

PULSE

AN ANNUAL PUBLICATION FROM THE DEPARTMENT OF BIOMEDICAL ENGINEERING



The University of Texas at Austin
Biomedical Engineering
Cockrell School of Engineering

2017-18

FROM THE CHAIR



“

We continue to attract undergraduate students who graduate in the top 3 percent of their class, and we prepare them with optimized hands-on learning and design experiences.”

THIS FALL MARKS MY SECOND YEAR serving as chair of the Department of Biomedical Engineering at The University of Texas at Austin. During my time here, I have worked closely with faculty to elevate our mission of advancing human health and health care delivery through outstanding education and research programs.

In the last year, our faculty have been recognized for their achievements, including an election to the American Academy of Arts and Sciences and as fellows of The Optical Society of America, Biomedical Engineering Society, and the American Institute for Medical and Biological Engineering, among other organizations. Two of our faculty members have been promoted to full professors, and our researchers have been awarded significant funding to further discovery in areas such as cancer treatment, drug delivery, immune engineering, and fundamental science.

We continue to attract undergraduate students who graduate in the top 3 percent of their class, and we prepare them with optimized hands-on learning and design experiences. This year, our impressive graduate students have been recognized for their specialized research by the Biomedical Engineering Society, Society for Biomaterials, the Functional Imaging and Modeling of the Heart Conference, and the International Society for Magnetic Resonance in Medicine.

In this inaugural issue of Pulse, our new annual publication, I am pleased to provide you with a snapshot of our department's successes and stories that exemplify our upward momentum. Read about innovative research advancements from two of our up-and-coming faculty members, meet our newest professor, and learn how our students and alumni are changing the world. We encourage you to keep in touch and to share your news with us. Your success is our success. Hook 'Em!

SHELLY SAKIYAMA-ELBERT

Chair, Department of Biomedical Engineering
Fletcher Stuckey Pratt Chair in Engineering
Cockrell Family Chair for Departmental Leadership #1

On the cover: Biomedical engineering researchers have developed ultra-flexible, nanoelectronic brain probes that integrate with neural tissue without forming scars. Learn more on page 3. Image courtesy of Ella Maru Studio.

ULTRA-FLEXIBLE NANOELECTRONIC PROBES

CREATING A SEAMLESS INTEGRATION WITH THE BRAIN

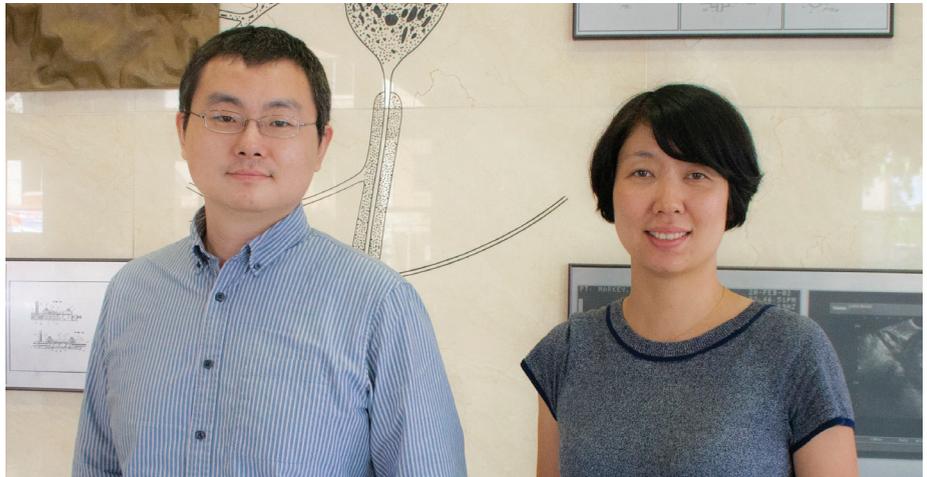
Bridging the gap between biology and technology is vital for the future of neurological health care. To further this goal, a team of UT Austin researchers has created a nanoelectronic (NET) neural probe so thin, the brain doesn't seem to mind that it is there.

