PULSE

2018-19

AN ANNUAL PUBLICATION FROM THE DEPARTMENT OF BIOMEDICAL ENGINEERING

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

FROM THE CHAIR

IN MY THIRD YEAR AS CHAIR of the Department of Biomedical Engineering at The University of Texas at Austin, we have progressed our strategic vision of advancing human health and health care delivery through outstanding education and research programs.

In the last year, our faculty have been recognized notably for their achievements, with elections to the National Academy of Inventors and the Chinese Academy of Engineering and awards from the National Academy of Medicine. Our dynamic faculty has grown with the addition of Sapun Parekh and Samantha Santacruz. Three of our faculty members have been promoted to associate professors, and our researchers have been awarded significant funding to further discovery in areas such as cancer and neurodegenerative disease treatment, drug delivery and immune engineering.

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, one undergraduate student was the first to receive a scholarship from the U.S. Department of State's Benjamin Gilman International Scholarship Program for a study abroad experience. Our graduate students and postdoctoral researchers received awards and support from the National Institutes of Health, the National Science Foundation, the American Heart Association, the American Association of Physicists in Medicine, and the American Association of Immunologists.

In this issue, 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 professors, and learn how our community is 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 Department Leadership #1

Cover photo: Biomedical engineering researchers are using a small-scale gut-on-a-chip model to show how gut inflammation develops in the human body. They have determined that intestinal barrier disruptions are the onset initiator of gut inflammation. Image courtesy of Hyun Jung Kim.

A NEW DISCOVERY FOR HIV

HIV CELL DYSFUNCTION DISCOVERY SHEDS LIGHT ON HOW THE VIRUS WORKS

According to the latest figures from the World Health Organization, about 40 million people worldwide are living with HIV/AIDS. In the U.S., about 1 million are living with the virus, and 1 in 7 of those infected don't know it. The number of recorded cases has been in steady decline—thanks to medical advances and greater public awareness. Still, major information gaps remain in understanding the fundamental nature of HIV, making every new insight important.

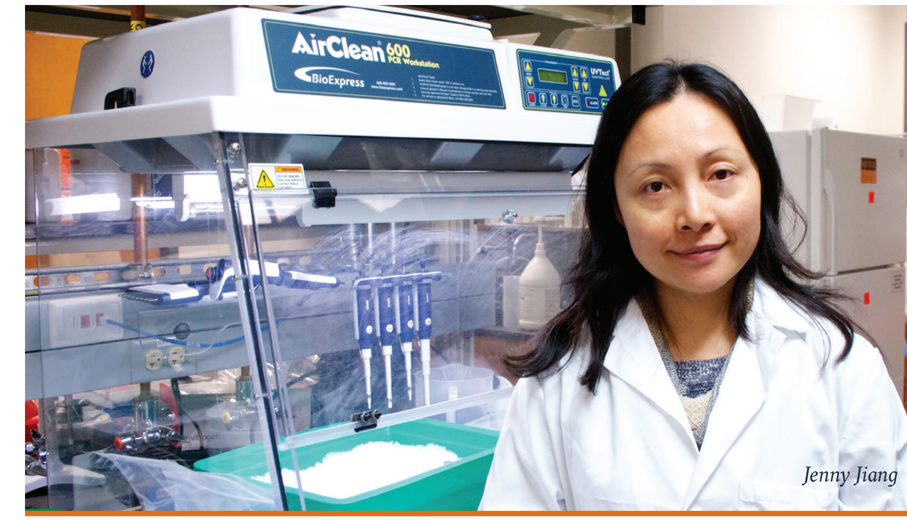
A new study, led by Jenny Jiang, associate professor in the Department of Biomedical Engineering, has revealed that certain immune cells behave differently in HIV-infected patients than they do in healthy individuals, a discovery that moves us one step closer to understanding how the virus works.

A team of chemical and biomedical engineers from the Cockrell School of Engineering at UT Austin, in collaboration with researchers from the University of Pennsylvania, discovered that HIV-infected patients experience a dysfunction in a certain type of immune cell: the follicular helper T (Tfh) cell.

In a paper published *Science Immunology*, the authors outline how, through combining a sophisticated sequencing technique with a mass cytometry method (the measurement of cell characteristics), they discovered the Tfh cell dysfunction.

