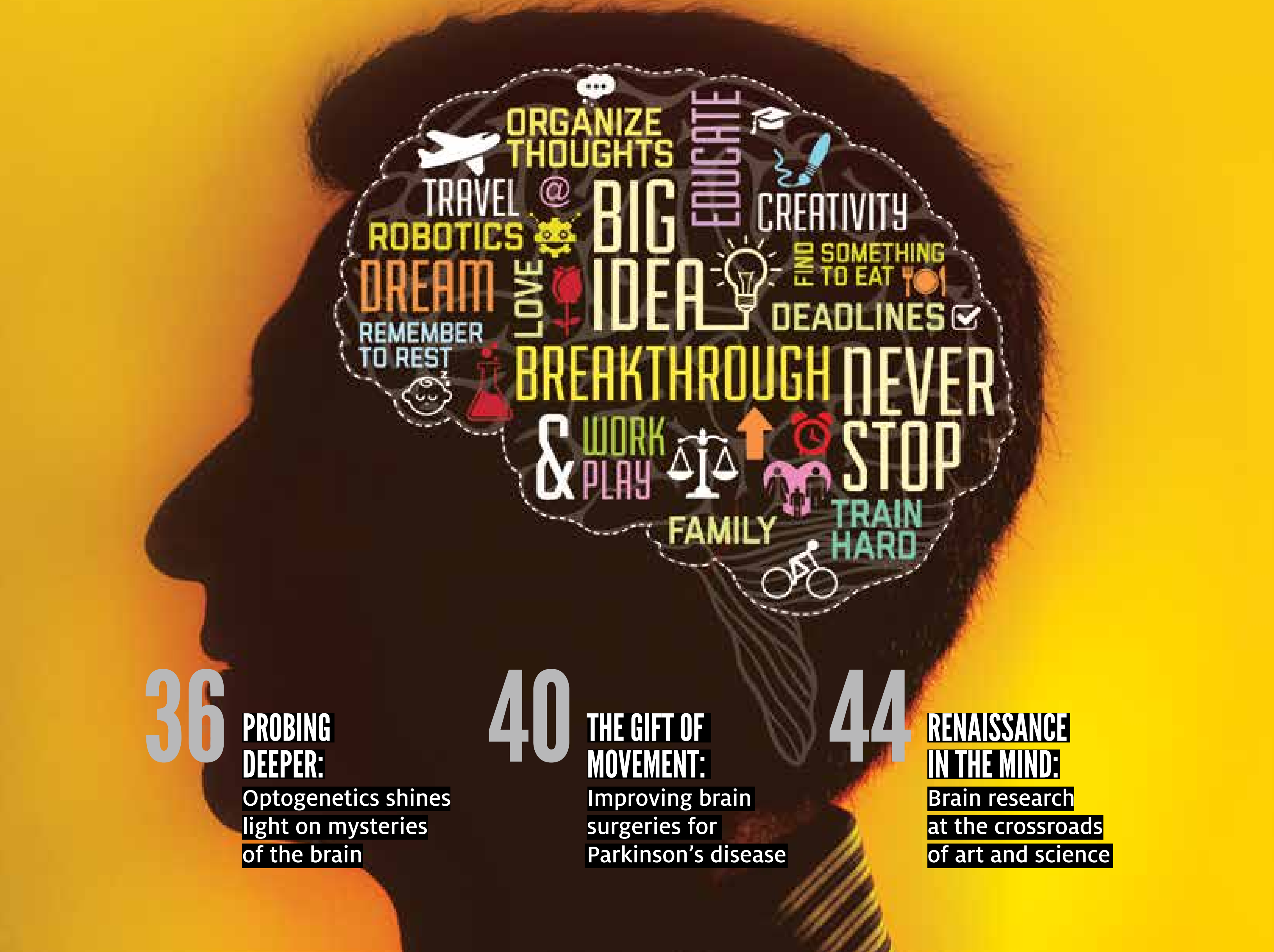
Fall 2015

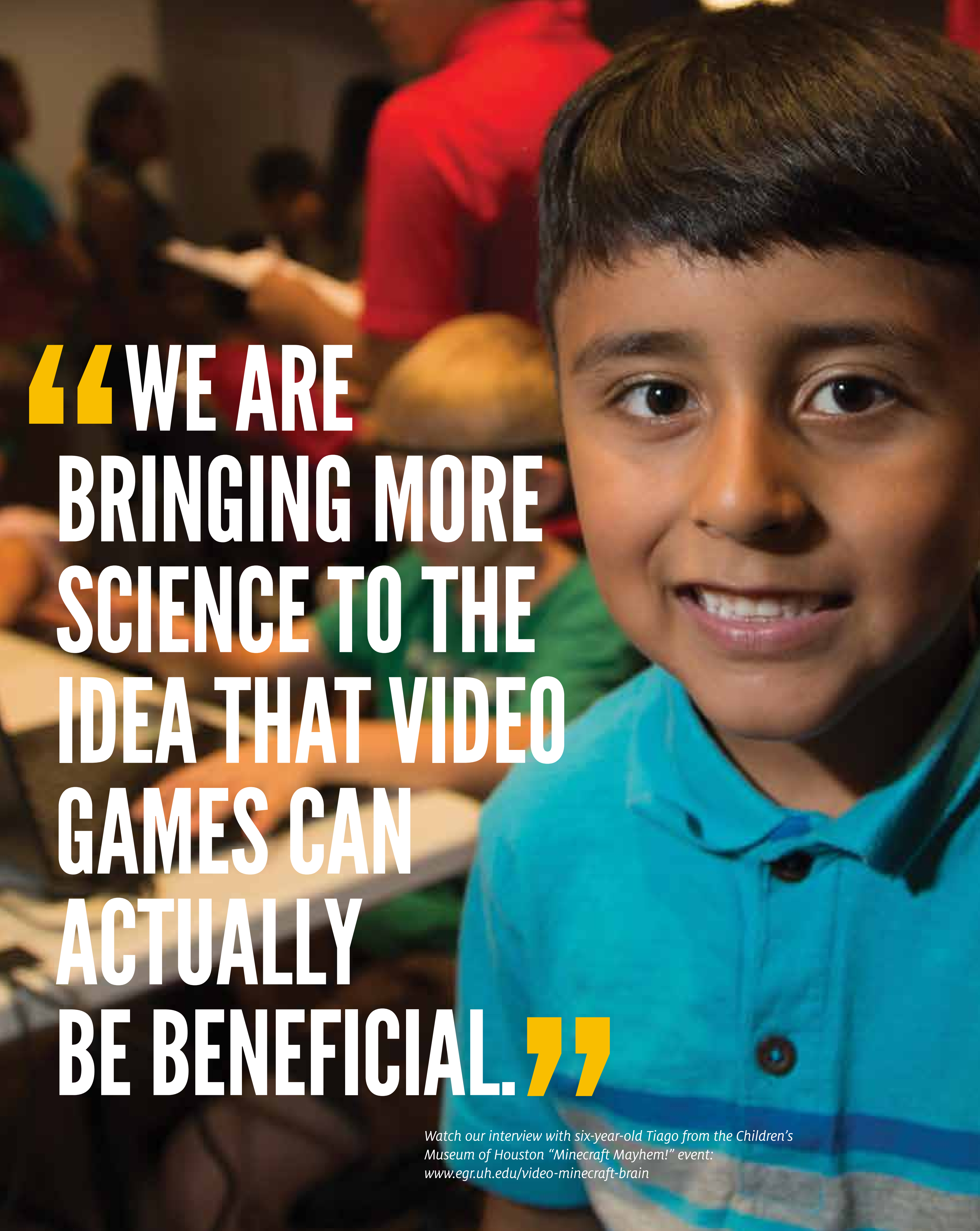
Parameters

Cullen College of Engineering Magazine

UNIVERSITY of HOUSTON | ENGINEERING

CRACKING THE BRAIN CODE





“WE ARE BRINGING MORE SCIENCE TO THE IDEA THAT VIDEO GAMES CAN ACTUALLY BE BENEFICIAL.”

Watch our interview with six-year-old Tiago from the Children’s Museum of Houston “Minecraft Mayhem!” event: www.egr.uh.edu/video-minecraft-brain

Thousands of visitors flocked to the Children’s Museum of Houston on Aug. 19 to play the top selling video game *Minecraft* while contributing to invaluable ongoing brain research at the UH Cullen College of Engineering.

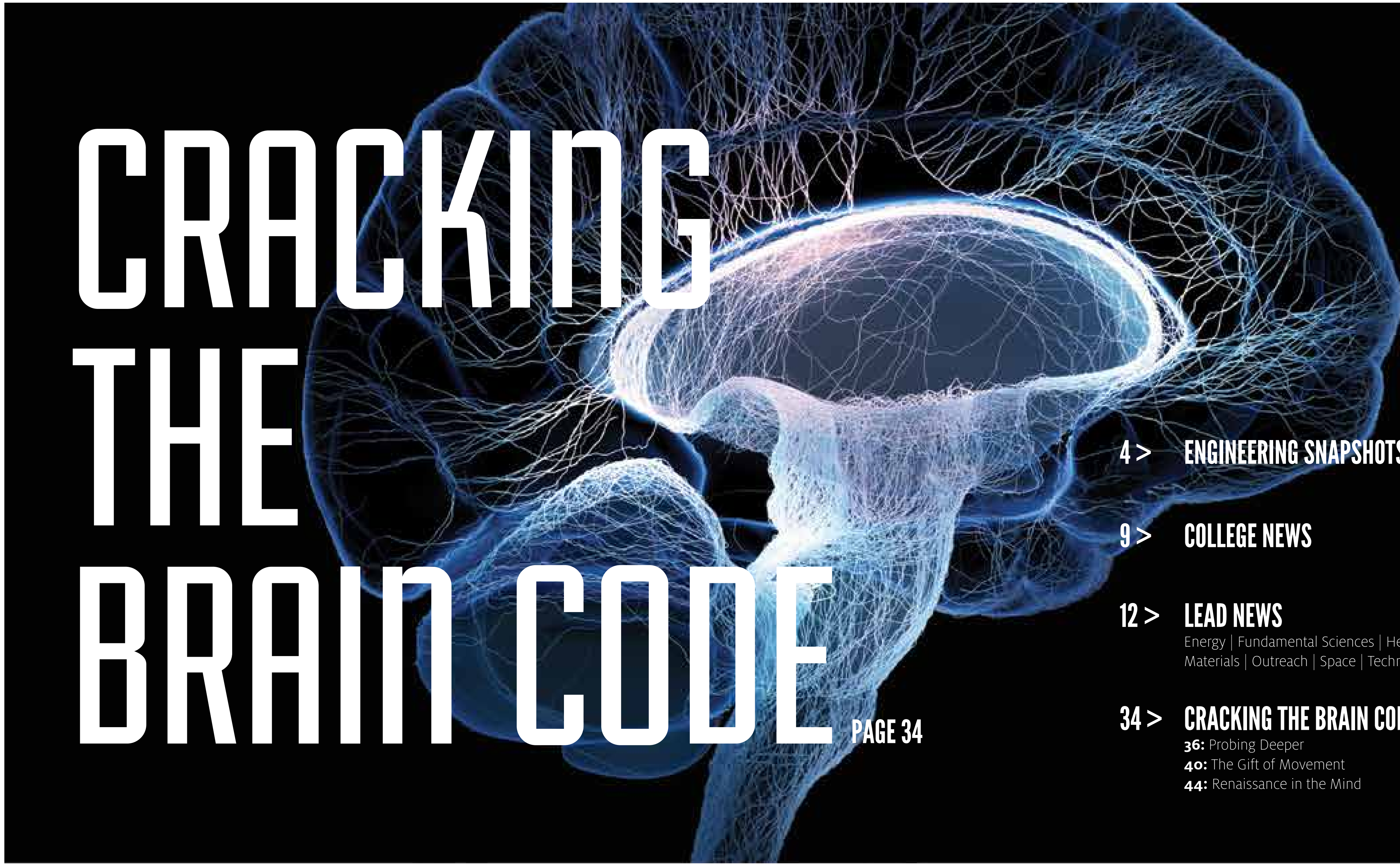
A team of Cullen College students led by **Jose Luis Contreras-Vidal,** Hugh Roy and Lillie Cranz Cullen University Professor of electrical and computer engineering, collected brainwave data on hundreds of children while they played *Minecraft* at the museum.

“Once we analyze the data it will likely show there’s a heightened connectivity and heightened attention span that is given to the game,” said Anastasiya Kopteva, an undergraduate electrical and computer engineering student at the Cullen College who assisted with the event. “We are bringing more science to the idea that video games can actually be beneficial.”

Contreras-Vidal, who also serves as the director of the UH Non-Invasive Brain Machine Interface Systems Laboratory, said the ultimate goal of this research is to map as much of the human brain as possible. His laboratory specializes in the development of robotic exoskeletons that can help patients with mobility impairments such as paralysis to regain control of their limbs using only the power of their thoughts.

By the end of the event, Contreras-Vidal and his team had collected data on over 400 children while they played the video game.

Watch our video of the Children Museum of Houston’s “*Minecraft* Mayhem!” event at www.egr.uh.edu/video-minecraft-brain.



CRACKING THE BRAIN CODE

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+ SPECIAL SPOTLIGHT INTERVIEW WITH BOB ZOCH

ALUMNI FEATURE

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Parameters is published biannually by the University of Houston Cullen College of Engineering, Office of Communications.

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ENGINEERING SNAPSHOTS

DEAN'S LETTER

I often tell Cullen College students that being an engineer in the 21st century is the most exciting career you could choose. There are hundreds of reasons why I believe this, but in this issue of *Parameters Magazine*, we are focusing on just one of them: decoding the human brain.

As I write this letter, tools and technologies are being developed in laboratories across the U.S. that will allow us to learn more about our own minds than ever before possible. Only 10 years ago, the tools to understand how individual neurons communicate with one another inside of the brain did not exist. By the end of the BRAIN Initiative, scientists will have mapped the activity of each of the brain's 100 billion neurons.

Over the next 10 years, our conceptual foundations of the human brain will likely be shaken to their core as researchers release new findings on the brain's circuitry, mental processes and development. Diagnosis and treatment for everything from mental illness to neurological disorders will likely change as we begin to shine more light on the mysteries of the brain.

To be an engineer during this time in the history of brain science is extraordinary. This is a fact not at all lost on University of Houston professors and students in the Cullen College of Engineering, who are conducting research at the cutting-edge of brain science alongside some of the world's leading physicians.

New tools, techniques and technologies are being developed inside of the Cullen College's classrooms, laboratories and research centers that are currently being tested in patients at the Texas Medical Center.

These developments will lead to new surgical techniques for Parkinson's disease, new technologies for patients with mobility impairments, new diagnostic methods for neurological disorders and new windows into the inner-workings of the brain. I invite you to learn more about these research projects and other recent updates from the UH Cullen College of Engineering in this issue of *Parameters Magazine*.

Warm regards,

Joseph W. Tedesco

Joseph W. Tedesco, Ph.D., P.E.
Elizabeth D. Rockwell Dean and Professor

YOUR BRAIN BY THE NUMBERS

Your brain accounts for about

2% of your body's weight, but uses **20%** of your total energy and oxygen intake

Your brain is about

60% FAT,

making it the fattiest organ in your body

Your brain contains about

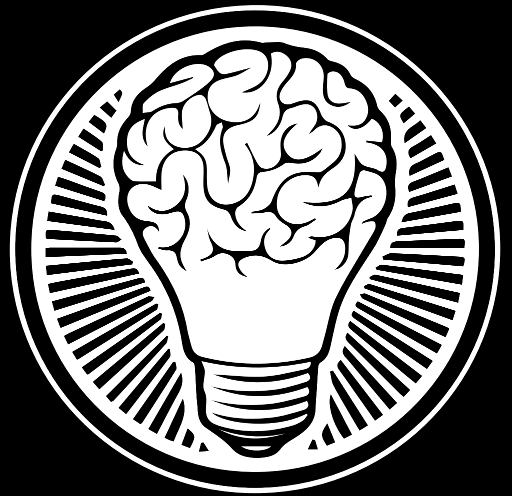
86 BILLION brain cells

Your brain has about

10,000 different types of neurons

A piece of brain tissue as small as a grain of sand contains about

100,000 neurons & 1 BILLION synapses, all communicating with each other



Writers ON THE BRAIN

"The brain is wider than the sky."
-Emily Dickinson

"There is nothing either good or bad, but thinking makes it so."
-William Shakespeare

"My own brain is to me the most unaccountable of machinery – always buzzing, humming, soaring, roaring, diving, and then buried in mud. And why? What's this passion for?"
-Virginia Woolf

"I said in 'Dorian Gray' that the great sins of the world take place in the brain, but it is in the brain that everything takes place.... It is in the brain that the poppy is red, that the apple is odorous, that the skylark sings."
-Oscar Wilde

"I like nonsense. It wakes up the brain cells."
-Theodor Seuss Geisel, "Dr. Seuss"

BRANCHING OUT:
NEW BUILDINGS, NEW CAMPUSES

The UH Cullen College of Engineering will double its student enrollment by 2025 while continuing to raise admission standards and graduation rates. To accommodate the growth of its faculty and student body, the Cullen College will add new, state-of-the-art classroom and research spaces and extend its reach to UH branch campuses, satellite campuses and other locations across the Greater Houston area.

NEW BUILDINGS

The 120,000-square-foot Multidisciplinary Research and Engineering Building (MREB), a $51 million engineering research facility, will allow students to conduct industry-relevant research inside one of the most cutting-edge laboratories in the city of Houston

PARTNERING WITH INDUSTRY

UH Engineering will partner with industries throughout Houston to create mutually beneficial educational facilities located within local corporations and businesses

ONLINE COURSE OFFERINGS

UH Engineering will expand its online course offerings and introduce new, industry-relevant certificate programs

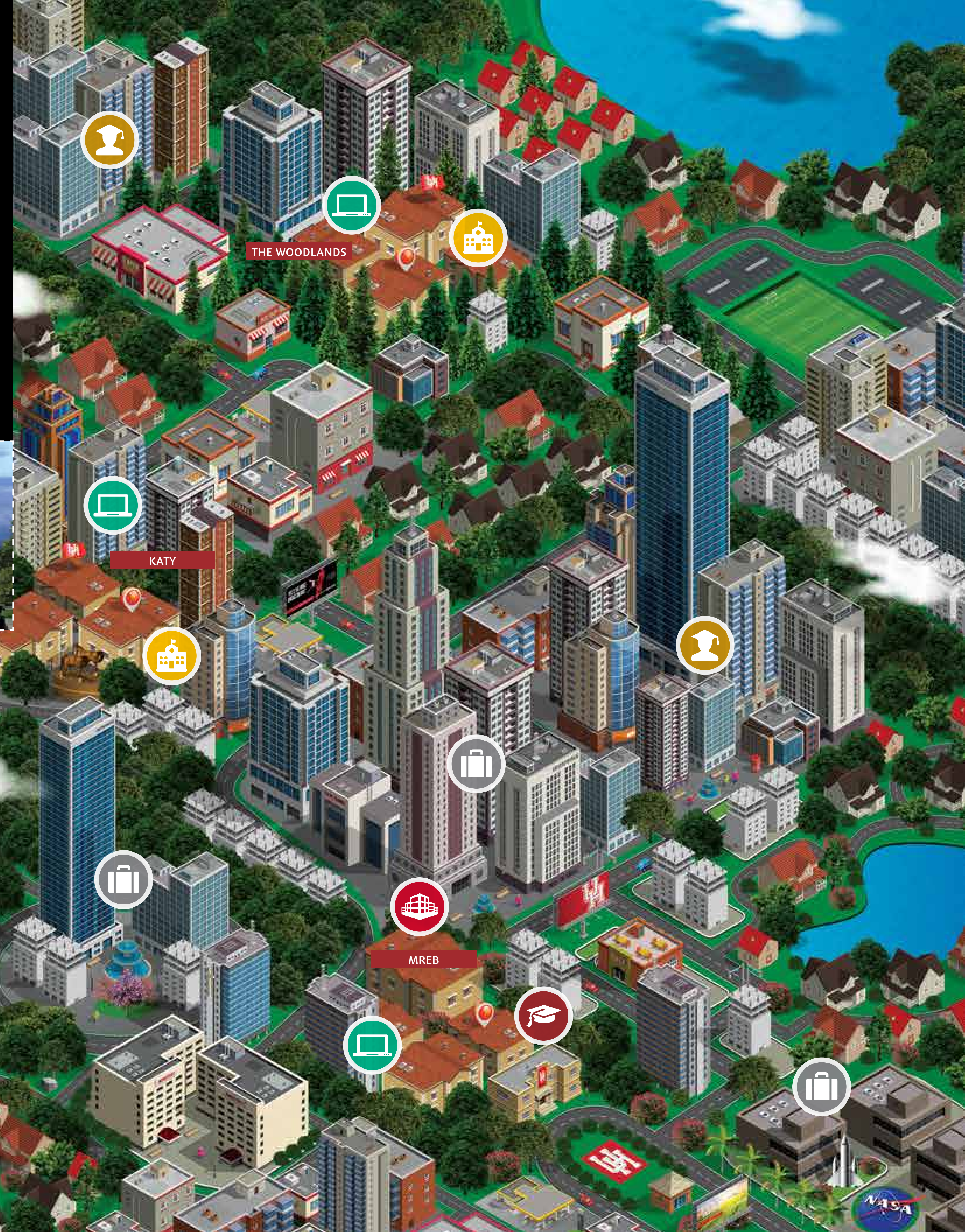
GRADUATION RATES

By 2025, 2,000 world-class engineers will graduate from UH each year

- 80% of all Cullen College graduates are employed in the state of Texas within one year of graduation

DIVERSIFYING STEM

600 female engineers, 700 Hispanic engineers and 300 African American engineers will graduate from UH and enter Houston's STEM workforce in 2025



VISIT WWW.EGR.UH.EDU/ENGINEERING-HOUSTON TO LEARN MORE!

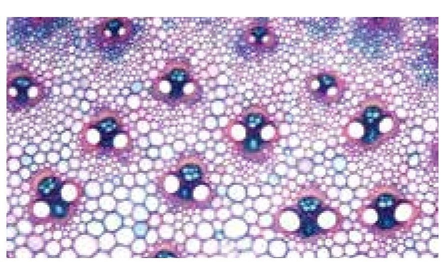
IN THE MEDIA SPOTLIGHT

SMARTPHONE-BASED EARLY WARNING SYSTEMS FOR EARTHQUAKES CAN SAVE LIVES

Featuring: Craig Glennie, assistant professor of civil and environmental engineering
Covered by:

livescience, Scientific American, Science AAAS, Los Angeles Times, boingboing, Gizmodo, gizmag, National Geographic, USA Today, NBC News, The Economist, Mashable

UH ENGINEERS TURN SMARTPHONE INTO MICROSCOPE FOR 3 CENTS



Featuring: Wei-Chuan Shih, associate professor of electrical and computer engineering
Covered by:

gizmag, CNBC, Slate, PHYS.ORG, UH Moment

SELF-ASSEMBLING GAUSS GUN IDEA WOULD HEAL PATIENTS FROM THE INSIDE

Featuring: Aaron Becker, assistant professor of electrical and computer engineering
Covered by: Engadget, ExtremeTech.com, Techxplore.com, IEEE Spectrum, Popsci.com

RESEARCHERS BUILD BRAIN-MACHINE INTERFACE TO CONTROL PROSTHETIC HAND

Featuring: Jose Luis Contreras-Vidal, Hugh Roy and Lillie Cranz Cullen University Professor of electrical and computer engineering
Covered by: Gizmag, Medical Xpress, Healio

COULD PLASTIC REPLACE STEEL IN BRIDGES?

Featuring: DJ Belarbi, professor of civil and environmental engineering
Covered by: KPRC Houston (www.click2houston.com)

RESEARCHERS DEVELOP LESS-INVASIVE METHOD FOR KIDNEY DIAGNOSTICS

Featuring: Chandra Mohan, Hugh Roy and Lillie Cranz Cullen Endowed Professor of biomedical engineering; Wei-Chuan Shih, associate professor of electrical and computer engineering
Covered by: Phys.org, Business Standard, Economic Times

ENGINEERING STUDENTS NOW HAVE SEAMLESS TRANSFER OPTION WITH UH

Featuring: UH Cullen College of Engineering
Covered by: YourHoustonNews.com, The Houston Chronicle

UH EXPANDS IN SUGAR LAND AND KATY, PLANS FOR BIG PARTNERSHIPS

State leaders have paved the way for a $54 million new construction at UH Sugar Land (UHSL), a campus of the University of Houston, and an entirely new campus in Katy worth $46.8 million. UHSL received the allocations in HB100, which the governor signed last June.

The 150,000-sq.-ft. Sugar Land facility, planned to be completed in 2019, will primarily house programs offered by the UH College of Technology. A portion of the college will relocate to Sugar Land, and additional programs in business, education and health-related fields are also expected in the next two to five years.

The addition of a fourth building to the 250-acre campus allows for expanded programs that complement the workforce needs of the area, which is home to a number of technology and engineering companies, such as Fluor, Schlumberger and Texas Instruments. Greater Fort Bend Economic Development Council CEO Jeff Wiley says the county is one of the largest in the state, boasts one of the most highly educated populations and consistently ranks nationally in the Top 10 for population employment growth rate.

