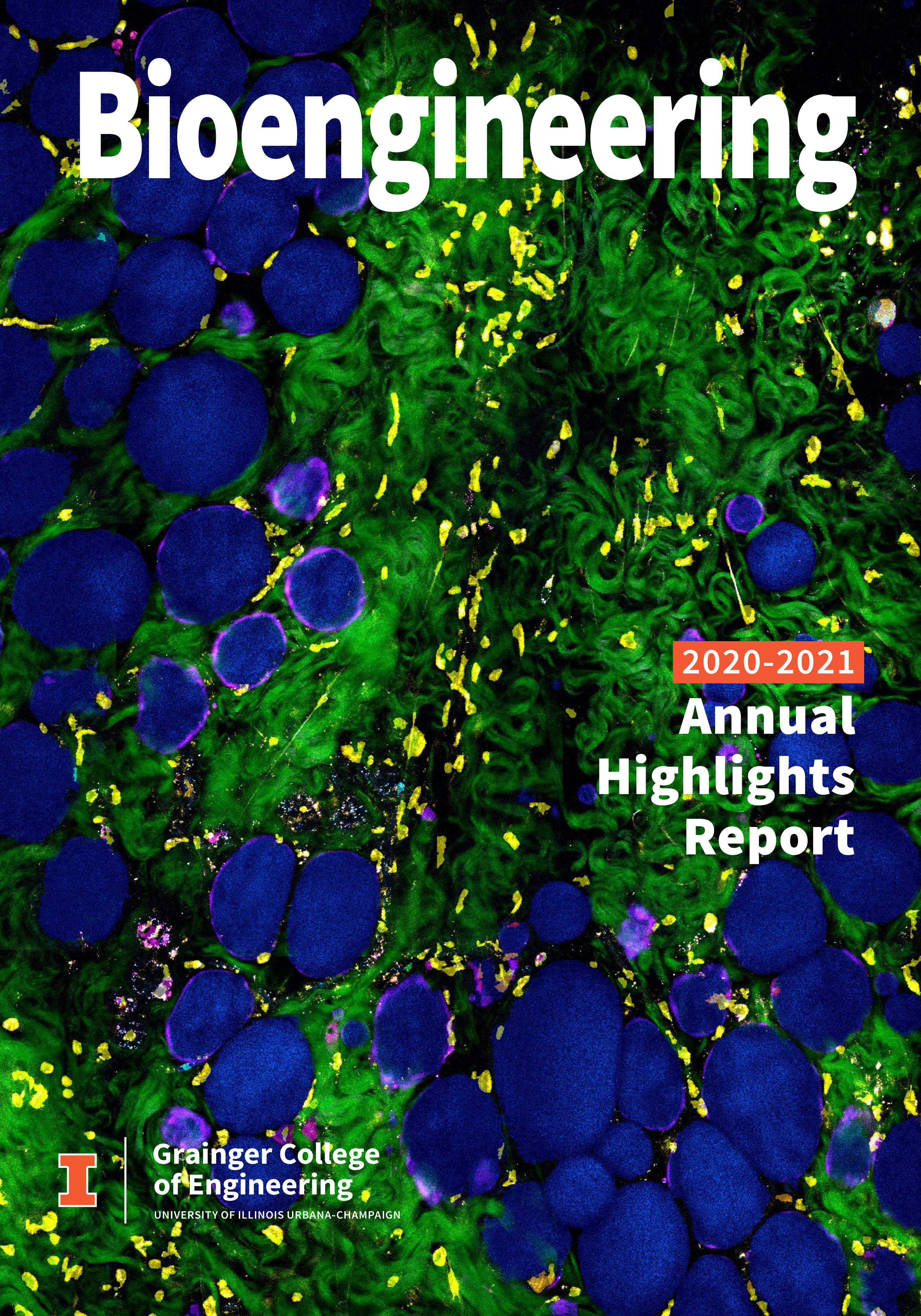

Bioengineering

2020-2021

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 2020-2021.

Bioengineering leadership

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Department Head Message

Dear Friends and Colleagues,

The past year was one of significant changes and growth - some welcomed and some unforeseen. I want to express my sincere appreciation for the hard work across the department that enabled us to persevere during this challenging time. For those who were actively involved in various COVID-19 efforts — thank you for answering the call to arms as bioengineers to use your expertise for the greater good.

We have come a long way since the department was established 17 years ago. Our undergraduate student body, which started with just 22 students, has grown to nearly 400. Our research expenditures now exceed $11M per year, averaging over $647K per tenure track faculty member. In addition, we've been fortunate to call the state-of-the-art Everitt Laboratory our home. The progress we have made has paved the way for future successes, and we are poised for unprecedented growth. This includes solidifying our leadership at the intersection of machine learning and modern medicine through the launch of the new AI in Medicine Certificate and the Master of Science in Biomedical Image Computing degree.

Looking forward to the future, I will be excited to welcome our first class of undergraduate students as part of a new Bachelor of Science in Neural Engineering degree — anticipated to launch in Fall 2023. Students will leverage engineering principles to design technologies that repair and enhance the function of the nervous system. Our department is well-positioned to train the next generation of leaders in this rapidly growing discipline.

Our work doesn't just enrich our own lives, but also the lives of those around us and people who we will never meet. The work we do matters and I have never been more optimistic about our department's future.

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

"Thank you for answering the call to arms as bioengineers to use your expertise for the greater good.

As a land-grant public institution, the University of Illinois Urbana-Champaign is committed to tackling global challenges through pioneering research and innovative instruction. Bioengineering researchers leaped into action in these two spaces as the COVID-19 pandemic raged across the world.

Through a collaboration with the Carle Illinois College of Medicine and the Carle Foundation Hospital, Illinois researchers set out to address current limitations in viral detection that relies primarily on polymerase chain reaction (PCR) tests. The research team led by bioengineering professor and dean of The Grainger College of Engineering, **Rashid Bashir**, optimized the reverse transcription loop-mediated isothermal amplification (RT-LAMP) approach for detecting viral RNA down to a few copies from nasopharyngeal swabs and saliva specimens. By adding a short 10-minute RT-incubation step and additional process, the team increased the sensitivity of the RT-LAMP reaction by two orders of magnitude over the current one-step or two-step RT-LAMP reactions.

"We believe our approach will allow rapid scaling of testing and detection of cases that might have been missed otherwise due to low viral amounts when using LAMP technology," said Bashir.

Point-of-care detection technologies that enable decentralized, rapid, sensitive, low-cost diagnostics of COVID-19 infection are urgently needed around the world. As the COVID-19 pandemic becomes endemic, the advances gained in POC technologies during this past year will likely play a critical role in future prediction of emerging outbreaks and pandemics.

"We expect that our vision of future challenges in COVID-19 diagnostics will contribute to deciding future research lines in this field," said bioengineering professor **Enrique Valera**. He anticipates that COVID-19 POC readiness will be paramount for mitigating future outbreaks of new strains or novel viruses.

The COVID-19 pandemic forced instructors to adapt their courses for online learning. Laboratory courses were particularly difficult due to the lack of access to specialized equipment for remote learners. To overcome this challenge, bioengineering professors **Karin Jensen** and **Pablo Perez-Pinera** designed a laboratory exercise and kit to teach students how to use micropipettes — an essential laboratory instrument used in several fields including molecular biology, microbiology and biochemistry.

