



# Engineering the future of medicine

School of  
**Biological and  
Health Systems  
Engineering**

**2015-2016**

**Annual Report**

[sbhse.engineering.asu.edu](http://sbhse.engineering.asu.edu)

# ASU Charter

ASU is a comprehensive public research university, measured not by whom we exclude, but rather by **whom we include and how they succeed**; **advancing research** and **discovery of public value**; and assuming fundamental **responsibility for the** economic, social, cultural and overall health of the **communities it serves**.

## What's inside





## Dear friends and colleagues,

I am happy to share with you our annual report about the School of Biological and Health Systems Engineering at Arizona State University. We have very exciting news about faculty and students and the positive impact that their work has on our community.

The school continues to expand the breadth and depth of expertise by hiring new faculty and engaging in many collaborative initiatives with industry and clinical partners. Honors, awards, publications in prestigious journals, and competitive extramural funding are some of the metrics that exemplify the quality and significance of contributions made by our faculty and students.

We are firmly dedicated to improve the quality of life and health of our community. To attain this objective, we continue to engage the biomedical industry and clinical community in tackling challenging clinical problems, while leveraging our faculty's interdisciplinary expertise and attracting talented students and faculty. The School's ultimate goal is to provide the next generation of biomedical engineers with the skills necessary to become problem solvers, innovators, leaders, and entrepreneurs.

If you want to stay up to date with our most recent achievements, please visit our website at [sbhse.engineering.asu.edu](http://sbhse.engineering.asu.edu) or drop by for a visit to experience firsthand what makes our students and faculty unique.

We look forward to hearing from you.



Marco Santello, Ph.D.  
Director, School of Biological and Health Systems Engineering



Fall enrollment  
**2016**

Doctoral  
**83**

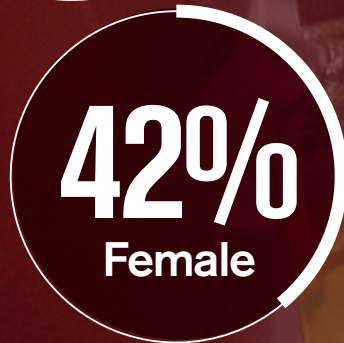
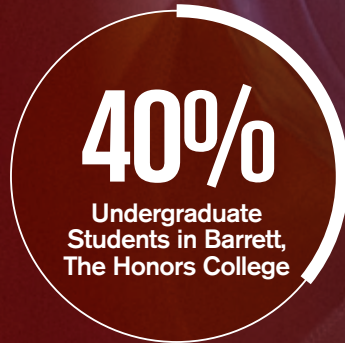
Master's  
**83**

Bachelor's  
**843**

Total  
**1,009**

Ranked  
**13th**

among bioengineering  
departments for research and  
development expenditures by  
NSF HERD



Degrees granted  
**2015**

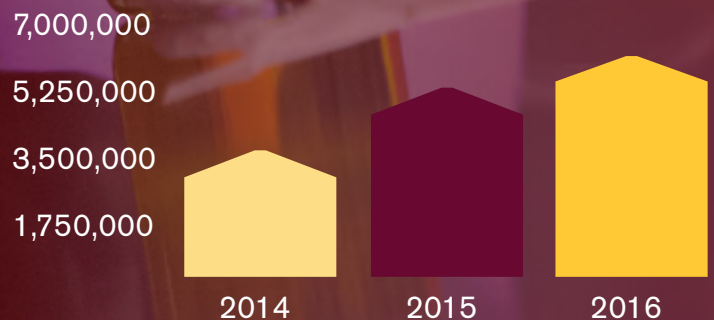
Doctoral  
**12**

Master's  
**79**

Bachelor's  
**153**

Total  
**244**

## Research expenditures





## Jeffrey Kleim

The **Fulton Exemplar Faculty** program recognizes tenured and tenure-track faculty distinguished by the unique combination of having high research productivity, instructional load, student evaluations and doctoral student mentoring.

Associate Professor Jeffrey Kleim studies how neural plasticity — the brain's ability to reorganize itself by forming new neural connections — supports learning in the intact brain and “relearning” in the damaged or diseased brain. His research focuses on developing therapies that

optimize plasticity in order to enhance recovery after stroke and Parkinson's disease. These experiments are being used to test therapies for enhancing motor recovery in stroke patients, including possible new drugs and electrical and magnetic stimulation of the brain to reverse the impacts of brain disease and injury. He has received multiple teaching and research awards, including several grants from the National Institutes of Health to develop therapies for traumatic brain injuries.



## David Brafman

Assistant Professor David Brafman established the ASU Stem Cell Training and Research (STaR) program with a grant from **Women & Philanthropy**, an ASU Foundation group that awards four ASU grants per year, including one in the field of biomedicine.

Stem cell research is at the cusp of new treatments and therapies for millions of patients suffering from debilitating conditions such as spinal cord injuries, Alzheimer's disease and cancer.

In particular, human pluripotent stem cells, which have the unique ability to generate all the mature cell types of the adult human

body, could revolutionize the manner in which scientists and clinicians study and treat these devastating diseases.

Brafman is recruiting, educating and training the first generation of ASU stem cell engineers — providing a pipeline of scientists that will not only broaden, but also increase, the impact of current interdisciplinary research being conducted at ASU.

STaR's training activities promote the translation of stem cell-based therapies from bench to bedside, resulting in new treatments benefiting patient communities in Arizona and beyond.



## Bench to bedside: Self-replicating cells help study, treat neurological disorders

Scientists estimate that human bodies contain anywhere from 75 to 100 trillion cells. And of these cells, there are hundreds of different types.

Yet one cell type in particular has captured the fascination of Assistant Professor David Brafman: the human pluripotent stem cell (hPSC).

As self-replicating cells — capable of dividing and forming new cells — hPSCs offer immense research potential. They are able to provide the raw material needed to generate the hundreds of different cell types that comprise the human body.

Think of it as a reverse *e pluribus unum*. Something like out of one, come many.

Brafman has received a \$420,000 grant from the National Institutes of Health to take discoveries related to hPSCs out of the research lab and into the clinical setting where they can transform, even save, lives.

In particular, his research focuses on using the remarkable qualities of hPSCs to generate large quantities of hPSC-derived neurons, which are instrumental in advances toward the study and treatment of Alzheimer's disease, ALS, spinal cord injuries and other neurodegenerative disorders.

"Neurodegenerative diseases and disorders remain some of the leading causes of mortality and morbidity in the United States," says Brafman.

According to the Alzheimer's Association, the disease affects more than 130,000 individuals statewide and is the fifth leading cause of death in Arizona.

"Several bottlenecks limit the translation of hPSCs and their derivatives from bench to bedside," says Brafman, referring to the need to take this research from the laboratory bench to the clinical bedside.

For one, it requires billions of cells for research in disease modeling, drug screening and cell-based therapies to be successful. So far, a rapid and comprehensive generation of these cells hasn't been possible, and Brafman's research aims to usher in the large-scale expansion of hPSC-derived neurons needed for these treatments and research applications.

"If successful, this work will provide researchers robust methods to generate the large quantities of cells needed for clinical applications," says Brafman.

This NIH funding builds upon previous funding support from the Arizona Alzheimer's Consortium, the Mayo Clinic, the California Institute of Regenerative Medicine and the National Science Foundation.

### Enhancing stem cell research at ASU

In addition to his NIH funding, earlier this year Brafman earned a grant from the ASU Women & Philanthropy Association for his work in establishing the ASU Stem Cell Training and Research (STaR) program, paving the way for ASU and Arizona to become world leaders in the development of stem cell-based technologies and therapies.

"The use of stem cell-based technologies to treat devastating diseases requires a strong stem cell engineering program that will train young scientists with specialized knowledge and skills," Brafman explains.

The STaR program will combine coursework, practical laboratory training and internship experience to provide ASU graduates with not only the knowledge, but also the hands-on skills required for careers in basic and translational stem cell research. In early 2016, ten students in STaR's first cohort completed their laboratory-based training courses and have begun their research internships in a diverse set of ASU laboratories.

Brafman also developed and taught the first-ever course at ASU in stem cell engineering.

"Dr. Brafman has brought a unique and much needed expertise to ASU in stem cell engineering," says Marco Santello, director of the School of Biological and Health Systems Engineering.

Santello says Brafman's expertise allows his research program to "attract top students and build interdisciplinary collaborations within ASU and several clinical institutions in the Phoenix area."



*Assistant Professor David Brafman mentoring biomedical engineering junior Lexi Bounds, who conducts research in his lab and plans to pursue a career in stem cell research.*

## Neuroprosthetic research strengthens virtual hand feedback loop

In the video accompaniment to a research paper, the smile that flashes across a man's face as he wiggles his virtual fingers for the first time captures the essence of the work being done by Bradley Greger's team — it has the potential to be life changing for those who have lost a limb.

According to Greger, an associate professor of biomedical engineering, having “super amazing” robotic limbs isn't enough. “The hard part is the interface, getting the prosthetics to talk to the nerves,” he said. “It's not just telling the fingers to move, the brain has to know the fingers have moved as directed.”