"If UH is going to continue to meet the higher education needs of the Houston area, we need to be building where people live," said Provost Paula Myrick Short, UH senior vice president for academic affairs. "There is tremendous growth in Fort Bend County. We are grateful for the incredible support of the legislature, which will help further develop this campus and expand higher education opportunities in the region."

The new UH campus in Katy – one of the fastest growing areas in the Houston region – will offer degrees most relevant to current industry demands, including engineering, business and nursing.

Read more about this story in the Daily Cougar: http://thedailycougar.com/2015/08/19/uh-expansion-in-sugar-land-katy-plans-for-big-partnerships.

Photo by Derrick Collins

ENGINEERING STUDENTS NOW HAVE SEAMLESS TRANSFER OPTION WITH UH

Beginning in fall of 2015, San Jacinto College students will be eligible for a seamless transfer into the University of Houston Cullen College of Engineering.

San Jacinto College has signed an articulation agreement with the Cullen College, which offers San Jacinto College students who are currently taking courses for completion of the Associate of Science in Engineering Science an option to seamlessly transfer into the UH Cullen College of Engineering.

"This articulation agreement between the University of Houston Cullen College of Engineering and San Jacinto College will ensure that the transition process from one campus to another is as seamless as possible for engineering students," said Joseph W. Tedesco, Elizabeth D. Rockwell Dean of the Cullen College of Engineering. "It will also provide students with a better understanding of the course requirements for transferring to the Cullen College, allowing them to save time and money by making the best course selection choices."

Qualified engineers are in high demand across the country, but the supply of engineering talent continues to lag behind. Kelly Services, a workforce solutions provider, ranked Houston as the city with the highest demand for engineers in the U.S. In terms of average annual salaries, Houston is the highest paying metro area for civil engineers ($112,480), chemical engineers ($128,380) and petroleum engineers ($168,280).

"I am very excited about this important step toward graduating more world-class engineers into the city of Houston," Tedesco said.

San Jacinto College students who want to transfer to the UH Cullen College of Engineering must complete the Associate of Science degree in Engineering Science (60 hours) and meet the Cullen College's admission requirements.

For more information, please visit http://www.sanjac.edu/article/engineering-students-now-have-seamless-transfer-option-uh-articulation-agreement-helps.

UH LAUNCHES PLANS FOR SUPERCONDUCTOR MANUFACTURING INSTITUTE

The University of Houston will lead plans for an Advanced Superconductor Manufacturing Institute (ASMI), aimed at speeding the full commercialization of high-temperature superconductors. Energetics Inc. will support UH in this effort.

Venkat Selvamanickam, M.D. Anderson Chair Professor of mechanical engineering at UH, will serve as principal investigator for a $500,000 planning grant from the National Institute of Standards and Technology (NIST). The grant will be used to develop an industry-led consortium to address technical obstacles that have limited superconductor manufacturing, as well as to develop a business plan for the institute.

Selvamanickam is also the director of the Applied Research Hub at the Texas Center for Superconductivity at UH, which develops high-performance superconducting wire, with support from the U.S. Department of Energy, Office of Naval Research, Army Research Laboratory, National Science Foundation, the state of Texas and industry.

The University of Houston was one of 16 recipients of the NIST planning grant, among 118 applicants in a competitive selection process.

The United States has five Advanced Manufacturing Institutes but none involve superconductor technology. None of the planning consortiums funded in 2014, the first year the grants were awarded, deal with superconductor technology, either.

COLLEGE ANNOUNCES NEW DOCTORAL PROGRAMS IN PETROLEUM AND GEOSENSING SYSTEMS ENGINEERING

The UH Cullen College of Engineering continues its tradition of providing innovative and industry-relevant academic programs by announcing the approval of new Ph.D. programs in geosensing systems engineering and petroleum engineering.

GEOSENSING SYSTEMS ENGINEERING AND SCIENCES

The University of Houston is currently the only institution in the world offering a graduate program in geosensing systems engineering and sciences, a cross-disciplinary field focusing on the use of airborne mapping to meet the needs of private industry, government agencies and academic institutions.

Graduate students pursuing a degree in geosensing systems engineering have the benefit of working within the NSF-funded National Center for Airborne Laser Mapping (NCALM), the world's leading center for using Light Detection and Ranging, or LiDAR.

With LiDAR, researchers fly a plane over an area they want to map, shooting hundreds of thousand of laser bursts per second at the ground. How that light returns to its source can be used to create extremely detailed topographical maps, even through dense vegetation and murky water.

In the past five years, NCALM has located ancient ruins, identified levees in danger of failing, charted land erosion following hurricanes, created flood maps for urban areas, found near-drought conditions in seemingly healthy plants, mapped the sea floor, charted areas prone to landslides, and helped identify how the presence of life impacts geographical features.

Ramesh Shrestha, NCALM director and Hugh Roy and Lillie Cranz Cullen Distinguished Professor of civil and environmental engineering, said as the geospatial technology sector continues to grow rapidly, so does the demand for scientists who are trained to use these technologies. "That's why we knew we had to develop a doctoral program," Shrestha said. "We developed the Ph.D. program in direct response to these industry trends."

To learn more about the Ph.D. program in geosensing systems engineering and sciences, please visit: http://www.cive.uh.edu/programs/geosensing-systems-graduate/doctor-philosophy-phd.

PETROLEUM ENGINEERING

On the heels of the successfully re-launched petroleum engineering undergraduate program, Tom Holley, director of the petroleum engineering program at UH, said it quickly became clear that "there was an essential need for a petroleum engineering doctoral program in the city of Houston."

With support and input from Houston's booming energy industry, the Cullen College established a petroleum engineering doctoral program at Energy Research Park (ERP). The program is administered by the Cullen College's chemical and biomolecular engineering department and has received support from ConocoPhillips, Devon Energy, Marathon Oil, Southwest Energy, El Paso Corporation, the Society of Professional Engineers Gulf Coast Chapter and major private donors.

Holley said that because of the program's location at ERP as well as the University's proximity to the energy industry's largest players, doctoral students will have unique opportunities for research and employment that students living in any other city in the U.S. would not have. This was certainly the case for the revived bachelor's degree program in petroleum engineering, which was lauded by the Business-Higher Education Forum as a model partnership between industry and academia.

To learn more about the Ph.D. program in petroleum engineering, please visit: http://www.petro.uh.edu/graduate/degree-programs/phd.

UH ENGINEER TESTIFIES BEFORE CONGRESS ON ENERGY TRAINING PROGRAM

Ramanan Krishnamoorti, acting vice president/vice chancellor for research and technology transfer at the University of Houston, was asked to testify before Congress about an innovative workforce training program developed for the energy industry.

Photo by Jeffrey Zeldman

Krishnamoorti, who also is chief energy officer at UH and professor of chemical and biomolecular engineering, addressed the Energy and Power subcommittee of the House Committee on Energy and Commerce last April.

The new UH program, which began in fall of 2015, involves three undergraduate certificate programs – advanced petroleum technology, advanced process technology and advanced safety technology. Students who complete two of the certificate programs can then spend an additional year to earn a bachelor's degree in Organizational Leadership and Supervision, offered through the UH College of Technology.

"For the energy industry, you need to have nimble solutions," Krishnamoorti said. "You need to offer what the industry and the workforce need. Stackable certificates are an innovative way to provide the critical skills the energy industry needs and to allow energy employees to advance their careers, instead of just their jobs."

Krishnamoorti and other UH officials were in Washington, D.C., to meet with members of Congress, as well as representatives from the Department of Energy, about the University's role in filling the need for skilled energy workers. Among other offerings, UH offers undergraduate and graduate degrees in petroleum engineering, and the nation's only master's degree in subsea engineering.

He was asked to testify about the new program at a hearing that focused on the 21st century energy workforce, in conjunction with legislation proposed by subcommittee member U.S. Rep. Bobby Rush of Illinois. Rush has proposed a bill to improve training for energy-related jobs, with an emphasis on increasing the number of skilled minorities and women in the industry.

According to the Greater Houston Partnership, there is likely to be a shortfall of 70,000 "middle-skill" workers in Houston by 2017, a situation created by both rapid technological change, coupled with the lack of training programs to provide the needed skills, and the looming retirement of baby boomers in the energy workforce.

Krishnamoorti said the program developed by UH, working with area community colleges and members of industry, can be replicated by other higher education institutions once it has been demonstrated and assessed here.

The certificate programs will require hands-on learning, using micro versions of the equipment used in petrochemical plants and elsewhere in the industry. Because of that, Krishnamoorti said they can't be moved entirely online; that makes sharing the idea critical for a broad national impact on the energy workforce.

The initial group of students will take classes on the UH campus, but the certificate courses ultimately could be taught at a community college, using university-accredited faculty.

MAGNESIUM-ION BATTERIES IN THE FAST LANE

Yan Yao, assistant professor in the Cullen College's electrical and computer engineering department, is developing alternatives to popular lithium-ion batteries, which are used to power much of the modern world. Now, a recent breakthrough in this research has been published in the journals *Nano Letters* and *ACS Applied Materials and Interfaces*.

Yao's batteries use magnesium ions instead of the traditional lithium ions, which are expensive and fraught with safety concerns. Lithium-ion batteries have a tendency to catch fire and even explode under certain conditions, especially when the batteries are used to power electric vehicles, Yao said.

Magnesium-based batteries have many benefits over their lithium-ion counterparts. Magnesium is a resource abundant material, making it potentially much cheaper than lithium ions. In addition to being safer than lithium-ion batteries, magnesium ions can discharge twice as much energy as lithium ions.

But magnesium ions have some drawbacks to overcome before they can replace lithium-based batteries. For starters, magnesium ions move very slowly in traditional host materials due to the strong interaction between the magnesium ions and the negatively charged host lattices inside of the batteries.

"In the *Nano Letters* paper, we demonstrated for the first time an interlayer expansion approach to transform an inactive host into efficient magnesium storage materials," Yao said. The interlayer expansion was realized by inserting a thin layer of ionic conducting polymer into the layered materials' lattice, which boosts magnesium's diffusivity by two orders of magnitude.

The interlayer expansion approach could be leveraged to a wide range of host materials for the storage of various ions, leading to novel intercalation chemistry and new opportunities for the development of advanced materials for next-generation electric vehicles.

"In the paper published in *ACS Applied Materials and Interfaces*, we reported the other key advantage of magnesium-ion over lithium-ion batteries," Yao said. "The dendrite-free deposition behavior of the magnesium-metal anode at high current density condition ensures safe operation, which is considered the Holy Grail for beyond lithium-ion technologies."

Yanliang Liang and Hyun Deog Yoo, both postdoctoral research fellows in the electrical and computer engineering department, were first authors of the two papers. Graduate students Yifei Li and Jing Shuai were coauthors on the papers. The work published in *Nano Letters* was in collaboration with Lars Grabow, assistant professor of chemical and biomolecular engineering at the Cullen College, professor Hector Calderon of the School of Physics and Mathematics at the National Polytechnic Institute in Mexico City, Mexico, and associate professor Francisco Hernandez from the UH College of Technology.

The magnesium ion research was funded by a grant from the U.S. Navy's Office of Naval Research Young Investigator Program (YIP) to develop safer and longer-lasting batteries for everything from electric vehicles to Navy vessels. In addition to research on magnesium-ion batteries, Yao and his team also work on aqueous-based batteries and sodium-ion batteries funded by the Advanced Research Projects Agency – Energy (ARPA-E) and the National Science Foundation, respectively.

RESEARCHERS RECEIVE BOOST FROM WELCH AWARDS

Three assistant professors of chemical and biomolecular engineering at the UH Cullen College of Engineering received Welch Awards in Chemistry from the Welch Foundation for their contributions to fundamental chemical research that benefits humankind. Located in Houston, the foundation is one of the largest private funding sources for chemistry research in the country.

Jeffrey Rimer earned a three-year, $330,000 award to continue his search for more effective drugs to treat kidney stone disease. The foundation awarded **Jacinta Conrad** with a three-year, $195,000 grant to explore the structure and dynamics of attractive nanoparticle glasses. **Jeremy Palmer** also earned $195,000 to expand his postdoctoral research on unusual phase behaviors exhibited by water molecules during supercooling.

JEFFREY RIMER

Occasional and chronic kidney stones, which are crystal aggregates that form in the kidney, affect approximately 10 percent of the U.S. population. Each year, more than half a million people visit emergency rooms with the painful mineral and acid salt deposits.

Jeffrey Rimer earned his first Welch Award in 2012 to study mechanisms of naturally occurring biological growth inhibitors on kidney stones. The foundation renewed Rimer's award this year to explore small, organic molecules as potential drugs to treat the kidney disease. The award funds more than three full-time graduate students to help conduct the research.

"In the past 30 years there have been no advancements in therapies for kidney stone disease," Rimer said. "We started a program with our first Welch award to design peptides as potential drugs to mimic natural proteins that inhibit the growth of crystals implicated in stone disease."

The current treatment for kidney stones is an organic molecule called citrate, which is an over-the-counter supplement. Citrate acts as a mild inhibitor of the crystals but is incapable of significantly reducing stone incidence rates among patients with chronic disease.

"There is so much we still do not understand about this system at a molecular level," Rimer said. "The premise is that understanding the factors governing the specific recognition and interactions between drug molecules and crystal surfaces will help us design more effective crystal growth inhibitors."

Rimer has patented a promising new drug for the treatment of kidney stones that serves as the basis for the next phase of their research. He is collaborating with a nephrologist at Litholink Corporation to perform human trials and a chemical engineering professor at the University of Pittsburgh to perform computational simulations of drug-crystal interactions.

Rimer intends to leverage Welch funding for future phases of his research. For example, he and his collaborators are recruiting other researchers to conduct animal testing to determine drug efficacy in vivo, which he is looking to the National Institutes of Health (NIH) to fund.

"The focus of this Welch project is on kidney stone research, but understanding and controlling molecule-crystal interaction is a general theme that connects much of my work," Rimer said. "The foundation has been integral in supporting my research in crystal engineering, and helped launch new research projects in my group."

JACINTA CONRAD

Jacinta Conrad earned her Welch Award to explore one of the most puzzling fundamental problems in physical chemistry, the origins of the glass transition. Glasses lack long-range order and look structurally like liquids but behave mechanically like solids. In contrast, many solids are ordered crystals, in which the molecules or atoms are arranged in a regular lattice. Ordered crystals and disordered glasses can be composed of the same molecules, but their structures and how they form are very different. Despite years of research, the reasons for these differences are poorly understood among scientists.

"While we have a basic understanding of crystal formation, we don't understand what drives the formation of glass," Conrad said. "There is not one unifying theory that explains the phenomenon."

For certain applications, glasses have mechanical advantages over crystals because their disordered structures are void of weak spots associated with ordered crystal structures. Conrad's research group uses a novel colloidal model system to study the structure and dynamics of colloidal particles across the phase transition from dense liquid to glass. Their objective is to test existing theories for the glass transition, which will increase fundamental understanding and help engineers tailor mechanical properties of glasses for practical applications.

Ordinary phase transitions often involve abrupt structural changes between ordered and disordered states, such as disordered liquid water freezing to form ordered crystalline ice. By contrast, the molecules in a liquid remain disordered as the material solidifies into a glass. Likewise, there is no structural change when solid glasses melt into liquids.

In her lab, Conrad uses confocal microscopy to image colloidal particles suspended in liquids and tracks them over time with computer software. In these dense colloidal solutions, particles move when jostled or bumped by solvent molecules or by other particles, much like crowds determine motions of people pushing through them. With the microscope, researchers can observe hard, spherical particles colliding with other particles and bouncing away like billiard balls. As the number of particles increases, these dynamics become slower and slower, and the suspension behaves more and more like a solid.

Colloidal systems are popular for studying fundamental questions about phase transitions and flow behavior because they allow researchers to track every particle on the micron scale and ask detailed questions on both the structure and dynamics of every particle.

"We can watch every single colloid as it transitions from a disordered liquid to an ordered solid, such as crystal," Conrad said. "But none of the theories work for glasses."

Conrad hypothesizes that differences between the predictions of existing theories and the measurements on experimental glasses are caused by attractive interactions between the colloids, which she and her team will control in this study. In her model system, she can make the particles attractive, or sticky, by adding small polymers to her solutions. The polymers crowd the colloids, and this crowding pushes the colloids together to create an effective attraction. She plans to study the effects of these attractions in controlled settings to better reconcile the gaps between theories and experiments.

"This novel modeling system is convenient and simple, yet we can control the particle size, the distance between particles at which attractions occur and the strength of attraction," Conrad said. "We have a few knobs to tune with this system, which allows us to ask detailed questions about existing theories."

Over the course of this three-year grant, Conrad hopes to establish the usefulness of her novel colloidal modeling system for testing existing theories and to study the glass transition in thin films and small drops, which is relevant for applications in coatings and 3-D printing.

JEREMY PALMER

Jeremy Palmer earned his Welch Award to expand on his postdoctoral research on the phase behavior of liquid water at low temperatures that published in *Nature* last year.

"We're trying to fill a knowledge gap about the unusual behavior exhibited by some liquids when they're cooled near or below their normal freezing point," Palmer said.

Water's density anomaly is one well-known example of this unusual behavior. As liquid water cools at ambient pressure, its density increases, like most simple liquids. However, at 4 degrees Celsius, water does something strange – it starts to expand and to become less dense as it cools. Although liquid water normally freezes into ice at zero C, it can be stabilized in experiments to about 42 C below zero, at which point freezing occurs too rapidly for measurements on liquid water to be performed. Remarkably, experiments on liquid water performed slightly above this temperature reveal that it continues to defy normal liquid behavior and expand upon cooling. Many other peculiar behaviors, such as its increased compressibility upon cooling, are also observed in water at low temperatures.

Although water is the most studied substance in the world, the physical origin of its unusual behavior upon cooling continues to elude scientists. And it is not the only substance that behaves strangely – evidence suggests that liquid forms of silicon and possibly carbon exhibit similar trends.

"These are some of the most ubiquitous and important substances on Earth," Palmer said. "They shape almost every aspect of our natural world and life as we know it, and yet we still don't understand why they behave the way that they do."

With Welch Foundation support, Palmer and his research team will use state-of-the-art computer simulation techniques to study molecular models of these substances to better understand their odd behaviors. Their investigation will focus on examining one particularly intriguing and controversial hypothesis that suggests these substances behave like a mixture of two liquids.

According to this theory, at cold temperatures far below the freezing point (colder than 42 C below zero), two different liquids can exist and undergo a phase transition, in which one liquid converts into the other. Although this hypothesis is consistent with the majority of experimental measurements, at least for water, phase transition of co-existing liquids is also thought to occur at very low temperatures under different conditions where crystallization occurs rapidly. As a result, definitive evidence to experimentally falsify this hypothesis has not yet been obtained.

"One advantage of computer simulations is that we can directly study the behavior of model substances under conditions where two liquids may exist," Palmer said. "Although models can't resolve this controversy for any real material, they can provide us with understanding of the physical mechanism responsible for this behavior and help in interpreting the vast amount of experimental data already published on this topic."

While such behavior is in principle easier to study in model systems, the possibility of it occurring in models of water had been the subject of vigorous debate for more than two decades until recently. In their 2014 *Nature* paper, Palmer and collaborators resolved this long-standing controversy by using computer simulation to provide the first unambiguous evidence demonstrating that at least one water model separates into two liquids at sufficiently low temperatures.

"We know for sure that two liquid phases coexist in at least one water model, but we don't know whether or not this happens in models of other important substances such as silicon and carbon," Palmer said. "We aim to answer this over the next few years."

Palmer also plans to explore how and why this behavior occurs. Answering these interesting scientific questions would help to establish an understanding of the broader role that this phenomenon could play in nature's design – if it occurs in real substances.

FUNDAMENTAL SCIENCES

REVEALING THE ROLE OF TRANSPORT PROTEINS IN BIOLOGICAL CELLS

Ashutosh Agrawal, assistant professor of mechanical engineering at the UH Cullen College of Engineering, has published a paper in the *Proceedings of the National Academy of Sciences* (*PNAS*) that provides unprecedented fundamental insight into the role of key proteins in regulating cellular transport in different mechanical environments.

Specifically, Agrawal's research looked at two proteins – actin and BAR proteins – and the roles they play in the transport of cargo into biological cells. Nikhil Walani, a mechanical engineering graduate student at the Cullen College, and Jennifer Torres, a mechanical engineering undergrad, were Agrawal's collaborators on this project.

When extracellular cargo reaches the cell's membrane, it is recognized by receptors that initiate a signaling cascade to remodel the membrane locally. Depending on the cell type and its mechanical environment, an elaborate set of proteins is engaged to work together to form an invagination, or vesicle, in the membrane. The cargo sits inside the vesicle and is completely enveloped by the membrane. Eventually, the piece of membrane surrounding the cargo forms a mature vesicle that snaps off and detaches from the rest of the cell's membrane. The closed, cargo-carrying vesicle is then free to travel to its destination inside of the cell.

One of such mechanisms, known as clathrin-mediated endocytosis (CME), is the key metabolic pathway for transporting molecules into cells. This process is required for many critical functions, including nutrition and communication between cells.

In mammalian cells, the formation of vesicles during this process is primarily driven by clathrin, a membrane-bending protein. In contrast, the formation of cargo-carrying vesicles in yeast cells involves clathrin, actin and BAR proteins that contribute to vesicle formation in different capacities. Experimental studies have shown that an increase in cellular tension in the plasma membrane necessitates the use of actin and BAR proteins in driving vesicle growth.

Although scientists have long known that the actin and BAR proteins are active players in the formation of cargo-carrying vesicles in a high membrane tension environment, their specific roles in the process have remained a mystery. That is, until Agrawal and his students at the Cullen College began investigating the role these proteins play in yeast cells.

To investigate this phenomenon, Agrawal and his team developed models to help predict and explain the shapes of vesicles that form when only actin proteins are driving the growth of cargo-carrying vesicles. Using these models, his team found that the formation of these vesicles is a relatively smooth and stable process until a critical amount of force is reached.

"Once the critical force is crossed, the vesicle undergoes a snap-through transition that drastically elongates and squeezes the vesicle," Agrawal said.

The next step was to develop a model for the effect of BAR proteins on the formation of vesicles. Agrawal's team found that in contrast with the rapid shape transition that took place during vesicle formation using only actin proteins, the BAR-driven vesicle formation was a gradual and controlled process.

"Basically, what we saw was that the actin provides a big push towards forming the vesicle, and right when the vesicle gets close to the critical point, the BAR proteins gently tip the system over and leave, letting the cargo-carrying vesicle undergo instability-driven growth," Agrawal said. "What this means is that the actin proteins are the driving force behind membrane deformation and vesicle formation, with BAR proteins acting as facilitators in this process."

This interplay of actin and BAR proteins that drives membrane deformation during the CME process could also be at play in many other shape-transforming processes in cells, Agrawal added. More research is needed in order to determine whether protein-induced instabilities are at play in other cellular processes, but Agrawal's *PNAS* article certainly lays the groundwork for future studies on this topic.

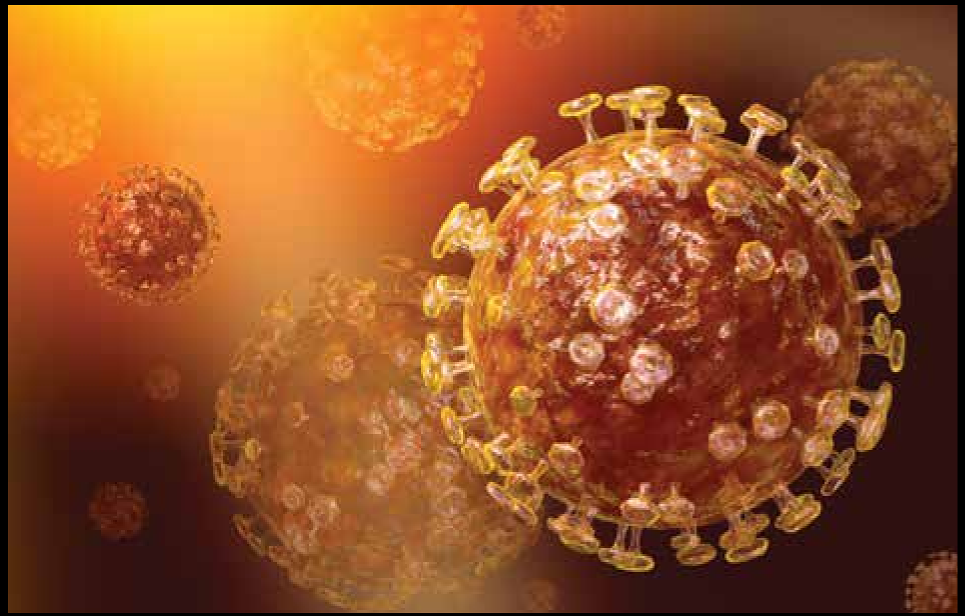
"Further research into these lingering questions could eventually lead to improved drug delivery," Agrawal said. "This is one major area worth investigating based on the fundamental groundwork we have laid out in this paper."

"FURTHER RESEARCH INTO THESE LINGERING QUESTIONS COULD EVENTUALLY LEAD TO IMPROVED DRUG DELIVERY."

HEALTH & MEDICINE

ENGINEERS DEVELOP METHODOLOGY TO TRACK EFFICACY OF LEUKEMIA TREATMENT

Researchers are gaining momentum with adoptive cell therapy (ACT), a type of immunotherapy that uses the patients' native or genetically modified immune cells to attack diseases such as cancer and chronic infection.



