Northwestern | McCORMICK SCHOOL OF ENGINEERING

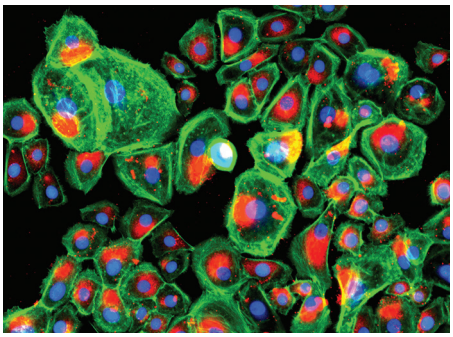
FALL 2018

BIOMEDICAL ENGINEERING

NEW CENTER FOR ADVANCED REGENERATIVE ENGINEERING LAUNCHES

At its inaugural event, the center highlighted its collaborative mindset and enterprising mission

Guillermo Ameer presents at the Symposium on Regenerative Engineering.



Stained epidermis cells cultured on the A5G81 peptide. (Credit: Ameer Research Lab, Northwestern University)

Northwestern's Center for Advanced Regenerative Engineering (CARE) officially launched this past spring with a bold mission and interdisciplinary mindset.

The Center aims to create an ecosystem that enables researchers and clinicians to regenerate tissues and organs for adult and pediatric patients. That effort began with CARE's inaugural event, the Symposium on Regenerative Engineering, hosted at Chicago's Prentice Women's Hospital in May.

"This event brought together people of significantly different backgrounds to understand the type of transdisciplinary collaborations and enterprise that are necessary to move the field of regenerative engineering forward," said **Guillermo Ameer**, CARE's founding director and Daniel Hale Williams Professor of Biomedical Engineering and Surgery at Northwestern.

The Center has two immediate goals: 1) to develop distributable, easy-to-use tools capable of regenerating tissues and organs, specifically prioritizing the needs of surgeons and patients; and 2) to construct a collaborative ecosystem for clinical implementation of regenerative technology.

CARE will also educate and train entrepreneurs and researchers skilled in regenerative engineering. Among its plans for accomplishing this are fellowships, internships, sabbaticals, and a regenerative engineering club for students.

Regenerative Bandage Accelerates Healing in Diabetic Wounds

A Northwestern team led by Ameer and Professor **Milan Mrksich** has developed a regenerative bandage that quickly heals painful, hard-to-treat sores without using drugs. During tests, Northwestern's bandage healed diabetic wounds 33 percent faster than one of the most popular bandages currently on the market.

The secret behind Ameer's regenerative bandage is laminin, a protein found in most of the body's tissues, including the skin. Laminin sends signals to cells, encouraging them to differentiate, migrate, and adhere to one another. Ameer's team identified a segment of laminin — 12 amino acids in length — called A5G81 that is critical for the wound-healing process.

Although Ameer's laboratory is specifically interested in diabetes applications, the bandage can be used to heal all types of open wounds. And because the bandage leverages the body's own healing power without drugs or biologics, it faces fewer regulatory hurdles. This means patients could see it on the market much sooner.

FROM THE CHAIR

Dear friends,

This past year has been filled with accomplishments by our students, faculty, and alumni. While much of this newsletter is devoted to individual accomplishments, I want to thank you for helping us build a community that promotes excellence in biomedical engineering, as this community helps our members thrive. We now have a substantial alumni base who connect with our undergraduates regularly, whether through sharing professional experiences in our Introduction to Biomedical Engineering class, sponsoring student design projects, or offering summer internships at their companies. Alumni giving has also grown, with a participation rate that has more than doubled in recent years. Your contributions, large and small, allow Northwestern to remain at the forefront of innovation in biomedical engineering education and research.

Faculty research is the foundation for many of our innovations. Last year, we received more than $38 million in new award funding. Notable achievements include **Milan Mrksich**'s $6.25 million grant from the Office of Naval Research to develop chemical methods for controlling the conformations and functions of proteins. **Mitra Hartmann** received a $3 million award from the National Science Foundation (NSF) to understand the neural basis for sensorimotor control loops using whisker-based robotic hardware platforms.

Our faculty are also investigators on three NSF Emerging Frontiers in Research and Innovation grants (page 4) focusing on chromatin and epigenetic engineering, an area in which our faculty excel. This excellence will be seen in the recently launched Center for Advanced Regenerative Engineering (page 1) and the Center for Physical Genomics and Engineering, which will launch in 2019 and be led by **Vadim Backman**. Our four BME-led research centers will facilitate research between our faculty and students and colleagues across Northwestern, including many in the Feinberg School of Medicine (page 3).