Despite the excitement of being able to manipulate virtual fingers, or even fingers attached to a functioning prosthetic device, it is not the same as feeling like the device is part of your own body.

Research by Greger's team, published in the March 2016 issue of the *Journal of Neural Engineering*, is seeking to establish bidirectional communication between a user and a new prosthetic limb that is capable of controlling more than 20 different movements.

The paper was co-authored by Tyler Davis, Heather Ward, Douglas Hutchinson, David Warren, Kevin O'Neill III, Taylor Scheinblum, Gregory Clark, Richard Normann and Greger, all at the University of Utah. Greger, a neural engineer, joined the School of Biological Health Systems Engineering at ASU three years ago.

In the nervous system there is a “closed loop” of sensation, decision and action. This process is carried out by a variety of sensory and motor neurons, along with interneurons, which enable communication with the central nervous system.

“Imagine the kind of neural computation it takes to perform what most would consider the simple act of typing on your computer,” said Greger. “We're moving the dial toward that level of control.”

The published study involved implanting an array of 96 electrodes for 30 days into the median and ulnar nerves in the arms of two amputees. The electrodes were stimulated both individually and in groups with varying degrees of amplitude and frequency designed to determine how the participants could perceive the stimulation. Neural activity was recorded during intended movements of the subjects' phantom fingers and 13 specific movements were decoded as the subjects controlled the individual fingers of a virtual robotic hand.

The motor and sensory information provided by the implanted microelectrode arrays indicate that patients outfitted with a highly dexterous prosthetic limb controlled with a similar, bidirectional, peripheral nerve interface might begin to think of the prosthesis as an extension of themselves rather than a piece of hardware, explained Greger.

### Collaboration is key

“We have come a long way in our understanding of the nervous system, but we've reached the point where collaboration across disciplines has become essential,” said Greger. “The day of the lone professor making the Nobel Prize-winning discovery is gone. Now scientists, engineers and clinicians are working together as technology advances.” The team assembled for the research reported on in the recent journal publication involved investigators with expertise in neuroscience, bioengineering and surgery. Access to the wide collaboration available across the Fulton Schools was a key component in Greger's decision to join the biomedical engineering



*“Imagine the kind of neural computation it takes to perform what most would consider the simple act of typing on your computer,” said Greger. “We're moving the dial toward that level of control.”*

faculty. “At ASU, there is amazing research happening in the areas of robotics and computer and software engineering,” he said.

Greger cites the achievements of Professor Marco Santello, director of SBHSE, particularly Santello's “amazing understanding of how the hand works.” In future research, Greger hopes to use SoftHand, which Santello developed with the researchers at the University of Pisa and the Italian Institute of Technology, as the prosthetic hand controlled by neural signals.

“The environment here differs from the classical academic research environment,” he said. “ASU has made structural changes to the university, such as implementing schools that span multiple classical departments, in order to promote interdisciplinary research in the academic community.”

Also important to Greger is the opportunity to work with clinical collaborators at the Barrow Neurological Institute, Phoenix Children's Hospital and the Mayo Clinic here in the greater Phoenix area. He has several projects underway at BNI and PCH, and has begun working with Shelley Noland, M.D., a Mayo Clinic plastic surgeon who specializes in hand surgery, on continuing the published had prosthesis research.

“One of the most challenging hurdles in moving from research to getting prosthetics...to...those who need them is navigating the FDA approval process,” said Greger.

The rigor exercised by the Mayo Clinic in its research initiatives is unparalleled, according to Greger, who describes Mayo as “massively patient-care focused” with rigorous, controlled research parameters.





**Bradley Greger**

"At Mayo, nothing is haphazard," he said. "These rigorous standards help with navigating the FDA approval process and facilitate producing research results that can be readily duplicated."

### **Virtual reality in the neural engineering lab**

"We're now at the stage in this process where we ask patients to mirror movements between hands," explains Greger. "We can't record what the amputated hand is doing, but we can record what a healthy hand is doing." Asking the patient to wave both hands simultaneously, or to point at an object with both hands, will be integral to the latest tech employed in the feedback loop: an Oculus Rift virtual reality headset.

The advantage of the virtual reality headset is that the patient is able to interact directly with his or her virtual limb rather than by watching it on a screen.

Kevin O'Neill, who was an undergraduate on the research team at Utah and now is a doctoral student at ASU, is developing the technology that not only allows the patient to see what his or her virtual limb is doing, but also "decodes" the neural messages that enable the motion to happen.

"At first, when patients are learning to manipulate their virtual hands, they will be asked to strictly mirror movements of a healthy hand," explained O'Neill. "Once we have learned what information the signals contain, we can build a neural decoding system and have patients drive the virtual representation of a missing limb independently of a healthy hand."

For Greger, the most important next steps are getting the technology into human trials and then creating effective limbs that are available to patients at an affordable price.

"There are prosthetic limbs that are amazing, like the DEKA arm or the arm from Johns Hopkins' Applied Physics Lab. But the costs can be in the hundred thousand dollar range," he said. "We're working toward limbs that are accessible both financially and in terms of usability. We want to create limbs that patients will use as true extensions of themselves."



## Nonlinear dynamical networks research published in Nature Communications

When Associate Professor Xiao Wang, an expert in systems and synthetic biology, joined the faculty at School of Biological and Health Systems Engineering, Professor Ying-Cheng Lai approached him almost immediately. "I realized during the hiring process that we could collaborate on a variety of problems in the interdisciplinary field of nonlinear dynamics, complex systems, systems and synthetic biology," explains Lai, an electrical engineer.

And collaborate they did. Their paper, "A geometrical approach to control and controllability of nonlinear dynamical networks", was published in April 2016 in the prestigious Nature Communications, an open access journal that specializes in high-quality research from all areas of the natural sciences.

In recent years the focus of controlling complex networks has centered on controllability of networks hosting linear dynamics, leaving the more challenging problem of controlling nonlinear dynamical networks unaddressed. The paper examines the concept of attractor networks which, for the first time, allows the formulation of a quantifiable controllability framework for nonlinear dynamical networks. In particular, a network is more controllable if the underlying attractor network is strongly connected. The control framework was tested using examples from various models of experimental gene regulatory networks (GRNs). A counterintuitive finding is that due to nonlinearity, a proper amount of noise, or electromagnetic energy, can facilitate control, which was explained theoretically and demonstrated using GRNs.

"The work in this paper established a theoretical foundation to facilitate my lab's research on synthetic gene network construction and manipulation," says Wang. "The combination of this paper's findings and our ongoing experimental verifications will advance our understanding of synthetic gene networks."

The findings are applicable to many kinds of complex infrastructures — the same principles can be applied to the power grids or to the energy flow in a modern, sophisticated building, according to the researchers.

In biology, nonlinear dynamical networks with multiple attractors have been employed to understand fundamental phenomena such as cancer emergence, cell fate differentiation and cell cycle control. The study used GRNs to demonstrate the practicality of the control framework, which used low-dimensional, experimentally realizable synthetic gene circuits and a realistic T-cell cancer network of 60 nodes.

The research articulates control strategies and develops a controllability framework for nonlinear networks that exhibit multi-stability. A defining characteristic of such systems is that there are multiple coexisting attractors in the phase space. The goal is to drive the system from one attractor to another using physically realizable, temporary and finite parameter perturbation, assuming that the system is likely to evolve into an undesired state (attractor) or is already in such a state and, one wishes to implement control to bring the system out of the undesired state and steer it into a desired one.

The basic idea of attractor networks originated in Lai's group and was first discussed in a brief, perspective paper in the journal National Science Review.

The collaborations between Lai's and Wang's labs have been very active and productive for the past five years, according to Wang. "The collision between biomedical engineering and electrical engineering minds has worked out very well for us so far, and I certainly would like it to continue," he said.

## Tailored gene therapies address need in cancer treatment

### Kiani's research and teaching methods motivated by patient advocacy

Samira Kiani works at the intersection of genome engineering and synthetic biology. Kiani joined the Fulton Schools faculty in 2015 with plans to further meld those disciplines to develop the next generation of gene therapies in the fight against cancer.

An assistant professor of biomedical engineering, Kiani arrived at ASU from the Synthetic Biology Center at the Massachusetts Institute of Technology. She earned her M.D. from the Tehran University of Medical Sciences.

Kiani's focus has been in the area of gene editing or gene modulation, with a particular concentration on custom DNA binding proteins in human cells. Her focus expanded dramatically with the development of the Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR). Kiani said the CRISPR method made the customization of the binding proteins extremely flexible and made the technology of gene manipulation more accessible to labs and researchers around the world.

One of the keys is that the technology will allow for extreme personalization and precision of gene-based therapies but the tools can also be used for any cell reprogramming purposes.

"Previously, in order to find a treatment for gene therapy, they would put a foreign DNA into the patient's body but there were often adverse effects," Kiani said. "CRISPR allows us to edit the patient's native DNA for a customized treatment"

Kiani has expertise in the communication of science, and she hopes to build partnerships within the cancer treatment and research community that will allow her to further public outreach about work in her field.

