Bioengineering

2019-2020

Annual Highlights Report

Grainger College of Engineering

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Contents

The Illinois Bioengineering Annual Highlights Report informs alumni, industry partners, peers, friends, faculty, students, staff and other stakeholders about the department's accomplishments and newsworthy activity. This issue covers the fiscal year 2019-2020.

bioengineering.illinois.edu

Department Head Message

Dear Friends and Colleagues,

Despite the unexpected challenges we have faced due to the COVID-19 pandemic, I am pleased to share positive and exciting updates from the department of bioengineering. In particular, I'm very proud of the response and contributions of our students, faculty and staff during this unprecedented time, which will be showcased in the following pages.

Over the past year, our talented faculty have continued to excel. We have acquired three new NSF CAREER awards and a national level ASEE teaching award, to name a few.

Our undergraduate program is currently enjoying record-high enrollments and we are on track to have a program size of 400 students within the next few years. We continue to make diversity a priority in recruitment and retention through our REU program, summer programs for high school students and participating in targeted recruitment programs such as MERGE and Aspire Illinois.

"I'm very proud of the response and contributions of our students, faculty and staff during this unprecedented time.

We continue to support the Carle Illinois College of Medicine, where 16 bioengineering faculty hold appointments and participate on crucial committees and in leadership positions. This first-of-a-kind engineering-based college of medicine presents tremendous opportunities for us to modify the paradigm of bioengineering education.

Finally, we have been busy developing new educational programs that will expand our impact. We have launched an online M.Eng. in Bioengineering program which will welcome students in the fall of 2020. In addition, we will introduce a new M.S. degree in Biomedical Image Computing and a graduate certificate in artificial intelligence (AI) for physicians. Please stay tuned for updates!

Thank you for your continued support and engagement with our department. I wish you health, productivity and happiness over the next year.

Mark A. Anastasio
Department Head
Donald Biggar Willett Professor in Engineering

A team led by the University of Illinois at Urbana-Champaign's Grainger College of Engineering and Carle Health has produced a prototype emergency ventilator, Illinois RapidVent, to help address the need for respiratory care associated with the COVID-19 pandemic.

The team brought together over 40 experts across industries and academia. Four bioengineering professors took part in this effort: Dean of The Grainger College of Engineering **Rashid Bashir**, **Jennifer Amos**, **Catherine Best** and **Stephen Boppart**. **Eliot Bethke**, a 2013 bioengineering graduate and engineering coordinator at the Carle Illinois College of Medicine, also served on this project.

"We had a group of really passionate people who had specific tasks to do and worked collaboratively," said Amos. Researchers formed smaller teams based on their expertise. Amos was a part of the Engineering Testing and User Experience Teams. She helped to write testing plans and drafted documentation for the prototype.

Amos said, "This particular type of ventilator is called a gas-powered ventilator. The ones that you typically see in an ICU are volume control ventilators." The Illinois RapidVent would plug into the oxygen source available in most hospital rooms or could plug into a tank of oxygen without the need for a power source.

"It's very portable and very small. The way that we tailored the design is to the type of lung condition that we are expecting in COVID-19 patients," said Amos. This design is also suitable in case patients need to be ventilated quickly.

In an emergency, there may be a shortage of respiratory therapists and others may need to step in and ventilate patients. "Part of the problem with introducing new equipment in a critical care setting is that there is a lot of uneasiness," said Best. As a part of the User Experience Team, she helped create a visual aid for the user manual. "As long as the steps are clear and you can see what you are doing, it alleviates a lot of anxiety and it can be better implemented and rolled out rapidly," she said.

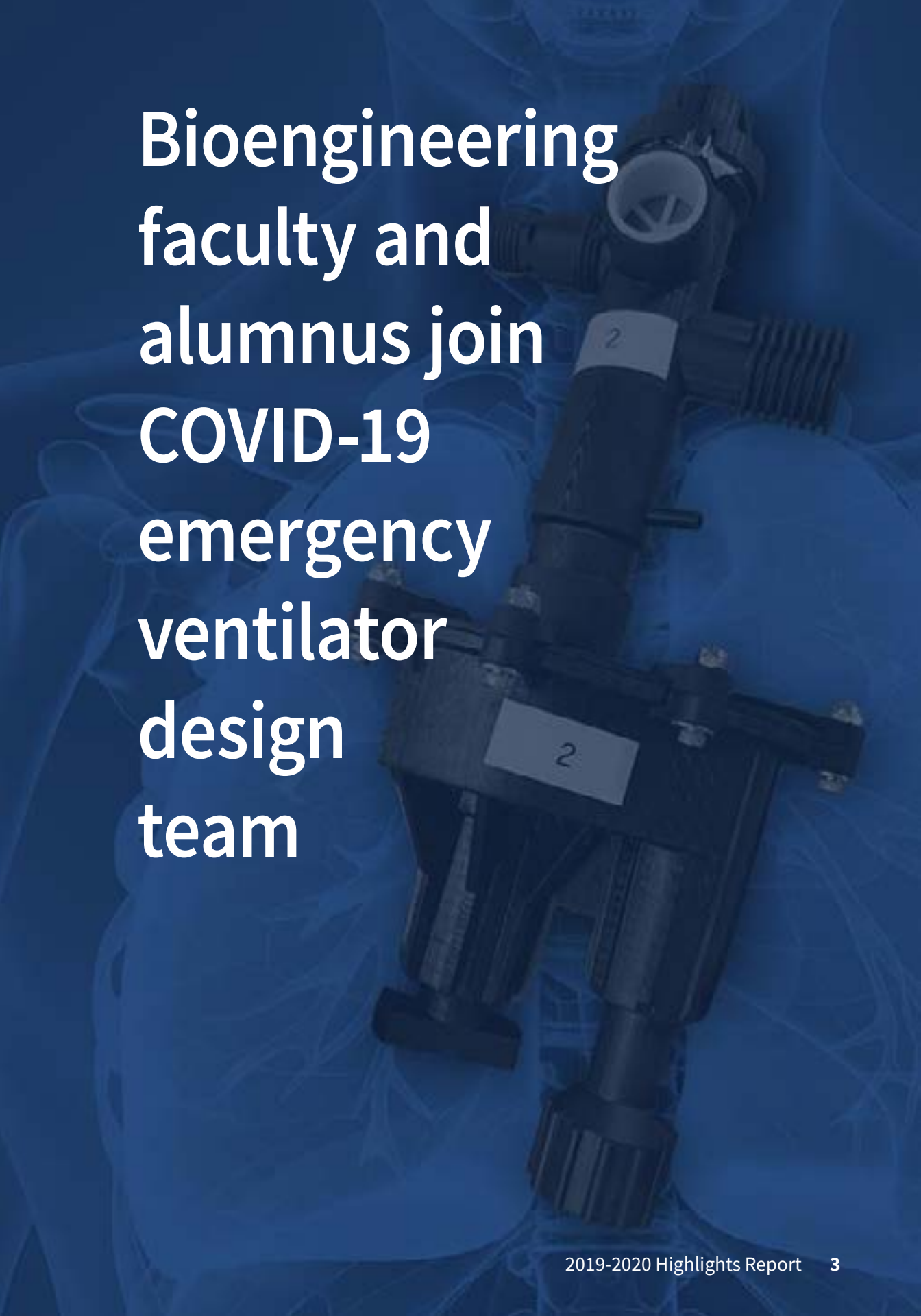
Each step of the Illinois RapidVent project was evaluated on the mechanical, regulatory and human aspects. Bethke said, "we were lucky to have experts involved who were fluent in each of those areas, which really accelerates the decision making."

