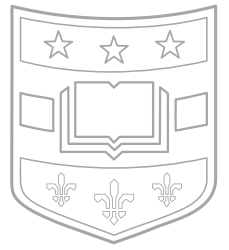


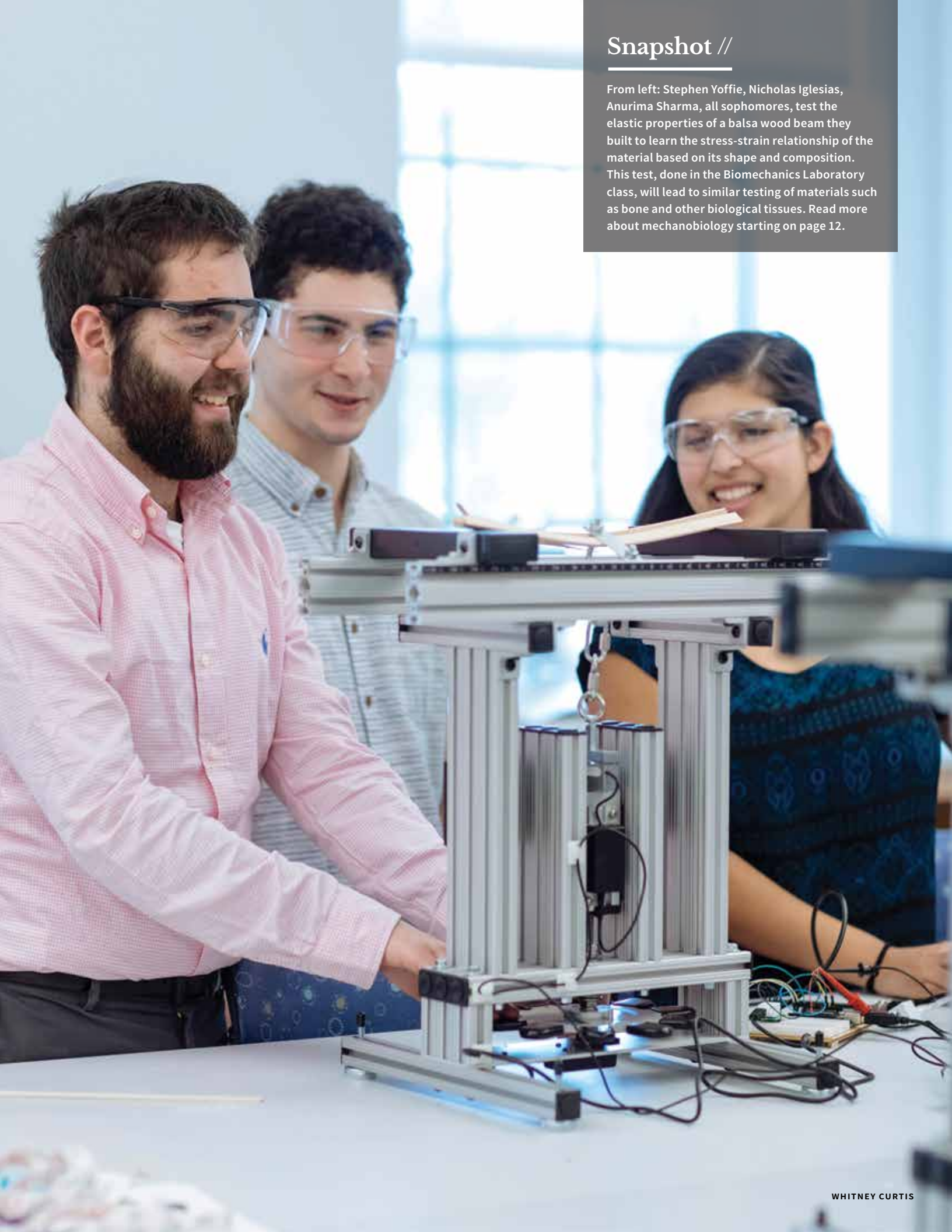
ENGINEERING Momentum

Across Disciplines. Across the World® // SPRING 2017



DRIVING FORCE

Mechanobiology
provides insight into life



Snapshot //

From left: Stephen Yoffie, Nicholas Iglesias, Anurima Sharma, all sophomores, test the elastic properties of a balsa wood beam they built to learn the stress-strain relationship of the material based on its shape and composition. This test, done in the Biomechanics Laboratory class, will lead to similar testing of materials such as bone and other biological tissues. Read more about mechanobiology starting on page 12.

From the dean //



Dear friends,

During my first year as dean, we focused on listening (and some doing), and during my second year, we focused on planning (and even more doing). For the past several months, the faculty and staff led a strategic planning effort that created a set of aspirational plans to advance the goals of the school and to increase our strength and impact. We used a bottom-up process, and the planning committee solicited ideas from all our constituents including students, faculty, staff, alumni, and leaders in industry, government and academia. The response was overwhelming with more than 450 submissions received!

The committee next distilled these seed ideas into a collection of 19 white papers — plans that represent strategic scale initiatives that advance the research and education missions of the school. The topics that emerged organically covered an even distribution of white papers targeting research, education, culture and operations. These areas represent thoughtful, deliberate efforts to dramatically improve the current status of our operations, to provide innovative educational experiences, to strengthen research directions in which we can have significant impact, and to strike out in bold new areas. We, of course, will not be able to pursue all these initiatives simultaneously, but they provide a strong set of opportunities. These white papers and the resulting overall strategic plan that distills out the objectives, goals and tactics embodied therein will be shared with the community when complete, likely this summer.

As a preview, I mention that one of the research thrust white papers is on *mechanobiology* — the study of how biological systems both respond to and generate force. This research area is highlighted in this issue of the magazine (page 12), and it is a quintessential WashU Engineering effort: interdisciplinary engineering research directed at biological and medical interventions. WashU Engineering partnered with Penn to win a National Science Foundation Science & Technology Center in Mechanobiology, and this focus represents a domain in which we can produce world leaders and have transformative, world-changing impact. And, that is about as strategic as we can be.

Aaron F. Bobick
Dean & James M. McKelvey Professor
afb@wustl.edu

DEAN

Aaron F. Bobick

ASSOCIATE DEAN &
EXECUTIVE EDITOR
Nick Benassi

SENIOR WRITER & EDITOR
Beth Miller

CREATIVE SERVICES
DIRECTOR & DESIGNER
E. Brook Haley

DIGITAL COMMUNICATIONS
Kristen Otto

COMMUNICATIONS
SPECIALIST
Suzanne Bremehr

WEB DEVELOPER
Vince Ruppert

CONTRIBUTORS
Erika Ebsworth-Gould
Tony Fitzpatrick
Kurt Greenbaum
Christopher Tritto
Jay Turner

Engineering Momentum is published by the School of Engineering & Applied Science at Washington University in St. Louis. Unless otherwise noted, articles may be reprinted without permission with appropriate credit to the publication, school and university.

CORRESPONDENCE
School of Engineering & Applied Science
Washington University in St. Louis
Campus Box 1163
One Brookings Drive
St. Louis, MO 63130-4899

EMAIL
magazine@seas.wustl.edu

PHONE
(314) 935-6350

WEBSITE
engineering.wustl.edu

IN EVERY ISSUE

- 1 // From the dean
- 3 // The buzz
- 4 // School news
- 6 // Faculty news
- 37 // Last word

COVER STORY

12 // **Driving force**

FACULTY FEATURE

18 // **Jay Turner**

STUDENT FEATURE

22 // **Beyond the 'bubble'**

ALUMNI FEATURE

28 // **Joseph Chamdani**

SPECIAL FEATURE

32 // **Jubel & McKelvey Halls**

ALUMNI FEATURE

34 // **Alumni Achievement Awards**

YOUNG ALUMNI FEATURE

38 // **Leah Honey**



THE BUZZ #WashUengineers



What's next after Clean Power Plan executive order?

“During the last administration, there were many changes to policy so it was difficult for utilities to make major investments. The reversal of the Clean Power Plan once again brings uncertainty to the power industry, and it delays efforts to contain carbon emissions. The democratic form of government is extremely effective in most areas, but when it comes to long-term planning for the power industry, it presents challenges that can be costly to the American people.”

— RICHARD AXELBAUM,
The Stifel & Quinette Jens Professor of Environmental Engineering Science

WashU Engineering student Jordan Gonen launched a website to celebrate an ever-growing list of immigrants who founded American businesses: celebrateimmigrants.us



2017 Solar Decathlon

Students from the Sam Fox School of Design & Visual Arts and the School of Engineering & Applied Science are preparing for Solar Decathlon 2017. Sponsored by the U.S. Department of Energy, the biennial competition challenges university teams from around the world to design and build full-size, solar-powered houses. This year's event will take place in Denver Oct. 5-15. Stay up to date on the WashU team's progress: solardecathlon.wustl.edu

@WashUengineers
Thanks @MindlinFndtn for bringing Ellen Zegura (She earned her BS, MS & DSc at WashU!) to speak on "Technology & Social Good" #engineersweek

@chasehartquist
I'm excited to announce that I've committed to study biomedical engineering and play football at Washington University in St. Louis #washu21

@TheRealBitner
Beyond happy to announce my commitment to study Mechanical Engineering at WashU as a Langsdorf Fellow! #WASHU21



Shout out to the nine WashU Engineering students who performed a hula dance last weekend's Lunar New Year Festival! FEBRUARY 15



#washuengineers @NHL college nights! Let's go @StLouisBlues! MARCH 1



Our @NSBE students won small chapter of the year in their region! #NSBE43 Go Bears! APRIL 3

WashU Engineering offers new master's in health care operational excellence



The School of Engineering & Applied Science is offering a new master's degree that will use engineering principles to dramatically improve health-care operations.

The Master of Health Care Operational Excellence will equip leaders in health care and health-care management to improve the quality and efficiency of the U.S. health-care system using engineering systems processes. The degree, which will launch in Fall 2017, is designed for health-care management and staff both within hospitals and clinics, including physicians, nurses, pharmacists, lab technicians, imaging professionals, and in environmental services and facilities, and food service and nutrition, as well as operations managers and process improvement engineers. In addition, engineers and managers with experience in performance improvement in other professions outside of health care will benefit from learning the systems, tools and change management that are unique to the health-care environment. Learn more: opex.wustl.edu

MD/PhD student honored at international engineering conference

A paper written by an MD/PhD candidate at WashU recently took first prize at the American Society of Mechanical Engineers International Mechanical Engineering Congress and Exhibition.

Stephen Linderman's paper, presenting technology for improving surgical suturing for better tendon repairs, won the top honor in the biomedical engineering and technology track at the exhibition — the world's largest, cross-disciplinary mechanical engineering conference. Linderman's research is conducted through the Department of Orthopaedic Surgery in the School of Medicine and the Department of Biomedical Engineering.

"Surgical suturing is a crude mechanical solution," said Linderman, the paper's first author. "Sutures are in tension along their length, but the load is predominantly transferred to the surrounding tissue where sutures bend at anchor points, and this leads to failed surgeries. We found a simple way to improve repair schemes by minimizing stress concentrations, without complicating the surgeon's workflow."

The paper identified the combination of strength and stiffness needed for an adhesive on the sutures to improve a surgical repair.

Written by Erika Ebsworth-Gould



Students develop software to connect homeless agencies



A team of Washington University School of Engineering & Applied Science students took third place in GlobalHack VI held in October. (From left) Justin Guyton, Ben Bush, Daniel Borstelmann, Darius Calliet, with Laurie Phillips, CEO of St. Patrick Center.

While it might seem counterintuitive to ask computer programmers from around the world to help solve the homelessness problem in St. Louis, that's exactly what a local organization did in October.

GlobalHack holds 48-hour intensive software development sessions, called hackathons, twice a year to give computer programmers and developers the opportunity to create a product prototype toward an assigned challenge. The company has hosted six hackathons since its beginning in 2013, all of which have included students and alumni from the School of Engineering & Applied Science at WashU who have been successful in winning cash prizes and even getting jobs through the experience.

In the October event, GlobalHack VI, a team of School of Engineering & Applied Science students and an alumnus took third place in the College division, which brought with it a \$25,000 cash prize. Members of the winning team, called STLUnited, were Daniel Borstelmann, who earned a bachelor's degree in applied science (computer science) with a minor in architecture in 2016; Ben Bush, a junior majoring in computer science; Darius Calliet, a senior majoring in computer science, applied science and business administration; and Justin Guyton, a junior majoring in computer science with a minor in electrical engineering. All four are veterans of the GlobalHack competitions

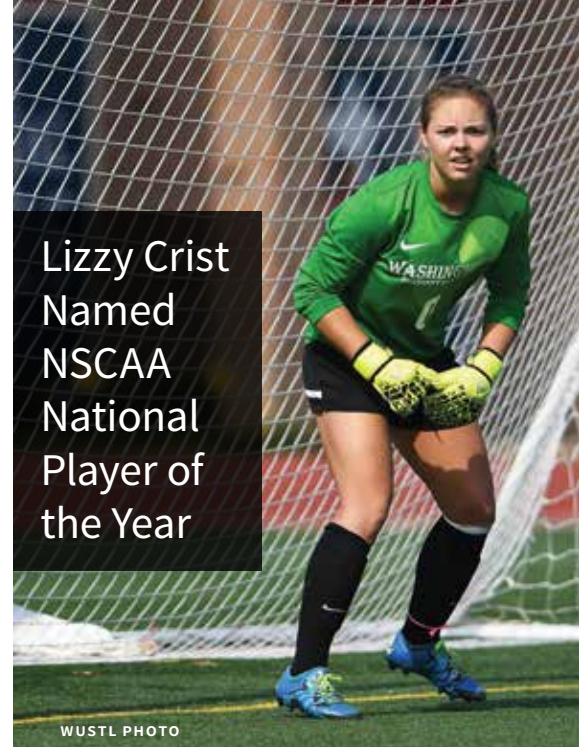
and have been on teams that have won previous competitions. Thirty-six other WashU students also participated in the event on other teams.

