to finish, offering graduates a path for advancement into future management and leadership positions.

Santiago Beltran (CE'17)

PHOTOGRAPH BY DANA SMITH



THE ART-FUL ENGINEER

ENG ALUM DESIGNS DISTINCTIVE CAREER PATH

BY LIZ SHEELEY

PHOTOGRAPHS BY KELLY DAVIDSON

Janice Ozguc never does anything halfway. When she developed an interest in art conservation, she set up her own business in her apartment. And when she wanted to take a budding fascination with science to the next level, she enrolled in the College of Engineering's inaugural Late Entry Accelerated Program (LEAP) class. Since then, she has melded the worlds of art and engineering into a dynamic career that continues to evolve at the pace of technology.

LEAP gave Ozguc the opportunity to attain her third BU degree—she had previously earned a bachelor's in art history and a master's in the history of art and architecture. Her initial interest in art conservation and restoration was rooted in materials science, a field that appealed to her passion for science and engineering. She wanted more training, but without an engineering undergraduate degree, she was leery about diving headfirst into a full-time materials science master's program. In the early 1980s, eager to enter a new phase of her career, she enrolled in LEAP even though at the time electrical engineering was the only master's degree track for LEAP students.

Established more than 30 years ago to support women who wished to transition into the engineering profession, LEAP was, and remains, a unique master's degree program for students with bachelor's degrees in non-engineering fields. After taking some foundational undergraduate engineering courses, LEAP students transition into one of several master's degree programs. It now attracts men and women from a wide array of academic backgrounds, from math and science to the humanities to business to—as in Ozguc's case—the arts.

"Entering the LEAP program and graduating with an engineering degree opened up a world of opportunities," she says. Upon graduation, she decided to move to Japan and accept a position at Mitsubishi designing semiconductors.

"The people on my team used to say that a 5000x magnified semiconductor was a work of art, but it wasn't exactly the type of artwork I was used to. It wasn't like the art hanging in the Museum of Fine Arts," Ozguc recalls. (And although her newfound passion for technology and engineering moved her career forward, she always maintained her love of the fine arts—she collected Japanese art prints and became an amateur photographer.)

"Engineering gives you an amazing skillset, a way of thinking, a way of adapting to changes and being able to morph into different things."

After two years of technical engineering at Mitsubishi, she moved on to applications engineering and then technical marketing. "Technical marketing for semiconductors is not like writing press releases; it's still very technical," she explains. "It's about where the market is going, what you need to do to be competitive, what kind of cells you need to develop for your semiconductors. It was still using my engineering background even though I wasn't designing semiconductors anymore."

It was when Ozguc began moving into the start-up space in 2003 that she was able to finally move toward a career that melded engineering and art. One of the latest of several start-ups that she cofounded was a company that specialized in developing mobile apps for the social photo-sharing segment. Ozguc helped spec out not only the look and feel of the app, but also all of the technical aspects. She also noted that in the start-up world, employees need to contribute to all aspects of the business, so, in addition to many other tasks, she was also curating the social media content for her budding companies. Since dipping her toe into start-ups, Ozguc has now completely immersed herself in that world and enjoys the fast pace, accelerated business plans, and the excitement of creating a new product that consumers will love.

"I really credit LEAP and the type of training that I received in the program for helping me make all of those transitions in my career from art history to semiconductors to applications engineering to technical marketing then into the mobile app space," she says. "Engineering gives you an amazing skillset, a way of thinking, a way of adapting to changes and being able to morph into different things."

Ozguc has always been a proponent of building a career where she could combine both her appreciation of art and her talent for engineering; her most recent business endeavor, Through My Eyes Media, is the closest she has gotten to fully interweaving the two. The brand-new consulting company will focus on curating social media content for individuals and businesses with a concentration on developing engaging Instagram accounts for clients.

"Instagram is the new web homepage," Ozguc says. "As a business, if you don't have a compelling Instagram feed, somebody is not going to use your company. And it has to be something that speaks to them and not just an arbitrary collection of photos."

Through interviews, she gains an understanding of how clients want their brand to be portrayed and then uses her expertise in marketing, consulting and photography to create an online presence for the clients.

"I think a lot of companies—especially start-ups—try to do too much," she says. "I always ask companies who their target market is to help them focus on what the market wants and then lead them to translating that into their technology. And I think those types of questions come from what I learned through the discipline of engineering because it's a very methodical and strategic way of thinking."

Ozguc sometimes calls herself a Renaissance woman, after an era she sees as reflecting her life's goal of "a masterful blend of art and science." And she's proven that she can translate her skillset across industries and disciplines.

"I started in the arts at BU as an undergraduate," she says. "When you come from a completely different background like that and then are able to learn engineering through LEAP, that jump gives you the confidence to say, 'I can do that' to just about anything." ■

SERVICE ON THE SOLES OF THEIR SHOES

ENG ALUMS CHANGE LIVES ON THE ROOF OF THE WORLD | BY LIZ SHEELEY

(Left) Larry Leszczynski (BME'85,'87) and Anne Hines (BME'87) celebrated the completion of an Alliance-funded school-building project with the father of Gopal Tamang, their Nepali project manager, who worked on the school. (Right) Hines with students from the completed school at the celebration ceremony.

PHOTOGRAPHS COURTESY OF ANNE HINES AND LARRY LESZCZYNSKI

Anne Hines (BME'87) and Larry Leszczynski (BME'85,'87) use their vacation time differently than most people—instead of trying to escape reality, they ground themselves in it. "Traveling in developing countries gives you a reality check on your situation in life," Leszczynski says. "You can reset your priorities and view of the world."

Traveling also offers them a chance to indulge their passion for trekking, and visiting one of the world's most exotic trekking locales proved to be a pivot point in their lives and the lives of hundreds of people who live and work there. During a solo 20-day Nepal trek in 2003, Hines witnessed a Nepali porter carrying a heavy load up a steep and rocky trail whose flimsy flip-flops were about to snap off.

"It was one of those images that just stuck with me," she recalls. That moment inspired their initial drive to found the Colorado Nepal Alliance, which began as a service project in 2012. Since then, the Alliance has supplied thousands of pairs of shoes to Nepali porters and villagers, and expanded its mission to include disaster relief, building schools and providing children with school uniforms.

Hines and Leszczynski first met at Boston University when they lived on the engineering floor in Warren Towers; their friendship continued while Hines was a student in a control systems class and Leszczynski the teaching assistant. Years later, the two reconnected online and developed a bond by helping each other cope after the loss of a parent. On New Year's Eve in 2003, they met in person for the first time since college and later married.

While planning a trip to Nepal in 2012, the couple wanted to find a way to support the Nepalis who had been so welcoming to them on previous treks. With the tattered flip-flop image in mind, they set about collecting 500 pairs of hiking boots and running sneakers from Colorado donors.

Some of the footwear was distributed on trails in the Everest region where people like the porter she had seen nine years earlier spent their lives walking up and down the mountains, while the lion's share was dispersed at an event near the Lukla airport. It made for a chaotic scene, with the queue dissolving into mad grabs for the shoes.