Kiani said she was drawn to ASU by the interdisciplinary nature of the research and the growing focus on the intersection of medicine and engineering. She expects the long-term growth in synthetic biology at ASU to rival any in the country.



**Samira Kiani**





## **Biosensors and bioinstrumentation**

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

### **Personalized Molecular Diagnostics Laboratory**

**Director: Antonio Garcia**

The Personalized Molecular Diagnostics Laboratory (PMDL) uses global technology to develop highly sensitive, yet low-cost and robust diagnostic devices using nanotechnology. Special emphasis is given to tailor devices that can make public health systems in emerging nations more effective for infectious disease prevention. Recent advances have been featured in Spanish-, English- and Portuguese-language media outlets and are of interest to several Latin American countries.

### **Precision Diagnostics Lab**

**Director: Tony Y. Hu**

Hu's laboratory develops tools and methods to understand and regulate complex biological networks that are critical to the development of disease, and developing nano-micro-fabricated sensors for biomaterial characterization that can be used to improve precancerous lesion detection. Nano-micro-scale science, information and biomedicine are integrative components of our research, and are used in combination with advanced engineering tools to facilitate biomedical studies and develop robust diagnostics for global health initiatives.

### **La Belle Laboratory**

**Director: Jeffrey La Belle**

La Belle's laboratory is developing point-of-care medical technologies that enable more accurate detection, monitoring and management of disease. Work is use-inspired, and the goal is to help make rapid advances in healthcare with innovations that can be brought to market today.

## **Neural Microsystems Laboratory**

**Director: Jit Muthuswamy**

The primary focus of the Neural Microsystems Laboratory is to understand the molecular and cellular mechanisms of neuronal plasticity that will naturally enable development of ways to achieve greater functional recovery through neuronal repair and plasticity, specifically the molecular interactions between the neurons and extra-cellular matrix/substrate, and the role of specific intracellular proteins in the development of spontaneous electrical activity and subsequent synaptic function in single neurons. Using in vitro primary neuronal culture models and in vivo rodent models and innovative microtechnologies developed in our lab, the goal is to understand the mechanisms of structural and functional plasticity.

## **Smith Laboratory**

**Director: Barbara Smith**

The Smith Laboratory focuses on engineering solutions to better 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 towards early stage detection and diagnostic monitoring. The overarching goal is to translate technologies developed in the lab for improved patient outcomes.

## **Laboratory for Applied Nonlinear Dynamics**

**Director: Mark Spano**

The Applied Nonlinear Dynamics laboratory's primary research focus is nonlinear dynamics of complex systems. The research seeks to use nonlinear dynamical techniques to understand epilepsy and to develop techniques for prediction and intervention. Projects include development of iPad and iPhone programs integrated with biomedical instrumentation for the collection and processing of medical data and integration of the iPad/iPhone platforms into medical data acquisition and record keeping.



## Bioimaging

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

### Image Processing Applications Laboratory

**Director: David Frakes**

The Image Processing Applications Laboratory (IPALab) addresses current and important image processing problems in a variety of different fields. Ongoing research at IPALab includes projects that are biomedical, industrial and military in nature. The ultimate goal is to improve human quality of life through the development and use of advanced image processing technologies.

### Prognostic Biomedical Engineering Laboratory

**Director: Vikram Kodibagkar**

The Prognostic Biomedical Engineering (ProBE) Laboratory focuses on engineering solutions for prognostic imaging of the tissue microenvironment in the diseased state. Current research involves 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 noninvasively obtaining prognostic information early, in response to disease and treatment.

### neuro-Electricity Lab

**Director: Rosalind Sadleir**

Research in the neuro-Electricity Lab is concerned with modeling and imaging 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.

## Molecular, cellular and tissue engineering

**Biomaterials, molecular and cell therapies, drug delivery**

### BioActive Materials Laboratory

**Director: Michael Caplan**

Caplan's lab applies engineering mathematics to understand and engineer solutions for problems related to biomaterials and drug delivery. One ongoing study, in collaboration with Dr. Alex McLaren at Banner Health, seeks to understand and control where antimicrobials mixed into bone cement go when the cement is placed in an orthopaedic wound to fight infection. Another study seeks to understand and control endothelial response to the material used to construct medical devices (such as stents or vascular grafts) and other aspects of the cell's microenvironment. A third study seeks to develop multivalent (more than one binding site) molecular probes for biosensing or drug targeting applications.

## Massia Laboratory

**Director: Stephen Massia**

Massia's laboratory focuses primarily on cell material interactions. The principles of cell biology, biochemistry, 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 research interest in Nikkhah's Laboratory is focused on the integration of innovative biomaterials, micro- and nanoscale technologies and biology to develop regenerative medicine strategies for treatment of organ/tissue failure and to better understand the mechanism of disease progression in humans. Specifically, our studies are centered on engineering of vascularized tissue models for regeneration of damaged myocardium and elucidation of key molecular and cellular signaling involved in fibrosis and heart attack. In addition, our lab is actively involved in the development of technologically advanced tumor microenvironment models with 3D-configurable cell-matrix layers to conduct mechanistic and preclinical studies on cancer invasion.

## Laboratory of BioInspired Complex Adaptive Systems

**Director: Vincent Pizziconi**

The BioCAS laboratory seeks to understand the biodesign heuristics of integrative bionanosystems that can lead to the design and development of bioinspired advanced diagnostic and therapeutic components, devices and systems.

## Stabenfeldt Laboratory

**Director: Sarah Stabenfeldt**

Each year in the United States over one million individuals will experience a traumatic or ischemic-related brain injury, with 350,000 persons sustaining a severe to moderate traumatic brain injury (TBI) and an additional 800,000 people suffering from stroke. While the inherent regenerative potential of nervous tissue has been realized, the hurdles and barriers formed by scar and inhibitory molecules limit endogenous regeneration and repair. In evaluating current clinical therapies, there is an obvious need for improving diagnostic imaging and in turn targeted delivery of therapeutics to injured or ischemic tissue. This 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.





## Neural/rehabilitation engineering

**Modeling and simulation of neural systems and their functions, signal processing, specialized technology for individuals with physical impairments, monitoring and treatment of nervous disorders, chaos in neural and cardiac systems**

### Center for Adaptive Neural Systems

**Director: James Abbas**

The Center for Adaptive Neural Systems (ANS) 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 at ANS utilize a wide variety of interdisciplinary research techniques and technologies to aid individuals whose lifestyles may be significantly affected or impaired by traumatic injury or neurological disease.

### Visuomotor Learning

**Director: Christopher Buneo**

The Visuomotor Learning laboratory seeks to understand how the brain combines different forms of sensory and motor information to help plan, execute and adapt movements ("sensorimotor integration"). Of particular interest is how uncertainty associated with movement planning and execution leads to variability in motor performance. The long-term goals of the lab are to improve and enhance human motor performance through the development of brain-centered training protocols and assistive technologies that interface directly with the nervous system.

### Neural Engineering Laboratory

**Director: Bradley Greger**

The overarching goal of the lab is to utilize current neuroscientific understanding and neural engineering principles to translate clinical needs into devices which improve quality of care and patient outcomes. Electrophysiological recordings and electrical micro-stimulation are used to gain an understanding of how the nervous system processes information related to various sensory, motor and cognitive functions. The results of these experiments are then used to guide implementation of novel devices for the treatment of various neural pathologies. Neural prostheses for treating the profoundly blind or paralyzed are being developed. Additionally, the lab is undertaking electrophysiological research in human patients using penetrating and non-penetrating electrode arrays aimed at improving our understanding of epilepsy and improving the diagnostic tools available to clinicians.

### The Sensorimotor Research Group

**Director: Stephen Helms Tillery**

Helms Tillery's group analyzes sensorimotor learning and representations in the nervous system and neural mechanisms which enable the brain to carry out fine motor skills. By duplicating that process, the goal is to advance the ability to create more lifelike prosthetics that respond to brain signals.

## Human Mobility Lab

**Director: Claire Honeycutt**

There are two major research thrusts of the Human Mobility Lab: fall prevention and enhancing arm function in individuals with neurological disease and injury. In fall prevention, we seek to understand what causes falls, identify those people most likely to fall, and develop interventions to prevent falling. In enhancing arm function, we use robots, virtual reality systems, and electromyography to evaluate motor planning both in unimpaired individuals and patient populations. We work with clinicians to enhance rehabilitation strategies at the hospital, clinic and home.

## Kleim Laboratory

**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**

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

## Neural Control of Movement Laboratory

**Director: Marco Santello**

Work at 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. The questions addressed by Santello's laboratory include the role of vision and tactile input for learning and controlling dexterous manipulation, neural mechanisms underlying the synergistic control of multiple hand muscles, and the effects of neurological disorders and neuropathies on neural control of the hand. This 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 Laboratory

**Director: Sydney Schaefer**

Research in the Motor Rehabilitation and Learning Laboratory is aimed at understanding mechanisms of motor skill learning, particularly in the context of age-related structural and functional changes within the brain. Studies are designed to optimize noninvasive, behavioral interventions for improving upper extremity motor function in geriatric neurological populations with underlying cognitive impairments, such as stroke and Parkinson's disease.



