School of **Biological** and **Health Systems Engineering**

2019 Annual Report

Innovating multidisciplinary solutions to global health challenges

Ira A. Fulton Schools of Engineering
Arizona State University

ASU Ira A. Fulton Schools of Engineering
Arizona State University

The Ira A. Fulton Schools of Engineering at Arizona State University offers
25 undergraduate programs and 44 graduate programs in its six schools:

School of Biological and Health Systems Engineering
Marco Santello, Director

School of Computing, Informatics, and Decision Systems Engineering
Sandeep Gupta, Director

School of Electrical, Computer and Energy Engineering
Stephen Phillips, Director

School for Engineering of Matter, Transport and Energy
Lenore Dai, Director

School of Sustainable Engineering and the Built Environment
Ram Pendyala, Interim Director

The Polytechnic School
Leila Ladani, Director

Innovation at scale

#1 in the U.S. for innovation
ASU ahead of Stanford and MIT
– U.S. News & World Report, 5 years, 2016–2020

BEST COLLEGES
U.S.News & WORLD REPORT
MOST INNOVATIVE
2020

29 **NSF CAREER** Awardees in the last four years

7 **National Academy of Engineering** Members

10 **American Association for the Advancement of Science** Fellows

4 **National Academy of Construction** Members

11 **American Society of Mechanical Engineers** Fellows

38 **IEEE** Fellows

7 **PECASE** Awardees

5 **National Academy of Inventors** Fellows

7 **American Society of Civil Engineers** Fellows

3 **American Institute for Medical and Biological Engineering** Fellows

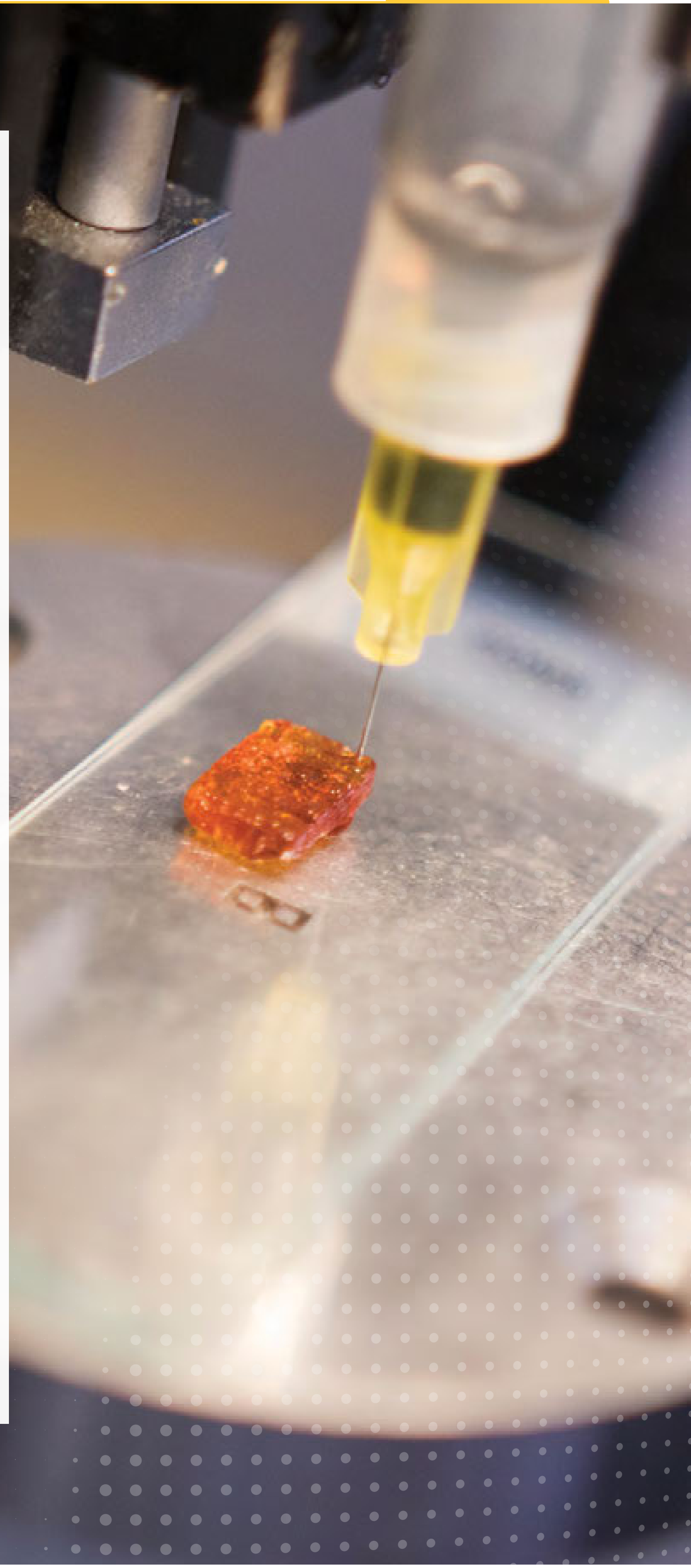
Lead institution on two National Science Foundation Engineering Research Centers

QESST

CBBG
Center for Bio-mediated & Bio-inspired Geotechnics

Lead institution of the Department of Homeland Security Center of Excellence

CAOE | CENTER FOR ACCELERATING OPERATIONAL EFFICIENCY
A DEPARTMENT OF HOMELAND SECURITY CENTER OF EXCELLENCE



Dear colleagues and supporters,

I am excited to share the 2019 Report for the School of Biological and Health Systems Engineering, within the Ira A. Fulton Schools of Engineering at Arizona State University.

This report will detail the innovation and impact that our faculty and students passionately strive to pursue. It all sources from our belief that we must reflect the needs of our community and the marketplace to be a truly effective partner with our clinical collaborators and within the biomedical industry. We are challenging the way we conduct research and deliver education by expanding our breadth and depth of expertise, taking direct feedback from our students and engaging deeply through use-inspired research that makes a real difference in the human condition.

The following pages are filled with examples of the people behind our school's innovation and impact. You will undoubtedly read about their honors, awards, publications and research grants, but also please pay attention to the ideas, discoveries and energy behind it all.

We have a strong desire to be more, discover more and impact more. We will never be satisfied with where we are. We are dedicated to improving the quality of life and health of our community and providing biomedical engineers who are problem solvers, innovators, leaders and entrepreneurs.

Please visit our website at sbhse.engineering.asu.edu or drop by for a visit to witness firsthand what makes our students and faculty unique.

Join us for some exciting discoveries,

Marco Santello, PhD

Director, School of Biological and Health Systems Engineering

SBHSE | School of Biological and Health Systems Engineering

Degrees granted 2017-18

- DOCTORAL 16
- MASTER'S 52
- BACHELOR'S 157
- TOTAL 225

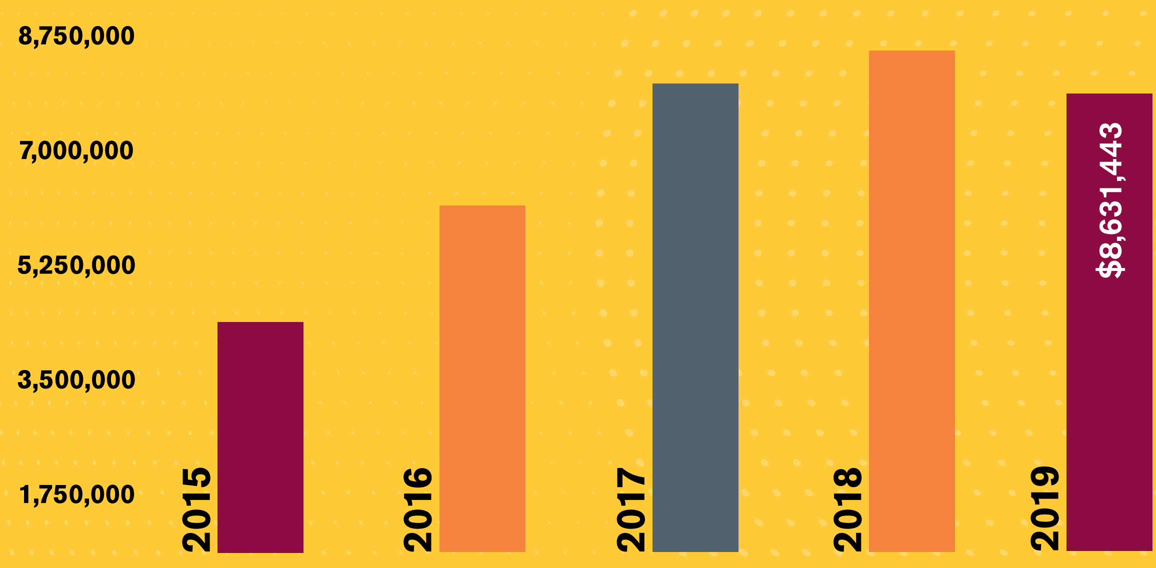
37% Undergraduate students in Barrett, The Honors College

47% Female

Fall enrollment 2018 (21st day)

- DOCTORAL 88
- MASTER'S 76
- BACHELOR'S 747
- TOTAL 911

Research expenditures



SBHSE Report 2019

Contributors

Article credits:
Joe **Caspermeyer**
Monique **Clement**
Terry **Grant**
Emma **Greguska**
Richard **Harth**
Gabrielle **Hirneise**
Joe **Kullman**
Haley **MacDonell**
Katherine **Reedy**
Nikai **Salcido**
Scott **Seckel**
Amanda **Stoneman**
Erik **Wirtanen**

Photo credits:
Marco-Alexis **Chaira**
Deanna **Dent**
Erika **Gronek**
Jessica **Hochreiter**
Charlie **Leight**

Production:
Monique **Clement**
Rhonda **Hitchcock-Mast**
Jessica **Hochreiter**
Stephanie **Mabee**
Elaine **Miller**
Craig **Smith**
Lanelle **Strawder**
David **Wahls**

Volunteer

Join us at E2, Homecoming and other events throughout the year. Reconnect with alumni, learn about new research initiatives and meet our outstanding students.

Faculty awards and honors 2018-2019

National Institutes of Health

James **Abbas**

Received NIH (R01) Research Award

"CRCNS: Improving Bioelectronic Selectivity with Intrafascicular Stimulation"

Received subcontract on NIH (R01) Research Award

"Enhancing Sensorimotor Integration Using a Neural Enabled Prosthetic Hand System"

David **Brafman,**
Sarah **Stabenfeldt**

NIH R21 grant

"A Pluripotent Stem Cell-Based Model to Investigate the Mechanisms of TBI-Induced AD" project to use pluripotent stem cell-based models to elucidate the link between TBI and development of Alzheimer's disease.

Samira **Kiani**

NIH U01 award

"Multicell type human liver on chip microphysiological platform to examine CRISPRbased gene modulation"

Samira **Kiani,**
Mo **Ebrahimkhani**

NIH Common Fund Somatic Cell Genome Editing (SCGE) grant

The $2.6 million, five-year grant will fund the first study of the genome editing technology CRISPR to be used on a "human liver on-a-chip" platform.

Vikram **Kodibagkar,**
Jit **Muthuswamy**

NIH U01 award

"Quantitative mapping of oxygenation around neural interfaces using novel PISTOL MR imaging"

Sydney **Schaefer**

NIH R03 award

"Using standardized visuospatial tests to predict motor training responsiveness in older adults"

Xiao **Wang,**
Yang **Kuang**
(School of Mathematics and Statistical Sciences)

NIH R01 award

"Predictive Modeling of Pattern Formation Driven by Synthetic Gene Networks"

National Science Foundation

Mehdi **Nikkhah,**
Jin **Park**
(ASU Biodesign Institute)

NSF grant

"Investigating the Biophysical and Biochemical Influences of Stromal Cells on Anti-Cancer Drug Resistance within Bioengineered Tumor Microenvironment Models"

Department of Defense

David **Brafman,**
Vikram **Kodibagkar**

Department of Defense ARMI BioFabUSA Award

"Adaptable Multi-Modality Nanoprobes for Non-Invasive Real-Time Monitoring of Engineered Tissues"

Tony **Hu**

Department of Defense research award

"Quantification of Circulating Mtb Antigens for Rapid TB Diagnosis and Treatment Monitoring"

ASU and Ira A. Fulton Schools of Engineering

David **Brafman**

Arizona Board of Regents (ABOR) $400,000 award to establish the Statewide Collaborative Regenerative Medicine Research and Training Facility

With additional funding provided by ASU's Office of Knowledge Enterprise Development, Brafman created the first comprehensive regenerative-medicine-based training and research facility in Arizona.

Fulton Outstanding Assistant Professor

This award is given to assistant professors who are contributing at high levels in all aspects of teaching, research and service.

Emma **Frow**

Seed Grant from ASU's Institute for Social Science Research

"Automating the biological: The future of work and life in bioengineering"

Claire **Honeycutt**

Recipient of a Women and Philanthropy Grant

"Smart Orthotics to Prevent Falls"

Tony **Hu**

SBHSE William J. Dorsen Jr. Outstanding Research Award

Vikram **Kodibagkar**

Collaborative Strategic Initiatives Program Award

"One-shot morphologic, hemodynamic and metabolic MR imaging of brain tumors."

Troy **McDaniel**

Ira A. Fulton Schools of Engineering 2019 Top 5% Teaching Award

Winner of the ASU Virtual Reality Innovation Challenge 2019

Team Keep Calm's work in VR and wearable technologies helps understand and overcome anxiety.

Jit **Muthuswamy**

NSF I-UCRC BRAIN Center Award

"Closed-loop control of deep brain stimulation (DBS) using models of electrode failure"

Mehdi **Nikkhah**

SBHSE Outstanding Assistant Professor Award

Barbara **Smith**

SBHSE Eric Guilbeau Outstanding Teaching Award

Sarah **Stabenfeldt**

SBHSE Metin Akay Graduate Service Award

Fulton Exemplar Faculty

This award aims to recognize and reward tenured faculty who are exemplary contributors to the Ira A. Fulton Schools of Engineering with outstanding accomplishments and contributions in research, teaching and service.