The research group is led by Chong Xie, an assistant professor, and Lan Luan, a research assistant professor, both in the Department of Biomedical Engineering. The team has developed ultra-flexible neural electrodes that integrate with the brain without forming scar tissue. The NET probes are thousands of times more flexible than previous counterparts.

Conventional implanted neural probes are important to both fundamental and clinical neuroscience applications. In scientific research, they remain our only option to record data on individual neurons and provide critical information to dissect the neural circuitry. In the clinical setting, neural probes have successfully treated a number of disorders, by using techniques such as deep brain stimulation to treat Parkinson's disease and peripheral nerve stimulation to control pain. Implanted neural probes also allow for direct communication between brain and man-made devices, which could enable futuristic applications such as human brain-machine interfaces with neuroprosthetics.

However, conventional neural probes are limited by unstable performance and substantial invasiveness. A reliable neural interface has been pursued for decades but remains highly challenging. This instability arises from the distinct physical mismatch between neural electrodes and brain tissue.

Xie has found that ultra-flexibility may be the answer to creating a



Assistant Professor Chong Xie and Research Assistant Professor Lan Luan have developed ultra-flexible neural electrodes that could be used to control pain and treat disorders such as Parkinson's disease.

long-term stable neural probe. The NET neural probes are flexible enough to comply with the microscale movements of tissue and stay in place. They fully integrate with the local cellular and vascular networks of the brain, without scarring, and demonstrate the possibilities of achieving reliable long-term neural recording.

"The most surprising part of our work is that the living brain tissue, the biological system, really doesn't mind having an artificial device around for months," Luan says.

In the team's experiments in mouse models, the researchers found that the probe's flexibility and small size prevented the brain's glial cells from becoming agitated. Past disruptions from conventional probes included issues with scarring and neural damage.

"What we did in our research is prove that we can suppress tissue reaction while maintaining a stable recording," Xie says. "In our case, because the electrodes are very, very flexible, we don't

see any sign of brain damage—neurons stayed alive even in contact with the NET probes, glial cells remained inactive and the vasculature didn't become leaky."

To ensure that the NET structures did not degrade within the mice models over four months of testing, the researchers also used advanced imaging techniques in collaboration with biomedical engineering professor Andrew Dunn, as well as neuroscientists Raymond Chitwood and Jenni Siegel from the Institute for Neuroscience at UT Austin.

The team published a paper describing their findings in the Feb. 15, 2017 issue of *Science Advances*. This summer they received additional funding from the National Institutes of Health, which will allow them to investigate the performance of NET probes over longer periods of time and in larger animal models with wider ranges of motion, more closely mimicking how the probes could interact in humans. This research will help Xie and Luan bring the NET probes closer to clinical use.



CONNECTOSOMES

DIRECTLY TARGETING CANCER CELLS FOR BETTER CHEMOTHERAPY

For cancer patients, the side effects of chemotherapy can be overwhelming, painful and exhausting. But what if there were a way to deliver chemotherapy directly to affected cancer cells, while sparing healthy surrounding tissue and decreasing undesirable side effects? UT Austin biomedical engineers have developed a breakthrough in drug delivery to do just that.

Researchers led by biomedical engineering Assistant Professor Jeanne Stachowiak and Avinash Gadok, who graduated with her Ph.D. in biomedical engineering in May 2017, have developed a new type of nanoparticles, which they call “connectosomes.”

Connectosomes are equipped with gap junctions, pathways that allow for rapid movement of molecules between

two cells. The gap junctions allow the connectosomes to create a direct channel to deliver drugs to each individual cell. This straight-shooting method could kill cancer cells more quickly than present chemotherapy approaches.

Connectosome targeting allows for a significant decrease in the dose required to kill a cancer cell. Driving down the dosage of chemo could lessen patients’ potential side effects, from nausea and hair loss to infertility and heart damage. Having a direct route to specific cells could also provide a more effective treatment for secondary tumors that metastasize later in different parts of the body, which are often out of reach of current chemotherapy delivery methods.