## **Tyler Laboratory**

**Director: Jamie Tyler**

The Tyler Laboratory focuses on developing neuromodulation devices and methods for enhancing human performance. An emphasis in the lab is aimed at better understanding the role of micromechanical forces in brain circuit function while developing technology for modulating or regulating these features to treat neurological and neuropsychiatric conditions, as well as to optimize healthy human functions like language learning, sensory processing, sensorimotor skill training, decision making, and vigilance/attention.

## **Synthetic biology and systems bioengineering**

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

## **Stem Cell Bioengineering Lab**

**Director: David Brafman**

The Stem Cell Bioengineering lab utilizes human pluripotent stem cells (hPSCs) 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.

## **Ebrahimkhani Lab for Synthetic Biology and Regenerative Medicine**

**Director: Mo Ebrahimkhani**

Research in Ebrahimkhani's lab combines mouse models with systems and synthetic biology-based approaches to advance multiscale regenerative technologies. Through engineering morphogenetic processes in human induced pluripotent stem cells, we pioneered development of a self-organized vascularized human liver platform called "complex organoid." We study cellular dynamics and perform human disease modeling using this platform. The lab vision is to advance human liver therapeutics through systems and synthetic biology.

## **Bioengineering, Policy and Society Lab**

**Director: Emma Frow**

The Bioengineering, Policy and Society Lab uses qualitative social science research methods to explore key questions concerning the governance of emerging biotechnologies. Our 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, evidence and expertise in experimental stem cell treatments, and the future of engineering education.

## **Haynes Synthetic Biology Laboratory**

**Director: Karmella Haynes**

The Haynes Synthetic Biology laboratory uses synthetic systems and quantitative biology to engineer useful gene and protein-based biological devices and deepen our understanding of molecular cell biology. The ultimate goal of the laboratory is to accelerate the pace of therapeutic technologies through modular design.

## **Laboratory for mammalian synthetic biology and therapeutic gene circuits**

**Director: Samira Kiani**

Kiani's lab employs logic-based design principles of synthetic biology to develop programmable Cas9 and gRNA-based gene modification tools that would allow us to modify cellular gene expression pattern based on predefined logic and design. Our motivation is to control "when," "where" and "how" CRISPR functions towards safer and more specific gene therapies.

## **Xiao Wang Laboratory**

**Director: Xiao Wang**

Wang's laboratory seeks 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. The focus is on synthetic multistable gene networks, systems biology on small network motifs with feedback, the role of noise in cell differentiation and development and 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 healthcare organizations, both locally and globally — offers our students access to top physicians and researchers, and hands-on experience in the field they may one day transform. Whether students choose to pursue medical school or join industry after graduation, this early exposure is invaluable.



# Industry engagement

## Collaborating on curriculum

### Industry engagement efforts pay dividends for student career opportunities and the curriculum

Close, collaborative partnering with industry ensures that curricula within Fulton Schools are up-to-date and prepare students for the constantly shifting workforce.

For instance, the rapidly changing, kinetic environment that is the medical industry means that Marco Santello, director of the School of Biological and Health Systems Engineering, has a responsibility to maintain industry relationships and build new ones to best prepare students entering the field.

In addition to their partnerships with companies such as National Instruments, Bard Medical, Medtronic and Gore Medical, SBHSE has close relationships with physicians.

"It's really important for our students to not only be engineers but to understand medical needs," said Santello. "There's nothing better than actually shadowing a physician. The technical details are important, but understanding what the patient needs is even more important."

Serving a patient's needs is not easily taught in the classroom, which is why students have the opportunity to intern at a variety of locations across the Valley, including the Mayo Clinic, Barrow Neurological Institute, Banner Health and Phoenix Children's Hospital.

Marco Santello



## W.L. Gore partnership shapes curriculum and careers

A great partnership is one that helps both parties to excel in their goals. The Ira A. Fulton Schools of Engineering and W.L. Gore & Associates have one specific goal in mind — to educate and employ world-class engineers who will move Arizona's economy forward.

This partnership began more than a decade ago with a gift from Gore to the Fulton Schools and remains vibrant today.

Gore is a technology and science-based enterprise that has a reputation for creating innovative, technology-driven solutions. Healthcare professionals and biomedical engineers respect their contributions in medical devices and implants, while outdoor enthusiasts and material scientists esteem them for producing high-performance Gore-Tex® fabrics.

### Co-developing a future workforce

Gore's interest in supporting Fulton Schools' students stems from its dependence on a highly skilled workforce in Arizona.

"Arizona is our home and for us to stay and thrive we require world-class workers to come out of universities like ASU," said Mike Vonesh, who offers leadership for the technical team in the Medical Products Division.

Founded in Delaware in 1958, Flagstaff, Arizona became the hub of Gore's medical product division in the early 1970s. They recently expanded into northern Phoenix with new manufacturing facilities — making collaborations with ASU even more accessible.

Gore has an open dialogue with Fulton Schools about traits and experiences that the ideal engineering graduate should possess.

"We consider the Fulton Schools our partners. They hear our voice about what skills sets we're looking for in graduating students and are willing to structure curriculum based on the industry's needs," said

Vonesh, adding that ASU is uniquely receptive in this regard, which makes its graduates very desirable.

Vonesh serves as an industry representative on the board for the School of Biological and Health Systems Engineering. "He offers the industry perspective in terms of the skill set that industries need from engineers and therefore what we should be implementing in our curriculum," said Marco Santello, a biomedical engineering professor and the School's director.

By investing in all three of Arizona's universities Gore is creating a strong workforce that helps their company to succeed and returns a dividend to the Arizona economy.

"We don't look at these gifts as philanthropy, but rather as a trusted investment," said Vonesh.

### Supporting student success programs

Students in the Fulton Schools benefit from Gore's collaboration through industry involvement in engineering research projects, support for undergraduate scholarships, student organizations and programs that enhance the student experience.

Gore champions and supports the Fulton Schools Accelerated 4+1 program, which allows students to earn a bachelor's and master's degree in engineering in five years.

Gore also judges design reviews for the Engineering Projects in Community Service (EPICS) Program. At these reviews students present their team's project before an industry panel for technical feedback, allowing them to further improve the design and implementation of their engineering solutions.

"Gore supports many engineering programs that impact a number of our students," said Margo Burdick, associate director of development in the Fulton Schools. "Besides their philanthropic support they are very supportive with their time by attending many Fulton Schools' events throughout the year."







*"I focus on identifying areas where Gore can partner with the Fulton Schools to enhance the student experience such as funding and support for EPICS projects, undergraduate scholarships and particular research programs," said Carolina Tostado, alumna and Gore recruiting liaison.*

Gore has been particularly involved in supporting biomedical, chemical, mechanical, manufacturing, electrical and materials science engineering programs, which are disciplines related to Gore's technological focuses.

Many of Gore's innovations stem from the use of proprietary technology with the versatile polymer polytetrafluoroethylene, which is used in fabrics, products for electronic signal transmission, medical implants, as well as filtration, sealant and fibers technologies for diverse industries.

Gore has been granted more than 2,000 patents worldwide and more than 40 million Gore Medical Devices have been implanted, saving and improving the quality of millions of lives around the world.

### **Alumni stay involved through partnership**

Dozens of Fulton Schools' students have been employed by Gore since the collaboration began. A handful of these students remain closely tied to ASU through recruitment and outreach efforts.

Biomedical engineering '12 alumna Carolina Tostado supports new product development as a quality engineer and is also one of Gore's College Champions for ASU. In this role, she serves as a recruiting liaison between college recruiting and technical associates at Gore and ASU.

"I focus on identifying areas where Gore can partner with the Fulton Schools to enhance the student experience such as funding and support for EPICS projects, undergraduate scholarships and particular research programs," said Tostado.

Tostado regularly attends a variety of events at ASU including Engineering Career Fairs, Career Exploration Night for Freshmen, on-campus interview events, student organizations' meetings, EPICS design reviews and industry panels.

She is joined by Fulton Schools alumni and current Gore employees Annette Dunn, mechanical engineering '11, Lindsey Jossund,

chemical engineering '05, and Daniel Dominguez, mechanical engineering '15.

"In addition to recruiting efforts, we work to identify ways that Gore can connect with students and faculty. Our goal is to build relationships and participate in activities that benefit all three parties: engineering students, ASU and Gore," said Jossund, who works as a technical leader for one of Gore's medical products.

"I am always energized by the innovative work from students on campus," said Dunn, who interned with Gore after her junior year and currently works as an engineer in new product development. "I think it's important to build strong connections between industry and the university to continue to be inspired and help grow top talent."

Dominguez began working for Gore in 2015 as a process engineer, but his familiarity with the company and their partnership with the Fulton Schools began as a student.