"There are a lot of excellent services in St. Louis that provide different resources and aid to homeless citizens, but from our perspective, what they were missing was a centralized system to share resources and more effectively communicate about who they were helping."

— BEN BUSH

The team developed a web application that lists all shelters in the area and the availability of their resources, such as open beds, meals or ability to take children. Their idea was that a homeless person could fill out an application with their basic information using the app, then two things would result: the person would receive an immediate recommendation on where to go for the resources they needed, and the person's information would appear in a database the team built that goes to all social workers.

Lizzy Crist Named NSCAA National Player of the Year



WashU Engineering senior goalkeeper Lizzy Crist was named the 2016 National Soccer Coaches Association of America (NSCAA) NCAA Division III Women's Soccer National Player of the Year, as announced by the Association.

Crist is the first player in school history to earn NSCAA National Player of the Year honors and joins MeghanMarie Fowler-Finn (2006, D3Kicks.com) as the only two student-athletes to receive National Player of the Year accolades.

"The fight, skill and intelligence of the 31 women on the 2016 team made the success we had this season possible," Crist said. "I not only have my teammates, coaches and administration to thank for every achievement earned and memory made this fall, but also the generations of women who came through the program before me and left a legacy of hard work and commitment to the Bear family."

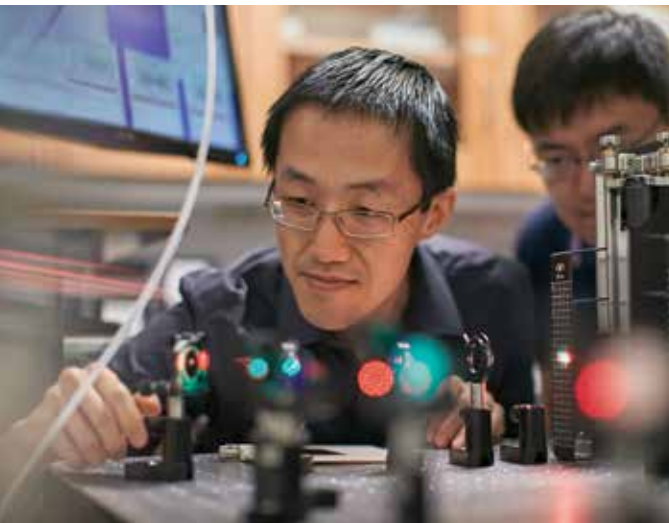
Crist started 23 games in goal and recorded a 19-1-2 mark with a WashU single-season school record 0.29 goals against average. She also set the single-season school record with 13 shutouts, and tied the win total.

A day after being named the 2016 NCAA Division III Women's Soccer National Player of the Year, Crist was featured in the Dec. 22 issue of *Sports Illustrated* as part of the Faces in the Crowd section.

EnWeek '17

- 1 Ellen W. Zegura, professor and chair in the College of Computing at Georgia Tech and a WashU Engineering alumna, who presented the Mindlin Lecture titled "Technology and Social Good."
- 2 At the Engineering Carnival, Dean Aaron Bobick was hit in the face with a pie as part of a fundraiser for clean water charities.
- 3 Matt Holton, senior vice president at MasterCard and a WashU Engineering alumnus, spoke about his experience and how to become a successful professional after college during an event sponsored by the National Society of Black Engineers.





Zooming in on the smallest machines inside a cell

Matthew Lew, assistant professor in the Preston M. Green Department of Electrical & Systems Engineering, will develop this technology with a five-year, \$500,000 CAREER Award from the National Science Foundation. The CAREER awards support junior faculty who model the role of teacher-scholar through outstanding research, excellent education and the integration of education and research within the context of the mission of their organization.

Lew's research intersects optics and biology to see molecules inside cells and study their behavior and activity. Cells are about 20 microns in size, or about one-fifth of the width of a human hair, so looking inside the cells to study the molecules — the small machinery that drives life — requires highly sensitive equipment.

"If we can't see the activities of individual molecules, we can't understand why cells become sick or build new devices based on biomolecules instead of electronic integrated circuits," Lew said. "One of the key challenges is to develop the imaging technology, and that's what our lab is trying to do."

"These molecules give our imaging technology a really unique capability," he said. "We can combine the sensing capabilities of those molecules with innovations in the imaging system, and then combine with new image processing algorithms to consider the whole thing as a full imaging system that can push the boundaries of what we're able to measure inside cells."

WashU engineer to design catalyst for wasted plant material

Marcus Foston, assistant professor of energy, environmental & chemical engineering, will use a five-year, \$250,000 grant from the American Chemical Society Herman Frasch Fund for Chemical Research to find a technology that will create a greater value for lignin, a byproduct of paper and bioethanol production, to be used to make other products.

"Waste biomass and agricultural residues are produced in enormous quantities globally, with up to 1.3 billion dry tons of biomass per year in the U.S. alone," Foston said. "This proposed catalytic conversion system for lignin will allow for more complete use of biomass, enhancing the use of waste produced during the processing of carbohydrates extracted from agricultural and energy crops."

"One of the major reasons lignin conversion is difficult and so challenging to investigate on a fundamental level is the high level of structural diversity that inherently defines lignin," Foston said. "The structure of lignin varies from species to species, or even from plant to plant, and is influenced by genetic, developmental and environmental factors."



MARCUS FOSTON

Common heart ailment target of new WashU Engineering research

Jonathan Silva, assistant professor of biomedical engineering, will conduct the research with a five-year, \$1.9 million grant from the National Heart, Lung, and Blood Institute of the National Institutes of Health. Specifically, Silva and his team will study how small molecules and proteins interact with ion channels in the heart to cause and prevent arrhythmia, when the heart beats too fast, too slow, or is too unstable.

"When people are trying to treat arrhythmias, they are trying to control the behavior of the whole organ with a molecule," Silva said. "Unfortunately, when you take multiple molecular properties and put them together, you get a new behavior at the cell and tissue levels that's very hard to predict."



Silva will use a type of specialized molecular imaging called voltage-clamp fluorometry to watch how the ion channels move and to understand how drugs control the molecules, then create a computer model with the information.

Genin elected AIMBE Fellow

Guy M. Genin, professor of mechanical engineering & materials science, has been elected to the 2017 College of Fellows of the American Institute for Medical and Biological Engineering.

Fellows of the institute represent the top 2 percent of medical and biological engineers in the United States and include the most accomplished engineering and medical school chairs, research directors, professors, innovators and successful entrepreneurs. Genin was inducted with 145 colleagues at AIMBE's annual meeting March 20 in Washington, D.C.



GUY GENIN

How is the brain controlled? WashU engineer seeks answers

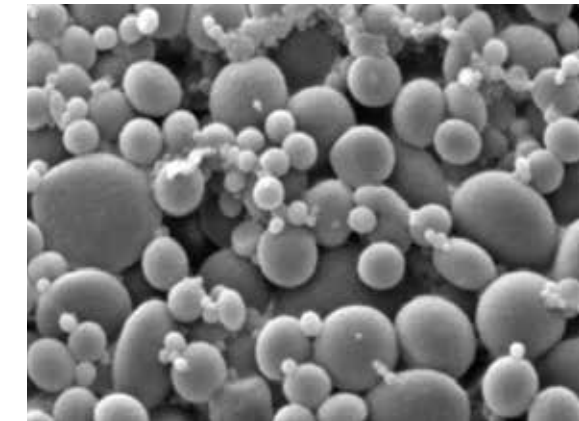


ShiNung Ching, the Das Family Career Development Distinguished Assistant Professor of Electrical & Systems Engineering, will take a systematic look at cognitive functions of the brain with a five-year, \$500,000 CAREER Award from the National Science Foundation. The awards support junior faculty who model the role of teacher-scholar through outstanding research, excellent education and the integration of education and research within the context of the mission of their organization. One-third of current Engineering faculty have received the award.

"We will use a systems approach to study whether certain cognitive functions are predicted by properties of the brain's neural circuits that we can elucidate through dynamical systems and control

theoretic approaches," said Ching, whose project is titled "System Theoretic Methods for Understanding the Dynamics of Cognition." "In a general sense, we are asking how easily different circuits in the brain steer each other or how pliable they are. We're not designing brain circuits and networks as we do with electrical and mechanical systems, but they have physical properties and dynamics just like any other system does, so we can try to develop the same understanding."

"The hypothesis is that there is a link between specific cognitive functions and the dynamics and control properties of these networks," he said. "We're trying to equip ourselves with the tools to be able to make those links in more precise, rigorous ways."



Better than a pill

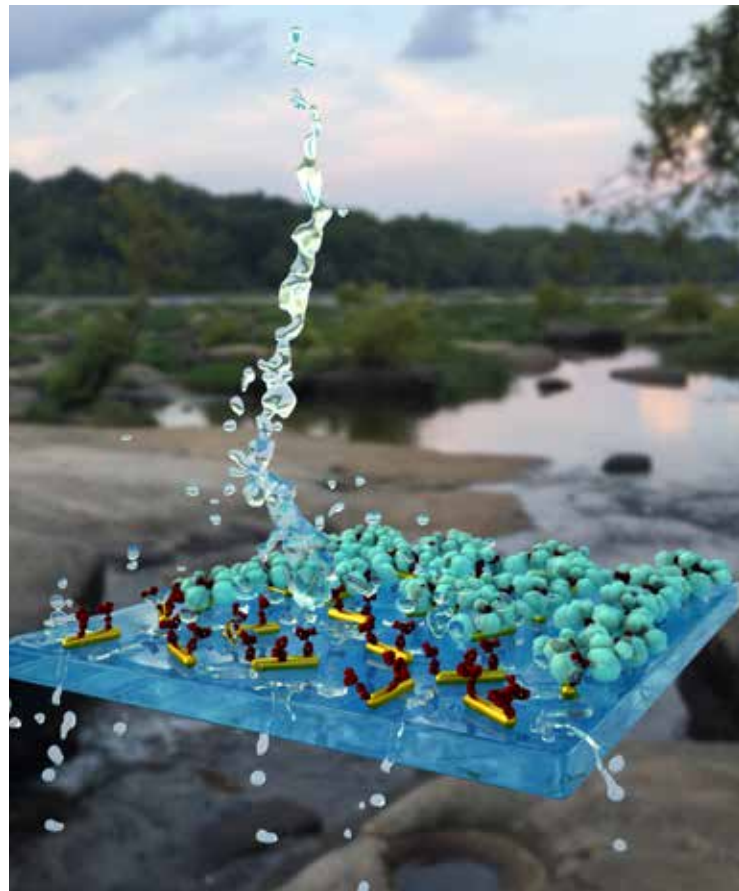
A twisted ankle, broken hip or torn knee cartilage are all common injuries that can have medical ramifications long after the initial incident that causes them. Associated pain, inflammation, joint degeneration and even osteoarthritis can sideline a variety of different people: athletes, weekend warriors and patients who are either aging or inactive.

A team from WashU was awarded \$1.7 million from the National Institutes of Health (NIH) to develop a new therapeutic treatment that can deliver disease-modifying compounds in a manner to delay the development of inflammation, joint degeneration and arthritis with all the associated discomfort, disability and pain.

"We're starting to see that many areas can't be reached via oral drug delivery," said Lori Setton, the Lucy & Stanley Lopata Distinguished Professor of Biomedical Engineering. "For example, synovial joint fluid in the knee is almost optimized to rapidly clear compounds out of the joint. So we're trying to trick the joint into being a good host for the therapeutic drugs we are delivering."

Setton and her co-investigators at the School of Medicine — including Yousef Abu-Amer, professor of orthopaedic surgery; Farshid Guilak, professor of orthopaedic surgery; and Gabriel Mbalaviele, associate professor of medicine in the Division of Bone & Mineral Diseases — soon will start testing the new delivery system in animal models.

Written by Erika Ebsworth-Gould



Storing and testing at any temperature

A team of engineers from Washington University and Air Force Research Laboratory have discovered an inexpensive work-around: a protective coating that could completely eliminate the need for cold storage and change the scope of medical diagnostic testing in places where it's often needed the most.

"In many developing countries, electricity is not guaranteed," said Srikanth Singamaneni, associate professor of mechanical engineering & materials science.