The next year, Hines went back alone and brought more than 700 pairs of shoes, with the distributions conducted indoors at various schools in the Dhading district. At one, the head of the school committee told her that what was needed most was a classroom. After returning to the US, she incorporated the Colorado Nepal Alliance, a Denver-based nonprofit with a mission to "enhance the lives of those living in rural Nepal."

The Alliance started up just as Nepal suffered a 7.8 magnitude earthquake in April of 2015 that devastated the country and destroyed more than 30,000 classrooms and 600,000 homes. To maximize their efforts, Hines and Leszczynski outlined clear objectives to rebuild in a way that would keep the money inside the community; teach residents to rebuild with local materials and in a more structurally sound way than before; pay men and women equally; and focus on repairing community buildings like schools.

To maximize their efforts, Hines and Leszczynski outlined clear objectives to rebuild in a way that would keep the money inside the community.

"It's important to listen to the communities and to what each community needs," Leszczynski stresses (doing just that led them to use local supplies and labor during all of the Alliance's projects). Many nonprofit organizations assemble high-tech wells for water, but replacement parts are expensive and locals do not know how to fix the unfamiliar equipment. To keep this from happening with their projects, the Alliance hired a Nepali architect who devised a plan to build broad, deep foundations suitable for the country's soil and building materials, utilize multiple reinforced concrete tie beams, and improve the techniques workers use when building with field stones. All these improvements are simply designed, help buildings better withstand the force from earthquakes, use less expensive and locally available supplies and allow the local workforce to learn new skills. "High-tech solutions aren't always the way," Leszczynski adds.

Over the last two years, the Alliance has built up a network of engineers, builders, suppliers and contacts to smoothly execute their plans. Hines' guide on one of her first trips to Nepal, Gopal Tamang, became an integral part of that network. He helps them plan around the rainy and farming seasons, recruit reliable labor and suppliers and navigate the Nepali laws. "Gopal figured out a lot for us," Hines says. "He was able to track down who the best suppliers are, how to get supplies on credit, navigate the communities and negotiate transportation for all of the supplies—we are lucky to work with him."

Hines and Leszczynski have full-time careers—Hines is a data analyst for cardiovascular research in the Department of Veteran's Affairs and Leszczynski works as a software and web application developer. "It can be a tough balancing act with our full-time jobs, but Anne is a mover and a shaker and our employers have been helpful and supportive over the years," Leszczynski says.

The Colorado Nepal Alliance continually supports Nepalis by raising money to rebuild schools and provide school uniforms and earthquake and disaster relief. Their original efforts to collect hiking boots and shoes for Nepali porters is still running as Shoes for Sherpas, a project under the Alliance.

After numerous trips to Nepal, the couple has developed strong relationships with the locals, and they try to go back at least once a year for several weeks. Leszczynski credits the Alliance with allowing them to continually strengthen their ties to the area through their support of community projects. "We've been able to make a difference and the Colorado Nepal Alliance has made a difference in people's lives," he says. ■

For more about the Alliance, visit: www.coloradonepalalliance.org.

Associate Professor Douglas Densmore and Assistant Professor Ahmad 'Mo' Khalil

PHOTOGRAPH BY MIKE PECCI

DEAN'S CATALYST AWARDS TURN 10

INTERNAL SEED FUNDING SPROUTS COLLABORATION AND INNOVATION

BY LIZ SHEELEY

Science can be a risky investment, and government institutions holding the purse strings to research dollars want to know their investment is sound—but great scientific ideas don't always come with a guarantee of success. Recognizing this reality, the Dean's Catalyst Awards (DCAs) allow College of Engineering faculty members to explore their riskier ideas, and the investment has paid off nearly tenfold.

Established in 2007 by Dean Kenneth R. Lutchen, the DCA program acknowledges that fields of study within engineering overlap and new perspectives on old problems help move research forward. "The college as a whole is a highly collaborative place," says Associate Dean for Research and Technology Development Catherine Klapperich. "And the Dean's Catalyst Awards program gives faculty that little extra push to reach out to their colleagues and get some of those exciting new areas of work started."

The competitive grant gives projects seed funding for two years to explore new areas of interest that could spark long-term research endeavors and yield new applications across fields. Over the past 10 years, the program has given almost $2.5 million to projects that have seen a return of over $21 million and counting from outside grants. In addition to a monetary return, the awards have forged strong bonds between colleagues within the college and across the University.

"The catalyst program is a spark for new areas of research at the college," Klapperich says. "We are extremely pleased with the success of the program in terms of collaborative publications and follow-on funding success."

These engineers and scientists have established continuing working relationships with each other; over half of the collaborations endure. One such partnership is between Professor Soumendra Basu (ME, MSE) and Professor Uday Pal (ME, MSE), who won a DCA in 2012 to investigate how a process patented by Pal in 2007 could be used to produce solar-grade silicon. The new technique would be environmentally friendly, cheaper and faster than the current standard method.

Silicon is found in many everyday products, not as a pure element but as silicon dioxide, which is the main ingredient in sand. To be used for computer chips and solar cells, silicon must be pure; the standard way to purify it involves two separate processes that require a lot of energy and are harsh on the environment due to the use of chlorine. The first process breaks the bonds between the silicon and oxygen, but the resulting silicon isn't pure enough for electronics. The second, separate process uses chlorine to draw out impurities, but "it's overkill, and the silicon is a thousand times more pure than silicon needed for solar cell applications," Basu explains. "But there's nothing in the middle and it's not like you can stop the process."

Pal's patented solid oxide membrane-based (SOM) electrolysis process would allow for the production of solar-grade purity silicon directly from silicon dioxide in a one-step, low-cost procedure that eliminates the need for chlorine. The solid silicon dioxide is dissolved into molten salt (called "flux") and then heated to over 1,000 degrees to break the silicon-oxygen bonds. A ceramic membrane allows pure oxygen gas to be collected as a valuable byproduct, and the resulting silicon is dissolved into liquid tin, again using high temperatures. When the silicon and tin cool, they separate.

"By combining the separation of silicon and oxygen using the membrane and the purification of silicon using the strong temperature dependence of the solubility of silicon in tin, we can produce solar-grade silicon in one step, keeping the membrane intact," Pal says.

One of the biggest challenges is containing the damage to the expensive ceramic membrane caused by extremely high temperatures and the corrosive nature of the flux. If they can minimize the corrosive attack and prolong the life of the membrane, the cost will decrease and open up the possibility for use in industry. Basu's expertise in how materials degrade at high temperatures will help solve this problem.

The work is ongoing to study how and why the membrane is destroyed during the purification process and solutions to damper or eliminate the damage are being tested. "We have a theory," Pal notes. "If we can match the basicity of the flux and the basicity of the membrane, then we can stop the attack." They've begun testing this theory by adding different compounds to the flux to see if one will create a less corrosive environment for the membrane.