The team's finding is significant because the Tfh cells — which are present in greater numbers in HIV-infected patients than in healthy individuals — help fight off infection by communicating with other immune-supporting cells in the lymph nodes about an impending viral attack. Researchers found that the Tfh cells present in those infected with HIV are not playing their usual part to defend against viral infections.

The research team combined techniques developed by Jiang and Laura Su, assistant professor of medicine at Penn's Perelman School of Medicine. These technologies allowed the team to profile T cells in the lymph nodes of HIV patients.



Jenny Jiang

"These types of cells play a critical role during viral infections of any kind," Jiang said. "They communicate with other immune cells and provide instructions to B cells to produce virus-neutralizing antibodies that kill it off and help prevent future infections."

Although the CD4+ T cell is notoriously depleted in patients infected with HIV, the population of Tfh cells is more elevated in the lymph nodes of those infected with HIV than it is in healthy individuals. This paradox is what makes analysis of Tfh cell behavior by anyone studying HIV vital.

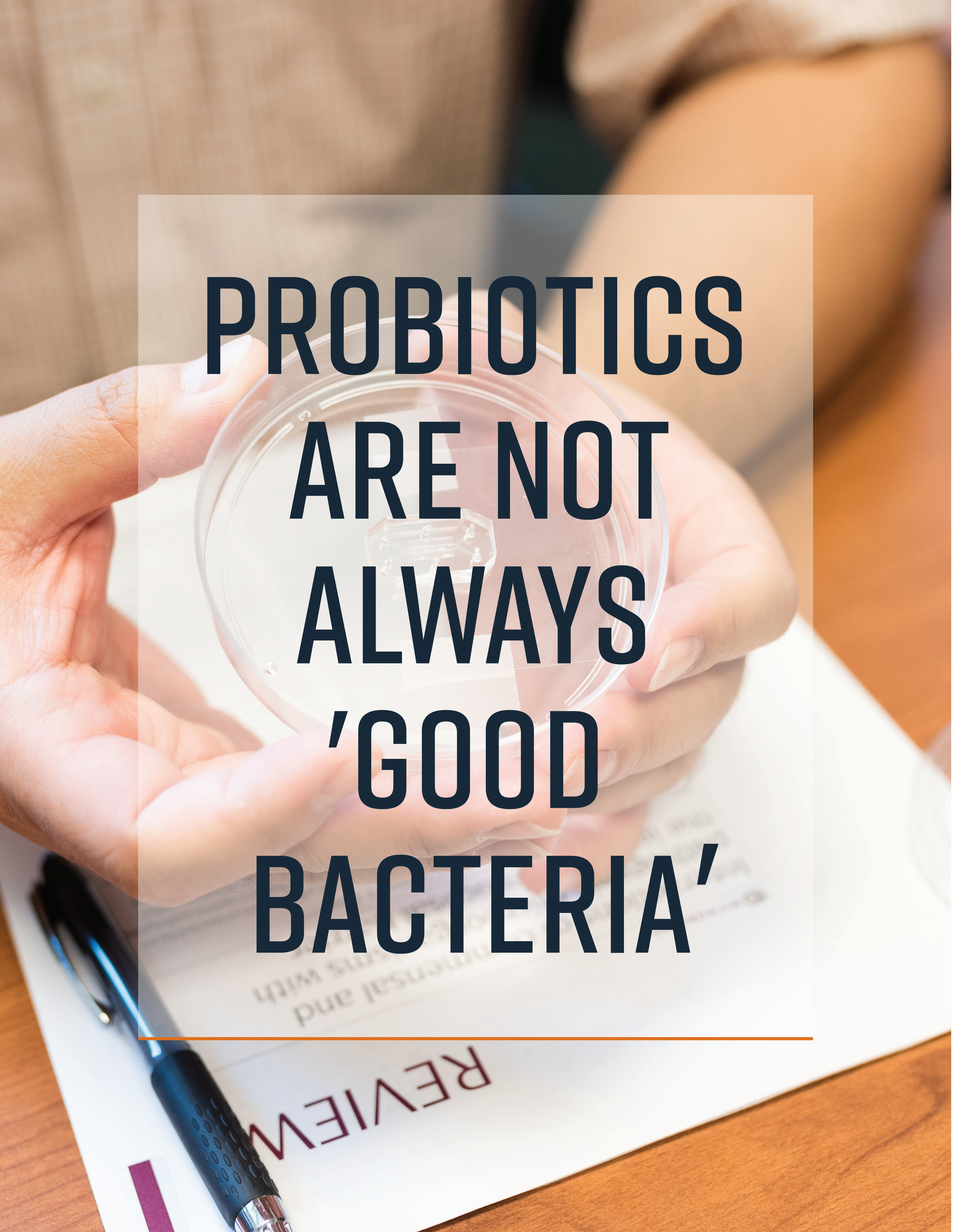
Based on their central role in generating protective antibodies, it would be intuitive to assume that the increased presence of Tfh cells should result in greater resistance to infection. However, the researchers found this not to be the case, suggesting that Tfh cells in HIV patients are ineffective at sending signals to B cells to request help to fight off the infection.