Jamie **Tyler**

Ira A. Fulton Schools of Engineering Top 5% Teaching Award

Brent **Vernon**

Collaborative Strategic Initiatives Program Award

"Multi-institutional program to translate liquid embolics to the clinic"

Fellowships

Bradley **Greger**

Selected participant in the Jewish National Fund's 2018 Winter Faculty Fellowship Program in Israel

Samira **Kiani**

First ASU recipient of the Leshner Leadership Institute Public Engagement Fellow

Jit **Muthuswamy**

Selected participant in the 2018 Jewish National Fund's Summer Faculty fellowship program in Israel

Additional honors and awards

Samira **Kiani,**
Mo **Ebrahimkhani**

Published article in Nature Methods

"An enhanced CRISPR repressor for targeted mammalian gene regulation"

Mehdi **Nikkhah**

CMBE 2018 Young Innovators of Cellular and Molecular Bioengineering awardee

Nikkhah presented his paper, "The Role of Desmoplasia and Stromal Fibroblasts on Anti-cancer Drug Resistance in a Microengineered Tumor Model," in a special, two-part invited platform session at the 2018 Annual Meeting of BMES in Atlanta, Georgia.

Named as one of the Biomaterials Science Emerging Investigators 2019

Sarah **Stabenfeldt**

Elected as the Secretary/Treasure-Elect for Society for Biomaterials

Selected to participate in the June 2019 China-America Frontiers of Engineering Symposium

James Abbas

James Abbas, **an associate professor of biomedical engineering and director of the Center for Adaptive Neural Systems,** is an expert in applications of neural engineering techniques and technology in the area of medical rehabilitation.

Abbas is part of a multi-institutional research team that has developed a first-of-its-kind prosthetic hand to restore “feeling” to a person with a hand amputation. Through a neurostimulator implanted into nerves of the upper shoulder, the Neural-Enabled Prosthetic Hand system uses two-way communication to send an electrical signal from the brain to the muscle and back to control and stimulate a feeling sensation in the prosthetic hand.

The prosthetic hand is the culmination of 12 years of work by Abbas and a Florida International University researcher. In addition to earning funding from the Defense Advanced Research Projects Agency of the U.S. Department of Defense and the National Institutes of Health, Abbas and the research team partnered with industry to develop the prosthetic. Medical device company Cochlear Corporation makes an electrode ear implant that Abbas’ team adapted for use with a hand prosthetic.

Jason Little, a 41-year-old from Orlando, Florida, was the first person to have the electrodes surgically implanted in his upper arm in 2018. For the first time in seven years, Little says he was able to feel his wife’s touch on his left hand.

In addition to prosthetics, Abbas studies neural engineering for rehabilitation in spinal cord injury and Parkinson’s disease, neural interfaces for prosthetic systems and neuromuscular stimulation technology to promote neural plasticity and adaptive biomimetic system design.

Watch a video of Jason Little using the Neural-Enabled Prosthetic Hand system.

Watch video

Jamie Tyler

William "Jamie" Tyler, **an associate professor of biomedical engineering,** believes being an entrepreneur is a way to try things others believe are impossible.

He is combining a decade of neuromodulation research with an entrepreneurial mindset to promote a complete paradigm shift in noninvasive brain stimulation over the next five years with his startup, IST, LLC. Their technology, Neuromodulation by Focused Ultrasound or NeuroFUS, allows researchers, scientists and physicians to manipulate very small circuits of the brain and nervous system using noninvasive ultrasound to unlock new possibilities in neural interfaces.

Beyond exploring the commercial aspects of his research, Tyler is contributing to the economic development and thriving startup culture in the Phoenix metropolitan area.

Tyler guided the establishment of the WearTech Applied Research Center located in the biomedical corridor of midtown Phoenix. WearTech aims to make the Phoenix metropolitan area the hub of wearable and medical technology. Together, a team of scientists, engineers, physicians and business development professionals established Arizona's first industry-led Applied Research Center.

Pairing student and faculty entrepreneurs with technology leaders in industry — from startups to Fortune 500 companies — is especially important to Tyler. He believes cultivating the entrepreneurial mindset makes for better scientists and engineers. Researchers gain a wider pool of "peer reviewers" by working with customers and industry collaborators. Students gain perspective into how industry validates and valuates emerging technologies in a way that can't be learned in the classroom.

Tyler says he actively encourages his fellow faculty members to put in the sweat equity and bootstrapping needed to facilitate entrepreneurial success for everyone involved — industry, professionals, researchers and students. Connecting investment capital to promising startups and spinouts in the early, high-risk phase of development will lead to the big wins needed to increase investment and turn Phoenix into a center for wearable and medical technology innovation, while improving its economic, educational, social and overall health.

Mehdi Nikkhah

Mehdi Nikkhah, **an assistant professor of biomedical engineering,** is one of ten 2018 Young Innovators of Cellular and Molecular Bioengineering for the Biomedical Engineering Society's CMBE journal.

Nikkhah presented a paper discussing his research on drug sensitivity and cancer-associated fibroblasts using a high-density 3D microengineered tumor model in a special, two-part invited platform session during the 2018 BMES Annual Meeting in Atlanta, Georgia. The early career faculty members selected for this honor conduct highly innovative and impactful bioengineering research.

He was also recognized as a Biomaterials Science Emerging Investigator by the Biomaterials Science journal's editorial and advisory boards, which endorses Nikkhah as a promising scientist with the potential to influence the future of biomaterials research.

The Nikkhah Laboratory is conducting research on the integration of innovative biomaterial and microscale technologies to create biomimetic model tissue constructs for regenerative medicine and disease modeling applications.

One method Nikkhah uses is microengineered, microfluidic chips to study cells — including tissues, tumors and diseases — and their interactions in a controlled environment. He holds several invention disclosures and patents for his work, especially in the area of microfluidic chips.

Nikkhah's multidisciplinary research using these chips to demonstrate the role of fibroblasts in breast cancer metastasis was published in the prestigious Cancer Research journal by the American Association of Cancer Research.

Liver-on-a-chip, the ideal test environment for CRISPR technology

Assistant professors **Samira Kiani** and **Mo Ebrahimkhani** are among the first recipients of Somatic Cell Genome Editing grants from the National Institutes of Health Common Fund.

The $2.6 million, five-year grant will fund the first study of the Clustered Regularly Interspaced Short Palindromic Repeats genome editing technology known as CRISPR to be used on a "human liver-on-a-chip" platform.

The Somatic Cell Genome Editing program, launched in January 2018, is aimed at improving therapeutic options for both rare and common diseases, including supporting methods to improve editing the human genome.

Kiani and Ebrahimkhani are combining their expertise in CRISPR technology and human microphysiological systems to assess the safety and efficacy of genome editing and its effects on human tissue function.

CRISPR enables researchers to target genes and genetic materials in cells to regulate how they behave and function. Because of CRISPR's ease of engineering and programmability, it is considered a breakthrough technology with the potential to help cure disease, repair damaged body tissue and in other ways restore people's health.

However, as with any new technology, applying the CRISPR method can potentially produce some unintended results.

"[CRISPR] is a pathogenic source, so to put this in humans, you face a number of concerns, such as toxicity, an immune response, or some other side effects that it might affect cell tissues in humans," said Kiani, the project lead for the multi-institution endeavor. "There's a chance introducing the system creates some sort of off-target effects in the genome, meaning that it not only influences the target DNA code, but also does some unintended modifications in parts of the genome that we don't know [about] and don't want."

Kiani and Ebrahimkhani will apply the CRISPR method on the Liverchip platform in an effort to identify the biomarkers within the human liver genome that indicate toxicity. DNA analysis will also reveal biomarkers that indicate the off-target effects of Cas9 — the DNA-cleaving enzyme used in CRISPR that enables highly precise gene editing and regulation.

Until now, CRISPR has only been tested in animal models or human cell lines. Using the Liverchip platform provides a model that recapitulates closely human biology and will significantly reduce the number of discrepancies introduced by animal models.

These organ-on-a-chip mediums are essentially a 3D cell culture system designed to create the specific microenvironment that would exist in a human body. Multiple cells within the medium self-assemble to generate a tissue similar to a human organ, even mimicking the human body's blood flow and the profusion of the media in cells.

Mo Ebrahimkhani and **Samira Kiani,** assistant professors in the School of Biological and Health Systems Engineering, will use a "human liver-on-a-chip" platform to assess the safety and efficacy of CRISPR on human tissue function.

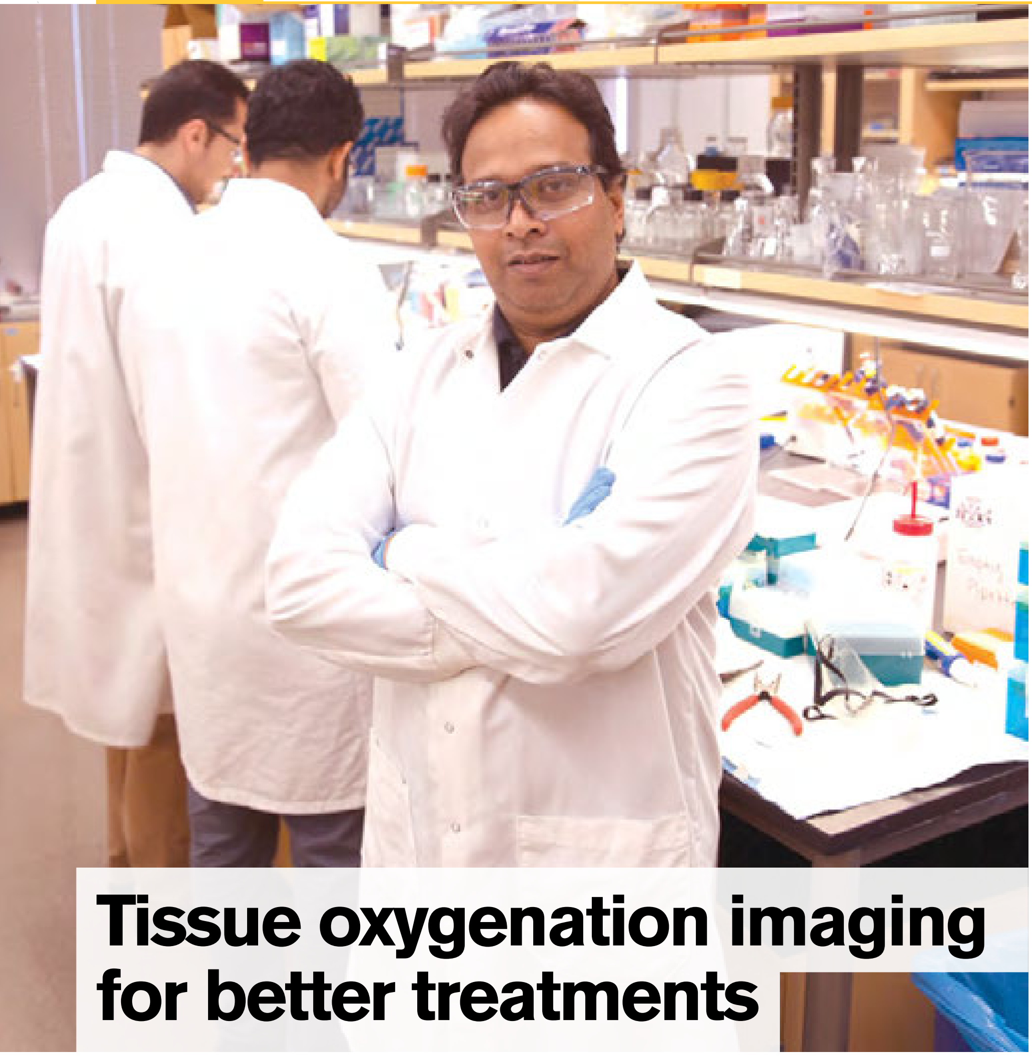
"The final objective is to create a culture system that can predict the liver tissue response in humans," said Ebrahimkhani, who worked with this platform during his studies at Massachusetts Institute of Technology. "In the long term, we hope to be able to achieve a candidate CRISPR system that can target a specific gene in humans with control over cell type, time of action and any potential toxicity."

The liver is likely to be one of the first human organs where gene therapies will be tested. Given the frequency of degenerative, genetic diseases associated with metabolism and the function of the liver, using the liver-on-a-chip platform as a proxy for human liver cells is ideal for studying CRISPR-Cas9's effectiveness as a therapeutic tool.

The multidisciplinary team of investigators includes Jin Park, an assistant research professor in the Virginia G. Piper Center for Personalized Diagnostics at ASU's Biodesign Institute. Park will help with data analysis of the RNA and DNA sequences to identify biomarkers in tissues. Linda Griffith, the School of Engineering Teaching Innovation Professor of Biological and Mechanical Engineering at the Massachusetts Institute of Technology and a leading expert in microphysical systems, and David Hughes of CN Bio Innovations, the commercial vendor for the Liverchip, are collaborating with the ASU team in this research. They will contribute novel technologies and their expertise relevant to human-based cellular platforms.

"We're excited this opportunity to see that NIH entrusted the leadership of this multi-institution grant to Samira and Mo," said Marco Santello, director of the School of Biological and Health Systems Engineering. "It's a true testament to the caliber of the faculty in the Ira A. Fulton Schools of Engineering"

The NIH Common Fund awarded 21 Somatic Cell Genome Editing grants totaling approximately $86 million over the next five years to support research aimed at improving methods to edit the human genome. These projects will help develop multicellular systems optimized for genome editing, advance delivery techniques of the CRISPR system and generate new, more effective genome editing tools.



Tissue oxygenation imaging for better treatments

Associate Professor **Vikram Kodibagkar** spent four years finding ways to quantify the amount of oxygen present in tissues using qualitative data, opening new doors for improved cancer treatments.

In many cases, as a cancerous tumor grows, it rapidly outgrows its blood supply, leaving portions of the tumor with areas where the oxygen concentration is significantly lower than in healthy tissues.

"Knowing about the oxygenation of tissues might allow us to tailor the therapy to make it better and to use other therapeutic interventions that are more appropriate," says Kodibagkar, director of the Prognostic Bioengineering Lab, which seeks to develop new imaging technologies to detect changes in tissue microenvironments and train new leaders in biomedical engineering.

Standard therapies such as radiotherapy are not optimally effective in hypoxic (low oxygen) regions. However, armed with a new technique to measure tissue oxygenation that provides information about hypoxic areas, radiologists can boost the dosage of radiotherapy where tumors pose the greatest risk of metastasizing or resisting therapy.