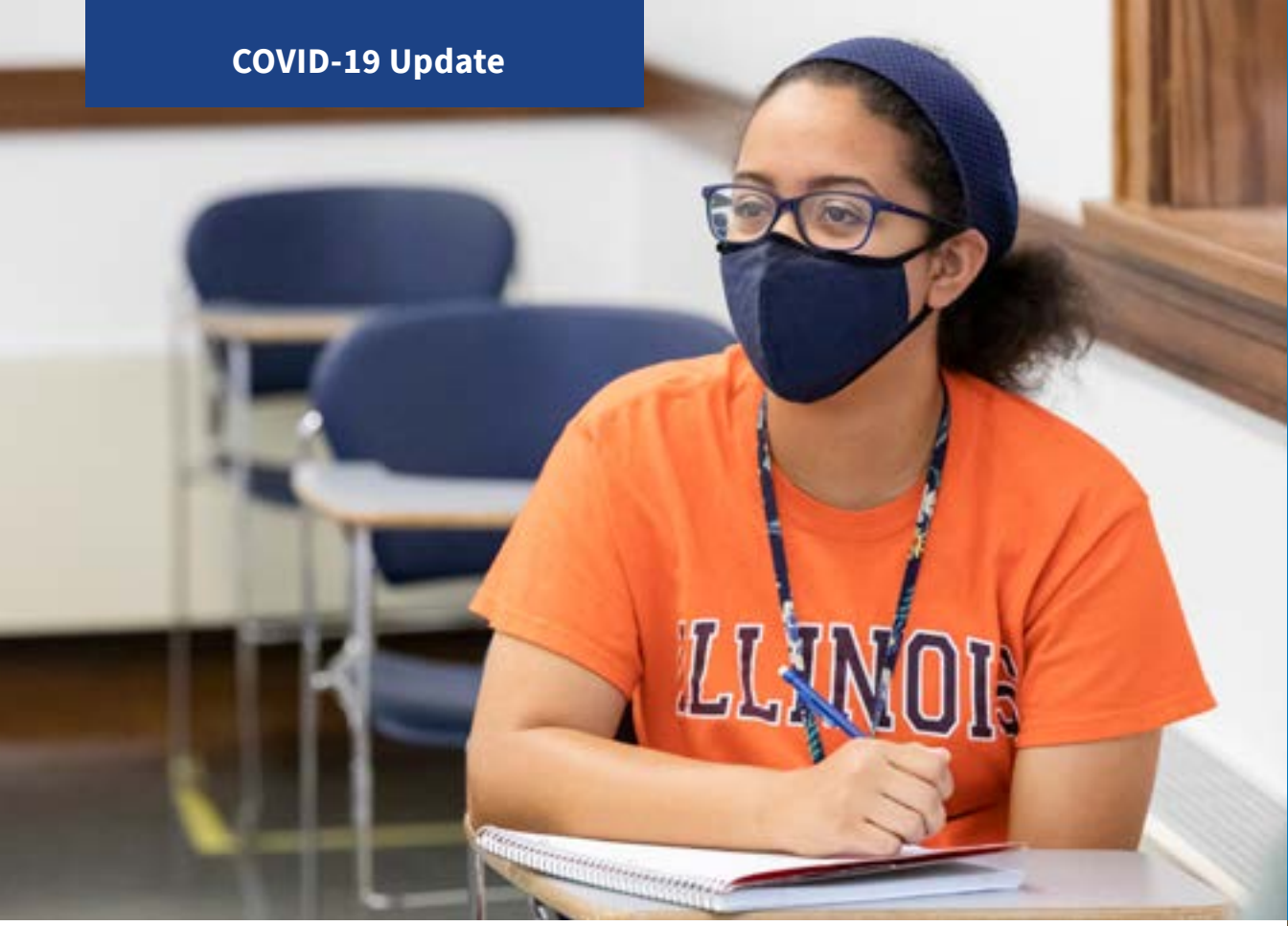
Boppart was able to offer input on the U.S. Food and Drug Administration (FDA) approvals process, having founded four medical device startups in his career. He consulted on several teams but spent most of his time on the Animal Studies Team.

"For bioengineers and those in our technology-focused Carle Illinois College of Medicine, it couldn't be more appropriate to recognize how important it is to know engineering, medicine, and biology and be able to design technologies that can help save people's lives," Boppart said. "This is why these degrees exist and why we train our students and people to think this way. What better way to highlight this than our current call to arms."

As of May 2020, Belkin, global consumer electronics leader announced its collaboration with the university for the design of the FlexVent™ Gas-Operated Ventilator. This emergency ventilator is based on the Illinois RapidVent concept and is pending the review and approval of its Emergency Use Authorization application by the FDA.

Bioengineering faculty and alumnus join COVID-19 emergency ventilator design team





Scientists help guide COVID-19 public policy in Illinois

A team of scientists has worked to create and analyze multiple COVID-19 epidemic models for the state of Illinois. Comparing these models has enabled the team to more accurately predict the likely trajectory of the disease in the state and advise Illinois Governor J.B. Pritzker on testing, stay-at-home orders, hospital capacities and reopening timelines.

Two Illinois faculty members, bioengineering professor **Sergei Maslov** and physics professor Nigel Goldenfeld led the governor's modeling taskforce. "Modeling is the only way we can predict the future. Modeling also allows us to quantify the consequences of different mitigation steps so we can plan accordingly," said Maslov. The team's models demonstrated that without the stay-at-home orders and social distancing practices, the death rate in Illinois from COVID-19 would likely have reached 20 times as high. They also correctly predicted the peak of the first wave of infections in Illinois during May.

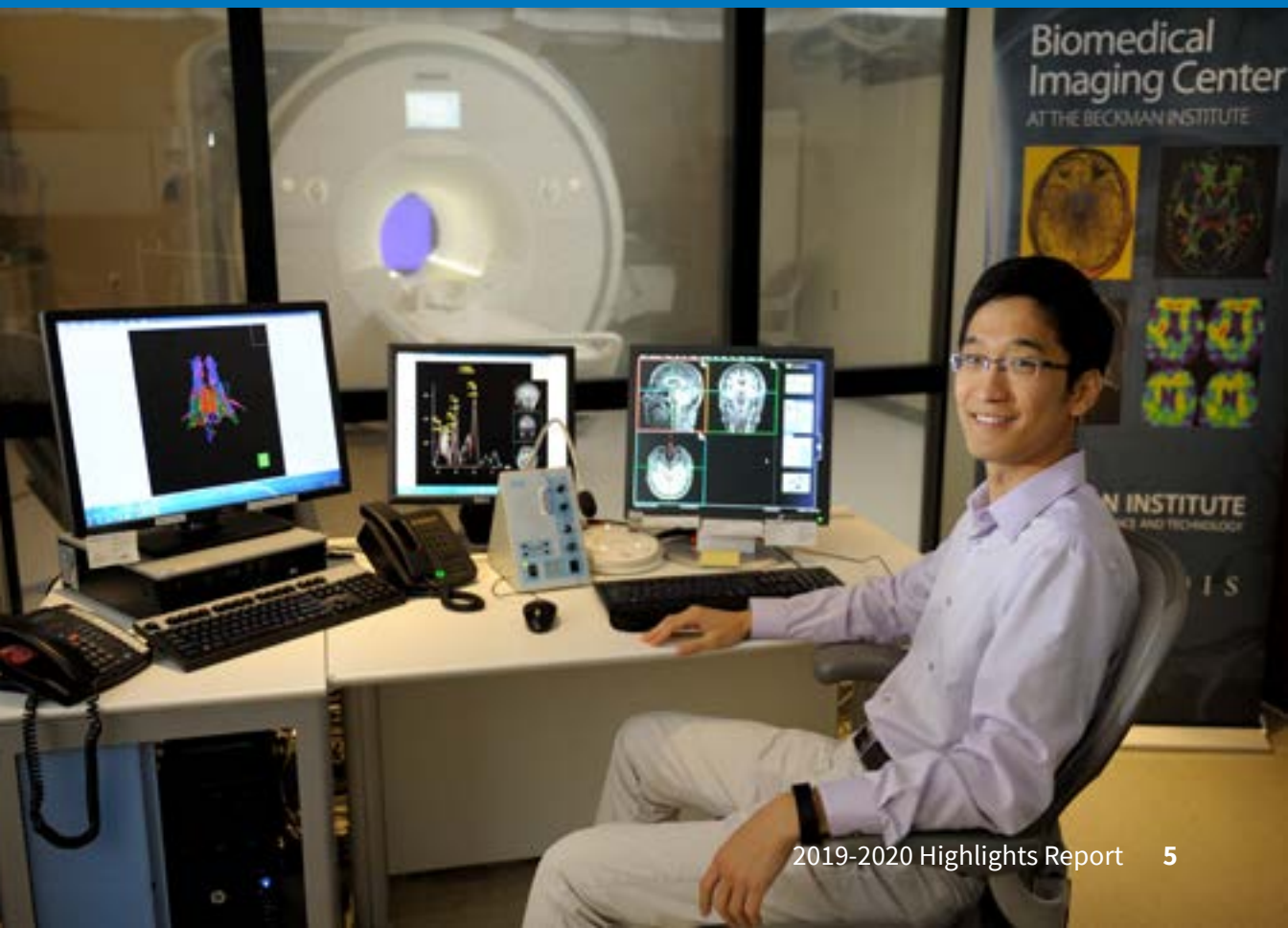
All team members volunteered their time to assist the governor in making difficult decisions that weighed the state's economic health against the potential loss of life. The taskforce is also actively modeling the spread of COVID-19 at the university level to advise on-campus mitigation strategies such as testing frequency and deploying the exposure notification app, Safer Illinois.