These cost-effective kits contained a mini-scale, a glucose meter, a pipet-aid and a set of micropipettes. Each student was provided with the kit, an instructional video, and a laboratory manual. They were instructed to follow the protocol step by step with the goal of learning how to correctly dilute the glucose solutions and verifying their accuracy using the glucose meter. "We found that most of the students were excited to use lab equipment despite being in an online section," Jensen said.

These researchers are now working to improve the exercise. "Beyond COVID-19, there is still a need to develop remote lab learning opportunities for students who cannot attend in-person labs," said Jensen. "Remote lab activities, similar to what we describe, will be important in increasing access to STEM education."

Extraordinary commitment to education and public service

Shaping the future of medicine through AI-integrated curricula

Bioengineering has launched two new programs that integrate machine and deep learning with biomedical principles. The **AI in Medicine Certificate** is a self-paced online course designed to equip healthcare professionals with a foundational understanding of AI and its applications through real-world medical case studies using machine learning models. This first-of-its-kind program was designed specifically for clinicians to better prepare them for partnering with computer science professionals, interacting with vendors, advancing health care delivery and improving patient care. Continuing education credits are available upon completion.

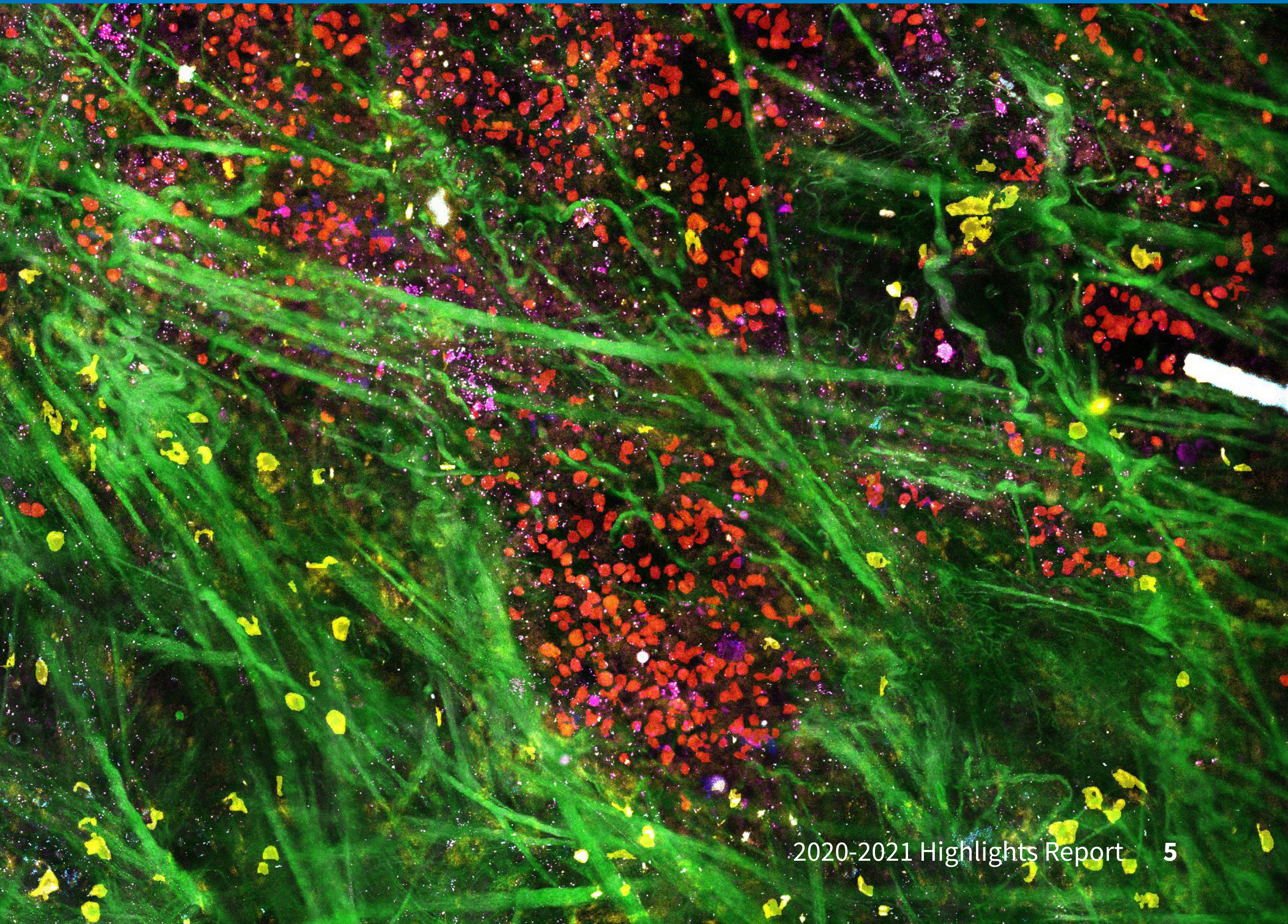
Biomedical image computing is a large, rapidly growing industry and research field comprising the formation and analysis of diagnostic images. Both image system design and biomedical image analysis are currently being revolutionized at a tremendous rate by the emergence of machine learning techniques. The new **Master of Science in Biomedical Image Computing** degree addresses the need for efficient, rigorous training focused at the intersection of biomedical imaging science, high-performance computing and machine learning. The innovative curriculum was developed and will be taught by leading bioengineering faculty who are actively working with a wide range of modern biomedical imaging modalities in well-funded imaging applications.

New microscope discovery combines AI to detect disease

A newly developed laser source and microscope are helping researchers better understand and search for biomarkers indicative of cancer and other diseases, offering new promise for early detection and treatment plans. The study, co-authored by Illinois professors **Stephen Boppart** and Saurabh Sinha, was published in Cancer Research.

The innovative laser source and microscope collects multiple optical signals and channels without having to add any stains or dyes. “The multimodal imaging approach allows us to visualize the dynamic cells and tissues without disturbing their functions, and not only distinguish and classify different cell types, but also characterize their dynamics and metabolic profiles,” said Boppart.

Researchers combined the new microscope with AI and deep-learning algorithms to investigate the tumor microenvironment. The computational framework can characterize the complexity and heterogeneity of the tumor microenvironment and differentiate it from the normal state. In this study, the research team explored the relationships between cells and extracellular vesicles (EV) and improved the ability to detect, image, and characterize EVs. The result opens possibilities for better representation and understanding of the evolving cancer landscape.



Illinois team discovers a novel competence pathway in oral bacterium *S. sobrinus*

Two bacteria have been linked to the initiation of dental caries or tooth decay: *Streptococcus mutans* and *Streptococcus sobrinus*. *S. sobrinus* has been understudied because most researchers believed that *S. sobrinus* lacks the competence pathways to regulate growth, virulence, bacteriocin production and quorum sensing. This was a decades long unsolved challenge for the dental research field until an Illinois research team led by bioengineering professor **Paul Jensen** discovered a quorum-sensing pathway in *S. sobrinus*, which controls its natural competence. This research was published in the Journal of Dental Research. Lab members also laid the foundation for *S. sobrinus* research by becoming the first group of researchers to successfully sequence the complete genome of *S. sobrinus* in 2018 and defining the workflow for this bacteria.

Current microbial control for dental caries uses mostly wide-spectrum treatments that can disrupt a healthy oral microbiome. A more effective way of controlling dental caries would be to use the genetic mechanisms of *S. sobrinus* to develop targeted treatments.