"I interacted with Gore as a student through information sessions, recruiting events, an internship and scholarship support," said Dominguez.

He enjoys making campus visits on behalf of Gore because it is a way for him to help students through professional mentorship and funding. "Interactions like these are important to me because this is how I paid for school, participated in extracurricular activities and stayed focused on academics," he said.

Tostado shares this commitment saying, "As someone who relied on mentors during college to shape my engineering career, I hope that I can provide some guidance and share opportunities with students that can help them be successful. This makes me feel like I am paying back to my community."





Associate Professor David Frakes (center) works alongside former students and Fulton Schools alumni at Google's Advanced Technology and Projects group. ATAP specializes in the rapid creation of transformative new technologies. Left to right: Rafeed Chaudhury, Vinay Venkataraman, David Frakes, Christopher Workman, Eric Aboussouan. Photo courtesy of David Frakes/Google ATAP

## ASU professor leads Google ATAP project, teams up with former students

What began with a series of grants to advance research in computer vision quickly culminated in a relocation to Google's main campus for Associate Professor David Frakes.

In March 2015, Frakes moved to Mountain View, California, to become a technical project leader in Google's Advanced Technology and Projects (ATAP) group.

He oversees ATAP's Mobile Vision program composed of 16 full-time researchers. The team includes three ASU graduates, two of which Frakes supervised at the graduate level, and another of Frakes' former students has also joined a different team at ATAP.

ATAP, originally started by Motorola and purchased by Google in 2011, specializes in bringing to market transformative technologies on a short timescale. The group is modeled after the Pentagon's Defense Advanced Research Projects Agency (DARPA) and run by Daniel Kaufman, the former DARPA Director of the Information Innovation Office.

Like DARPA, Google ATAP operates in what Frakes describes as a "pressure cooker" for big ideas — meaning tangible results, demonstrating the project can reach convincing scale, and must be obtained within two years or it is shelved to make room for the next big project. And also like DARPA, ATAP projects are kept under tight wraps.

### Former students turn coworkers

Strong relationships with students have characterized Frakes' career. He has mentored 20 doctoral students, 32 master's students and 207 undergraduates — including students pursuing undergraduate research as part of capstone senior design projects, the Fulton Undergraduate Research Initiative and Barrett, the Honors College — since joining ASU in 2008.

ASU alumni Eric Aboussouan and Christopher Workman work alongside Frakes, their former professor and graduate supervisor, in the Mobile Vision program.

Aboussouan, who has worked for Google ATAP since 2014, actively supported Frakes in landing the position at ATAP.

"It's very gratifying not only to see your students go on and do great things, but also to have a relationship with them where they want to keep working with you professionally," said Frakes.

Workman began conducting research in ASU's Image Processing Applications Laboratory, led by Frakes, during his sophomore year. He went on to earn bachelor's degrees in biomedical engineering and biochemistry in 2014, and graduated with a master's degree in biomedical engineering under Frakes' supervision in 2015.

"Throughout [my time in Frakes' lab], he challenged me to approach the solutions to problems people face in creative ways," said Workman. He credits the "inquisitive way of thinking" championed by Frakes with enabling the smooth transition into his position as a prototyping engineer.

"It is completely exhilarating to have an opportunity to create at the edge of what we think is possible. I can't imagine a more fulfilling place to begin my career than Google ATAP," said Workman.

Vinay Venkataraman, who earned a doctoral degree in electrical engineering from ASU in 2016, is also a new member of Frakes' ATAP team. Rafeed Chaudhury, who earned a bachelor's degree in biomedical engineering from ASU in 2015, conducted research with Frakes as an undergraduate and is now working on a separate team at ATAP.

"Everything that I learn and every way that I grow during my time at Google ATAP I get to bring back to the ASU faculty and my students," Frakes said of his experience.





## Symposium unites researchers, community partners

The Molecular, Cellular and Tissue Bioengineering (MCTB) Symposium held at Arizona State University on Saturday, April 2, 2016, was the first in what will be a series of annual events designed to bring ASU biomedical engineering faculty together with research centers from across the valley and the country.

The MCTB group at ASU, cutting across multiple engineering disciplines, has partnerships with world-class clinicians, translational and basic scientists and engineers in the Phoenix area, as well as with faculty from ASU's Biodesign Institute and the School of Life Sciences. MCTB research specifically includes metabolic engineering, biosensors, molecular and nanoscale bioengineering, microelectromechanical systems (bioMEMS), cellular mechanics, drug and gene delivery and protein engineering.

Four research thrusts were covered during the symposium: Regenerative Medicine and Tissue Engineering; Synthetic and Systems Biology; Biosensors and Diagnostics, and Contrast Agent and Therapeutic Delivery.

## Sharing work in progress

The conference offered opportunities to share research-in-progress with both interdisciplinary faculty members and with clinicians and partners, according to Sarah Stabenfeldt, a bioengineering assistant professor in the School of Biological and Health Systems Engineering.

For example, a nurse practitioner from Arizona Arrhythmia Consultants addressed patient and provider perspectives on bio-monitoring, a business development executive from Medtronic outlined what the company looks for in collaborative research projects, and a researcher from Barrow Neurological Institute addressed biological barriers to drug delivery systems.

"The symposium enabled us to share new findings and directions with those who will ultimately use that research in practice; but we also heard about our partners' priorities," explained Stabenfeldt, who noted that attendees included representatives from area medical and research centers, such as the Mayo Clinic, Phoenix Children's Hospital and Barrow Neurological Institute.

Also presenting work in each of these thrusts were keynote speakers from Stanford University, the University of California at Los Angeles, the University of Washington and University of Texas Southwestern. "Some of the work presented is yet unpublished, and it's exciting to see where the research is headed," said Stabenfeldt. "I know of at least four potential collaborations that were discussed at the symposium. Many of us are working along parallel lines – the symposium is an opportunity for us to gather in one place at the same time to share ideas, learn about each other's research, and perhaps forge new collaborations."

Coordinated by the school, the symposium received financial support from by the dean's office in Ira A. Fulton Schools of Engineering. Participants represented "the Fulton Schools of Engineering and beyond," Stabenfeldt explained, citing presentations by Fulton schools faculty from the School for Engineering of Matter, Transport and Energy and the School of Electrical, Computer and Energy Engineering, as well as ASU units like the Biodesign Institute and the School of Life Sciences.

"The symposium was an excellent platform to showcase outstanding bioengineering research carried out at ASU to our local and national peers," said co-chair Kaushal Rege, associate professor of chemical engineering. "This also was a wonderful medium for our students and trainees at ASU to learn about cutting-edge bioengineering research and technologies that can transform human health in the future. We hope to grow this to be a sought-after yearly event in the southwestern United States."

## Poster competition for ASU students


A faculty-scored poster competition presented research projects from 16 ASU students. First place was awarded to Danh Truong, a biomedical engineering doctoral student advised by Assistant Professor Mehdi Nikkha, for "Microengineered Breast Cancer Invasion Platform." Second place went to Vimala Bharadwaj, a biomedical engineering doctoral student co-advised by Assistant Professor Vikram Kodibagkar and Stabenfeldt, for "Next Generation Precision Diagnostics For Brain Injury." Cassandra Barrett, a biological design doctoral student advised by Assistant Professor Karmella Haynes, received third place for "Investigating crosstalk in natural quorum sensing systems to design synthetic signaling networks."

As the symposium continues to grow, Stabenfeldt expects to attract a wider range of both presenters and attendees. "The opportunity to share the discoveries and insights across our research clusters is valuable for all of us," she said.



**Sarah Stabenfeldt**



A photograph of an ice climbing activity. In the foreground, three people are smiling and making peace signs. They are wearing helmets and climbing gear. The background shows a steep, snow-covered mountain slope with a person climbing in the distance. A yellow text box with a quote is overlaid on the upper part of the image.

**“We had no real agenda,”  
said Helms Tillery. “The  
goal was to spark the  
students’ imaginations  
as they became better  
acquainted with the  
world of adaptive  
devices and prosthetics.”**



## Adaptive ice climbing excursion heats up capstone thinking

Why should students wait until their senior year to start thinking about the culminating project of their undergraduate experience?

Biomedical engineering Professor Stephen Helms Tillery saw an ice climbing event as a good opportunity to excite junior year students about their upcoming capstone project.

The event, hosted in Ouray, Colorado by Paradox Sports, was an adaptive ice climbing event, meaning that all of the participating climbers had a disability — ranging from amputations to traumatic brain injuries.

Helms Tillery and his wife planned to attend the event out of personal interest, but then had the idea to include students on their three-day journey.

Helms Tillery invited three biomedical engineering juniors — Shawn Womack, Rene Reynolds and Shelby Martin — in hopes that the experience would be the basis for their capstone project the following academic year.

“We’re trying to enable students to take off running with their projects right at the start of their senior year,” said Helms Tillery.