New method developed to efficiently reconstruct MRI images

Magnetic Resonance Imaging (MRI) relies on a strong background magnetic field to image the human body and, ideally, would require this background field to be uniform for accurate localization of signals from different parts of the body. However, achieving uniformity is nearly impossible in practice because different tissues in the body have different magnetic properties and cause variations in the magnetic field. This variation is known as B_0 inhomogeneity and is a universal problem in many MRI experiments.

Bioengineering professors **Fan Lam** (below) and **Brad Sutton** identified which encoding element of the model can be approximated and still result in high-quality imaging. By identifying the major characteristics of the B_0 inhomogeneity variations in the brain, they can establish a few key assumptions that allow a low-rank approximation of the model. This new method dramatically reduces the memory usage and the computation complexity by three orders-of-magnitude.

“It enables us to do things that would not have been possible before, such as going to higher resolutions, more time points in a data time series, or to incorporate additional components of the MRI physics for better-reconstructed images,” said Sutton and Lam.



Study maps landmarks of peripheral artery disease to guide treatment development

Novel biomedical advances that show promise in the lab often fall short in clinical trials. For researchers studying peripheral artery disease (PAD), this is made more difficult by a lack of standardized metrics for what recovery looks like. In a new study from University of Illinois at Urbana-Champaign, researchers identified major landmarks of PAD recovery, creating signposts for researchers seeking to understand the disease and develop treatments.

PAD is a narrowing of the arteries in the limbs, most commonly the legs, so they don't receive enough blood flow. It often isn't diagnosed until walking becomes painful, when the disease is already fairly advanced.

The researchers used multiple imaging methods to create a holistic picture of the changes in muscle tissue, blood vessels and gene expression through four stages of recovery after mice had the arteries in their legs surgically narrowed to mimic the narrowing found in PAD patients.

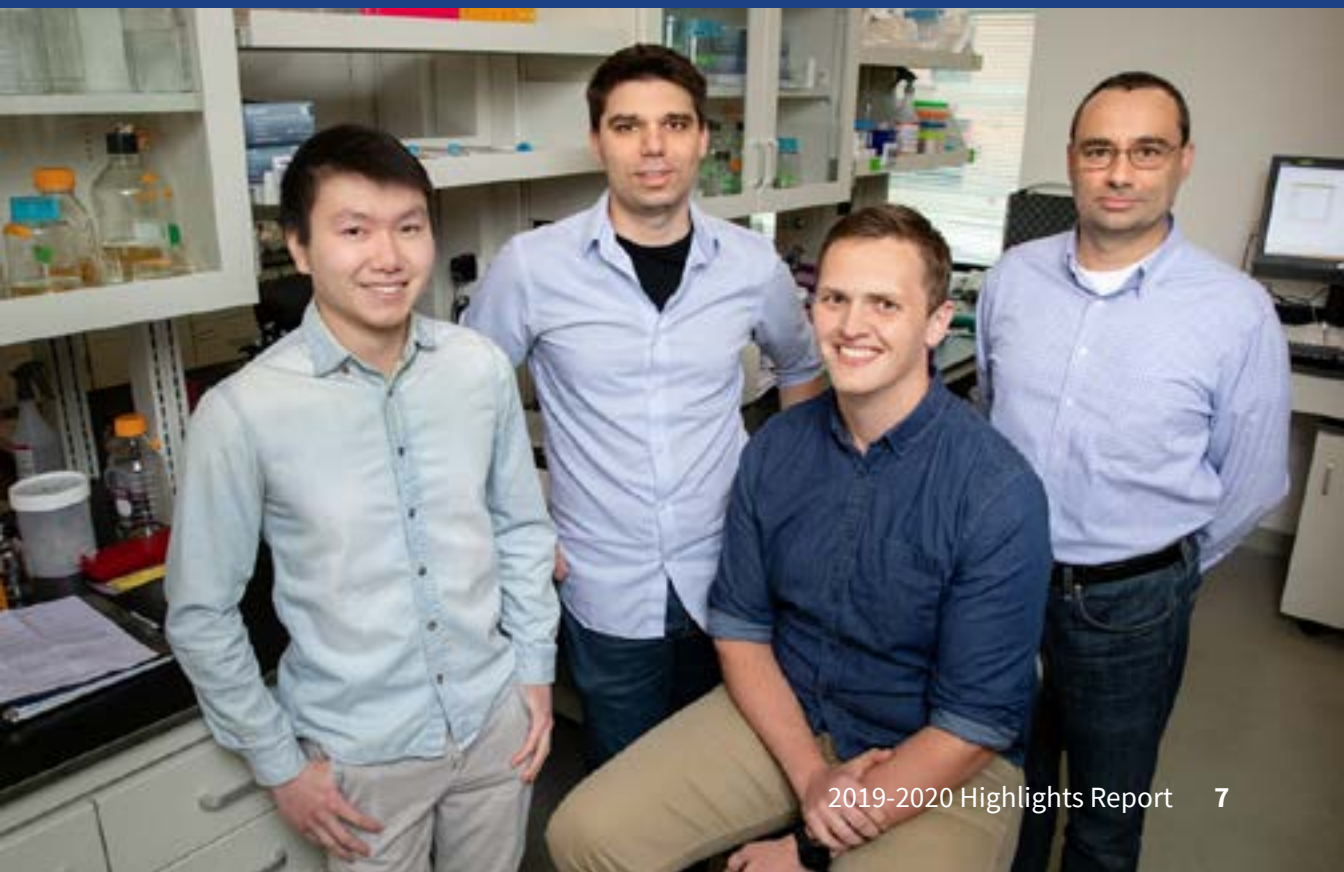
"Having these landmarks could aid in more optimal approaches to treatment, identifying what kind of treatment could work best for an individual patient and when it would be most effective," said Illinois bioengineering professor **Wawrzyniec L. Dobrucki**, who led the study.

CRISPR base-editing technology slows ALS progression in mice

With a new CRISPR gene-editing methodology, Illinois bioengineering professors **Thomas Gaj** (below, second from left) and **Pablo Perez-Pinera** (below, far right) co-led a study that inactivated one of the genes responsible for an inherited form of amyotrophic lateral sclerosis (ALS) – a debilitating and fatal neurological disease for which there is no cure. The novel treatment slowed disease progression, improved muscle function and extended lifespan in mice with an aggressive form of ALS.

Traditional CRISPR gene-editing technologies cut both strands of a DNA molecule, which can introduce a variety of errors in the DNA sequence. The Illinois group instead used base editing to change one letter of the DNA sequence to another without cutting through both DNA strands.

"Base editors are too large to be delivered into cells with one of the most promising and successful gene therapy vectors, known as adeno-associated virus," Gaj said. However, in 2019, Perez-Pinera's group developed a method of splitting the base editor proteins into halves that can be delivered by two separate AAV particles. Once inside the cell, the halves reassemble into the full-length base editor protein. By combining the power of AAV gene delivery and split-base editors, Gaj and Perez-Pinera targeted and permanently disabled a mutant SOD1 gene, which is responsible for roughly 20% of inherited forms of ALS. Also pictured below are bioengineering graduate students Colin Lim (far left) and Michael Gapinske (third from left).



Hybrid microscope could bring digital biopsy to the clinic

The gold standard of tissue pathology is to add dyes or stains so that pathologists can see the shapes and patterns of the cells under a microscope. However, it can be difficult to distinguish cancer from healthy tissue or to pinpoint the boundaries of a tumor, and in many cases diagnosis is subjective.

A research team led by bioengineering professor **Rohit Bhargava** developed a hybrid microscope by adding an infrared laser and a specialized microscope lens, called an interference objective, to an optical camera. The infrared-optical hybrid measures both infrared data and a high-resolution optical image with a light microscope – the kind ubiquitous in clinics and labs.

Pairing infrared measurements with high-resolution optical images and machine learning algorithms, the researchers created digital biopsies that closely correlated with traditional pathology techniques and also outperformed state-of-the-art infrared microscopes.