Before this study, all ComRS systems could be classified into three classes based on their sequences of XIP, or the seven amino acid pheromone that turns the system on; all previously-known XIPs also have two aromatic amino acids. The *S. sobrinus* XIP defines a new, fourth class, of ComRS system with no aromatic amino acids. This new class turns out to be widespread in other streptococcal bacteria.

3D microscopy clarifies understanding of the body's immune response to obesity

Researchers who focus on fat know that some adipose tissue is more prone to inflammation-related comorbidities than others, but the reasons why are not well understood. Thanks to a new analytical technique, scientists are getting a clearer view of the microenvironments found within adipose tissue associated with obesity. This advance may illuminate why some adipose tissues are more prone to inflammation — leading to diseases like type 2 diabetes, cancer and cardiovascular disorders — and help direct future drug therapies to treat obesity.

In a new study, bioengineering professor **Andrew Smith**, department head **Mark A. Anastasio**, molecular and integrative physiology professor Erik Nelson and nutritional sciences professor Kelly Swanson, detail the use of the new technique in mice. The results are published in the journal Science Advances.

Inflammation in adipose tissue presents itself as round complexes of inflammatory tissue called crownlike structures. Using a new 3D microscopy technique combined with deep-learning algorithms, the researchers discovered that obesity tends to be associated with a prevalence of rare, massive crownlike structures that are not present in the lean state. This finding may lead to new drug therapies and new ways to evaluate patients' metabolic health.

Pictured from the left: Xiaohui Zhang, Andrew Smith, Kelly Swanson, Erik Nelson, Mark A. Anastasio and Junlong Geng

Researchers develop new techniques to study "microcancers" and screen drugs

A team from Illinois and Mayo Clinic have developed a new technique for creating "microcancer" cell cultures. A cancerous tumor's microenvironment has a significant influence on how a tumor progresses and responds to cancer-fighting medications. Reproducing those cells in a culture that can be imaged and studied is a crucial step in cancer treatment. This technique allows researchers to form hundreds of microcancers in a high-throughput format using a small, microfabricated chip, enabling direct measurement of cell health or response to drugs. It also enables researchers to control the shape of the culture using capillary forces and thus create cultures that more closely resemble in-vivo cells' three-dimensional geometry.

Creating "microcancer" cell cultures is possible even when there is very little tissue in a biopsy and would allow physicians to test many drug treatments against an individual patient's cancer quickly, thus decreasing the decision time on therapeutic interventions.

This work was published in Science Advances and was completed as part of the Mayo Clinic and Illinois Alliance for Technology-Based Healthcare. The team includes bioengineering professors **Rashid Bashir** and **Andrew Smith**. Bashir also serves as the dean of The Grainger College of Engineering. This simple, scalable, and customizable platform is suitable for drug screening purposes in precision medicine, as well as a broad range of applications in drug discovery, regenerative medicine, stem cell research, and biotechnology.

Mantis shrimp-inspired camera provides second opinion during cancer surgery

Humans can perceive three colors whereas the mantis shrimp can perceive upward of 12 colors thanks to the stacks of light-sensitive cells at the tip of its eyes. The mantis shrimp's eyes can see things that humans cannot imagine — and do so in a fraction of the space. A new Illinois study details a mantis shrimp-inspired camera that works with tumor-targeted drugs to see cancer in animal and human patients. The study involved bioengineering professors **Wawrzyniec Dobrucki** and **Shuming Nie** and is published in Science Translational Medicine.

In the hopes of replicating this visual system in a single imaging device, the team integrated advanced semiconductor devices and specialized optical filters. The technology can capture the three colors of visible light that a doctor would normally see as well as three colors of invisible near-infrared light that the doctor would miss. It can then be paired with multiple tumor-targeted probes that accumulate in cancerous tissue and emit near-infrared light, permitting the doctor to see exactly where the tumors are located in a patient. These probes are just now entering medical markets.

The combination of this bioinspired camera and emerging tumor-targeted drugs will ensure that surgeons leave no cancer cells behind in the patient's body. The next step for the team is the integration of the camera with endoscopic systems to satisfy the demands of minimally invasive surgeries in resource-limited hospitals.

Pictured from the left: Wawrzyniec Dobrucki, Zhongmin Zhu, Viktor Gruev, Zuodong Liang, Steven Blair and Shuming Nie

Using magnetic resonance elastography to detect epilepsy

Mesial temporal lobe epilepsy is the most common form of epilepsy that is resistant to medication. Unfortunately, current detection methods, which include magnetic resonance imaging, can only visualize the epilepsy-induced changes in the brain after significant damage has occurred. Researchers from Illinois and Carle Neuroscience wanted to detect brain damage earlier using MR elastography (MRE). MRE is a non-invasive technique that sends vibrations into brain tissues which change as the composition and the organization of the tissue changes.

In the early stages of epilepsy, there is some damage to the structure of the hippocampus, which can be detected with MRE. MRE is already used clinically for the staging of various liver diseases and has replaced invasive liver biopsies. It may prove to be similarly useful for staging progressive epilepsies, affording clinicians the opportunity to change the course of treatment and informing doctors about when to intervene with surgery.

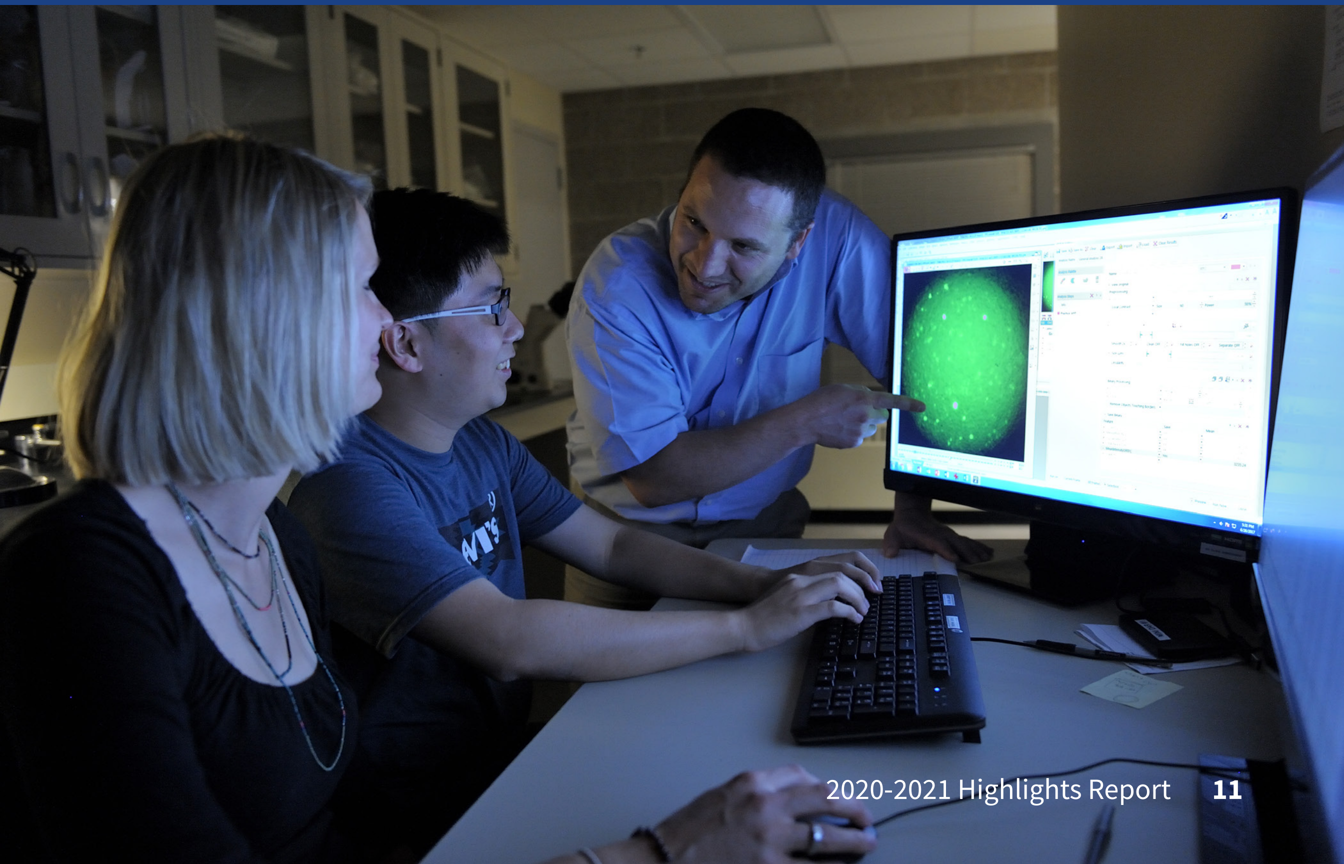
The team, including bioengineering professor **Brad Sutton**, published their findings in Neuralimage: Clinical and are now focusing on how to optimize the technique and also look at other types of epilepsy.