"We believe Tfh cells behave differently when fighting chronic infections like HIV versus when fighting off acute infections like the common cold, potentially making them an easy target for HIV," Jiang said. "Our next step is to determine why the Tfh cell dysfunction occurs in HIV-infected patients, moving us one step closer to better understanding the virus."

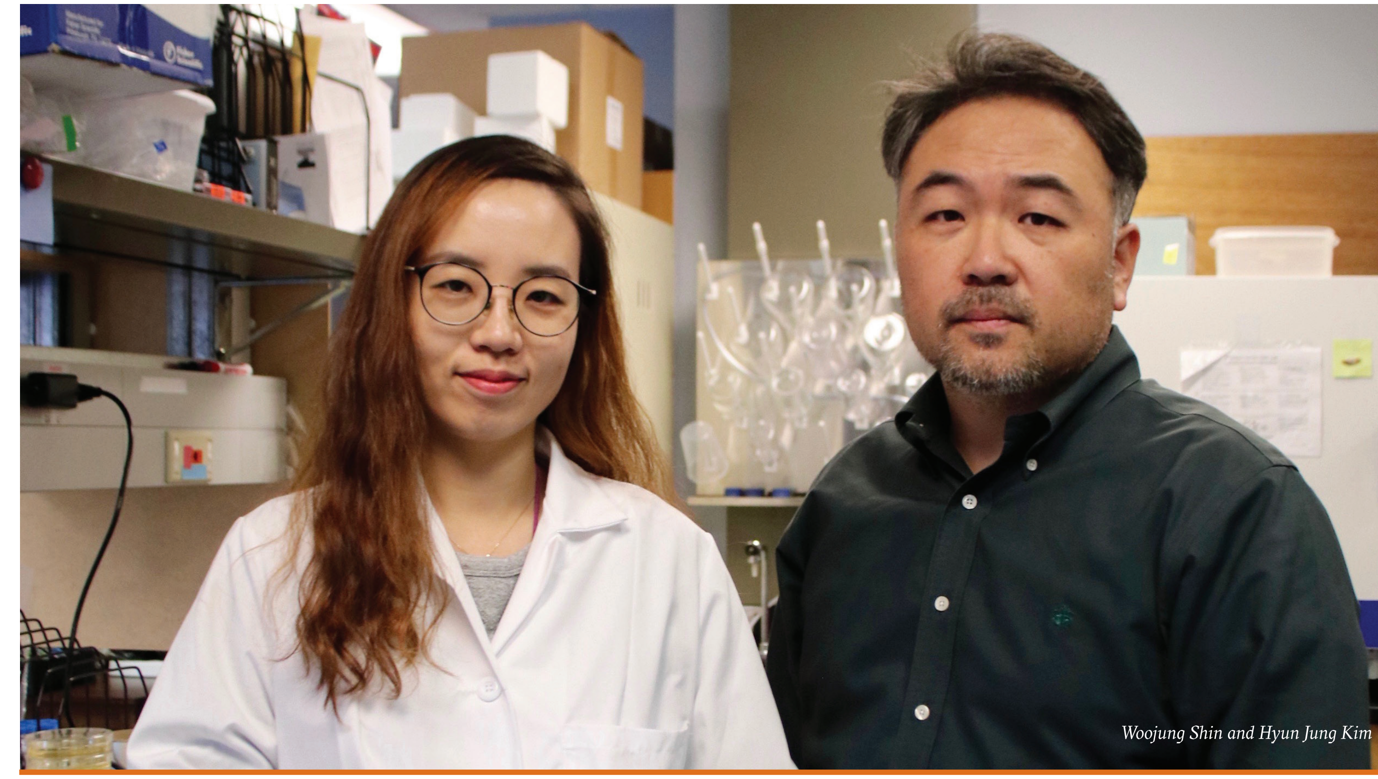
Other investigators include graduate students from UT's Institute for Cellular and Molecular Biology. The team also collaborated with the Instituto Nacional de Enfermedades Respiratorias in Mexico.