The students volunteered at the event by helping to belay athletes, set up for events, and transport food and equipment. They also had the opportunity to interview and interact with the adaptive athletes, meet the founder of Paradox Sports and become acquainted with some of the businesses that produce adaptive climbing gear.

For the students, learning from and interacting with the participants was the most informative part of the experience.

“Their attitudes amaze me the most because most people think that [a disability] would get you down...but these athletes get up and go do outstanding, challenging activities, like ice climbing,” said Womack, who is also pursuing a minor in business administration.

“The participants don’t let their disability define them,” said Reynolds, adding, “These are the people I want to dedicate my life to helping out.”

Martin, who is just starting to figure out what area within biomedical engineering she would like to pursue in her career, said the event “opened my eyes to the field of prosthetics and adaptive athletics.”

Martin also felt particularly drawn to the participants, many of whom were wounded veterans, because her father served in the United States Army for more than 20 years.

Reynolds said the trip “provided a huge head start” to their capstone project.

“We had no real agenda,” said Helms Tillery. “The goal was to spark the students’ imaginations as they became better acquainted with the world of adaptive devices and prosthetics.”

This approach worked.

The group is currently narrowing down a list of ideas to tackle for their capstone project in the fall semester.

The team is interested in examining the unfortunate rigidity of some of the current prosthetic designs, including exploring the possibility of improved socket design to allow for enhanced movement in leg and arm prosthetics.

The team is also considering the possibility of implementing a pneumatic system in the amputated area. “A gas spring could activate or compress with applied weight to allow more movement and act more like a physiological leg,” said Womack. This device could improve control over body movement for those with neurological disorders.

Helms Tillery, an expert in neuroprosthetics, intends to mentor the students throughout their capstone project.

“It means the world to me...[that] Dr. Helms Tillery dedicated his time to helping and mentoring us. He really went above and beyond as a professor to provide this amazing opportunity,” said Reynolds.

Womack reflects on the experience saying, “I think we are better prepared to tackle our senior year and capstone because we now have an idea of what we would like to solve, and we have seen up close and personal how these individuals are affected by these devices every day.”

For Reynolds, the trip also confirmed that she chose the right field of study in biomedical engineering, which she said offers “the technological side of helping people.”

## La Belle highlights art, creativity at national academies conference

Jeff La Belle, assistant professor in Biomedical Engineering was one of only 100 faculty members selected to attend and present at the National Academies Keck Futures Initiative Conference on Art and Science, Engineering, and Medicine Frontier Collaborations: Ideation, Translation & Realization.

La Belle presented with a team of artists, engineers, musicians, dancers, a museum curator, a writer, a neuroscientist and a pediatrician about a solution to fusing art into STEM education. He will serve as the principal investigator on a future Keck grant based on the conference work.

“We presented a concept called the Undisciplined Classroom,” La Belle said. “Art is not a vehicle or tool to be used by STEM, it is fused with it. An embodiment of this is a sculpture called ‘What is Time?’”

La Belle, who is an engineer and a blacksmith, is building the metal sculpture of three Japanese Water Fountains. The liquid running through each has a different viscosity causing the bamboo shoots to drop and clang at different times with different notes. He notes that time, volumes, fill volumes, apparent viscosity are among the scientific principles that can be observed in the piece.





## Doctoral student develops better brain diagnostics

A plane ride, a magazine and a curious mind led Nathan Gaw to engineering.

Before a flight from Arizona to Chicago, Gaw picked up a National Geographic magazine that had a feature on neuroprosthetics. He read it once, then again and kept re-reading it until the plane landed.

"It was about using engineering to help translate really complicated signals from the brain, which I believe is the last frontier of the human body," Gaw said. "I was fascinated by how you can use technology and engineering to translate the brain's complex signals."

This moment was more influential to Gaw's decision to pursue engineering than his interest in math and science and growing up with an engineer for a father. And when college acceptance letters started coming in, it wasn't difficult for Gaw to choose Arizona State University even though he was accepted into the University of Pennsylvania, among other good options.

"I could have studied really hard at UPenn and never gotten my hands very wet with research, but ASU gives you more room to get involved in research and actually apply what you're learning on top of rigorous academics," Gaw said.

As an undergraduate, Gaw participated in research opportunities wherever he could, including in the Neural Control of Movement Laboratory, led by Marco Santello, a biomedical engineering professor and director of the School of Biological and Health Systems Engineering.

After he completed his biomedical engineering bachelor's degree, Gaw continued to study biomedical engineering for his master's, working on research to discover the underlying neural mechanisms the brain uses to give commands to the hand.

## Shift to industrial engineering facilitates advanced data interpretation

"Diagnostic data, such as results from an MRI, is very high dimensional, has high resolution and can be hard to interpret," Gaw said. "I decided [ ... ] to better understand what parts of the brain are important for different brain diseases and help make better diagnostic decisions based on information from the image."

He began to integrate industrial engineering studies into his research, which led to his involvement in genetic database data analysis research under Jing Li, an associate professor in both industrial engineering and computer engineering who became his doctoral advisor, and Teresa Wu, an industrial engineering professor.

Staying at ASU to pursue a doctoral degree in industrial engineering was a clear choice. The university's collaboration with Mayo Clinic and Banner Health doctors and other industry partners provided excellent opportunities for his medical focus.

Gaw's research involves developing theoretical methods to analyze data and apply those methods to help doctors solve problems they have with their data. The theoretical and practical approaches play off one another — once a data problem is solved, he can use that solution on other problems.

So far Gaw has been helping Mayo Clinic doctors use algorithms to analyze MRI and fMRI data to diagnose patients who have migraines, as well as using genetic and tissue contrast data to help diagnose tumors like glioblastoma brain tumors. Gaw has published academic

papers with doctors based on his research, one of which received the 2015 Harold G. Wolff Award and another was submitted to Cephalalgia, a publication by the International Headache Society.

## Strong professors inspire interest in teaching

In addition to the research opportunities he found, Gaw thinks ASU's program boasts world-class professors.

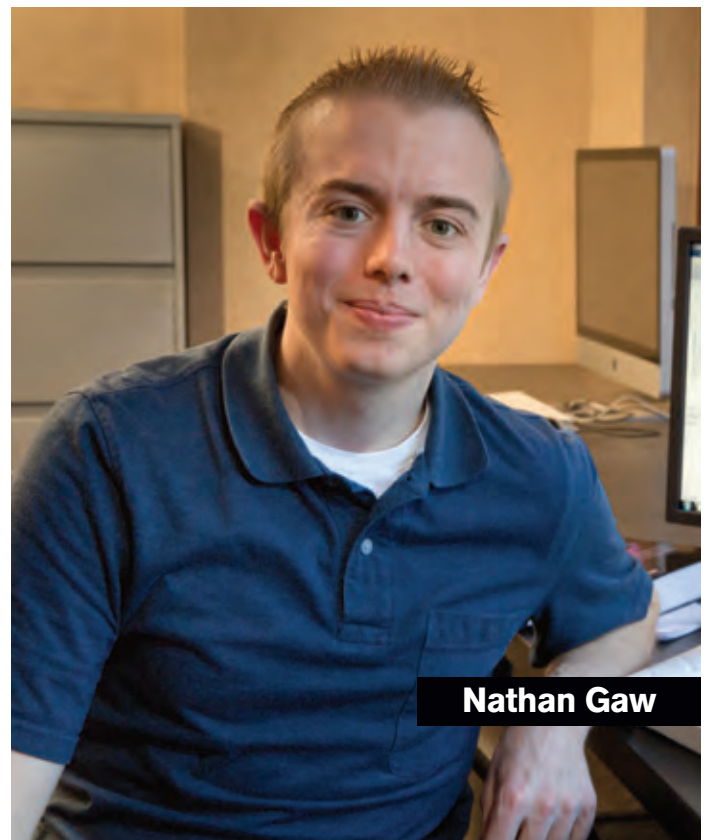
"Every professor you meet here is a superstar in their field," Gaw said. "I have a class with a professor who has taught at other great universities like Georgia Institute of Technology and has more than 70,000 citations in his lifetime. He is known across the entire world. Another professor revolutionized transportation engineering and has highly impacted the way traffic is managed. The drive of the professors and the way they teach and do their research shows they love what they do and they're very good at it"

Gaw finds that along with how influential and smart they are, they're also willing to help and connect with students.

"Professors are friendly and I feel comfortable stopping by their offices to pick their brains and ask questions about research, even if they're not my advisor," Gaw said.

Once Gaw finishes his dissertation on methods of integrating different data sources to make a decision, he wants to become a trailblazing professor like those he's learned from to pass on his knowledge at the intersection of medicine and engineering.

"I like to teach other people," Gaw said. "As a professor you get to mentor one-on-one and teach others in a bigger setting. I get to learn from people I collaborate with and teach them the tricks from my domain. It's fun to be a lifelong learner, and being a professor is one of the only jobs where you get paid to discover and explore."