"So how do we best get them medical diagnostics? We did not know how to solve this problem previously."

In this new research, published in *Advanced Materials*, Singamaneni worked with faculty from Washington University's School of Medicine and researchers from the Air Force Research Lab to grow metal-organic frameworks (MOFs) around antibodies attached to gold nanorods. The crystalline MOFs formed a protective layer around the antibodies and prevented them from losing activity at elevated temperatures. The protective effect lasted for a week even when the samples were stored at 60°C.

Written by Erika Ebsworth-Gould



The power of tea

A compound found in green tea could have lifesaving potential for patients with multiple myeloma and amyloidosis who face often-fatal medical complications associated with bone-marrow disorders, according to a team of engineers at WashU and their German collaborators.

Jan Bieschke, assistant professor of biomedical engineering, studies how proteins fold and shape themselves and how these processes can contribute to a variety of diseases. He says the compound epigallocatechin-3-gallate (EGCG), a polyphenol found in green tea leaves, may be of particular benefit to patients struggling with multiple myeloma and amyloidosis. These patients are susceptible to a frequently fatal condition called light chain amyloidosis, in which parts of the body's own antibodies become misshapen and can accumulate in various organs, including the heart and kidneys.

"The idea here is twofold: We wanted to better understand how light chain amyloidosis works, and how the green tea compound affects this specific protein," Bieschke said.

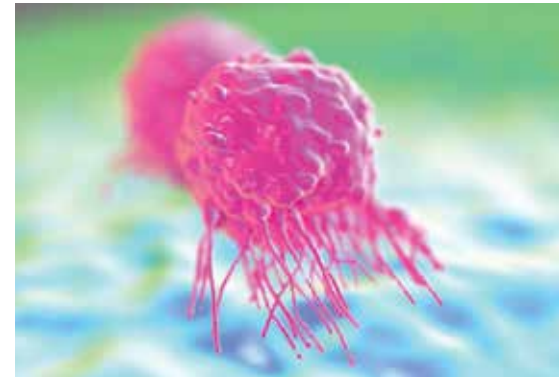
Bieschke's team first isolated individual light chains from nine patients with bone marrow disorders that caused multiple myeloma or amyloidosis, then ran lab experiments to determine how the green tea compound affected the light chain protein.

Written by Erika Ebsworth-Gould

Detecting, diagnosing women's cancers in new ways

The National Institutes of Health has awarded a WashU faculty member a total of \$1.3 million to study new imaging techniques designed to better fight breast and ovarian cancers. In her research, Quing Zhu, professor of biomedical engineering with a secondary appointment as a professor of radiology at the School of Medicine, combines ultrasound with two additional optical imaging components — diffused near infrared light and photoacoustic waves — to give doctors a more accurate understanding of a patient's tumor and how to best treat it.

"We're hoping down the line that we can give breast oncologists new options to predict who will respond to neoadjuvant chemotherapy and who will not. This will allow them to better determine if a different treatment regimen or earlier surgery is needed," Zhu said.



Used on its own, ultrasound can often paint an incomplete picture of a tumor. Zhu has developed a novel approach to combine it with infrared light, which has the ability to track blood vessels and quantify blood volume typically correlated with malignant breast cancers. When used with ultrasound that guides the infrared light to target the lesions, this new technique has the potential to better determine blood volume changes, and then treatment response, on an individualized basis.

Written by Erika Ebsworth-Gould

Yang named Fellow of The Optical Society



LAN YANG

Lan Yang, the Edwin H. & Florence G. Skinner Professor, has been named a Fellow of The Optical Society.

Yang, a professor in the Department of Electrical & Systems Engineering, was recognized for "her seminal contribution in

nanophotonics and photonic sensing." She was one of 96 new fellows representing 19 countries.

Samuel Achilefu, the Michel M. Ter-Pogossian Professor of Radiology at the School of Medicine in St. Louis and professor of biomedical engineering, also was elected as a fellow to The Optical Society.

Fellows of The Optical Society are elected based on their contributions to the advancement of optics and photonics and are selected based on several factors, including scientific, engineering and technological contributions.

A probiotic stress fix

U.S. sailors and Marines face continuous periods of excessive stress in "fight-or-flight" situations, triggering surges of chemical messengers called neurotransmitters, often known as an adrenaline rush. While these surges are important for relaying messages in the brain, prolonged high levels can cause long-term health problems, including anxiety and susceptibility to infection.

Imagine if a naval officer and other members of the Navy could swallow a probiotic pill or yogurt to better protect them from the effects of these surges.

Tae Seok Moon is working to create a probiotic from a commercially available, beneficial bacterial strain of *Escherichia coli* after receiving a three-year, \$508,635 grant from the Office of Naval Research's 2017 Young Investigator Program. The nationwide award was one of 33 given to early-career engineers and scientists from more than 360 applicants.



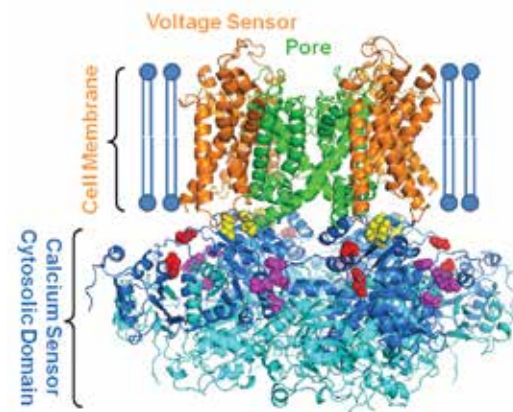
Moon, assistant professor of energy, environmental and chemical engineering, specializes in building synthetic gene circuits to control and improve cellular process for human-defined functions. For this project, he will change the genes of *E. coli* Nissle 1917, then study its administration as a probiotic supplement to regulate the neurotransmitters in the brain and gut in an animal model of anxiety. Eventually, such an approach may offer improved protection of humans from the harmful effects of long-term exposure.

Molecular function connected to high blood pressure, other diseases investigated

By changing one small portion of a stimulus that influences part of one molecule's function, engineers and researchers at WashU have opened the door for more insight into how the molecule is associated with high blood pressure, autism and movement disorders.

The finding, published online Feb. 14 in the *Journal of General Physiology*, lays the foundation for further insight into mechanisms behind the connection of the molecule with these and other diseases, such as epilepsy and circadian rhythm disorders.

Cells have ion channels, which are pathways that regulate current through the cell membrane and open in response to physical signals, such as voltage, or chemical signals, such as calcium, potassium or sodium. But these channels typically allow one type of ion



to pass through, for example, the BK (big potassium) channel, only allows potassium to pass through.

Jianmin Cui, professor of biomedical engineering, and collaborators in three labs at WashU are studying the BK channel, which has been found to be important in regulating neuronal function and blood pressure.

Preventing lead spread

A team of WashU engineers has developed a new way to track where dangerous lead particles might be transported in the drinking water supply during a common abatement procedure.



One common abatement: Dig up old lead lines and replace a portion of them with another metal, such as copper. However, this technique can dislodge lead particulates and release them into the water supply. Furthermore, partially replacing the lead pipe connection instead of entirely exchanging it is problematic.

“We all know lead is not safe, it needs to go,” said Assistant Vice Chancellor of International Programs Pratim Biswas, the Lucy & Stanley Lopata Professor and the chair of Energy, Environmental & Chemical Engineering.

“This is the first comprehensive model that works as a tool to help drinking water utility companies and others to predict the outcome of an action. If they have the necessary information of a potential action, they can run this model, and it can advise them on how best to proceed with a pipe replacement to ensure there are no adverse effects.”

— PRATIM BISWAS

In the research, recently accepted by the journal *Environmental Science & Technology*, Biswas and graduate research assistant Ahmed A. Abokifa present their approach, which predicts how far lead particles and dissolved species might travel after they’ve been disturbed. Utilizing water quality modeling they’d previously developed for the Environmental Protection Agency, Biswas and his team built a new computational model to predict lead particulate release, taking into account factors such as pipe age and dimensions, water-use patterns, water chemistry and previous pipe disturbances.

Written by Erika Ebsworth-Gould

WashU engineer, collaborators win \$1 million international grant

A biophysicist in the School of Engineering & Applied Science is part of an international team of scientists that has received a three-year, \$1 million 2017 Human Frontier Science Program grant to



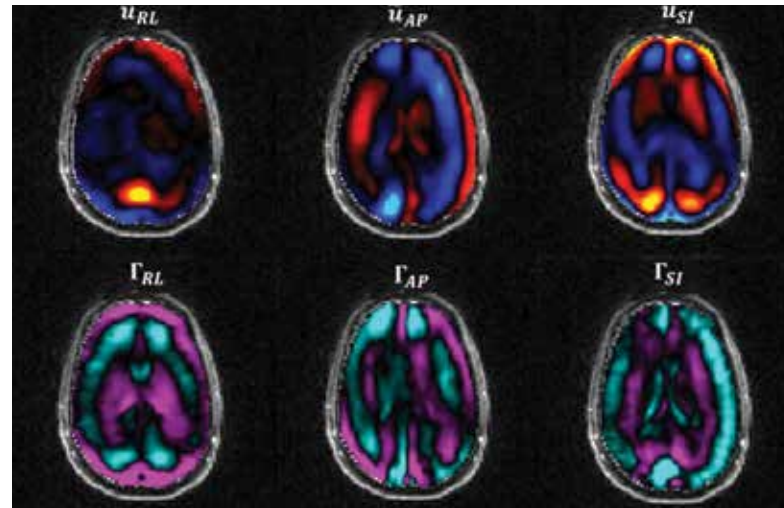
ROHIT PAPPU

uncover the molecular logic and organization of specialized micrometer-sized structures in cells.

Rohit V. Pappu, the Edwin H. Murty Professor of Engineering in the Department of Biomedical Engineering and director of the Center for Biological Systems Engineering, is part of a team that will use advanced imaging and modeling to answer fundamental questions about membraneless organelles that encompass protein

and RNA molecules and serve as microreactors and stress response depots in cells. Their work will focus on uncovering the organization of membraneless organelles and the selective permeability of biomolecules into these organelles.

These studies are directly relevant to understanding how cells control crucial decision-making processes such as division, movement and programmed death. In addition, the proposed studies will have a direct impact on understanding how membraneless organelles serve as crucibles for degenerative processes in diseases such as ALS and in proliferative processes that give rise to cancers.



Studying the brain’s suspension system in TBIs

“The idea was to find out how protective are the layers of membranes that connect the brain to the skull,” said Philip Bayly, the Lilyan & E. Lisle Hughes Professor of Mechanical Engineering and chair of the Department of Mechanical Engineering & Materials Science. “They serve the same function as the suspension in your car. When you go over a bump in a car, there’s a big oscillation of the wheels but you get very little motion in your body because the suspension absorbs it.”

Paul C. Paris

Former professor Paris’ law of engineering lives on beyond his death

Written by TONY FITZPATRICK



Paul C. Paris, longtime professor of mechanical engineering in the School of Engineering & Applied Science at Washington University in St. Louis, was the notable exception.

Paris, who died Jan. 15, 2017, of natural causes at age 86, was known for many things, but one of the most remarkable is the equation he developed relating repeated mechanical loads to crack growth.

Known as Paris’ law, the equation predicts how fast a structural crack will grow in response to repeated cycles of stress, thus providing a reliable, theory-driven estimate of a machine part’s life.

His paper on the equation was published in 1961, but only after it was first rejected by three of the leading journals in the fracture mechanics field. Paris’ law now is routinely used to design parts that vibrate, such as in commercial and military aircraft and ground vehicles.

His work created the basis for new analytical methods to address fatigue crack problems, which are still widely used to assess safety problems in an array of devices and structures where cracks pose a significant safety or economic concern.

His insights on fracture mechanics continue to set the standard in engineering education worldwide. His no-holds-barred outlook on life and his colorful personality also left an indelible mark on the WashU community.

“Paul was an outstanding teacher and mentor, accomplished at discussing his work with students in the classroom, engineers in industry and academics in research,” said Kenneth L. Jerina, the Earl E.

recycling of cabin pressure, stress and fracture contributed to the disintegration of the aircrafts. Cracks had developed in the fuselage, and the planes came apart.

The following year, Paris joined Boeing Co. in Seattle as a research associate asked to get to the bottom of the jet failures. Before Paris’ law, there had been no theoretical basis for predictions of failure caused by cracks, just empirical estimations.

Paris first started teaching classes in fracture mechanics short courses during his Boeing years from 1955-60. He held a teaching position at the University of Washington from 1957-60. He returned to academia in 1960 to earn a doctorate from Lehigh University in 1962 and was on the faculty there until 1972. He was a visiting professor of engineering at Brown University from 1974-76.

Paris received many awards and honors over his long career, notably the Crichlow Trust Prize of the American Institute of Aeronautics and Astronautics, which included a citation and \$100,000 honorarium; in 2009, he received an honorary doctorate from, fittingly, the University of Paris West.

For most of his WashU years, Paris lived on a farm on the outskirts of St. Louis. Farming was one of his hobbies, as were flying (he had a pilot’s license), fine wines and France. He will be remembered for his rare, regal manner, highlighted by a dramatic shock of white hair and eyes that were intense, wise and warm. Through his books, teaching and professional appearances, he affected hundreds of thousands of engineers worldwide, and because of his law, his influence endures.