In fact, a team of University of Houston researchers, in collaboration with M.D. Anderson Cancer Center physicians and scientists, recently identified attributes of the immune cells that could help researchers optimize cell designs for improved mediation of tumor regression in leukemia patients.

Ivan Liadi, UH Cullen College chemical and biomolecular engineering graduate student, was lead author on a paper that published in the May edition of *Cancer Immunology Research*, a journal of the American Association for Cancer Research. He utilized Timelapse Imaging Microscopy in Nanogrid Wells (TIMING), a novel technique developed in the UH Single-cell Lab, to examine the functional efficacy of chimeric antigen receptor-modified T cell (CAR+ T cell) in killing of tumor cells in vitro.

"We anticipate that TIMING may be used to rapidly determine the potency of T-cell populations and may facilitate the design and manufacture of next-generation CAR+ T cells with improved efficacy," Liadi wrote in the journal paper.

The research was also conducted by **Navin Varadarajan,** professor of chemical and biomolecular engineering, **Badri Roysam,** electrical and computer engineering department chair and professor, along with postdoctoral fellow Gabrielle Romain, among other scholars.

Navin Varadarajan

Badri Roysam

"The Single-cell Lab at the University of Houston aims to pioneer single cell methodologies with an eye on translation," Liadi said. "We've tried to look at the bigger picture in order to optimize and expand the methodology, either with applications into different immune cells or into the realm of dynamic imaging."

World-renowned immunotherapy expert Carl H. June referenced the UH study in his *Cancer Immunology Research* commentary that published last May. June, a professor of immunotherapy at the University of Pennsylvania, indicated that one of the strengths unique to Liadi's study was his use of CAR+ T cells already used in clinical trials.

One of the challenges of CAR+ based immunotherapy is identification of specific antigens present on target cells by immune cells with minimal off-target toxicity. In the context of leukemia, approximately 95 percent of malignant B cells express CD19 surface markers, making them highly attractive targets for CAR+ based immunotherapy.

The UH team constructed a unique array containing approximately 85,000 nanowells to capture, observe and repeatedly image interactions between the immune cells and tumor cells. They classified the CAR+ T cells into CD8+ CAR+ T cells (CAR8/cytotoxic T cells) and CD4+ CAR+ T cells (CAR4/helper T cells) and found that both CAR+ T subsets can participate in serial and multiplex killing.

The researchers discovered that CAR4 cells kill less efficiently than CAR8 cells because they take two hours longer to kill tumor cells. This is caused by lower expression of a cytotoxic molecule called granzyme B. However, improved resistance of CAR4 cells to activation-induced cell death (AICD) counterbalances this inefficiency. Furthermore, both cell subgroups suggested that highly motile CAR+ T cells could indicate high killing efficacy of tumor cells as well as low activation-induced death of immune cells.

"So instead of infusing heterogeneous mixtures of CAR+ T cells, specific modified phenotypes could lead to better tumor regression in patients," Liadi said. "Helping design new generations of optimized CAR+ T cells used in clinics is rewarding, high-impact research."

RESEARCHERS IDENTIFY GROUNDBREAKING TECHNIQUE FOR MALARIA DRUG DEVELOPMENT

More than 3 billion people – almost half of the world's population – are at risk of contracting malaria, which is spread by infected mosquitos.

In 2013, an estimated 200 million malaria cases worldwide resulted in approximately 585,000 deaths of mostly African children under the age of 5, according to the World Health Organization.

Last April, the *Proceedings of the National Academy of Sciences of the United States of America*, a scientific journal established in 1914, published results of a groundbreaking malaria study conducted by professors and graduate students in the Cullen College of Engineering at the University of Houston.

Jeffrey Rimer, Ernest J. and Barbara M. Henley assistant professor of chemical and biomolecular engineering, and **Peter Vekilov,** professor of chemical and biomolecular engineering and chemistry, developed a technique that can help facilitate development of new antimalarial drugs.

The UH engineers discovered the fundamental mechanisms for hematin crystal growth and drug-induced crystal inhibition in malarial parasites. Their research also yielded potential for accelerating high-throughput combinatorial drug screening, a shot-in-the-dark approach to drug development.

The project began three years ago with seed funding from the Alliance for NanoHealth at the Methodist Hospital Research Institute in the Texas Medical Center, and Rimer and Vekilov enlisted the help of two graduate students, Katy Olafson and Megan Ketchum.

"Not many researchers are looking at malaria with the same set of techniques and approaches we are bringing to bear," Rimer said. "To this end, we feel that we can make a significant contribution to this field of research."

The malaria parasite, which is transmitted by mosquitoes, goes through several stages in its life cycle after it enters the human body. During the asexual stage, the parasite infects red blood cells and breaks down hemoglobin, releasing heme. Heme is then oxidized to toxic hematin, which crystallizes within the digestive vacuole, thereby removing the toxin from the parasite.

While the quinoline class of antimalarials has proven effective, fundamental knowledge of hematin crystallization and the mechanism by which antimalarial drugs potentially inhibit crystallization were not well understood until Rimer and Vekilov conducted their study. This lack of understanding among scientists was attributable to their inability to conduct in situ studies of crystal growth at the microscopic level.

Consequently, the first objective of the UH study was to develop a biomimetic platform for assessing hematin crystallization. Rimer, Vekilov and their students used time-resolved atomic force microscopy, AFM, to render three-dimensional topographical images of crystal surfaces at near-molecular resolution. They discovered a method of growing hematin crystals that is similar to those formed in vivo, and published their breakthrough last year in *Crystal Growth and Design*, a journal of the American Chemical Society.

"It was exciting to identify a growth solution that was capable of producing hematin crystals similar to those observed in parasites," Rimer said. "This biomimetic growth solution became an enabling platform for our AFM study."

Rimer and Vekilov conducted the first-ever in situ AFM study of hematin crystallization in the absence and presence of a common antimalarial drug, chloroquine. The UH team observed that hematin grows by a classical pathway involving the generation and spreading of layers via the incorporation of hematin molecules. They identified four types of crystal surface sites for hematin to incorporate into the crystal. They also quantified the rate of layer generation and the velocity of layer advancement as a function of growth conditions, such as hematin concentration.

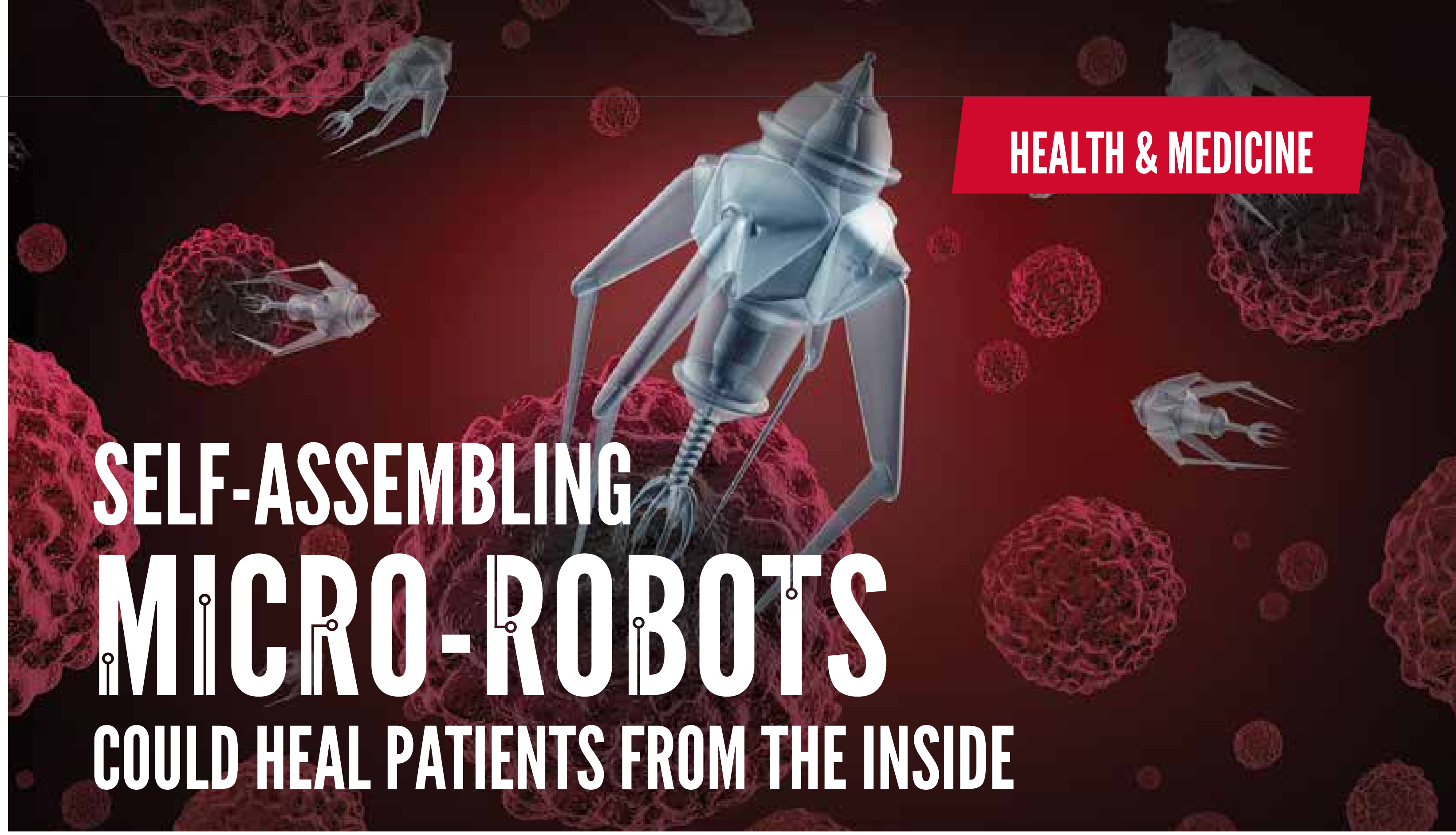
In situ AFM revealed that a two-micromolar concentration of chloroquine – an amount almost 100 times less than the solubility of hematin – suppresses the growth of layers on crystal surfaces. The drug concentration disproves a popular hypothesis that complexation, which involves the binding of an antimalarial drug molecule to free hematin in solution, is the primary mode by which the drug arrests hematin crystallization. While drug-hematin complexes do exist, this mode of action would require a significantly higher and toxic concentration of drug to achieve the same effect they observed for crystal growth inhibition, Rimer said.

The research validates another hypothesis that antimalarial drugs bind to crystal surfaces and block the attachment of hematin. This leads to the accumulation of toxic hematin in the digestive vacuole that ultimately kills the parasite.

"In essence, the parasite commits suicide by generating this toxin without a way of removing it," Rimer said.

Elucidating the effects of molecules on hematin crystal growth could help pharmaceutical companies better streamline efforts to design and screen new antimalarial drugs. The UH team's findings could also potentially accelerate high-throughput combinatorial drug screening, which is effective but time consuming. Researchers could prescreen the effects of numerous molecules on crystal growth to narrow the pool of potential drugs from thousands to hundreds before conducting more intensive parasite assays. Rimer and Vekilov have filed a provisional patent application for this technique.

"Identifying potential applications for our work is where our engineering mindset comes into play," Rimer said. "We are always thinking about the practicality of our research, and in this particular case, we believe our method of assessing hematin crystallization can help facilitate the development of new antimalarial drugs."



SELF-ASSEMBLING MICRO-ROBOTS COULD HEAL PATIENTS FROM THE INSIDE

Hydrocephalus is a nightmarish medical condition. Accumulating fluid in the skull ratchets up pressure on the brain and can cause lifelong mental disabilities. Current treatment requires physicians to cut through the skull and implant pressure-relieving shunts.

The necessary surgery is effective but invasive. For surgeries like these, science fiction authors have long dreamt of shrinking surgeons to mere millimeters to allow them to navigate interior passageways of the body instead of cutting large access holes. Arriving at problem sites, the fictional physicians might provide targeted drug delivery or surgical intervention.

Aaron T. Becker, electrical and computer engineering professor at the UH Cullen College of Engineering, is working collaboratively to deliver a robotic version of this microsurgeon. His submission to ICRA, the flagship conference of the IEEE Robotics and Automation Society in Seattle, Washington, was nominated for best conference paper and best medical robotics paper.

With collaborators Pierre E. Dupont, visiting professor of surgery at Harvard Medical School, and Ouajdi Felfoul, Harvard Medical School postdoctoral fellow at Boston Children's Hospital, Becker presented, "Toward Tissue Penetration by MRI-powered Millirobots Using a Self-Assembled Gauss Gun" at the conference earlier this year.

"Hydrocephalus, among other conditions, is a candidate for correction by our millirobots because the ventricles are fluid-filled and connect to the spinal canal," Becker said.

"Our noninvasive approach would eventually require simply a hypodermic needle or lumbar puncture to introduce the components into the spinal canal, and the components could be steered out of the body afterwards," he added.

Using a clinical Magnetic Resonance Imaging (MRI) scanner, the researchers map routes to problem sites on high-quality brain images to deliver medical interventions with tiny, maneuverable robotic components. Becker and his colleagues hack the scanners to enable them to use the MRI's own magnetic fields to push the small metal-filled robots. The team has already demonstrated use of magnetic forces to actuate needle-biopsy robots and to walk robots around an MRI.

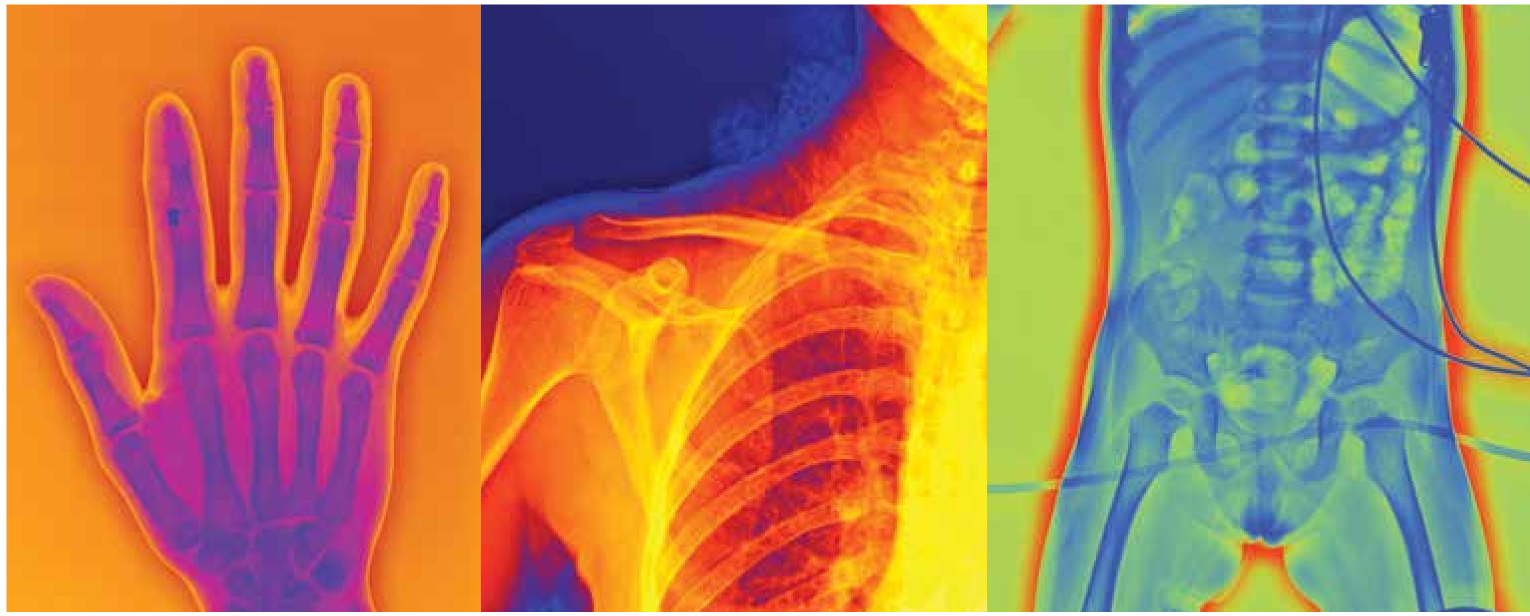
However, MRI scanners are not designed to push robots around, so they cannot apply enough force to pierce tissues or insert needles. These weak forces are a significant obstacle to using the MRI for medical interventions.

A toy called a Gauss gun inspired Becker's solution. The toy offers surprising results from a simple row of steel balls separated intermittently by several high-powered magnets. A single steel ball rolled toward one end of the row sets off a chain reaction when it smashes into the first ball. Sequentially, each steel ball smashes into the next until the last ball flies forward at a speed much faster than the initial ball's. Spacing between the magnets and steel balls stores potential energy, which the first ball converts to speed when it hits one end.

Similarly, the medical robot is a barrel self-assembled from smaller, separate components that navigate easily through the body. Each barrel component is 3D-printed from high-impact plastic with slender titanium rod spacers that separate two steel balls. Magnets are unnecessary because the MRI scanners magnetize the steel balls. The first component is a specialized delivery vehicle equipped with an 18-gauge needle tip used to pierce membranes or deliver drugs. The final component is a trigger with a long spacer so the two steel balls are only weakly attracted to each other. The approaching trigger is attracted to the barrel, which unleashes the stored potential energy and fires the other end component towards the target. Additional barrel components increase firing speeds. Becker's ongoing work focuses on exploring clinical context, miniaturizing the device and optimizing material selection.

"The work is still conceptual, but we have demonstrated the procedure working on plastic, fluid-filled containers, or phantoms, inside an unmodified clinical MRI scanner," Becker said. "The benefit of our research is that we can now create clinically relevant forces inside a standard MRI scanner, using just the MRI magnetic field."

ENGINEER IMPROVES DIAGNOSTIC TECHNIQUES FOR PATHOLOGISTS



> "[WE] ARE PUSHING THIS TECHNOLOGY TO THE POINT WHERE IT CAN BE CLINICALLY VIABLE IN THE NEAR FUTURE."

When performing diagnoses, pathologists rely heavily on qualitative chemical staining techniques that date back to the 19th century to detect signs of disease in tissue biopsies, to serve as bases for treatment plans and to measure disease progression in patients.

Medical schools train physicians extensively to recognize microscopic molecular and structural abnormalities using colorful patterns created when chemical stains are applied to tissue samples.

"Chemical staining has disadvantages, though," said **David Mayerich**, assistant professor of electrical and computer engineering at UH Cullen College of Engineering. "The method is sensitive to many factors that are difficult to control, so pathologists in different labs can get different results when they analyze the same tissue sample."

In a collaborative project, Mayerich has developed a technique to produce digital versions of popular chemical stains, relying instead on quantitative molecular information collected using mid-infrared light. Their research published in the journal *Technology* last March. The team hopes to provide technology that can either complement or replace current chemical staining, resulting in more reliable histopathological diagnoses and fewer mistakes.

Mayerich, who joined the UH faculty last year, arrived with a three-year, $750,000 grant from the National Institutes of Health that he earned as a postdoc at the University of Illinois. He has since earned an additional $2 million grant from the Cancer Prevention Research Institute of Texas to continue his scholarly pursuits. The collaborative project includes Rohit Bhargava, professor of bioengineering at the University of Illinois at Urbana-Champaign, and Michael Walsh, professor of pathology at the University of Illinois at Chicago, among other researchers.

The primary focus of the project is cancer detection in needle biopsies, Mayerich said. Currently, pathologists place tissue samples in wax blocks and dye sections with contrasting stains, such as hematoxinylin-eosin (H&E), to examine them for molecular features and patterns.

Uniformity is difficult to achieve in histopathology because of the complicated chemical processes, Mayerich said. Some laboratories use automated systems that attempt to support pathologists by achieving color consistency in application of chemical stains to tissue samples. However, numerous variables that are difficult to control still influence results, and diagnoses of the same tissue sample by different pathologists can vary.

Mayerich and the other researchers aim to diminish or eliminate the detrimental effects of variables, such as different environments and tissue preparation methods, inherent in chemical staining.

"We want to duplicate these chemical stains digitally to enable pathologists to use their years of training and experience with better results," Mayerich said. "The goal is to replace chemical stains whenever possible with digital versions that give pathologists information that they can trust more."

The researchers are simultaneously developing an automated, quantitative system for disease detection. They are utilizing mid-infrared microscopy to identify and classify exact chemical compositions of various tissues to which they can apply their universal digital stains.

"We shine beams of light through the tissue samples to determine their chemical composition, so we expect the same diagnoses when we apply digital stains to the same tissue images at different labs," Mayerich said. "We get very accurate results based on tissue classification, so the results are very promising."

Unlike the chemical staining technique that destroys tissues, digital staining allows pathologists to apply different stains repeatedly to the same samples. Reliability and repeatability of histopathological diagnoses are the main focuses of the research, but the technology could also save laboratories costs associated with expensive chemical stains and specimen storage and spare patients the additional expense and discomfort of multiple biopsies.

"After initial equipment investments, the staining is basically free for laboratories," Mayerich said. "They purchase the instrumentation that measures data, and they store the results on computer systems that are backed up so they never worry about losing them."

However, some chemical features could be difficult to detect using mid-infrared microscopy but significantly clear using chemical staining. So laboratories could ideally incorporate a combination of the two technologies, Mayerich said.

"We don't know how far we can take it yet," Mayerich said. "We are creating as many digital stains as possible for each of the various types of tissues we classify."

In the past, mid-infrared imaging required too much time to make much mainstream progress, but new, speedy laser instrumentation could remove that barrier. The University of Houston is acquiring mid-infrared imaging systems to aid Mayerich with his software development.

"I believe that recent advances in instrumentation combined with continued increases in computer resources are pushing this technology to the point where it can be clinically viable in the near future," Mayerich said.

Photos by Nevit Dilmen

HEALTH & MEDICINE

JOURNAL FEATURES UH BIOARTIFICIAL HEART RESEARCH ON COVER

Heart failure remains a major epidemic in today's society, which makes development of novel treatment strategies critical. In cases of end-stage heart failure, heart transplantation is the only viable option. However, the number of donor organs is significantly lower than the number of patients needing transplants.

Bioartificial heart research conducted by biomedical engineers at the UH Cullen College of Engineering's Artificial Heart Laboratory (AHL) could potentially help many of these patients.

The American Society for Artificial Internal Organs (*ASAIO*) journal recently published, "Establishing the Framework for Fabrication of a Bioartificial Heart," a UH study that could also benefit researchers around the world. Furthermore, the journal selected Cullen College's illustrations to serve as cover art for the July/August 2015 edition. This marks the second time in six months that the publication has featured the work of **Ravi Birla,** UH associate professor of biomedical engineering, on its cover. His research also appeared on the front of the January/February 2015 edition.

Ze-wei Tao, post-doctoral fellow in Birla's lab and current faculty member at the University of Arkansas Medical School, served as lead author on the paper. Matthew Hogan, Betsy Salazar and Nikita Patel, all recent AHL alumni, and Mohamed Mohamed, an AHL doctoral student, also made significant contributions.

In this study, the researchers used detergent-based decellularization to remove all cellular components from rat hearts, leaving behind intact extracellular matrixes. The advantage of using acellular scaffolds was that their distribution and composition of extracellular proteins closely approached those of mammalian tissues. Primary cardiac myocytes were then transplanted in the acellularized hearts and the recellularized hearts were cultured in a custom perfusion apparatus.

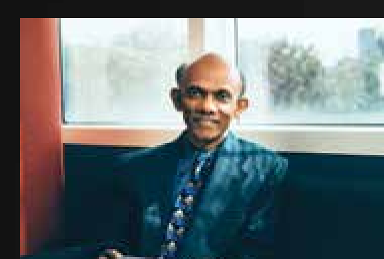
After two days, the hearts contracted like mammalian hearts, and the researchers observed these contractions in culture for as many as eight days. As with human hearts, the bioengineered hearts responded to various electrical pacing frequencies and pharmacological agents.

"The most remarkable outcome from this study was that the bioartificial hearts respond to external stimulation the same way ours hearts respond, highlighting the similarity between engineered and human hearts," Birla said.

At this stage of development, much research is still needed to bridge the performance gap between bioengineered and mammalian hearts. Birla and his team continue to explore strategies such as enhancing cellularization, using bioengineered heart muscle, conditioning with electrical stimulation bioreactors and pulsatile fluid flow.

NEW METHODS FOR LESS-INVASIVE KIDNEY DISEASE DIAGNOSTICS

Wei-Chuan Shih



Chandra Mohan

Two UH engineering professors have developed novel optical probes with potential applications in improving diagnosis and treatment for patients with kidney disease. Exciting new results on the two probes were recently published in *Biomedical Optics Express*, the flagship journal of the Optical Society of America, and the *Journal of Biophotonics*, another top journal in this field published by Wiley.

Wei-Chuan Shih, assistant professor of electrical and computer engineering, and **Chandra Mohan,** Hugh Roy and Lillie Cranz Cullen Endowed Professor of biomedical engineering, began collaborating just over a year ago. Shih's expertise is in molecular sensing using light-based sensing technologies such as optical probes. Mohan is a renowned expert on the genomics and proteomics of lupus and other autoimmune diseases; the central goal of his research is to find new biomarkers and targets for treating these diseases.

Although their research interests may not appear so compatible at first glance, the two professors realized an ideal partnership in one another. Shih's optical probes – which have been used for applications ranging from non-invasive glucose monitoring to detecting bacteria and sensing environmental hazards such as oil spills – can also function as a less invasive method of determining creatinine levels in patients with kidney disease.