“Gap junctions are the cells’

mechanism for sharing small molecules between neighboring cells. We believed that there must be a way to utilize them for better drug delivery,” Stachowiak says. “The big challenge was in making the materials efficiently and showing that the drugs are delivered through the gap junctions and not some other component.”

To form the connectosomes, Gadok used a chemical process to derive liposomes from donor cells that were engineered to over-produce gap junctions. She then loaded the connectosomes with the chemotherapy drug doxorubicin.

The team’s connectosomes address a main challenge in chemotherapeutics — getting a concentrated dose of drugs to cross through the cell’s

plasma membrane barrier and reach its target inside of the cell. Even highly membrane-permeable drugs, such as doxorubicin, have limited transport rates, requiring large doses to deliver a lethal amount to the cancer cell. Under this common delivery method, doxorubicin kills healthy cells along with the intended cancer cells, leading to harmful side effects.

During in-vitro tests of the new connectosome delivery with human cells, the researchers found that chemo is 10 times more efficient at killing cancer cells than with conventional freely delivered doxorubicin. The connectosome delivery is also 100 to 100,000 times as efficient as conventional nanoparticles in delivering chemo. "Connectosomes could open doors for the improved utilization of nanoparticles to deliver other types of therapies," Gadok says. "A huge advantage of nanoparticles is that they can target cells, which helps protect off-target tissues."

In two related projects, the researchers are seeing whether connectosomes can biochemically target tumor cells and inhibit the migration of those cells. Gap junctions are known to suppress cell migration, so connectosomes could potentially limit the movement of tumor cells into the bloodstream.

"We would like to see whether this approach could delay metastasis while



Avinash Gadok (left) graduated with her doctoral degree in 2017. She studied under Assistant Professor Jeanne Stachowiak (right) to find a more efficient method to deliver chemotherapy to individual cancer cells.

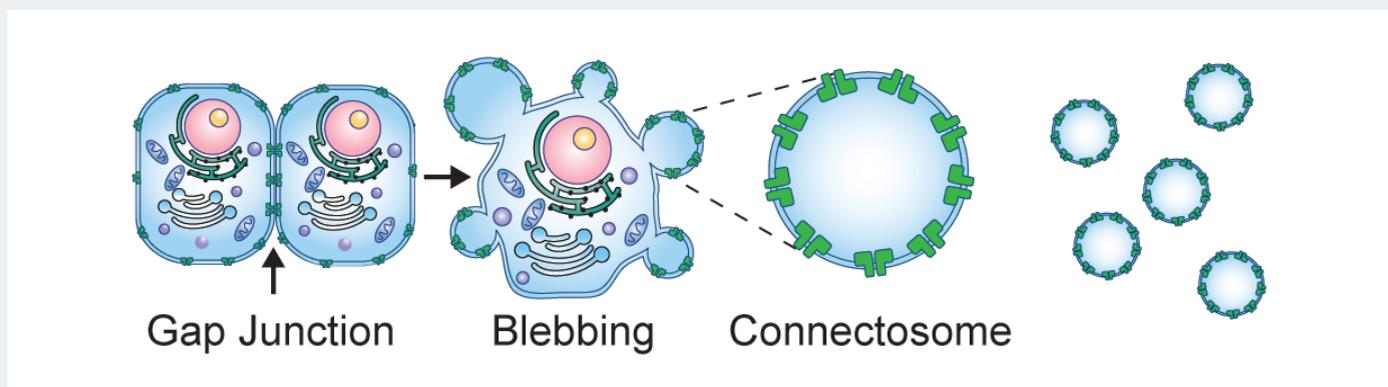
treating the tumor," Stachowiak says of her future research goals. "It would be nice to have a multipronged approach where you have a particle that slows down metastasis, rapidly delivers drugs, and turns off expression of genes that are promoting the migration of tumor cells."