& Myrtle E. Walker Professor of Engineering and friend and colleague of Paris for more than four decades. “Yet, he was personable, flamboyant, colorful, dramatic, insistent and sometimes controversial.

“He went to great lengths to be an effective teacher,” said Jerina, also associate department chair for mechanical engineering. “One semester he returned from a European trip with two broken arms he’d suffered in a fall. He finished the semester seated in front of the class lecturing while colleague Hiroshi Tada wrote notes and equations on the chalkboard to aid his students.”

Paris’ worldwide reputation was well established long before he joined WashU as a professor of mechanics in 1976.

His career and his law were borne out of a new transportation age that featured diesel train engines and jet airliners replacing coal and props, respectively. In 1954, two mysterious crashes of avant garde de Havilland jets put the industry and the U.S. military on full alert. Eventually, engineers determined that the combination of fatigue,

DRIVING FORCE

Mechanobiology provides insight into life

AMIT PATHAK



Invasion of a colony of breast epithelial cells into the surrounding 3-D collagen matrix. Cell cytoskeleton (actin) in red, nuclei in blue, and mechano-sensing protein YAP in green

Written by **BETH MILLER**

In the past few decades in science, major advances have been made in biochemistry, molecular and cell biology, genetics and genomics. However, engineers and scientists have recently identified a missing link that is critical to understanding and improving human health and the living environment — the emerging field of mechanobiology, or how biological systems sense, generate and respond to physical forces. These mechanical forces influence the nervous, musculoskeletal, circulatory and immune systems and play a role in diseases such as hypertension, osteoarthritis and cancer.

The School of Engineering & Applied Science at Washington University in St. Louis, in partnership with the School of Medicine and the School of Arts & Sciences, has long been a leader in mechanobiology, a field that centers around the biological response to mechanical loads on cells and tissue, such as form, function, composition and biochemical and genetic signaling. It covers all living things, which opens opportunities for discoveries in medicine and health, agriculture, systems science and biotechnology.

“Until recently, the field was considered a side concept, and it’s becoming very clear that if you don’t consider the mechanics and look at the biology alone, you may get answers that aren’t exactly right,” said Farshid Guilak, professor of orthopaedic surgery and co-director of the Center of Regenerative Medicine at the School of Medicine, as well as the director of research at Shriners’s Hospitals for Children-St. Louis.

“It’s also opened up whole new areas of research because we’re now understanding that mechanics are necessary for health in certain areas and are actually responsible for disease or degenerative changes in other areas,” Guilak said.

Mechanobiology is a high priority in the school as part of its five-year Strategic Plan, which includes taking advantage of the existing strong group of faculty members in this area, as well as the strong collaborations with faculty members at the School of Medicine and the School of Arts & Sciences, facilities, equipment and students. Adding up to eight new faculty members

in mechanobiology, as well as investing resources in doctoral students, postdoctoral fellows and shared equipment will help to raise the school’s influence and visibility in the field both nationally and worldwide, said Jessica Wagenseil, associate professor of mechanical engineering & materials science and co-chair of the school’s Strategic Planning Committee. While the School of Engineering & Applied Science has numerous faculty involved in mechanobiology research, we’ve chosen a few to highlight here.

DEVELOPMENT

Mechanobiology plays a role in the earliest stages of development. Organs, including the heart, brain and eyes, require forces to grow and develop into their final shapes. For example, in a chicken embryo, the heart starts as a tube. In half of a day, mechanical forces cause the tube to bend into a C-shape, a process called C-looping, and it begins to pump blood. Over the next 24 hours, forces transform the C-shaped tube into a complete loop with two ends, similar to an awareness ribbon one would pin on a lapel. In humans, the heart begins to beat at about three weeks of gestation, then looping takes about a week, said Larry Taber, the Dennis & Barbara Kessler Professor of Biomedical Engineering and a longtime leader in morphogenesis, or the development and growth aspect of mechanobiology.

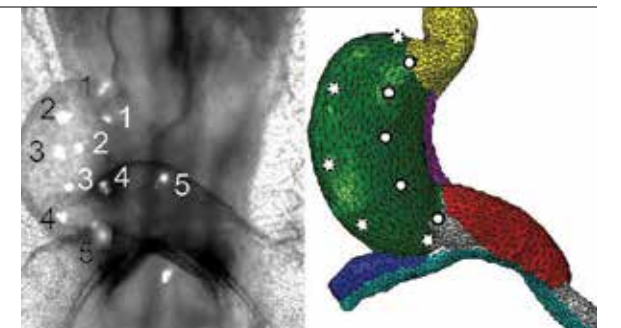
“If organs such as the heart and blood vessels do not experience forces such as blood pressure as they develop, they will never survive normal physiological loads after birth,” Taber said.

While mechanical forces have a necessary influence on development, they also play a role in correcting defects.

LARRY TABER



Developing heart of chick embryo after two days of incubation (left) compared to predicted shape given by computational model (right). Numbers indicate fluorescent tissue labels used to visualize rotation of heart tube during looping.



“Early on, you’ll see significant differences in heart shape from one embryo to the next,” Taber said. “Somehow it then adapts and acquires the right shape before birth. There seems to be a kind of functional adaptation built in to the embryo that helps it develop in the right way.”

MECHANOBIOLOGY IN DISEASE AND INJURY

While blood pressure can rise when a person is under stress, additional mechanical forces also play a big role: If the pressure increases on an artery, it will grow thicker to help decrease the stress on the artery wall, which will then increase the arterial stiffness and cause a further rise in blood pressure.

Wagenseil’s research focuses on the functions of the large arteries. While Taber studies the development of organs from a tube, Wagenseil studies the maturation and remodeling of the tubes. She and her team manipulate the tubes through genetic modification of extracellular matrix proteins, which alter the mechanical properties of the tube and the resulting form and function.

“When the pressure gets higher, the arterial wall remodels,” Wagenseil said. “We’re interested in how that process works, how we can interfere with that process and what the feedback signals are. A lot of the feedback signals depend on the mechanics of the wall — whether it’s stiff or not — and the mechanics are dictated by the amount and arrangement of matrix proteins.”

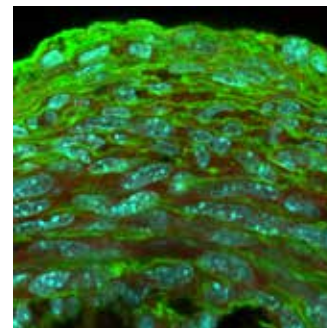
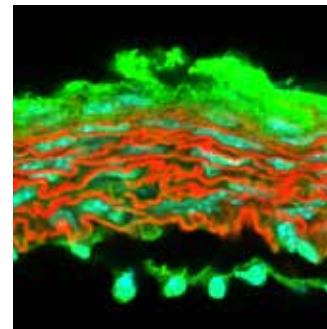
Wagenseil’s recent work in arterial mechanobiology could change the scope of how heart disease, the leading cause of death in the world, is detected and treated. She showed that increased artery stiffness is a consequence of plaque buildup, not the cause as previously believed. With this knowledge, researchers can take a new look at the relationship among increased plaque and diet, exercise and other lifestyle choices commonly associated with artery health.

Some systems in the body are not mechanical in their normal function, but are influenced by mechanical factors. One of those systems is cancer. Cancer tissues can be up to 10 times stiffer than healthy tissues, which contributes to their survival.

In his research, Amit Pathak, assistant professor of mechanical engineering & materials science, has found that cancer cells can migrate alone or in groups to metastasize. His lab is making different kinds of biomaterials that mimic different properties present in humans, such as stiffness in the environment or geometry, then studying how cells behave in those environments.

In addition to studying cancer, Pathak, who combines material fabrication with cell biology and computational modeling, also is collaborating with faculty at the

JESSICA WAGENSEIL



Cross-sections of newborn mouse aorta. Top is a “normal” aorta and bottom is from a mouse with no elastin. Elastin is stained red, cell nuclei are blue, and collagen is green. In the one without elastin, the cells receive different mechanobiological cues and divide out of control, thickening the wall of the aorta, and further altering its mechanical behavior.



Amit Pathak (left) and Bapi Sarker (right), postdoctoral research associate

School of Medicine to devise mechanically optimized platforms for immunotherapy and to study the roles of mechanics in kidney inflammation.

“We are going from mechanics to biology within the same system,” he said. “The input is mechanical by changing the stiffness, while the output is biological, meaning the cells are breaking up. Then you go inside of the cell, find the molecule that’s responsible for that behavior, which may provide new therapeutic targets. That’s the ideal sequence of events in connecting mechanics to biology and therapy.”

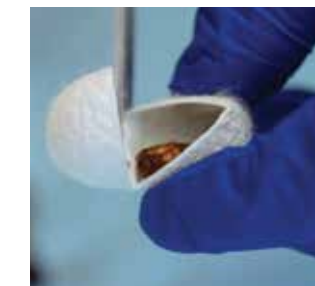
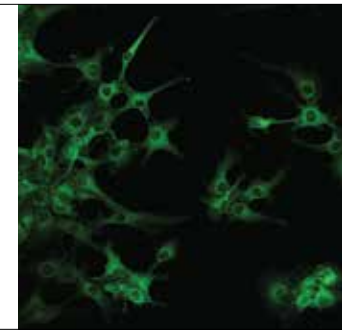
Lori Setton, the Lucy & Stanley Lopata Distinguished Professor of Biomedical Engineering, and Spencer Lake, assistant professor of mechanical engineering & materials science, work closely with the Musculoskeletal Research Center at the School of Medicine. Setton is a renowned researcher in the role of mechanical factors in the degeneration and repair of soft tissues of the musculoskeletal system, including the intervertebral discs, or the cushions between vertebrae that act as shock absorbers, which are an excellent example of mechanobiology in action, Setton says.

“The intervertebral disc experiences some of the largest magnitudes of stress and deformation of any structure in the body,” says Setton, who specializes in tissue regeneration and drug delivery. “It has no blood or nerve supply to help repair it, so it is the perfect system to study mechanics, because mechanics is the only thing that it sees or experiences.”

LORI SETTON



YAP/TAZ signaling is an important cellular regulator in the sensing of mechanical cues. Here, human nucleus pulposus cells stain positive for YAP/TAZ in green.



Top: Doctoral students Nick Cho (left) and Young Guang (right). Right: Doctoral student Marcos Barcellona

WHITNEY CURTIS

Mechanobiology and osteoarthritis

Understanding how mechanics influence health and disease, including the steps and mechanisms involved between the mechanical forces and the cellular response, will open up new avenues to develop prevention methods or therapies, said Farshid Guilak.

Guilak’s lab studies mechanical loading of joints and tissues, particularly osteoarthritis, which affects more than 30 million Americans. Based on the body’s sensory system, his lab is working on a pharmaceutical target for arthritis that would turn on and off the sensation of mechanical loading on the cartilage.

“If cells are experiencing abnormal mechanical loading, we can shut off the signals,” he said. “Even

though you might be hammering on your joint, the cartilage doesn’t know it and doesn’t respond. If you’re not loading your cartilage and it needs to be loaded, we can trick it into thinking it’s being loaded through this pharmacologic chemical.”

While organs in the body can sense whether or not they are being loaded, tissues such as cartilage cannot because they have no nerves or blood supply, Guilak says. If loaded properly, they function well and the tissue remains healthy, but if not loaded, the cells make enzymes that remove tissue that leads to atrophy, such as when a broken leg is in a cast and the muscles shrink. If loaded improperly, injury can result.

FARSHID GUILAK



Setton's lab has identified some novel ways in which cells interact with their environment, particularly in fibrosis — the thickening and scarring of connective tissue, usually as a result of injury — which can take place in organs, tendons, ligaments and the intervertebral discs.

Lake, assistant professor of mechanical engineering and of biomedical engineering in Engineering and of orthopaedic surgery in the School of Medicine, studies how a displacement, load or strain at the large scale, such as a joint, muscle or tendon, gets transferred down to the smaller scales, such as the nanoscale. In addition, he studies how joints contract and shorten after a traumatic injury, particularly in the elbow, one of the most anatomically and biomechanically complex joints in the body.

“Following an injury, there is a fibrotic response that is driven by the cells in the tissues in the elbow joint,” Lake said.

“We’re trying to understand what tissues are involved in the response, what cells are causing that response and how we can intervene to limit that so that people maintain range of motion of their joints and are not debilitated by it,” Lake said.

THE FUTURE

While researchers are creating models of injury and disease now with data they are collecting, physicians may soon use that data in addition to biological testing.

“Mechanical factors are going to play a bigger role in diagnosis,” says Philip Bayly, the Lilyan & E. Lisle Hughes Professor of Mechanical Engineering and chair of the Department of Mechanical Engineering & Materials Science. “Physicians will try to use the changes or differences in mechanical properties of tissue and diagnostics to determine, for example, if a stiff tumor is worse than a soft tumor. Or, based on the stiffness, are the tumors changing?”