**Nathan Gaw**



**Barrett Anderies**

## Goldwater scholar plans to pursue neuroscience in graduate school

In 2016, a mere 252 students were selected from a field of 1,150 nominees to be awarded a prestigious Barry M. Goldwater Scholarship — considered the premier undergraduate scholarship for mathematics, science and engineering majors. Out of those 252 exceptional recipients, four students hail from Arizona. Out of the four Arizonans, three are students in the Ira A. Fulton Schools of Engineering.

Over the last 10 years, ASU has become one of the nation's leading producers of Goldwater Scholars, with 27, outperforming lauded institutions such as Stanford, Princeton, Harvard and Yale. This year's SBHSE Goldwater Scholar, Barrett Anderies, is a double major in biomedical engineering and mathematics.

The honors student originally chose to pursue a biomedical engineering degree due to his interest in robotic prosthetics. He recognized that it was a field that required both biological and engineering expertise.

Anderies work in a neural engineering lab reinforced his interest to pursue graduate studies in neuroscience, where he plans to combine mathematical analysis, engineering tools, biological expertise and clinical experience to improve treatment of neurological disorders.

Anderies is currently participating in the Fulton Undergraduate Research Initiative (FURI) for the second straight semester where he works on quantitative analysis of electrocorticography data for rapid screening and identification of electrographic features in epileptic patients.

"My work has been focused on improving the performance of an experimental feature identification and extraction algorithm," he said. "I have managed to improve the algorithm performance to a point where automated analysis might soon be possible."

ASU President's Professor Eric Kostelich, a professor in the School of Mathematical and Statistical Science, suggested that Anderies should apply for the honor. His Goldwater application highlighted his research from his mathematics background.

"The goal of my mathematics research is to develop and validate mathematical models of tumor growth which are capable of estimating the missing information as well as making predictions about future tumor dynamics. This information could better inform treatment regimes on a patient-specific basis, resulting in improved patient survival and quality of life," he said.

The Goldwater Scholarship Program, honoring the late U.S. Sen. Barry Goldwater of Arizona, is intended to encourage outstanding students to pursue graduate studies and careers in engineering, science and mathematics fields. It provides up to \$7,500 per year to support completion of undergraduate studies. This year 252 students were selected from a field of 1,150 nominees.





# Innovative education

## Addington receives Dean's Dissertation Award

Caroline Addington, a fall 2015 doctoral graduate in bioengineering, has been named as winner of the Dean's Dissertation Award.

The dissertation award recognizes exceptional work by doctoral students that encourages the highest levels of scholarship, research and writing.

Addington is originally from Greenville, South Carolina, and received an undergraduate degree in bioengineering from Clemson University. She is a student of Assistant Professor Sarah Stabenfeldt.

Addington's dissertation is "Modulating chemokine receptor expression in neural stem cell transplants to promote migration after traumatic brain injury." The research focuses on the development of a platform to enhance efficacy of stem cell therapy after traumatic brain injury.

Addington said current stem cell transplants after a brain injury suffer low rates of retention and survival, limiting their effectiveness.

"We've worked to develop a novel biomaterial that enhances neural stem cell response to some of the pro-regenerative signaling locally available within the injury microenvironment," she said. "By increasing transplant response to some of these pro-regenerative signals, we hope to overcome the pathological signaling that is largely responsible for transplant death, thus increasing their therapeutic benefit"

For Addington, the work represents a significant progression into neural tissue engineering from her undergraduate focus of orthopedic tissue engineering.

"I have always been fascinated by the principles of tissue engineering and regenerative medicine, having worked in orthopedic tissue engineering as an undergraduate," she said. "While the orthopedic problem space was interesting, I am very interested in and excited about working on problems facing tissue engineering within the brain. There's still so much to learn about neural tissue and it's inspiring to be a part of a field tackling these problems."



Addington said she originally came to ASU in part to work with Stabenfeldt, who has been an "engaged and supportive graduate mentor." Likewise, Addington, who plans to pursue a career in academia, said her time working with and mentoring undergraduates has been particularly rewarding.

"Having mentored students for four years, I've been able to watch their growth into critical thinkers," she said. "As an undergraduate student, I was very fortunate to have been mentored by an exemplary graduate student and I enjoy passing the mentoring experience forward."

She will be working as a postdoctoral researcher under Jeffrey Kleim, an associate professor of biomedical engineering. In this role, she will couple her expertise in traumatic brain injury pathophysiology with Kleim's expertise in motor rehabilitation and neural plasticity.

# Outstanding graduates



**Sydney Vanda**  
Fall 2015 Outstanding Graduate,  
Double major with Computer  
Systems Engineering



**Caroline Addington**  
Fall 2015 Dean's  
Dissertation Award



**Nathan Kirkpatrick**  
Spring 2016 Outstanding Graduate



**Priya Nair**  
Spring 2016 Outstanding  
Graduate, Convocation speaker



**Emily Herring**  
Spring 2016 Distinguished  
Service Award



**Mikayle Holm**  
Spring 2016 Distinguished  
Service Award



## ASU alumni illuminate new way to treat jaundice

Sivakumar Palaniswamy, biomedical engineering graduate student, saw the shortcomings of current jaundice treatment firsthand while working in a hospital in India.

This sparked Neolight, a medical device company with an improved solution to treat jaundice in newborns, which was co-founded in 2014 by ASU alumni Chase Garrett, Deepak Krishnaraju, Vivek Kopparthi and Palaniswamy.

While jaundice is easily treatable with phototherapy, access to devices and electricity is scarce in the developing world, resulting in high rates of infant death or brain damage.

Neolight developed cost-effective LED (light-emitting diode) lights that function on a narrow spectrum, both speeding up treatment and eliminating side effects. Moreover, Neolight's device is compact, modular, simple and can run on renewable power.

An Edson Student Entrepreneur Initiative grant kick-started Neolight, which also gained \$600,000 in seed-funding this year. Palaniswamy spoke at the 2016 Clinton Global Initiative University (CGI U) where he committed to install 50 jaundice phototherapy devices in Assam, India.

In addition to its ties to ASU, Neolight has established partnerships with the Children's Hospital of Los Angeles and Dignity Health and plans to begin selling their device within the year.

## Biomedical engineering student secures Edson Student Entrepreneurship Initiative support

Emily Herring, a senior biomedical engineering student and Grand Challenge Scholar, is a recent Edson Student Entrepreneur Initiative winner for the project she co-founded, Adaptive Designs. The Edson Initiative provides opportunities for ASU's student startup teams to further their projects.

Adaptive Designs focuses on assisting people with developmental and cognitive disabilities. As part of the Engineering Projects in Community Service program, Herring worked with Scottsdale Training and Rehabilitation Services (STARS). She noticed individuals with cerebral palsy who had the ability to read were often unable to do so due to physical disabilities. Simply turning pages could require the assistance of a STARS staff member.

Herring and her team developed the idea of an e-reader that would allow people with disabilities to read independently. The design includes a sensor-activated page turner and an adjustable mount. This e-reader offers more than reading time, it can encourage feelings of independence and an improved quality of life.

"We are hopeful that through this program we will be able to expand the impact of our project and create a successful business that improves the lives of our customers," Emily Herring said.

The Edson program opens the doors to multiple opportunities for winning teams. The program offers office space, mentoring, seed funding and an educational program to further winning teams' startup works. During this semester, the Adaptive Design team has been able to conduct extensive market research and customer surveys through the assistance of contacts and mentors provided by the Edson program.





## James Abbas



**Associate Professor**

Ph.D., Case Western University

**Expertise:** Neural engineering, rehabilitation, prostheses, and biomimetic design

## Casey Ankeny



**Lecturer**

Ph.D., Emory University

**Expertise:** Cardiovascular research, bioreactors, microRNAs, shear, endothelial cell mechanobiology/pathology

## David Brafman



**Assistant Professor**

Ph.D., University of California, San Diego

**Expertise:** Pluripotent stem cells, drug discovery, disease modeling, biomaterials, Alzheimer's disease, cardiac diseases, pulmonary fibrosis

 Women & Philanthropy Award

## Christopher Buneo



**Associate Professor**

Ph.D., University of Minnesota

**Expertise:** Motor control, neurophysiology, neuroprosthetics

 Top 5% Teaching Award

## Michael Caplan



**Associate Professor**

Ph.D., Massachusetts Institute of Technology

**Expertise:** Rational design of bioactive materials, local drug delivery, multivalent drug-targeting, and cooperative bio-sensing

## Gordon Cohen



**Professor of Practice**

MD, Tulane University  
Ph.D., University of California, Los Angeles

**Expertise:** Fluid dynamics, hemodynamics, artificial heart technology, blood pumps, pharmacology, congenital heart disease, cardiac surgery, hypothermic circulatory arrest, cardiac imaging

 New faculty

## Jerry Coursen



**Lecturer**

Ph.D., University of Arizona

**Expertise:** Neuroscience, healthcare systems

## Mo Ebrahimkhani



**Assistant Professor**

M.D., Tehran University of Medical Science

**Expertise:** Synthetic biology, stem cell engineering and human organoids, synthetic morphogenesis, liver on a chip, immune regulation and tissue repair, in vivo liver regeneration and tissue dynamics