One of the most common organs to be attacked by lupus is the kidney, manifesting in lupus nephritis. An estimated 40 percent of lupus patients develop this condition, which causes inflammation of the kidneys, impairing their ability to get rid of waste products and other toxins from the body effectively. Lupus nephritis is a leading cause of lupus-related deaths and results in tens of thousands of hospitalizations per year.

In order to track the kidney health of lupus patients, physicians must closely monitor the levels of creatinine, a chemical waste molecule, in the patients' blood and urine streams. Creatinine is a fairly reliable indicator of impaired kidney function; as a patient's kidneys become more impaired, the creatinine levels in the patient's blood will increase.

"Currently, patients need to go into a doctor's office or hospital to provide blood and urine samples. Doctors then use a chemical assay to determine creatinine levels in the patient's blood and urine, and those are expensive and time consuming," Mohan said.

"More importantly, a patient can't assay these at home, for sure," he added.

Shih's optical probe, however, provides a cheaper, faster and less invasive alternative for monitoring a patient's creatinine levels. The probe is made up of a biochip integrated with a gold plasmonic nanostructure consisting of light-excited electrons. Plasmonics enables very strong light-matter interactions near the surface of these gold nanostructures, which Shih said will allow certain "hotspots" on the biochip to interact with nearby molecules.

Based on how excited the electrons become – that is to say, how much they oscillate in response to a certain interaction – Shih is able to develop what he calls "fingerprints" of various molecules.

Because creatinine has a unique Raman scattering signal, Shih said the optical probes can detect creatinine levels with far higher sensitivity than the chemical assay tests that are currently used to quantify creatinine levels in urine or blood. Moreover, the probe only needs a tiny sample of urine – 5 microliters to be exact – to provide an accurate read of creatinine levels in a matter of seconds.

"The increased sensitivity of this probe in comparison to chemical assay tests could allow for earlier detection of renal impairment and therefore earlier intervention for patients with kidney diseases," Mohan said.

The ultimate goal of this research is to miniaturize the probe so that patients can purchase it over-the-counter and use it to quantify creatinine levels in the blood and eventually even on the surface of the skin.

Applications for the optical probe could be expanded to help diagnose other diseases beyond renal disease, Shih and Mohan said. However, the researchers said more work needs to be done before the probes can be sold to patients over-the-counter.

Shih and Mohan published this study as an open access paper, titled "Reagent- and separation-free measurements of urine creatinine concentration using stamping surface enhanced Raman scattering (S-SERS)," in the January 2015 issue of *Biomedical Optics Express*.

In another study, published in the *Journal of Biophotonics*, Shih and Mohan outline a novel method for using Raman spectroscopy to provide diagnostic information on kidney conditions and their severity.

Currently, physicians rely on an invasive procedure called a renal biopsy, or kidney puncture, to directly observe a patient's kidney function. In addition to potential side effects, renal biopsies cannot be repeated serially because of the damage it causes to the kidney tissue. Shih and Mohan believe the optical probes they developed can offer a far less invasive alternative for diagnosing kidney disease.

In this study, Shih and Mohan did not have a specific molecule or biomarker, such as creatinine, that they were looking to identify using Raman scattering. What they did have, however, was the knowledge that a diseased kidney and a healthy kidney give off two different Raman signals.

Using mouse models with induced kidney disease, Shih and Mohan were able to use the optical probe to differentiate between a healthy and a diseased kidney without puncturing the organ's tissue. Shih's research team developed a metric to broadly quantify the level of disease using the Raman scattering signals.

"We are proposing the nephrologist will puncture the patient's skin, go to the surface of the kidney, and not puncture kidney, but probe the surface of the tissue and acquire Raman signals," Mohan said. "The patient will feel a little pinch and poke through the skin, but the kidney is not hurt at all."

The morbidity and mortality associated with the optical probe would be significantly less than the kidney puncture procedure. However, Shih and Mohan urged that more research is needed before the optical probe can replace the kidney biopsy for patients with renal disease.

"We hope that the Raman signals on the surface of the kidney are as good as a microscopic pathology, but we don't know yet," Mohan said. "The next step is to see if spontaneous models of lupus kidney disease can also be accurately diagnosed using the Raman probe."

HEALTH & MEDICINE

RESEARCHERS BUILD BRAIN-MACHINE INTERFACE TO CONTROL PROSTHETIC HAND

A research team at the UH Cullen College of Engineering has created an algorithm that allowed a man to grasp a bottle and other objects with a prosthetic hand, powered only by his thoughts.

The technique, demonstrated with a 56-year-old man whose right hand had been amputated, uses non-invasive brain monitoring, capturing brain activity to determine what parts of the brain are involved in grasping an object. With that information, researchers created a computer program, or brain-machine interface (BMI), that harnessed the subject's intentions and allowed him to successfully grasp objects, including a water bottle and a credit card. The subject grasped the selected objects 80 percent of the time using a high-tech bionic hand fitted to the amputee's stump.

Previous studies involving either surgically implanted electrodes or myoelectric control, which relies upon electrical signals from muscles in the arm, have shown similar success rates, according to the researchers.

Jose Luis Contreras-Vidal, Hugh Roy and Lillie Cranz Cullen University Professor of electrical and computer engineering, said the non-invasive method offers several advantages: It avoids the risks of surgically implanting electrodes by measuring brain activity via scalp electroencephalogram, or EEG. And myoelectric systems aren't an option for all people, because they require that neural activity from muscles relevant to hand grasping remain intact.

The results of the study were published March 30 in *Frontiers in Neuroscience*, in the Neuroprosthetics section.

Contreras-Vidal was lead author of the paper, along with graduate students Harshavardhan Ashok Agashe, Andrew Young Paek and Yuhang Zhang.

The work, funded by the National Science Foundation, demonstrates for the first time EEG-based BMI control of a multi-fingered prosthetic hand for grasping by an amputee. It also could lead to the development of better prosthetics, Contreras-Vidal said.

Beyond demonstrating that prosthetic control is possible using non-invasive EEG, researchers said the study offers a new understanding of the neuroscience of grasping and will be applicable to rehabilitation for other types of injuries, including stroke and spinal cord injury.

The study subjects – five able-bodied, right-handed men and women, all in their 20s, as well as the amputee – were tested using a 64-channel active EEG, with electrodes attached to the scalp to capture brain activity. Contreras-Vidal said brain activity was recorded in multiple areas, including the motor cortex and areas known to be used in action, observation and decision-making, and occurred between 50 milliseconds and 90 milliseconds before the hand began to grasp.

That provided evidence that the brain predicted the movement, rather than reflecting it, he said.

"Current upper limb neuroprosthetics restore some degree of functional ability, but fail to approach the ease of use and dexterity of the natural hand, particularly for grasping movements," the researchers wrote, noting that work with invasive cortical electrodes has been shown to allow some hand control but not at the level necessary for all daily activities.

"Further, the inherent risks associated with surgery required to implant electrodes, along with the long-term stability of recorded signals, is of concern. Here we show that it is feasible to extract detailed information on intended grasping movements to various objects in a natural, intuitive manner, from a plurality of scalp EEG signals."

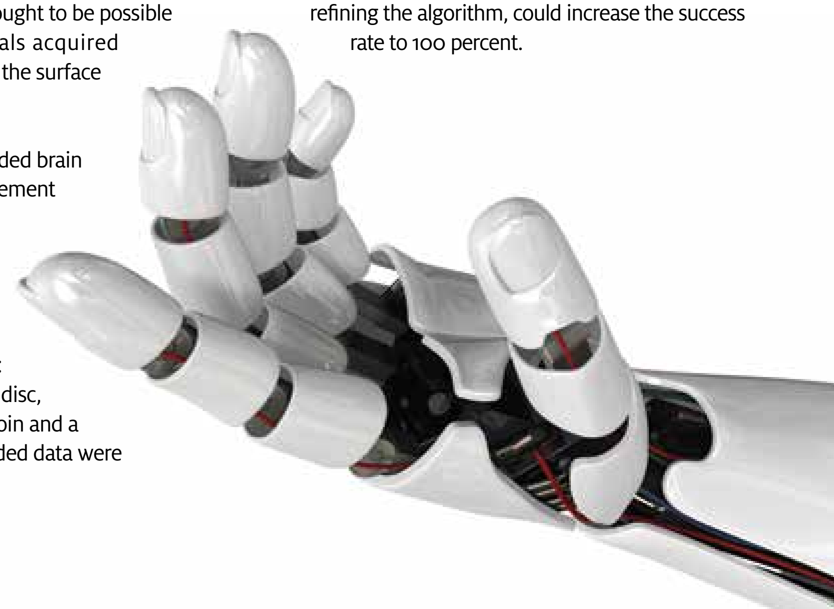
Until now, this was thought to be possible only with brain signals acquired invasively inside or on the surface of the brain.

Researchers first recorded brain activity and hand movement in the able-bodied volunteers as they picked up five objects, each chosen to illustrate a different type of grasp: a soda can, a compact disc, a credit card, a small coin and a screwdriver. The recorded data were used to create decoders of neural activity into motor signals, which successfully reconstructed the grasping movements.

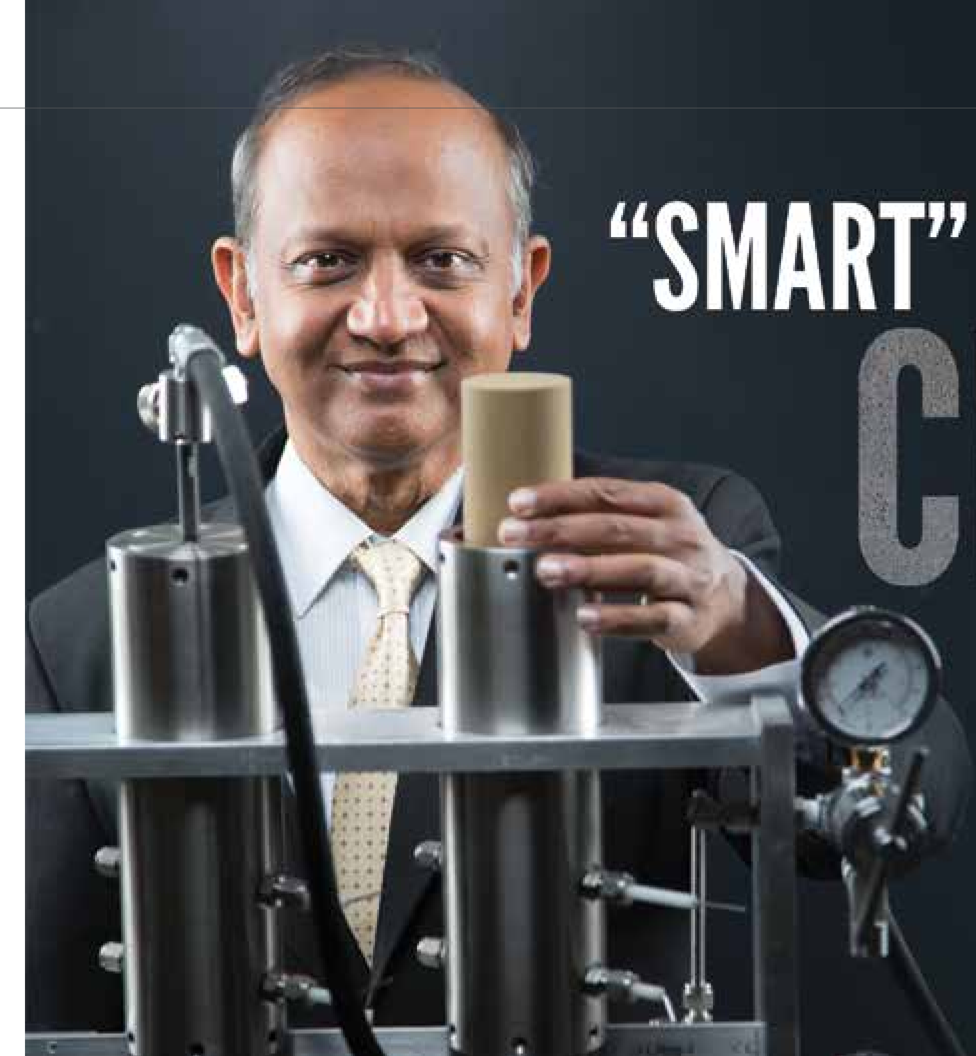
They then fitted the amputee subject with a computer-controlled neuroprosthetic hand and told him to observe and imagine himself controlling the hand as it moved and grasped the objects.

The subject's EEG data, along with information about prosthetic hand movements gleaned from the able-bodied volunteers, were used to build the algorithm.

Contreras-Vidal said additional practice, along with refining the algorithm, could increase the success rate to 100 percent.



MATERIALS



"SMART" CEMENT

COULD TALK TO ENGINEERS ABOUT WELL CONDITIONS

With the rattle and hum of a giant drilling bit churning through clay, a new frontier in oil and gas exploration began at the University of Houston last spring.

A 40-foot well, designed to test "smart" cement developed by **Cumaraswamy Vipulanandan,** professor of civil and environmental engineering, was drilled on the outskirts of the University's Energy Research Park, a complex of research labs, technology incubation space and administrative offices just two miles from the main campus.

The results could be far-reaching. Knowing where to find oil or natural gas is the first step in drilling a successful well, but what happens next – and how those next steps are performed – is crucial.

Vipulanandan's smart cement is a new piezoresistive material that can be monitored from an offshore platform thousands of feet above the well or even from hundreds of miles away. He is also developing the monitoring system.

Cement slurry is pumped into a well to hold the casing to the natural geological formations, as well as to isolate the formations, even thousands of feet under the ocean floor.

"Currently, how do you know the cement is setting?" Vipulanandan asks. "You don't know. With smart cement, you can monitor it."

The cement has been tested in the lab, but the test well will allow the researcher and graduate students working with him to see how it works under more natural conditions.

Smart cement isn't regular concrete studded with sensing materials – Vipulanandan said embedding sensors in the cement mixture would result in weaker cement. Instead, the sensing materials – less than 0.1 percent by weight – are actually incorporated into the mixture, forming a "bulk sensor" with sensing properties several hundred times higher than current cements. The performance is further enhanced using nanotechnology and surfactant technology.

The modifications enhance the mechanical properties of the smart cement, without affecting the rheological properties.

The sensors measure changes within the material, allowing those who monitor the well to determine if it has set or is cracking, if pressure is increasing and other performance variables.

Cement's critical role in offshore wells came into sharp relief after the 2010 Deepwater Horizon explosion, which killed 11 people and spilled almost 5 million barrels of oil into the Gulf of Mexico. Regulators and government investigative panels found the accident was caused by deficient cementing.

Smart cement could help to avoid similar accidents.

Vipulanandan, director of the Center for Innovative Grouting Materials and Technology at the Cullen College of Engineering, as well as director of the Texas Hurricane Center for Innovative Technology, began working on the cement in 2012 with a $2.6 million grant from the Department of Energy. Oilfield services company Baker Hughes provided additional funding.

Vipulanandan compares the smart cement to the sensors in your skin. "When someone touches you, it will tell you when they do it, how much pressure they are applying," he said.

But the brain might be a better analogy, as the cement reports its status to engineers and other monitors – Is it curing? Has it set? Has there been fluid loss or circulation loss? Are cracks forming that could allow hydrocarbons to escape?

And that reporting doesn't stop once the well begins pumping oil or natural gas, Vipulanandan said.

"People can monitor the cement throughout its entire lifetime."

GRADE camp REDEFINES STEM FIELD ROLES

Engineering and computer science professions attract fewer women than other STEM (science, technology, engineering and mathematics) fields in the United States. For more than a decade, professors at the UH Cullen College of Engineering have worked to change this longstanding tradition by hosting summer engineering camps strictly for girls.

Julie Rogers was glad that she attended UH G.R.A.D.E. Camp (Girls Reaching and Demonstrating Excellence) in 2012 because it was the summer before her junior year at Friendswood High School and that's when "all the college talk started."

Rogers didn't know that she liked building and programming until she attended the camp because she'd always foregone opportunities to work on LEGO Mindstorms with her father and brother in favor of chances to dance.

When the time came to make decisions about college, Rogers chose the University of Houston and enrolled in the Cullen College of Engineering. One of her professors in the Honors Engineering Program helped to arrange her academic schedule so she could pursue both passions at UH.

"Having the left brain-right brain thing at the same time, sometimes I feel like I lead a double life: I engineer during the day, and I dance at night," Rogers said. "But I like to think they all come together and help me problem solve."

After completing her freshman year, Rogers returned to G.R.A.D.E. Camp as a college engineering student to continue the cycle that inspired her in high school. In June, she joined a dozen other female student mentors on campus for two week-long camps hosted by Cullen College. The student mentors and their engineering professors introduced middle school and high school girls to fundamental engineering concepts and important roles engineers play in the world.

"There's a whole other insight that these women are going to have with their unique experiences," Rogers said. "I think with more women engineers, we'll find solutions, and maybe we'll cure cancer and find ways to fix problems we haven't fixed already."

WHERE ARE THE WOMEN?

Women are not adequately represented in engineering classrooms, and the differences between men and women are needed in the field, said John Glover, UH Cullen College professor of electrical and computer engineering who has co-directed G.R.A.D.E. Camp since its inception in 2002.

"Right now, culturally, girls are led to believe that engineering is for boys, so they stay away from it and that doesn't make any sense," Glover said.

Many studies link the scarcity of women in STEM fields to attitudes about gender differences, and some trace the situation back to gender stereotyping that begins with childhood toys. For example, LEGOS Friends sets, currently popular with young girls, place dolled-up female minifigures in stereotypical environments such as hair salons and shopping malls. Yet, advocacy and consumer pressure are slowly changing such cultural norms.

Last year, LEGOS introduced the Research Institute, a limited-edition set of three female minifigures including a paleontologist, a chemist and an astronomer, which immediately sold out. LEGO Space Port sets also included mould-breaking female scientists and astronauts among their minifigures.

Sluggish recruitment and retention of women in engineering colleges and careers likely result from complex combinations of implicit and explicit cultural, environmental and even biological influences, but job availability and pay rates are certainly not among them.

Earlier this year, Forbes published a list of the 20 best-paying jobs for women, which included petroleum, aerospace, and electrical and electronics engineering as well as positions in sales engineering and engineering management. Based on salary, work-life balance and expected employment growth, both mechanical and civil engineering made U.S. News and World Report's "25 Best Jobs of 2015" list. CNN Money's top 100 jobs, based on pay, 10-year growth potential and work satisfaction, included biomedical, civil, transportation and structural engineering.

In spite of these reports, women account for less than 20 percent of engineers with bachelor's degrees in the United States, according to the National Science Foundation's (NSF) "Women, Minorities and Persons with Disabilities in Science and Engineering" statistics. A paltry 6 percent of those are classified as underrepresented minorities and Asian women. Furthermore, only 25 percent of engineers with master's and doctoral degrees are women.

The 2014 U.S. Bureau of Labor and Statistics' "Women in the Labor Force Databook" lumped engineering and architecture occupations together and reported that only 14 percent of professionals who worked in those fields were women. The bureau also reported that female engineers earned 18 percent less than their male counterparts. Similar percentages of women earned degrees in computer sciences, while women outnumbered men in other STEM fields, such as biosciences, social sciences and psychology.

The student gender trend in the UH Engineering College, including undergraduate and graduate students in 2014, paralleled the national averages, with women accounting for approximately 25 percent of students enrolled. The UH colleges of social work and education enrolled the highest percentages of women, with 90 percent and 80 percent respectively.

"If we're looking for ways to find more students to major in engineering, one way is to tap underrepresented sources, such as female students," said Stuart Long, developer and co-director of the camp who has taught electrical and computer engineering at Cullen College for more than four decades. "Only 2 percent of female high school students choose to major in engineering in college… so there are large numbers of qualified girls who could be engineers who never see the direction."

FINDING THE WOMEN

Diverse participation inspires novel solutions to the world's most challenging problems, so humankind suffers without women in science, engineering and computer science fields, according to an American Association of University Women blog from last July.

Since 2002, G.R.A.D.E. Camp has introduced approximately 850 girls between the ages of 13 to 17 to the fundamentals of engineering through team-based, interactive activities. Each summer, the Cullen College's two week-long sessions have exposed campers to basic engineering concepts, career options and mentorship opportunities.

"The G.R.A.D.E. Camps inform young ladies about career paths they might not know exist for them," said Fritz Claydon, Cullen College professor of electrical and computer engineering who has also co-coordinated the camp since it began.

Providing students with sufficient STEM education early is important because they need strong backgrounds in chemistry and physics to master calculus, which is often the first math course they encounter in college, said Claydon, who also serves as director of both the UH Honors Engineering Program and the Cullen College's Division of Undergraduate Programs and Student Success.

"Those preliminary courses that they take in 8th through 12th grades are so important because they build the foundation so they're well prepared after high school to pursue difficult degrees such as engineering," he continued.

The camp curriculum is a product of many years of trial and error using hands-on activities and project-based demonstrations rather than theories about how students learn, Long said. Intervals of short lessons, fun activities and snack breaks have proven the best way to keep the girls engaged in learning.

"We don't put them in a room and lecture to them in hour chunks," Long said. "That's not going to work for anybody."

Problem-solving techniques, teamwork and presentation skills are emphasized during the summer camps. Teams of campers build and program LEGO Mindstorm robots to navigate a maze, and they present their projects to an audience of family and friends on the final day of camp.

"Communication is an important part of being an engineer," Glover said. "So, starting on Thursday, they work on their oral presentations – straightforward explaining of what they did in G.R.A.D.E. Camp."

The campers learn to write computer algorithms by outlining detailed steps necessary to make peanut butter and jelly sandwiches. Among other principles, they learn about voltages, currents, motors and generators during morning classes, and they apply their knowledge to their LEGO Mindstorm robot projects during afternoon labs. Camp mentors help the girls overcome challenges by teaching them debugging techniques rather than giving them answers.

"We don't just tell them what to do in the labs," Glover said. "We switch them into problem-solving mode, so they feel that they – and it's true – solve the problems themselves."

Many campers have commented to Claydon over the years that they wished their schools taught science and engineering principles the way G.R.A.D.E. Camp taught them because they learned so much in one week.

Data suggests that approximately 70 percent of the G.R.A.D.E. Camp alumnae who have graduated from high school chose to pursue engineering in college. Some, like Cullen College sophomore engineering student Julie Rogers, have even enrolled at UH and become G.R.A.D.E. Camp mentors.

WOMEN INSPIRE WOMEN

Serrae Reed, mechanical engineering sophomore and student co-director of the camp, attended similar STEM camps her sophomore and junior years in high school, which she credits, in part, for her decision to major in engineering.

"At these camps, I had the opportunity to talk to students who were going through classes I was going to be taking soon, professors who were teaching them and women in industry," Reed said.

Reed chose the University of Houston because of the curriculum, the professors and the Honors Engineering Program. In her opinion, dispelling preconceived notions about engineers was G.R.A.D.E. Camp's most important achievement.

"At G.R.A.D.E. Camp, they have the opportunity to see that engineers come in all different shapes and forms, and that they have all kinds of interests," Reed said. "They get to see that women engineers are just as successful as men, and that there's a support system – people who want them to come into this field and people to help them when they arrive."

Women bring different skills to the table. While some might have missed introductions to coding, building and AutoCAD in middle school, they still have the ability to learn those disciplines and to use different ways of thinking to their advantage, Reed said.

Samantha Branum, sophomore engineering student and camp co-director, said G.R.A.D.E. Camp helps to build the girls' confidence. She most enjoyed watching the skeptical girls transform into enthusiastic participants as they engaged in activities such as the speaker lab. The campers built speakers from Styrofoam plates, magnets and metal wires that they plugged into their phones with auxiliary cords to play music.

"The girls never think it's going to work, and then when it does, it blows their minds, and that's the coolest part," Branum said. "They never knew they could do these things as girls because nobody told them."

While the obvious benefit of G.R.A.D.E. Camp is student recruitment, the unintentional consequence is student retention, Long said. The camp pays about a dozen female engineering students, typically after completion of their freshmen years, to mentor the middle school and high school girls.

"We found that the very act of mentoring the girls changes the undergraduates' attitudes about engineering," Long said. "As a result, they are much more likely to stay in engineering, to do well in their classes and to graduate on time than the girls not involved in the mentoring."

CAMPERS GAIN CAREER INSIGHTS

Devyn Yanello, a 16-year-old junior at Hargrave High School in Huffman, attended G.R.A.D.E. Camp because her father, an engineer, wanted her to understand her career options. Yanello and Kennedi Mitchell, a 14-year-old sophomore at Travis High School in Fort Bend ISD, said they gained better understandings of the many branches of engineering and their respective objectives.

"Overall, I think engineering is just going out and fixing problems, making sure things are done the right way and making sure things are safe," Mitchell said.

Cullen College offers majors in mechanical, industrial, biomedical, petroleum, chemical and biomolecular, civil and environmental, and electrical and computer engineering. Subsea engineering, materials engineering, aerospace engineering and space architecture programs offer students additional opportunities.

"There are so many different types of engineering, so it's nice to know what each kind does," Mitchell said. "I don't think it's fair for people to assume that women can't do everything guys can do."

Torn between architecture and engineering, Anisha Lal, granddaughter of UH System Board of Regents member Durga Agrawal, also attended the camp to gain clarity about career opportunities. Consequently, she said she is more optimistic about engineering.