Kodibagkar found the technique can also be useful for rehabilitation from traumatic brain injuries, stroke or heart attacks.

The noninvasive imaging method Kodibagkar developed involves using magnetic resonance imaging scanners to observe how a contrast agent binds to its environment. If it accumulates in a region of tissue, researchers can infer it passed through "leaky" or more damaged vessels, which are commonly found in tumors or as a result of traumatic brain injury.

If the contrast agent is retained for a period of three hours or more, it indicates the presence of hypoxia in the tissue.

"Based on the time course of the agent, or rather the concentration, now we can tie that to actual pharmacokinetic models of how molecules behave when injected into the bloodstream," Kodibagkar says.

The use of MRI scanners means Kodibagkar's technique is widely accessible to clinical teams.

Attracting the next generation of imaging engineers

Vikram Kodibagkar used his NSF CAREER Award to introduce high school and undergraduate students to the possibilities of a career in biomedical imaging science and engineering, one he finds to be "very fulfilling and impactful."

Together with Assistant Professor Barbara Smith, Kodibagkar also established a global summer internship program to recruit undergraduate students from India.

He also used the project to mentor doctoral students Shubhangi Agarwal and Babak Moghadas in imaging research.

"The work I did with Dr. Kodibagkar has provided me with a strong foundation not only in the field of imaging, but also as a scientist for conducting good quality research in the future," says Agarwal, who is now a postdoctoral researcher at the University of California, San Francisco.

Agarwal continues to apply the MRI techniques she learned at ASU to study cancer metabolomics.

"The biggest impact of the NSF CAREER Award," Kodibagkar says, "has been on the students who received training in cutting-edge imaging techniques under its auspices and who represent the next generation of leaders in imaging."

Engineering electronic medicine

Bioelectric medicine is the future of health care, and Associate Professor **Jit Muthuswamy** and Professor Emeritus Bruce Towe are working on the cutting edge of it — developing a wireless approach to modulate nerve function using sound waves and injectable electronics.

Precisely targeting a certain nerve with sound, light or electricity can modulate bleeding or inflammation.

Wired electrical stimulation can cause problems of tugging, pulling and instability. But putting a device inside the body and then powering it up from the outside eliminates those issues.

In research funded by a grant from the Defense Advanced Research Projects Agency of the U.S. Department of Defense, Muthuswamy and Towe are developing a passive, wireless, injectable nerve modulation system.

"We want to get this on the nerve and then shoot a sound wave at it," Muthuswamy says. "Then the device converts the sound wave into electricity that can modulate the nerve function."

Instead of designing new drugs, the researchers are designing therapy based on careful administration of electricity, or modulating electrical functions of neurons in targeted places that lead to treating organs.

Axons — the thousands of threadlike parts of a nerve cell that conduct impulses and transmit information to different neurons, muscles and glands — are not well understood. However, Muthuswamy and Towe are working on how to target specific nerves and how to monitor the applied electricity to get the desired effect in a way to make it "a reliable, long-term technology that can target precise axons," Muthuswamy says. "We now have a potential technology that can address this problem."

Gene-editing advances with CRISPR-Cas9

CRIPSR has been heralded for the possibilities it presents to harness and enhance the power of the human body to heal itself. Assistant Professor **Samira Kiani** is one of the top researchers in this area.

In a paper published in Nature Methods, a leading journal that spotlights discoveries of new scientific methods and techniques, Kiani and her nearly 20 research collaborators describe a breakthrough in the use of CRISPR-Cas9.

The team is using Cas9 technology derived from the bacterial immune system to develop synthetic gene circuits to reprogram mammalian cells. The goal is to empower the cells to repair or disable genes in a way that mimics natural processes.

A particular benefit of Cas9 is that it is a DNA-cleaving enzyme that binds guide RNA to enable highly precise gene editing and regulation. The team is also working on a way to more efficiently adapt Cas9 to turn a gene on or off — a method called transient gene modulation.

Their Cas9 research might help people with diabetes by reprogramming cells to produce more insulin, or help others by targeting specific DNA sequences that have mutated and are causing cancer by cutting out the harmful gene mutation.

Listen to Samira Kiani talk CRISPR on the Future Tech podcast:

Scan to listen

Chipping away at mysteries of cancer metastasis

One of the current paradigms in cancer treatment is not to treat a tumor itself. Rather, therapeutics can focus on a tumor's microenvironment — the area where tumor cells and a patient's healthy cells collide.

In a project led by recent ASU biomedical engineering doctoral graduate Danh Truong, a multidisciplinary team uncovered a new role that fibroblast cells play in the spread of breast cancer tumors using microfluidic tumor models.

Assistant Professor **Mehdi Nikkhah,** Truong's primary doctoral studies advisor, partnered with multidisciplinary collaborators at the ASU Biodesign Institute, Mayo Clinic and the University of Arizona Cancer Center to study particular patients' fibroblast cells and their interactions with commercially available breast cancer cells that matched the patients' tumors.

The research team deposited these cells in the 3D channels of a microengineered microfluidic chip that in part replicates the patient's tumor microenvironment and used high-resolution imaging to see individual cancer cells and fibroblast cells interact. They observed cancer cells speeding up when they came into contact with fibroblast cells. Using a technique called RNA sequencing, which revealed thousands of possible molecular targets, the team made a novel discovery.

"Our big 'aha' moment happened when we were poring over the data and comparing what we found to literature data," Truong says. "We uncovered a possible target, the protein GPNMB, which was corroborated with data in literature, but not yet observed in the interaction between cancer cells and cancer-associated fibroblasts. We thought this protein may be involved in the interaction and decided to disrupt it."

When they silenced the GPNMB gene's expression in cancer cells in the chip model, the cancer cells stopped spreading to surrounding tissue.

"The microenvironment is inducing changes in gene expression of cancer cells, specifically because of fibroblast cells that lead them to be in a highly invasive state," Nikkhah says. "The fibroblasts change their phenotype in the tumor microenvironment in a way to help the tumor spread."

This research can lead to new ways to study therapeutics and create personalized medicine for each patient's particular cancer and tumor microenvironment.

The chips are also inexpensive and more scientifically effective compared to animal models, which could lead to great improvements upon the low success rate of animal model clinical trials.

The results were published in a highly influential research journal, Cancer Research, after rigorous peer review.

Bioinformatics scientist and ASU Biodesign Institute Assistant Research Professor Jin Park says the publication of the team's paper helps put ASU on the map as a leader in cancer research.

"As an institution without a medical school," Park says, "this paper will certainly help boost the status of ASU toward a major research university in cancer research."

Nikkhah's goal going forward is to isolate all cell types derived from a single patient to study on the chip. This would help to better cross-correlate their findings with the same patients' data or other clinical data. A fully patient-derived, cancer-on-a-chip model would be a big step toward using the chips for personalized medicine.

Read the paper in Cancer Research:

Scan to read more

Better brain and body electrical imaging

Knowing how cells and tissues conduct electricity is key to understanding readings from medical imaging systems that detect traces of these signals. For many diseases, distinguishing normal and unexpected electrical activity in the body is a key part of making a diagnosis.

However, measuring the electrical properties of different types of tissue is tricky, and common methods of measurement don't fully capture what's happening in the body.

Rosalind Sadleir, an associate professor of biomedical engineering, is working to resolve these shortcomings. She's exploring how new methods and applications of current technologies can better characterize the body's electrical properties, especially in the brain.

Historically, electrical properties have typically been measured with electrodes placed on dissected or biopsied tissues — an invasive procedure that yields inaccurate results.

"The moment you cut tissues out of somebody, the properties start changing immediately," Sadleir says.

Much of what is known about the low-frequency electrical properties of tissues was gathered using the dissected tissue method — often using dissected animal tissues or directly on anesthetized animals. The last major publication of this type of data was released in 1996, with relatively few updates since then. However, many models of tissue electrical properties use this outdated, possibly inaccurate data.

Sadleir is going back to square one, gathering the baseline data in humans in noninvasive ways to determine the normal electrical conductance values of living tissues. In particular, she wants to measure the low-frequency range of detection as it is the hardest range to capture and the least measured.

Low-frequency ranges from 1 kHz to 20 kHz are the frequencies characteristic of the body's natural processes. For example, the heart beats around 1 Hz, or once per second, and neural activity mostly occurs in the 1 kHz range. Measurement of electrical properties in the low-frequency range therefore aids understanding of the interplay of activity and conduction of signals through the brain.

One method her team is using is magnetic resonance electrical impedance tomography, or MREIT. This involves putting electrodes on a person's body that deliver an electrical current and create a magnetic field. The person is then placed inside an MRI machine that measures the magnetic field. Through this process, Sadleir's team is able to characterize living tissues' electrical properties.

This isn't a new method, but Sadleir's team is tailoring it to be used with living humans — a key difference from past use which involves simulated tissues or animal tissues. The result will help scientists conducting neuroscience and neuromodulation research (changing the brain's activity by applying electricity). In these types of research, accurate values are necessary for developing new treatments and new understanding of the brain.

To go beyond low-frequency measurements, Sadleir's team is also developing a spectroscopic technique to help fill this knowledge gap for living human tissue. Knowing the measurements along the range of frequencies helps reveal the biophysics of the tissue to get an accurate picture of what's happening in the body as it interacts with both the body's own internal signals and with externally applied therapies.

Going forward, Sadleir is interested in measuring a wider variety of tissues than brain tissues and at a wider range of frequencies. She is particularly interested in skull bone conductivity "because its properties are very difficult to measure using traditional techniques and they are critical determinants in locating sources using EEG."

"There's been some controversy about what the properties of the skull are," Sadleir says, "and they're extremely important — perhaps the most important tissue — for all these transcranially applied techniques."

Detecting pancreatic cancer and countering therapy resistance

Pancreatic cancer is notoriously difficult to detect in its early stages and has a five-year survival rate of less than 5%.

Associate Professor **Tony Hu's** research describing the use of peptides to pinpoint telltale signs of pancreatic cancer well before the appearance of any clinical manifestations of the disease was published in the journal Nano Research. A mutation in a cancer-linked gene known as KRAS leads to a cascade of events that ultimately causes uncontrolled cell division and other hallmarks of the disease. The ratio of two forms of a critical peptide used as a critical diagnostic biomarker is altered by the KRAS mutation.

This noninvasive technique, which requires only a small sample of blood, could revolutionize early diagnosis of the disease and enable early life-saving intervention.

Hu, who is also a researcher in the ASU Biodesign Institute's Virginia G. Piper Center for Personalized Diagnostics, also mentored a team of researchers who were looking into therapy resistance, which is particularly prevalent in pancreatic cancer.

ASU Biodesign Institute researchers Jia Fan and Bo Ning concluded in an article published in the journal Theranostics that chemoresistance is linked to exosomes — bubble-like vesicles released by most cells, including cancer cells, that contain factors that can alter the function of the recipient cells. Fan and Ning's experiments revealed that blocking the expression of one of the exosome factors greatly reduced chemoresistance transfer.

Since exosome-derived factors can be detected in standard blood samples, they could be used as a minimally invasive predictive biomarker for pancreatic cancer treatment response.

Linking the mind and body for better physical therapy

Nearly half of physical therapy patients are ages 65 and above.

Older bodies often have unique needs for therapy, but they're not necessarily treated with different approaches than younger patients. To get better results, all it might take is a pencil and paper.

Sydney Schaefer, an assistant professor of biomedical engineering, is working toward developing more personalized solutions for neurorehabilitation (treatment for a nervous system injury) that are better tailored to older patients. She and her research team are researching inexpensive and easy-to-implement solutions similar to current practices.

"We use tools and assessments that are already being used by clinicians, but we are using them in nontraditional ways that could innovate standard care," Schaefer says.

By identifying and testing a number of cognitive domains — memory, language and attention, for example — Schaefer and her team found visuospatial tests are the best predictors of success for physical therapy outcomes. These types of tests determine how well people can visually perceive objects and their features.

"We know that specific parts of the brain are involved in visuospatial function and our hypothesis is that similar networks are critical for learning motor skills, which are fundamental to the rehabilitative process," Schaefer says.

A common visuospatial test involves drawing the face of an analog clock and setting it to a particular time specified by a clinician or experimenter.

Schaefer and the research team are studying the use of pencil and paper tests, and sometimes computer-based tests, to evaluate older patients' visuospatial skills. Questions include visualizing an object's orientation, mentally rotating an object to a different orientation and recreating the shape of an object by drawing or building it, sometimes from memory.

The results they've gotten so far suggest that clinicians focused on cognitive and rehabilitation should communicate more.

"In clinical care, motor and cognitive issues are often treated separately," Schaefer says. "Neural circuitry may have more overlap than originally thought."

The team is also developing low-cost tests that can be widely implemented in clinical and community-based settings.

Their research also suggests that treating visuospatial deficits may have downstream effects on improving motor rehabilitation. Cognitive testing prior to motor rehabilitation can inform how patients should be treated in physical therapy for the best results.

She attributes much of the project's success to the wealth of clinical partnerships available through the School of Biological and Health Systems Engineering and the quality of graduate students the school recruits.

Going forward, Schaefer's team is exploring additional therapeutic solutions and whether enhancing visuospatial function through neuromodulation can enhance skill learning.

Synthetic biology builds multi-industry solutions

The synthetic biology faculty members are confident advances within their research will help provide solutions to an array of challenges in medicine, health care, fuel production, energy, environmental protection, industrial processes and much more.

Researchers explored those possibilities at the 2018 Synthetic Biology: Engineering, Evolution and Design gathering called the SEED conference, hosted by the American Institute of Chemical Engineers.

Assistant Professor **Karmella Haynes** co-chaired the event held near ASU's Tempe campus, which drew more than 400 attendees including industry representatives, government agency leaders, academics and researchers from many universities across the United States, as well as faculty members from research universities in Europe, Canada and Mexico.

Discussions and presentations focused on questions researchers are trying to answer about how genes, proteins, chromosomes, DNA and the like can be synthesized and made to behave predictably for productive and beneficial purposes.

Haynes develops synthetic proteins that can perform a range of biological functions and could provide a safer and more effective method of injecting medicinal drugs into specific locations in the body.

Associate Professor **Xiao Wang** is working on the design, modeling and engineering of novel gene-regulation networks. His goal is to better understand what triggers the cell differentiation process that takes place within those networks and causes stem cells to transform into the kinds of specialized cells critical to the functioning of essential bodily systems.