The original $45,000 DCA allowed Basu and Pal to verify their idea of using the SOM method to produce solar-grade silicon. "Those feasibility results were subsequently used to attract two additional National Science Foundation (NSF) projects on that topic," Pal points out. They also led to a new patent application. The NSF grants totaled $312,000 and led to a collaboration with Argonne National Laboratory starting in spring 2018 that could be the first of many.

"The initial investment has different branches," Basu says. "It's interesting that what started as the SOM process moved to an emphasis on the membrane interaction with the molten salt to the study of the molten salt itself, and now, using that knowledge to branch out."

One DCA allowed Associate Professor Douglas Densmore (ECE, BME) and Assistant Professor Ahmad 'Mo' Khalil (BME) to explore a topic freely, generate new ideas and innovate beyond their own labs, thus helping the two BU engineers lay the groundwork for a $10 million, multi-institutional NSF grant called the Living Computing Project (LCP). The project, of which Densmore is principal investigator, brings together synthetic biologists from BU, the Massachusetts Institute of Technology and MIT Lincoln Laboratory to study and develop methods to program biological processes that will benefit sectors such as human health and agriculture. (Although the research produced during the DCA funding is not a direct link to the NSF grant, the collaboration is.) The DCA allowed two scientists from separate fields to think and connect with each other, thereby establishing a successful partnership.

"The DCA gave Doug and me a real opportunity to think tangibly about how we can create paradigms of computation in biological systems," Khalil explains. "The LCP grant, which Doug has so deftly championed and led, is a much more expanded form of that, bringing together many of the best synthetic biologists working on different parts and systems under the umbrella of computation."

What starts as a small seed of an idea can grow far-reaching branches of collaboration. "We have many, many sub-branches we can start exploring," Basu says. "And that's what the DCAs would like to happen." ■

"The college as a whole is a highly collaborative place. And the Dean's Catalyst Awards program gives faculty that little extra push to reach out to their colleagues and get some of those exciting new areas of work started."

Catherine Klapperich
Associate Dean for Research and Technology Development

10 YEARS | $2.5M GIVEN

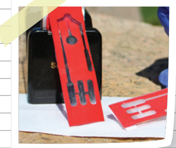
$21M RETURN

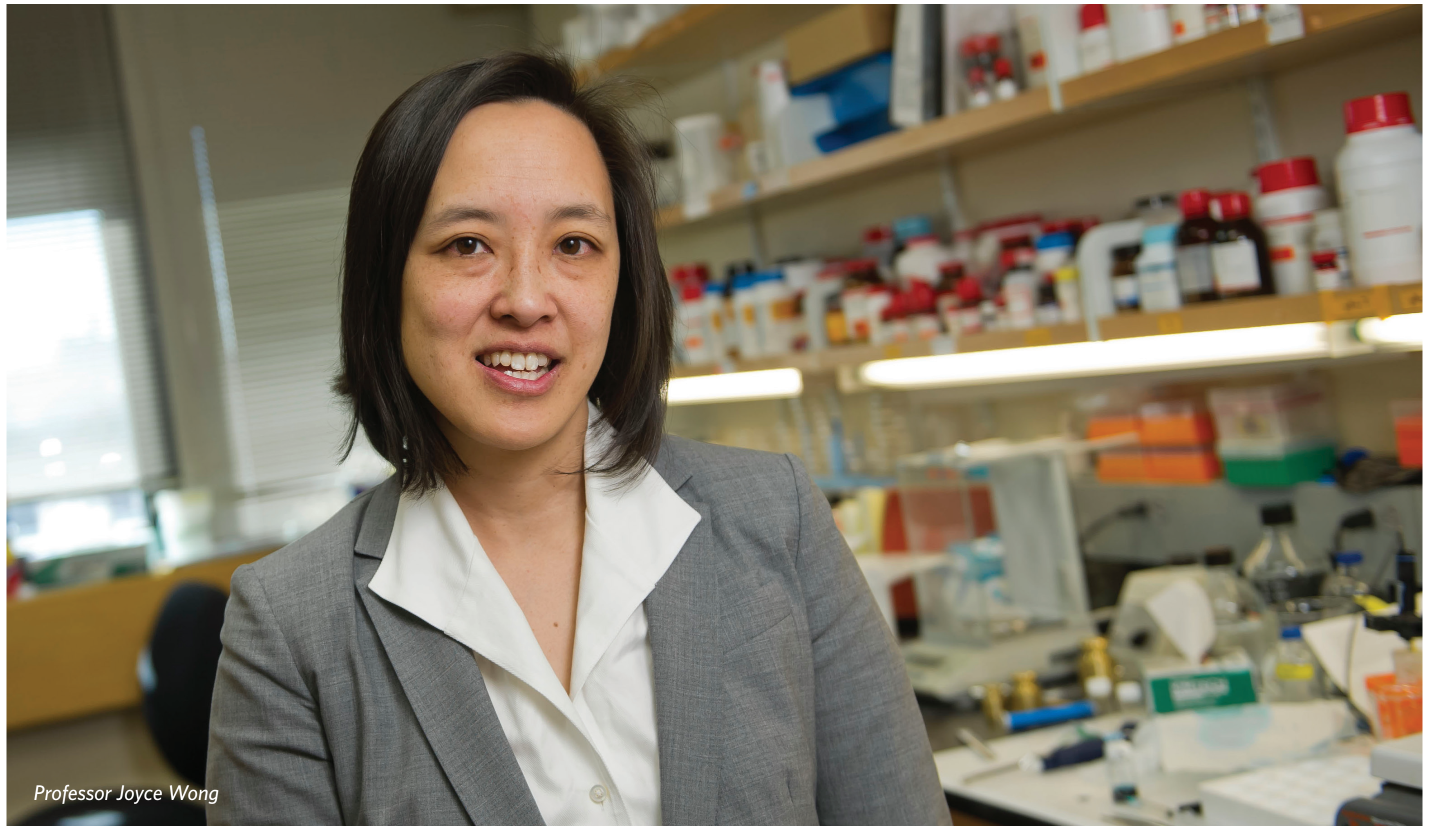
Professors Soumendra Basu and Uday Pal

PHOTOGRAPH BY VERNON DOUCETTE

faculty

27 PROFESSOR WINS GATES FOUNDATION GRANT





Professor Joyce Wong

PHOTOGRAPH BY KALMAN ZABARSKY

Wong Named AAAS Fellow

Professor Joyce Wong (BME, MSE) has been named a fellow of the American Academy for the Advancement of Science (AAAS) "for innovative discoveries in biomaterials development to probe how structure, material properties and composition of cell-biomaterial interfaces modulate fundamental cellular processes, and for promoting women in STEM." The largest general scientific society in the world, AAAS also publishes the journal *Science*. The fellowship dates back to 1874 and is awarded to members by a panel of their peers. Wong received her award at the 2018 AAAS Annual Meeting in Austin in February.

"I am honored to be an AAAS fellow," Wong says. "AAAS has always led the charge in standing for what is right in science even when it wasn't popular."