Questionnaires are given to the girls on the camps' opening and closing days and often reveal transformations in their attitudes toward engineering. During their final presentations, they always impress their parents with their explanations of the control theory behind the operation of their robots, Long said.

"I work for Texas higher education, and we know girls are way behind in STEM education, so it's great for us to encourage girls and minorities to have STEM classes," said Durga Agrawal, an engineer and president and CEO of Piping Technology and Products, Inc.

UH ANSWERS NATIONAL CALL

G.R.A.D.E. Camp was originally funded in 2002 by student tuition and a state grant aimed at increasing numbers of electrical engineering students in Texas. The NSF funded the camps for the next five years followed by several years of support from Houston-area engineering firms.

"The tuition is a small part of the actual expenses," Long said. "And we give scholarships to those with financial need."

G.R.A.D.E. Camp at the Cullen College launched approximately three years before the Texas Science, Technology, Engineering and Math Initiative (T-STEM). The $71 million public-private partnership formed in 2005 to increase numbers of STEM students and professionals by redesigning Texas schools, improving teacher recruitment and training, and aligning long-term educational and economic development objectives.

Through a competitive process, seven T-STEM Centers were designated to serve more than 100 T-STEM Designated Academies and blended Early College High School/T-STEM Academies. The T-STEM Centers, which are strategically located across Texas, work together in a coalition to leverage resources and their unique areas of expertise.

The Southeast Regional Texas STEM Center, a division of the Office of Educational Outreach at the University of Texas Medical Branch at Galveston, serves Galveston County and the Houston Metroplex. The center provides college preparatory pipeline programs for students and kindergarten through 12th grade teacher development in engineering design, land and aquatic robotics and space biomedical sciences among other academic and instructional concentrations.

In the Houston area, 16 T-STEM Academies serve as learning labs to improve science and math instruction for students in either sixth through 12th or ninth through 12th grades. The academies are rigorous secondary schools that aim to increase the number of students who enter STEM careers by improving instruction and academic performance in science and mathematics-related subjects, said Marguerite Sognier, SRT-STEM Center executive director.

A 2007 National Academies of Sciences, Engineering and Medicine report found that "scientific and technical building blocks of our economic leadership are eroding at a time when many other nations are gathering strength." The report, "Rising Above the Gathering Storm," recommended urgent comprehensive and coordinated federal effort to maintain the nation's competitiveness.

In 2012, a report from the President's Council of Advisors on Science and Technology supported those findings. To maintain the nation's standing in science and technology during the coming decade, the council predicted a need for approximately 1 million more STEM professionals than the United States would produce at rates when the report was written.

Although the UH Cullen College of Engineering was already ahead of the game with its G.R.A.D.E. Camps, UH established a centralized center in 2013 to support and expand those efforts. The UH STEM Center adopted G.R.A.D.E. and Step Forward Camps and launched new outreach efforts including kindergarten through 12th grade teacher training; additional elementary, middle and high school student training programs, fairs and camps; and supportive programs for current university STEM students.

The UH STEM Center is working to develop collaborations with the Houston Museum of Natural Science, Space Center Houston, NASA's Johnson Space Center and Texas Medical Center institutions.

STEM SHORTAGES AND SURPLUSES

While shortages of women exist across all branches of engineering and many other STEM fields, shortages of men also exist in some of these areas. A 2015 labor review by the U.S. Bureau of Labor and Statistics found shortages of employees in some STEM fields and surpluses in others, with job opportunities also influenced by geographic location.

In the public sector, the bureau found shortages of doctoral-level materials science and nuclear engineers as well as systems engineers of all degree levels because of the U.S. citizenship requirement. Temporary shortages of advanced-degree electrical and mechanical engineers were also found in government agencies. In the private sector, the bureau found petroleum engineers, data scientists and software developers in high demand with the fluctuating need for electrical engineers.

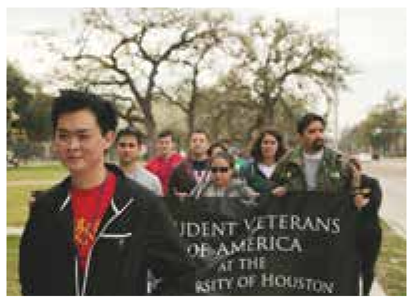
Conversely, the bureau found surpluses of doctoral candidates for tenure-track faculty positions in some STEM areas of academia, such as biomedical and physical sciences. Biomedical engineers with doctoral degrees in government STEM fields and doctoral-level biomedical, chemistry and physics professionals were also in abundance.

Forbes published a National Association of Colleges and Employers study that surveyed 300 companies and compiled lists of the best college majors for 2015 graduates seeking employment. Six engineering fields – chemical, electrical, computer, mechanical, materials and aerospace/aeronautical – made the top 10 list for doctoral degrees. The top 10 master's degrees included mechanical, electrical and computer engineering. Mechanical and electrical engineering also made the top 10 list of bachelor's degrees.

Watch our video about the 2015 G.R.A.D.E. Camp at www.egr.uh.edu/grade-camp-2015-video.

LEAD NEWS

OUTREACH



UH ENGINEERING COMMUNITY WALKS FOR SUICIDE PREVENTION

In a show of campus-wide solidarity against the stigmas surrounding mental illness, nearly 300 participants raised over $17,000 for the sixth annual Out of the Darkness campus walk that took place at the University of Houston last March.

The walk, sponsored by the Cullen College's PROMES program, is a short, 3-mile walk around campus with huge impacts. Money raised by participants directly helps the American Foundation for Suicide Prevention (AFSP) to perform vital research and establish education programs to prevent suicide, increase national awareness about depression and suicide, and provide support for those whose lives have been affected by suicide.

Kathy Zerda, retired PROMES (Program for Mastery in Engineering Studies) director and chair member of the Houston AFSP chapter, coordinated the event. She said part of this year's success was due to the inclusion of new organizations, like the UH Student Veterans of America (SVA).

"This year's Campus Walk was a success primarily because of the groups from across campus that were represented for the first time," she said. "The SVA led the walk carrying their banner in honor of military veterans, while teams from Cougar Village 2, the National Residence Hall Honorary, UH Gamma Iota Sigma, Sigma Phi Epsilon, UH Zeta Phi Beta and UH Delta Sigma Pi joined in the Campus Walk for the first time."

The walk continues to grow each year, and with suicide remaining the second-leading cause of death for college-aged students, the gravity of the event could not be more relevant at UH.

"The Out of the Darkness Walk has become a campus-wide annual forum to spread hope and education to reduce the stigma associated with mental illness so that those who suffer will seek help," Zerda said.

View photos from this year's Out of the Darkness Walk at www.egr.uh.edu/news/photo-gallery.

CULLEN COLLEGE CELEBRATES FEMALE ENGINEERS WITH "2015 WOMEN IN ENGINEERING DAY"

It's no secret that women are underrepresented in both professional and academic engineering fields, but each year the female trailblazers in these industries are celebrated at the University of Houston Women in Engineering (WIE) Day. The event is presented with special thanks to Cynthia Oliver Coleman, a UH alumna and founder of the Engineering Alumni Association (EAA) EWeek event. This year's celebration was held on March 5 at the University of Houston Hilton Hotel.

The Women in Engineering Program brings together women from all engineering disciplines to foster a community of support among female engineering students and professionals. The 2015 WIE Day event was titled "Weaving the Stories of UH Women Engineers," and one of those stories was told by Elebeoba May, an associate professor in the department of biomedical engineering and guest speaker for this year's gathering. Biomedical engineering student Tessy Lal was also presented with the 2015 Cynthia Oliver Coleman P. E. Women in Engineering Rising Star Award.

View photos from May's talk and the WIE Day reception at www.egr.uh.edu/news/photo-gallery.

SPACE

NASA INVITES SICSA FACULTY TO HUMAN MARS MISSIONS WORKSHOP

NASA invited Sasakawa International Center for Space Architecture (SICSA) faculty members at the UH Cullen College of Engineering to participate in the First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars. The workshop is planned for the last week in October at the Lunar Planetary Institute in Houston.

The purpose of the workshop is to identify and discuss exploration zones on the Martian surface where humans can land, live and work. An exploration zone contains the landing site, habitation site and regions of interest. The regions are located within approximately 100 kilometers of the centralized landing site and are relevant for scientific investigation as well as development and maturation of resources necessary to sustain human life.

NASA's Human Exploration and Operations Mission Directorate (HEOMD) and Science Mission Directorate (SMD) intend to use the candidate zones as part of the process to plan exploration of Mars with humans. The immediate objectives are to identify locations that maximize potential for scientific discovery and human life support resources, to develop necessary concepts and engineering systems for humans to conduct work in the zones and to define precursor measurements needed in advance of human missions. Robotic spacecraft can gather data from specific Mars surface sites within the zones to support the activities of the directorates.

"It is anticipated that funding and support for future calls will be available for teams of scientists and engineers to conduct detailed characterizations of the zones that emerge from this workshop," noted Ben Bussey, NASA's HEOMD chief exploration scientist, and Richard Davis, NASA's SMD assistant director for science and exploration, in the invitation. "Input from the science and human spaceflight communities is critical to identification of optimal landing sites for future human missions to the surface of Mars."

TECHNOLOGY

IMPROVING WIRELESS CELLULAR INFRASTRUCTURE

Zhu Han, professor of electrical and computer engineering at the UH Cullen College of Engineering, was awarded $140,000 from the National Science Foundation (NSF) to enhance software-defined network planning and administration of wireless cellular infrastructure.

In collaboration with Arizona State University, Finland's University of Oulu and VTT Technical Research Centre of Finland, Han's project aims to realize efficiencies for the dense and heterogeneous software-defined cellular network to improve user experiences. The software-defined network provides opportunities for dynamics and layers at the edge, or user access points, which were not available with the original, flat version of the radio access network. Han plans to dynamically optimize cellular network performance with resource allocation for hierarchal structures.

"It's routing cellular signals to servers in different network layers, similar to the concept of optimizing traffic on highway ramps," Han said. "We are concentrating on the consumption-based, human-machine interface."

The project involves network architecture design, theoretical modeling and analysis, and experimental simulations to quantify performance benefits, Han said. The research addresses challenges that include coexistence of interfering mobile clusters and elastic resource allocation in novel frameworks, he added.

"The intellectual merit originates from the interdisciplinary fusion of different technologies including software-defined radio and networking, wireless communications, machine learning and game theory," Han said. "The proposed scheme offers reduced overhead control and system latency through exploration of locality, which enhances system scalability."

The research project enriches game theory curriculum at the involved universities and strengthens wireless research communication collaborations between the United States and Finland, Han said. Han also plans to engage minority and underrepresented students and to promote science and engineering among K-12 students with this venture.

The NSF grant will continue through 2017.

ENGINEERS TURN SMARTPHONES INTO MICROSCOPES FOR 3 CENTS

Researchers at the University of Houston have created an optical lens that can be placed on an inexpensive smartphone to amplify images by a magnitude of 120, all for just 3 cents a lens.

Wei-Chuan Shih, associate professor of electrical and computer engineering at the Cullen College, said the lens can work as a microscope, and the cost and ease of using it – it attaches directly to a smartphone camera lens, without the use of any additional device – make it ideal for use with younger students in the classroom.

It also could have clinical applications, allowing small or isolated clinics to share images with specialists located elsewhere, he said.

In a paper published in the *Journal of Biomedical Optics*, Shih and three graduate students describe how they produced the lenses and examine the image quality. Yu-Lung Sung, a doctoral candidate, served as first author; others involved in the study include Jenn Jeang, who began graduate school at Liberty University in Virginia this fall, and Chia-Hsiung Lee, a former graduate student at UH now working in the technology industry in Taiwan.

The lens is made of polydimethylsiloxane (PDMS), a polymer with the consistency of honey, dropped precisely on a preheated surface to cure. Lens curvature – and therefore, magnification – depends on how long and at what temperature the PDMS is heated, Sung said.

The resulting lenses are flexible, similar to a soft contact lens, although they are thicker and slightly smaller.

"Our lens can transform a smartphone camera into a microscope by simply attaching the lens without any supporting attachments or mechanism," the researchers wrote. "The strong, yet non-permanent adhesion between PDMS and glass allows the lens to be easily detached after use. An imaging resolution of 1 (micrometer) with an optical magnification of 120X has been achieved."

Conventional lenses are produced by mechanical polishing or injection molding of materials such as glass or plastics. Liquid lenses are available, too, but those that aren't cured require special housing to remain stable. Other types of liquid lenses require an additional device to adhere to the smartphone.

This lens attaches directly to the phone's camera lens and remains attached, Sung said, adding that it's also reusable.

For the study, researchers captured images of a human skin-hair follicle histological slide with both the smartphone-PDMS system and an Olympus IX-70 microscope. At a magnification of 120, the smartphone lens was comparable to the Olympus microscope at a magnification of 100, they said, and software-based digital magnification could enhance it further.

Although his primary appointment is in the Cullen College's Department of Electrical and Computer Engineering, Shih is also affiliated with the biomedical engineering and chemistry departments. His interdisciplinary team is focused on nanobiophotonics and nanofluidics, pursuing discoveries in imaging and sensing, including work to improve medical diagnostics and environmental safety.

> "I THINK IT WILL BE FUN, WE COULD INVITE SCIENCE TEACHERS TO WATCH WHAT WE DO."

Sung said he was using PDMS to build microfluidic devices and as he worked with a lab hotplate, realized the material cured on contact with the heated surface.

Intrigued, he decided to try making a lens.

"I put it on my phone, and it turns out it works," he said. Sung uses a Nokia Lumia 520, prompting him to say the resulting microscope came from "a $20 phone and a 1 cent lens."

That 1 cent covers the cost of the material; he and Shih estimate that it will cost about 3 cents to manufacture the lenses in bulk. A conventional, research quality microscope, by comparison, can cost $10,000.

"A microscope is much more versatile, but of course, much more expensive," Sung said.

His first thought on an application for the lens was educational – it would be a cheap and convenient way for younger students to do field studies or classroom work. Because the lens attaches to a smartphone, it's easy to share images by email or text, he said. And because the lenses are so inexpensive, it wouldn't be a disaster if a lens was lost or broken.

"Nearly everyone has a smartphone," Sung said. "Instead of using a $30 or $50 attachment that students might use only once or twice, they could use this."

For now, researchers are producing the lenses by hand, using a hand-built device that functions similarly to an inkjet printer. But producing the lenses in bulk will require funding, and the researchers are currently exploring the viability of taking their idea out of the laboratory and into the consumer market.

"I think it will be fun," Shih said. "We could invite science teachers to watch what we do."

RESEARCHERS TEST SMARTPHONES FOR EARTHQUAKE WARNING

Smartphones and other personal electronic devices could, in regions where they are in widespread use, function as early warning systems for large earthquakes, according to newly reported research. This technology could serve regions of the world that cannot afford higher quality but more expensive conventional earthquake early warning systems.

The study, published April 10 in the inaugural volume of the AAAS journal *Science Advances*, found that the sensors in smartphones and similar devices could be used to build earthquake warning systems. Despite being less accurate than scientific-grade equipment, the GPS (Global Positioning System) receivers in a smartphone can detect the permanent ground movement caused by fault motion in a large earthquake.

University of Houston researchers **Craig Glennie** and **Darren Hauser** are among those participating in the study.

Using crowd-sourced observations from participating users' smartphones, earthquakes could be detected and analyzed, and customized earthquake warnings could be transmitted back to users.

"The speed of an electronic warning travels faster than the earthquake shaking does," said Glennie, assistant professor of civil and environmental engineering at UH.

Sarah Minson, U.S. Geological Survey (USGS) geophysicist and lead author of the study, said the crowd-sourced alerting "means that the community will benefit by data generated by the community." Minson was a post-doctoral researcher at Caltech while working on this study.

While much of the world's population is susceptible to damaging earthquakes, earthquake early warning (EEW) systems are currently operating in only a few regions around the globe, including Japan and Mexico.

"Most of the world does not receive earthquake warnings, mainly due to the cost of building the necessary scientific monitoring networks," said USGS geophysicist Benjamin Brooks.

Researchers tested the feasibility of crowd-sourced EEW with a simulation of a hypothetical magnitude 7 earthquake, and with real data from the 2011 magnitude 9 Tohoku-oki, Japan earthquake. The results show that crowd-sourced EEW could be achieved with only a tiny percentage of people in a given area contributing information from their smartphones. For example, if phones from fewer than 5,000 people in a large metropolitan area responded, the earthquake could be detected and analyzed fast enough to issue a warning to areas farther away before the onset of strong shaking.

The authors found that the sensors in smartphones and similar devices could be used to issue earthquake warnings for earthquakes of approximately magnitude 7 or larger, but not for smaller, yet potentially damaging earthquakes.

Comprehensive EEW requires a dense network of scientific instruments. Scientific-grade EEW, such as the USGS's ShakeAlert system currently being implemented on the west coast of the United States, will be able to help minimize the impact of earthquakes over a wide range of magnitudes. However, crowd-sourced EEW has significant potential in parts of the world where consumer electronics are increasingly common but there aren't sufficient resources to build and maintain scientific networks.

The U.S. Agency for International Development has already agreed to fund a pilot project, in collaboration with the Chilean Centro Sismologico Nacional, to test a pilot hybrid earthquake warning system comprising stand-alone smartphone sensors and scientific-grade sensors along the Chilean coast.

"The use of mobile phone fleets as a distributed sensor network — and the statistical insight that many imprecise instruments can contribute to the creation of more precise measurements — has broad applicability including great potential to benefit communities where there isn't an existing network of scientific instruments," said Bob Iannucci of Carnegie Mellon University, Silicon Valley.

"Thirty years ago it took months to assemble a crude picture of the deformations from an earthquake. This new technology promises to provide a near-instantaneous picture with much greater resolution," said Thomas Heaton, a coauthor of the study and professor of Engineering Seismology at Caltech.

"The U.S. earthquake early warning system is being built on our high-quality scientific earthquake networks, but crowd-sourced approaches can augment our system and have real potential to make warnings possible in places that don't have high-quality networks," said Douglas Given, USGS coordinator of the ShakeAlert Earthquake Early Warning System.

"Crowd-sourced data are less precise, but for larger earthquakes that cause large shifts in the ground surface, they contain enough information to detect that an earthquake has occurred, information necessary for early warning," said study co-author Susan Owen of NASA's Jet Propulsion Laboratory, Pasadena, California.

The research was a collaboration among scientists from the USGS, California Institute of Technology (Caltech), the University of Houston, NASA's Jet Propulsion Laboratory, and Carnegie Mellon University-Silicon Valley, and included support from the Gordon and Betty Moore Foundation.

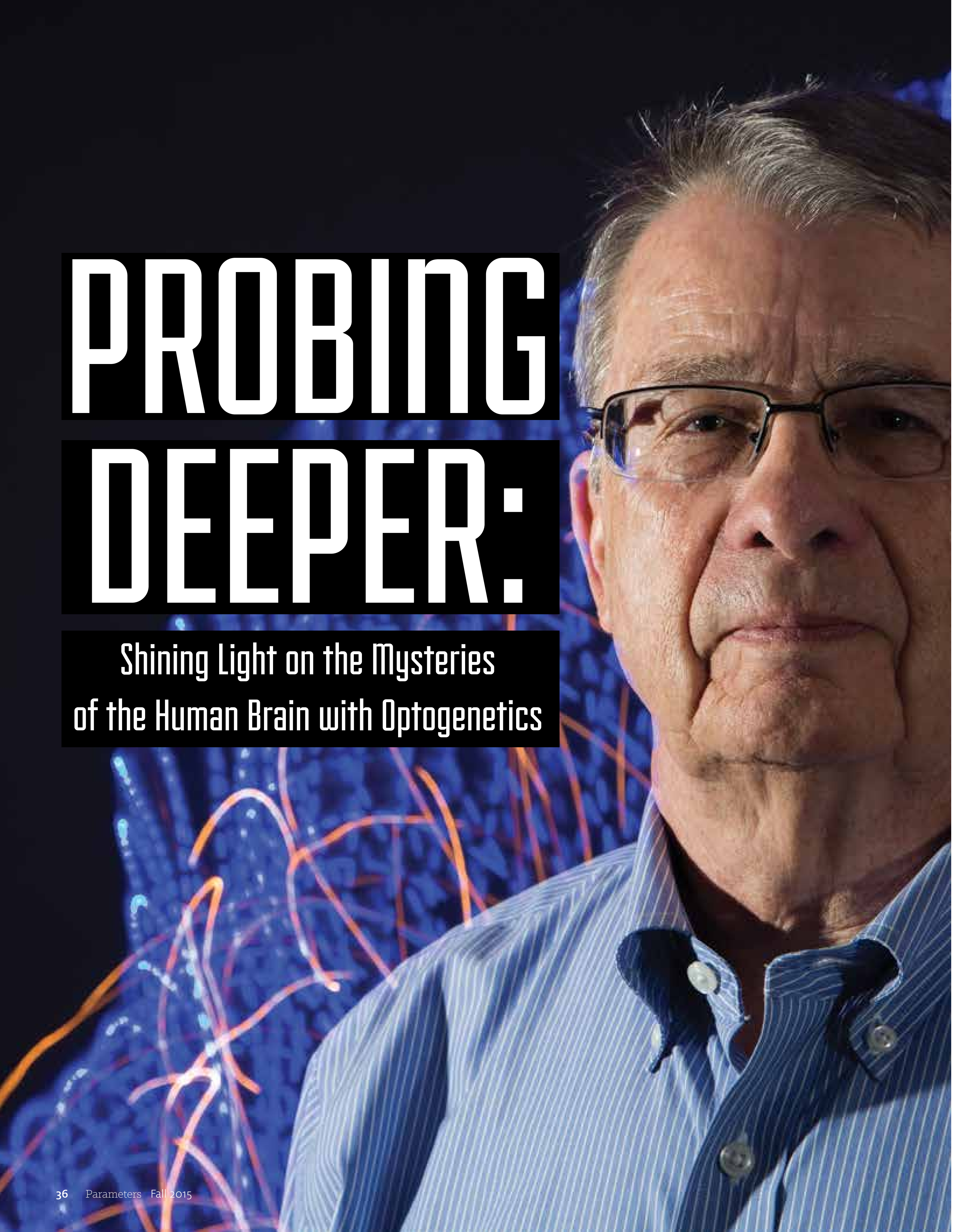
CRACKING THE BRAIN CODE

Floating in cerebral fluid inside 22 bones that form the face and skull, each of the 7 billion brains belonging to Earth's human inhabitants govern intelligence, creativity, memory, emotion, speech, movement, sensory systems and other organs. Yet, for millennia, the 3-pound mass of delicate tissue, which is the essence of humanity and inhumanity experienced internally and externally by every living creature, has remained as mysterious as it is extraordinary. The human brain, which intimately controls every aspect of human life with complex communication between billions of neurons through trillions of connections, strangely enough, renders its possessor incapable of understanding its processes.

Advancements in computing technologies that enable big data analysis and discoveries of new engineering techniques have created watershed moments in the study of neuroscience. In 2013, the European Commission provided the Human Brain Project with $1.3 billion to build a computer model of the brain. Months later, the United States government invested $4.5 billion in the 12-year Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative to map the brain's neural connections, the connectome, through an assortment of scientific methods.

In accordance with the international focus on human brain research, professors at the UH Cullen College of Engineering are converging on the globulous human command center from different perspectives with various research projects. By exploring the organ inside out and outside in, from both microscopic core and broad perimeter perspectives, with invasive and non-invasive methods, they hope to meet on common ground with research that contributes to a comprehensive understanding of its function.

Watch our video series on "Cracking the Brain Code" at www.egr.uh.edu/parameters-fall-2015-videos



PROBING DEEPER:

Shining Light on the Mysteries of the Human Brain with Optogenetics

A scientific breakthrough that combines optics and genetics provides researchers with unprecedented insight into one of life's most challenging puzzles – the human brain.

Coherent processes in the brain that prompt unconscious movements such as walking with seamless fluidity are complex enough that they have remained somewhat mysterious. Despite existence of technology and tools to explore brain activity, methods for tracking singular conversations among the hundreds of thousands of neurons necessary to perform even the simplest body movement remained elusive until 2005, the year *Nature Neuroscience* journal published the first paper on optogenetics.

The ability to manipulate targeted neurons within specific neural circuits in the human brain – important in understanding the organ's overall function – has spawned studies around the world. One such groundbreaking research project is in full swing at the University of Houston's Cullen College of Engineering.

Jack Wolfe, professor of electrical and computer engineering at the UH Cullen College of Engineering, is leading an effort to develop a new tool for optogenetics. Wolfe's collaborators are **Wei-Chuan Shih** and **Ji Chen,** also UH electrical and computer engineering professors, as well as Valentin Dragoi, professor of neurobiology and anatomy at UT Medical School-Houston, and a cadre of talented graduate students.

Fabrizio Gabbiani at Baylor College of Medicine, John A. Dani at the University of Pennsylvania, and particularly, Gopathy Purushothaman, formerly with Vanderbilt University, provided Wolfe with neuroscience mentorship in the early stages of the project.

"I am indebted to my neuroscience mentors for providing the essential advice and guidance that I needed to tailor our technology toward important applications in neuroscience," Wolfe said.