## David Frakes



**Associate Professor**

Ph.D., Georgia Institute of Technology

**Expertise:** Cardiovascular fluid dynamics, surgical and interventional planning, image processing

## Emma Frow

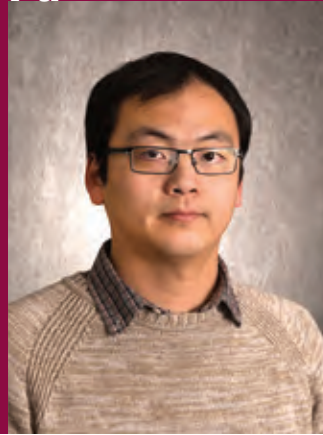


**Assistant Professor**

Ph.D., University of Cambridge

**Expertise:** Synthetic biology, science & technology studies, engineering studies, standard-setting, design and values

## Qiushi Fu



**Assistant Research Professor**

Ph.D., Arizona State University

**Expertise:** Neural control of human movement, design of robotic systems, control of robotic grasping and locomotion

## Antonio García



**Professor**

Ph.D., University of California, Berkeley

**Expertise:** Medical diagnostic devices, nanotechnology surface science

## Bradley Greger



**Associate Professor**

Ph.D., Washington University, St. Louis

**Expertise:** Neural engineering, vision restoration, neuroprosthetics, epilepsy

## Leland Hartwell



**Nobel Laureate and Professor**

Ph.D., Massachusetts Institute of Technology

**Expertise:** Identify biomarkers to enable personalized, pre-symptomatic diagnoses, develop tools for providing the intelligence needed for better patient outcomes

## Karmella Haynes



**Assistant Professor**

Ph.D., Washington University, St. Louis

**Expertise:** Synthetic biology, molecular genetics, controlling cell development, chromatin

## Stephen Helms Tillery



**Associate Professor & Fellow of the Lincoln Center for Applied Ethics**

Ph.D., University of Minnesota

**Expertise:** Cortical neurophysiology, neural control of movement, neuroprosthetics



# Faculty

**Claire Honeycutt**



**Assistant Professor**

Ph.D., Georgia Institute of Technology/Emory School of Medicine, Atlanta

**Expertise:** Neural control of balance, reaching and grasp

**Tony Hu**



**Associate Professor**

Ph.D., University of Texas at Austin

**Expertise:** Real-time therapeutic monitoring, early detection, nanotechnology-based strategies, personalized medicine



New faculty

**Samira Kiani**



**Assistant Professor**

M.D., Tehran University of Medical Science

**Expertise:** Programmable Cas9/CRISPR system, mammalian synthetic biology, genome engineering, synthetic genetic circuits and sensors, immunoengineering and cancer regulation

**Jeff Kleim**



**Associate Professor**

Ph.D., University of Illinois

**Expertise:** Neural plasticity; neurorehabilitation; stroke; Parkinson's disease



Top 5% Teaching Award, 2016 Fulton Faculty Exemplar

**Vikram Kodibagkar**



**Assistant Professor**

Ph.D., Washington University, St. Louis

**Expertise:** Cellular and Molecular Imaging of Cancer, MR oximetry, development and multimodality imaging of novel probes and reporter molecules

**Jeffrey La Belle**



**Assistant Professor**

Ph.D., Arizona State University

**Expertise:** Biosensors, point-of-care technologies, and sensing systems for health and environmental purposes

**Thurmon Lockhart**



**Professor**

Ph.D., Texas Tech University

**Expertise:** Biomechanics, biodynamics, biosensors, neuro rehabilitation, gait and posture, fall prevention

**Stephen Massia**



**Associate Professor**

Ph.D., University of Texas, Austin

**Expertise:** Cell-material interactions





## Troy McDaniel



### Research Assistant Professor

Ph.D., Arizona State University

**Expertise:** Haptics, ubiquitous computing, human-centered computing, and assistive/rehabilitative technology

## Jit Muthuswamy



### Associate Professor

Ph.D., Rensselaer Polytechnic Institute

**Expertise:** Neural interfaces, BioMEMS, Micro- and nano-scale technologies, gene delivery, robotics

## Mehdi Nikkhah



### Assistant Professor

Ph.D., Virginia Tech

**Expertise:** Cardiovascular tissue engineering, stem cell bioengineering, BioMEMS, cancer detection and metastasis

## Scott Parazynski



### University Explorer and Professor of Practice

MD, Stanford Medical School

**Expertise:** Medical devices, technology to aid those with physical disabilities and surgical robotics

## Vincent Pizziconi



### Associate Professor

Ph.D., Arizona State University

**Expertise:** Bioresponsive and biomimetic materials

## Rosalind Sadleir



### Assistant Professor

Ph.D., University of Western Australia

**Expertise:** Neuro imaging and neural activity detection, dynamic physiological monitoring, computational modeling

## Marco Santello



### School Director and Professor

Ph.D., University of Birmingham, Birmingham, UK

**Expertise:** Neural control of movement, neurophysiology, motor learning, hand biomechanics

## Sydney Schaefer



### Assistant Professor

Ph.D., Pennsylvania State

**Expertise:** Motor control and learning, cognitive neuroscience, clinical neurorehabilitation



New faculty



# Faculty

**Barbara  
Smith**



**Assistant Professor**

Ph.D., Colorado State University, Fort Collins

**Expertise:** Non-invasive, point-of-care medical diagnostics

**Mark  
Spano**



**Research Professor**

B.S., Saint Joseph's University

**Expertise:** Nonlinear dynamics of biological systems, dynamics of epilepsy, control of cardiac arrhythmias

**Arati  
Sridharan**



**Assistant Research Professor**

Ph.D., Pennsylvania State

**Expertise:** Neural interfaces, soft biomaterials, tissue biomechanics, targeted gene delivery technologies

**Sarah  
Stabenfeldt**



**Assistant Professor**

Ph.D., Georgia Institute of Technology

**Expertise:** Regenerative medicine, biomaterials, neural injury and repair, neural tissue engineering

**Jamie  
Tyler**



**Associate Professor**

Ph.D., University of Alabama at Birmingham

**Expertise:** Neural engineering

**Michael  
VanAuker**



**Lecturer**

Ph.D., University of Pittsburgh

**Expertise:** Cardiovascular mechanics, prosthetic heart valves, targeted drug delivery systems

**Brent  
Vernon**



**Associate Professor**

Ph.D., University of Utah

**Expertise:** Biomaterials, drug delivery, tissue engineering

**Xiao  
Wang**



**Associate Professor**

Ph.D., University of North Carolina at Chapel Hill

**Expertise:** Synthetic and systems biology







At the core of the School of Biological and Health Systems Engineering lives a single concept – the search for solutions to problems that impact human health and well-being.

Our students are excited about our program and ASU as evidenced by nearly doubling enrollment over the past five years and a freshman retention rate over 90 percent. Through strong academic leadership and teamwork, we offer a high quality of instruction — and achieved a perfect score during the recent Accreditation Board for Engineering and Technology review.

With a series of strategic hires, our faculty is growing and adapting to address challenges in biomedical engineering such as brain cancer, paralysis, amputation, stroke, and concrete solutions like specialized point-of-care devices, low-cost diagnostics, focused delivery of chemotherapeutic agents, and reengineering of stem cells. The School is gaining critical mass in neural engineering; molecular, cellular, and tissue engineering; synthetic biology; biomedical imaging; and biosensors, biomarkers, and biomimetic materials.

By taking novel approaches to important biomedical problems, our faculty have been successful in securing financial support in a very competitive environment, drawing from federal funding sources, including National Science Foundation, National Institutes of Health, and the Defense Advanced Research Projects Agency, as well as

clinical partners, industry and foundations. And this is just the beginning: our research expenditures are trending upward. In 2016, SBHSE research expenditures reached nearly \$6 million.

We continue to build relationships with industry and the clinical communities, both locally and nationally. Two initiatives exemplify our synergies with industry and clinical partners. One of these initiatives is an annual workshop in rehabilitation robotics — now in its fifth year — which brings together industry, academia, and clinicians in the multidisciplinary field of robotics, including human-robot interaction and human motor control. BRAIN (Building Reliable Advances and Innovation in Neurotechnology) is a new National Science Foundation Industry/University Collaborative Research Center in partnership with the University of Houston. The BRAIN center will address rigorous testing of efficacy, safety and long-term reliability of neurotechnology. This collaboration would be nearly impossible within the traditional 'silos' of academia, industry, regulatory agencies and clinical communities.

As the School looks ahead, we will continue to work at the intersection of engineering, medicine, physiology, biology and policy to develop use-inspired technologies with the potential to improve human health and well-being. Stay tuned, we look forward to sharing our exciting news with you!

**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 improving the educational tools and opportunities we offer our students.

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**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, AZ 85287-9709

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**Thank you... to all who attended  
the 5th ASU Rehabilitation  
Robotics Workshop on  
Feb. 6-7th, 2017**

**– Marco Santello**