The researchers believe their approach is a major step forward in realizing the advantages of nanoparticle-based drug

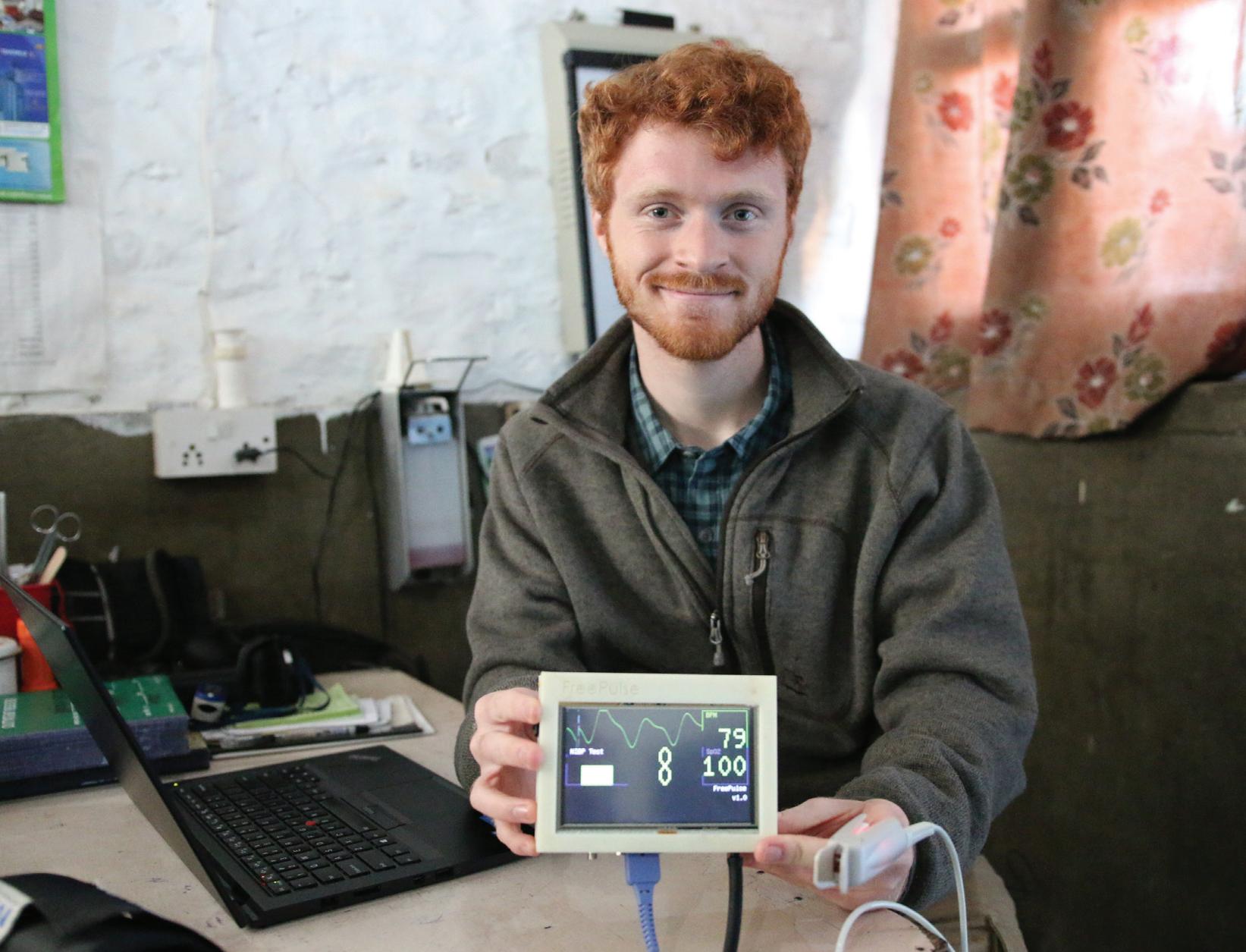
delivery materials and improving the effectiveness of treatments.

The team also included Professor Hugh Smyth and postdoctoral fellow Silvia Ferrati from UT Austin's College of Pharmacy. The research approach was described in the in the September 2017 edition of the *Journal of the American Chemical Society* and funded by the National Science Foundation, the National Institutes of Health and Texas 4000 for Cancer.