Wong's research focuses on enabling early detection and treatment of human disease using biomaterials, with an emerging interest in creating new materials for doctors to use in blood vessel reconstruction in children. Current grafts used to repair blood vessels in children are not able to grow as the child does, resulting in patients undergoing multiple procedures throughout their lifetimes. Wong is engineering sheets of cells that would grow with the child, thus offering a better quality of life and cutting down on medical expenses.

In addition, Wong's lab studies how cells migrate depending on their environment; one branch of this research is looking at how cancer cells spread in the body to learn how to predict where they will go. Another arm of this research examines why certain cardiovascular cells will move according to their chemical and mechanical environment, knowledge of which could benefit those suffering from cardiovascular disease, cancer and other ailments where this phenomenon has been observed.

The academy also honored Wong's commitment to promoting women in science. Since 2013, she has directed ARROWS (Advance, Recruit, Retain & Organize Women in STEM), a BU organization that helps connect undergraduate, postdoc, staff and faculty women in science and develops the mentoring, advocacy, networking and professional development practices at BU.

As a new AAAS fellow, Wong joins three other Boston University College of Engineering professors: Professor Xin Zhang (ME, MSE), Professor Emeritus Temple Smith (BME) and Professor David Campbell (Physics, ECE, MSE) have all been recognized for "their efforts toward advancing science applications that are deemed scientifically or socially distinguished."—**LIZ SHEELEY**

PHOTOGRAPH BY JACKIE RICCIARDI

ENG Prof Elected Fellow of National Academy of Inventors

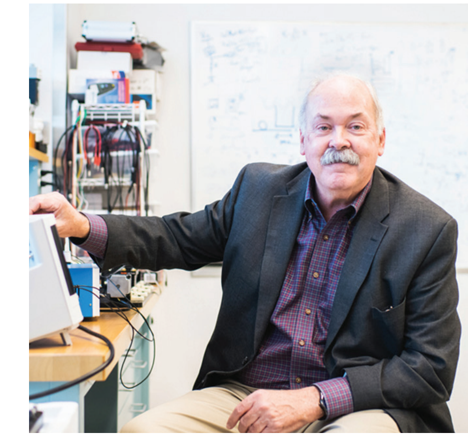
Materials Science & Engineering Division Head Professor David Bishop (ECE, MSE) has been elected a fellow of the National Academy of Inventors (NAI), an elite group of 912 individuals who "have demonstrated a prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development, and welfare of society."

Bishop was recognized for inventing an optical switch that facilitated the rapid transmission of massive amounts of data—including videos, music, photos and email—over the internet in the late 1990s, when demand for bandwidth was exploding. Then-director of micromechanical research at Lucent Technologies Bell Laboratories, Bishop proposed applying microelectromechanical systems (MEMS), at the time a relatively new technology, to create a set of micromirrors that could be used to construct an optical switch capable of relaying huge volumes of data in fiber optic networks.

"Everyone thought he was crazy," says Professor Alice White (ME, MSE), Bishop's longtime friend, colleague and fellow Bell Labs scientist. Now chair of the Mechanical Engineering Department, White recalls, "But he convinced them to invest in the project."

Using 256 micromirrors, Bishop and his team of mechanical and electrical engineers, physicists and chemists built what was then the world's largest optical switch, the Lambda Router. "We went from research prototype to shipped product in 18 months," he says.

As an NAI fellow, Bishop—who holds US patents for 47 micromechanical inventions and is one of the field's most highly cited researchers—joins a group that includes more than 100 presidents and senior leaders of research universities and nonprofit research institutes, 29 Nobel laureates, and 142 fellows of the American Academy of Arts & Sciences (other NAI fellows include BU President Robert A. Brown, ENG Distinguished Professor of Photonics and Optoelectronics Emeritus Theodore Moustakas, and ENG Distinguished Professor of Translational Research Mark Grinstaff). "Those are amazing and wonderful scientists. So to be told you're in the same club as folks like that is really quite an honor," he says.



David Bishop (ECE, MSE), director of BU's new Engineering Research Center, holds 47 US patents for micromechanical inventions.

"Professor Bishop has an impressive record of identifying real-world applications for his scientific and technical research and translating this research into patents and practice," ENG Dean Kenneth R. Lutchen says, noting that Bishop's approach is reflected in his success as principal investigator on the BU team that competed successfully for the $20 million, five-year National Science Foundation Engineering Research Center (ERC) grant to synthesize personalized heart tissue for clinical use (see story on page 3).
—**SARA RIMER**

Densmore Named Under 40 Innovator

HONORED FOR CONTRIBUTIONS TO ELECTRONIC DESIGN AUTOMATION, SOCIETY

This year, Associate Professor Douglas Densmore (ECE, BME) is one of two academic researchers to be named among the top five young, global innovators in the field of electronic design automation by the Design Automation Conference (DAC).

DAC's Under 40 Innovators Award recognizes design automation innovators in industry, research labs, start-ups and academia who have made outstanding contributions to the discipline and society. These contributions can include commercial products, software or hardware systems and algorithms.

A founding member of the Biological Design Center at BU, Densmore is a dedicated, influential researcher in the design automation community known for his cutting-edge reseawrch. Widely recognized for his work developing tools to help create computation in living cells, he is principal investigator of the Living Computing Project, a $10M National Science Foundation–funded collaborative research project. His work applies semiconductor research methods to electronic computing and has far-reaching applications in biosensors, biomaterials and biomedicine.

Densmore, who has participated in DAC since 2002, praises the Under 40 Innovator award for its potential to bring engineering disciplines together. "The award highlights how applicable electrical and computer engineering concepts can be toward biomedical engineering areas like synthetic biology," he explains.

An accomplished researcher, Densmore holds numerous appointments and honors; he is a senior member of the Institute of Electrical and Electronics Engineers and the Association for Computing Machinery and served as Hariri Institute Faculty Fellow in 2016. His accolades include the National Science Foundation Faculty Early Career Development Award, BU Ignition Award and BU College of Engineering Early Career Excellence Award.
—**AMY POLLARD**

Katherine Zhang Wins $1.7M for Diabetes Study

PLANS TO STUDY HOW INDIVIDUAL ELASTIN, COLLAGEN FIBERS CHANGE WITH DIABETES

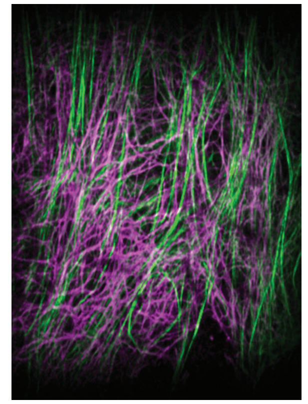
Cardiovascular disease is a leading cause of death in the US, and diabetics are two to four times more likely to have heart disease or a stroke than non-diabetics. For the past seven years, Associate Professor Katherine Zhang (ME, MSE) has been working under a National Institutes of Health (NIH) grant to find out why that is, and has just received a $1.7 million renewal to continue her promising work.