Not only will it help with diagnosis, but treatments and therapies as well.

“Mechanobiology is going to lead to all sorts of new therapies for a variety of diseases, ranging from osteoporosis, osteoarthritis, atherosclerosis, cancer and 30 or 40 other diseases that have some type of mechanical interaction that either influences the disease or the condition or is a primary risk factor or cause for it,” Guilak said.

Currently, drugs are being developed that are likely ignoring some of the mechanical inputs that the body provides, Pathak said.

“If we have more information, then the drug development or screening or tissue engineering platforms will be better informed if you’re accounting for mechanical changes in the body,” he said. “That’s a very substantial outcome of this.”

SCIENCE & TECHNOLOGY CENTER FOR ENGINEERING MECHANOBIOLOGY

Washington University’s role as a leader in the mechanobiology was confirmed in late 2016 when it was co-recipient of a five-year, \$23.6 million grant from the National Science Foundation (NSF) to establish the nation’s first NSF Science & Technology Center on mechanobiology and one of only 12 STCs in the country.

The NSF Science & Technology Center for Engineering MechanoBiology (CEMB) at WashU brings together a consortium of leading mechanobiology researchers from WashU and University of Pennsylvania, as well as satellite sites at the University of Texas at Austin, the New Jersey Institute of Technology, Alabama State University, Bryn Mawr College and Boston University. These researchers are charged with developing mechanobiology as a discipline and discovering how mechanical force affects plants and human health in areas such as growth, development, stem-cell differentiation and cancer metastasis.

Guy Genin, professor of mechanical engineering & materials science and principal investigator of the CEMB at WashU, said research conducted by the center’s faculty has nearly limitless potential, ranging from stopping cancer cells from metastasizing to developing hardier crops and more sustainable growing methods that could boost food production.

“The mission of our center is to define how molecules, cells and tissues integrate mechanics within plant and animal biology,” Genin said.

Genin’s group seeks to understand and harness the mechanical control of cells. With Elliot Elson, the Alumni Endowed Professor in Biochemistry & Molecular Biophysics at the School of Medicine and a supporting faculty member in biomedical engineering and an affiliate faculty member in mechanical engineering; Tony Pryse, senior scientist in Elson’s lab; and Delaram Shakiba, a CEMB postdoctoral fellow, Genin seeks to uncover how a class of diseases called fibrosis can be controlled and reversed.

“Deciphering mechanobiological signals and responses is critical to curing fibrosis,” Genin said. “CEMB’s resources for this are remarkable.”

Genin also studies how mechanical signals of plant cells interact with Barbara Pickard, professor emerita of biology and a CEMB faculty fellow. They

investigate how plant cells transduce sound and interact with their electromechanical environments with the aim of developing mechanical means of fighting insect invasion and drought.

Using mechanobiological technologies to optimize the form and composition of the plant cell wall, the team seeks to improve the efficiency with which biomass can be used for other products, such as biofuels or materials, which is the expertise of Marcus Foston, assistant professor of energy, environmental & chemical engineering.

“Plants have evolved mechanical feedback schemes that we can harness to improve production of biofuels and chemicals from them,” Foston said. “One example is tension wood. A plant that is pushed down tries to straighten out by adjusting its cell wall composition, including the amount of carbohydrates, which stiffen and straighten it.

“Even though tension wood has only 30 percent more carbohydrates, we were able to exploit the other chemical changes occurring upon tension wood formation to extract about three times the amount of sugar,” he said. “This means that tension wood formation increases the amount of carbohydrates for sugar extraction and biofuel production, but also makes those carbohydrates much easier to extract.”

Foston said the CEMB will allow researchers at all of the partner institutions to share the tools developed for animal systems and apply them to plant systems.

“As this center unravels how plant and animal cells are controlled by force and by their mechanical microenvironment, we hope to apply this knowledge to develop technologies for new therapies, materials and agricultural technologies.”

— GUY GENIN

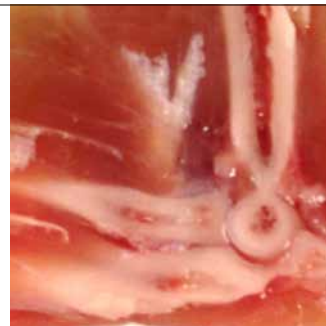
Learn more about the center:
cemb.wustl.edu

Barbara Pickard (left) and Guy Genin

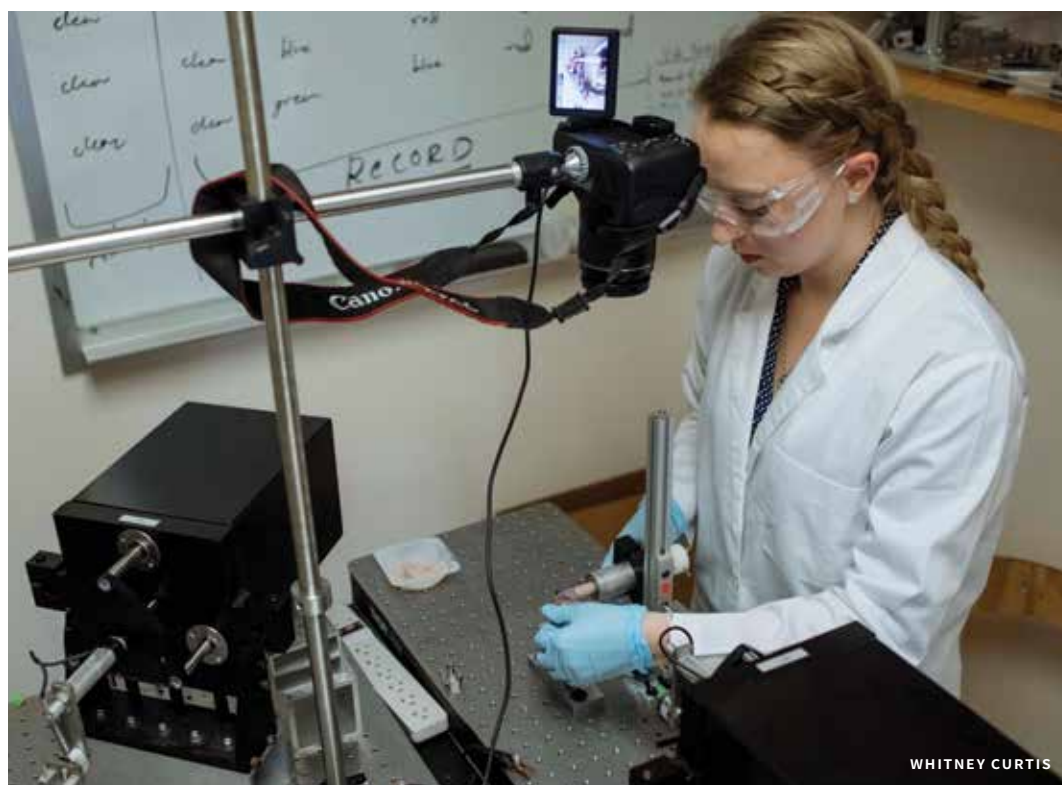
SPENCER LAKE



Cut through section of a rat elbow showing key anatomical structures of this complex joint. Visible white structures are bones (humerus, radius, ulna), red tissues are muscles, and glistening white object is part of the biceps tendon connecting muscle to bone.



Doctoral student Chelsey Dunham mechanically testing rat elbows in the Lake Lab to evaluate joint motion following injury.



WHITNEY CURTIS



WHITNEY CURTIS



Clearing the air

JAY TURNER WORKS TO IDENTIFY RISKS AND SOLUTIONS TO POOR AIR QUALITY

Written by **KURT GREENBAUM**

As a high school student sailing under clear skies on the San Francisco Bay, Jay Turner would gaze toward shore, gauging weather conditions by watching the banks of fog high on the city's hillside.

Later, as a University of California, Los Angeles freshman in 1980, he noted the similarity as he stood on the docks in Marina del Rey and spied the smog east over Los Angeles. But as he sailed into the Pacific Ocean and peered back at shore, he realized the smog also blanketed the marina he'd just left.

The smog wasn't just inland. It was everywhere.

"You realize you're in it, too, and that visual perception of your local environment did not completely align with reality," recalled Turner, associate professor of energy, environmental and chemical engineering. "That was a moment that moved me."

That experience, along with a research opportunity at UCLA in his sophomore year, propelled Turner into a lifelong career studying air quality in locations as close as St. Louis and as

far-flung as Hong Kong.

It's also led to a 23-year teaching career at Washington University in St. Louis, where Turner was recently appointed vice dean for education in the School of Engineering & Applied Science — a new role in which he will lead the schoolwide effort to enhance the undergraduate student experience in what we teach and the best way to teach the next generation of engineers and leaders, said Aaron Bobick, dean of the Engineering school, when announcing Turner's appointment to the new post.

The appointment, which began Sept. 1, heaps new responsibility onto Turner's already-full plate. In addition to managing a full slate of research projects, Turner serves on the U.S. Environmental Protection Agency's Science Advisory Board and chairs that board's Science and Technological Achievement Awards committee and Risk and Technology Review Methods panel.

All of this while teaching classes, leading to a 2016 Emerson Excellence in Teaching Award and five "Professor of the Year" awards from the school's graduating class.

EDUCATION

DSc, Washington University in St. Louis
BS and MS, University of California, Los Angeles

AWARDS

2016 Emerson Excellence in Teaching Award
Professor of the Year (five times)

APPOINTMENTS

Serves on the Environmental Protection Agency chartered Science Advisory Board
Vice Dean for Education, School of Engineering & Applied Science

Turner said the new role is exciting and will focus on both pedagogy and effective teaching strategies. While still in the formative stages, the goal is clear: Apply the same rigor and innovation to the education side of the school's mission as it does to the research side. How can professors introduce more "active learning" in the classroom? How can they challenge students with a more project- and problem-based focus on their education?

"There are innovations in teaching, and there is no reason to assume the tried-and-true approaches of the past are the most effective," Turner said. "One of my roles is to help enable faculty to embrace evidence-based teaching practices. This requires a suite of supports and structures."

Curriculum reform is also in the making. For example, Engineering is in discussion with programs across campus to develop joint majors, such as a joint degree with the Olin Business School and a joint degree with mathematics and computer science.

While Turner begins his work to shape the trajectory of undergraduate education within the engineering and applied sciences, he is also managing the changing trajectory of his

own research. Over two decades of work in environmental science and air quality, Turner said his research has increasingly moved toward studying the health effects of pollution.

"While I'm not a health scientist, I collaborate extensively with health scientists, and the interactions are very rewarding," Turner said.

One paper published recently with environmental health researchers from Emory University in Atlanta studied how certain airborne pollutants affected visits to emergency rooms in the St. Louis metropolitan area. The study found strong correlations between specific health risks and certain types of pollutants. High levels of airborne carbon particulates, for example, drove more ER visits for congestive heart failure. Patients complained to emergency room doctors more of asthma and wheezing when ozone and nitrogen dioxide levels spiked.

Turner also is collaborating on a study led by Brad Racette, MD, the Robert Allan Finke Professor and executive vice chairman of neurology at the School of Medicine, to determine whether airborne manganese is a risk factor for neurodegenerative diseases such as Parkinson's disease.

"What's really impressed me is how we, the broad research community, have been able to

"What's really impressed me is how we, the broad research community, have been able to identify risks that are caused by air pollution."

— JAY TURNER

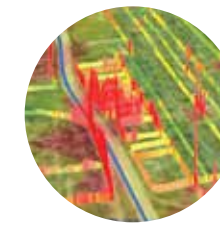
Turner (left) preparing for helicopter flight over Hong Kong to view monitoring stations, with Peter Louie, Hong Kong Environmental Protection Department.

View of Hong Kong from the flight



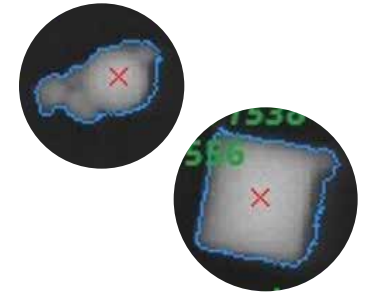
LOUISVILLE, KY

Vehicle-based measurement of ultrafine particles in a Louisville neighborhood where future greening is planned.



SOUTH AFRICA

Scanning electron microscopy (SEM) images of airborne particles that are oxides of manganese, collected in a community downwind of a manganese smelter in South Africa.



RON KLEIN



identify risks that are caused by air pollution," Turner said. "Smaller and smaller risks have been detected because we have sharpened the tools used for conducting measurements, estimating exposures and probing relationships with health outcomes."

For Turner, it's not just about identifying risks, but solutions. He recently collaborated on a half-million-dollar study of lead emissions at four general aviation airports where small, piston-engine aircraft still use lead-based fuel. Airport operators sought information to understand how those emissions affect lead levels at and near airports and how that information can guide future abatement strategies.

In October, the City of Louisville, Ky., launched a collaboration with nonprofit organizations, a local private school and researchers — including Turner — to measure whether a buffer of trees and shrubs between the school and a neighboring highway can improve air quality on campus. Turner created and oversees the air-monitoring plan for the school.