Assistant Professor **Samira Kiani** uses CRISPR technology and synthetic biology techniques to control when, where and how genes in the body can be modulated to perform safe and controllable gene therapies.

Assistant Professor **Mo Ebrahimkhani** is trying to find ways to trigger body tissue regeneration by essentially "wiring" gene-regulation networks onto human cells. Those regulatory networks would then program cells to generate new tissues for internal organs, particularly the liver.

Besides expertise in various facets of biology and biotechnology, researchers are drawing on chemistry, computer science and genetic, molecular, electrical and systems engineering to examine how to construct biological systems in new ways that maximize the functions those systems are capable of performing.

Combining metabolic and bioprocess engineering with biology and microbiology, David Nielsen, an associate professor of chemical engineering at ASU, is working with his lab team to overcome technological barriers that are limiting the potential to produce bioderived fuels and chemicals.

Cheryl Nickerson, a professor in ASU's School of Life Sciences, leads work that combines microbiology, tissue engineering and physics to understand the dynamic interactions between a host, its microenvironment and the microbial pathogens that lead to infection and disease.

> **We will add a new dimension to the field of tissue engineering to program the generation of new tissue from the inside out.**
>
> **— Mo Ebrahimkhani, assistant professor, Arizona State University**

Generating discussion on regenerative medicine

The 2019 Statewide Symposium in Regenerative Medicine, hosted by Arizona State University, brought together Arizona's lead scientists, clinicians and other industry leaders in the areas of stem cell biology and regenerative medicine.

The three-day pre-symposium workshop provided undergraduate and graduate students, postdoctoral fellows and research scientists a hands-on introduction to culture and manipulations of human pluripotent stem cells.

During the symposium, Assistant Professor **David Brafman,** the director of the Stem Cell Training and Research Program at ASU, gave an overview of regenerative medicine efforts at the university. Assistant Professor **Mo Ebrahimkhani** discussed next-generation liver organoids to advance human precision medicine. Assistant Professor **Emma Frow** presented on experimental stem cell treatment.

The School of Biological and Health Systems Engineering faculty were joined by speakers from other ASU schools, the University of Arizona, Northern Arizona University, the Barrow Neurological Institute, Mayo Clinic and the Translational Genomics Research Institute.

Faculty expertise

Faculty members in the School of Biological and Health Systems Engineering apply engineering principles and methods to understand, define and solve problems in medicine, physiology and biology. Through their wide range of research expertise and interests, they seek to transform society through developing use-inspired technologies and multidisciplinary collaboration.

James **Abbas**
Associate Professor
PhD, Case Western University
Expertise: Neural engineering, rehabilitation, prostheses, biomimetic design

David **Brafman**
Assistant Professor
PhD, University of California, San Diego
Expertise: Pluripotent stem cells, neurodegenerative disease, developmental biology, regenerative medicine biomanufacturing, gene editing

Christopher **Buneo**
Associate Professor
PhD, University of Minnesota
Expertise: Neural engineering, neuromodulation, neurorehabilitation, neurophysiology, sensorimotor control

Jerry **Coursen**
Lecturer
PhD, University of Arizona
Expertise: Neuroscience, health care systems

Emma **Frow**
Assistant Professor
PhD, University of Cambridge
Expertise: Bioengineering, policy and society; governing emerging biotechnologies

Bradley **Greger**
Associate Professor
PhD, Washington University, St. Louis
Expertise: Neural engineering, movement disorders, vision restoration, seizure disorders

Stephen **Helms Tillery**
Associate Professor and Fellow of the Lincoln Center for Applied Ethics
PhD, University of Minnesota
Expertise: Cortical neurophysiology, neural control of movement, neuroprosthetics, neuromodulation, neural engineering ethics

Claire **Honeycutt**
Assistant Professor
PhD, Georgia Institute of Technology/Emory School of Medicine, Atlanta
Expertise: Clinical biomechanics, motor control, stroke, falls, orthotics

Jeff **Kleim**
Associate Professor
PhD, University of Illinois
Expertise: Neural plasticity, neurorehabilitation

Vikram **Kodibagkar**
Associate Professor
PhD, Washington University, St. Louis
Expertise: MRI probe and technique development for cellular, molecular and metabolic imaging

Thurmon **Lockhart**
Professor
PhD, Texas Tech University
Expertise: Neural engineering, sensorimotor deficits associated with aging and neurological disorders from fall accidents

Stephen **Massia**
Associate Professor
PhD, University of Texas, Austin
Expertise: Cell-material interactions

Jit **Muthuswamy**
Associate Professor
PhD, Rensselaer Polytechnic Institute
Expertise: Neural Interfaces, neuromodulation, BioMEMS

Mehdi **Nikkhah**
Assistant Professor
PhD, Virginia Tech
Expertise: Micro and nanoscale technologies, disease modeling, tissue engineering, cancer, tumor microenvironment models

Vincent **Pizziconi**
Associate Professor
PhD, Arizona State University
Expertise: Medical device design innovation and regulation, cell and tissue regenerative medicine products, biomanufacturing, bioinspired and biomimetic complex adaptive biosystems, space bioengineering

Christopher **Plaisier**
Assistant Professor
PhD, University of California, Los Angeles
Expertise: Systems biology, transcriptional regulatory networks, cancer, immunology

Rosalind **Sadleir**
Assistant Professor
PhD, University of Western Australia
Expertise: Neuroimaging and neural activity detection, dynamic physiological monitoring, computational modeling

Marco **Santello**
Director and Professor
PhD, University of Birmingham, Birmingham, UK
Expertise: Neural control of movement, sensorimotor learning, neuromodulation, neuroimaging, prosthetics

Sydney **Schaefer**
Assistant Professor
PhD, Pennsylvania State
Expertise: Motor control and learning, cognitive neuroscience, clinical neurorehabilitation

Barbara **Smith**
Assistant Professor
PhD, Colorado State University, Fort Collins
Expertise: Imaging and biomarker discovery, innovating point-of-care diagnostics

Sarah **Stabenfeldt**
Associate Professor
PhD, Georgia Institute of Technology
Expertise: Regenerative medicine, targeted theranostics, neurotrauma

Xiaojun **Tian**
Assistant Professor
PhD, Nanjing University, China
Expertise: Systems biology, synthetic biology, nonlinear dynamics gene circuits, EMT

William "Jamie" **Tyler**
Associate Professor
PhD, University of Alabama at Birmingham
Expertise: Neurotechnology development, neuromodulation, brain plasticity, performance enhancement

Brent **Vernon**
Associate Professor
PhD, University of Utah
Expertise: Biomaterials, drug delivery, tissue engineering

Xiao **Wang**
Associate Professor
PhD, University of North Carolina at Chapel Hill
Expertise: Synthetic and systems biology

Newly tenured faculty

J.M.R. Apollo **Arquiza**
Lecturer
PhD, Cornell University

Apollo Arquiza brings a background in molecular biology, design and simulation of biomedical devices and the study of growth kinetics of species growing in microbial communities in waste. While earning his doctorate, he researched the effect of astronaut-generated garbage on health, water recovery and microbial stabilization for life support in space exploration.

Benjamin **Bartelle**
Assistant Professor
PhD, New York University

Benjamin Bartelle joins the faculty with a focus on building molecular tools for functional imaging with MRI. Bartelle connects multiple specialties in his research: understanding magnetic resonance mechanisms that produce signal and contrast, as well as the neurobiology and synthetic biology methodology needed to get the tech working in a living organism.

Scott **Beeman**
Assistant Professor
PhD, Arizona State University

Scott Beeman brings significant expertise in magnetic resonance imaging. At ASU, he will continue pursuing his passion for the physical and applied sciences and their applications in advancing medicine.

Olivia **Burnsed**
Lecturer
PhD, Georgia Institute of Technology

Olivia Burnsed has a background in biomaterials, stem cell biology and tissue engineering. While earning her doctorate, she studied the effects of both the structural and biomechanical cues provided by the extracellular matrix on modulating cell phenotype and inflammation.

Sung-Min **Sohn**
Assistant Professor
PhD, University of Minnesota

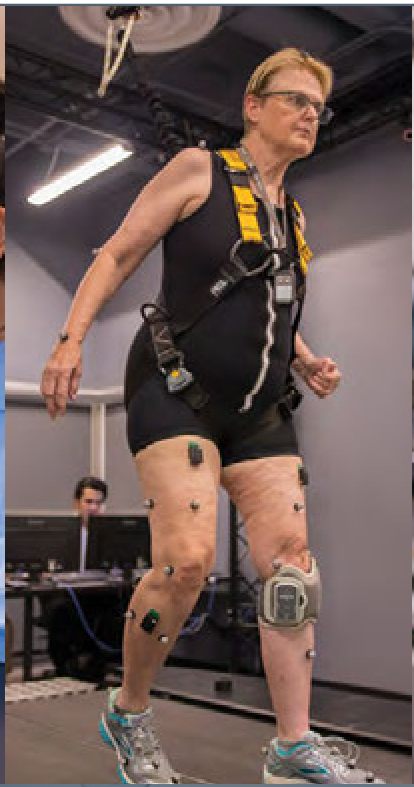
Sung-Min Sohn's research focuses on hardware development for magnetic resonance imaging (MRI) using state-of-the-art RF/analog/digital circuits and systems. He is working to advance next-generation MRI of low-cost, miniaturized and lightweight for more population and better health.

Kuei-Chin (Mark) **Wang**
Assistant Professor
PhD, University of California

Kuei-Chin (Mark) Wang's research focus is applying nanotechnology to treat atherosclerosis, the most common cause of heart disease, and evaluating the efficacy of nanomedicine treatments. He seeks to develop more effective therapeutic approaches to improve the lives of people with cardiovascular disease.

Jessica **Weaver**
Assistant Professor
PhD, University of Miami

Jessica Weaver's research expertise lies in integrating biomaterials, drug delivery, and tissue and immune engineering for the development of functional, immune-protected tissue and cell grafts. She seeks to develop safe, translatable technologies with long-term efficacy to widen the applicability of cell therapies to broad patient populations through the elimination of chronic immunosuppression.



Biosensors and bioinstrumentation

Diagnostic tools to monitor human health and the environment, microactuators and microsensors for drug delivery systems

Our biosensing and bioinstrumentation faculty members focus their attention on research diagnostics for monitoring human and environmental health. They build microelectromechanical systems for better neural signal recording and drug delivery, and devices for interacting in real time with biological systems.

Locomotion Lab

Director: Thurmon Lockhart

The Locomotion Lab focuses on understanding the fundamental mechanisms associated with movement disorders leading to fall accidents by using a combination of experimental, computational biomechanical and biodynamical techniques to reduce falls and improve human health.

Neural Microsystems Laboratory

Director: Jit Muthuswamy

The Neural Microsystems Laboratory explores novel neural interfaces and neuromodulation technologies for the central and peripheral nervous system that would directly or indirectly restore functionality and lifestyle to patients with neurological diseases, disorders and injuries.

Laboratory of BioInspired Complex Adaptive Systems

Director: Vincent Pizziconi

The Laboratory of BioInspired Complex Adaptive Systems explores the biodesign heuristics of integrative bionanosystems that can lead to the design and development of bioinspired advanced diagnostic and therapeutic components, devices and systems.

Bioimaging

Magnetic resonance imaging and spectroscopy, optical imaging, image processing and enhancement

Our imaging faculty members work on developing new techniques and contrast agents that target specific pathologies, creating translational imaging technologies and using novel MRI phase mapping methods to measure tissue electrical properties. They collaborate closely with local medical centers across Phoenix, the Magnetic Resonance Research Center at ASU and the Keller Center for Imaging Innovation at Barrow Neurological Institute.

Bartelle Laboratory

Director: Benjamin Bartelle

The Bartelle Lab develops tools and methods for molecular fMRI. The group's work extends from synthetic biology, designing reporters and sensors, to functional experiments in living animals. The lab's goal is to reverse engineer the genetic and molecular circuits of healthy brain function to build new therapies for neurodegenerative diseases.

Beeman Laboratory

Director: Scott Beeman

The goals of the Beeman Laboratory are twofold: to devise non-invasive magnetic resonance-based methods to quantify tissue microstructure and function in vivo and to apply these techniques to advance the scientific understanding of health and disease. Ongoing research leverages expertise in biophysical modeling, MR pulse sequence design and MR-detectable molecules to design purpose-built MR protocols that extract objective and quantitative physiologic information. Examples of quantitative MR-based metrics include cell size, organ perfusion and tissue oxygenation.

Prognostic Biomedical Engineering Laboratory

Director: Vikram Kodibagkar

The Prognostic Biomedical Engineering Laboratory focuses on engineering solutions for prognostic imaging of the tissue microenvironment in diseased states. Current research involves the development of techniques for fast Magnetic Resonance Imaging of tissue hypoxia and metabolites, engineering novel MRI and optical imaging probes, and theranostics. The group works on all aspects of MRI: physics of the acquisition, hardware development, sequence development, in vivo studies, image reconstruction and processing. Current disease states under study include cancer and traumatic brain injury. The group's emphasis is on non-invasively obtaining prognostic information early, in response to disease and treatment.

Neuro-electricity Lab

Director: Rosalind Sadleir

Research in the Neuro-electricity Lab models and images biological conditions using targeted electrical methods. Work in the lab varies from the very practical (including device design and commercial development) to the conceptual and theoretical.

Smith Laboratory

Director: Barbara Smith

The Smith Laboratory focuses on engineering solutions to diagnose problems associated with women's health and mental illness. Ongoing research in the lab utilizes imaging technologies and olfactory sensing to forge an entirely new path toward early stage detection and diagnostic monitoring. The overarching goal is to translate technologies developed in the lab for improved patient outcomes.

Bio-inspired Circuits and Systems

Director: Sung-Min Sohn

The Bio-inspired Circuits and Systems lab focuses on the development of novel RF coils (antenna-like devices in MRI) and RF/analog/digital interface circuits to maximize the performance of the RF coils and accessibility of the MRI scanners. Ultimately, higher quality MR images can be obtained with the research results of the BiCS lab under various MR studies. The modern RF/analog/digital design also will be applied to many different biomedical applications such as electrical impedance tomography, electrical brain stimulation, wearable devices and more.