Her initial research led to in-depth understanding of how different microstructures contribute to the behavior of artery walls. Two different fiber types—elastin and collagen—make up a majority of the vascular extracellular matrix (ECM) of arterial walls and work in tandem to bear the pressure loads within the cardiovascular system (collagen is the more naturally stiff fiber, while elastin is more, well, elastic).

Elastin provides the flexibility to gracefully handle the ever-changing volume and pressure within the cardiovascular system. Zhang's research has found that prolonged exposure to glucose alters the fundamental mechanical properties of elastin by stiffening it. Stiffer arteries put a strain on the system as the body must raise blood pressure to generate flow in the affected areas. These changes could have detrimental effects on cardiac function, but the long-term effects of increased elastin stiffness and the resulting change in how the heart and vessels behave are not yet known.

In collaboration with Dr. Seok-Hyun Yun from Harvard Medical School and Dr. Francesca Seta from BU School of Medicine, Zhang plans to use her grant renewal to study how individual elastin and collagen fibers change with diabetes. By observing how the ECM changes over age and disease states, the researchers can better understand at a structural level the changes happening due to prolonged glucose exposure.

"These understandings are highly clinically relevant," Zhang says. "Altered structure and composition of the ECM are main factors attributed to stiffening of the arterial wall in diabetic patients."



Intertwined elastin (magenta) and collagen (green) fiber networks in the extracellular matrix of an arterial wall captured with multi-photon microscopy.

IMAGE COURTESY OF ASSOCIATE PROFESSOR KATHERINE ZHANG

The novel approach will link the biological, structural, biochemical and mechanical perspectives of how diabetes changes elastin and ultimately contributes to the faster progression of cardiovascular disease.

"ECM mechanics in diseases is under-studied," Zhang notes. "Looking at the ECM may open up new perspectives in therapeutic interventions. Targeting the ECM might be an effective alternate route to treatment for some conditions due to the important reciprocal interactions between cells and ECM."

—LIZ SHEELEY

Team of Researchers Awarded $1M Department of Energy Contract

PROJECT AIMED AT BUILDING A SENSOR SYSTEM THAT WILL REDUCE ENERGY COSTS IN COMMERCIAL BUILDINGS

A team of College of Engineering researchers has won a $1 million contract from the Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) to develop Computational Occupancy Sensing System (COSSY), a system of sensors that can estimate the number of people in a room and adjust airflow in heating, ventilation and air conditioning (HVAC) appropriately to save energy.

Professor Janusz Konrad (ECE) will lead the three-year project, one of 15 funded by ARPA-E and aimed at reducing HVAC energy usage, which accounts for 37 percent of energy consumed in commercial buildings in the US.

Most commercial buildings operate airflow on a timer according to a fixed schedule, typically a minimum airflow at night and another matched to a room's capacity during the workday. With a system of sensors that can provide an accurate count of the number of people in a room, the workday airflow can be reduced while still maintaining air quality; by reducing it across many rooms in a building, the team can meet the ARPA-E's goal of 30 percent average energy savings.

The team is well equipped to attack this challenge: Konrad specializes in signal processing and computer vision; Professor Prakash Ishwar (ECE) in machine learning; Professor Thomas Little (ECE) in networking; and Associate Professor Michael Gevelber (ME, MSE, SE) in control of commercial HVAC systems and energy. Additionally, three industrial partners have already agreed to collaborate with the BU team on the project.

The team will develop a scalable system that uses both high-resolution panoramic cameras and low-resolution thermal door sensors. The cameras and door sensors will work together to estimate how many people are in the room at any given time. When visual privacy is of concern, just the thermal sensor will be installed so the system can still sense the number of people without using a camera.

"While we will be developing COSSY to reduce energy use in commercial buildings, there is a potential for much wider impact of this technology, from optimizing room usage in educational and office buildings to maximizing hotel revenue, both based on room-occupancy analysis," Konrad says.

—LIZ SHEELEY

Klapperich Awarded Gates Foundation Grand Challenges Grant

SAMPLE PREPARATION AND STORAGE SYSTEM WILL BENEFIT HIGH-RISK HIV PATIENTS

SNAPflex (System for Nucleic Acid Prep–Flexible) can be used in low-resource areas to extract, prep, store and ship patient samples as a low-cost and simple method to consistently monitor HIV-infected and high-risk patients.

PHOTOGRAPH PROVIDED BY PROFESSOR CATHERINE KLAPPERICH

Known as antiretroviral therapy, long-term HIV treatment has dramatically changed the quality of life and longevity of infected and even at-risk patients, but patients receiving this treatment must be constantly monitored by having their blood tested several times a year with nucleic acid amplification testing (NAAT). Sensitive and effective for early detection, NAAT is also expensive and requires that samples be refrigerated, which can be a challenge in developing countries.

Professor Catherine Klapperich (BME, MSE) has devised a new, inexpensive, easy-to-use method for preparing samples for NAAT without refrigeration called SNAPflex (System for Nucleic Acid Prep-Flexible). The promise of the technology has been recognized by the Bill and Melinda Gates Foundation, which has awarded Klapperich (in collaboration with Cambridge, Mass.-based MakerHealth) a $100,000 Grand Challenges Explorations grant to develop it.

A $100 million initiative that supports research to solve global health and development challenges, Grand Challenges Explorations has funded over 1,365 projects in more than 65 countries since its launch in 2008. It covers a wide breadth of disciplines, including innovations for integrated diagnostic systems and health systems strengthening to ensure effective health supply chains. If successful, projects can receive follow-on funding of up to $1 million.

"This project takes everything we have learned in our lab about small-scale and portable blood preparation and combines it with smart, usable design for manufacturing and scale-up," says Klapperich. "We are very excited to get started."

The simple sample preparation and storage system will allow infected and high-risk patients in low-resource areas to be consistently monitored. The potential to directly reduce transmission rates and new infections considerably increases when doctors in low-resource areas can combine the effective use of antiretroviral therapy and NAAT diagnostics. The new system also creates more opportunities for faster diagnoses to allow those who are newly infected to limit their exposure to others and implement safe protocols to stop the virus from spreading.

Rather than test for antibodies, NAAT looks for the presence of the virus' genetic material, a method that provides more sensitive and quantitative monitoring but also requires samples to be kept cold during transit to a laboratory in addition to expensive sample preparation and testing equipment. Klapperich's storage solution is a flexible, layered plastic and paper system that looks like a roll of tape. Along the roll are a series of fluidic systems, each able to store and extract the genetic material used in NAAT. The storage cards can be torn off one-by-one from the roll, and then a patient provides a small amount of blood from a finger prick onto the card. Klapperich developed two innovative liquid solutions that would extract, clean and dry the genetic material from the patient's blood.

Not only is the cold-storage element of the previous process cut out, but this new device also eliminates the need to use needles, syringes and other medical equipment to draw and store blood samples; laboratory costs are also significantly lowered since the cards prepare the sample for processing. And because it is easy to use, medical professionals should be able to adapt it with little training. Klapperich's card system can be manufactured using either laser cutting or stamping—both low-cost processes—because of the simple and flexible design. All of these factors allow the new device to be implemented quickly and economically, getting patients faster access to test results and potential treatments.