The study was supported in part by the UT Austin Cockrell School of Engineering Graduate Fellowship, the Smith Charitable Trust Foundation, the Penn Center for AIDS Research, the Veterans Affairs Merit Award, the National Institute of Allergy and Infectious Diseases, the National Institute on Aging, the National Institutes of Health Shared Instrumentation Grant Program and the Welch Foundation.

Citation: *Kalina Paunovska and Cory D. Sago, et al., "A direct comparison of in vitro and in vivo nucleic acid delivery mediated by hundreds of nanoparticles reveals a weak correlation," (Nano Letters 2018). https://pubs.acs.org/doi/10.1021/acs.nanolett.8b00432*



PROBIOTICS ARE NOT ALWAYS 'GOOD BACTERIA'



Woojung Shin and Hyun Jung Kim

The first study investigating the mechanism of how a disease develops using human organ-on-a-chip technology has been successfully completed by engineers at The University of Texas at Austin.

Researchers, led by Hyun Jung Kim, assistant professor in the Department of Biomedical Engineering, were able to shed light on a part of the human body — the digestive system — where many questions remain unanswered due to the inability to replicate the human gut microenvironment in the laboratory. The technique uses a small-scale model of the human gastrointestinal tract about the size of a thumb drive. Using their "gut inflammation-on-a-chip" microphysiological system, the research team confirmed that intestinal barrier disruption is the onset initiator of gut inflammation.

The study also includes evidence that casts doubt on the conventional wisdom of taking probiotics — live bacteria that are considered good for gut health and found in supplements and foods such as yogurt — on a regular basis. According to the findings, the benefits of probiotics depend on the vitality of one's intestinal epithelium, or the gut barrier, a delicate single-cell layer that protects the rest of the body from other potentially harmful bacteria found in the human gut.

"By making it possible to customize specific conditions in the gut, we could establish the original catalyst, or onset initiator, for the disease," said Kim. "If we can determine the root cause, we can more accurately determine the most appropriate treatment."

The findings were published in the *Proceedings of the National Academy of Sciences.*

Until now, organs-on-chips, which are microchips lined by living human cells to model various organs from the heart and lungs to the kidneys and bone marrow, solely served as accurate models of organ functionality in a controlled environment. This is the first time that a diseased organ-on-a-chip has been developed and used to show how a disease develops in the human body — in this case, the researchers examined gut inflammation.

"Once the gut barrier has been damaged, probiotics can be harmful just like any other bacteria that escapes into the human body through a damaged intestinal barrier," said Woojung Shin, a biomedical engineering Ph.D. candidate who worked with Kim on the study. "When the gut barrier is healthy, probiotics are beneficial. When it is compromised, however, they can cause more harm than good. Essentially, 'good fences make good neighbors.' "

Shin plans to develop more customized human intestinal disease models such as inflammatory bowel disease or colorectal cancer in order to identify how the gut microbiome controls inflammation, cancer metastasis and the efficacy of cancer immunotherapy.

Kim is a leading researcher in the development of human organs-on-chips. He developed the first human gut-on-a-chip in 2012 at Harvard University's Wyss Institute for Biologically Inspired Engineering.

This research was supported in part by the Alternatives in Scientific Research of The International Foundation for Ethical Research Graduate Fellowship and the National Research Foundation of Korea.

MEET OUR NEWEST FACULTY MEMBERS

LEARN WHY TWO PROFESSORS ARE EXCITED TO BE AT UT AUSTIN

Samantha Santacruz joined UT Austin in the fall of 2018 as an assistant professor. She completed her postdoctoral fellowship at UC Berkeley, received her Ph.D. and M.S. degrees in electrical and computer engineering from Rice University and her B.S. in applied mathematics with honors from UC Berkeley.

Sapun Parekh joined UT Austin as an assistant professor in the spring of 2019. He worked at the Max Planck Institute for Polymer Research in Mainz, Germany. Parekh received his Ph.D. in bioengineering from UC Berkeley and UC San Francisco and his B.S. in electrical engineering from UT Austin.

What drew you to UT Austin?

Santacruz: I was drawn to UT Austin because of its reputation as a top engineering school, and because of the people. Beyond performing as top researchers in their respective fields, the faculty here have a strong commitment to public higher education that aligns with my own values and priorities.