The implantable neural probe delivers light to photosensitive neurons in deep regions of the brain and simultaneously records and maps their optically-stimulated electrical signaling. The tool can provide a more detailed understanding of the neuronal networks near the probe to help researchers answer basic questions about microscopic structures in the brain. The project, which is supported by a $425,000 grant from the National Institutes of Health and additional funding from the Cullen Foundation and the Texas Center for Superconductivity, relies heavily on the unique toolset developed in the UH Nanosystem Manufacturing Center, directed by Wolfe.

"It's a fascinating project because my background is in integrated circuit fabrication, and this project involves going beyond current fabrication techniques to define patterns on cylindrical optical fibers," Wolfe said. "Until I started working on this, I had no contact with neuroscience, so it's a window on a new field for me."

Primitive meets modern to shine light on age-old brain

Remarkably, primitive microorganisms that form slimy green coatings on pools of still water make a modern scientific method possible. Optogenetics uses tools of molecular biology to insert a gene from green algae, a unicellular photosynthetic plant, into the neurons of living, freely behaving animals. Whether in a plant or a neuron, the gene enables the cell to produce a protein that detects light and generates electrical impulses by opening ion channels in the cell wall. In algae,

> "[This project] will provide a useful push for neuroscience and technology."

these impulses move the cell toward regions of higher light intensity to increase photosynthesis. In neurons, the impulses are transmitted to each of the neurons that normally receive inputs from the photo-activated cell.

"The journey of optogenetics shows that hidden within the ground we have already traveled over or passed by, there may reside the essential tools, shouldered aside by modernity, that will allow us to map our way forward," wrote Karl Deisseroth, a leading developer of optogenetics, in a 2010 *Scientific American* article. "Sometimes these neglected or archaic tools are those that are most needed – the old, the rare, the small and the weak."

For 60 years, scientists have known that inducing electrical currents to flow in a region of the brain known as the lateral hypothalamus, LH, can trigger overeating in well-fed mice. It was concluded that the LH drives the primal functions, which include sexual activity and aggression in addition to eating. Exactly how the current-induced overeating was not clear since electrical stimulation activates many different types of neurons both inside and outside the LH.

A 2013 *Science* magazine article describes the use of optogenetics to pinpoint the neurons that provide the triggering input to the LH that causes overeating. Their hypothesis was that neurons in a region bridging the amygdala, responsible for emotion, and the LH could provide the spark. They tested their hypothesis by sensitizing just those neurons to light. As anticipated, shining a light on the cells induced overeating in well-fed mice. A surprising video that accompanies the paper shows the mouse's overeating switched on and off by the light.

Electrical stimulation experiments helped determine the region of the brain that drives eating, but optogenetics was the key to identifying the specific neurons that trigger it. The study shows that a biological mechanism, not a lack of discipline, is responsible for binge eating and that potential exists for the development of drugs to target the pinpointed nerve cells to control binge eating and other disorders.

Among numerous accolades, the prestigious journal *Nature* named optogenetics the 2010 Method of the Year and Denmark's Lundbeck Foundation split the $1 million Brain Prize between six of the method's developers in 2013, which could serve as indicators of events to come. Murmurs circulating in scientific circles suggest that lead developers of the new technique might one day meet the King of Sweden and walk away with three-inch solid gold medals. Many expect the scientific breakthrough to win a Nobel Prize.

"We find meaning for the modern world – not just for science, but also for medicine and psychiatry – that makes a strong and clear statement for environmental protection, for preservation of biodiversity and for the pure quest for understanding," Deisseroth wrote in the same magazine article about his discovery.

Wolfe joins hunt for better tools to explore the brain

The brain integrates the information generated by the sensory organs to build an internal model of the external environment. This is carried out by neurons, cells that process the inputs they receive from local and long-range connections and send outputs to other neurons. In the visual system, which is the focus of this study, retinal cells encode the visual image as electrical impulses that travel from neuron-to-neuron to a switching center in the middle of the brain. From there, information flows through a complex network to the visual cortex where a mental image is formed. Thus, understanding the visual system requires the ability to probe electrical activity in deep as well as shallow brain structures.

Mapping these circuits is typically done by stimulating a population of neurons chemically, electrically, or optically, and recording the resulting spike activity with an array of electrodes on an implanted probe. Probes may be planar blades or cylindrical needles. Planar probes can accommodate large, 24-to-48 electrode arrays at very low costs by leveraging semiconductor manufacturing technology. However, this approach is suitable only for flat substrates, not the curved surfaces of cylindrical probes. Because of this limitation, most cylindrical probes today have only four electrodes.

Wolfe has developed a powerful technique to fabricate dense electrode arrays on fine cylindrical substrates, thereby providing the design flexibility of planar probes in the cylindrical format required for deep brain applications. His approach is like printing letters on a pipe using a stencil and a can of spray paint – except the stencil is a thin membrane with etched open windows and the spray paint is a beam of energetic ions.

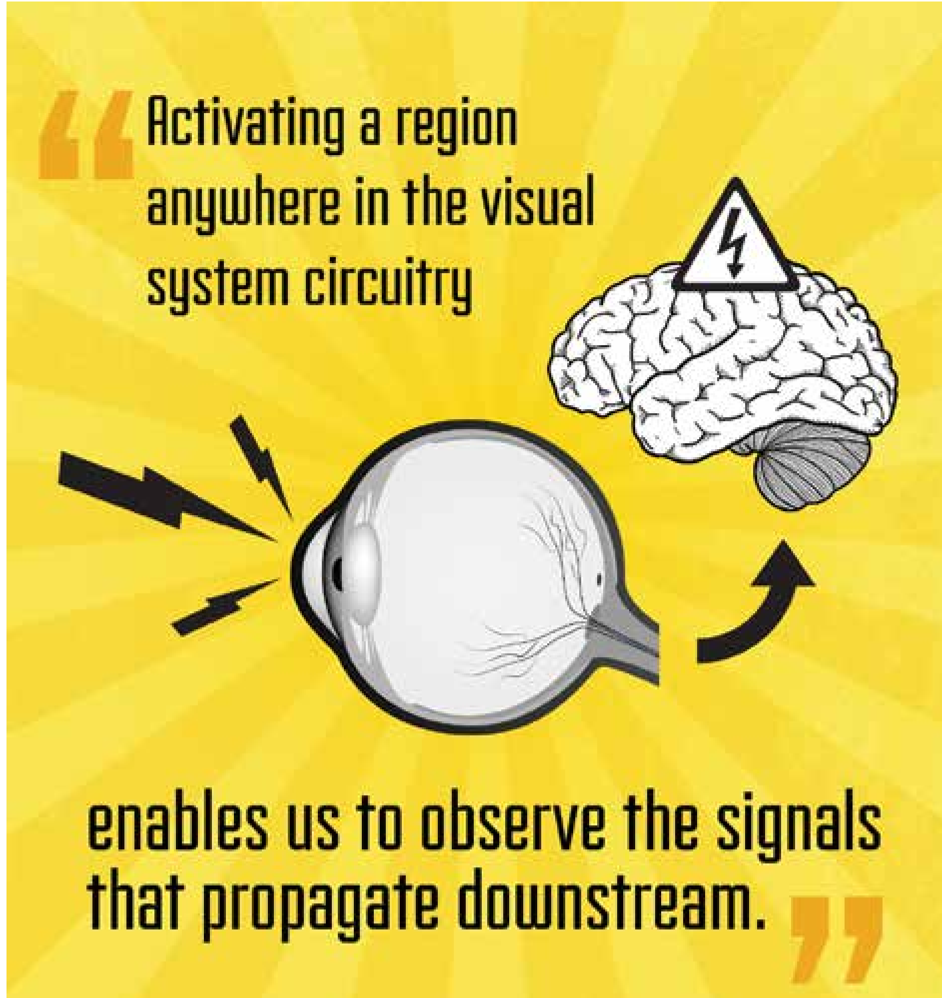
"These are not run-of-the-mill flat substrates we're printing on, which would make tools used to manufacture them ubiquitous," said Apeksha Awale, electrical and computer engineering graduate student and research assistant to Wolfe for five years. "It is difficult to print electrodes 2 microns wide on a cylinder."

An optical fiber as thin as a single strand of human hair, about 60 microns, serves as the base material for Wolfe's neural probe. The fiber is pointy enough at one end to penetrate brain tissue, long enough to reach the core of the brain and flexible enough to sway with the organ to activities as subtle as breathing. With modified integrated circuit design technology, Wolfe prints approximately 70 electrodes, each 5 microns wide, in dense tiers at varying depths around the diameter of the fiber.

"We are developing a very dense electrode pattern that no one has ever produced because it can provide a very detailed map of the active neurons in the neighborhood of the tip of the probe," Wolfe said. "The real sweet spot for this technology is the thalamus – trying to understand parts of the circuitry that are very deep inside the brain."

The UH team produced a prototype of the probe that Purushothaman tested in nonhuman primates to study the brain's vision system. This led to their most recent design, which has the high electrode count necessary to pinpoint the photo-activated neurons.

"Activating a region anywhere in the visual system circuitry enables us to observe the signals that propagate downstream," Awale said. "We can follow the impulses generated by the neurons as they travel through the neural circuitry."



Neural probes are not built in a day

Before the manufacturing began, Awale, graduate student Pratik Motwani, and Mufaddal Gheewala, their predecessor in Wolfe's lab who has since graduated and gone to work at Intel, helped to build the hardware and tools that make printing dense patterns of electrodes on cylindrical surfaces possible.

"The research assistants are learning techniques beyond integrated circuit manufacturing, though they're all derived from the same principles," Wolfe said. "I would hope to stimulate some of them to enter the neuroengineering field and solve some of the big problems that are still open."

Manufacturing the probes raises challenges – mainly cost and time associated with production – that are entirely different from those encountered in research. The graduate students are currently refining processes to maintain optimal efficiency and reliability of the probes during mass production.

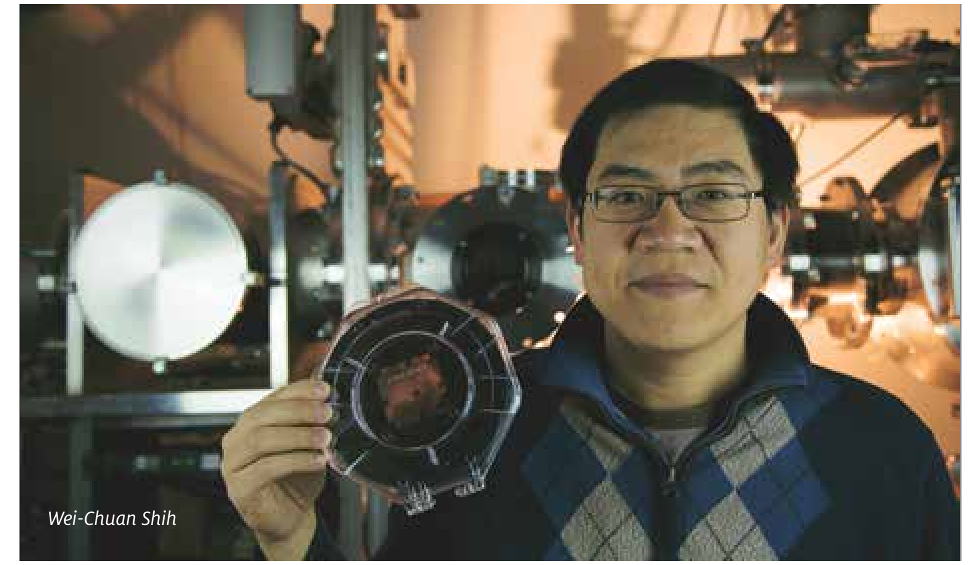
"We won't produce anything we can't mass manufacture, because what's the point if you can only make one a year," Awale said. "And we must be able to manufacture enough of them to bring the cost down and build a market for them."

Wolfe and his assistants have developed tools and methods to manufacture 50 neural probes at once, and they have filed patents for their most important technological advancements. They expect to demonstrate the probe's manufacturability next year.

"We ought to be able to make all the probes as good as the best probe," Wolfe said.

Collaborators join Wolfe's research pack

Initially, Wolfe intended to print high-density patterns of electrodes on wire for recording neuronal activity rather than optical fiber for activating and recording. He replaced the base material for his neural probe in 2009 when Shih, an optics engineer, arrived at the University with ideas about optogenetics. Because optics technology was already mature, Shih suggested Wolfe use optical fiber as the substrate to instantly achieve half of


Wei-Chuan Shih

the probe's function, delivering light stimulation to sensitized neurons.

"We had lots of interesting meetings where we collaborated on how to make these things, and some of the early work that is still very important was developed jointly during these discussions," Wolfe said. "You have to know where the light is going, and its intensity at different distances from the tip, so Shih would be the one to design that type of probe."

A novel probe design evolved out of these meetings for an optrode that encapsulated a twisted-wire tetrode, a traditional four-channel probe, in a capillary tube. Easy to make, the invention made it possible for anyone making electrical recordings with tetrodes to produce a tool for optogenetics. The idea was published in *Optics Letters* in 2012.

While Wolfe began applying his prior research to the new substrate, a possibility because both were cylindrical, Shih and his graduate student, Arnob Masud, began building a 3-D model to analyze the power and intensity of the light in the brain tissue ahead of the fiber tip.

"Mapping light-brain interaction – writing code to understand how light is scattered and distributed from the excitation point and how it interacts with brain tissue – is very challenging for us," Masud said.

Chen, their Cullen College colleague with expertise in modeling electromagnetic waves, especially in the biological sphere, joined the project to make sense of the immense amounts of data the Houston probe can generate. He and his graduate student are developing an algorithm to precisely map the patterns of electrical impulses emitted by the sensitized neurons.

Next year, neurobiologist Valentin Dragoi plans to begin testing the latest version of the neural probe on nonhuman primates, the modeling system genetically closest to humans. In his UT Medical School lab, his intention is to excite and record large-scale neuronal activity while primates perform behavioral tasks.

"Substantial progress has been made in rodents in the experimental world," Dragoi said. "In primates, less is known about the ability of neurons to respond to optical stimulation and the control of behavior using optogenetic stimulation."

Wolfe's probe offers flexibility and large-scale recording of neural populations not available with existing state-of-the art technology, such as chronic implants. Dragoi can position the Houston Probe, or many of them, in different regions of the brain daily to record fresh, active neuronal activity with minimal damage to brain tissue. Implantable probes are printed with about 100 electrodes for large-scale neuronal recording, but remain fixed in one location, cause micro-bleeding at the penetration site and destroy neurons within months, resulting in a steady decline of signal recording.

"Essentially, Wolfe wants to develop his probe with our feedback, and we'll test them, so it's a handshake project that will provide a useful push for neuroscience and technology," Dragoi said.

Better treatments for brain diseases

By mapping the ways billions of neurons interact through trillions of connections in the human brain, researchers hope to find better treatments for incurable brain disorders, such as Alzheimer's disease, Parkinson's disease, epilepsy and depression.

"Ultimately, the goal is to map brain circuits to understand how they work with the idea that if we have all that information, and we have something not working right, we can develop a therapy to address it," Wolfe said.

In the meantime, while the field of neuroscience is still in its infancy, the National Institutes of Health, one of the federal BRAIN Initiative's lead institutions, has urged scientists to shift their research approaches from practical to theoretical, like physicists who study the pure science behind particle collisions rather than practical applications for them, Dragoi said.

"We may not understand precisely how the brain works in our lifetime, but we can uncover fundamental principles applicable to sensory, memory, language and other systems," Dragoi said. "The benefits will come, but they will take time."

Despite lengthy lab-to-clinic approval processes for new medical technology, optogenetics could eventually benefit patients with drug-resistant brain disorders whose only approved treatment options are currently electrical and chemical stimulation.

With optogenetics, physicians could excite targeted neurons without disrupting others, alleviating negative side effects experienced by patients who undergo less accurate treatments. Furthermore, the new method does not seem to harm the neurons like the existing methods.

"While the benefits of electrical and chemical stimulation outweigh the drawbacks for some patients with drug-resistant brain diseases, injecting electrical currents into the brain is still detrimental," Awale said. "Optogenetics is potentially a more benign way to stimulate activity in the brain for treatments of these disorders."

Wolfe's neural probe also shows promise for examining microcolumns, vertical arrangements of about 100 interconnected neurons that form 30-micron diameter structures prevalent in the outer layer of the brain called the cerebral cortex. Researchers have noticed potential links between abnormalities in microcolumn structures and patients with aging and diseased brains, but questions have remained unanswered because probes capable of exploring such small structures have not existed – until now.

"Our probe is very small in diameter, so we hope to observe communication that controls activity in these structures," Awale said. "It's terrible to have a disease of the brain and not understand what causes it or how to treat it, and this gives us a better chance for therapies – that's the motivation for the whole project."

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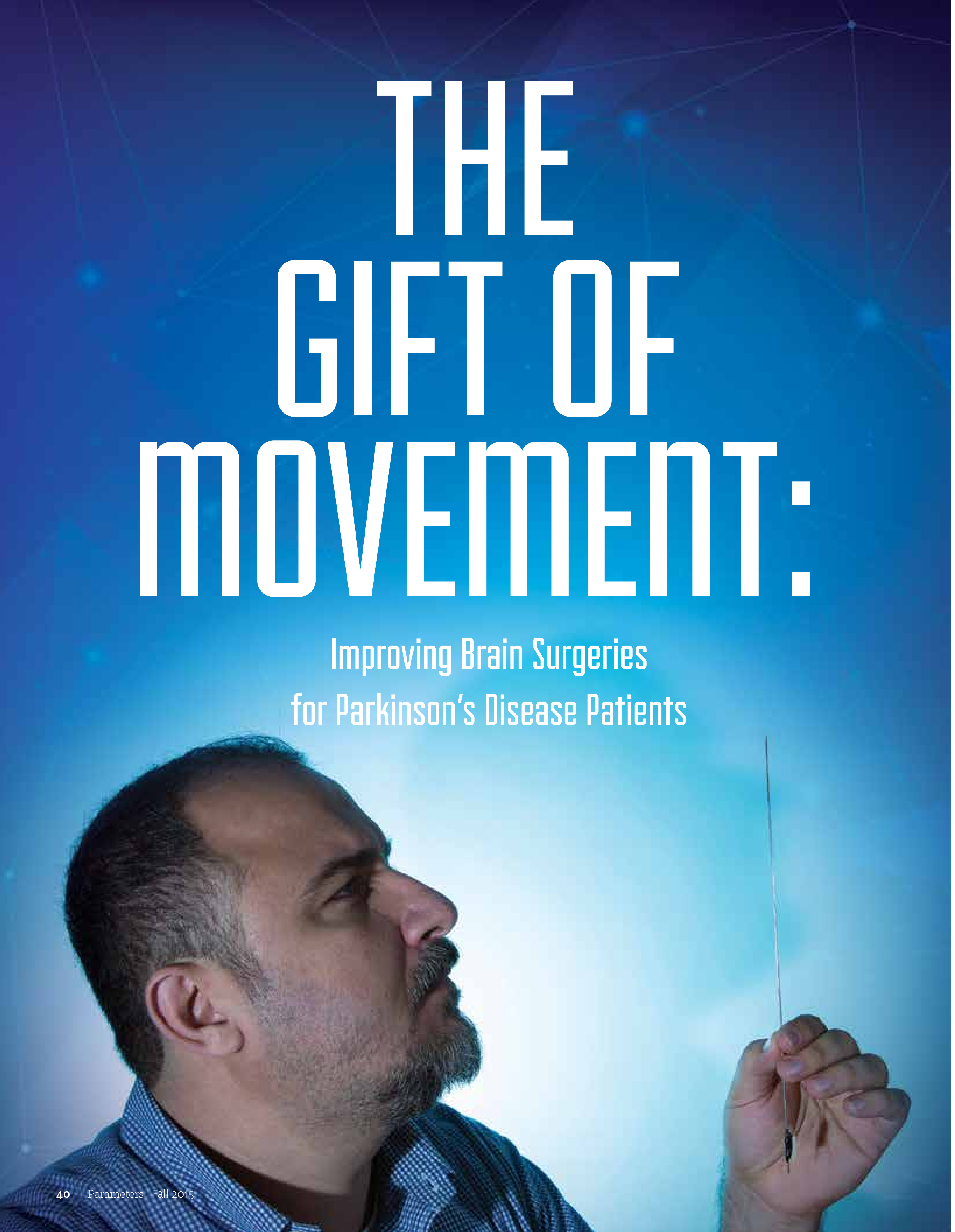


THE GIFT OF MOVEMENT:

Improving Brain Surgeries for Parkinson's Disease Patients

Struggling to climb out of bed each morning after a restless night's sleep with stiffness that, at times, slows movement to a standstill is a reality for many Americans. Compounded by uncontrollable muscle movements, basic tasks such as bathing, dressing and eating become arduous efforts that take twice as long as they once did.

This is an overly simplistic portrait of the challenges experienced by individuals with Parkinson's disease.

Approximately 60,000 Americans are diagnosed with the degenerative neurological movement disorder each year, and as many as 1 million Americans and seven to 10 million people worldwide live with the disease. Common symptoms of Parkinson's disease, PD, include tremors and other uncontrollable movements, rigidity, slow movement, problems standing, impaired balance and abnormal gait. Patients can also experience cognitive impairment, mood disorders, sleeping problems, slurred speech and difficulty swallowing, among other issues, but the disease is highly individualistic. While one person with the disease might struggle with pushing a button through a shirt's buttonhole, another might easily sew a missing button on a shirt.

The disorder typically strikes older individuals but approximately 4 percent experience the progressive disease before age 50, according to the Parkinson's Disease Foundation website. While researchers do not understand the underlying reasons for brain cell death that lead to functional decline in PD patients, and a cure does not exist, they have found ways to treat the disorder.

Nuri Firat Ince, assistant professor of biomedical engineering and director of the Clinical Neural Engineering Lab at the UH Cullen College of Engineering, is working to improve one such treatment. With a $350,000, three-year National Science Foundation grant, he is collaborating with Baylor College of Medicine to develop neural interfaces and signal processing tools for optimization of deep brain stimulation, DBS, a surgical procedure proven to help patients with Parkinson's disease and other movement disorders.

Ince finds a new window into the human brain for engineers

As a postdoctoral fellow at the University of Minnesota, Ince began composing algorithms for brain-machine interfaces to control communication capabilities for handicapped individuals. To detect and record neuronal activity, he worked mainly with invasive electrodes in nonhuman primates and with noninvasive electroencephalography, EEG, in human subjects.

Limitations of EEG prompted Ince to contact neurosurgeons about potential collaborations for another window on the human brain. His efforts culminated in joint studies of several patients during epilepsy and DBS surgeries in Minnesota.

"This was my first step into the operating room," Ince said. "Collaborating with neurosurgeons, we placed electrodes on the cortical surface and deep brain during surgeries, and we obtained recordings to understand the pathological neural activity of the brain in PD and epilepsy."

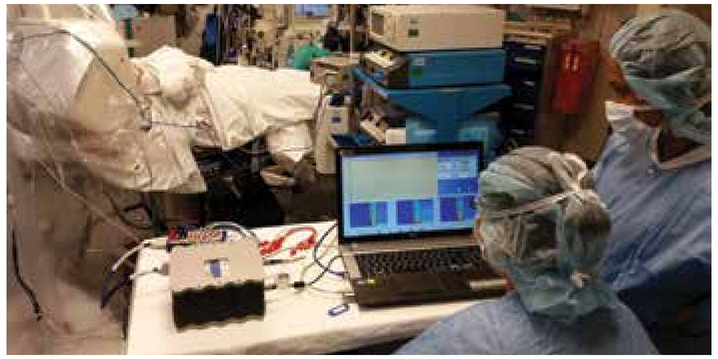
When Ince joined the Cullen College faculty, his first phone calls were to members of the neurosurgery faculty at the Baylor College of Medicine to explore similar collaborations. For the past two years, Ince and his partners in the Texas Medical Center have studied abnormal neuronal activity in shallow cortical and deep regions of the brain during 35 DBS surgeries, and they have gained ground in optimizing accuracy of the procedure. Together, they have collected enough data to publish several joint abstracts and conference papers, which have led to additional funding from Medtronic, a medical device manufacturing company.

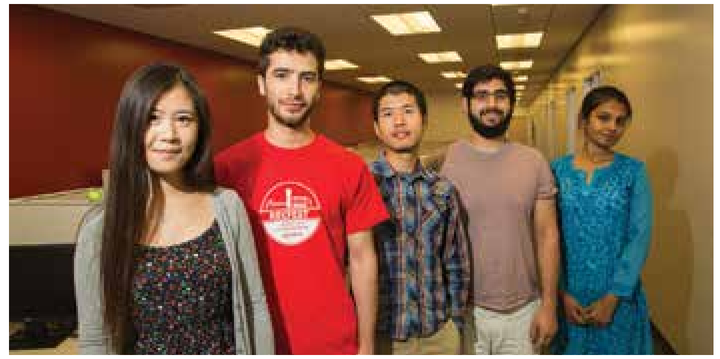
The interdisciplinary study that coordinates the efforts of Baylor neurologists and neurosurgeons with UH biomedical engineers has provided the first opportunity for a medical resident to work in a UH engineering lab. Similarly, Ince's research assistant has participated in dozens of DBS surgeries in hospital operating rooms as well as all stages of project development and data analysis in the lab.

"This project provides unique experience for engineering students to see medical problems in the field – in the surgery room – and that provides them with a greater educational environment," Ince said.

Surgeons open operating rooms to engineers for collaborative research

Ince's research assistant, Ilknur Telkes, is a doctoral biomedical engineering candidate with a background in neurobiology and neuroinformatics, specifically studying PD in animal models. Before she joined Ince's lab, Telkes knew little about the engineering techniques that complemented biological sciences. She has since learned about coding, hardware and signal processing as well as detailed operating procedures that coincide with neurosurgeries.