—LIZ SHEELEY

Cheng Is Inaugural Moustakas Chair Professor in Photonics and Optoelectronics

MOUSTAKAS LAUDS CHENG AS "VISIONARY RESEARCHER"

Upon Professor Ji-Xin Cheng's (ECE, BME) appointment to the College of Engineering last summer, he was awarded the first endowed Theodore Moustakas Professorship in Photonics and Optoelectronics. Earlier this month, Dean Kenneth R. Lutchen gathered Cheng and his chair's namesake, Professor Emeritus and Distinguished Professor of Photonics and Optoelectronics Theodore Moustakas (MSE, ECE), to celebrate the latter's legacy and the former's appointment.

Joining BU in 1987, Moustakas developed an innovative method that made the large-scale manufacturing of blue LEDs possible, a technology now widely used in myriad electronic devices. He has received multiple commendations during his tenure, including being named a fellow of the American Physical Society and of the Institute of Electrical and Electronics Engineers; he is also a charter fellow of the National Academy of Inventors. His work in semiconductors and electronic materials has generated 36 US patents, including one on a method to create blue light from an LED that was cited as foundational by Shuji Nakamura, who shared the Nobel Prize for advancing Professor Moustakas' method to create the blue LED product. Beyond his research contributions, Moustakas is also known as an outstanding professor and was awarded the ECE Award for Excellence for Teaching in 1998.

"I am grateful and proud that the University has created the endowed chair in Photonics and Optoelectronics in my name," Moustakas says. "I am also very pleased to see that its first recipient is Professor Ji-Xin Cheng, who is a visionary researcher in the areas of imaging technologies and disease diagnostics and treatment. His contributions in these areas will further enhance the fields of life sciences and engineering at BU."

Cheng holds dual tenure in the departments of Electrical & Computer Engineering and Biomedical Engineering at Boston University as well as secondary appointments in chemistry and physics. He is a member of the Photonics Center and a pioneer in applying optics and photonics to the development of label-free spectroscopic imaging technologies, applications of which are numerous and include precise disease diagnostics and treatment, particularly in prostate cancer. These technologies can discover new biological markers that indicate how far cancer has progressed more precisely than existing methods. "This is how photonics can create better medicine," Cheng explains.

Professor Ji-Xin Cheng (second from left) celebrates his appointment as the inaugural Moustakas Professor in Photonics and Optoelectronics with colleagues Professor and ECE Department Chair W. Clem Karl (from left), Professor and Director of the Photonics Center Thomas Bifano (ME, MSE), Dean Kenneth R. Lutchen and Distinguished Professor of Photonics and Optoelectronics Emeritus Theodore Moustakas.

PHOTOGRAPH BY DAVE GREEN

"Being recruited to BU as the inaugural holder of the Moustakas Chair Professorship is a great honor to me and a key step in my career," he adds. "I wish that I will be able to extend Professor Moustakas' legacy through inventing game-changing technologies and mentoring next-generation scientists."

Cheng's accolades include being appointed a fellow of the American Institute of Medicine and Biological Engineering in 2014 and winning a translational research award from the International Society for Optics and Photonics the same year. He also received a Research Excellence Award from the Purdue University College of Engineering, where he was most recently a professor. His innovations have led to 10 US patents and over 200 peer-reviewed publications.

At Boston University, Cheng is building a highly interdisciplinary and collaborative biophotonics research program with applications in cancer metabolism, neuroscience and infectious diseases—for example, his group is developing a drug-free treatment of superbugs, like MRSA, by using light to break down bacteria. For his first test of the technique, Cheng used blue LEDs.

"The College of Engineering is honored to have been able to establish a professorship named after Professor Moustakas, whose career has transformed the field," Lutchen says. "We are also extraordinarily fortunate that this professorship helped recruit someone with the prestigious reputation and inherent interdisciplinary impact as Professor Ji-Xin Cheng."

—LIZ SHEELEY

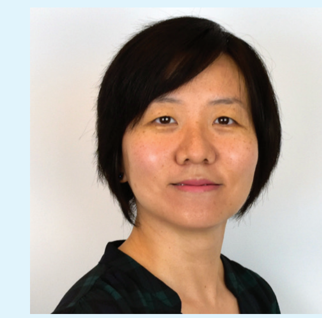
ENG Welcomes New Tenure-Track Faculty

The College of Engineering is pleased to introduce five new tenure-track faculty within mechanical engineering, systems engineering, electrical and computer engineering, and biomedical engineering.

Before her appointment as assistant professor in the Mechanical Engineering Department, **Sheila Russo** (ME) was a postdoctoral fellow in the Microrobotics and Biodesign labs at the Harvard John A. Paulson School of Engineering and Applied Sciences and the Wyss Institute for Biologically Inspired Engineering. Her research interests include surgical robotics, soft robotics, sensing and actuation, multi-scale and multi-material manufacturing methods and advanced materials. She completed her PhD in biorobotics at the BioRobotics Institute, Sant'Anna School of Advanced Studies, Italy.

Assistant Professor **Tommaso Ranzani** (ME) joins the Mechanical Engineering faculty from his appointment as a postdoctoral fellow at the Harvard Microrobotics Laboratory and at the Harvard Biodesign Laboratory. His main research area is soft robotics; he has explored soft robotic technologies to develop novel manipulators, which integrate design principles from biological systems for performing advanced procedures in minimally invasive surgery. Ranzani received his PhD in biorobotics and surgical robotics at the BioRobotics Institute, Sant'Anna School of Advanced Studies, Italy.

Assistant Professor **Rebecca Khurshid** (ME, SE) was a postdoctoral associate in the Interactive Robotics Group at MIT before joining the ENG faculty. During her postdoctoral work, she investigated how humans can best teleoperate robots and how varying levels of robot autonomy affect the team's performance. Her current research aims to enable humans of all skill and ability levels—and their robotic counterparts—to accomplish previously impossible tasks through human-robot interaction. She received her PhD in mechanical engineering and applied mechanics from the University of Pennsylvania.



Before joining the Electrical & Computer Engineering Department, Associate Professor **Chen Yang** (ECE, Chemistry) was an associate professor in the Department of Chemistry and Department of Physics at Purdue University. Yang's research interest focuses on developing functional nanomaterials for photonics and biomedical applications. Specifically, her research programs currently encompass three major areas: interfacing nanomaterials with biology for in vivo biomedical applications; understanding and designing new nanomaterials with unique optical properties for photonics and solar energy applications; and nanowire architecture for electronics and photonics applications. She received her PhD in chemistry from Harvard University.

Ji-Xin Cheng (ECE, BME) joins the college as the inaugural holder of the endowed Theodore Moustakas Professorship in Photonics and Optoelectronics (see page 28 for more).

Dunlop Receives Young Investigator Award

RECOGNIZED FOR EARLY CAREER IMPACT ON SYNTHETIC BIOLOGY

ASSISTANT PROFESSOR MARY DUNLOP (BME) has received the 2017 *ACS Synthetic Biology* Young Investigator Award, which recognizes the contributions of scientists who have made a major impact on the field of synthetic biology early on in their careers.