Molecular, cellular and tissue engineering

Biomaterials, molecular and cell therapies, drug delivery

Our molecular, cellular and tissue engineering faculty focus on novel biomaterials for rebuilding damaged tissue, molecular and cellular therapies, and localized drug delivery systems for hard-to-treat cancers.

Stem Cell Bioengineering Lab

Director: David Brafman

The Stem Cell Bioengineering Lab utilizes human pluripotent stem cells to address fundamental questions about human development, model and study disease, and develop methods for cell-based therapies. To that end, they have developed an interdisciplinary approach that combines various aspects of developmental biology, genetic engineering, biomaterials science and bioinformatics to investigate the chemical, biological and physical stimuli that govern stem cell fate.

Massia Laboratory

Director: Stephen Massia

The Massia Laboratory focuses primarily on cell material interactions. The principles of cell biology, biochemistry and organic and inorganic chemistry are utilized to better understand the interaction of cells with synthetic materials and to exploit this knowledge to enhance the compatibility of these materials with tissues that contact them. Current projects include developing nanofabrication methods to construct biomimetic scaffolds for tissue regeneration and replacement.

Nikkhah Laboratory

Director: Mehdi Nikkhah

The Nikkhah Laboratory's current research focus lies at the interface of micro/nanotechnology, advanced biomaterials and biology. Specifically, the research is centered on the integration of advanced biomaterials, stem cells and micro- and nanoscale technologies to develop functional vascularized tissue substitutes. In addition, the lab is actively involved in the development of highly innovative microscale platform for cell-biomaterial interactions and cancer metastasis studies.

Laboratory of BioInspired Complex Adaptive Systems

Director: Vincent Pizziconi

The Laboratory of BioInspired Complex Adaptive Systems explores the biodesign heuristics of integrative bionanosystems that can lead to the design and development of bioinspired advanced diagnostic and therapeutic components, devices and systems.

Smith Laboratory

Director: Barbara Smith

The Smith Laboratory focuses on engineering solutions to diagnose problems associated with women's health and mental illness. Ongoing research in the lab utilizes imaging technologies and olfactory sensing to forge an entirely new path toward early stage detection and diagnostic monitoring. The overarching goal is to translate technologies developed in the lab for improved patient outcomes.

Stabenfeldt Laboratory

Director: Sarah Stabenfeldt

The Stabenfeldt Laboratory specifically focuses on engineering novel targeted diagnostic and therapeutic ('theranostic') biomaterials for neural injury/disease and identifying endogenous neural stem cell homing mechanisms after injury, and incorporating such biosignals into tissue-engineered matrices.

Biomaterials Laboratory

Director: Brent Vernon

The Biomaterials Laboratory uses principles of polymer science and chemistry to design and develop in situ gelling materials for drug delivery, tissue engineering and tissue reconstruction.

Weaver Laboratory

Director: Jessica Weaver

The Weaver laboratory focuses on developing biomaterials-based strategies for immunoengineering and translatable cell-based therapies. The main thrusts of the lab's work include engineering transplant sites for cell-based therapies, device design for translatable and immunoisolated cell transplantation and developing strategies to induce tolerance to transplanted tissue.

Neural/rehabilitation engineering

Modeling and simulation of neural systems and functions, signal processing, specialized tech for individuals with physical impairments, nervous disorder monitoring and treatment, chaos in neural and cardiac systems

Our neural faculty work on modeling and simulation of neural systems to gain insight into neural function, neural signal acquisition and analysis, and the development of specialized technology to evaluate and treat individuals with neural and biomechanical pathologies.

Center for Adaptive Neural Systems

Director: James Abbas

The center seeks to design and develop technology to offset the effects of spinal cord injury, orthopedic injury, Parkinson's disease and cerebral palsy. Driven by the needs of potential users, the engineers and scientists utilize a wide variety of interdisciplinary research techniques and technologies to aid individuals significantly affected or impaired by a traumatic injury or neurological disease.

Visuomotor Learning Lab

Director: Christopher Buneo

The Visuomotor Learning Lab seeks to understand how the brain combines different forms of sensory and motor information to help plan, execute and adapt movements. They are particularly interested in how uncertainty associated with movement planning and execution leads to variability in motor performance. Their long-term goals are to improve and enhance human motor performance by developing brain-centered training protocols and assistive technologies that interface directly with the nervous system.

Neural Engineering Laboratory

Director: Bradley Greger

The lab utilizes current neuroscientific understanding and neural engineering principles to translate clinical needs into devices that improve patient care and outcomes. Electrophysiological recordings and electrical micro-stimulation help gain an understanding of how the nervous system processes information related to various sensory, motor and cognitive functions. The results are used to guide the implementation of medical devices and therapies to treat various neural pathologies. Researchers perform electrophysiological research with human patients using arrays of micro-electrodes arrays to improve our understanding of movement and seizure disorders.

Sensorimotor Research Group

Director: Stephen Helms Tillery

This group analyzes sensorimotor learning and representations in the nervous system and neural mechanisms, which enable the brain to carry out fine motor skills. Within their research, the group duplicates the process, seeking to advance the ability to create more lifelike prosthetics that respond to brain signals.

Human Mobility Lab

Director: Claire Honeycutt

This lab supports two major research thrusts: fall prevention and enhancing arm function. The team works with clinicians to enhance rehabilitation strategies for the hospital, clinic and home.

Kleim Lab

Director: Jeffrey Kleim

The Kleim Lab studies how neural plasticity supports learning in the intact brain and "relearning" in the damaged or diseased brain. Research is directed at developing therapies that optimize plasticity in order to enhance recovery after stroke and Parkinson's disease.

Locomotion Lab

Director: Thurmon Lockhart

The Locomotion Lab focuses on understanding the fundamental mechanisms associated with movement disorders leading to fall accidents by using a combination of experimental, computational biomechanical and biodynamical techniques to reduce falls and improve human health.

Neural/rehabilitation engineering (cont.)

Neural Microsystems Laboratory

Director: Jit Muthuswamy

The Neural Microsystems Laboratory explores novel neural interfaces and neuromodulation technologies for the central and peripheral nervous system that would directly or indirectly restore functionality and lifestyle to patients with neurological diseases, disorders and injuries.

Neuro-electricity Lab

Director: Rosalind Sadleir

Research in the Neuro-electricity Lab models and images biological conditions using targeted electrical methods. Work in the lab varies from the very practical (including device design and commercial development) to the conceptual and theoretical.

Neural Control of Movement Laboratory

Director: Marco Santello

The Neural Control of Movement Laboratory focuses on the hand as a model to investigate the mechanisms underlying sensorimotor integration responsible for motor learning and control. Research thrusts include the role of vision and tactile input for learning and controlling object manipulation, neural mechanisms underlying the synergistic control of multiple hand muscles, and the effect of neurological disorders and neuropathies on hand control. The research has potential for improving the efficacy of rehabilitation of hand function following surgery as well as neuromuscular and neurodegenerative diseases such as stroke, dystonia and carpal tunnel syndrome.

Motor Rehabilitation and Learning Lab

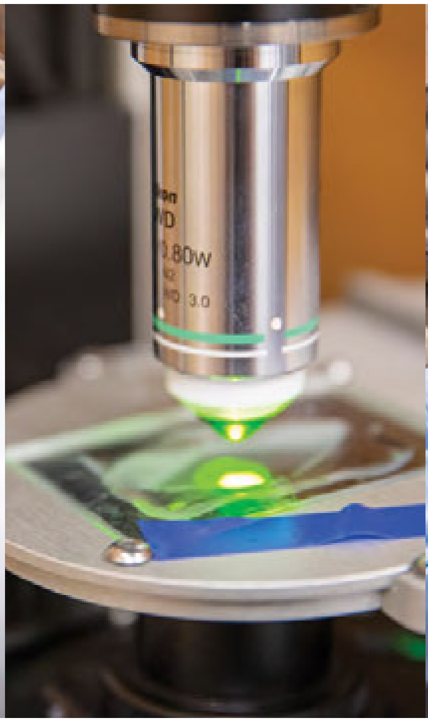
Director: Sydney Schaefer

The Motor Rehabilitation and Learning Lab is focused on the principles and neural mechanisms of functional motor skill learning to better inform clinical neurorehabilitation. The team is particularly interested in aging and how specific cognitive impairments do or do not interfere with older adults' ability to acquire upper extremity motor skill through experience. The lab's work incorporates neuropsychological, behavioral and neuroimaging approaches to studying the human nervous system.

Tyler Lab

Director: William "Jamie" Tyler

Work in the Tyler Lab is focused on developing, optimizing and validating non-invasive neuromodulation and brain stimulation methods for the enhancement of human performance.



Synthetic biology and systems bioengineering

Design of genetically encoded information and cell microenvironments, advanced medical treatments, engineered gene networks, biological network modeling and biomaterials for multicellular systems

This field is based on the premise that living systems are modular, and thus, able to be engineered. It has made a substantial impact on molecular and cell biology. Here, you will find research and coursework in engineered gene networks, policy and governance, biological network modeling and biomaterials for multicellular systems.

Stem Cell Bioengineering Lab

Director: David Brafman

This lab utilizes human pluripotent stem cells to address fundamental questions about human development, model and study disease, and develop methods for cell-based therapies. They have developed an interdisciplinary approach that combines developmental biology, genetic engineering, biomaterials science and bioinformatics to investigate the chemical, biological and physical stimuli that govern stem cell fate.

Bioengineering, Policy and Society Laboratory

Director: Emma Frow

The laboratory uses qualitative social science research methods to study and influence the governance of emerging biotechnologies. Their work involves engaging with scientists performing cutting-edge research, potential users of new biotechnologies and policy actors shaping the governance landscape for bioengineering. Current research projects focus on design and automation in synthetic biology, the governance of experimental stem cell treatments and the future of engineering education.

Laboratory of BioInspired Complex Adaptive Systems

Director: Vincent Pizziconi

The Laboratory of BioInspired Complex Adaptive Systems explores the biodesign heuristics of integrative bionanosystems that can lead to the design and development of bioinspired advanced diagnostic and therapeutic components, devices and systems.

Plaisier Laboratory

Director: Christopher Plaisier

The Plaisier Laboratory uses omics-level snapshots of complex biological systems to inform computational models that reveal biological underpinnings, describe the state space of biological systems and allow the prediction of interventions that push the system toward beneficial states (for example, non-cancerous or healthy). They focus on developing and applying experimental and computational approaches that when integrated together build predictive models of cancers derived from single tumor cells, whole heterogeneous tumors and patient clinical data. These predictive models of tumors are then used to gain insights into tumor biology and identify the best possible interventions for a given tumor, such as a drug or combination of drugs.

Tian Laboratory

Director: Xiaojun Tian

The Tian Laboratory combines multidisciplinary modeling and quantitative experimental approaches to elucidate the mechanisms of complex biological processes and complex diseases. The lab focuses on understanding 1) the underlying design principles of cellular phenotype transition and pathological phenotypes transition, 2) how individual cells from multicellular organisms use multiple layers of regulation to achieve the cellular phenotypes maintenance and transition, 3) how cells communicate with each other through paracrine and autocrine to establish complex pathological phenotypes in tissue level, and 4) searching optimal treatment designs for complex diseases.

Wang Laboratory

Director: Kuei-Chun "Mark" Wang

The Wang Laboratory uses systems biology combining in vitro and in vivo models to investigate how biophysical stimuli in the arterial microenvironment control transcriptional and epigenetic regulation to modulate vascular functions. The lab is also working to develop novel lesion-targeted nanomedicine to reverse gene dysregulation in vascular cells and prevent disease progression.

Xiao Laboratory

Director: Xiao Wang

The Xiao Laboratory works to understand and exploit the effects of nonlinear dynamics and stochasticity in engineered gene networks in microbes and extrapolate this knowledge to the understanding of cell differentiation and development in higher organisms. They emphasize researching multistable gene networks, systems biology on small network motifs with feedback, noise's role in cell differentiation and development in conjunction with molecular evolution.

Research and clinical partnerships

Industry and clinical partnerships tie our research endeavors to the needs of the communities we serve. Our strong network of partners — hospitals and health care organizations, both locally and globally — offers our students access to top physicians and researchers and hands-on experience in fields they may one day transform. Whether students choose to pursue medical school or join industry after graduation, this early exposure is invaluable.

MAYO CLINIC
Phoenix Children's Hospital
Medtronic
BARROW Neurological Institute | Dignity Health. St. Joseph's Hospital and Medical Center
stryker
THE CORE INSTITUTE® Outcomes by HOPCo
BD
Cactus Materials
tgen TRANSLATIONAL GENOMICS RESEARCH INSTITUTE
VA | U.S. Department of Veterans Affairs Veterans Health Administration *Phoenix VA Health Care System*
Lundbeck
SYNTHEGO
qb robotics
MIHS MARICOPA INTEGRATED HEALTH SYSTEM Maricopa County Special Health Care District
PROJECT HoneyBee
THESE THREE MEDICAL INC Sense|Analyze|Deliver.
John C. Lincoln HEALTH NETWORK An affiliate of Scottsdale Lincoln Health Network
ATD Advanced Tear Diagnostics
Sandia National Laboratories
GORE
Banner Sun Health Research Institute
Banner Health. Research Institute
Banner MD Anderson ~~Cancer~~ Center Making Cancer History
ATI Aneuvas Technologies, Incorporated
SONORAN BIOSCIENCES
ARIZONA ARRHYTHMIA CONSULTANTS
PINNACLE TRANSPLANT TECHNOLOGIES
IML The Institute for Mobility and Longevity

ASU, Barrow Neurological Institute partner to advance neuroengineering

Some say space is the final frontier. Michael Lawton, president and CEO of Barrow Neurological Institute, says it's the human brain.

The world-renowned institute announced that it is partnering with ASU on a new enterprise to survey and conquer that frontier.

The Barrow-ASU Initiative for Innovation in Neuroengineering will bring together leading experts from both institutions to innovate devices, technology, therapies and research to improve brain and spinal cord function and transform the lives of people with neurological disorders.

"We'd like people to think of Phoenix as this mecca of neuroscience innovation in the way that people think of Houston as the mecca for space exploration," Lawton says. "We're capitalizing on the most innovative university in the country and the largest, busiest neurological institute in the country. It's a natural marriage for the two leaders within this domain and we hope this will be an economic engine for this city."

Neuroengineering is a field with tremendous potential for impacting health and quality of-life outcomes, says Sethuraman Panchanathan, ASU's executive vice president and chief research and innovation officer.