Above (from left): Ince and Telkes assist with brain surgery at Baylor College of Medicine; A team of biomedical engineering students prepare to conduct research in Ince's laboratory
Below: Ince and Ashwin Viswanathan, a neurosurgeon at Baylor College of Medicine

"I took engineering courses, but if you don't use the information, it's just information, not knowledge," Telkes said. "This is translational science, from biology to engineering, so we're trying to understand the neurophysiology of the brain using engineering tools to create devices and techniques for investigation."

Ince and his team work with Ashwin Viswanathan, a neurosurgeon at Baylor College of Medicine, whose focus is DBS for the treatment of movement disorders and some psychiatric conditions. The team's objective is to precisely locate the dysfunctional subthalamic nucleus, STN, in the brains of PD patients and to deliver exactly the electrical stimulation necessary to ease problematic symptoms of the disease.

"Historically, we've used a trial and error approach in terms of treating patients and finding optimal settings for DBS," Viswanathan said. "Ince provides a more scientific and quantitative manner of stimulating the brain, so we can record for the abnormal activity, and we can stimulate to treat exactly what's wrong."

Novel partnership improves deep brain stimulation outcomes for patients

In 2002, the U.S. Food and Drug Administration approved DBS for PD patients who were unresponsive to medications. During DBS surgery, neurosurgeons implant a battery-powered neurostimulator, generally under the collarbone, that sends electrical impulses up a tiny wire located under the skin to an implanted electrode in the brain. The impulses are delivered chronically to block abnormal electrical signals that cause PD symptoms.

However, available technology and tools cannot target the football-shaped, 4-by-6 millimeter STN with absolute accuracy, so the procedure remains challenging for neurosurgeons. With electrodes, Ince is capturing abnormal firing patterns and oscillations in deep regions of the brain and developing interpretive computer algorithms to help with decision-making.

"Efficacy of DBS depends on accurate placement of the chronic electrode, and a misplaced electrode can cause cognitive side effects," Ince said. "If clinical decisions are more accurate, then the therapy is better."

During surgical planning, Viswanathan fuses MRI and CT scan images of the brain with anatomical atlases to determine microelectrode trajectories to his target. Surgeries begin early in the morning, and Ince sets up his computer system in the operating room before the neurosurgeon arrives.

"The most amazing thing is that when we do experiments in the lab, it takes a long time to see outcomes," Telkes said. "In the OR, we develop algorithms, apply them in the surgery and see results immediately."

At the beginning of the surgery, Viswanathan positions a neural frame on the skull of the patient to position the electrodes for accurate insertion in the brain. Through a 4-millimeter burr hole in the skull, he pushes three to five microelectrodes 1-millimeter at a time into the brain.

Meanwhile, the electrodes, which are attached to the computer system, record the pathological synchrony in the brain to help determine optimal depth and position for placement of the chronic DBS electrode. The researchers look for excessive and unusual neuronal firing patterns as indicators of their target. Viswanathan then implants the electrode and runs a tiny wire under the skin to the neurostimulator implanted in the chest cavity.

"We are collecting large amounts of data during and after surgery about the patient's condition, brain function and the effects of stimulation, and we can use that information as a means to develop next-generation technologies," Viswanathan said. "The partnership between Baylor and UH is one of the strongest we've developed, and we look forward to what will happen in the next several years."

Researchers take deep brain stimulation techniques to the next level

Aside from improved efficacy and fewer side effects for patients, improved DBS precision can extend the life of the battery-powered neurostimulator, which typically lasts three to four years, by targeting specific areas with less electrical stimulation.

"Now with our industry partner, Medtronic, we can take this research to the next stage," Ince said. "We can move towards a closed loop model where we only stimulate the brain as needed, which is necessary to provide patients with the best possible DBS outcomes."

Together with Joohi Shahed-Jimenez, a neurologist at Baylor College of Medicine, Ince is extending his DBS research to neurological movement disorders including Tourette's syndrome, associated with multiple motor tics, and dystonia, characterized by involuntary muscle contractions and abnormal posture. Ultimately, the goal is to contribute to the broad understanding of the human brain that can lead to effective therapies for these diseases.

In addition to determining neuromarkers associated with many cognitive and movement disorders, Ince's lab uses data collected during surgeries to develop neural decoding algorithms and visual interfaces for developing neuroprosthetics.

"Given outcomes and benefits, I think DBS is going to be an important strategy or treatment technique to suppress the symptoms of Parkinson's disease and similar movement disorders," Ince said. "My hope is that in the next few years, we will train engineers who will participate in the surgeries, and who will work closely with neurosurgeons to help with interpretation of signals for electrode placement."

"THIS PROJECT PROVIDES UNIQUE EXPERIENCE FOR ENGINEERING STUDENTS TO SEE MEDICAL PROBLEMS IN THE FIELD

– IN THE SURGERY ROOM –

AND THAT PROVIDES THEM WITH A GREATER EDUCATIONAL ENVIRONMENT."

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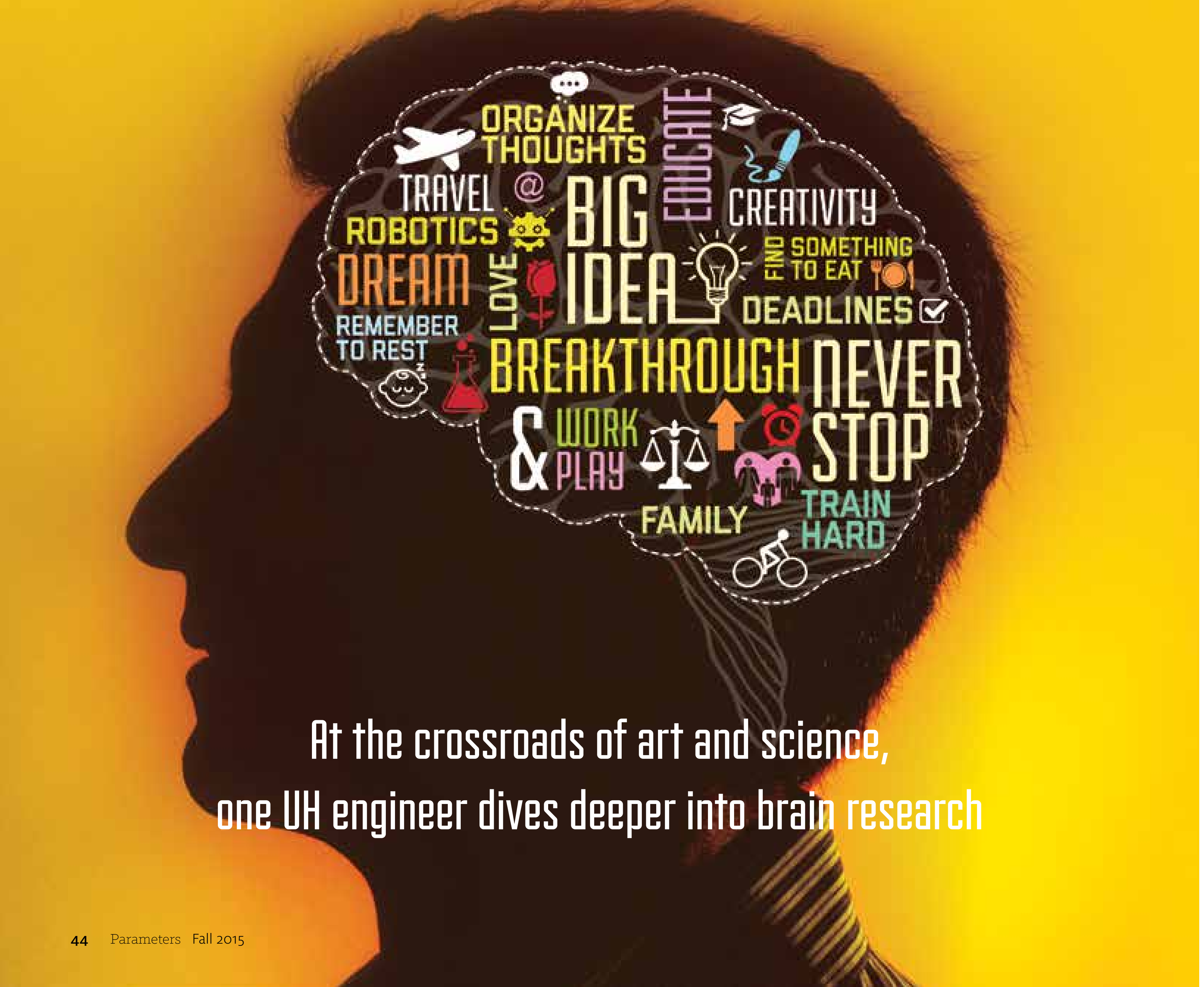
A RENAISSANCE IN THE MIND:



At the crossroads of art and science, one UH engineer dives deeper into brain research

> "My work involves not only research and developing new methods, but also training students – the next generation of engineers."

Intentionality is the core of human cognition and movement, and **Jose Luis "Pepe" Contreras-Vidal** is intent on understanding, for all intents and purposes, the neural mechanisms of intention in the human brain. The UH Cullen College electrical and computer engineering professor is using electroencephalography (EEG) to noninvasively record electrical activity in the brains of thousands of human subjects across multiple research projects to develop brain-machine interfaces that benefit populations affected by various affective, cognitive and motor skill deficits.

Pepe's passion for neuroscience, and consequently his prolific body of work, emerged from his intent to deal proactively with a harrowing experience that occurred when he was a young adult. During his final semester as an undergraduate electronics and communications student at the Monterrey Institute of Technology in Monterrey, Mexico, his mother slipped into a coma that left her unresponsive for an entire year.

General incomprehension among doctors about his mother's prolonged state of unconsciousness left Pepe feeling powerless. He wondered whether or not she heard him when he talked to her, and desperate for signs that she was still somewhere inside her motionless body, he wondered whether her occasional eye movements were attempts to communicate or just involuntary tics. He began reading as much literature about the brain and models of the brain as was available at the time, and his doggedness eventually led to academic pursuits. He earned his master's degree in electrical engineering from the University of Colorado-Boulder and his doctoral degree in cognitive and neural systems from Boston University. He pursued postdoctoral research in computational clinical neuroscience at Arizona State University and the University of Fribourg in Switzerland.

"It's been a long journey for me," Pepe said. "I moved to Houston for the support UH is providing and for the medical resources Houston is providing – my colleagues in the medical center – so I can do this work."

Neuroscientists would do well to study Pepe's brain in similar ways considering the generous funding that pours into his laboratory and the abundant research that flows out. Since joining UH in 2011, Pepe has earned more than 12 individual and collaborative grants that amount to approximately $12 million. More than 30 undergraduate, graduate and post-doctoral students work in his Laboratory for Noninvasive Brain-Machine Interface Systems at the University of Houston. Students and faculty from around the world visit his lab to acquire training and to conduct collaborative research.

His teams are training brain-machine interfaces to control movement of next-generation upper and lower prosthetic limbs and to instruct exoskeletons to walk for paralyzed children. They are developing neural interfaces to induce neuroplasticity for restoration of the brain's ability to learn cognitive-motor functions and to reveal mechanisms of imitation and social cognition in normally developing infant brains to better treat dysfunctional development. In collaboration with visual and performing artists, their interfaces are capturing and analyzing massive amounts of natural brain activity in large populations of participants responding to aesthetic stimuli, creating art in public settings and moving expressively during dance performances.

"My work involves not only research and developing new methods, but also training students – the next generation of engineers – who will continue developing technology and providing specialized system maintenance and novel applications," Pepe said. "So my grants support the research, but also the training of students and post-doc fellows."

Balancing art and science for better brain research

Among other definitions, the Merriam-Webster Dictionary defines balance as, "equipoise between contrasting, opposing or interacting elements; a state in which different things occur in equal or proper amounts or have an equal or proper amount of importance; and the ability to move or to remain in a position without losing control or falling." Perhaps balanced is the best way to describe the Renaissance, a period of immense innovation in world history that struck a balance between art and science.

To ensure a prosperous future for America, leaders in art, science and education fields are pushing for another period of innovation with efforts to convert STEM (science, technology, engineering and mathematics) into STEAM, with the addition of arts to education. In 2012, the National Science Foundation (NSF) granted almost $3 million to the Art of Science Learning initiative for a project aimed at fostering innovation through a combination of STEM and arts-based learning. The Rhode Island School of Design amassed support to launch the STEM to STEAM Initiative, which prompted the 2013 bipartisan Congressional caucus held in Washington, D.C., to discuss ways to implement STEAM education.

"I argue that art and science are on a continuum in which artists work with possible worlds whereas scientists are constrained to working in this world," wrote physiologist Robert Root-Brownstein in "The International Handbook of Innovation." "But sometimes perceiving this world differently is the key to making discoveries. Thus, arts and sciences are on a continuum in which artistic thinking produces possibilities that scientists can evaluate for efficacy here and now."

Leonardo Da Vinci, an artist, scientist, architect, engineer and inventor, best embodied the Renaissance movement, which began in Italy in the 14th century and spread throughout Europe for 400 years. His masterpiece, "The Last Supper," a mural painted on an interior wall of a convent in Milan, depicts immediate reactions of the 12 apostles to Christ's announcement about imminent betrayal by one of them. Da Vinci described those reactions as "motions of the mind," according to the Metropolitan Museum of Art website. The genius intended to provide outward interpretations of his subjects' inner minds with his artistry, which is echoed five centuries later by scientists intending to reveal relationships between behavior and brain activity with complex modeling systems.

Important inventions such as the printing press, compass and telescope emerged during the movement, as well as prestige and financial support for visual artists, musicians and writers. For the first time, philosophers made it acceptable to challenge longstanding beliefs, artists used mathematics and geometry to achieve perspective and proportion in their compositions, and scientists established mathematical relationships with the natural world.

Specialization during the last century has widened the schism between art and science so much that intellectuals have trouble straddling the divide, according to a 2005 *Nature* journal editorial by Alison Abbott and Adam Rutherford.

"It is hard to find today a true artist–scientist like Leonardo da Vinci, as noted for his science and engineering skills as his 'Mona Lisa' and 'Last Supper'," the authors wrote. "But in the past decade there has been an increasing awareness on the part of some artists of the heritage of scientists and vice versa."

Albert Einstein did not credit logic or mathematics for his insights, but rather intuition and inspiration, according to a 2010 *Psychology Today* article by Root-Brownstein and his wife Michele Root-Brownstein. "The greatest scientists are artists as well. When I examine myself and my methods of thought, I come close to the conclusion that the gift of imagination has meant more to me than any talent for absorbing absolute knowledge," the authors quoted the musically inclined Einstein saying. "All great achievements of science must start from intuitive knowledge … At times, I feel certain I am right while not knowing the reason."

During the 19th century, Spaniard Santiago Ramón y Cajal, known as the father of neuroscience, also balanced artistry and logic for innovation. The scientist, who possessed a talent for illustration, used Golgi's method, a silver staining technique for observing nerve tissue under a light microscope, to accurately draw the intricacies of thousands of neurons, which he compiled in a journal. He discovered that each neuron is an autonomous unit, and he established the law of dynamic polarization – information flows in one direction through a neuron, from the dendrites, through the cell body, to the axon.

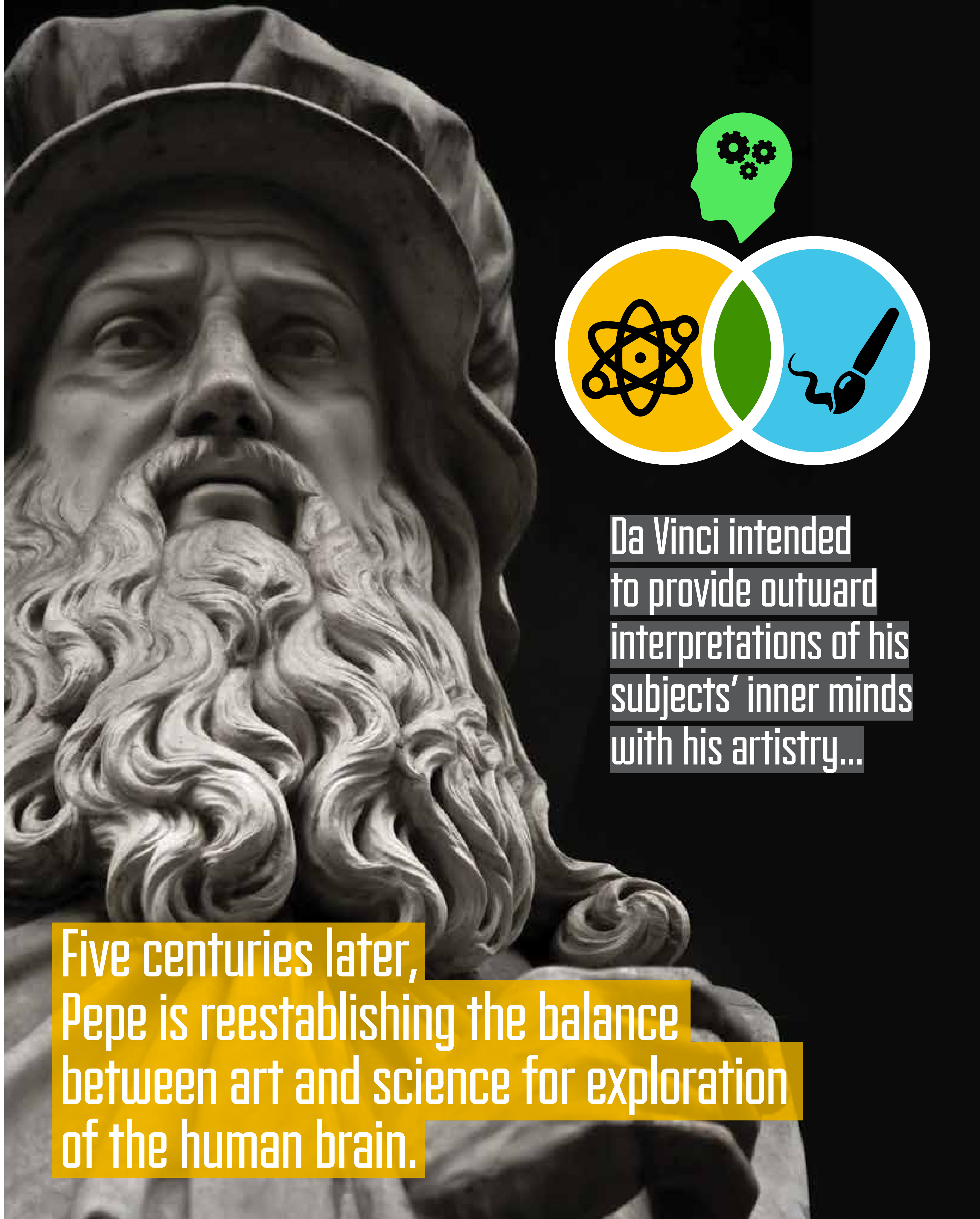
At the University of Houston, Pepe is reestablishing the balance between art and science for exploration of the human brain. In collaborations with conceptual artist, Dario Robleto, and UH dance faculty member, Becky Valls, he is mapping activity in brains of both expert and amateur observers and creators of art to determine neural bases for their creativity and insight. The U.S. Food and Drug Administration is supporting their efforts.

"By recognizing signatures in the brain for creative processes, maybe we can help people reach those levels of innovation through assimilation training," Pepe said. "Understanding what it takes to innovate and think outside the box could also be very useful for education and for engineering new technological innovations."

Pepe's research also can assist efforts to reverse-engineer the human brain and to develop advanced therapies and medical applications. For example, art therapies are known to help patients with mental and movement disorders but researchers cannot explain the reasons. Patients with Parkinson's disease, which causes poverty of movement, can move normally to rhythmic music of marching bands, yet the mechanisms that allow external music to bypass their internal motor pathways are inexplicable. Furthermore, researchers do not understand additional positive effects they observe in Parkinson's patients who dance with partners. Many believe reward and affective signals are important aspects of these benefits.

Most likely, creativity shares commonalities in the brain across different domains such as visual art, music, language and dance, but to confirm this, researchers must map regions of the brain engaged during these aesthetic experiences.

"There are many ramifications of understanding this process that have been neglected for a long time because it was hard to quantify, hard to measure," Pepe said. "But now we have technology, algorithms and partnerships, so it's the right time to start asking questions that were unthinkable just a few years ago."



Art museums moonlight as laboratories for brain research

Driving to an art exhibit, an individual might crank up the radio's volume when an old song stimulates memories of someone from the past. Perusing the exhibit, that same person might stop at a particular sculpture that stimulates a sense of camaraderie with its creator. Engaging with an interactive piece, that individual might repeatedly navigate a virtual reality that stimulates motivation for some reason.

Graceful or jarring dance movements, understated or electrifying theatrical performances, and budding or shriveling landscapes can provoke both common and different responses among observers. The mechanisms in the brain behind these aesthetic experiences are not understood.

To study human brains operating under innumerable influences such as food, stress, mood, medication, genetics and personal experiences, Pepe and his team must mine data from thousands of freely behaving individuals across wide ranges of demographics including gender, age, occupation and educational background.

"If we want to understand how the brain works, we need to capture all of those aesthetics, and that's very difficult in a lab with just a few volunteers," Pepe said. "So we need to go outside the lab to public places."

Last fall, Pepe partnered with the Menil Collection to record electrical signals in the brains of 450 individuals as they engaged with the work of artist Dario Robleto in a public art installation. The demonstration led to a $300,000 grant from the NSF, in support of the BRAIN Initiative, to further explore individuality and variation in neural activity among large and diverse groups of people (including children) who are experiencing aesthetics at the UH Blaffer Art Museum and other venues.

"Having the opportunity to collaborate with our colleagues from the arts provides a very constructive way of understanding the process of creativity and uncovering in very large numbers of people any patterns associated with enjoyment, pleasure and beauty," Pepe said. "For the first time, we have a way to capture activity in action and in context, in a real public setting, from many, many people from different backgrounds and demographics. That provides very valuable information that we can use to learn a little bit more about the brain and how the brain responds, in this case, to art."

Robleto's installation at the Menil Collection, "The Boundary of Life is Quietly Crossed," combined sculpture, historical recordings of heartbeats and brainwaves, and objects belonging to the museum. The inspiration for the exhibit originated with an early version of an artificial heart that Robleto studied as an art-research fellow at the Smithsonian Institute in Washington, D.C, which led to early recordings of heart and brain activity and interesting associated stories.

On his artistic journey into science, Robleto discovered the recordings of brainwaves and heartbeats belonging to Ann Druyan, executive producer and writer for the television series "Cosmos: A Spacetime Odyssey," just after she fell in love with Carl Sagan, famous cosmologist and author. Sagan included the recordings on the Golden Records that were among other contents in a time capsule launched beyond Earth's atmosphere aboard the Voyager 1 space probe in 1977. Robleto found the consummation of art and science in NASA's project to reach unknown expanses of the universe with an encapsulation of humankind.

Although technology to detect emotion in EEG and EKG recordings did not exist on Earth, Sagan and Druyan hoped that some form of extraterrestrial life might find the Golden Records and have the means to decipher human love in her brainwaves and heartbeats. Almost 40 years later, the idea of extracting emotion from such recordings did not seem so outlandish to Robleto, and his search for technology led to Pepe.

Although the large-scale study is still underway, Pepe and his team developed computer algorithms to analyze the brain recordings in a subset of the 450 participants who found one particular work of art most pleasing. In unison with timing of their activities captured with local positioning devices, their answers to questions about their perceptions of the artwork and their demographics, the team mapped the neural networks engaged while the participants experienced aesthetically pleasing visual art. Appropriately, Robleto's scientifically inspired artistic installation and Pepe's artistically inspired scientific study crossed boundaries. Pepe recently submitted the first of a series of papers, which is currently in review.

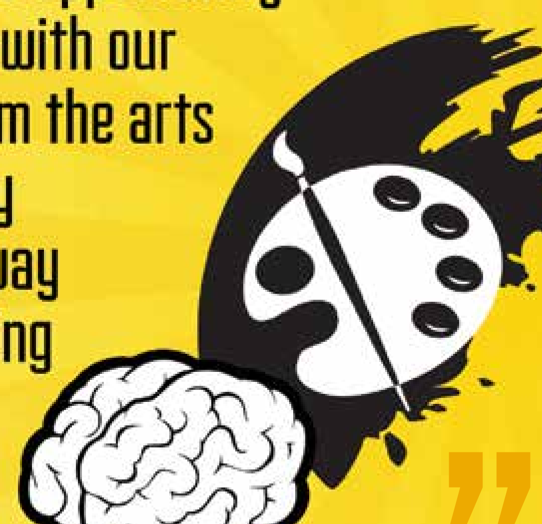
"Beauty is in the eye of the observer, it's very difficult to define that," Pepe said. "We want to see if there is a pattern by looking at the brain activity generated at that moment – it will not lie to you, it's very dynamic. It's going to use sensory information, prior experience, and situational and emotional context as ways to generate these sensations, these judgments."

Pepe's groundbreaking Menil Collection collaboration led to funding to expand his research. With a recent NSF grant, he is partnering with the UH Blaffer Art Museum to map brain activity in thousands more subjects fitted with EEG skullcaps as they respond to still art. With an interactive exhibition, he also intends to explore patterns in the brain related to the process of creating art.