Parekh: I was an electrical engineering major at UT Austin and started in biomedical optics, which led to my now 15-year career in biomedical engineering. I enjoy being involved in undergrad research and want to offer opportunities to my students. I am thrilled to be part of the BME community and rediscover how rewarding biomedical technology development and science can be. Austin is a special place—good people, good music, good food and an overall good vibe.

What are your impressions of campus and living in Austin?

Santacruz: Energetic. The student body is incredibly lively and in one-on-one interactions with students I feel how passionate they are about academics and research. That same level of spirit is felt off campus as well, and it's clear to me that people in Austin are engaged in their community.

Parekh: A lot has changed since 2002. The ENS building is gone and BME is now its own department. I'm excited to see that the Hole in the Wall bar is still around. Coming back after bring away, I feel "the hustle." Things are getting done, ideas are popping out of walls and people have energy. Austin has developed a strong tech and innovation spirit over the years. Having lived in Europe for 7 years. I was keen to find a place with a sense of community — close-knit neighborhoods where people look out for each other. So far, we like what we have found and I look forward to summer block parties with the other middle-aged parents in my neighborhood.

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

Santacruz: I'm a food lover. I enjoy cooking and trying new restaurants. It's been fun exploring local food options and learning about Austin cuisine.

Parekh: I hang out with my wife and kids. If I'm not in the lab or with family, I'm playing (non-checking) hockey.

What excites you about doing research at UT Austin?

Santacruz: There are so many opportunities for collaboration at UT since it's such a large institution and excels with such breadth. Neuroengineering is by nature multidisciplinary and draws from expertise in biomedical engineering, electrical engineering, neuroscience, psychology, neurology and so many other fields. There are amazing faculty members in all of these areas making UT Austin such an intellectually stimulating environment in which to perform research.

Parekh: I'm excited to be around students and faculty across the university. People are the engine of research and development. The expertise and ambition of the whole community is energizing.

NICHOLAS PEPPAS RECEIVES PRESTIGIOUS HONORS

In 2018, Nicholas Peppas, one of the most decorated engineers in the U.S., received two more awards that emphasize four decades worth of pioneering work to transform health care.

Peppas, professor in the Cockrell School of Engineering Department of Biomedical Engineering, McKetta Department of Chemical Engineering, UT's Dell Medical School and College of Pharmacy, has received recognitions from the National Academy of Medicine (NAM) and the American Association of Pharmaceutical Scientists (AAPS).

He has served as director of the Institute for Biomaterials, Drug Delivery and Regenerative Medicine, and is the first engineer to receive the Adam Yarmolinsky Medal from the National Academy of Medicine. This medal is awarded to a member from outside of health and medical sciences who has contributed to the NAM mission over a long period of time.

In its announcement of the medal recipients, NAM wrote: Peppas is a true pioneer in the development of principles in biomedical and chemical engineering that paved the way for groundbreaking scientific advances with applications such as delivery of insulin for diabetes treatment, calcitonin for osteoporosis and interferon alpha and beta for the treatment of cancer and multiple sclerosis.

Peppas is an engaging and effective educator, having mentored more than 230 graduate students and visiting scientists. His ability to bring together researchers from disparate fields and his revolutionary research on biomedical and chemical engineering have had a tremendous impact on the NAM and the nation's scientific progress.

The AAPS' Distinguished Pharmaceutical Scientist Award recognizes Peppas for his lifetime of achievements and the impact that his discoveries have had on industries and quality of life.

Sharon L. Wood, dean of the Cockrell School of Engineering, says these recognitions are well deserved.

"It has been a tremendous year for Nicholas," Wood said. "The UT community continues to be proud of his accomplishments and inspired by the impact he has made in his career."

With over 1,600 publications, Peppas' achievements are also acknowledged by his peers.

"Nicholas has been recognized as one of the most cited and highly published authors in gels, hydrogels and intelligent materials," said Robert S. Langer, professor at MIT and one of the foremost bioengineers in the world. "I believe he is the ideal person for the Distinguished Pharmaceutical Scientist Award."

Peppas has made profound contributions to the pharmaceutical drug delivery field in the design of new pharmaceutical formulations and the oral delivery of drugs and therapeutic proteins. These discoveries have led to the design, optimization and commercialization of numerous new products. He has been a leading researcher, inventor and pacesetter in the field of drug delivery and controlled release, a field that he nurtured into scholarly and applied research, and he is also a leader in biomaterials and bio-nanotechnology.