After a career of collaborating with other researchers around campus, the nation and the globe, he's particularly excited to collaborate with colleagues at the School of Engineering & Applied Science, driving curriculum innovations, best practices in teaching and improving undergraduate education.

"WashU is a distinctive place to work," Turner said. "You can see why prospective students fall in love with the campus when they visit. The sense of community, the collaborative nature — it's really impressive and it's something I don't take for granted."

Left: Turner with doctoral student Pradeep Prathibha

Center: Turner touring Jaipur with Shrikar Dole from IL&FS

Right: Wife Sandy and son Benjamin canoeing on the Charles River, Boston.

Turner sailing off the coast of Norway in 2014



From left: Daozhou Liu and Quincy Marting talk with engineers at the Chain of Rocks Water Treatment Plant overlooking the Mississippi River.

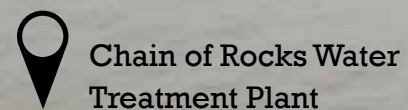
BEYOND the 'BUBBLE'

Students find opportunities for learning and giving back around St. Louis

While most students in the School of Engineering & Applied Science come from outside of the St. Louis area, becoming a part of the community through student groups, class projects, field trips and personal interests is high on their priority lists.

Written by **BETH MILLER**

Here we highlight several Engineering students, from undergraduate to doctoral students, who are using what they are learning in the Engineering classrooms and laboratories to make their marks in St. Louis. These experiences have not only benefited the people, organizations and businesses they work with, but enriched the students' lives as well.



In 2013, St. Louis native Abby Stylianou used her skills in computer vision to help the St. Louis community in a more unusual and unique way than she had while a student in the St. Louis Public Schools or as a WashU undergraduate. Stylianou, who earned a bachelor's degree in environmental studies in 2012, helped the St. Louis Police Department and the city's medical examiner locate the grave of an unidentified young girl who had been found murdered in 1983. The case has been unsolved and was moved to the "cold case" files until the *St. Louis Post-Dispatch* wrote an article about volunteer efforts to find the young girl's grave in the Washington Park Cemetery in north St. Louis County. Unfortunately, the cemetery had suffered from years of neglect and overgrowth, and some headstones had been damaged or moved, making the task an extraordinary challenge.

"I've always been interested in the intersection of technology and social justice and am excited to see how much research can be helpful to the community," Stylianou said. "When the grave case came up, it was an exciting opportunity to help out."

Stylianou, who was then working as research staff in the lab of Robert Pless, then professor of computer science, used a tool the lab created called Geocalibration.org, which uses computer vision and algorithms to compare the locations of objects in photos of the grave site from 1983 to current satellite images to find the location where the grave was likely located. The day of the exhumation, Stylianou's calculations were only 8 inches off from where the remains were found. Since then, the remains have been reburied in the Garden of

"I've always been interested in the intersection of technology and social justice and am excited to see how much research can be helpful to the community."

— ABBY STYLIANOOU

Innocents at Calvary Cemetery while detectives continue to work on the case and identify the young girl.

"It was an amazing thing to be a part of, but it's bittersweet," she said. "We really want to know who she is and to be able to find her killer, and while that's not solved yet, it's nice to know they are making progress toward that, and she now has a better resting place."

Since then, Stylianou has been working on another computer-vision-related project that has a worldwide impact. She and Pless have worked with a St. Louis entity, the Exchange Initiative, to develop an app, called TraffickCam, that allows anyone to upload a photo of their hotel room into a database that law enforcement officials can use to determine where victims are being trafficked.

"It's very challenging," Stylianou says. "To do this at a national scale requires new research into how to do image-based search efficiently and accurately."

The technology behind TraffickCam is the body of Stylianou's doctoral research.

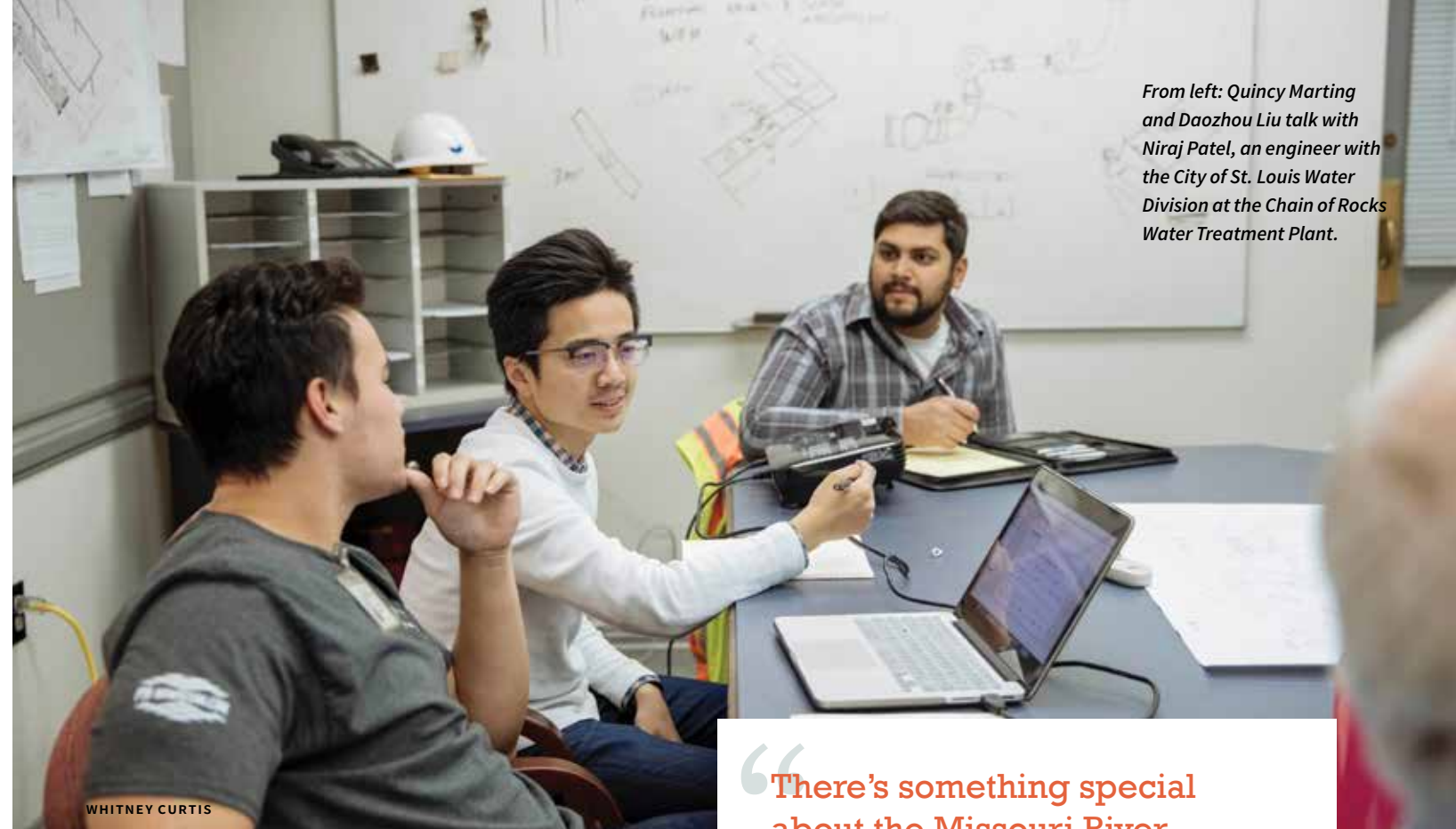


Abby Stylianou



Washington Park Cemetery

BROOK HALEY



From left: Quincy Marting and Daozhou Liu talk with Niraj Patel, an engineer with the City of St. Louis Water Division at the Chain of Rocks Water Treatment Plant.

"There's something special about the Missouri River water, and when the Missouri and the Mississippi meet at the Confluence, it brings those minerals in the two rivers together."

— QUINCY MARTING

Master's students Quincy Marting and Daozhou Liu are getting involved in St. Louis by working on a basic human need — clean drinking water. Marting, who is from Hawaii, and Liu, a native of China, are doing an independent study project with Ray Ehrhard, senior research associate in energy, environmental & chemical engineering, and the City of St. Louis Water Division at the Chain of Rocks Water Treatment Plant in north St. Louis. Opened in 1894, the plant is the largest treatment facility in St. Louis and is capable of pumping 450 million gallons of water a day.

The team is analyzing data from the water that comes in and is doing an energy audit to determine utility rates, how much water has been pumped and how much energy is being used and where. They will present the data to the plant's engineers to determine how the plant can optimize its process to save money and energy. In addition, they are calculating what size of a backup generator the plant needs in case of a power failure.

Marting, who earned a bachelor's degree in chemical engineering from WashU in 2016 and played on the football team, saw the project as a way to apply what he has learned as well as to give back to the community.

"I've been in St. Louis for four years, and I want to be able to do something for the city," he said. "By doing this, I feel more a part of the city."

Marting, who is earning a master's in mechanical engineering, said the project has taught him why St. Louis' drinking water is often ranked as the best-tasting city water in the country.

"A lot of treatment plants will take out all of the minerals, but water tastes good because of its mineral content," he said. "There's something special about the Missouri River water, and when the Missouri and the Mississippi meet at the Confluence, it brings those minerals in the two rivers together. They can keep a lot of minerals in the water because there are so many."

Liu, who is in his first year in the U.S. and is earning a master's in energy, environmental & chemical engineering, said the project is teaching him how to solve problems.

"A project is a big challenge sometimes," he said. "We should know how to start it and what the process will be, as well as how to express yourself and share what you found with the engineers."

Clockwise from left: Carlos Gonzalez, Dawn Manske, Andrew McNeel, David Lie-Tjauw



Sean Fallon, a junior from Cincinnati, has taken advantage of numerous opportunities to get involved in the St. Louis community in his few years at WashU. From working on experiential learning projects with Engineering and the Olin Business School, to serving as a renewable energy intern with the university's Office of Sustainability, Fallon's out-of-the-classroom learning has spanned a number of fields.

Through the Sustainability Exchange practicum course in Engineering last fall, Fallon's team, which included Quincy Marting, worked to implement University City's Climate Action Plan and to reduce municipal greenhouse gas emissions. This included developing strategies to retrofit city streetlights with LED bulbs; to install

solar panels on several city buildings, and to conduct a lighting audit for the Heman Park Community Center. These plans will not only help University City achieve its goal to reduce greenhouse gas emissions by 25 percent by 2020, but also to generate significant savings from reduced energy costs, Fallon said.

Through Olin Business School's Center for Experiential Learning (CEL), Fallon worked with the St. Patrick Center in St. Louis and helped with market research and a marketing strategy to bring in more donors and volunteers dedicated to ending homelessness. Additionally, Fallon took part in the CEL Practicum and worked with NVP Energy, a wastewater treatment company based in Galway, Ireland, for which Fallon helped design and implement a U.S. market entry strategy and traveled to Ireland to present his findings to NVP's senior management.

"A practicum course is a great way to make a tangible impact in the lives of others, through the real-world application of skills we learn in class —no matter how varied those skills may be," Fallon said. "It's a really good way to give back to, and become more connected with, the surrounding community."

Sean Fallon, right, who is majoring in chemical engineering with a second major in economics and strategy, was part of a student team that worked with Jenny Wendt, project manager for the City of University City, to implement the city's Climate Action Plan.

Student group Engineering Test Kitchen was designed in 2013 to connect WashU Engineering students with businesses and organizations in St. Louis that needed help with a project but did not have staff to complete it. Last fall, a group of Engineering students worked with Made For Freedom, a local for-profit social enterprise founded by Dawn Manske that offers clothes, jewelry, bags and other products made by human trafficking survivors. The company offers jobs to women who are victims of and at-risk for human trafficking, and to date has provided more than 9,000 hours of employment for these women worldwide.

Carlos Gonzalez, a dual-degree student earning a bachelor's in computer science, led a team of four students, including Andrew McNeel, a sophomore majoring in computer science with a second major in economics & strategy, and David Lie-Tjauw, a freshman majoring in computer science with a second major in financial engineering, to boost Made for Freedom's search-engine optimization.

Gonzalez, a native of Mexico who earned his first bachelor's degree in physics from the College of Wooster in Ohio, said the project appealed to him for several reasons.

"Part of it was the experience to get to apply things I've learned in class on a real-world project,"

"I would definitely like to work with other local companies and help them in one way or another. That's what we should be doing — improving our communities."

— CARLOS GONZALEZ

he said. "Also because it benefited the local community in a very direct way and solved a lot of problems they were having. Considering that Dawn's project is entirely online, it has a very big impact.

"I would definitely like to work with other local companies and help them in one way or another, because that's what we should be doing — improving our communities," Gonzalez said.

"Without ETK I wouldn't have been able to make the connections I have and meet these people," said Lie-Tjauw, who has both a Langsdorf Fellowship and a McKelvey Undergraduate Research Award. "I'm really thankful to the university and the donors for making my presence here possible. I've really been able to focus on ETK, doing incredible things and learning more about myself."