Researchers hunt for drugs that keep HIV latent

When the human immunodeficiency virus infects cells, it can either exploit the cells to start making more copies of itself or remain in a dormant state called latency. Current drug treatments block uninfected and healthy cells from becoming infected by the latent reservoir which can spontaneously reactivate to produce virus. As such these latent cells pose a threat to patients' long-term health. Illinois researchers led by bioengineering professor **Roy Dar** have found a way to look for chemicals that can keep the virus latent and published their finding in the Proceedings of the National Academy of Sciences.

Commercial drug screens usually look at mean gene expression. Instead, this team used a time-series drug screening approach that looks at fluctuations in gene expression which allowed the team to find more compounds that could have been overlooked. The researchers used a T- cell population, which is a reservoir for HIV, that had been infected by the virus. They imaged the cells in 15-minute intervals for 48 hours and tested over 1800 compounds. They looked at noise maps to identify which drugs can modulate the gene expression and found five new latency-promoting chemicals. This finding raises the possibility that similar screens can be successfully adapted to study other systems that exhibit variability in gene expression, such as cancer. They are currently working on understanding how the five novel drugs suppress viral reactivation.

Pictured from the left: Kathrin Bohn-Wippert, Yiyang Lu and Roy Dar



CRISPR-Induced immune diversification in host-virus populations

The CRISPR-Cas system originated as an adaptive immune system for microbes. In this system, "protospacers" — segments of DNA from the infecting virus — are incorporated into the microbial host genome, termed "spacers." The host molecular machinery uses these spacers to recognize, target and destroy viruses, analogous to the human adaptive immune system.

A research team including bioengineering professor **Sergei Maslov** used computational models to explore the influence of microbial immune diversity on population dynamics of host-virus interactions. Their simulations revealed two alternating major regimes: the virus diversification regime (VDR) where viruses proliferate and diversify, and the host-controlled regime (HCR) where hosts constrain virus diversification, leading to their extinction. Their findings were reported in Nature Ecology & Evolution.

As the viruses diversified in VDR regimes, so too did the hosts. The viruses that were able to escape host control harbored mutations in their protospacers, thereby leading to higher encounter rates with hosts. From these increased encounters, hosts were able to acquire new spacers, increasing CRISPR diversity. In turn, the immunity network exhibited weighted-nestedness, which enabled host control. By understanding the dynamics of host-virus populations in natural systems, researchers can better control microbes in industrial settings.

Researchers develop a new technique to treat middle ear infections

Middle-ear infections affect more than 80% of children in the U.S.; antibiotics are often employed as a first line of defense but sometimes fail against the pathogenic bacteria that can develop in the middle ear behind the eardrum. In a new study, researchers explore the use of microplasma — a highly focused stream of chemically excited ions and molecules — as a noninvasive method for attacking the bacterial biofilms that resist antibiotic treatment in the middle ear. This study was co-led by bioengineering professor **Stephen Boppart** and was published in npj Biofilms and Microbiomes.

To study this, the team developed a 3D-printed device that could generate and deliver microplasma via a carrier gas emitted through an array of tiny jets. They first tested the device on a bacterial culture of *Pseudomonas aeruginosa*, a common bacterial culprit in middle-ear infections and then on an eardrum-mimicking artificial membrane with a biofilm of *P. aeruginosa*. Those tests revealed that the microplasma disrupted bacterial growth and viability. They next tested microplasma on a model that simulated an infected, enclosed middle-ear cavity. The researchers also found that microplasma enhanced the potency and effectiveness of the antibiotic treatment against *P. aeruginosa* biofilms.

The team proposed that a microplasma-delivery device be integrated into an otoscope speculum, a standard diagnostic tool for problems in the ear.

Pictured from the left: Thanh H. (Helen) Nguyen, J. Gary Eden and Stephen Boppart

B.S. '04

Vilas Dhar

President and Trustee of the Patrick J. McGovern Foundation

Vilas Dhar (left) is an entrepreneur, technologist and human rights advocate. In 2021, he spoke at the World Economic Forum on advancing artificial intelligence and data solutions to create a thriving, equitable and sustainable future for all. Prior to his current role, Vilas founded and led two successful social impact organizations including a nonprofit incubator and a sustainable public interest law firm.

B.S. '20, M.Eng. '21

Jacqueline O'Connor

Systems Engineer at Medtronic Brain and Spine Therapies

Jacqueline O'Connor (left) is a two-time alumna of the bioengineering department - first, as an undergraduate student and then as a student in the Master of Engineering (M.Eng.) in Bioengineering program. Through applied learning and case-based teaching, the M.Eng. program provided her with a well-rounded understanding of medical devices, project management and business fundamentals.

M.S. ‘16, Ph.D. ‘19

Sixian You

Assistant Professor at Massachusetts Institute of Technology

Sixian You (left) is the Alfred Henry and Jean Morrison Hayes Career Development Assistant Professor in the MIT EECS department, and the Principal Investigator of the Optical Imaging Group at MIT RLE. She did her Ph.D. work under the direction of professors Stephen Boppart and Saurabh Sinha. Her research focuses on developing microscopy technologies and imaging solutions for biomedical problems through the lens of optical physics, instrumentation and algorithms.

M.S. ‘17, Ph.D. ‘20

Indrajit Srivastava

Alexander von Humbolt Research Fellow

Indrajit Srivastava (left) is a postdoctoral researcher at Illinois where he also completed his Ph.D. degree. He strives to build a career in academia and has previously received the 2020 Biomedical Engineering Society Career Development Award in recogniton of him as a rising star in this field. Through the Humbolt fellowship, Indrajit will leverage his past experience and traverse into evaluating mRNA-based lipid nanotherapeutics in patient-derived tumor organoids.