"It is a great honor to receive the *ACS Synthetic Biology* Young Investigator Award this year," Dunlop says. "Synthetic biology is an emerging field with many excellent early career scientists. I am thrilled to be recognized for my research group's efforts on engineering biological feedback control systems."

Before joining Boston University's faculty in January 2017, Dunlop was an assistant professor at the College of Engineering and Mathematical Sciences at the University of Vermont. Her research focuses on systems and synthetic biology with an emphasis on feedback in gene regulatory networks. The Dunlop lab studies naturally occurring examples of feedback to understand how microorganisms use it to respond to changes in their environment and also engineers novel, synthetic feedback control systems. To support her research, Dunlop has three current grants: a National Science Foundation Early Career Development Award; a National Institutes of Health R01; and a Defense Advanced Research Projects Agency award.

—LIZ SHEELEY

Assistant Professor Mary Dunlop

NEWS BYTES

FACULTY

Nominated by an advisee for his strong support of women who are ECE PhD candidates, Research Professor **Robert Gray** (ECE) spoke at The Gender/Race Imperative, a speaker series led by attorney, academic and activist Anita Hill.

Research Associate Professor **Toshi Nishimura** (ECE) received recognition from the *Journal of Geophysical Research: Space Physics* editors as an outstanding reviewer in 2016.

Associate Professor **Ayse Coskun** (ECE) won the 2017 Ernest S. Kuh Early Career Award from the Council on Electronic Design Automation of the Institute of Electrical and Electronics Engineers (IEEE).

Associate Professor **Vivek Goyal** (ECE) received the 2017 IEEE Signal Processing Society Best Paper Award for his paper, "Message-Passing De-Quantization with Applications to Compressed Sensing," published in *IEEE Transactions on Signal Processing*.

Six researchers earned the Gauss Award at the 2017 International Supercomputing High Performance Conference for their paper, "Diagnosing Performance Variations in HPC Applications Using Machine Learning." Associate Professor **Ayse Coskun** led the team, which included Assistant Professor **Manuel Egele** (ECE) and Postdoctoral Associate **Ata Turk** (ECE) with PhD students **Ozan Tuncer**, **Emre Ates** and **Yijia Zhang**.

In his June blog, Director of the National Institutes of Health (NIH) Dr. **Francis Collins** highlighted Assistant Professor **Ahmad 'Mo' Khalil**'s (BME) work to develop a rapid test for antibiotic resistance.

Assistant Professor **Ahmad 'Mo' Khalil**'s yTRAP research (see page 10) was noted in *The Scientist* magazine and recommended in F1000Prime, a database of important articles in biology and medical research publications that are identified by peer-nominated global faculty of the world's leading scientists and clinicians.

Professor **Ioannis Paschalidis** (ECE, BME, SE) hosted the second Symposium on the Control of Network Systems (SCONES) in October.

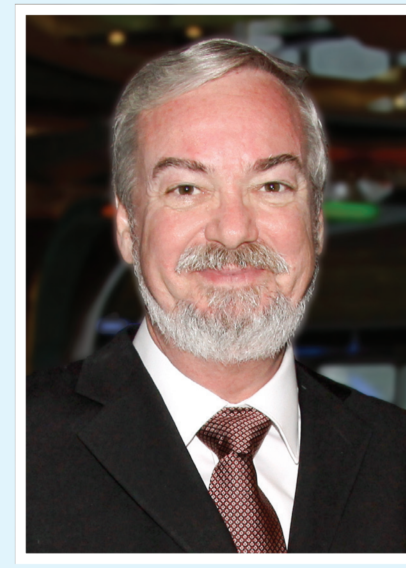
STUDENTS

Advised by Assistant Professor **Michel Kinsy**, **Lake Bu** (ECE PhD student) and **Hien Nguyen** (ECE MS student) received a Best Paper nomination and the Best Student Paper Award at the 2017 IEEE International Symposium on Defect and Fault Tolerance in Very-Large-Scale Integration and Nanotechnology Systems Conference.

Nithin Sivadas (ECE PhD student), advised by Professor **Joshua Semeter**, was one of nine students selected for the 2017 NASA Heliophysics Research Fellowship Program.

Advised by Associate Professor **Ayse Coskun**, **Anthony Byrne** (CE'19) received the Best Lightning Talk Award at the IEEE MIT Undergraduate Research Technology Conference for "DeltaSherlock: Cloud Integrity Through Machine Learning."

Longtime BME Faculty Member Herbert Voigt Mourned



Voigt was an uplifting and optimistic presence through the years of developing the department and its reputation, and he took major roles in research, teaching and administration.

Professor Herbert F. Voigt, a longtime Biomedical Engineering faculty member who helped set the department on a course that would lead it to elite, national stature, died suddenly on January 25. He was 65.

Voigt joined the BME faculty in 1981 and played an important role as the department's small faculty established a research portfolio, the first step on its journey to becoming one of the nation's largest and highest-ranked biomedical engineering departments.

"Herb Voigt was one of only seven faculty in BME when I joined back in 1984," said Dean Kenneth R. Lutchen, a BME professor. "He was truly a pioneer in transforming the department from an undergraduate-only program to a full, research-active one with master's and PhD programs. Herb also amplified the department's influence nationally in its early years through his service as a leader in several biomedical engineering organizations."

"Herb was critical in setting us on the path to the success we enjoy today," said Professor John White, chair of the BME department. "He was department chair during a critical time, working with then-Dean Charles DeLisi to expand our research efforts into applied molecular biology. He had a remarkable record of service to the global community of biomedical engineering."

Voigt's research centered on the neuronal circuitry in the cochlear nucleus, a complex within the brain stem that carries information from the inner ear to the brain.

Voigt was awarded a Fulbright Scholar grant in 2015 to work with the Pontifical Catholic University of Peru on developing a new BME PhD. He also collaborated with the Instituto Nacional de Salud, Peru's equivalent to the National Institutes of Health, to create a research program that focused on detecting heavy metals in biological samples.

Through his leadership position in the International Union for Physical and Engineering Sciences in Medicine, of which he was president from 2014 to 2015, he assisted in developing programs and policies that advocated for women in engineering, addressed global health issues and supported the development of engineering and healthcare in resource-poor nations.

Voigt was a fellow of the American Institute for Medical and Biological Engineering and was elected the organization's president in 2005. He also served as president of the International Federation for Medical and Biological Engineering, the Biomedical Engineering Society and the biomedical engineering honor society Alpha Eta Mu Beta. He was appointed the Institute of Electrical and Electronics Engineers' Engineering and Biological Society Distinguished Lecturer for 2012–13.

In addition to his service in professional organizations, Voigt was active in the life of the University and the College of Engineering. He won the college's Faculty Service Award in 2000 and served as secretary/treasurer and, later, chair of the University Faculty Council.