Student involvement in St. Louis



Students from the Hawthorn Leadership School of Girls conducted experiments during the "Researcher for a Day" event.



Imani Paul, who is earning a degree in biomedical engineering and an MBA, reads to kindergarteners at Flynn Park School in University City as part of the African-American Read-In.



Engineering undergraduate students immerse themselves in Ferguson, Mo., for a week as part of the "Destination Ferguson: Looking at Urban Sustainability Challenges Through the Lens of Engineering Ethics, Leadership and Conflict Management" course.



Joseph (Joe) Chamdani,
co-founder and CEO of
TuringSense

Joe Chamdani's path to Silicon Valley by way of Washington University in St. Louis traces back to a life-changing encounter as a schoolboy in his hometown of Jakarta, Indonesia.

A well-to-do friend invited him over to demonstrate the capabilities of a new Commodore 64 desktop computer. Chamdani was already fascinated with science and mathematics and aspired to become an aeronautical engineer. But the moment he saw the power of what that little machine could do, he put aside his model airplanes and became determined to learn all he could about computer engineering.

ACE ENGINEERING

Serial entrepreneur Joseph Chamdani draws from his WashU education — in the classroom and on the tennis court — to drive TuringSense, his latest Silicon Valley startup.

Written by CHRISTOPHER TRITTO

CHARLES BARRY

“I found computer engineering amazing, and I decided to go to the United States to learn about this technology and discover where innovation happens.”

— JOSEPH CHAMDANI

1986

Bachelor's degrees in electrical engineering and computer science from WashU

1995

Master's degrees and doctorate in electrical engineering from Georgia Tech

51

U.S. patents with another 36 patents pending

2014

Launched TuringSense

Today at age 52, Chamdani is CEO of TuringSense Inc., his third in a string of successful high-tech startups. The Santa Clara, Calif.-based enterprise combines his computer science and engineering expertise with his passion for sports. With \$5.5 million in angel funding and venture capital raised in the past two years, TuringSense is developing a digital 3-D platform that uses wearable sensors to generate real-time, full-body motion capture and analysis. Its first consumer product, PIVOT, is rolling out through a trial program this spring. It will focus on tennis instruction and biomechanical evaluation, as well as athlete injury prevention and rehabilitation.

Later this year, the company plans to start testing its technology with professional soccer clients in the English Premier League. Future applications could address other sports as well as augmented reality and gaming, dance, health care, workplace safety and more.

As an immigrant student in the early 1980s, Chamdani initially attended Texas A&M University. But training in software engineering was then still in its early stages, and no computer science major was offered at the College Station, Texas, campus. After a couple of semesters, Chamdani found one in the School of Engineering & Applied Science at Washington University in St. Louis and transferred there.

“I learned about transistors, logic design, digital algebra — all the foundations of how computers work,” Chamdani recalls. “It was the heyday of programming languages and early operating systems. One class combined programming and robotics, and I used six motors in a robot to pick up an object and move it. I thought, ‘Wow, my program can come alive, and I can use it to really do things.’”

Chamdani earned bachelor's degrees in electrical engineering and computer science in 1986. He then went on to Georgia Tech, where he earned a master's and then a doctorate in electrical engineering.



Chamdani (center)

COURTESY PHOTO



From left to right: Adrian (son), Aty (wife, short name of Setiawati), Joe, Mariska (daughter)

COURTESY PHOTO

That led to a career in the San Francisco Bay area. Chamdani spent five and a half years at Sun Microsystems, where he became chief architect of microprocessors and pioneered many technology enhancements now used in server systems, data centers and cloud computing. He then co-founded Sanera Systems, a storage area networking startup acquired by McData in 2003, followed by Kickfire, a database analytics startup bought by Teradata in 2010. Along the way he became the

holder of 51 U.S. patents, with another 36 patents pending. Those experiences helped him and his co-founders to launch TuringSense in October 2014.

This time Chamdani is drawing from another component of his WashU education: collegiate tennis. He played for the Bears in Division III competition, solidifying a lifelong love of the sport and learning important lessons in the process.

“Training was intense, and the bonding we experienced is applicable in the real world in any company or startup,” Chamdani says. “You learn to help team members work together to achieve a goal, how to fight and never give up, how to solve problems on your own feet and compete, and how to practice time management.”

Chamdani's own children have taken that to heart. He and his wife, Setiawati, who earned a bachelor's in electrical engineering from WashU in 1986, have a

“This country offers the best system in the world for education, investment and opportunities to grow. Immigrant or not, the dream is real.”

— JOSEPH CHAMDANI

daughter, Mariska, who plays tennis for Brown University and will graduate in May with a degree in business and entrepreneurship. Their son, Adrian, left Duke University tennis to explore a startup opportunity but is now returning to college with a tennis scholarship from the University of Oklahoma.

Whatever one's educational or career interests, Chamdani encourages perseverance and passion. He recalls how he had to drop his first class in digital logic because he became so confused. But he went back and found another class to complete first before

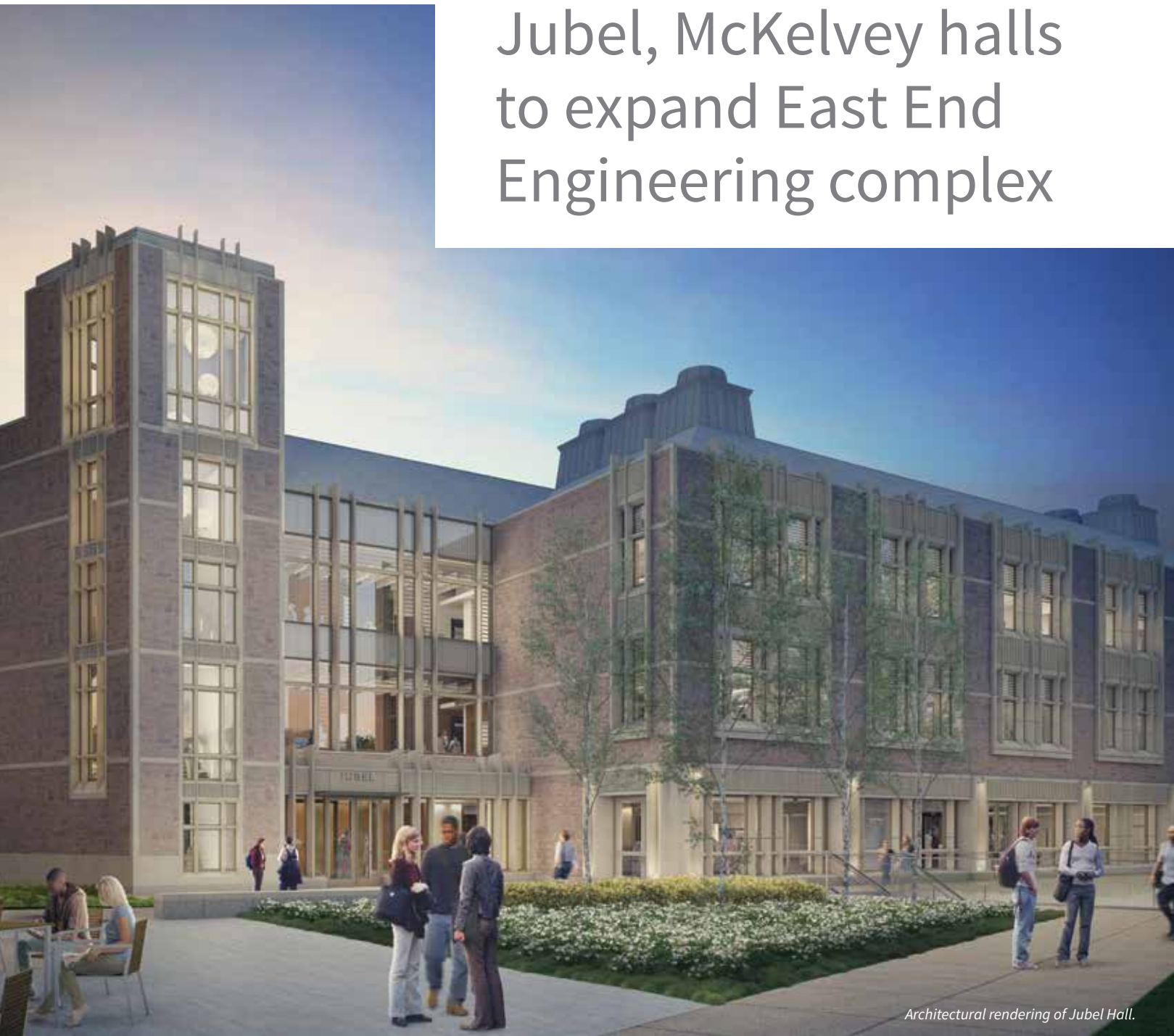
retaking the one he had dropped. The second time around he got the hang of it.

“Find a subject you love,” he says. “Be determined to learn, and don't be discouraged if you discover it is hard or you are not getting good grades. It can take time to find your groove. It's a luxury to be at a prestigious college like WashU with so many good students and faculty around you. Develop connections with friends who share your passions and cultivate opportunity.”

Amid today's turbulent political climate and policy debates, Chamdani maintains a hopeful outlook as a U.S. citizen who first arrived from a developing country as an immigrant seeking an education and a better life.

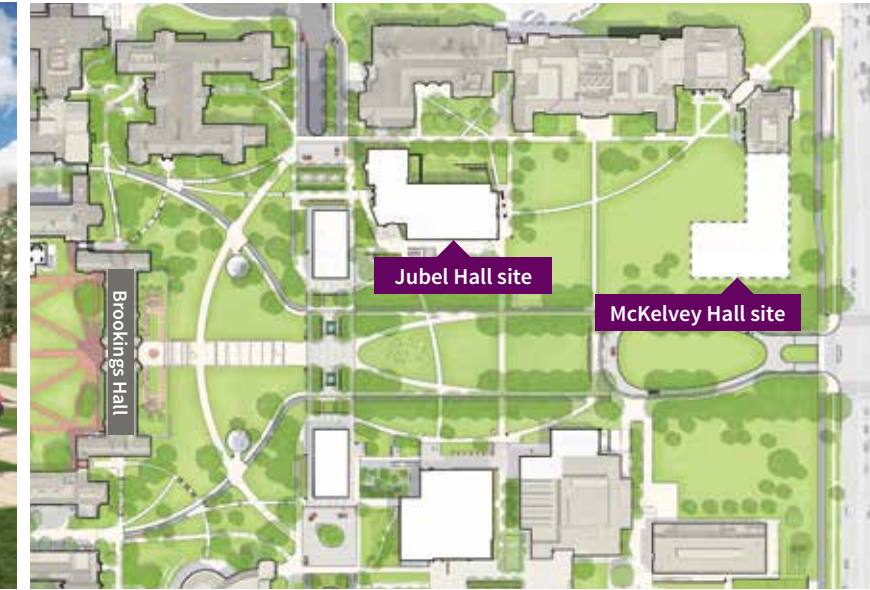
“I live the dream of America,” he says. “This country offers the best system in the world for education, investment and opportunities to grow. Immigrant or not, the dream is real.”

Jubel, McKelvey halls to expand East End Engineering complex



Architectural rendering of Jubel Hall.

THE SCHOOL OF ENGINEERING & APPLIED SCIENCE WILL ADD TWO NEW ACADEMIC BUILDINGS TO ITS COMPLEX ON THE EAST END OF THE DANFORTH CAMPUS BEGINNING THIS SPRING.



Henry A. and Elvira H. Jubel Hall and James M. McKelvey, Sr. Hall will join the university's largest capital investment in recent Danforth Campus history on the east end of the campus, with work to begin following Commencement May 19.

Jubel Hall, partially funded with a gift from the Henry A. Jubel Foundation, will be the new home of the Department of Mechanical Engineering & Materials Science and provide research space for faculty and students. The 80,600-square-foot building will include research lab space, faculty offices, a makerspace, machine shop and studio space, and two classrooms. The building will connect to Uncas A. Whitaker Hall, located directly north.

Jubel Hall is named in honor of Henry Jubel, who earned a bachelor's degree in mechanical engineering in 1940 and went on to found Spartan Aluminum Products in Sparta, Ill., and his wife, Elvira. Donald Jubel, Henry's son, chose to honor his parents with the building "to create enthusiasm and attract bright students who will serve as our leaders of tomorrow." Donald Jubel earned a bachelor's degree in mechanical engineering from WashU in 1973 and is chief executive of the company, now known as Spartan Light Metal Products.

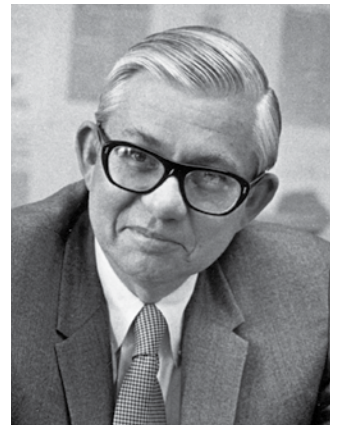
McKelvey Hall, partially funded with a \$15 million gift from Jim McKelvey Jr., will be the new home of the Department of Computer Science & Engineering and support the university's data science efforts. The building, to be located south of Preston M. Green Hall, is named in honor of James M. McKelvey Sr., dean of the School of Engineering & Applied Science from 1964-1991. McKelvey Sr. also

earned a master's degree in chemical engineering in 1947 and a doctorate in chemical engineering in 1950 from WashU.