Accelerated cancer research and impactful educational programming

At the Cancer Center at Illinois (CCIL), scientists are engaged in mitigating the unique challenges facing cancer patients and their loved ones today, tomorrow, and years from now. And these scientists wield a secret weapon that is rapidly transforming the medical industry — their world-renowned expertise in engineering and technology. CCIL engineers collaborate with researchers across disciplines to understand the biology of cancer and its progress. Using the data collected, they are able to develop tools and technologies that lead to new discoveries in therapeutics and new advancements in diagnostics. University of Illinois scientists are creating more efficient, precise imaging technologies, improving cancer diagnostics tools and developing personalized cancer treatment methods.

"Therapeutics developed by CCIL researchers are now being tested in humans. We are accelerating new therapies with our expertise in drug design and development. MRI technology invented by Illinois faculty is widely used today. Imaging technologies already invented here are now poised to provide doctors and patients with more efficient and precise cancer assessments," Rohit Bhargava, bioengineering professor and CCIL Director, said.

Exceptional progress has been made in the past year to further support and accelerate CCIL research and education programming. In Spring 2021, the CCIL initiated a number of grant and scholarship opportunities including the CCIL Bridge Grant Program, CCIL High-Throughput Screening Support grants, undergraduate and graduate cancer research scholarships and a postdoctoral

fellowship in cancer research. The CCIL's Seed Grant Program supported nine interdisciplinary projects — the largest group to date.

"Due to the proven success of the CCIL Seed Grant Program, we were able to support additional initiatives in 2021 compared to previous years," Paul Hergenrother, CCIL Deputy Director, said. "CCIL scientists are making bold discoveries and leading innovative initiatives that will create technologies and techniques that will translate from labs to clinics. The depth of science, engineering, and technology expertise at the University of Illinois Urbana Champaign will transform the cancer industry for years to come."

Collaboration is at the heart of the achievements and accomplishments of CCIL scientists. In 2020 - 2021, CCIL members earned a $3M National Cancer Institute award to advance glioblastoma research and a $2M Department of Defense grant to improve breast cancer imaging; they led campus COVID mitigation efforts, including the discovery of the rapid COVID testing that allowed our research endeavors and the University to remain high-functioning and continue life-changing research at pace.

"

Imaging technologies already invented here are now poised to provide doctors and patients with more efficient and precise cancer assessments.

A new model for medical education

Carle Illinois welcomed its Class of 2025 in July 2021, marking the first time in the medical school's history that Carle Illinois has held four full classes of students. An additional historic milestone will be achieved when the Carle Illinois inaugural class graduates in May 2022.

The fourth-year medical students will spend their final year working with a team of Grainger engineers, including students from Illinois bioengineering, transforming one of their projects into a Capstone Project. By graduation, the "physician innovators" will have developed an inventive new product that will solve a problem in healthcare.

Innovation is peaking across the board at Carle Illinois as students' research and projects are evolving and showing real promise in solving healthcare challenges. Even first-year medical students are winning awards and recognition for their ideas and their potential to navigate a myriad of challenges to bring new products and services to market.

Carle Illinois students have thrived during the pandemic, pushing out innovative solutions, including a COVID-19 innovation cited by the U.S. Centers for Disease Control, engaging in outreach to diverse and low-income communities about COVID-19 vaccination and volunteering as vaccinators at community clinics.

"Carle Illinois students are demonstrating our mission in action, proving that our curriculum combining data, engineering, innovation, and humanities is producing the kind of physician innovators that can change the face of medicine and improve patient outcomes," said King Li, dean of the Carle Illinois College of Medicine.

> When I first started my own lab at Illinois, I wanted to work on something that's both intellectually challenging and societally impactful. Food generation is such a topic. As bioengineers, we are called to use science and technology in service of humanity by improving human health and nutrition. It's a real privilege to use my knowledge and to partner with other researchers to tackle harrowing issues.

Ting Lu (above), a professor of bioengineering, jointly received the €1 million ($1.19 million) 2021 Future Insight Prize established by Merck KGaA, Darmstadt, Germany, a leading technology company. This prize aims to stimulate innovative solutions to some of humanity's greatest problems. The 2021 theme is food generation with a target to convert non-edible biomass to edible biomass. Lu's research at Illinois focuses on microbial synthetic biology. His innovation utilizes synthetic microbial consortia — a combination of natural and rationally engineered microorganisms — for efficient conversion of waste to readily edible food. In addition, his team uses synthetic biology approaches to augment probiotics to improve food quality by increasing nutritional contents, improving the resistance to foodborne pathogens and further adding personalized therapeutic benefits.

AIMBE recognizes Illinois faculty for educational and research impact

Rashid Bashir (above) professor of bioengineering and dean of the University of Illinois Urbana-Champaign's Grainger College of Engineering, has been awarded the American Institute for Medical and Biological Engineering's (AIMBE) 2021 Professional Impact Award for Education. This award recognizes his leadership in bioengineering education, diagnostic technology development, and for playing a crucial role in the development of the first of its kind curriculum that balanced clinical, biological and engineering instruction at the Carle Illinois College of Medicine.

Bashir, the former department head of bioengineering, also led an NSF training grant on cell and molecular mechanics and an NIH training grant on cancer nanotechnology. With other faculty, he also co-led an NSF grant on reforming the undergraduate bioengineering curriculum. Bashir's research has focused on Bio-Micro and Nanotechnology, lab on chip, and applications to sepsis, infectious disease diagnostics and cancer. His group has also developed muscle cell based centimeter scale biological robots using 3D bioprinting. He has published over 250 journal papers and has 51 patents.

In addition to Bashir's award, three bioengineering faculty members were elected to the AIMBE College of Fellows, one of the highest professional distinctions in the field.

Jennifer Amos (right) was elected to the AIMBE College of Fellows Class of 2021 for her outstanding contributions to the development of curriculum and assessment methods in biomedical engineering and engineering-driven medical education. Amos is part of the Illinois NSF RED (Revolutionizing Engineering & Computer Science Departments) research team leading efforts to innovate assessment practices for engineering toward producing more holistic engineers. She currently serves on the board of BMES.

Gabriel Popescu (left) was elected to the AIMBE College of Fellows Class of 2021 for pioneering contributions in interferometric and quantitative phase imaging to assess the nanoscale tissue architecture and dynamics of live unlabeled cells. At Illinois, he directs the Quantitative Light Imaging Laboratory (QLI Lab) at the Beckman Institute for Advanced Science and Technology. He is also an OSA Fellow and SPIE Fellow.

Sergei Maslov (right) was elected to the AIMBE College of Fellows Class of 2021 for his contributions to computational biology including microbiome dynamics, microbial and viral ecology, genomics, and studies of complex biological networks. During the COVID-19 pandemic, Maslov co-led the Illinois governor's modeling task force to help monitor the spread of the disease and advise public health efforts. Maslov not only supported public policy at the state level, he also played a key role in the University's testing and mitigation strategies.

Bioengineering faculty appointed Health Innovation Professors

The Carle Illinois College of Medicine Health Innovation Professor appointment leverages champions of interdisciplinary health research to advance the discovery and translation of breakthrough health innovations. These professors will help to pioneer new approaches to medical education and integrate health innovation concepts into graduate and undergraduate courses. Two bioengineering professors were appointed.

Joe Bradley is a clinical assistant professor of bioengineering, teaching assistant professor in the department of biomedical and translation sciences and a lecturer in business administration. His research focuses on innovation management, entrepreneurship, technology transfer strategy, socio-technical systems design, entrepreneur formation in historically minoritized communities and examining how information is used and managed within new STEM ventures.