HOW IT WORKS



Connectosomes are formed by blebbing them from the membranes of cells that are engineered to produce a large number of gap junctions (green). Credit: *Journal of the American Chemical Society*.



DOING A WORLD OF GOOD

TACKLING GLOBAL HEALTH WITH NEW PATIENT MONITOR

For one eye-opening month, biomedical engineering student Reece Stevens joined the staff of a remote hospital in Rwanda, where he saw nurses struggling to care for hundreds of patients with only a handful of patient monitors. From that point forward, Stevens became determined to build a new device that could be manufactured less expensively and in higher quantities—one that he felt could potentially save hundreds of thousands of lives around the world.

After gaining acceptance into the

Engineering World Health Summer Institute, a student program aimed at building and repairing medical devices in low-income countries, Stevens arrived in Rwanda in June 2014. He quickly learned the basics of the Rwandan language of Kinyarwanda before joining his colleagues for a month of intensive device-repair training.

“I had just finished my freshman year and didn’t know anything about in-depth hardware design or fixing complex machines,” Stevens said. “But

once you start cracking them open, you learn pretty quickly what to look for and how to recognize what is broken.”

Equipped with his new skills, Stevens spent the next month repairing devices for a local hospital, where he experienced the challenges facing medical providers in developing countries. When he took inventory of the hospital’s equipment, he was disheartened by how quickly he completed the task, so scarce were the hospital’s resources.

“There were 400 beds in the hospital and only five patient monitors,” he said. “I will never forget seeing three patients in critical condition with only one monitor. The nurses were hooking one patient up to the monitor and measuring their vitals, then immediately disconnecting that patient, connecting to the next patient and repeating the process. I’d see people actually standing in lines that wrapped around the hospital, waiting hours for surgery because of the lack of monitors. It was unbelievable.”

Certain that lower-cost, readily available monitors could solve these problems, Stevens began working with his Engineering World Health student group at UT Austin to design a new device that could function in an unsealed environment with no climate control and frequent power outages.

During his time in Rwanda, Stevens also noticed that nurses frequently move from one hospital to another, bringing their training with them. To account for this high turnover rate, he wanted the monitor to require minimal training to operate. Borrowing a phrase from Steve Jobs, he wanted to make a device that “just works.”

That sentiment became the guiding mandate of FreePulse, the social venture project that Stevens launched for the development of this new monitor. The team’s initial prototype was well received at engineering design competitions in 2015, taking first place at the international Engineering World Health Design Competition and second place at the prestigious National Institutes of Health Design by Biomedical Undergraduate Teams Challenge.

“Most of us were only sophomores,” he recalls, “so it was encouraging to realize that you don’t need to be so far along in your college career to generate good ideas and sound engineering. Anyone can be an inventor.”

Stevens still wanted to add functionality. He developed a second prototype from scratch that could measure pulse oximetry, which detects changes in blood oxygen levels. To measure blood pressure, he modified the device to use standard arm cuffs already present in Rwandan hospitals.



Department Chair Shelly Sakiyama-Elbert recognizes Stevens with the 2017 Student Leadership Award.

“*We had several clear goals for this device that we thought would make it successful: make it work with what’s on hand, don’t make it difficult for the end user, make it battery-powered and easy to read, and make sure it costs less than \$250.*”

Ultimately, Stevens hopes to make FreePulse completely compatible with the equipment he inventoried in Rwanda. “We had several clear goals for this device that we thought would make it successful: make it work with what’s on hand, don’t make it difficult for the end user, make it battery-powered and easy to read, and make sure it costs less

than \$250.”

Stevens returned to Rwanda in the summer of 2015 and met with device distributors to determine a manageable price point and desired specs for the device. He then visited remote hospitals in Nepal that winter.

Nurses in both countries were thrilled with the smaller form factor and extended battery life, and they were grateful to have a device that began measuring vitals as soon as it was turned on. Though there were a handful of requests for additional features, hospital staff were happy with a product that could potentially solve a pressing problem in their communities.

After improving the device based on this feedback, Stevens returned to Nepal, this time prepared to use FreePulse in a clinical setting.