Peppas is a recipient of many international awards and distinctions, including induction into the Royal Society of Chemistry and the National Academy of Inventors. He is a member of the National Academy of Engineering, National Academy of Medicine, American Academy of Arts and Sciences, French Academy of Pharmacy, Royal Academy of Spain, Academy of Athens, Chinese Academy of Engineering and The Academy of Medicine, Engineering and Science of Texas.

STEP BY STEP

5 QUESTIONS WITH FITBIT ENGINEER AND BIOMEDICAL ENGINEERING ALUMNA JACKIE LEVERETT WASSON (B.S. 2012)

Jackie Leverett Wasson sometimes finds herself running around wearing as many as three fitness trackers at once. She considers herself part of the "Quantified Self" movement, which incorporates tech and data to log aspects of daily life.

This all comes into play in her role as a staff electrical engineer on the research team at Fitbit, a leader in wearable fitness devices and digital health. During her two years with the company, Wasson has helped design new biosensors for Fitbit's future devices.

Before her entrance into the world of wearable tech, Wasson earned her master's degree in electrical engineering from UC Berkeley in 2014, after graduating with her B.S. in biomedical engineering from UT Austin.

We sat down with Wasson, a native of Sugarland, Texas, to learn more about her work at Fitbit, and how her experiences in biomedical engineering at UT Austin prepared her for success.

What is it like to work at Fitbit?

It's exciting to work on products that give people information about their bodies and empower them to take control of their own health. Most people don't take physiology classes, so they don't understand how their bodies work. If there are issues, they expect a doctor to fix it.

I'm a firm believer in giving people the information they need to understand how their daily life choices affect their well-being. Small choices, like making sure you stand up at your desk and walk around every hour, really affect your overall health.

What can you tell us about the future of wearable tech?

Most of what we work on is confidential at this point. However, I would love to see wearable tech that gathers data and gives people actionable insights on what they should do with that data.

A lot of people get overwhelmed with information and not necessarily know what to do with it. I think the next great leap in wearable devices is using all the info in a really smart way to help people take control of their health.

Did you always know you wanted to go into industry?

I knew at a young age that I wanted to help people and to see the bigger picture of what I was doing day to day. I gravitated toward medicine, but once I learned more about what doctors actually do, I realized I was more excited about the devices they were using. I wanted to build devices to make their jobs easier.

The track I did in BME was electronics-focused, and I felt like I wanted to dive deeper into that area, so I pursued a master's in electrical engineering from Berkeley.

What kind of research did you do at UT and later at UC Berkeley?

At UT, I worked with Kenneth Diller on therapeutic-induced hypothermia. If you can reduce the core body temperature of someone who's had a stroke, you can also reduce the amount of damage done to the brain after the stroke. I helped build a device to record temperature from a lot of different places to track those experiments. I also did research with Adela Ben-Yakar looking at using nanoparticles to make more efficient cancer therapies.

At Berkeley, I worked with Jan Rabaey on brain-machine interfaces. Berkeley has a big brain-machine interface program with a lot of people working on a lot of hard problems. I worked on a project where I designed a tiny wireless device that sits on rat's head and records action potentials from the brain. The future application would be used for prosthetic arms that could be controlled with your mind.

How did your time at BME prepare you?

I have great memories at UT. Going to Cambridge with Professor Diller and taking his Transport Phenomena course was amazing. You're learning cool stuff and at this great university with so much history. We took weekend trips around Europe and got to know the area. That was a great experience and I would encourage everyone to study abroad.

The professors really cared and the students were all smart, friendly and welcoming. I liked that the courses were pretty evenly split between men and women, which you don't always see in engineering.

The BME program taught me to think about problems in a variety of ways, which is important if you're designing something for humans. [At Fitbit,] I think about the how the electrical part works with biology, biocompatibility, patient comfort and mechanical design. At UT, I valued being able to take a lot of different types of courses that prepared me for designing wearable and biomedical devices.