Wawrzyniec Dobrucki is a professor of bioengineering and directs the Experimental Molecular Imaging Laboratory. His expertise is in molecular multimodality imaging, and his fields of professional interests include the development of novel targeted microSPECT/PET-CT imaging strategies to assess myocardial and peripheral angiogenesis in animal models of disease, including diabetes.

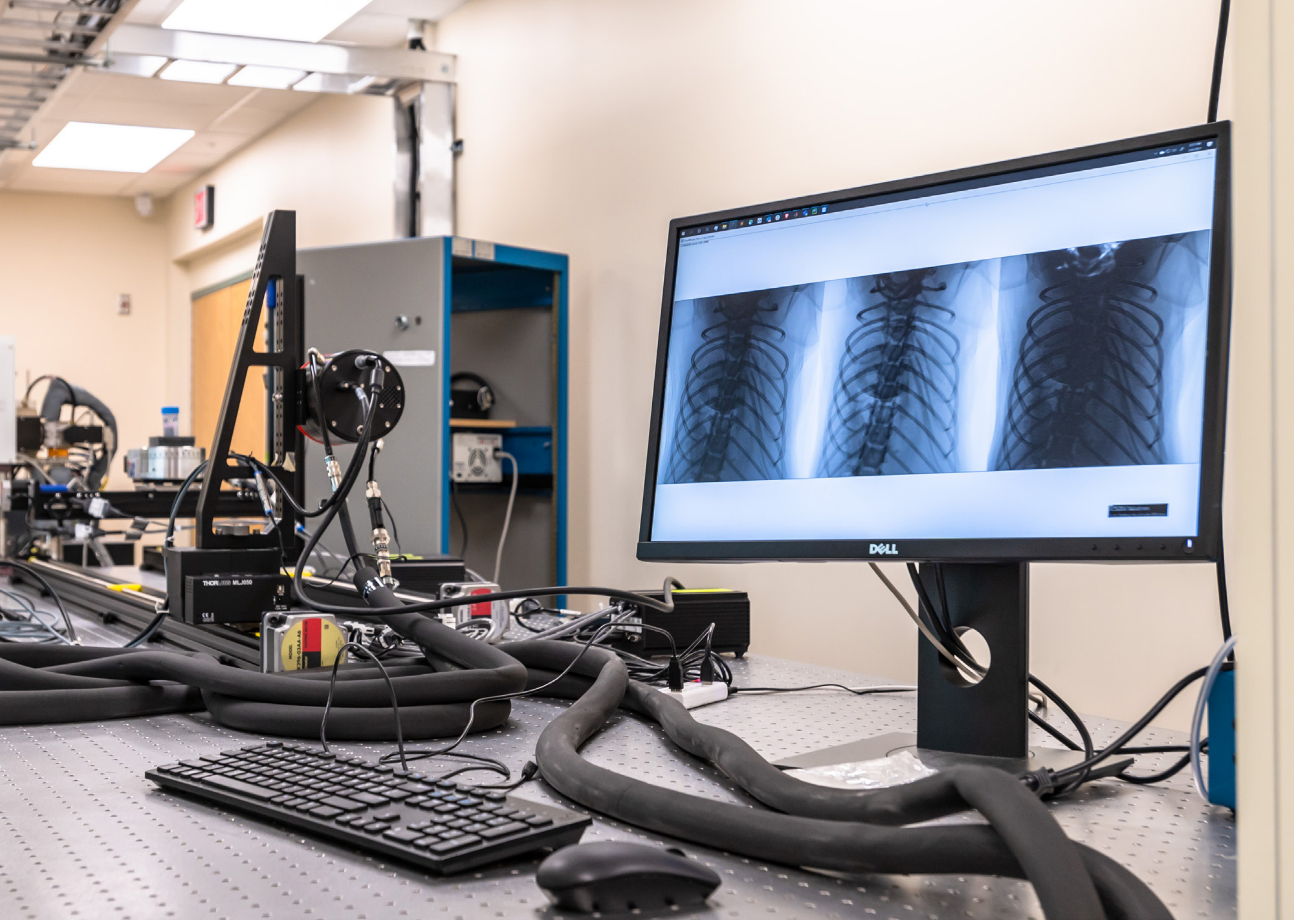
Department welcomes four new faculty

Sarah de Ramirez (right) is a Harvard Medical School-trained physician-researcher and joined Illinois bioengineering as a clinical associate professor in spring 2021. She currently serves as the vice president and chief medical officer for clinical innovation at OSF Healthcare where she leads the Complex Solution Innovation Team and the Jump Health Equity Innovation Lab. Additionally, she is a practicing emergency medicine physician and an associate professor of emergency medicine at the University of Illinois College of Medicine, Peoria, where she directs the Innovation in Global Rural Health programs.

Rebecca Reck (right) joined the bioengineering faculty as a teaching associate professor in fall 2020. She is an alumna of the University of Illinois Urbana-Champaign and Grainger Engineering. She previously taught at Kettering University in Flint, Michigan and worked as a senior systems engineer in the Automatic Flight Control Systems Division of Rockwell Collins, Inc. She has a long record of teaching innovation, has conducted innovative research that has been disseminated to the engineering education research community and has been actively engaged in university and professional service.

Enrique Valera (right) joined the bioengineering faculty as a research assistant professor in spring 2021. His research is focused on biosensor technology and more recently on the development of electrical and optical point-of-care devices for clinical diagnostics applications. He has extensive experience in the development of new microfluidic approaches for cells, proteins and pathogens detection. He graduated with a Ph.D. in electronic engineering from Universitat Politècnica de Catalunya in Barcelona, Spain and is also a research affiliate at the Carle Hospital Biomedical Research Center.

Yogatheesan Varatharajah (right) joined the bioengineering faculty as a research assistant professor in fall 2020. He is a two-time alumnus of the University of Illinois Urbana-Champaign where he obtained his Ph.D. and M.S. degrees from the department of electrical and computer engineering. His research interests are in developing domain-guided models for analyzing healthcare datasets. With a focus on neurological applications, he collaborates with clinical experts at the Mayo Clinic and machine learning experts across Illinois and Google.



New X-ray imaging facility opens at Beckman Institute

A cross-campus collaboration has created a new 3D X-ray phase-contrast imaging laboratory that will allow researchers to overcome some limitations of conventional X-ray imaging and enable core research for the life and material science communities. The Computational X-ray Imaging Science Laboratory is led by bioengineering department head **Mark A. Anastasio**.

The laboratory has been designed to advance and translate phase-sensitive X-ray imaging technologies. X-ray phase-contrast imaging is a technique that exploits the dual nature of X-rays, which are both wave-like and particle-like. Conventional X-ray imaging uses the particle nature of the X-rays and has limited use for applications that comprise similar materials such as those with small differences in densities and atomic numbers.

This new imaging capability will allow researchers to conduct in vivo imaging experiments involving small animal models and will improve upon existing micro-CT capabilities for soft-tissue imaging applications. It will also permit high-resolution imaging of heterogeneous samples and enable quantitative 3D imaging for applications that include characterizing micro-defects and pores in materials.