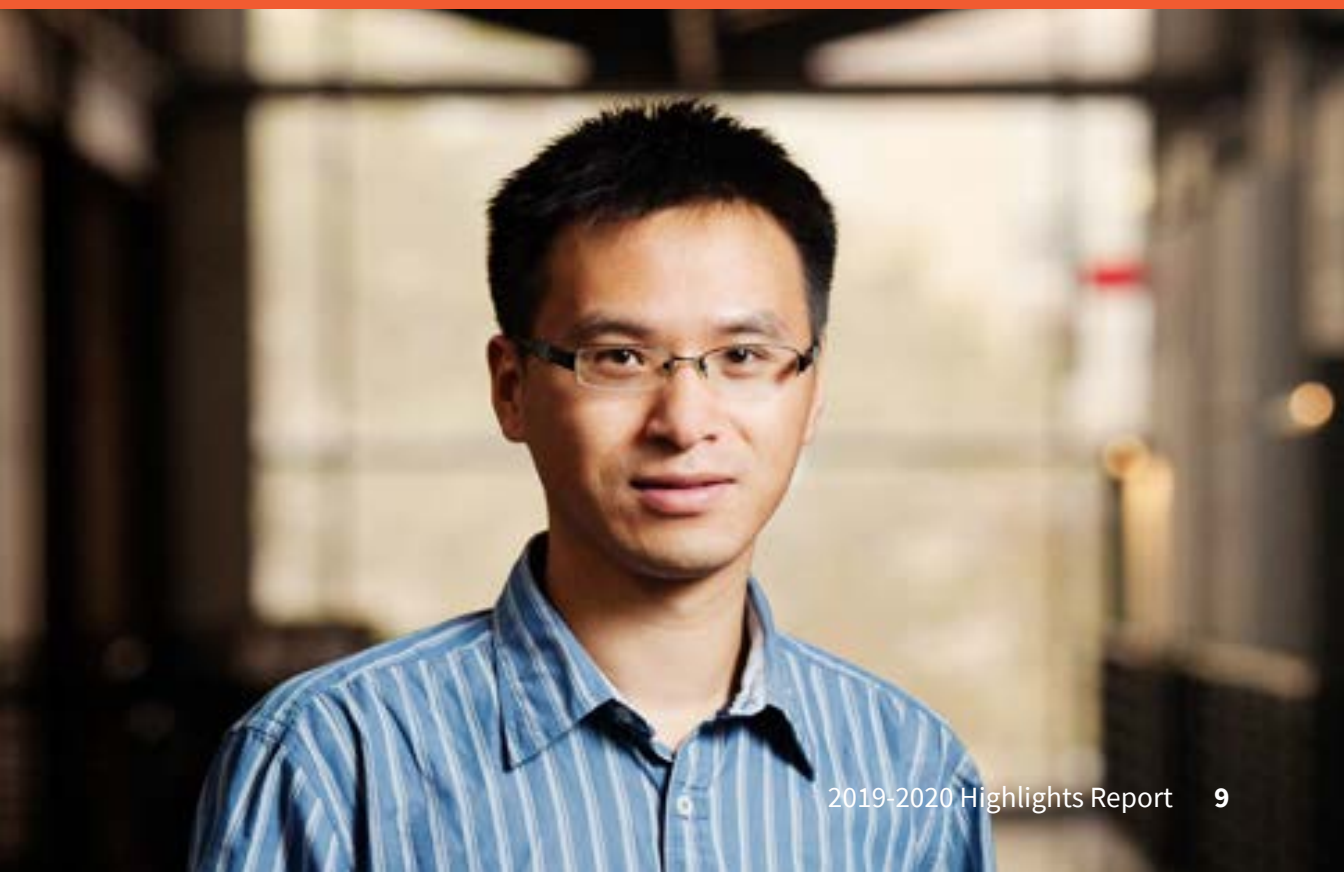
“The advantage is that no stains are required, and both the organization of cells and their chemistry can be measured. Measuring the chemistry of tumor cells and their microenvironment can lead to better cancer diagnoses and better understanding of the disease,” Bhargava said. Through his research, Bhargava hopes to bring cancer diagnosis into the digital era.

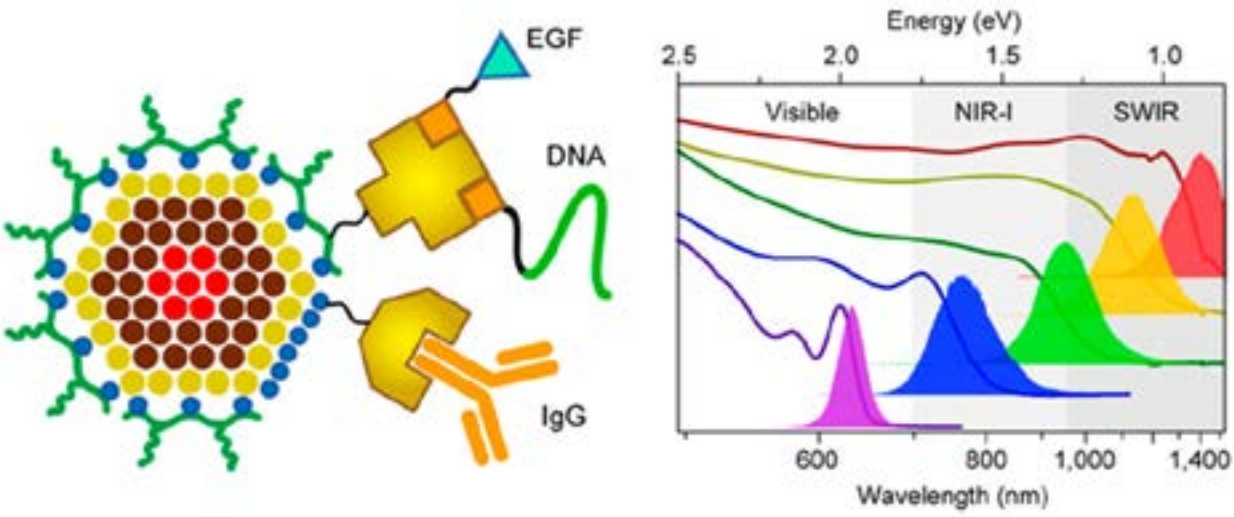
Researchers reverse engineer interaction dynamics of microbial communities

Microbes play a key role in environmental health, food production, and human wellness. While initially considered to be static, uniform entities, microbial communities are highly complex and contain internal chemical swapfests that are in constant flux. One important way that microbes interact is through the exchange of the compounds they produce—nutrients, chemical signals, and even toxins—that kill off competitors.

Researchers at Illinois led by bioengineering professor **Ting Lu** (below) have demonstrated that the dynamics of these communities can be explained and even predicted by examining the variability trait of microbial social interactions. "The ultimate goal of our research is to develop effective strategies to program the composition and functionality of microbial communities," Lu said.

By examining two strains of the bacteria *Lactococcus lactis*, the study found that when the cooperation and competition are additionally modulated by pH, ecosystem succession becomes jointly controlled by the variations of both interactions and yields more diversified dynamics—some communities changed dramatically over time, while other stayed more stable. The researchers constructed mathematical models that explicitly incorporated the variability of interaction into ecosystem description. This work serves as a foundational step toward the analysis, prediction, and engineering of complex communities.





Innovative new quantum-dot imaging probes lead to more effective disease diagnoses

In a study conducted at Illinois, a research team led by bioengineering professor **Andrew Smith** developed a new form of quantum dots with short-wave infrared (SWIR) emission for imaging single molecules in cells and tissues. The SWIR is a unique spectral range which the eye cannot see, and the quantum dots' emission can be tuned over an extremely broad range of colors and spectrums, from the visible to the infrared, allowing for a wide range of use.

The big advantage of the SWIR is that there is almost no autofluorescence (background signal) emitted from cells compared with the most commonly used spectral ranges in the visible light. Researchers can see sharper details in images and recognize individual molecules more accurately. The team evaluated a wide range of biological studies — from cells to tissues — replacing visible wavelength QDs with SWIR-QDs, finding that all scenarios benefitted from their use.