"We are delighted to collaborate with BNI on this frontier initiative that will no doubt have a significant impact through innovations, research and training," Panchanathan says. "This is indeed an incredibly exciting partnership."

The goals of the new initiative are to foster ideas between clinicians and engineers that could change the way we do things. The initiative, Lawton says, "will create a special place where we can capture these ideas and take them from a lightbulb in someone's head to an actual prototype and then a product — and sometimes even a business — and change the way we practice medicine and achieve better outcomes for our patients."

The partnership can also help create a new kind of doctor: the physician-engineer or surgeon-engineer. Modeling after Lawton himself, who was an engineering student in college, training doctors to think like engineers and medical professionals provides many possibilities to innovate.

Ira A. Fulton Schools of Engineering Dean Kyle Squires says the initiative aims to speed up an impactful convergence.

"The convergence of ideas in engineering and neuroscience has to accelerate in order to fundamentally understand brain function and how we can augment it, not only in the case of accidents or diseases, but also for healthy patients," Squires says. "We want to come together in creative ways that merge what each of us is good at."

Engineering researchers at ASU will need to advance human-machine interactions and "reverse-engineer" the brain to understand its complexities and how we can enhance it. Robotics and interfaces between brain and machine will also be important to help people with neurological disorders.

Barrow is also contributing to new technology with the development of the first robotic system to place screws into the spine to correct deformities or stabilize broken bones.

"It's one of — if not the — first game-changing robotics operations in the neurosurgical operating room," Lawton says. "Now neurosurgeons are starting to see the robotics applications for other procedures beyond the spine."

Barrow Neurological Institute President and CEO Michael Lawton (left) and ASU President Michael Crow announced their institutions' new partnership at Celebrity Fight Night in Phoenix March 23. Photo courtesy of Sethuraman Panchanathan

With past collaborations between BNI and ASU, including with Marco Santello and the BRAIN Center, and the enterprising spirit of student doctors, Squires and Lawton are eager for the possibilities this initiative presents.

"We see again and again that the problems that are worth solving lie at the interfaces between disciplines," Squires says, "and this partnership will provide the catalyst needed to accelerate progress."

Academic and industry researchers put their heads together at the BRAIN Center

The Building Reliable Advances and Innovations in Neurotechnology (BRAIN) Center is an Industry/University Collaborative Research Center that is rigorously testing efficacy, safety and long-term reliability of neurotechnology that would not otherwise be possible within traditional academic, industry, regulatory and clinical communities alone.

Professor and director **Marco Santello** and University of Houston Cullen College of Engineering Professor Jose Luis Contreras-Vidal are leading multidisciplinary efforts to develop safe, effective and affordable personalized neurotechnologies for diagnostics, restoration, enhancement and rehabilitation with the help of more than 50 researchers at their home universities and with 14 industry partners and hospital systems.

Originally funded in 2017 with a $1.5 million grant from the National Science Foundation, the BRAIN Center has **broadened the scope and number of industry-faculty research collaborations, added one domestic and four international center sites, and reached thousands of people in the field of neurotechnology** through conferences and events.

By joining the BRAIN Center, your membership will allow you to leverage research supported by federal grants and corporate members from other center-funded projects. You will also have direct access to the center's intellectual property, expert faculty, graduates, students and the infrastructure and capabilities within participating labs and universities. Together, we will revolutionize the diagnosis and treatment of brain disorders.

brain.engineering.asu.edu

WearTech positions Phoenix as center of wearable tech industry

The future of health care is wearable. Handheld, on-body and in-body devices that monitor a person's health status and provide therapy will become more integral to health care over the next few years.

WearTech, a partnership between Partnership for Economic Innovation, ASU, industry and local economic organizations, is positioning the Phoenix metropolitan area as the hub of high-impact wearable and medical technology innovation.

In this unique collaborative project model, industry can leverage their project investments with matching public-sector funds and in-kind talent, equipment and facility resources from ASU — including the School of Biological and Health Systems Engineering — and other universities.

The central hub of this effort is the WearTech Applied Research Center, a collaborative enterprise established and operated by the Partnership for Economic Innovation. Co-located with the Wearable Robotics Association at Park Central in downtown Phoenix, the WearTech Applied Research Center will support an entrepreneurial ecosystem to improve quality of life and human performance through the development of innovative wearable technologies.

The facilities provide validation and prototyping lab space and expertise from Fulton Schools researchers and other ASU faculty for local startups such as FlexBioTech — an interdisciplinary effort between ASU faculty, students and industry and medical professionals.

Jennifer Blain Christen, an associate professor of electrical and computer engineering and FlexBioTech chief operations officer, is helping to lead industry-sponsored projects at WearTech with her partner, medical oncologist and immunologist Karen Anderson. FlexBioTech is developing an at-home rapid diagnostic patch that uses sweat to monitor health care needs after a person is discharged from the hospital. WearTech is helping Blain Christen and Anderson adapt the sweat patch to monitor drugs and alcohol to catch relapses in real time to help counselors intervene and provide support for people recovering from addiction.

WearTech helped connect Blain Christen and Anderson with a local company, True Mobile Health, which provides clients with a personalized approach to care that mirrors what FlexBioTech is doing with diagnostics. Blain Christen calls it a partnership that is greater than the sum of its parts, where each partner can approach individualized health with their own expertise.

"WearTech has really allowed us to focus on the research in this partnership by providing us with both financial and 'red tape' support," Blain Christen says. "They have done an amazing job of determining how to facilitate the partnership and worked within ASU to allow us to work on the project without needing to focus on the details of contracts and negotiations."

Along with industry-partnered spinouts and startups, student entrepreneurial ventures — like Hoolest, the cranial-nerve modulation treatment startup co-founded by ASU biomedical engineering graduate student Nicholas Hool — also utilize the WearTech space in midtown Phoenix.

ASU and WearTech are partnering to train the next generation of wearable technology experts by supporting projects and courses for students interested in learning more about wearables.

William "Jamie" Tyler, an associate professor of biomedical engineering and founding academic director of WearTech, helped restructure ASU's undergraduate biomedical engineering instrumentation course to include content and approaches directed toward applied learning techniques. Incorporating the WearTech mission, the course teaches concepts related to rapid design and iterative testing evaluation approaches used by modern engineers to develop new technologies and devices. His efforts for this course led in part to a Top 5% Teaching Award from the Fulton Schools.

To date, these learning opportunities and startup support resources have been aided by funding from an i6 Challenge Grant from the U.S. Economic Development Administration, which is part of a three-year project under the administration's 2018 Regional Innovation Strategies program to help connect entrepreneurs with local hospitals and local resources to get their wearable technology products off the ground. This funding, paired with matching funds from the State of Arizona to be used in applied research centers, will help startups and industry looking to work with WearTech to develop new wearable technologies.

"Our success getting funding appropriated in the Arizona State Budget (HB 2747) to match investments in industry-led research makes us better equipped to compete with science and tech growth in other cities and states, such as Texas, California, Massachusetts, New York, Washington and Georgia," Tyler says.

WearTech is exploring investment opportunities with local industry and clinical partners, including Medtronic, Barrow Neurological Institute, Avnet, Mayo Clinic and others to identify high impact projects in this space. Tyler notes WearTech has caught the attention of many potential high-profile wearable technology partners.

"WearTech has attracted strong interest from Fortune 500 companies, professional industry trade associations, professional sports teams, the Department of Defense, mid-size strategic investment organizations and state-based clinical partners," Tyler says. "Together, we can combine our resources and talent to foster the development of high-impact advances in wearable technology in Arizona."

Faculty spend the summer at Mayo Clinic

Photo courtesy of Mayo Clinic News Network

ASU and Mayo Clinic researchers spend their summers tackling major health issues through the Faculty Summer Residency Program.

Associate Professor **Stephen Massia** spent his summer working with Phoenix and Scottsdale Mayo Clinic investigators Jeffrey Cornella and Longwen Chen to assess the regenerative capacity of a vaginal wall tissue construct prototype from rabbit explants.

Associate Professor **Vincent Pizziconi** and Mayo Clinic investigator David Lott collaborated in the Phoenix Mayo Clinic location to work toward the development of a bioengineered artificial larynx.

The six-week residency program, now in its second year, is designed to support long-term collaborations between research teams at Mayo Clinic and ASU faculty in areas that will impact clinical outcomes and enhance patient experiences.

"Our second cohort of ASU Alliance for Health Care Fellows have the unique opportunity to work side-by-side with researchers at Mayo Clinic to deeply understand key issues facing patients," says Grace O'Sullivan, ASU assistant vice president of corporate engagement and strategic partnerships. "These collaborations will support the development of noteworthy, interdisciplinary health solutions and also continue to strengthen the Mayo Clinic and ASU relationship."

Identifying Alzheimer's causes with Mayo Clinic

In the search for treatments of Alzheimer's disease, researchers are now looking for new approaches to understand how the progressive disease starts so they can put a stop to it.

David Brafman, an assistant professor of biomedical engineering, partnered with the Mayo Clinic's Richard J. Caselli, M.D., to use a stem-cell-based approach to identify causes of Alzheimer's disease in people with various levels of risk based on variations of the apolipoprotein E gene, known as ApoE.

Brafman uses human-induced pluripotent stem cells, or hiPSCs, from patients with different genetic risk factors for Alzheimer's disease to create living brain cell models to examine a variety of neuronal pathways and cellular mechanisms that may relate to how Alzheimer's disease begins.

Caselli and Brafman received a two-year grant from the National Institute on Aging, part of the National Institutes of Health, for their project, "Generation and characterization of isogenic hiPSC lines with various ApoE genotypes."

Brafman uses hiPSC technology to take white blood cells, provided by the Caselli laboratory, from both patients with Alzheimer's disease and people without the disease and transform them into hiPSCs. In turn, these hiPSCs are able to differentiate into the various cell types that comprise the brain.

"Having living brain cells gives [Brafman] the ability to study cellular mechanisms that could not otherwise be studied in either living or deceased people," Caselli says.

Brafman says the various cell types the team can generate from hiPSCs derived from patients with Alzheimer's disease are a rare and valuable resource, especially those with specific genetic risk factors.

"We were fortunate enough to receive funding via the ASU-Mayo Seed Grant mechanism to perform the first, and arguably the riskiest, aspect of this research, which was to generate hiPSC lines directly from patient samples," Brafman says. "In collaboration with the Caselli laboratory, we generated a comprehensive library of hiPSC lines from patients with different ApoE genotypes."

The hiPSC cell lines will be shared freely among collaborators, and the ASU-Mayo Clinic team hopes their use will advance the study and creation of treatments for Alzheimer's disease.

ASU, Dignity Health tackle public health challenges

The Collaborative Strategic Initiatives Program offers grants to ASU faculty and Dignity Health investigators for collaborative research projects that accelerate the health and well-being of the community.

Launched in 2017, the program advances joint research in key programmatic areas such as population health, educating a prepared health care workforce and building a healthy clinical workforce.

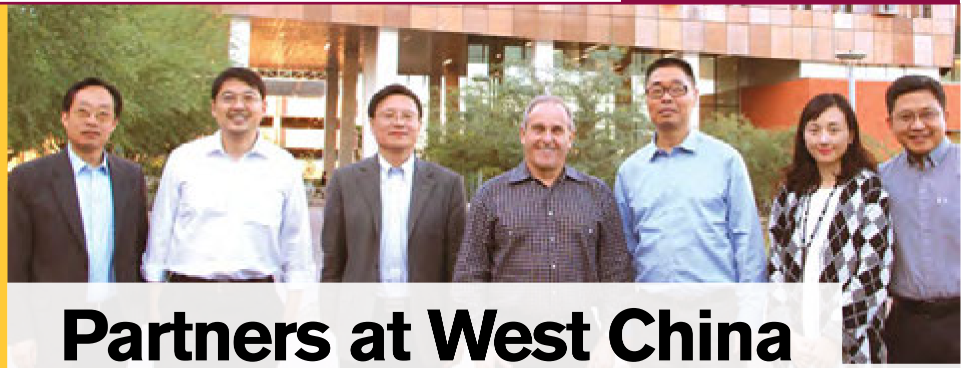
Associate Professor **Vikram Kodibagkar** investigated one-shot morphologic, hemodynamic and metabolic magnetic resonance imaging of brain tumors with Barrow Neurological Institute investigator C. Chad Quarles.

Associate Professor **Brent Vernon** and Barrow Neurological Institute investigators Mark C. Preul and Andrew Ducruet collaborated on a multi-institutional program to translate liquid embolics to the clinic.

Grant recipients embark on projects that address an array of public health challenges that will result in the dissemination and implementation of evidence-based practices into public health, clinical practices and community settings.

The vibrant, innovative Dignity Health and ASU partnership formed in 2015 on the foundation of clinical and academic excellence.

"ASU's partnership with Dignity Health reflects the spirit of collaboration, discovery and community impact that is central to the university's mission," says Sethuraman Panchanathan, ASU executive vice president of Knowledge Enterprise Development and chief research and innovation officer. "The work being done through these grants advances scientific inquiry and knowledge and also offers hope for solutions to some of our most pressing health challenges."



Partners at West China Hospital advance research

ASU Biodesign Institute investigators and representatives of Sichuan University and West China Hospital.

Associate Professor **Tony Hu** co-hosted a symposium with ASU Biodesign Institute Executive Director Joshua LaBaer inviting representatives from Sichuan University and West China Hospital to explore strategies for the detection and treatment of infectious diseases and cancer.

West China Hospital and its accompanying Sichuan University are highly regarded in China, especially in the realm of medical research.

"The West China Hospital definitely has great facilities and it's a well-known hospital. Its medical research is often No. 1 in China, so it could be perfect for collaboration," Hu says.

LaBaer also led a delegation to visit key Chinese partners including Sichuan University, Huaxi Hospital and Soochow University.

"In Soochow, you can tell how quickly the technology can be translated within their high-tech park," says Hu, who has made several breakthroughs in tuberculosis, which has infected about one-third of residents in China. "From the standardization of the product, to licensing, to negotiating with the investor or company of incubation, and also sales and marketing… The pipeline for translation is all there."

This is very appealing to Hu and his research team, who have also adapted their technology to turn smartphones into handheld microscopes to make an impact as a versatile and powerful new tool in the worldwide fight against infectious diseases.