McKelvey Sr.'s vision helped transform the School of Engineering & Applied Science from a regional program to a nationally recognized research institution. During his more than quarter-century tenure as dean, he led the school to prominence in engineering research, education and innovation. Under his visionary leadership, three new buildings — Bryan, Lopata and Jolley Halls — were constructed. The school's endowment grew more than tenfold, from \$4 million to nearly \$52 million, and research expenditures grew substantially. Although he officially retired in 1996, McKelvey continued teaching in the chemical engineering department through the 2007-2008 academic year.

In addition to Jubel and McKelvey halls, the complete east end transformation will include Sam Fox School of Design & Visual Arts' Weil Hall, an expansion of the Mildred Lane Kemper Art Museum, two new multi-use facilities, an underground parking garage and an expansive new Central Green.

When work is completed in 2019, a transformed entrance will greet visitors to the university, and the facilities on the east end will foster a stronger programmatic and physical link to the rest of the Danforth Campus.



James M. McKelvey Sr.

School honors alumni for service and innovation



The 2017 Alumni Achievement Awards were held March 31 at the Saint Louis Art Museum. From left: Michael Lefenfeld, David Gast, Peter Young, Libby Allman, Carol Gast, Raghu Sugavanam, Brian Hoelscher

Libby Allman

As vice president of manufacturing and product procurement at Hallmark Cards, Libby Allman leads domestic manufacturing and direct global sourcing activities in support of the greetings, home décor, gifts and retail businesses. A Kansas City resident, Allman earned a bachelor of science degree in mechanical engineering at Washington University in 1991, a bachelor of arts degree in physics from William Jewell College, and an MBA from Rockhurst University.

Brian Hoelscher

Leveraging a 30-year career with engineering and management experience, Brian Hoelscher has led the Metropolitan St. Louis Sewer District (MSD) since 2013. As executive director and CEO, he is responsible to execute more than \$3 billion in capital improvements while servicing 1.3 million people. Hoelscher has driven MSD's Capital Improvement Diversity program and has advocated for minority-owned and women-owned companies. Hoelscher earned a bachelor of science degree in civil engineering from Washington University in 1985.

Raghu Sugavanam

In 2014 Raghu Sugavanam co-founded Interpreta, an analytics company that updates, interprets and synchronizes clinical and genomics data by creating a personalized health-care roadmap. A San Diego resident, Sugavanam earned a bachelor of science degree in chemical engineering from the Indian Institute of Technology, a master's degree in chemical engineering from Washington University in 1978 and a master's degree in computer science from Rutgers University.

Peter Young

In 1983, Peter Young founded Chemcentral Group, which provides raw materials and equipment for manufacturers in China. Chemcentral Group has grown into an international trade and investment organization with branches specializing in paper industry products, chemical materials, real estate, ecotourism and recreation. With

offices worldwide, Young's companies have remained the largest supplier of coating clay in China since 1984. A resident of Hong Kong, Young earned a bachelor of science degree in chemical engineering from Washington University in 1980.

Engineering Entrepreneurship Award

Michael Lefenfeld

Michael Lefenfeld is co-founder and chief executive officer of New York City-based SiGNa Chemistry, which manufactures highly active, environmentally friendly chemicals. SiGNa's products improve production processes in the energy recovery, petrochemical refining and chemical manufacturing industries. Prior to SiGNa, Lefenfeld developed and commercialized several new technologies, launched and sold three companies by age 30. He holds more than 50 patents. After earning a bachelor of science degree in chemical engineering at Washington University in 2002, Lefenfeld, a resident of New York City, earned a master's of philosophy in chemistry at Columbia University and an executive education certificate at Stanford University's Graduate School of Business.

Dean's Award

David and Carol Gast

As an undergraduate at Washington University, David made a business of installing sound systems around campus, including the first system in Graham Chapel. After serving in the U.S. Army, he later joined the electrical and mechanical industrial equipment sales firm Carl F. Gast Co., which his parents founded in 1935, as a salesman and later became CEO. Carol later became the bookkeeper for the firm. Since Gast's 2005 retirement, the company is managed by third-generation owners. David earned a bachelor of arts degree in physics and a bachelor of science degree in electrical engineering in 1953 and a master's of science degree in electrical engineering in 1954 from Washington University. Carol was in the Liberal Arts class of 1956.

Leah Honey

Written by BETH MILLER

For some people, spending 30 days in a closed living area monitored by cameras at all times may seem daunting, but for alumna Leah (Pike) Honey, it was her idea of fun.

In February 2016, Honey, who earned a bachelor's degree in mechanical engineering from the School of Engineering & Applied Science in 2006 and is now a flight controller at Johnson Space Center in Houston, and three other women took part in NASA's first all-female-led Human Exploration Research Analog (HERA), a 30-day simulation of a

700-day, near-Earth asteroid mission. The crew lived in a two-story enclosed habitat at Johnson Space Center in Houston during which they simulated a live mission, including daily communication with Mission Control, but only 30 minutes a week to talk with family. They also took part in numerous biological tests and tried new foods designed for maximum energy and reduced mass, including some rather dense, 700-plus-calorie breakfast bars. While Honey compared the experience to "living in a fishbowl for 30 days," she enjoyed it thoroughly.

"It makes a big difference who is selected to be on the crew together, and my crew had a lot of fun," she says. "We got along very well. Overall, the experience was challenging and pushed me out of my comfort zone, but it was more fun than stressful by a longshot."

Honey and the rest of crew, which included a NASA scientist, a structural design engineer and a physician/researcher, trained for two weeks before the mission began, then had a one-week debriefing. During the mission, they conducted experiments involving sea



Honey and three other women spent 30 days in a simulator for a near-earth asteroid mission.



COURTESY PHOTO

monkeys, plants and a 3-D printer, but spent a lot of time training for spacewalks to the asteroid using virtual reality.

The experience was seven weeks away from Honey's daily job, in which she works for the contractor Leidos to keep the International Space Station in operation.

"When things break, we figure out how to fix them," she says. "We're installing new hardware that needs coolant lines but also needs power running into it from a different module, so we have to go behind the wall and get all of the right pipes and the right cables to the right hardware and figure out how to do it on the ground, then write procedures for the crew to execute it on the Space Station. We're there in the flight control room to help them out when things don't go exactly as planned."

For Honey, being a flight controller is the only job she ever wanted, thanks to the 1995 movie "Apollo 13," based on the real-life mission of Apollo 13 in 1970.

"Growing up I said I wanted to be an astronaut, until I saw 'Apollo 13,'" she said. "It was the particular scene where the flight controllers had to fit the square peg into the

"A lot of times it's easy to get consumed in getting a 4.0 GPA, and in any of the jobs that I've been in, no one needs to be that smart — you just need to be good at working with other people."

— LEAH HONEY

round hole to make a carbon dioxide filter, and at that moment, I said I wanted to do that rather than be an astronaut. I realized that flight controllers get to do more of the problem-solving and the puzzles and making things work. I never had a Plan B."

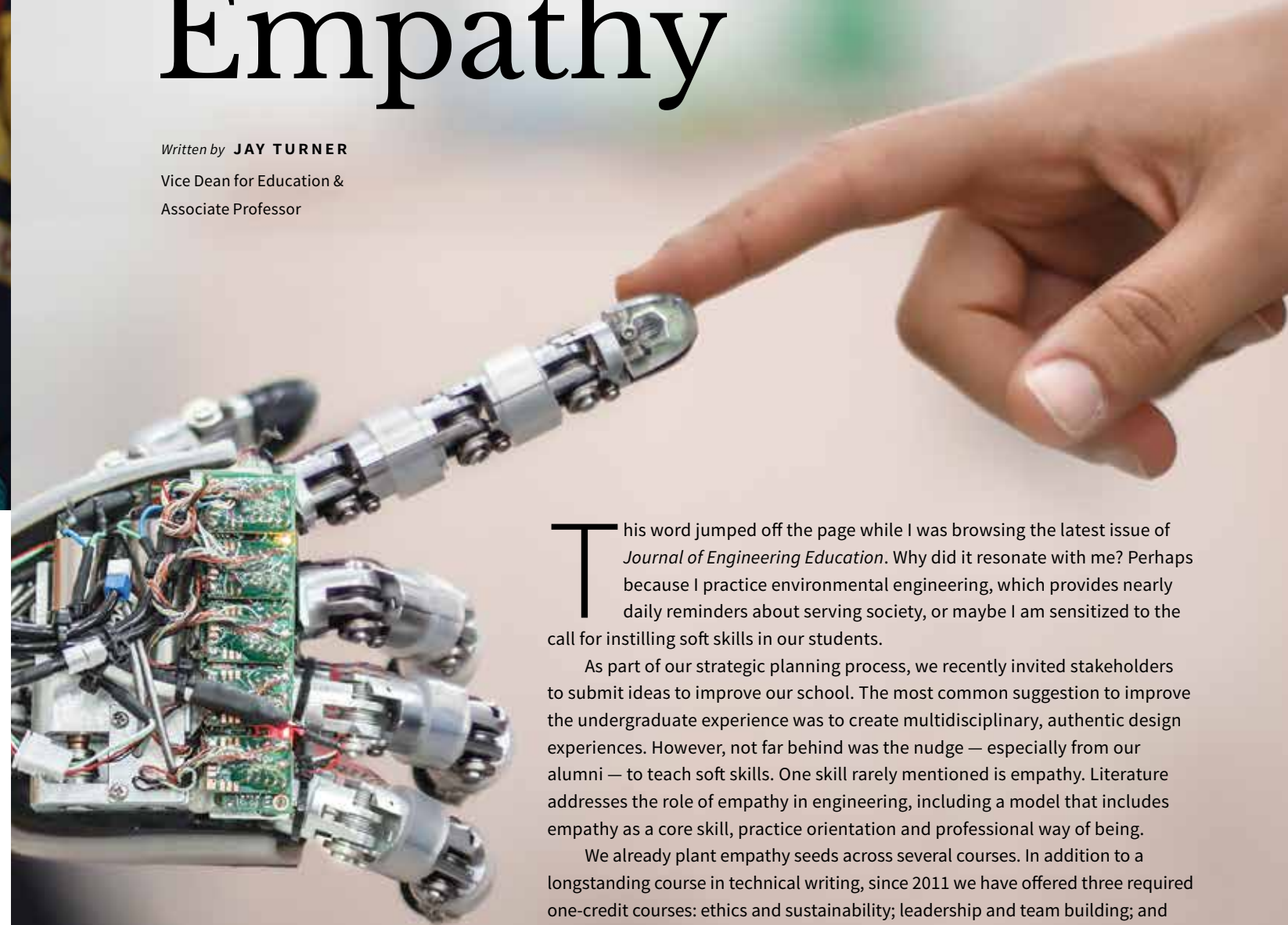
Honey credits her experience as a mechanical engineering student at WashU for preparing her to work well with a group in her career.

"At WashU I did almost all of my problem sets with a group of five or six of us," she recalls. "That kind of syncing with a group and bouncing things off of each other, and not just locking myself in my room and working alone is definitely the same kind of environment I work in now."

Empathy

Written by JAY TURNER

Vice Dean for Education & Associate Professor



This word jumped off the page while I was browsing the latest issue of *Journal of Engineering Education*. Why did it resonate with me? Perhaps because I practice environmental engineering, which provides nearly daily reminders about serving society, or maybe I am sensitized to the call for instilling soft skills in our students.

As part of our strategic planning process, we recently invited stakeholders to submit ideas to improve our school. The most common suggestion to improve the undergraduate experience was to create multidisciplinary, authentic design experiences. However, not far behind was the nudge — especially from our alumni — to teach soft skills. One skill rarely mentioned is empathy. Literature addresses the role of empathy in engineering, including a model that includes empathy as a core skill, practice orientation and professional way of being.

We already plant empathy seeds across several courses. In addition to a longstanding course in technical writing, since 2011 we have offered three required one-credit courses: ethics and sustainability; leadership and team building; and conflict management and negotiation. Students rewrite correspondence for various scenarios, learning to shift the tone to avoid alienating the recipient. They learn to work with different personality types and how to approach conflict considering differences in disposition. A combined, one-week intensive version of these courses takes students to Ferguson to focus on urban systems and access to vital goods and services most of us take for granted. They are prompted to reflect on their observations and how it will make them better engineers.

We can and should do more to nurture empathy and other soft skills: move the aforementioned courses forward and drill and assess these skills in subsequent courses; teach the principles of empathic design, whether applied to a prosthetic, rural water supply system or an app; and promote extracurricular experiences to hone empathy skills. Keep feeding us your ideas, and we'll get there.

CHANGE SERVICE REQUESTED

#WashUengineers

$p = mv$

Snapshot //

Doctoral students in the lab of Fuzhong Zhang, assistant professor, conduct research in biofuels and in finding ways to turn *E. coli* into an energy source.