“It was important to show doctors the actual device,” he said. “You can talk about it all you want, but when someone holds it in their hands, it’s a lot easier to see what does or doesn’t work.”

Stevens graduated with his biomedical engineering degree in May 2017. He continues to work on his devices and plans to have a clinic-ready prototype in 2018. He then hopes to return to hospitals in Nepal and leave fully functional monitors behind.

To follow Stevens’ work on FreePulse and learn more about his experiences abroad, visit freepulsem.com

GET TO KNOW ELIZABETH COSGRIFF-HERNANDEZ

Biomedical engineering's newest faculty member, who holds the L.B. (Preach) Meaders Professorship in Engineering and joins the department from Texas A&M University, tells us what she thinks of Austin so far and what attracted her to UT.



Elizabeth Cosgriff-Hernandez joined the faculty in 2017 and holds the L.B. (Preach) Meaders Professorship in Engineering

Cosgriff-Hernandez's research focuses on enhancing the body's ability to heal itself by providing scaffolds for tissue repair and regeneration. She develops new biomaterials with unique properties and fabrication strategies that can

mimic the complexity of native tissue. Clinical applications of her research include injectable bone grafts, chronic wound dressings, tissue-engineered ligaments, and bioactive vascular grafts.

Cosgriff-Hernandez completed a postdoctoral fellowship in orthopedic tissue engineering at Rice University and received both her B.S. and Ph.D. in macromolecular science and engineering from Case Western University.

She is a fellow of the American Institute of Medical and Biological Engineering and the recipient of a Texas A&M University Excellence in Teaching Award, Dean of Engineering Excellence Award, and TEES Select Young Faculty Award, among many other recognitions.

What attracted you to The University of Texas at Austin?

The leadership and people in biomedical engineering as well as the opportunities afforded by the Dell Medical School. UT Austin provides an incredible convergence of key players and state-of-the-art resources to do cutting-edge biomedical research. On the personal

side, it was an opportunity to be closer to my family and live in my favorite city.

What are your impressions of campus and living in Austin?

I grew up in Texas and all of my siblings live in Austin. Although I have visited frequently, living here has been even better than I expected. Every city has a feeling and, in Austin, it seems to be about living well and enjoying life. There is more focus on healthy living, outdoor activities, and following your interests. There is a strong sense of community, and it is inclusive, which is not always typical of a city. My boys absolutely love it here.

How do you like to spend your time outside of work?

I spend most of my time with my family — my husband and our two sons. I also like to read and I have been exploring trail runs since we moved here.

To learn more about our faculty, visit bme.utexas.edu/faculty



A CLOSER LOOK INTO TEXAS BIOMEDICAL ENGINEERING

The Department of Biomedical Engineering in the Cockrell School of Engineering at UT Austin has been growing and expanding since it was established as a department in 2001. In this section, we offer a snapshot of the current students, faculty, research and alumni to highlight our successes in developing leaders in the field and advancing clinically translatable solutions for human health.

A BRIEF HISTORY

1963

John J. McKetta Jr. becomes dean of the College of Engineering.

1973

UT Austin begins offering independent M.S. and Ph.D. degrees in biomedical engineering.

2006

The department graduates its first baccalaureate class of biomedical engineers.

2009

Professor Nicholas Peppas is named the second department chair.

1966

Dean John McKetta initiates conversation with faculty to add a biomedical engineering graduate program at UT Austin.

2001

UT Austin establishes the Department of Biomedical Engineering and begins offering undergraduate degrees. Kenneth Diller serves as inaugural department chair.

2008

Construction is completed on the biomedical engineering building.

2016

Shelly Sakiyama-Elbert joins the Cockrell School of Engineering and becomes the third department chair.