Fellowship program invites international collaboration

Israel is positioning itself as a "startup nation" focused on international collaboration to foster innovation. ASU biomedical engineering researchers have traveled to the country to learn how to partner on those efforts.

Jit Muthuswamy was one of five ASU faculty members selected to participate in the Jewish National Fund's 2018 Summer Faculty Fellowship Program in Israel. Associate Professor **Bradley Greger** also joined five ASU faculty members for the 2018 Winter Faculty Fellowship Program.

Faculty are invited for two-week competitive academic fellowships designed to link scholars from diverse disciplines and similar research interests to develop collaborations, research projects, co-authoring opportunities and to establish exchange programs between faculty and students.

Along with exploring contemporary Israeli society and culture, academics meet with professionals and experts in government, industry, education, media and other sectors to understand Israel's evolving national and international policies for addressing regional and global challenges.

Startups and spinouts

NanoCheQ

Founded by recent biomedical engineering graduate Nitish Peela

Developing nanoparticle-based rapid, easy-to-use diagnostic tools for bacterial and chemical contaminants.

nanocheq.com

Sonoran Biosciences, Inc.

Founded by Associate Professor Brent Vernon's research group

Preclinical-stage pharmaceutical company focused on the prevention and treatment of surgical site infections through the targeted delivery of antibiotics directly to the surgical site.

sonoranbiosciences.com

Aneuvas Technologies, Inc.

Founded by Associate Professor Brent Vernon's research group

Developing a novel medical device to treat and eliminate the threat of aneurysms in the brain with a device that promotes a bioactive healing response with a quick and minimally invasive technique.

Droplet Inc.

Founded by recent biomedical engineering graduates Levi Riley, Byron Alarcon, Sheldon Cummings and Rex Moore

Developing a process for the reliable fabrication of polymer microparticles to be used in the drug delivery and therapeutics industry.

linkedin.com/company/droplet-llc

Endovantage

Founded by Associate Professor David Frakes

Developing a cloud-based computational modeling platform that uses a patient's CT scan to create a personalized 3D vasculature model for visualization and anatomical measurements.

endovantage.com

IST

Founded by Associate Professor William "Jamie" Tyler

Developing wearable, bioelectronic neurostimulation platforms and focused ultrasound neuromodulation technologies for treating pervasive human medical disorders and to optimize human performance.

isensetec.com

Hoolest

Founded by biomedical engineering graduate student Nicholas Hool

Developing a new wearable technology that activates the body's natural relaxation response.

hoolestpt.com

NanoPin

Founded by Tony Hu

Developing a diagnostic platform for infectious diseases that pulls target biomarkers directly from blood samples and significantly enhances signal strength for rapid detection and optimal treatment.

"The top 10 world ranking in patents is a reflection of ASU's vibrant, innovative and entrepreneurial culture with a focus on impacting society," says Sethuraman Panchanathan, executive vice president of Knowledge Enterprise Development and chief research innovation officer at ASU. "I'm incredibly proud of the contributions and achievements of our faculty, researchers and students. This shows what can be accomplished when you empower the academic community to engage in use-inspired research focused on societal challenges."

SBHSE PATENTS

Acceleration-Sensing Electrochemical Pressure Sensor Compositions
Jim Blumsom, **Jeffrey La Belle,** Peter Lazaravich
Patent #9,909,942

Use of Superhydrophobic Surfaces for Liquid Agglutination Assays
Antonio García, John Schneider
Patent #9,995,688

Apparatus, Systems, and Methods for Current Monitoring in Ultrasound Powered Neurostimulation
Bruce Towe
Patent #10,022,566

Neurostimulator
William Crisp, **Bruce Towe**
Patent #10,016,612

Engineering of a Novel Breast Tumor Microenvironment on a Microfluidic Chip
Roger Kamm, **Mehdi Nikkhah, Danh Truong**
Patent #10,017,724

10th

ASU was 10th in the National Academy of Inventors' list of top 100 worldwide universities granted utility patents in 2018. Of ASU's 130 patents, 79 were filed by engineering faculty and staff. The School of Biological and Health Systems Engineering earned five patents for innovative work in biomedical engineering.

Microfluidic chip about to earn second patent

Assistant Professor **Mehdi Nikkhah,** his recent doctoral student **Danh Truong** and their collaborators aren't the only group developing microfluidic chips, but their chips have key innovations that set them apart from the others. Nikkhah's team was granted a U.S. patent in 2018 for a chip that played a role in discovering how fibroblasts promote the spread of cancer cells. Another three-layer, 3D chip design is pending a U.S. patent in 2019. It adds the possibility of studying how tumor cells enter into capillaries and circulate throughout the body, which promotes cancer metastasis.

Hoolest lends an ear to anxiety relief

When he decided to pursue a doctoral degree after earning a bachelor's degree in biomedical engineering, Nicholas Hool also knew he wanted to start his own company based on his dissertation research.

Hool's graduate research focuses on vagus nerve stimulation and neural engineering and its applications in anxiety relief. From the beginning of his studies, Hool's mentor, Associate Professor William "Jamie" Tyler, was a strong supporter in helping him reach his goals.

"When I joined the PhD program, he and I both knew that I wanted to start a company and build some kind of novel stimulator," Hool says of Tyler. "It started in his lab and now that we're officially a company, we've licensed the tech back from ASU and we're our own private entity. Jamie is still around — I see him a lot and he's still our number one supporter and who I rely on for good advice."

Hool founded his company Hoolest Performance Technologies, Inc. alongside computer engineering graduate student Sami Mian and electrical engineering undergraduate student John Patterson in May 2017. They designed and built an affordable, easy-to-use device modeled after music earbuds. By stimulating the vagus nerve, the device helps users get up to an hour-long relaxing effect after using the device for only 10 minutes.

Less than a year after founding the company, Hoolest took home the first-place prize of $100,000 at the 2018 ASU Innovation Open finals. Hool believed they were successful in the competition because of the size of the market and the social impact the device could have.

"Every single person in that room could relate to the problem we're solving," Hool says. "300 million people in America are familiar with stress and anxiety and would pay to overcome it."

After building several prototypes of the earbud and completing another round of seed funding, they're currently working on getting U.S. Food and Drug Administration clearance as a medical device.

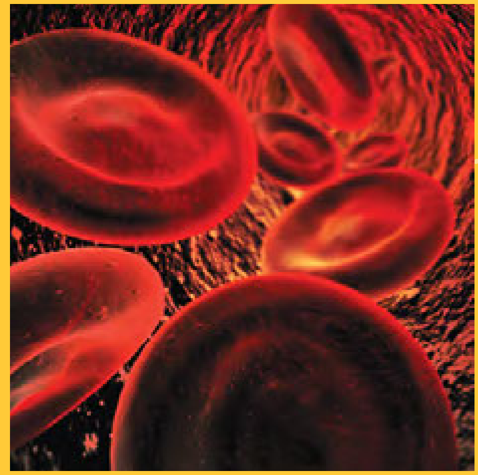
"Since the start of 2019, we've really been hitting hard trying to figure out everything for FDA clearance, what sort of safety testing we have to pass, running a clinical trial and talking with doctors and FDA consultants," Hool says.

The startup's first clinical trials will focus on the product's effect on managing anxiety attacks for those diagnosed with anxiety disorders, such as post-traumatic stress disorder, panic disorder and even anxiety associated with overcoming addiction. Leading up to this stage in its development, Hoolest has talked with potential customers to "show them the devices and get a feel for what they really need and what's lacking in the market," Hool says.

Hoolest is using the WearTech Applied Research Center in Phoenix to run its user testing and to strategize next steps.

"The data looks good so far," Hool says. "We just have to keep collecting so we have a large enough sample size to make sure it's statistically significant. We don't want to be just another wellness device. We want to make sure our product provides real value with real clinical applications."

Pinning down tuberculosis diagnoses



NanoPin, founded by Tony Hu in 2017, is developing a proprietary technology that uses a nano-particle based platform, coupled with high-throughput mass spectroscopy, to detect and quantitate disease biomarkers in patient blood samples.

Specifically, Nanopin addresses the urgent need for more accurate, cost-effective diagnostic tools for tuberculosis, a deadly disease estimated to affect some 10 million people worldwide and cause 1.7 million annual deaths.

Tuberculosis can be difficult to diagnose using conventional methods, particularly in children and "paucibacillary" cases in which the abundance of mycobacterium — the causative agent of the disease — is very low. Speed is also a critical component. The current gold standard diagnostic test can take six to eight weeks to yield a final result as opposed to NanoPin's rapid diagnostic.

The versatile platform holds the promise for rapid diagnosis of a range of diseases. NanoPin received $2 million in seed funding to develop this diagnostic and monitoring platform for tuberculosis management.

Charla Howard, PhD

Entering graduate school in 2008, Charla Howard knew she wanted to research gait analysis and lower limb prosthetics.

Working under Professor James Abbas, Howard gained research experience and developed the skills that would help her tackle any new challenges in her career.

"It is imperative to be taught specific skills while in school, but it is rare those skills translate directly to your future work," says Howard, who earned her doctorate in bioengineering and biomedical engineering in 2017. "I always felt I had the guidance I needed to help me learn, but was also taught to think for myself."

She now works as a research scientist at Ripple LLC, a Salt Lake City-based company that develops neuroscience research tools and medical devices. Working with a multidisciplinary engineering team, Howard ensures prosthetic systems improve the experience and lives of prosthesis users. Howard's work is currently focused on the clinical evaluation of implantable medical devices for improved control of prosthetic limbs, which utilizes her expertise in prosthetics, neurophysiology and biomechanics along with additional skills she has developed in study design and data analysis to assess complex neuroprosthetics systems.

Christopher Workman, MS

As a prospective undergraduate student, Christopher Workman realized ASU was the right choice when he saw the projects biomedical engineering students were working on.

"I had good evidence that ASU could help me make a quantum leap to that level," Workman says.

His education up to that point, along with "nearly unlimited opportunities beyond the classroom," were good preparation for a meaningful career. The extracurricular programs challenged Workman to make useful contributions through his engineering skills. As an undergraduate researcher, he was able to talk to community members about how biomedical research could affect the lives of their loved ones and then get to work on solutions.

Workman had the opportunity to talk about his biomedical engineering research with the ASU engineering school's namesake, Ira A. Fulton.

"He said that I was a good investment," Workman says. "It felt good to be supported and it made me want to accomplish more."

His lab research and work cofounding computing and artificial intelligence startups with other students equipped him to take on ambitious challenges similar to those he now faces in his career.

After graduating with his master's degree in biomedical engineering in 2015, Workman joined Google as a hardware engineer. He currently pushes the boundaries of what's possible in "moonshot" projects at Google Advanced Technologies and Projects.

He's optimistic about the future of technology and inspired by the people at Google who are dedicated to users' needs.

Undergraduate

Sydney **Connor**
Robert H. Chamberlain Memorial Scholarship Award

Sarah Rosemary **Davis**
Katie Conrad Memorial Award

Jarrett **Eshima**
NSF Research Experiences for Undergraduates program
Eshima completed his first authored publication during the REU at Georgia Tech University.

Madeleine **Howell**
NSF Research Experiences for Undergraduates program
University of Michigan
Goldwater Fellowship

Karolena **Lein**
Outstanding SBHSE Undergraduate Research Assistant

Gabrielle **Mills**
Recipient of the prestigious Gates Cambridge Scholarship

Levi **Riley**
Outstanding SBHSE Senior
Spring 2019 Outstanding Graduate: Biomedical Engineering
"I believe the skills engineering education teaches are indispensable," Riley says. "They have allowed me to take my knowledge of abstract subjects and apply it to solve real-world problems."

Jordan **Todd**
Robert H. Chamberlain "Memorial Scholarship Award
Hosted talk at 2018 Biomedical Engineering Society Annual Meeting
Todd's research focuses on synthetic platelets reducing neuroinflammation in experimental traumatic brain injury.

Doctoral

Jennapher **Lingo VanGilder**
NIH NRSA F31 Predoctoral Fellowship with three years of support
"Using diffusion tensor imaging to identify the structural neural correlates of visuospatial and motor skill learning processes." Mentor: Sydney Schaefer
Advancing Science in America award
"Achievement Reward for College Scientists," sponsored by Dr. Robert and Nancy Spetzler correlates of visuospatial and motor skill learning processes." Mentor: Sydney Schaefer

Joel **Lusk**
Selected for oral presentation at Biomedical Engineering Society National Conference

Danh **Truong**
Fall 2018 Ira A. Fulton Schools of Engineering Convocation Speaker
"My biggest achievement is seeing the students I mentored succeed in their research and be able to move on to great jobs or graduate school," Truong says.

Christopher **Miranda**
Selected for oral presentation at Biomedical Engineering Society National Conference

Peiyuan **Wang**
Phoenix Pride Scholarship Award

Graduate

Scott **Boege**
Outstanding SBHSE Teaching Assistant

Ethan **Marschall**
Outstanding SBHSE Graduate Research Assistant


Karolena Lein presents her research at the Fulton Undergraduate Research Initiative Symposium.

Team awards

Emmanuella **Adjei-Sowah,** Dzifa **Kwaku** and Ermyntrude **Adjei**
2019 MasterCard Foundation Scholars Research Fund Award
Mentor: James Abbas

Joshua **Cutts,** Danh **Truong,** Victoria **Smith** and Jennapher Lingo **VanGilder**
Achievement Rewards for College Scientists Foundation Award


Danh Truong speaks at the fall 2018 Ira A. Fulton Schools of Engineering Convocation ceremony.

Student medtech design team heads to London

Mariam El Sheikha and Kelsey Boos work on their stroke rehabilitation device. The students presented their project in summer 2019 during the PLuS Engineering Summer School Showcase.

When Mariam El Sheikha's grandfather suffered a stroke in Egypt, "not only did he not have access to the biomedical devices we have in the U.S., he didn't have access to comprehensive physical therapy," says El Sheikha, a biomedical engineering student. "I wanted to do something that will help people's lives."