Our faculty have also translated their accomplishments into commercial successes (page 4). Aptinyx, a clinical-stage biopharmaceutical company founded by **Joseph Moskal**, recently completed an IPO supporting development of novel therapeutics to treat brain and nervous system disorders, while **John Rogers**'s Epicore Biosystems has commercialized a proprietary microfluidic sensing platform that analyzes small droplets of sweat on the skin. **Milan Mrksich**'s company, Samdi Tech, received a Small Business Innovation Research Program Phase 1 grant from NIH to develop the first cell-based and label-free, high-throughput assay of specific enzyme activities.

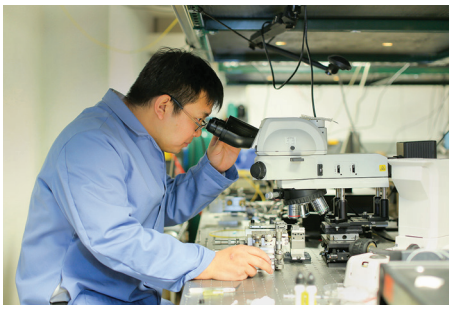
BME students have also received accolades for research. Last year, 30 percent of our PhD students were supported by their own research fellowships. Many students were also recognized for research accomplishments through non-fellowship awards. **Amy Adkins** received the DeLuca Foundation Research Scholarship for her work on how surgical reconstruction alters muscle properties, while **Mary Bucklin** received the prestigious Journal of Biomechanics Award for her presentation on motor learning during locomotion. Senior **Tara Cornwell** received the American Society of Biomechanics inaugural Undergraduate Research Award for her presentation on how hearing loss affects gait stability.

As you can see, 2018 has been an exciting year. We continue to be an engine for innovation at Northwestern. Throughout this newsletter, you can read more about faculty and student accomplishments and our innovative programs that facilitate their work. To stay connected to our community, please join the Northwestern Biomedical Engineering group on LinkedIn. linkedin.com/groups/3299815.

Eric J. Perreault
Department Chair

Department Celebrates $4.7 Million in Gifts

Two major gifts will expand research and education initiatives



Northwestern Biomedical Engineering received two major gifts totaling $4.7 million in 2017-18 to expand research and educational opportunities within the department.

An endowment from the trust of David Cugell and Christina Enroth-Cugell, a founding member of the department, will support graduate and postdoctoral fellowships in visual neuroscience and biomedical engineering.

A gift from the Jaharis Family Foundation will support expanding undergraduate educational opportunities, particularly in the area of pharmaceutical engineering. **David O'Neill** has joined the department as its new director of experiential learning to lead these initiatives, which also include an annual seminar and additional support for undergraduate research fellowships.

At left: Two new department gifts will support graduate and postdoctoral fellowships in visual neuroscience, as well as expanding undergraduate opportunities in the area of pharmaceutical engineering.

BME EXPANDS CONNECTIONS WITH MEDICAL SCHOOL ON THE CHICAGO CAMPUS

Collaboration with Feinberg School of Medicine grows with joint appointments, shared research space

Northwestern Engineering's Department of Biomedical Engineering (BME) and Northwestern's Feinberg School of Medicine are expanding their collaborations to further translate engineering research into the clinical environment.

With joint appointments in biomedical engineering and the medical school, new Assistant Professors **Molly Bright**, **Laleh Rad**, and **Zhe Ji** are ramping up research and strengthening connections between biomedical engineering and fields like physical therapy, radiology, and pharmacology.

"Joint appointments between radiology and BME have been critical to the growth of research and innovation in our department," said James Carr, chair of Feinberg's Department of Radiology.

Many BME faculty members also serve as research scientists at Shirley Ryan AbilityLab. Photo courtesy of the Shirley Ryan AbilityLab.

The new Simpson Querrey Research Building is scheduled to open in summer 2019.

"Not only do they foster cross-campus collaboration between different schools, but they also provide graduate students unique experiences to work with different groups of researchers."

The department will continue building on its long-standing relationship with the medical school and the Shirley Ryan AbilityLab. Bright, Rad, and Ji join several BME faculty members with cross-appointments, including Professors **Patrick Kiser**, **Michael Markl**, **Wendy Murray**, **Eric Perreault**, and **Matthew Tresch**.