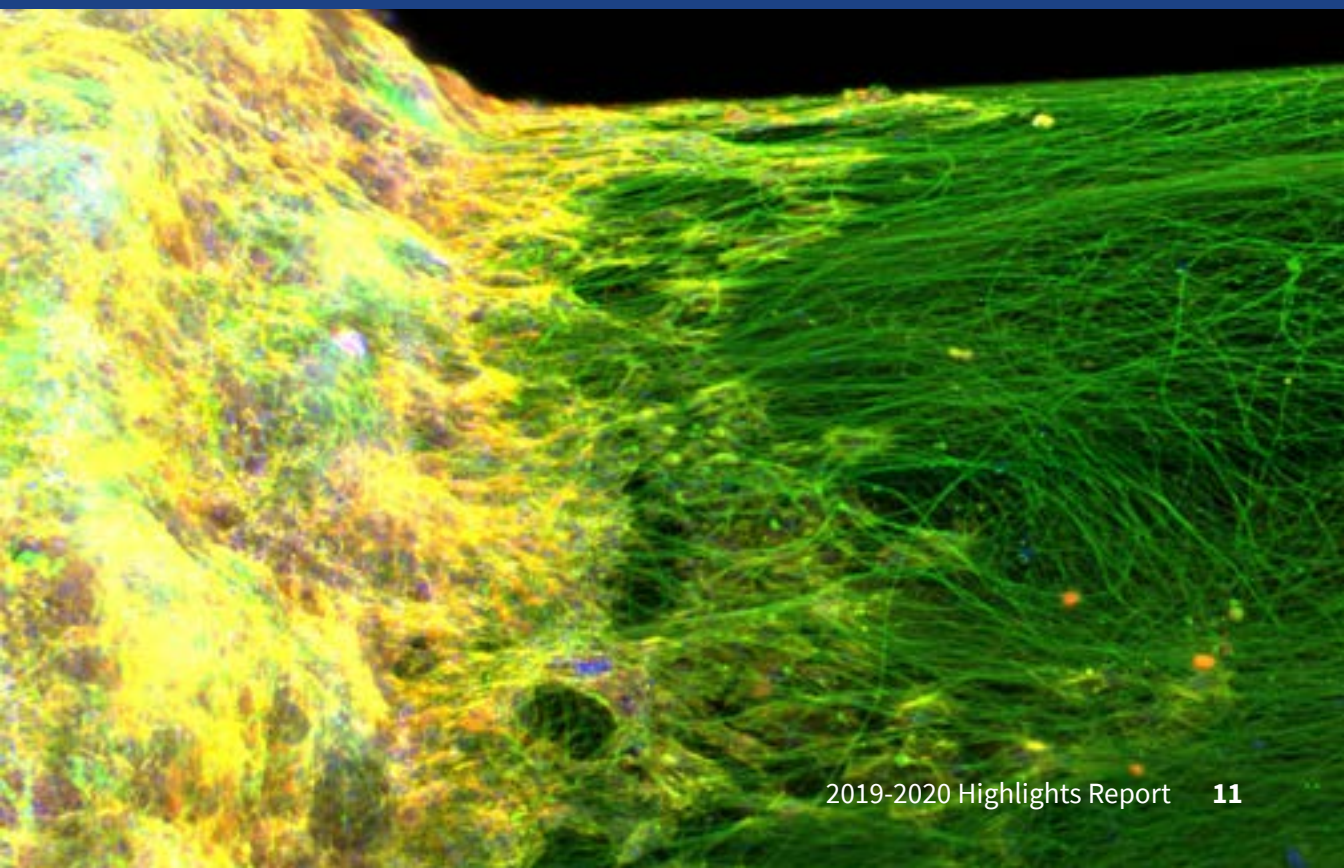
This SWIR quantum dot research is unique because, for the first time, it shifts the emitted light colors from the visible spectrum into the short-wave infrared spectrum, opening the door to much more effective imaging. The researchers expect the biggest impact of this work to be in diagnosing diseases in patients.

Illinois team develops first-of-a-kind in vitro 3D neural tissue model

An interdisciplinary team at Illinois including **Rashid Bashir**, bioengineering professor and the dean of The Grainger College of Engineering, have successfully used stem cells to engineer living biohybrid nerve tissue to develop 3D models of neural networks with the hopes of gaining a better understanding of how the brain and these networks work.

The team was able to give 3D geometry to the living tissue made of neurons with optogenetics, so they could be activated with blue light. These tissues could be used to study complex behaviors that happen in the brain and how these tissues react with new drugs being developed. It could also mean less reliance on animals to test these drugs in the future.

Besides drug testing, the team is especially interested in being able to recapitulate the way these networks might develop learning and memory. The brain is challenging to study in an actual person, but being able to understand how these networks develop using a 3D model outside the body promises to give researchers a new tool to better understand how it works. These models will be able to help understand how abnormalities form, including what gives rise to diseases such as Alzheimer's.



Label-free microscopic techniques visualizes extracellular vesicles in cancer

The Biophotonics Imaging Lab team led by bioengineering professor **Stephen Boppart** has developed imaging techniques that investigate tissues without using any staining or labels.

Traditional visualization techniques are dependent on the use of labels, which involves a lot of effort and can render the tissue unusable for additional investigation. The new technique involves using ultrashort laser pulses, which interact with the tissue samples. Normal cells use extracellular vesticles to communicate with each other. Tumor cells will alter these extracellular vesicles and release more throughout the body, making them potential markers for cancer progression.

The researchers created a unique system using a laser source that can capture more information about a tissue as compared with traditional imaging techniques. Using this method, researchers can acquire information about the structure and metabolism of the living tissue and see how these vesicles interact with each other and with the tumor. The new system provides better visualization of extracellular vesicles particularly in their connection to breast cancer cells.

Soft robotics research and design broadens the pathway to STEM

Soft robotics is an emerging subfield of robotics and holds tremendous potential for biomedical applications. Some examples include exoskeletons, wearable devices, and implanted pneumatic actuators to assist organ functions. It is also an engaging way to teach mechanics, robotics and healthcare devices in K-12 classrooms and beyond as evidenced in this work.

Bioengineering professor **Holly Golecki** is the principle investigator of a study to create a method of fabricating soft robotic actuators that is durable and uses tools and materials accessible to teachers and students. The novel molding method developed by a group of high school students presented in the study uses a 3-D printed mold that suspends a soluble insert to create the pneumatic network. Using this method, an actuator's shape can be easily customized and its single part system makes it more rupture resistant under high pressure.

In addition to using traditional silicone actuators, this research team also tested gelatin candy actuators with sugar-based inserts as a food-safe and biodegradable option. The team introduced the design in two different classroom settings: a wearable mechanical assistance device that guides an art student's hand while throwing a clay pot and an independent exploration program at University High School in Urbana, Illinois.

B.S. | Class of 2016

Ashley Moy

Forbes 30 Under 30
Co-founder &
CEO of Cast21

Ashley Moy (left) co-founded Cast21 as an undergraduate student in the bioengineering department with two other engineering students. Cast21 disrupted the orthopedic casts industry with its alternative waterproof and breathable exoskeleton casts that conform to patient's bodies. The team grew out of the Research Park at Illinois, received numerous accolades, raised venture capital investments, and is based in Chicago.

M.Eng. | Class of 2019

Allen Bell

Knowledge Discovery Services Associate at AbbVie

Allen Bell (left) received a bachelor's degree in agricultural & biological engineering at Illinois. The M.Eng. program equipped him with technical and business skills to transition into the medical field. At AbbVie, he creates automated workflows that extract data on relationships between biological entities from medical research databases and leads internal technical consulting initiatives.

M.Eng. | Class of 2019

Madhuri Krishnamurthy Ratnakumar

Quality Analyst at FUJIFILM Medical Systems

Madhuri Krishnamurthy Ratnakumar (left) was an international student who leveraged her M.Eng. degree to grow her career in healthcare IT. During the program, she gained a deeper understanding of biological systems and technologies. In particular, her courses in biomedical imaging and bioinstrumentation directly help with her current test engineer responsibilities.

Ph.D. | Class of 2019

Phuong Le

Schmidt Science Fellow

Phuong Le (left) was one out of twenty-two science leaders selected world-wide for the prestigious Schmidt Science Fellowship 2020 cohort. While earning her doctorate, Le was part of professor Andrew Smith's lab where she worked on quantum dot nanotechnology and single-molecule counting.