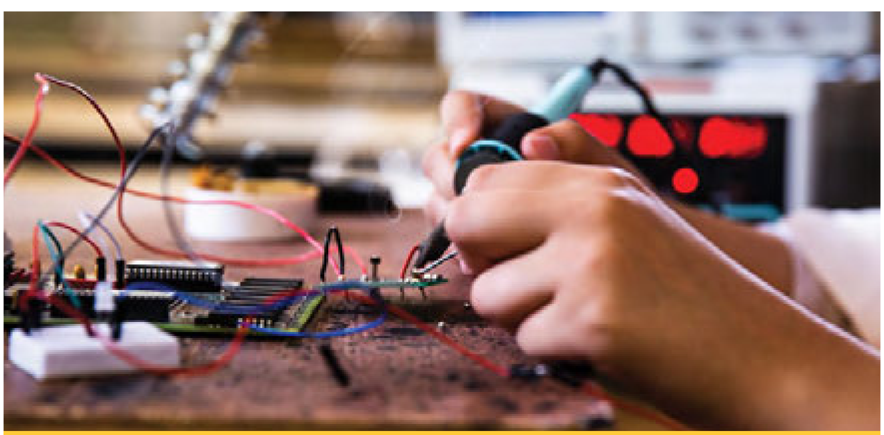
El Sheikha and fellow undergraduate biomedical engineering student Kelsey Boos are working on the design and initial development of a therapeutic medical device that enhances physical therapy for upper limb function recovery for people who have had strokes.

Both women were involved in a bioengineering interdisciplinary product development team for a class focused on the fundamentals of developing and bringing to market a biomedical device. Students applied the entrepreneurial mindset to industry best practices, including ethics, Food and Drug Administration regulatory processes and business practices.

The class of 20 students, split into four core technology groups (circuits, electrodes, microprocessor and systems integration), were challenged to develop a low-cost, noninvasive (nonsurgical), self-directed device that would facilitate at-home therapy for stroke patients that would speed recovery and function — while reducing treatment costs and minimizing adverse events associated with implantable devices.

The team assignment was based on a relatively new stroke therapy that uses a surgically implanted vagus nerve stimulation device to enhance physical therapy after stroke. According to recent studies, vagus nerve stimulation in concert with therapy can as much as double upper limb function recovery.

"When stroke causes damage to the brain, repetitive physical therapy supports neural



The device, worn externally, stimulates the vagus nerve through it auricular branch, which is located near the ear. It is designed to speed recovery and function, reduce treatment costs and minimize adverse events associated with implantable devices.

plasticity — a reorganization of neural circuits, which, over time, assigns lost functions to new pathways and ultimately improves motor function," says Jeffrey Kleim, an associate professor of biomedical engineering.

The external device built by the team is worn as an earpiece that stimulates the vagus nerve located near the ear.

El Sheikha was a member of the electrodes design team, where she developed the electrode circuit for the earpiece. Boos, the section leader for the systems integration team, designed an earpiece that accurately targeted the auricular branch of the vagus nerve for stimulation, while also guiding her team in the integration of the Xbox Kinect technology.

"It was a valuable learning process to see that it could be done with multiple groups of people," Boos says about the process that had teammates working in their assigned areas before coming together to integrate all of the components.

According to Vincent Pizziconi, an associate professor of biomedical engineering and interdisciplinary product development team course instructor along with Kleim, the novel concept of using Kinect technology has the potential to set the project apart from other medtech competitors.

The project is the perfect gateway between biomedical engineering and medicine — both El Sheikha and Boos are studying for their Medical College Admissions Tests as they travel the course to medical school.

"As a doctor, it's important to investigate how you can improve a device and provide feedback to the technology developers," El Sheika says.

In summer 2019, the two women traveled to London to debut their device on a world stage in London as part of the PLuS Engineering Summer School program. The program is part of the PLuS Alliance international knowledge sharing collaboration between ASU, King's College London and UNSW Sydney.

El Sheikha and Boos presented their project and got feedback from international perspectives.

Girl power: Biomedical engineering students lead STEM outreach effort

The ASU chapter of Society of Women Engineers hosts about 100 local Girl Scouts each spring for Girl Scouts in Engineering Awareness and Retention, or GEAR Day.

In spring 2019, biomedical engineering seniors Gabrielle Mills, ASU's Society of Women Engineers chapter president, and Amber Sogge, the organization's outreach officer, led the event with a multidisciplinary group of chapter members. They encouraged girls to apply their creative skills, learn how engineering helps people and build prototypes using the STEM skills they learned.

The event included girls and boys from schools across the Phoenix metropolitan area during its afternoon sessions.

"Part of establishing a foundation on which the next generation of female engineers can achieve is not only reliant on empowering girls to pursue engineering," Sogge says, "but encouraging the boys to value their input and see them as equals."

Biomedical Engineering Society student chapter earns top national recognition

Past Biomedical Engineering Society ASU chapter presidents Ethan Marschall, Allison Marley and past vice president Scott Boege hold their Commendable Achievement Award after giving their speech at the BMES Annual Meeting. Photo courtesy of Ethan Marschall.

The ASU chapter of Biomedical Engineering Society recently earned the Commendable Achievement Award, marking it as one of the best chapters in the nation. The award recognizes the ASU BMES chapter for its activities, outreach and impact.

"The commitment among the leadership in this group is outstanding," says Associate Professor Sarah Stabenfeldt, faculty advisor for the chapter.

The chapter's central location in the Phoenix metropolitan area gives it the ability to tour places such as Mayo Clinic and Stryker. BMES also brings in guest speakers from a wide variety of backgrounds, such as neurosurgeons from Barrow Neurological Institute and engineers from biomedical companies such as Medtronic. The organization pairs each industry speaker with a faculty member for presentations.

The student leaders had an opportunity to discuss their operations at the BMES Annual Meeting's Outstanding Chapter presentation.

"During our presentation at the conference, a student from another university's chapter asked us how to get faculty involved at their events," said Scott Boege, past vice president for the chapter. "This is something we take for granted since we have a plethora of unique and engaging faculty members who love to talk at our events."

BMES also does outreach, going to local schools and presenting to classes and participating in ASU's events that open labs to the public and volunteering with local nonprofit Project C.U.R.E.

Solving health's Grand Challenges

Engineers solve the world's biggest problems, but they need more than technical skills to create meaningful solutions.

The Grand Challenges Scholars Program, a National Academy of Engineering endorsed program at ASU, challenges students to become transdisciplinary, collaborative and global problem solvers.

During the 2018-2019 academic year, 13 students in the Ira A. Fulton Schools of Engineering were added to the official NAE Grand Challenges Scholars Registry, including four biomedical engineering students.

The students choose one the NAE's 14 Grand Challenges facing society, including health, to conduct coursework and experiential opportunities in service learning, multicultural awareness, entrepreneurship, developing an interdisciplinary perspective and conducting research or a creative project related to their theme.

Biomedical engineering graduates Bhavna Ramesh and Ekta Patel worked to solve health-related Grand Challenges through their research project. They worked together to develop a pressure ulcer risk assessment device for patients confined to hospital beds. When areas of a patient's body that don't have much fat between bone and skin make contact with the hospital bed, the skin can break and cause pressure ulcers, which are painful and can often cause irreversible damage.

Ramesh took on an interdisciplinary research approach that involved studying and using machine learning techniques to develop a patient classifying algorithm. Working on a patient device helped Patel feel more prepared for medical school. Both students believed the experience helped them become more well-rounded scholars.

Ramesh, Patel and their team are also dipped their toes into the entrepreneurial side of medical device development, working with clinical mentors at Phoenix Children's Hospital to obtain a patent on their device.

Studying novel infectious disease treatments across the pond

Biomedical engineering senior Gabrielle Mills was selected as a 2019 Gates Cambridge Scholar — an outstanding, socially committed U.S. student who will continue fully funded postgraduate studies at the University of Cambridge in the U.K.

Mills began pursuing a doctoral degree in chemical engineering in fall 2019. She is building upon her interest in epidemiology and its engineering applications that she developed at ASU.

"I seek to be a leader in the worldwide pursuit to alleviate the burden of disease on developing populations by delivering technologies that are simple, inexpensive and, above all else, feasible in their applicable environments," Mills says.

Mills is the fourth Gates Cambridge Scholar from ASU in the past five years. Scholars are chosen for their outstanding intellectual ability, leadership potential and a commitment to improving the lives of others.

NSF fellowship helps grad improve lives with synthetic biology

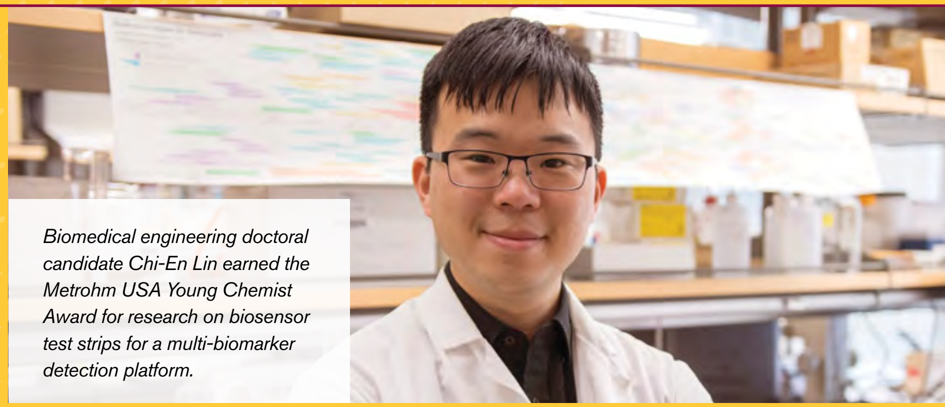
During her second year at ASU, Lexi Bounds joined Assistant Professor David Brafman's lab and studied the concept of in vitro disease modeling to find new approaches to understand how Alzheimer's disease starts so scientists can develop better treatments.

This research led the recent biomedical engineering graduate to be selected as one of 2,000 National Science Foundation Graduate Research Fellows in 2018. Bounds is continuing her research at Duke University where she studies biomedical engineering with a focus on synthetic and systems biology, tissue engineering and regenerative medicine.

The program supports outstanding students considered to be potential leaders in science, technology, engineering and math. Bounds joins a group of students who are contributing to the high-impact research, teaching and innovation needed to maintain the nation's technological strength, security and economic vitality.

Students

Multi-biomarker detection tech earns doctoral candidate Young Chemist Award



Biomedical engineering doctoral candidate Chi-En Lin earned the Metrohm USA Young Chemist Award for research on biosensor test strips for a multi-biomarker detection platform.

Chi-En Lin's revolutionary biosensor doctoral research earned the Metrohm USA Young Chemist Award in 2018.

This marked the second year in a row an ASU graduate student earned the award.

Due to the complex nature of diseases and the potential risk of multiple diseases occurring simultaneously, current state-of-the-art detection methods are insufficient. They only monitor a single biomarker at a time, and it takes weeks or even months to eventually get a comprehensive picture of a person's health. By then, the body has already changed.

The underlying mechanism for Lin's multi-biomarker detection technology is called optimal frequency, which works similar to radio channels. Channel one detects biomarker one, channel two detects biomarker two and so forth.

To create this multi-biomarker detection platform, Lin designed and developed biosensors similar to blood glucose test strips for diabetes management. These are relatively robust, easy to use and obtain results rapidly — ideal characteristics for clinical diagnostics, disease management and early screening.

Selected biomarkers include saliva and tears for noninvasive glucose monitoring, tear diagnosis for dry eye disease, insulin levels for diabetes management, immunosuppressant levels for organ transplants, cardiovascular sensors for heart disease and screening tools for breast cancer.

His research was sponsored by Advanced Tear Diagnostics, Mayo Clinic and the Industrial Technology Research Institute of Taiwan, as well as a few startup companies. He also collaborated with genetic engineering exchange scholars from the Tokyo University of Agriculture and Technology.

As a bioengineer recognized for great chemistry on a medical device, Lin's doctoral research is highly interdisciplinary and includes electrochemical biosensors, wearable technology and advanced manufacturing.

NIH supports motor rehabilitation research

Biomedical engineering graduate student Jennapher Lingo VanGilder completed her first semester of a three-year National Institutes of Health Ruth L. Kirschstein Predoctoral Individual National Research Service Award Fellowship.

The fellowship supports predoctoral students in their research with supervision by four advising mentors and additional training.

Lingo VanGilder is conducting her research in the ASU Motor Rehabilitation and Learning Lab under the guidance of her mentor, Assistant Professor Sydney Schaefer. The research at the lab

investigates the representation of motor learning processes within the aging brain. Millions of older adults who undergo motor rehabilitation for neural damage, especially from strokes, may not benefit from their therapeutic regimens due to diminished motor ability. Lingo VanGilder and Schaefer's approach to study aging brains differs from the typical method of recording human movement to understand the brain's structure and function.

"Our work to date has all been behavioral in nature," Schaefer says. "Jennapher's neuroimaging work is critical for us to begin understanding some mechanism underlying our previous findings, which will allow us to develop targeted motor therapies for older adults."

Lingo VanGilder's project extends the previous findings that motor learning ability is related to visuospatial function, the ability to perceive objects in 3D space. Her work aims to determine the neural basis of motor learning and visuospatial integration and provide a clinical tool that can be used to predict how well someone is able to learn or relearn new motor skills.

"We may be able to administer a quick and easy pencil-and-paper test prior to therapy to determine if that individual will respond to motor rehabilitation," Lingo VanGilder says. "This may aid in a clinician's ability to select appropriate therapies."

Giving

Join us in our vision to become a leading biomedical engineering program that effectively engineers novel solutions to improve human health and provides unique interdisciplinary training for the next generation of biomedical engineers.

Donations support senior projects, student and faculty research and improve the educational tools and opportunities we offer our students.

To make a donation of any amount, call Kati Martinez at kati.martinez@asu.edu, or mail your gift to Ira A. Fulton Schools of Engineering, ATTN: Kati Martinez, P.O. Box 879309, Tempe, Arizona, 85287-9309.

Please make checks payable to the “ASU Foundation” with “SBHSE” noted in the memo line.

Published by the School of Biological and Health Systems Engineering, one of the Ira A. Fulton Schools of Engineering at Arizona State University P.O. Box 879709, Tempe, Arizona, 85287-9709

480-965-3028

sbhse.engineering.asu.edu

To manage your mailing list preferences, visit: engineering.asu.edu/mailing-list

We love to hear from our alumni.
Send us your updates:
engineering.asu.edu/alumni-updates

Ira A. Fulton Schools of Engineering
Arizona State University

School of Biological and Health Systems Engineering
P.O. Box 879709 ▪ Tempe, AZ 85287-9709
sbhse.engineering.asu.edu