"The Department of Physical Therapy and Human Movement Sciences (PTHMS) at Feinberg is among the most engineering-oriented physical therapy educational and research programs in the nation," said Julius Dewald, professor of biomedical engineering and professor and chair of PTHMS. "The department has a number of faculty engineers as well as quantitative scientists that have benefited greatly from a growing link with BME."

Biomedical engineering will further collaborate with medical school colleagues in the new Simpson Querrey Research Building, scheduled to open in summer 2019. The top floor of the building will be devoted to bioengineering and will be the first space dedicated to the biomedical engineering department on Northwestern's Chicago campus. The building will house the Center for Synthetic Biology, the Center for Bio-Integrated Electronics, and the Simpson-Querrey Institute for BioNanotechnology. The space will facilitate further expansion of BME faculty.

RESEARCH HIGHLIGHTS

New research shows that the central nervous system is mindful of the body's well-being when it experiences excessive stress within its joints.

PROTECTING JOINTS VIA THE CENTRAL NERVOUS SYSTEM

Research offers new understanding of the role of the central nervous system in protecting joints

A research team led by Professor **Matthew Tresch** has found that when it comes to preventing potentially excessive stress within the body's joints, the central nervous system is an active player mindful of the body's well-being. The findings have the potential to influence injury rehabilitation and help unlock even bigger mysteries related to the body's neurocircuitry.

"Our study provides evidence that the nervous system chooses muscle activations to avoid joint injury, which is something that hasn't been so clearly demonstrated before and opens the door to exciting future experimentation," Tresch said.

Tresch co-authored the paper with Northwestern physiology postdoctoral fellow Cristiano Alessandro, former physiology postdoc Filipe Oliveira Barroso, and **Benjamin Rellinger** (PhD '13). Tresch, whose lab is located in the Department of Physiology at Northwestern's Feinberg School of Medicine, also holds a dual appointment as associate professor of physical medicine and rehabilitation.

Matthew Tresch

FACULTY STARTUPS GAIN TRACTION

Aptinyx and Epicore Biosystems were born in Northwestern Biomedical Engineering research labs

John Rogers's microfluidic device for sweat analysis

Northwestern Biomedical Engineering professors are taking their research out of their lab and bringing it to the public through successful startups.

Aptinyx, a clinical-stage biopharmaceutical company, recently completed an IPO and began trading on the Nasdaq market. The company raised $102 million for its development of novel, synthetic molecules for the treatment of brain and nervous system disorders. Founded by Professor **Joseph Moskal**, Aptinyx was spun out of a predecessor company, Naurex, which was purchased by Allergan for $560 million.

Epicore Biosystems, a startup spun out of the lab of Professor **John Rogers**, has commercialized a proprietary sweat microfluidic sensing platform that is low-cost and capable of analyzing small droplets of sweat directly from the skin. The company recently partnered with Gatorade, the Seattle Mariners, the US Air Force, and the Shirley Ryan AbilityLab to bring these patches into widespread distribution.

NSF GRANTS FOR CHROMATIN AND EPIGENETIC ENGINEERING RESEARCH

Northwestern Engineering has received two Emerging Frontiers in Research and Innovation grants from the National Science Foundation to fund research in chromatin and epigenetic engineering, a new field that has the potential to jumpstart breakthroughs in biotechnology.

The two grants — plus a third, which was awarded to Northwestern as a sub-grant from the University of Chicago — total $5.4 million.

Professor **Vadim Backman**, a principal investigator on one grant and a collaborator on the other two, has pioneered physical genomics and chromatin engineering techniques. He and collaborators have identified a chromatin "packing code" that plays a major role in controlling which genes get suppressed or expressed in cells.

Backman's new Center for Physical Genomics and Engineering will launch next year to help advance research in this innovative field.

NEW BIOTECH TECHNIQUE ACCELERATES PROTEIN THERAPY RESEARCH

Dubbed GlycoSCORES, the technique rapidly screens sequences for making glycoproteins

A new technique, dubbed GlycoSCORES, combines two technologies to rapidly screen sequences for making glycoproteins. Credit: Justin Muir

A Northwestern-led synthetic biology research team has developed a new biotech technique that promises to accelerate research into protein therapies that could become the next defense against antibiotic-resistant supergerms or the next new drug.

Milan Mrksich, the Henry Wade Rogers Professor of Biomedical Engineering, chemistry, and cell and molecular biology, and Michael Jewett, the Charles Deering McCormick Professor of Teaching Excellence and professor of chemical and biological engineering, joined forces to lead the research, which combined the Mrksich lab's mass spectrometry technology with the Jewett lab's expertise in glycosylation and rapidly making proteins.