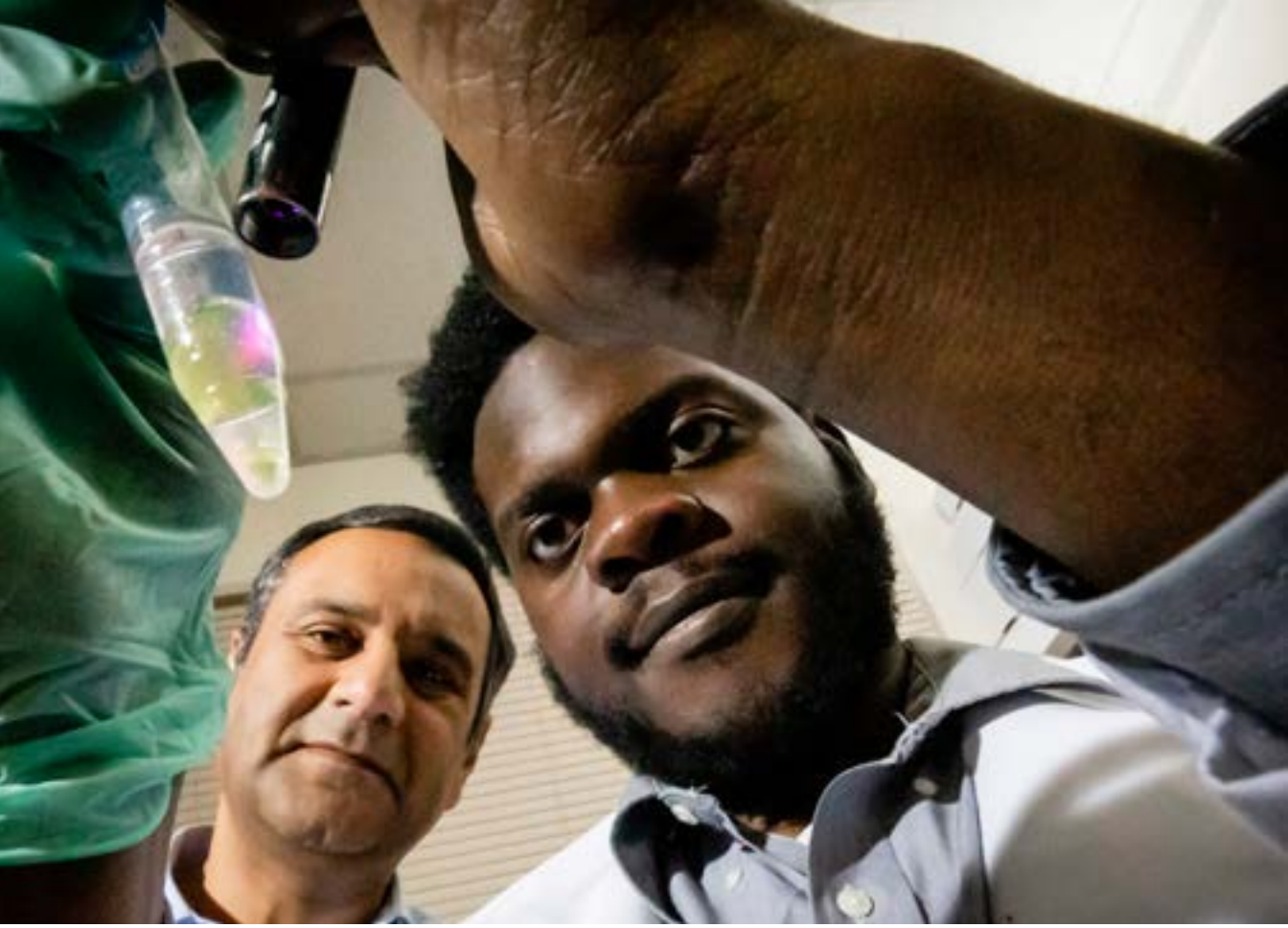
She is the second Schmidt Science Fellow in the history of Illinois and will be combining bio-imaging with stem cell modeling to study neurodegenerative diseases.

Outstanding investigators. Cutting-edge infrastructure. Clinical partners. Interdisciplinary collaborators. Survivors and advocates.

The Cancer Center at Illinois (CCIL) is unlike any other, translating engineering and basic science innovations to cancer care. The 70+ cancer center scientists and their labs have banded together to fight cancer for over a decade and were elevated to campus wide institute status in 2018. CCIL researchers are improving cancer diagnoses and detection through the development of improved imaging techniques and artificial intelligence to better analyze data. Cancer scientists are using 3D-printing techniques to re-create tissue and tumor environments, discovering promising new cancer treatments, and developing collaborations with external science and medical facilities, like Carle Health and Mayo Clinic.

"The tools developed through CCIL research can help eliminate guesswork for physicians, eliminate waiting for patients, and accelerate the search for cures to enable precise and personally fulfilling care for everyone, regardless of their socio-economic status," said **Rohit Bhargava** (above, left), Founder Professor of bioengineering and CCIL director.

In addition to conducting transformative research, the CCIL is shaping the next generation of cancer researchers through robust educational programs starting with high school students through post-doctoral



researchers. Bioengineering students are partnered with CCIL scientists and oncologists in labs and clinics, giving the students a real-life experience conducting cancer research. These projects and partnerships have led to innovative cancer discoveries.

The CCIL continues to move forward with the addition of Seed and Planning Grant Programs, calling for interdisciplinary research teams working together to develop new cancer technologies and techniques that can transition from labs to clinics.

"The CCIL's research programs and shared resources boost Illinois Bioengineers in developing novel approaches to fight cancer. Just as our daily lives have been transformed by inventions by teams of Illinois researchers, there now exists a remarkable opportunity to engineer transformative advances against cancer," says Bhargava.

Also pictured above is bioengineering graduate student Craig Richard.

> **We're advancing knowledge in science, technology, and engineering to develop game-changing interventions. The result? Innovation in cancer detection, prevention, diagnosis, therapy, and quality of life.**

As an undergrad I started research early on. The mentors I had there were integral in my success and in informing my career path. Coming to Illinois, I knew I wanted to focus on facilitating research and design experiences for undergraduates.

Holly Golecki (above) is a new teaching assistant professor at the department of bioengineering. Her research interests include biomaterials and soft robotics. She also studies how research programs can be used to support first generation and female engineering students and served on The Grainger College of Engineering's anti-racism task force in summer 2020. Prior to the move to Illinois, she taught in the materials science and engineering departments at the University of Pennsylvania and Drexel University as well as served as director of robotics at a K-12 school in the Philadelphia area. She now studies impacts of such programs with the perspective of the classroom teacher in mind. Golecki received her B.S. in Materials Science and Engineering from Drexel University and her Ph.D. in Engineering Sciences from Harvard University.

Nexus of engineering and health

Forty-eight new medical students began their journey at the Carle Illinois College of Medicine in July 2020. These students come from across the U.S. and from a range of academic disciplines: 85.5% have an engineering background, and 14.5% come from the basic sciences. Nine students hold an advanced degree (three doctorate degrees and six master's degrees) and 14% of the incoming students come from historically minoritized groups.

Carle Illinois completed its LCME Provisional Accreditation visit on August 27-28, 2020. The culmination of two-and-a-half years of work, the virtual visit included meetings with faculty, students, and staff. The LCME review team will submit its report in time for review at LCME's February 2021 meeting. Carle Illinois achieved preliminary accreditation in October 2018.

A team of engineers, physicians, researchers and designers from Illinois and Carle Health developed and launched several new personal protective equipment products to support the needs of health care workers responding to the COVID-19 pandemic. In addition, Dr. Marty Burke, Carle Illinois' associate dean of research, was appointed by Chancellor Jones to chair the SHIELD team, charged with returning the university to on-campus operations in the safest way possible. A team of researchers, epidemiologists, physicians and others designed the novel COVID-19 saliva test, and modeled and launched the testing and exposure notification strategies.

Three bioengineering faculty receive NSF CAREER awards

Roy Dar (above, right) received a National Science Foundation (NSF) CAREER award for his project, "Viral Control of Cell Migration in Diverse Host-cell Types." Dar and his research group have been studying viral-host relationships specifically for the human immunodeficiency virus (HIV), which attacks the immune system by targeting CD4+ T-cells (T-lymphocytes).

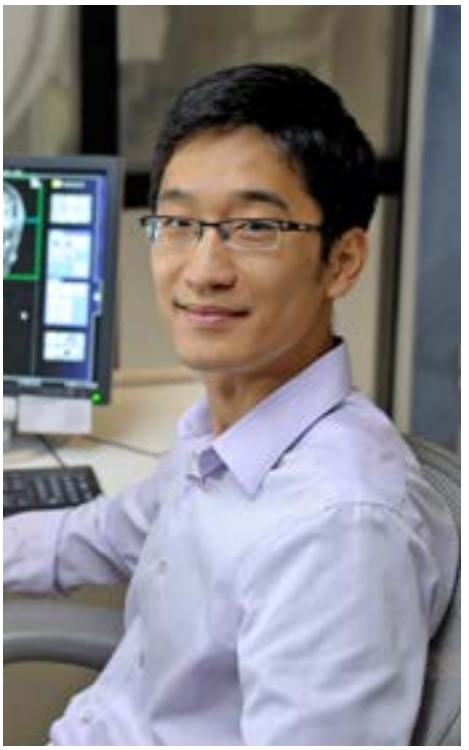
Viruses can adapt to the human host and take over cell expression for their survival and reproduction. HIV, for example, can stay dormant in infected patients and spontaneously reactivate after antiretroviral treatment is removed. "The latent pool of dormant cells is the major barrier to a cure," explained Dar. "We currently don't know how to completely control or get rid of the latent cell population, enabling infected cells to evade treatments, reactivate and spread the virus," he said.