A CLOSER LOOK AT TEXAS BIOMEDICAL ENGINEERING IN 2018

STUDENTS

UNDERGRADUATE

555 enrolled undergraduate students

1467 average SAT score of admitted students

52% participate in internship programs

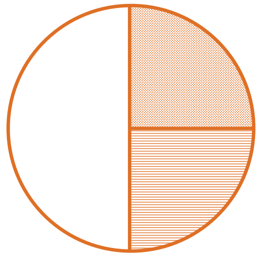
81% participate in research groups or labs

Junior Emily Yang took first place in the Science in Plain English competition, where she described research she is working on in Aaron Baker's lab, using a type of sugar found in certain seaweed to replace damaged barriers in fat-clogged arteries.

30% participate in study abroad programs

Alex Chiu, a sophomore, was awarded a Benjamin A. Gilman International Scholarship from the U.S. State Department. Chiu is the first UT Austin BME student to receive this scholarship. The support will allow Chiu to study abroad in Porto, Portugal and take International Perspectives on Biomedical Engineering Design with Dr. Mia Markey.

105 bachelor's degrees awarded in 2018



50% of graduates find industry jobs

25% pursue medical degrees

25% pursue graduate degrees

$70,250 average starting salary

Our graduates find positions at **Epic, Merck, GE Healthcare, Stryker, Amazon and Proctor & Gamble** among many other organizations

Where Our Students Go

Georgia Tech University
Rice University
University of Michigan
UC Berkeley-UC San Francisco
Northwestern University

GRADUATE

94 enrolled graduate students

3.84 average GPA of admitted students

32 students recieved external fellowships

14 National Science Foundation fellows

3 Master's degrees awarded in 2018

19 Doctoral degrees awarded in 2018

FACULTY

28 faculty

18 endowed faculty positions

21 affiliated faculty around the world

AWARDS

6 NSF CAREER Award recipients

17 American Institute for Medical and Biological Engineering fellows

4 American Association for the Advancement of Science fellows

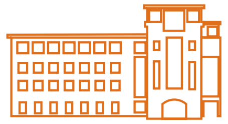
4 National Academy of Inventors fellows

2 National Academy of Engineering members

2 National Academy of Medicine members

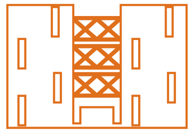
1 American Academy of Arts and Sciences member

FACILITIES



Biomedical Engineering Building

- 106,000 square feet
- LEED Silver certification
- Opened doors in 2008



Engineering Education and Research Center

- 430,000 square feet
- Multidisciplinary research labs
- Student project center
- Opened doors in 2017

RESEARCH

AREAS

Biomedical Imaging and Instrumentation

Cellular and Biomolecular Engineering

Computational Biomedical Engineering

Cellular, Tissue and Molecular Biomechanics

CENTERS

James T. Willerson Center for Cardiovascular Modeling and Simulation

Center for Computer Oncology

Center for Emerging Imaging Technologies

Institute for Biomaterials, Drug Delivery and Regeneragtive Medicine

PAPERS AND PATENTS

186 research papers and publications in 2018

38 patents filed in 2017-18

FUNDING

$12.7 million in research funding in 2018

FUNDING SOURCES

National Science Foundation

National Institutes of Health

Kwanieong Educational Foundation

International Foundation of Ethical Research

American Heart Association

University Fellowships

Diversity Fellowships

The Department of Biomedical Engineering has over **1,600 alumni** around the world.

ALUMNI NEWS

W. CASEY FOX | M.S. 1984, PH.D. 1990

Casey Fox received a 2018 Cockrell School of Engineering Distinguished Engineering Graduate Award. Fox is the founder and current chief executive and technology officer of Metric Medical Devices Inc., a ***WORLD LEADER IN THE DEVELOPMENT AND COMMERCIALIZATION*** of products that advance the musculoskeletal repair standard.

KELLY MOYNIHAN | B.S. 2012

Kelly Moynihan was named a Boston Business Journal 40 Under 40 Honoree. In 2017, Moynihan completed her Ph.D. in biological engineering at MIT as a Hertz Fellow, NSF Fellow, and Siebel Scholar. She currently is a senior associate at Third Rock Ventures.

NIMMI RAMANUJAM | PH.D. 1995

Nimmi Ramanujam was named a fellow of the Academy of Inventors for her work in photonics-based health technologies. Ramanujam is the Robert W. Carr, Jr. Professor of Biomedical Engineering at Duke University.

JOHN SLATER | PH.D. 2008

John Slater received an NSF CAREER Award to develop a tissue-engineered model of ischemic microstrokes. Slater is an assistant professor at the University of Delaware. The NSF CAREER Award is among the most prestigious grants for junior faculty members.