Donations in his memory may be made to the Bach, Beethoven, and Brahms Society of Brookline, Mass., and to Congregation Beth Shalom of the Blue Hills in Milton, Mass.

—LIZ SHEELEY

alumni / IN MEMORIAM

Mr. George J. Arouchon *('54), Nashua, N.H.*
Mr. Harry T. Breul *('55), Monroe Township, N.J.*
Mr. Ronald P. Martin *('56), Wakefield, Mass.*
Mr. John D. Lowe *('58), Gloucester, Mass.*
Mr. Richard Elwyn Jenness *('63), Warren, R.I.*
Mr. Raymond H. Stone *('63), Brockton, Mass.*
Mr. Robert J. Blozie *('65), West Brookfield, Mass.*
Mr. Robert M. Shorey *('65), Peabody, Mass.*
Mr. Norbert Pawlak *('67), Vine Grove, Ky.*
Mr. Richard L. Prevost *('67), Nashua, N.H.*
Mr. James D. Mulholland *('69), Peabody, Mass.*
Mr. Francis A. Harrington, Jr. *('70, '77), Marlborough, Mass.*
Mr. Scott Alan Walker *('87), Oak Creek, Colo.*
Mr. Richard E. Lord, Jr. *('93), Braintree, Mass.*
Mr. William Christopher Rockers *('14), Kansas City, Mo.*

alumni

WE WANT TO HEAR FROM YOU! SEND YOUR CLASS NOTES SUBMISSIONS TO ENGALUM@BU.EDU OR VISIT WWW.BU.EDU/ENG/ALUMNI.

ENG distinguished alumni (from left) William Weiss, Denise Schier and Bettina Briz-Himes receive their awards at a reception during Alumni Weekend 2017 with Dean Kenneth R. Lutchen (right).

PHOTOGRAPH BY FRANK CURRAN

Distinguished Alumni Awards Honor ENG Grads

During BU Alumni Weekend 2017, the College of Engineering honored three alumni for their career achievements and the support they have shown for the Boston University community.

After Dean Kenneth R. Lutchen's welcoming address on Friday, September 15, two current students, Natalia Frumkin and Aidan Ryan, and one recent alumnus, Santiago Beltran (CE'17), introduced the three 2017 honorees, Bettina Briz-Himes (EE'86), Denise Schier (ME'81, ME) and Bill Weiss (SE'83, CE'97). Weiss supports the Societal Engineering Endowed Fund benefiting the Technology Innovation concentration.

Frumkin and Ryan were part of the Summer Term Alumni Research Scholars (STARS) program, which provides housing support for undergraduates to make it easier for them to perform research and work with faculty over the summer; Beltran completed the new Technology Innovation concentration during his time at ENG.

Briz-Himes graduated with a master's from ENG after earning her BA in biophysics from the University of California, Berkeley. She works as the senior director of strategic alliances at GoPro, based in San Francisco, Calif., where she has been since September 2013. A technology executive for many decades, Briz-Himes has helped advise and grow businesses internationally across diverse technologies and markets.

Schier was involved in the Society of Women Engineers during her time at ENG, and after graduating with her bachelor's, she earned her MBA from Northeastern University. She then served as manager of operations at General Electric before moving to Ametek in 1989, which specializes in electronic instruments and electromechanical devices. Schier just recently retired from her role of vice president and general manager of Ametek after serving in a number of senior positions, including manager of operations, strategic marketing and heading up their cable business and power and industrial products division.

Weiss earned both his bachelor's and master's degrees from ENG, and has worked for General Dynamics for the past 34 years. He leads their mission systems ground systems line of business, which is focused on military networks, networked computing and mission command systems and satellite ground systems. During his career at General Dynamics, Weiss has directed a number of important programs and business efforts, including the US Army's Warfighter Information Network-Tactical and Common Hardware Systems programs. ■

PHOTOGRAPH BY LIZ SHEELEY

Boston University College of Engineering

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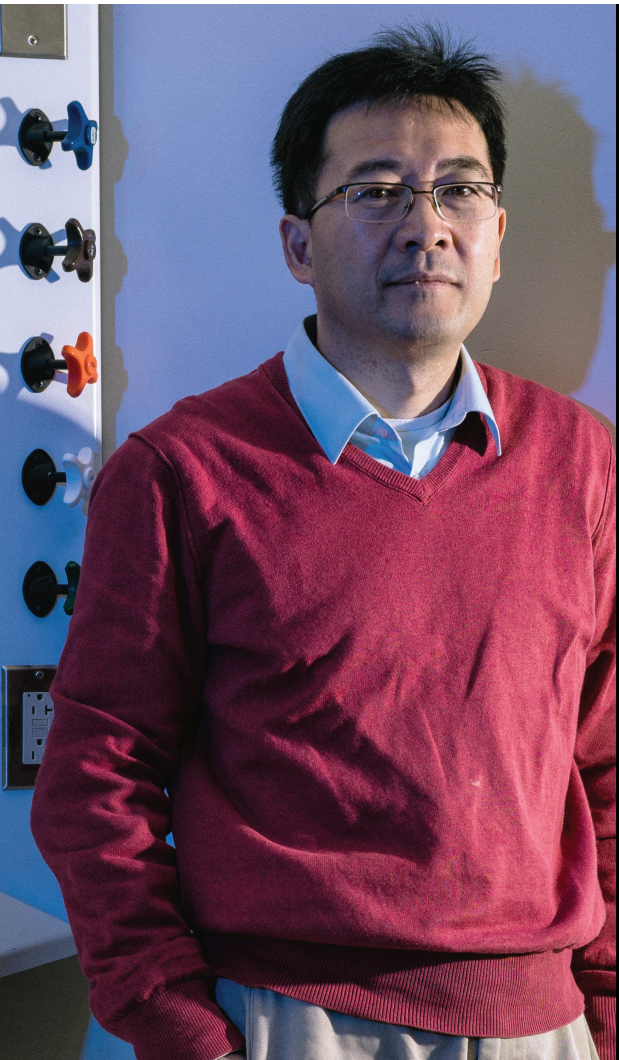

Ji-Xin Cheng

PHD, UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA, HEFEI, CHINA

MOUSTAKAS PROFESSOR IN PHOTONICS AND OPTOELECTRONICS

PROFESSOR OF BIOMEDICAL ENGINEERING, ELECTRICAL & COMPUTER ENGINEERING, CHEMISTRY, AND PHYSICS

As a new faculty member, I'm excited to bring my passion for interdisciplinary research and developing real-world applications to a university that also recognizes those values. My lab focuses on three goals, which build on each other: the development of new imaging technologies; the discovery of new biology; and the delivery of innovative diagnostic tools to a clinical setting.

We focus on label-free imaging, which holds the potential to discover unknown cellular mechanisms involved in human diseases. By developing a new biological imaging method, we can see things we couldn't before. The imaging techniques and tools paired with true discovery allow us to build devices for increasingly precise diagnosis and treatment of human diseases, including breast cancer and spinal cord injury.

To learn more, visit bu.edu/eng.

PHOTOGRAPH BY MICHAEL D. SPENCER