This study will examine the mobility of HIV infected cells in five host-cell types. The results may provide further insights into the mechanism of transmission and the pathogenicity of the virus.

Also pictured above is bioengineering graduate student Yiyang Lu.

Fan Lam (below) earned a NSF CAREER award to support his project, "Ultrahigh-Resolution Magnetic Resonance Spectroscopic Imaging for Label-Free Molecular Imaging of the Brain." Lam is developing advanced MRI technology to study the brain, how it functions, how it is affected by central nervous system disorders and how to better detect and treat those diseases.

Lam and his research group are creating enhanced imaging tools to study molecular-level activities in the human brain noninvasively, without using contrast agents, and in a way that allows scientists to "see information beyond anatomy and neuronal activation," he said. They are working to advance the MRI's capability of imaging molecules in the brain to generate more information and in greater detail than previously available.



Karin Jensen (above) has received a NSF CAREER Award for her project, "Supporting Undergraduate Mental Health by Building a Culture of Wellness in Engineering." **Jensen is the first member of the teaching faculty at Illinois to earn the NSF CAREER award.**

Jensen will study how mental health in engineering undergraduate programs is perceived by students in the programs, as well as exploring the roles that faculty, administrators and staff play in supporting or dismantling the idea that a successful engineering degree requires a high-stress environment.

Her aim is to learn how students feel about the high-stress environment and what positive strategies they develop to cope with it. The eventual goal for this project is to develop and implement proactive, research-based training in engineering programs for faculty, staff and administrators to promote student wellbeing and create a positive, healthy culture.

Jump ARCHES partnership expands; endowment now exceeds $100M

A longstanding partnership between OSF HealthCare and The Grainger College of Engineering for joint research to revolutionize clinical simulation, health care systems and medical education will expand dramatically through additional endowments. This will fuel a new generation of joint research projects to include mobile sensors, Internet of Things applications, data analytics and understanding social and behavioral determinants of health. Known as Jump ARCHES (Applied Research for Community Health through Engineering and Simulation), the partnership was established in 2013 with $62.5 million in support. A 6,000 square foot state-of-the-art simulation and education facility, Jump Simulation Center, formally opened in July 2018 and is managed by the Health Care Engineering Systems Center (HCESC). With new commitments of $50 million, Jump ARCHES will now be backed by a total of $112.5 million in endowment support.

“This incredible new support from the DiSomma Family Foundation and the OSF HealthCare Foundation will allow our partnership to grow in exciting areas that we had not previously tackled,” said **Rashid Bashir**, dean of The Grainger College of Engineering. “We will continue to focus on medical simulation and health care engineering, but we will broaden our scope tremendously.”

Illinois, in partnership with the Carle Foundation Hospital, will soon join an elite network of sites (currently less than a dozen nationwide) to offer patients access to the Siemens Terra 7 Tesla (7 T) MRI scanner, the highest magnetic field imaging strength commercially available in the United States approved by the Food and Drug Administration (FDA) for brain and knee scans of patients. The 7 Tesla MRI scanner can uncover abnormalities undetected by conventional, lower-strength clinical MRI systems and its use also extends to patients suffering from traumatic brain injury.

The Beckman Institute's Biomedical Imaging Center (BIC) will conduct University of Illinois research using the scanner, which will be located at Carle Foundation Hospital. The new MRI scanner provides more than double the signal of the existing research scanners at BIC. Research is expected to advance imaging science and improve clinical outcomes.

The Microscale Biofabrication Lab located at the bioengineering department is one of the latest equipment-focused investments by the Carver Charitable Trust at Illinois. A bioengineering faculty team including **Pablo Perez-Pinera** (above), **Andrew Smith**, **Kris Kilian**, **Jenny Amos** and **Marcia Pool** have developed an innovative, hands-on laboratory and instructional course to teach fundamental principles in forward-design of microscale biofabrication. An emergent field, biofabrication combines biological and solid-phase materials to create diagnostic, therapeutic, and tissue engineering devices and tools that are profoundly impacting biology and medicine.

The course and lab will also provide first-in-class opportunities for education and research to students enrolled in the Carle Illinois College of Medicine, bioengineering senior design students and students from other engineering disciplines.

Degradation of C9orf72 Repeat RNAs using RNA-Targeting CRISPR Effectors
PI: **Thomas Gaj**
Supported by: ALS Association

Safe, rapid & functional pediatric brain imaging using photoacoustic computed tomography
PI: **Mark A. Anastasio**
Supported by: California Institute of Technology

Multimodal biomarkers for oro-phyaryngael cancer
PI: **Hua Li**
Supported by: National Institutes of Health (National Cancer Institute)

An enabling technology for preclinical x-ray imaging of biomaterials in-vivo
PI: **Mark A. Anastasio**
Supported by: National Institutes of Health (National Institute of Biomedical Imaging and Bioengineering)

Ultrasonic perfusion imaging of peripheral vascular disease
PI: **Wawrzyniec L. Dobrucki** and **Michael Insana**
Supported by: National Institutes of Health (National Heart, Lung, and Blood Institute)

Advanced image reconstruction for accurate and high-resolution breast ultrasound tomography
PI: **Mark A. Anastasio**
Supported by: National Institutes of Health (National Institute of Biomedical Imaging and Bioengineering)

Integrative circuit-host modeling of synthetic gene networks
PI: **Ting Lu**
Supported by: National Institutes of Health (National Institute of General Medical Sciences)

Development of a rapid method for imaging regional ventilation in small animals without contrast agents
PI: **Mark A. Anastasio**
Supported by: National Institutes of Health (National Institute of Biomedical Imaging and Bioengineering)

Genetic modification of asynuclein with CRISPR Base Editors for correction of Parkinson's disease
PI: **Pablo Perez-Pinera**
Supported by: Parkinson's Disease Foundation

Optimization of biochemistry and bioinformatics methods for dual RNA-Seq
PI: **Paul Jensen**
Supported by: Sandia National Laboratories (US Department of Energy)

Partnership 2020: Leveraging US-India cooperation in higher education
PI: **Rohit Bhargava**
Supported by: US Department of State

GIANT building confidence and increasing engagement through undergraduate research
PI: **Holly Golecki**
Supported by: University of Illinois at Urbana-Champaign IDEA Institute

$3.5M for STEM entrepreneurship research

Joe Bradley (below), a clinical professor in bioengineering at Illinois, is a member of a multi-institutional collaborative team that was awarded nearly $3.5 million from the National Science Foundation to research and evaluate ways to develop infrastructure that improves diversity and inclusion in STEM entrepreneurship.

This research team includes members from the National GEM Consortium, Rutgers University, Berry College, Vanderbilt University, University of Michigan and BioTechnical Communications. The team will work with participants in the NSF's Innovation Corps (I-Corps™) Program and help remove barriers that may be keeping them from gaining an effective experience to continue as STEM innovators. The team plans to use a variety of methods to identify targeted solutions for historically minoritized entrepreneurs while taking intersectionality, racialized experiences and business opportunity identification into consideration.

"It is my hope that the broader impacts of this research will support historically minoritized STEM scholars as they become more involved in the STEM entrepreneurship landscape, resulting in more diverse, affirming and innovative solutions to pressing societal problems," said Bradley who is also an alumnus of the I-Corps Program.

Excellence in education, research and innovation

Illinois bioengineering undergraduates continue to excel as students, researchers and professionals. Cancer Scholars and rising bioengineering juniors **Shweta Khorana** and **Elisabeth Martin** were recipients of research awards this past year. Khorana was named a Clare Boothe Luce Undergraduate Research Scholar, an award that supports women undergraduates seeking to study or teach in the STEM fields. Martin won one of just 25 campus-wide research awards from the Office of Undergraduate Research to support her research project, "Stability of Stored Microvesicles Characterized by Label-free Optical Imaging," as part of the biophotonics imaging lab at Illinois, led by professor **Stephen Boppart**.