Biomedical engineering students can participate in study abroad programs in

9

countries around the world



\$67,104

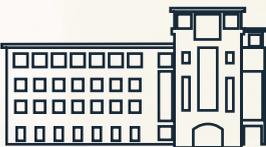
is the average starting salary for recent graduates



These companies hire the most Texas Biomedical Engineering graduates:

- EPIC
- STRYKER
- SMITH & NEPHEW
- ACCENTURE
- NATIONAL INSTRUMENTS
- HOSPIRA
- GENENTECH

BIOMEDICAL ENGINEERING BUILDING



106,000 FT.²

LEED Silver Certification
Opened its doors in 2001



UNDERGRADUATE STUDENTS

560 enrolled undergraduate students

1449 average SAT score of admitted students

84% participate in research groups or labs

60% participate in internship programs

33% participate in study abroad programs

65 Bachelor of Science degrees awarded in 2017

50% of graduates find industry jobs

25% pursue medical degrees

25% pursue graduate degrees

Students can also participate in one of

7

biomedical engineering student organizations



These universities recruit the most graduate students from our undergraduate program:

- MIT
- DUKE UNIVERSITY
- UNIVERSITY OF WASHINGTON
- RICE UNIVERSITY
- UNIVERSITY OF MINNESOTA



Our graduate students receive funding from:

- National Science Foundation
- National Institutes of Health
- Kwanjeong Educational Foundation
- Japan Student Service Organization
- International Foundation of Ethical Research
- American Heart Association



GRADUATE STUDENTS

91 enrolled graduate students

3.84 average GPA of admitted students

32 graduate students received external fellowships

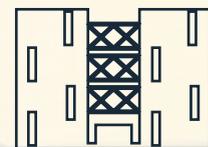
13 National Science Foundation fellows

3 Masters of Science degrees awarded in 2017

6 Doctoral degrees awarded in 2017

FACILITIES

ENGINEERING EDUCATION AND RESEARCH CENTER



430,000 FT.²

Multi-disciplinary research labs
Student project center
Opened its doors in 2017



Texas Biomedical Engineering faculty and researchers have also received awards from the following organizations:

- 15 American Institute for Medical and Biological Engineering
- 4 American Association for the Advancement of Science
- 4 National Academy of Inventors
- 2 National Academy of Engineering
- 2 National Academy of Medicine
- 1 American Academy of Arts and Sciences



FACULTY

28 affiliated faculty from around the world
20 endowed faculty positions

6 National Science Foundation CAREER Award recipients



\$12,000,000

in research expenditures in 2017



RESEARCH

152 research papers and publications in 2017

42 patents filed

4 research centers

4 research areas



Biomechanics

Biomedical imaging and instrumentation

Cellular and biomolecular engineering

Computational biomedical engineering



James T. Willerson Center for Cardiovascular Modeling and Simulation

Center for Computational Oncology

Center for Emerging Imaging Technologies

Institute for Biomaterials, Drug Delivery and Regenerative Medicine

OVER 1,550 LIVING ALUMNI FROM AROUND THE WORLD. LEARN ABOUT THREE WHO RECEIVED AWARDS IN 2017:



JENNIFER WEST
M.S. 1994,
PH.D. 1996

was elected to both the National Academy of Inventors and the National Academy of Engineering. West is a professor and the associate dean for Ph.D.

education in the Department of Biomedical Engineering at Duke University. West's research focuses on the development of novel biomaterials and tissue engineering to address biological problems such as glaucoma and cancer.



ANDREW DUNN
PH.D. 1997

received the 2017 Edith and Peter O'Donnell Award in Engineering from The Academy of Medicine, Engineering and Science of Texas and elected a fellow of the Biomedical Engineering Society

and The Optical Society of America. Dunn is a professor in the UT Austin Department of Biomedical Engineering and the director of the Center for Emerging Imaging Technologies. He develops innovative imaging techniques that make it possible to see blood flowing in the brain in real time.



MICHAEL HEMATI
B.S. 2013

was named a 2017 Medtech Rising Star. Hemati is the senior R&D engineer at TheraNova, a medical device developer. He also heads the medical device startups Leo

Labs and TruKinetics, and he co-founded the startup SmartDerm.

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LAB COATS PODCAST

Graduate students Shane Allen and Ahmed Hassan host this entertaining podcast in which they discuss emerging topics in biomedical engineering with peers, professors and experts in the field — and make it easy for anyone to understand.

Available on iTunes, Stitcher and Podcaster



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