DAVID WATERS | B.S. 2012

David Waters was one of five to be named a Fannin Innovation Studio Entrepreneurship Fellow. The Fellowship is a two-year full-time fellowship for scientists, physicians and engineers who have an entrepreneurial interest in drug or medical device development. Waters also received an M.D. from The University of Texas Health Science Center at Houston.

RESEARCH ON THE RISE

Faculty members in the Department of Biomedical Engineering are garnering support for promising new research to further treatment of cancer and neurodegenerative and cardiovascular diseases. Here are some of the grants our researchers have been awarded in the past year.

AARON BAKER

$1.5 million NIH R01 funding to create better quality small vascular grafts, which would retain healthy blood flow longer and present a more durable solutions for vascular disease patients.

AMY BROCK

$3 million NIH R01 grant to analyze individual cells within a tumor population to learn more about what prompts cancer growth.

ANDREW DUNN

$3 million NIH R01 grant to develop instrumentation and computational technologies that will help researchers understand the effect of type 2 diabetes on the brain's microvasculature.

LAN LUAN

$2.3 million NIH R01 grant to measure long-term pathological effects of mini strokes on the brain's vasculature using novel ultraflexible neural electrodes and optical technologies.

JENNY JIANG

$2.5 million grant from the Chan Zuckerberg Initiative to study high-througput 3D profiling of single T Cells in neurodegenerative diseases.

MICHAEL SACKS

$3 million NIH R01 grant to develop advanced computational models that predict how fast aortic valve disease will occur in patients with bicuspid aortic valve disease.

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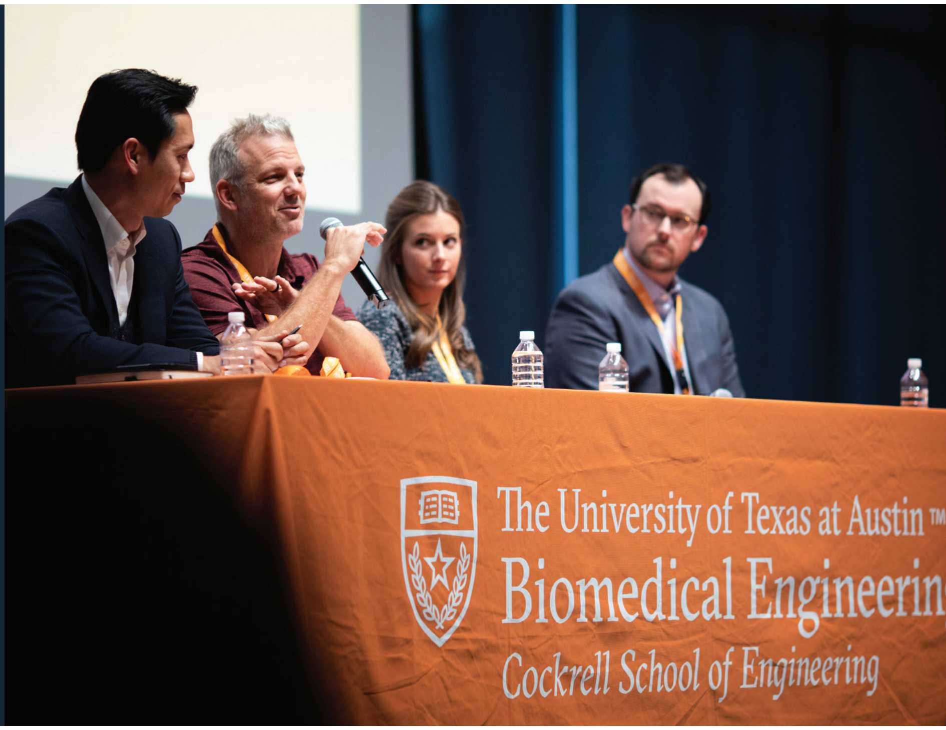
RETURN SERVICE REQUESTED

This year the department hosted its first ever AlumNight career panel and networking event, to highlight influential alumni and connect them with the UT Austin BME community. Panelists included: Stephen Chen (B.S. BME 2006) of Norton Rose Fulbright, John Cox (M.S.E. BME 1997) of Visible Health, Andrea Davis (B.S. BME 2012) of Texas Children's Hospital, Cristal Glangchai (Ph.D. BME 2008) of VentureLab, and Michael Sinclair (B.S. BME 2008) of Pipeline Strategy - Osiris Therapeutics.



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