A Sampling of New Research Funding

Evaluation of HTT-Lowering Strategies Using Engineered CRISPR-Base Editors
(PI: **Thomas Gaj & Pablo Perez-Pinera)**
Supported by: Cure Huntington's Disease Initiative Foundation

BioPROTEIN - Biological Plastic Reuse by Olefin and Ester Transform Engineered Isolates and Natural Consortia (PI: **Ting Lu)**
Supported by: Defense Advanced Research Projects Agency

Macrophage-Targeted Nanocarriers for Localized Treatment of Chronic Inflammation in Diabetic Wounds
(PI: **Andrew Smith)**
Supported by: Diabetic Complications Consortium

Development of Approaches to Treat ALS using CRISPR Technology (PI: **Thomas Gaj**)
Supported by: Judith and Jean Pape Adams Charitable Foundation

Machine Learning and Clinical Electrophysiology in Support of Artificial Intelligence in Neurology
(PI: **Yogatheesan Varatharajah)**
Supported by: Mayo Clinic

Development of Technologies for Efficient In Vivo Prime Editing (PI: **Pablo Perez-Pinera & Thomas Gaj)**
Supported by: National Institutes of Health

A New J-Resolved MRSI Framework for Whole-Brain Simultaneous Metabolite and Neurotransmitter Mapping
(PI: **Fan Lam)**
Supported by: NIH National Institute of Biomedical Imaging and Bioengineering

Epigenetic Regulation of Prostaglandin E2 (PGE2) Synthesis Alters Macrophage Function to Promote Inflammation and Impair Diabetic Wound Healing (PI: **Andrew Smith)**
Supported by: National Institutes of Health

R01 JMJD3 Regulates Abdominal Aortic Aneurysm Expansion (PI: **Andrew Smith)**
Supported by: National Institutes of Health

R01 Notch Signaling in Diabetic Wounds (PI: **Andrew Smith)**
Supported by: National Institutes of Health

A Microfluidic System Coupling Amplified Nanofluidic Virion Purification and Mass Spectrometry for Detection of SARS-CoV-2 (PI: **Aaron Timperman)**
Supported by: NIH National Institute of Biomedical Imaging and Bioengineering

Microenvironmental Control of Liver Progenitor Cell Differentiation and Spatial Patterning
(PI: **Pablo Perez-Pinera & Gregory Underhill)**
Supported by: NIH National Institute of Diabetes and Digestive and Kidney Diseases

Engineering students' outcome expectations for AI careers: An exploratory study (PI: **Paul Jensen)**
Supported by: National Science Foundation

Building a Community of Mentors in Engineering Education Research Through Peer Review Training
(PI: **Karin Jensen)**
Supported by: National Science Foundation

Disruption of Mutant Huntingtin Gene Expression by CRISPR-Cas9 Nucleases for Treatment of Huntington's Disease (PI: **Thomas Gaj)**
Supported by: Sarepta Therapeutics

Excellence in education, research and leadership

The global pandemic brought Illinois bioengineering undergraduates unique challenges and opportunities, especially for students who graduated in the Class of 2020 and 2021. Despite these unforeseen circumstances, these students excelled in and out of their virtual classrooms, realized impressive accomplishments and earned accolades across campus and beyond.

When classes became remote last March, one of the biggest challenges was to transition lab courses online. Lab skills are essential building blocks for bioengineering students. Sophomores and juniors practiced hands-on laboratory skills remotely through our cell and tissue engineering lab and bioinstrumentation lab. Students received mailed lab kits with materials to facilitate their study of wet lab techniques such as pipetting, electrical circuit modeling, and collection and analysis of biomedical data. Instructional best practices were published in the Journal of Biomedical Engineering Education.

In fall 2020, bioengineering offered three new courses in **regulatory and safety issues**, **quantitative pharmacology**, and **soft robotics**. These innovative courses provided students the opportunity to apply their knowledge and skills to coursework which focused on real-world, industry challenges in pharma and medtech industries.

Outside the classroom, bioengineering students are active in research, entrepreneurship, athletics and campus leadership. Recent bioengineering graduate **Joy Chen** (BIOE '20) received the Fall 2020 Kristine Neuhoff Twyman Breast Cancer Scholarship for her undergraduate research project and she also graduated in May, 2020 as a Cancer Scholar - a flagship program of the department and the Cancer Center at Illinois. **Courtney Ketchum**, **Michael Nelappana**, and **Elizabeth Troy** (BIOE '21) were awarded the ASTM International Grant for their senior design project in collaboration

with Mayo Clinic. Bioengineers led three of the ten winning teams at the 2021 Health Make-a-Thon, each awarded $10,000 in seed funding. These projects include the Nano-Hyperbaric Oxygen Delivery System for Chronic Wounds led by **Neelabh Sharma** (BIOE '22), ProteCKD: Earlier Detection of Chronic Kidney Disease among Underrepresented Patient Populations with **Isabella Lebovic** and **Priya Kumar** and a STEM Vocabulary App for Deaf Students developed by **Mona Jawad**, **Ethan Gaughan**, **Ryan Martin**, **Amy Lee**, **Elizabeth Troy**, and **Sri Medisetti**.

At the campus level, **Yamenah Ambreen** (BIOE '22) received the 2021 Beckman Institute Undergraduate Fellowship for her research on age-related hearing loss and Alzheimer's disease. Our student athletes **Kristin Slaughter (**BIOE '21) and **Abby Cabush** (BIOE '22) received the Big Ten Distinguished Scholars award and were also named Academic All-Big Ten. Three seniors were selected for the 2020 Homecoming Court: **Joy Chen**, **Berat Gulecyuz**, and **Thomas Romanchek**. Berat and Thomas, along with **Ashley Mitchell**, **Evan Ko** and **Vongai Tizora** also held five out of the 12 honorary 2021 Knights of St. Patrick titles.

From earning university recognition to adjusting to a whole new way of learning through remote lab courses and even enrolling in brand new department courses, bioengineering undergraduates showed remarkable adaptability and resilience.

Pictured from left to right are Vongai Tizora, Ashley Mitchell, Evan Ko, Thomas Romanchek and Berat Gulecyuz. The Knights of St. Patrick recognizes students for their leadership, excellence in character and exceptional contributions to Grainger Engineering and Illinois students at large.

Bridging the undergraduate research participation gap

Approximately 45% of undergraduates at Grainger Engineering conduct research, but this figure plummets for those from historically underrepresented backgrounds. As a first-generation college graduate, bioengineering professor **Holly Golecki** is driven to break down barriers to entry in research. In 2020, she was awarded a Grassroots Initiatives to Address Needs Together (GIANT) seed grant to work with students in the Academic Redshirt in Engineering (ARISE) program. ARISE helps academically talented students from low-income backgrounds and under-resourced school districts. Centered on soft robotics research, this project provides students with funded research experiences and technical and professional development — introducing them to a culture of research. This work was published in proceedings of the ASEE Annual Conference and Exposition.

Building on the success thus far, the next phase aims to extend research opportunities to undergraduates from the Illinois chapters of the NSBE and SHPE. The team will investigate how hands-on, human-centered design projects in soft robotics can impact students' abilities to build technical competencies and confidence in engineering. Additionally, Golecki will collaborate with researchers from Harvard University through a NSF Research Experience and Mentoring (REM) program to expand the GIANT pilot project and start an undergraduate research lab at Bunker Hill Community College.

> The unlimited potential of bioengineering has always sparked my utmost interest with its innovative translational applications. Currently, we are experiencing a once-in-a-century life-changing event. We are responding to this global need from a holistic approach by developing multidisciplinary tools for early detection and diagnosis and treatment for SARS-CoV-2.