Recent bioengineering graduate **Faisal Masood** received the 2020 Student Employee of the Year award for his laboratory assistant role in BIOE 202, Cell and Tissue Engineering Lab, chosen from 10,000 student employees. His work in developing virtual labs and lab practicals was instrumental in the shift to online learning during the pandemic.

This past spring, the department offered **four new elective courses** in **immunoengineering**, **cancer technologies**, **systems biology** and **experimental design**. These courses provided students in diverse tracks the opportunity to gain knowledge in specialized areas of medicine and the life sciences, and to apply analytical skills and engineering design principles to emerging societal and technological challenges. In Immunoengineering, taught by professor **Shannon Sirk,** students worked in teams to identify and explore problems in immunology and diseases involving the immune system and then proposed a technological solution. This course was particularly relevant in the context of the mid-semester interruption due to COVID-19, and many students shifted the focus of their final projects to COVID-19-based issues. In Introduction to Systems Biology, taught by professor **Ting Lu**, students

constructed mathematical models of biological networks and analyzed experimental data to understand underlying natural design rules of living organisms. In Cancer Technologies, taught by professor **Andrew Smith,** students learned fundamentals of cancer biology and procedures in clinical oncology, and proposed technologies to address current limitations in cancer treatment and diagnosis, facilitated by iterative writing and in-class peer-review of research proposals. In Experimental Design and Optimization, taught by professor **Paul Jensen**, students used statistical approaches to design experiments that address hypotheses about biological systems that are otherwise too complex to evaluate with simple analytical procedures.

Bioengineering is offering several courses online this fall, including Soft Robotics developed and taught by professor **Holly Golecki**. This course is most strongly connected to the biomechanics track, focusing on the design of wearable and implantable robotics which have mechanical properties that match human tissue. Students will develop working robot prototypes using actuators and sensors, even those students working from home while taking the course fully online.

Pictured from left to right are Craig Soares, Justin Tao, Hannah Thompson and Ana Valles who won the top prize at the 2019 BMES Coulter College Venture Capital Pitch. They presented their winning idea for pediatric heart valve replacements at the annual BMES meeting. Holly Golecki served as the faculty advisor.

Quantitative light imaging research group

Michael Fanous

McGinnis Medical Innovation Graduate Fellow

"I have recently completed undertaking the configuration of a novel imaging modality that has successfully evaluated the correlation of myelin content with different diet regimens. My current work focuses on single axon activity with new optical methods that have excellent promise for benefiting the realm of medical equipment and clinical treatments.

Biophotonics imaging research group

Jungeun Jenny Won

McGinnis Medical Innovation Graduate Fellow

"My research is to develop advanced imaging techniques using optical coherence tomography (OCT), which is an optical analogue to ultrasound imaging. I implement OCT inside small handheld probes to noninvasively image the human middle ear cavity.

Online Master of Engineering program launches

The department of bioengineering at the University of Illinois at Urbana-Champaign has launched an Online Master of Engineering (M.Eng.) in Bioengineering program. Following the success of the in-person M.Eng. program, this online program is a way to offer a more flexible learning format that can be accessible to students around the country and around the world. This non-thesis program is suitable for recent graduates looking to gain additional technical and business skills, early-career professionals looking to combine full-time work with part-time continuing education or those looking to transition to a career in healthcare with an engineering perspective. Students can choose from one of two tracks: general bioengineering or bioinstrumentation (with a focus on medical imaging).

The M.Eng. degree is a stepping-stone to technical and managerial roles within the healthcare industry and will add value for students looking to develop tools for biomedical imaging, medical diagnostics and life science research. Previous M.Eng. graduates have enjoyed professional success through roles in industry and continued education in Ph.D. programs, medical school and dental school.

Awards and Honors

Mark A. Anastasio was invested as a Donald Biggar Willett Professor in Engineering.

Karin Jensen received the 2020 American Society for Engineering Education (ASEE) Biomedical Engineering Teaching Award.

Shuming Nie received the 2019 Lifetime Achievement Award from the Chinese American Society of Nanomedicine and Nanobiotechnology.

Rohit Bhargava received an Engineering Council 2020 Outstanding Advising Award.

Paul Jensen received the Stanley H. Pierce Faculty Award.

Pablo Perez-Pinera earned an Impact Award from the Parkinson's Foundation.

Stephen Boppart was named a Fellow of the National Academy of Inventors and received the best healthcare product award at the SPIE Prism Awards.

Ting Lu earned an NIH Outstanding Investigator Award.

Andrew Smith received the 2020 Dean's Award for Excellence in Research.

Maddie Darling, Assistant Director of Undergraduate Programs, received an Engineering Council 2020 Outstanding Advising Award.

Ashley Mitchell, bioengineering junior, earned Third Place at the 2019 Society of Hispanic Professional Engineers (SHPE) poster competition.

Yogatheesan Varatharajah Ph.D. candidate, was named a finalist in the 2020 Engineering in Medicine and Biology Society Student Paper Competition.

Maha Alafeef, Ph.D. candidate, received the Golden Key Graduate Scholar Award.

Fatemeh Ostadhossein, Ph.D alumna '19, was awarded Second Place in the 2020 Carbon Journal Prize from Elsevier.

Jackson Winters, Ph.D. candidate, was appointed to the Northwestern University Clinical and Translational Sciences Institute (NUCATS) fellowship program.

Faisal Masood, bioengineering senior, was named a Knight of St. Patrick.

Diana Slater, bioengineering senior, was named a Knight of St. Patrick.

Everitt Laboratory earned a LEED® Gold certification from the U.S. Green Building Council.

Illini success

Each year, the Illini Success Initiative surveys graduates who have earned a bachelor's degree to find out what they are doing after graduation. There were 48 students who self-reported as part of this survey. For bioengineering graduates from 2018-2019, 46% are employed, 46% are continuing with their education and 8% have alternative plans.

The average starting salary for Illinois bioengineering graduates with a bachelor of science degree is $67,040 as compared with the national average of $59,015 according to the National Association of Colleges and Employers (NACE).

Top 10 destinations for Illinois bioengineers employed in industry are: Abbott, AbbVie, Eli Lilly & Co., Epic Systems, Cook Medical, Boston Scientific, Baxter International, Catalent, Jump Simulation and Veeva Systems. This information was collected by Illinois bioengineering.

Engineering Visionary Scholarship

2019 -2020 Recipients

Grace Huberty | Class of 2023
My scholarship has a monumental financial impact on me and my family. I recognize that my scholarship is the reason that I have time to explore all of the opportunities that Illinois has to offer. I joined the volunteering team of the Biomedical Engineering Society to give back and I am a co-lead on an Engineering Open House project. I also have time to participate in research.

Vince Lam | Class of 2023
I am incredibly thankful to the donors who gave me this opportunity to study at a world-renowned university. I am interested in the cellular and tissue specialty of bioengineering research. Applying engineering principles to the complex issues of healthcare would enable me to impact others globally.

Elizabeth Martin | Class of 2022
My scholarship was the key deciding factor for my enrollment in the Grainger College of Engineering. I plan to take full advantage of the amazing opportunity I have at Illinois. This includes continuing my research at the Beckman Institute, volunteering with Carle Hospice, and generally taking advantage of opportunities like my Cancer Scholars courses or campus events.

To see philanthropic support in action, visit bioengineering.illinois.edu/giving/

UNIVERSITY OF ILLINOIS
URBANA-CHAMPAIGN

Department of Bioengineering
Everitt Laboratory
1406 W. Green Street
Urbana, IL 61801

217.333.1867
bioengineering.illinois.edu

NONPROFIT
ORGANIZATION
U.S. POSTAGE
PAID
CHAMPAIGN, IL
PERMIT NO. 453

At A Glance

18	Tenure Track Faculty
59	Graduate Program Faculty
1	Clinical Faculty
5	Research Faculty
5	Teaching Faculty
$568k	Research Expenditures Per Tenure Track Faculty
288	B.S. Students Enrolled
35	M.Eng. Students Enrolled
6	M.S. Students Enrolled
88	Ph.D. Students Enrolled
68	B.S. Degrees Awarded
24	M.Eng. Degrees Awarded
23	M.S. Degrees Awarded
5	Ph.D. Degrees Awarded

ON THE COVER Illinois researchers used a suite of imaging methods to create the first holistic picture of peripheral artery disease recovery. Pictured here are postdoctoral researcher **Jamila Hedhli** (left) and professor **Wawrzyniec L. Dobrucki** (right).

Photo by UI News Bureau/Fred Zwicky