Glycosylation, which is the attachment of sugars to proteins, plays a critical role in how proteins form and work in cells and how cells interact with other cells.

Working with Cornell University Professor Matt DeLisa, they developed a new platform for characterizing and optimizing sequences for making glycoproteins using cell-free protein synthesis and mass spectrometry. The new technique speeds up the time needed to test compounds for potential new drugs.

"Where researchers today can evaluate a couple of hundred potential glycosylation tags in a given period, we've brought together two high-throughput technologies that allow us to evaluate several thousand in that same time frame," Mrksich said.

NEW METHOD BENCHMARKS ORGANIC MIXED CONDUCTORS

New framework compares the performances of organic materials for bioelectronics and energy storage

Professor **Jonathan Rivnay** and his team have developed a novel framework to benchmark and compare organic mixed conductor performance. Not only does this method allow for the comparison of existing materials, it could also be used to inform the design of new organic materials.

Organic conductors are soft materials that conduct electricity. They show promise in inexpensive, lightweight, flexible technologies, including solar cells, printable electronic circuits, and organic light-emitting diodes. One single material, however, cannot bring all of these applications to reality. Each application requires a material with a certain set of characteristics.

To solve this problem, Rivnay and his team looked to the organic electrochemical transistor, a type of transistor in which ions flow between an organic conductor and an electrolyte in order to switch the electrical current flowing through the device on or off.

After building electro-chemical transistors from 10 different organic mixed conductors, Rivnay and his team measured how well each transistor performed, comparing parameters such as how easily each device transported ions and stored an electronic charge. By evaluating each material's performance as a transistor, Rivnay then easily rated their strengths and weaknesses.

"We used organic electrochemical transistors as a tool to understand new organic mixed conductors," Rivnay said. "This tool doesn't just allow us to see if one material is better than another, it also tells us why."

Jonathan Rivnay

"THIS TOOL DOESN'T JUST ALLOW US TO SEE IF ONE MATERIAL IS BETTER THAN ANOTHER, IT ALSO TELLS US WHY."

JONATHAN RIVNAY

BME WELCOMES MORRIS AND CHEN TO ADVISORY BOARD

Milton Morris

Emile Chen

The Department of Biomedical Engineering is excited to welcome **Milton Morris** and **Emile Chen** as the newest members of its advisory board.

Morris is president and CEO at NeuSpera Medical Inc., a medical device company that specializes in bioelectronic medicine. The company has experienced steady growth fueled by more than $35 million in investment capital toward the development of its ultra-miniaturized neurostimulators that are used to treat an array of chronic and debilitating diseases.

Prior to joining NeuSpera Medical, Morris served as principal at MEH BioMedical, where he helped jumpstart the creation of startup companies in the biomedical device space. He also served as senior vice president of research and development and emerging therapies at Cyberonics, a medical device company that uses vagus nerve stimulation therapy to treat epilepsy and depression.

An inventor on 30 patents and author of 20 peer-reviewed publications and book chapters, Morris earned his MBA at the Kellogg School of Management, his master's and PhD in electrical engineering from the University of Michigan, and his bachelor's in electrical engineering from Northwestern.

Chen is director of system modeling and translational biology at GlaxoSmithKline, one of the world's largest pharmaceutical companies. In his role, he uses physiologically-based PK/PD modeling, quantitative system pharmacology, and other mathematical modeling techniques to solve project questions and enhance scientific productivity.

Chen holds more than 22 years of industrial experience ranging from early discovery to late-stage development, including authoring and reviewing regulatory documentation and New Drug Application submissions. He has led efforts to improve research and development productivity using innovative mathematical modeling and simulation methods to help reduce attrition while enhancing the ability to predict efficacy and safety in humans.

Chen received his bachelor's degree from the University of California at Los Angeles and his PhD from Northwestern in biomedical engineering, specializing in developing mathematical models for information processing in the brain.

Faculty Honors

Guillermo Ameer was named a fellow of the American Institute of Chemical Engineers. He also received the Key to Panama City, Panama, by Vice Mayor Raisa Banfield.

Patrick Kiser, **Robert Murphy**, and **Wendy Murray** were elected to the American Institute for Medical and Biological Engineering's College of Fellows Class of 2018.

John Linehan was elected fellow of the American Association for the Advancement of Science.

Jonathan Rivnay received a Faculty Early Career Development Program (CAREER) Award from the National Science Foundation.