Maha Alafeef (above), is a bioengineering Ph.D. candidate and the recipient of the 2021 McGinnis Medical Innovation Graduate Fellowship. "I have been highly impressed with her knowledge, determination and ambition. I felt that for her, sky is the limit," said her advisor, professor **Dipanjan Pan**. As the pandemic unfolded, she pivoted her research to focus on point of care sensing of the virus. She developed a paper-based electrochemical sensor that can detect COVID-19 in less than five minutes and published her finding in ACS Nano. She has designed, developed, fabricated, and provisionally patented several technologies, and this testing sensor was recently licensed for commercialization. Her unwavering dedication to research has led her to receive many prestigious accolades including the 2021 Illinois Innovation Award and the 2020 BMES Career Development Award.

Awards and Honors

Jennifer Amos received the 2021 Excellence in Undergraduate Teaching Award

Stephen A. Boppart was appointed as a Grainger Distinguished Chair in Engineering and elected as a 2021 IAMBE Fellow

Karin Jensen was selected as a University of Illinois Distinguished Teacher-Scholar

Mark A. Anastasio was elected as a 2021 IAMBE Fellow

Yoram Bresler was elected as a 2021 IAMBE Fellow

Sergei Maslov was elected as a 2020 American Physical Society Fellow

Rohit Bhargava received the OSA 2021 Ellis R. Lippincott Award, the SPaRC Collaboration Award and elected as a 2020 AAAS Fellow

Joseph Irudayaraj received the SPaRC Collaboration Award and elected as a 2020 Royal Society of Chemistry Fellow and 2021 IAMBE Fellow

Rebecca Reck received the Society of Women Engineers Outstanding Counselor Award

Shannon Sirk was appointed the Associate Director for the Illinois Microbial Systems Initiative

Ishita Jain, Ph.D. candidate, received the 2020 BMES Career Development Award

Elena Maria Zannoni, Ph.D. candidate, was chosen as the first-place winner of the PIDSC Young Investigator Award

Yurii Vlasov was elected to the National Academy of Engineering

Varun Kelkar, Ph.D candidate, was awarded an Oak Ridge Institute and FDA Fellowship for medical imaging research

Evan Ko, bioengineering junior, received the 2021 H.L. Wakeland Undergraduate Leadership Award

Aidan Brougham-Cook, Ph.D. candidate, received a Student Sustainability Committee Grant to pilot Clean Meats at Illinois

Carlos Renteria, Ph.D. candidate, received the Environmental Toxicology Traineeship through the Illinois College of Veterinary Medicine

Illinois iGEM Team earned silver at the 2020 international competition for SARS-CoV-2 spike protein modeling

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 31 students who self-reported as part of this survey. For bioengineering graduates from 2019-2020, 38.7% are employed, 58.1% are continuing with their education and 3.2% have alternative plans. The average starting salary for Illinois bioengineering graduates with a bachelor of science degree is $65,070 with an average signing bonus of $6,423.

A selection of employers include: Abbott Laboratories, AbbVie, Accenture, Genentech, Medline Industries, National Institutes of Health.

A selction of graduate schools include: Georgia Institute of Technology, John Hopkins University, Stanford University, University of Illinois Urbana-Champaign, University of California, San Diego.

Engineering Visionary Scholarship

2020 -2021 Recipients

Ethan Gaughan
BIOE '23

The Engineering Visionary Scholarship helped to take the burden off of me and my family this year, who have been arduously trying to get me through college. I am grateful and humbled by your kind gift.

Clara Kochanski
BIOE '21

With both my parents not being able to work in the height of COVID-19, it was very difficult to pay for rent and school. My scholarship made the weight on my shoulders significantly lighter. I will always be very grateful that I have been given the chance and opportunity to finish my senior year to begin my journey to making an impact on our world.

Isabella Palm
BIOE '24

Receiving my scholarships was a major factor in my decision to enroll in The Grainger College of Engineering. This scholarship has given me a chance to prove what I am capable of, and I hope to do the same for the next generation.

Harpal Singh
BIOE '21

I was in my last semester of college when I ran into financial hardship and lost more than 50% of my financial aid support and my family would not be able to significantly support me. This scholarship helped me graduate so I could fufill my dreams and become a first generation graduate and engineer of the family.

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

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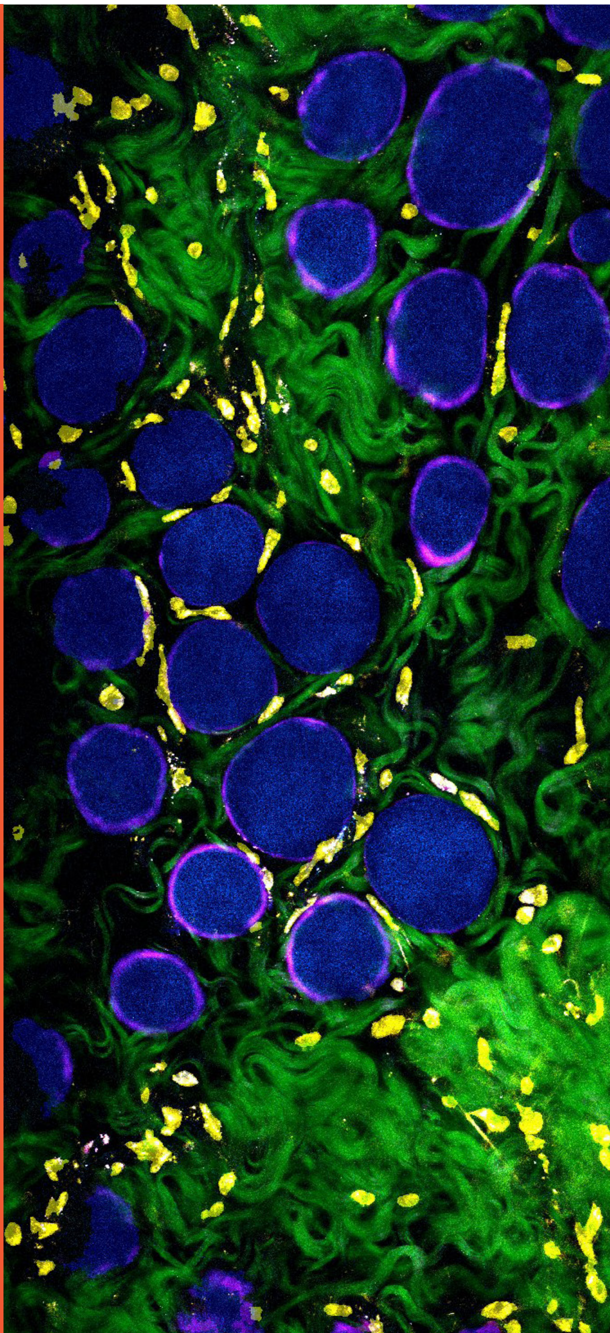
At A Glance

18	Tenure Track Faculty
59	Affiliate Faculty
6	Research Faculty
5	Teaching Faculty
$647K+	Research Expenditures Per Tenure Track Faculty
314	B.S. Students Enrolled
33	M.Eng. Students Enrolled
94	M.S./Ph.D. Students Enrolled
55	B.S. Degrees Awarded
24	M.Eng. Degrees Awarded
12	M.S./Ph.D. Degrees Awarded



ON THE COVER Label-free multiphoton imaging enables visualization of normal and malignant living cells in their native tissue microenvironment. In the image of normal tissue obtained from a control rat, the saturated colors represent the segmentation mask that is overlaid with the original label-free image. Navy blue, adipocytes; yellow, stromal cells.

Photo by Sixian You and colleagues. See page 5 for details.