Evan Scott received a 2018 Young Innovator Award in NanoBiotech from *Nano Research*.

Teresa K. Woodruff was named a 2018 fellow of the National Academy of Inventors and a member of the National Academy of Medicine.

At the end of the day, from a patient perspective, it looks like a Band-Aid that's talking to their cellphone.

— PROFESSOR JOHN ROGERS, whose new skin sensor device non-invasively monitors brain shunt performance, which could prevent unnecessary surgeries or CT scans for a million patients who suffer from hydrocephalus.

BME PROFILES

Chelsi Serba

Senior leverages engineering skills to help others

After tearing her ACL twice in high school while skiing competitively, senior **Chelsi Serba** devoted her undergraduate career to researching medical devices to improve the quality life of amputees and individuals recovering from injuries.

Working with Professors Keith Gordon and Matthew Major in the Feinberg School of Medicine's Human Agility Lab and the Northwestern University Prosthetics-Orthotics Center, Serba studied the biomechanics of trans-tibial amputee gait stability. Using MATLAB, she developed code to analyze data on the walking patterns of trans-tibial prosthesis users, revealing trends influencing subjects' recovery responses to different limitations placed on movement.

Serba was included as an author on the research, which was published in the January 2018 issue of *Scientific Reports*. She also presented the study at the 2017 and 2018 American Society of Biomechanics Conference.

Over the summer, Serba interned at Verb Surgical, a surgical robotics company formed from a corporate partnership between Google and Johnson & Johnson. Located on the Google campus in Silicon Valley, she worked with the verification team to ensure that requirements for surgical robots were met and verified. Her time was split between coding, mechanical design and testing, and documentation/protocol development.

"I was fully integrated into the team as an engineer and was able to make productive contributions to the company," Serba said. "Verb's product is going to make a difference and improve so many lives around the world."

Serba hopes to work at a medical device company following graduation, and she may not wait long to achieve that goal. Verb has already offered her a full-time position to rejoin the company after she graduates in June 2019.

When she's not conducting research, Serba is a productive member of the Northwestern community. She is currently serving as president of the Northwestern Ski and Snowboard team, a member of the Society of Women Engineers and Delta Gamma sorority, and a Red Cross CPR training instructor with Northwestern's Community Health Corps.

Regan Via

Undergraduate experience helps alumnus make early-career impact

After graduating with a degree in biomedical engineering from Northwestern in 2015, **Regan Via** joined EdgeOne Medical, a medical device developer that also offers product development support and life-cycle management for innovative medical technologies.

In his role as product development engineer, Via works with clients ranging from leading pharmaceutical companies to startups to provide key deliverables for FDA medical device submission. He also designs and executes protocols for medical device verification and validation testing, and authors design history documents supporting the development of several medical devices, including a syringe stabilizer and dry-powder inhaler.

Via's early-career success is a credit, in part, to his experience gained as an undergraduate at Northwestern, which included an engineering co-op at Baxter International and research within Northwestern's Center for Innovation in Global Health Technologies, where he helped test a p24 antigen assay — a low-cost, point-of-care HIV diagnostic for infants.

"Regan's undergraduate experience accelerated his onboarding and contributions to successful testing programs for combination product projects," said **Lilli Zakarija** ('95, MEM '01), president of EdgeOne Medical, a biomedical engineering alumna, and member of the BME Advisory Board. "Whether through research or internships, hands-on experience as an undergraduate is critical to achieving success in the medical and biotechnology industry."

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Engage with Biomedical Engineering

Gifts to the Department of Biomedical Engineering are used to aid innovative educational experiences and help the department reach new levels of excellence and impact. Donations made this year will be strategically used to support students and our two newest research centers:

Summer Research Awards, which provide biomedical engineering students with immersive, full-time, 10-week summer research experiences within faculty labs.

Northwestern's **Center for Bio-integrated Electronics**, led by Professor **John Rogers**, which provides research on the development of new, bio-compatible forms of electronics with unique functionality of critical relevance to human health.

Northwestern's **Center for Advanced Regenerative Engineering**, led by Professor **Guillermo Ameer**, a targeted initiative that promotes research, technology development, and clinical expertise to improve the outcome of tissue and organ repair and regeneration.

If you would like to invest in our mission, please direct your gift to mccormick.northwestern.edu/biomedical/donate.

Gifts to Northwestern Biomedical Engineering are used to support innovative research experiences for students. Read about recent undergraduate research experiences on page 7.