"We all create at some point, but we don't understand the mechanisms that make some more creative than others – the people who innovate and see things in different ways," Pepe said. "We need a permanent collection where everyday people can go to contribute their data to science and be part of the exhibit."

Pepe and his team are extending their neuroaesthetic studies to other venues like the Children's Museum of Houston as well as to other artistic mediums, such as dancing.

"Having the opportunity to collaborate with our colleagues from the arts provides a very constructive way of understanding the process of creativity."



Dancers open their minds for advanced understanding of expressive movement

Pepe is no stranger to visual and performance art. When the neuroscientist is not developing algorithms to analyze complex communication in the brain, he is designing pieces of contemporary stained glass and practicing the expressive movements associated with Spanish Flamenco dancing. He selected dance for his first dip into understanding brain mechanisms involved in aesthetic experiences.

In a 2014 collaborative paper that published in the *Frontiers in Human Neuroscience* journal, Pepe explored brain activity in dancers modulating functional movement to express messages. The partnership with dance professor Karen Bradley at the University of Maryland led to a collaborative demonstration with Becky Valls at the UH School of Theatre and Dance earlier this year. This semester, Pepe and Valls are expanding their partnership to study brain activity in dancers through monthly performances on the UH campus.

"Dancers want to communicate intent, an emotional state or an conceptual idea with expressive movement, so it goes beyond functional movement like walking, which has a purpose in terms of action," Pepe said.

For the University of Maryland project, Pepe fitted professional and amateur dancers with EEG skullcaps to record brain activity while they danced, and he developed computer algorithms to determine patterns of brain signals associated with specific expressive movements. He and his team determined 16 patterns related to different dance efforts, such as feeling light or heavy and moving quickly or slowly. By the end of the study, they could successfully predict the dancers' movements based on their brain activity alone.

"We were able to match the grammar of expressive dance with the grammar of emotional brain activity," Pepe said.

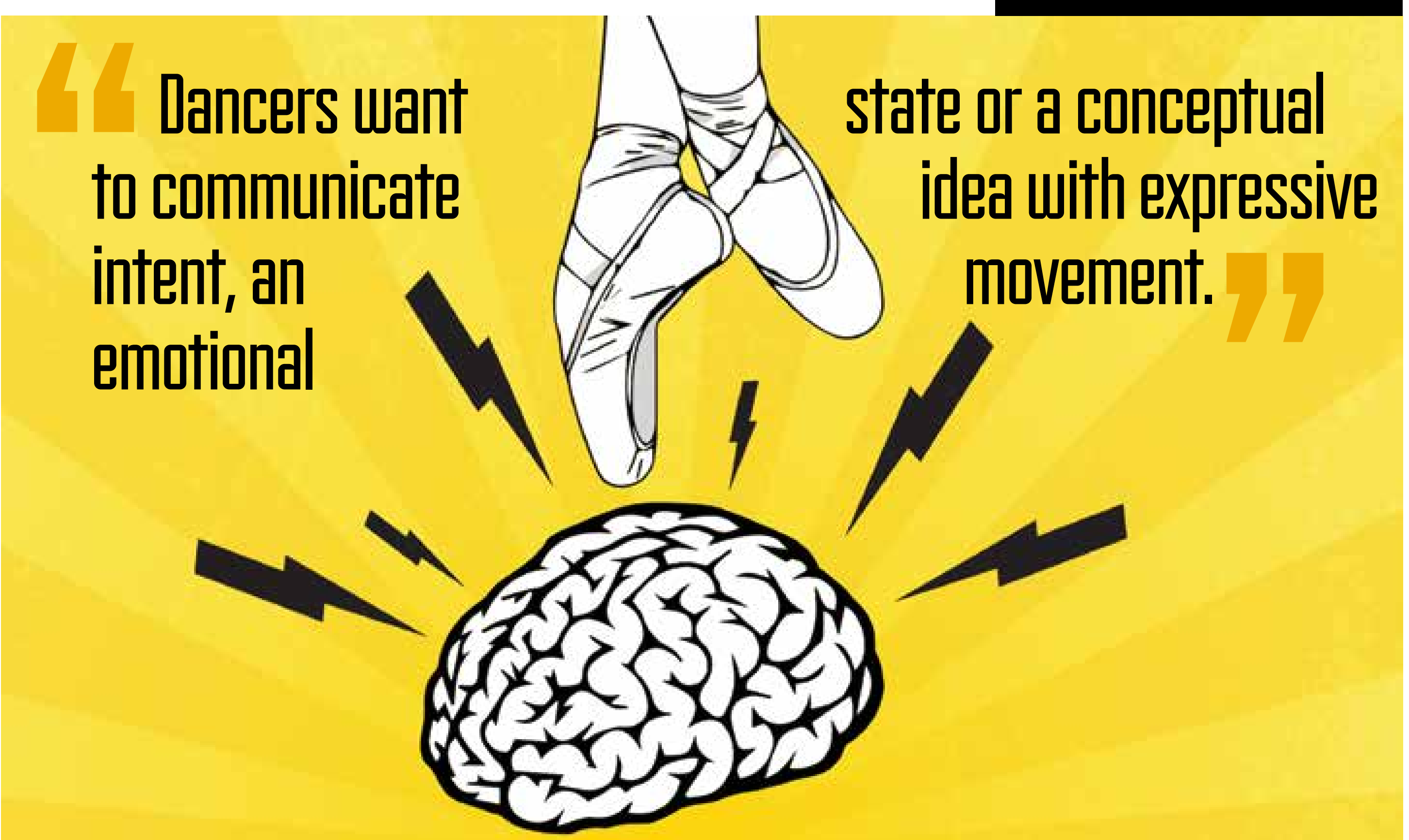
In February, Valls sported an EEG skullcap when she performed her mesmerizing composition, "Red Square," in the Jose Quintero Theatre on the UH campus. As Ravi Shankar's music played, she danced against a backdrop featuring projections of her brainwaves. Pepe used patterns of Becky's emotional brain activity to modulate the stage lighting in real time, so the environment evolved with the internal states of Valls' brain.

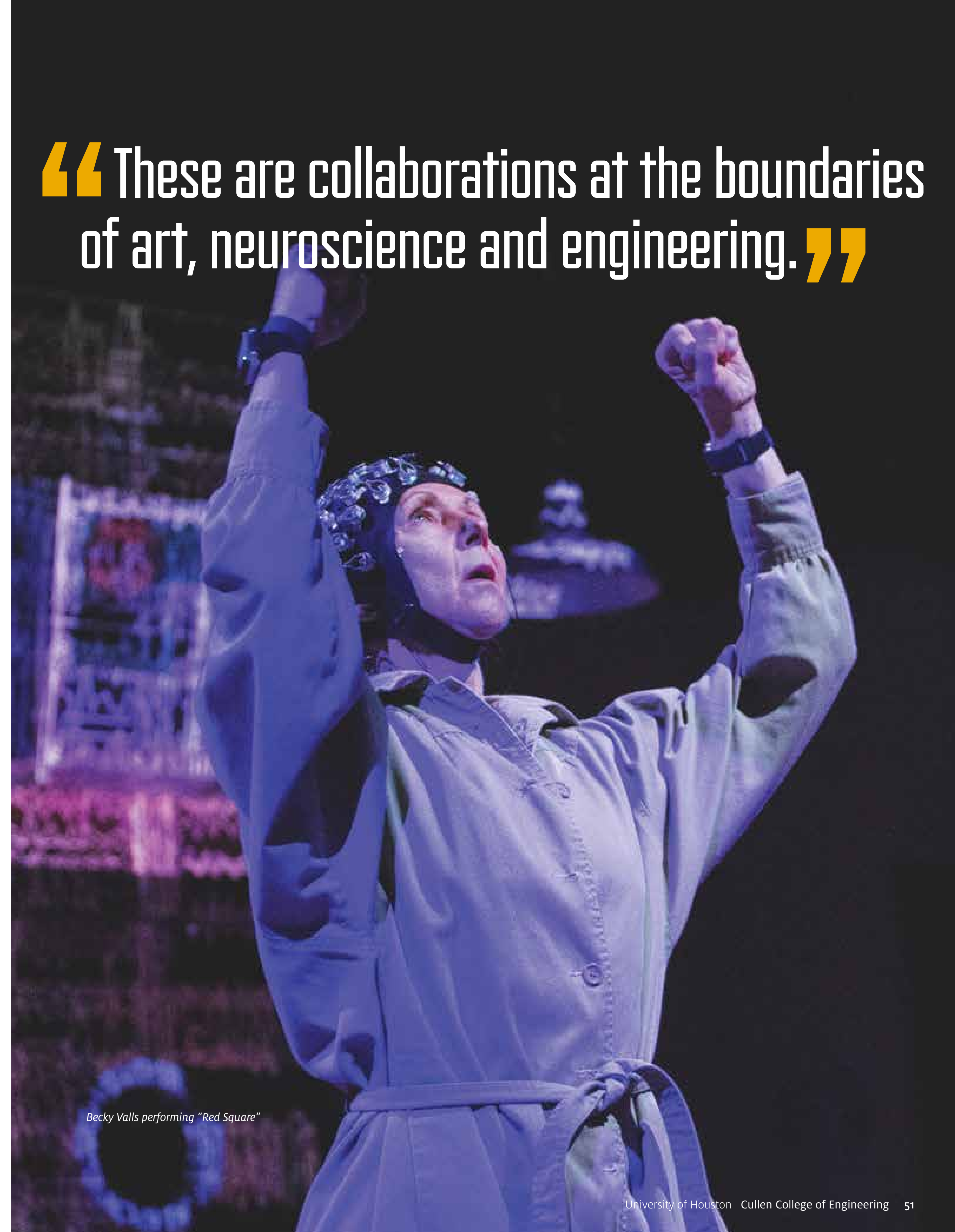
This semester, Pepe and Valls are hosting dance performances each month in the atrium of the UH architecture building. Pepe is recording brain activity in three types of dancers – the choreographer, the professional dancer and the amateur dancer – as they perform the same composition. He and his team are developing computer algorithms to analyze the differences in brain activity between deliveries of the performance art by dancers with varying levels of skill and creative input.

Neuroaesthetic studies of dance and visual art offer potential for understanding and developing therapeutic art treatments, but also provide potential for creating new types of media art installations and for teaching the arts.

"These are collaborations at the boundaries of art, neuroscience and engineering that could tell us a little more about the process of creating art – creativity – the process of understanding art, making judgments about art, and understanding how that processing, those judgments, are affected or modulated by your cultural background, your past training, your age and your life," Pepe said. "This is still an open question, and we're just starting, so we're very excited about the initial results we're getting."

Watch our video series on "Cracking the Brain Code" at www.egr.uh.edu/parameters-fall-2015-videos





Becky Valls performing "Red Square"

MECHANICAL ENGINEERING DEPARTMENT CHAIR RECEIVES ASME MELVILLE MEDAL

Pradeep Sharma, M.D. Anderson Chair Professor and chair of the mechanical engineering department at the UH Cullen College of Engineering, received the 2015 Melville Medal from the American Society of Mechanical Engineers (ASME). The Melville Medal is the highest ASME honor for the best original paper published in a two-year period in any of the 28 ASME journals.

Sharma received the Melville Medal for his paper titled "A theory of flexoelectric membranes and effective properties of heterogeneous membranes," which was published in the *Journal of Applied Mechanics* in January 2014. Co-authors on the paper included Parnia Mohammadi, Sharma's former Ph.D. student, and Liping Liu, professor of mechanics, materials and mathematics at Rutgers University.

Formal presentation of the award will take place at the 2015 International Mechanical Engineering Congress and Exposition held from Nov. 13-19 in Quebec, Canada.

Flexoelectricity is a phenomenon whereby certain materials produce electricity when bent, stretched, or otherwise exposed to mechanical strain. Although flexoelectric qualities have been observed in many materials over the years, there was no mathematical framework to explain how it worked in two-dimensional materials such as biological membranes or graphene.

Sharma and his collaborators developed the first-ever mathematical model to describe flexoelectricity in 2-D materials, providing a framework for understanding how a material's mechanical behavior is linked to its electrical behavior.

"The mathematical theory we created has all kinds of interesting applications," Sharma said. "There's an entire class of 2-D materials that have become very important to us technologically, and our model can be used for many applications that will not show up until much later on."

Examples of two-dimensional materials include graphene and molybdenum disulphide, both of which are just one atom thick, Sharma said. The membranes surrounding human biological cells are also a type of 2-D material, he added.

The mathematical model developed by Sharma and his collaborators can be used to further understand biological membranes, such as those responsible for hearing.

"In order for our hearing mechanism to work, the membranes of ear hair cells must convert mechanical motion into an electrical signal," Sharma said. His post-doctoral researchers and a Ph.D. student are currently applying the mathematical theory to understand the human hearing mechanism.

Sharma also detailed potential future applications of the mathematical model, including energy harvesting. For example, the motion of a heartbeat could someday be converted into electrical power and used to power a nanosensor or an implanted pacemaker.

The paper has been cited more than 10 times In the past year, but Sharma believes the mathematical model his team developed will be relevant to researchers for many years to come.

"We anticipate many future applications," he said.

JOSEPH TEDESCO, DEAN OF CULLEN COLLEGE, ELECTED AS ASCE FELLOW

Joseph W. Tedesco, Elizabeth D. Rockwell Professor and Dean of the UH Cullen College of Engineering, has been elected as a Fellow of the American Society of Civil Engineers (ASCE). This prestigious honor is held by less than 4 percent of ASCE members.

Tedesco's primary research interests are in modeling of load-bearing and stress on concrete and other structural materials. An outstanding educator and researcher in the field of civil engineering, Tedesco authored two textbooks on structural dynamics and served as an author, coauthor, or editor of over 170 books, book chapters, presentations and conferences. He has also been the principal investigator on several dozen granted research projects.

Tedesco earned his doctorate degree in civil engineering from Lehigh University. Prior to his role as Dean of the Cullen College, he taught civil engineering at the University of Florida (Gainesville), Auburn University and Oregon State University. He received the Loyd M. Carter Award at Oregon State University and the Outstanding Professor Award at Auburn University for his excellence in teaching.

As an active member of ASCE, Tedesco has served on numerous ASCE technical committees and on the editorial board of ASCE's *Journal of Structural Engineering* for 12 years. He also served as faculty advisor to the ASCE Student Chapter at Auburn University from 1986 to 1992.

THOMAS HSU NAMED ASCE DISTINGUISHED MEMBER

Thomas Hsu is a Moores Professor of civil and environmental engineering, an author of multiple civil engineering textbooks and a world-renowned researcher. Now, Hsu will add another title to his resume: Distinguished Member of the American Society of Civil Engineers (ASCE).

Distinguished Membership is the highest honor ASCE bestows its members; it is reserved for civil engineers who are either ASCE Members or Fellows. According to the ASCE website, "a Distinguished Member is a person who has attained eminence in some branch of engineering or in the arts and sciences related thereto, including the fields of engineering education and construction." Only one out of every 7,500 ASCE members is granted Distinguished Membership. Hsu is one of only 13 inducted in the 2015 class.

Hsu earned his B.S. in architectural engineering from the Harbin Institute of Technology in China. He earned both his M.S. and Ph.D. in structural engineering from Cornell University. Hsu spent six years in industry as a development engineer for the Portland Cement Association before entering academia in 1968 as an associate professor of civil engineering at the University of Miami. He joined the Cullen College of Engineering in 1980 as department chair, and he has taught classes at UH for 35 years. He was named John and Rebecca Moores Professor in 1998, only one year after the establishment of the professorship. Hsu also earned the Fluor-Daniel Faculty Excellence Award and Abraham E. Dukler Distinguished Engineering Faculty Award from the University of Houston.

Learn more about the ASCE Distinguished Membership, please visit http://www.asce.org/membership/distinguished.

UH HOSTS WORKSHOP TO INSPIRE STUDENTS INTO CAREERS IN ACADEMIA

Debora Rodrigues, an assistant professor in the department of civil and environmental engineering, said many of her female students approach her not just for course help, but for life advice. They ask about things like balancing work and home life, childcare, and prejudices in STEM (science, technology, engineering and math) careers.

"Students wish they had more faculty who are like them, faculty they can relate to," she said.

Part of the problem, according to Rodrigues, is the dwindling number of women and minority faculty members in STEM fields.

The 2013 National Science Foundation (NSF) report "Women, Minorities, and Persons with Disabilities in Science and Engineering" states that women's participation in engineering and computer sciences remains below 30 percent, and since 2000, underrepresented minorities' shares in engineering and the physical sciences have been flat while participation in mathematics has dropped.

"Despite the attention given to the STEM disciplines over the last several years, the number of minorities and females pursuing STEM careers are still far from ideal," Rodrigues said.

But instead of bemoaning the lack of representation in her field, Rodrigues teamed up with researchers from the University of Ohio and Mississippi State University to fix the problem. With funding from the NSF, they're putting on a series of workshops aimed at encouraging women and minorities to pursue research and careers in academia.

The workshop, "Career Development: From Senior Undergraduates to Navigating Assistant Professorship," took place at the University of Houston from June 4-5. It was open to STEM students from the undergraduate level all the way through recently hired junior STEM faculty looking for career advice, mentoring and networking opportunities.

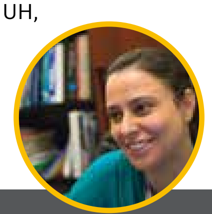
Rodrigues said she hopes the workshop will reach students at all university levels and encourage them to keep pushing their research and academic pursuits. The workshop also aims to create a community of underrepresented groups that can support each other.

"I want them to think academia can be a possibility, can be a career path. That's the thought I want them to leave with," she said.

The workshop topics spanned subjects including assistant professorship careers, time management, applying for grants and NSF CAREER awards, college-level STEM teaching and culturally responsive STEM teaching. It also included specific information for undergraduates looking at graduate school as well as a roundtable discussion for the entire group.

For Rodrigues, the push for more talent in academia is just as important as in industry. "There are so many good people in engineering going to industry – much more than academia. It's sad because we need good professors, we need people with good research backgrounds, and I see all this great talent going away," she said. "And who wouldn't like to have their student as a colleague? I would feel so proud of one of my students becoming a faculty member."

For more information on the engineering career development workshops at UH, please visit www.egr.uh.edu/workshops/NSF.



"I WOULD FEEL SO PROUD OF ONE OF MY STUDENTS BECOMING A FACULTY MEMBER."

- Debora Rodrigues

BIOMEDICAL ENGINEERING CHAIR RECEIVES HONORARY DOCTORAL DEGREE FROM AALBORG UNIVERSITY

Metin Akay, founding chair of the biomedical engineering department at the UH Cullen College of Engineering, received an honorary doctoral degree in biomedical engineering and science from Aalborg University in Denmark last April.

Akay's degree was presented by the rector of Aalborg University, Michael Johansen, in front of an audience of about 500 invitees. The invited audience members included representatives from the Aalborg University Board and the Danish Ministry of Education. The event was followed by a reception for nearly 2,000 invited guests.

"Aalborg University is one of the most respected universities in the areas of neural and rehabilitation engineering, pain and bionanoscience," Akay said. "I am excited and humbled to receive this honoris causa (honorary doctoral degree)."

Akay is a native of Turkey who earned his Ph.D. from Rutgers University in 1990. He served as the interim chair of bioengineering at ASU from 2006 to 2010, when he began his post at UH.

As a researcher, Akay has conducted extensive work in the fields of neural engineering and genomics and health informatics. He is also one of the biomedical engineering community's most active members and staunchest advocates. He has given more than 100 plenary, keynote and invited presentations at national and international conferences and served as an editor for several engineering books and journals.

Akay has been handpicked to serve on boards charged with everything from raising public awareness of engineering to fostering international research partnerships. In 2012, Akay was named to the inaugural group of IEEE Brand Ambassadors, a program designed to communicate the importance of engineers and engineering to those outside of the profession and to promote IEEE within the engineering world. Additionally, Akay has received an invitation to join the International Academy of Medical and Biological Engineering, a member organization of the International Federation for Medical and Biological Engineering (IFMBE).

He's also deeply committed to engineering education; over the years he has helped mentor several up-and-coming young researchers, many of whom have gone on to become highly regarded in their fields.

PROFESSOR EARNS 2015 EURASIP BEST PAPER AWARD FOR COLLABORATIVE SPECTRUM SENSING STUDY

Zhu Han, professor of electrical and computer engineering at the UH Cullen College of Engineering, earned the 2015 EURASIP Best Paper Award for a paper he co-authored in the *EURASIP Journal on Advances in Signal Processing*.

The European Association for Signal Processing (EURASIP) was established in 1978 to provide a platform for the dissemination of signal processing information and for the facilitation of discussion about all aspects of the technology, according to the association's website.

Han and three other authors received certificates and travel allowances to attend the 2015 European Signal Processing Conference in Nice, France last summer for their paper "Securing Collaborative Spectrum Sensing Against Untrustworthy Secondary Users in Cognitive Radio Networks." Han's collaborators include Winkai Wang and Yan Sun, professors of electrical, computer and biomedical engineering at the University of Rhode Island, and Husheng Li, professor of electrical engineering and computer science at the University of Tennessee.

Cognitive radio spectrum sensing is a revolutionary secondary user network that improves primary network performance by optimizing scarce spectrum resources. However, untrustworthy secondary users can significantly degrade the performance of collaborative spectrum sensing, according to the journal paper.

In this computational study, Han and his colleagues used an onion-peeling approach to analyze cases involving both individual and multiple attackers. They identified secondary users, calculated their trust values, defined damage metrics, investigated attacks that maximized damage and proposed defense schemes, according to the paper. Those with highly suspicious reports were excluded from decision-making.

"Compared with existing defense methods, the proposed scheme can effectively differentiate malicious nodes from honest nodes," the authors wrote in their paper. "As a result, it can significantly improve the performance of collaborative sensing."

ENGINEERING UNDERGRAD HOSTS ROBOTICS WORKSHOP

As robotic technology takes over many industries, so does the need for skilled robotic technicians. Luckily for UH students, electrical and computer engineering student **Rakshak Talwar** spread his love for and knowledge of robotics to his peers through a workshop at the UH College of Natural Sciences and Mathematics last April.

Talwar, CEO and co-founder of RaptorBird Robotics, Inc. provided an info session about an upcoming series of robotics workshops to teach students how to program GPS-enabled self-driving rovers based on the RAVN drone platform. RaptorBird creates the hardware in the form of the RAVN platform; Talwar wants his fellow students to learn how to program it to suit the parameters they choose.

"What I've noticed is the typical electrical engineer will have a hard time moving away from building hardware to creating something bigger, and the typical computer science student will dream of bigger things, but they don't know how to communicate them down to the hardware. [RAVN] bridges the two and makes it a complete package," he said.

Talwar said the information session also served as a focus group to determine the interest level in the robotics projects on the part of the students, which will help him decide whether to pursue a workshop that regularly meets and performs robotics work.

"It's research. My mentality is that we have to know our customer. We have to know if they even exist, and if so, what they want," Talwar said.

CIVIL ENGINEERING STUDENT WINS PRESTIGIOUS NASA EARTH AND SPACE SCIENCE FELLOWSHIP

Ting Yuan, a civil engineering Ph.D. student at the UH Cullen College of Engineering, won NASA's Earth and Space Science Fellowship (NESSF) for the 2015-2016 academic year. The award provides a maximum of $30,000 in funding each year for up to three years. Out of 391 earth science proposals submitted to the NESSF program, only 64 were chosen to receive the prestigious fellowship.

According to the NASA website, the purpose of NESSF is to ensure continued training of a highly qualified workforce in disciplines needed to achieve NASA's scientific goals.

The fellowship will provide funding for Yuan's research investigating surface water fluxes over the Congo River Basin using one-dimensional and two-dimensional linear diffusion models combined with satellite remote sensing data. Yuan began working on this research with her faculty advisor, assistant professor Hyongki Lee, in 2012.

With a surface area of approximately 3.7 million square kilometers, the Congo River Basin is the second largest river basin in the world, surpassed only by the Amazon. Compared to the Amazon, though, the Congo Basin is still a mystery. Its remote location combined with political instability in the region has prevented researchers from gathering even the most basic information about the hydrology and hydrodynamics of the Congo's waters and their connections to global climate change.

Until now, many researchers hypothesized that the hydrology and hydrodynamics of the Congo floodplain were similar to that of the Amazon, Lee said. However, by combining synthetic aperture radar images, satellite altimetry data and multispectral images collected from NASA, the Japan Aerospace Exploration Agency (JAXA) and the European Space Agency (ESA), Yuan was able to show that these wetlands are very different from the Amazon Basin.

"What we see is that most of the water stored in the floodplains in the Congo River Basin are from upland runoff or direct rainfall," Yuan said. "In the Amazon, the floodplains are filled mostly from the river itself rather than from runoff. So, the Congo Basin is quite opposite from the Amazon Basin."

By integrating the different satellite data sets with the hydrology and hydrodynamics model that she developed, Yuan was able to produce 2-D, high-resolution water level maps illustrating the water levels throughout the Congo floodplains. After rendering of the 2-D models is complete, Yuan will be able to quantify the fine-scale hydrologic fluxes in the floodplains and investigate their seasonal and annual variations.

"By completing this research we will have a better understanding of global hydrology by understanding the Congo River Basin," said Lee. "The hydrology of the Congo Basin has an impact on climate change as well as the global water cycle, and we will have answers to many of those questions by the end of this research."

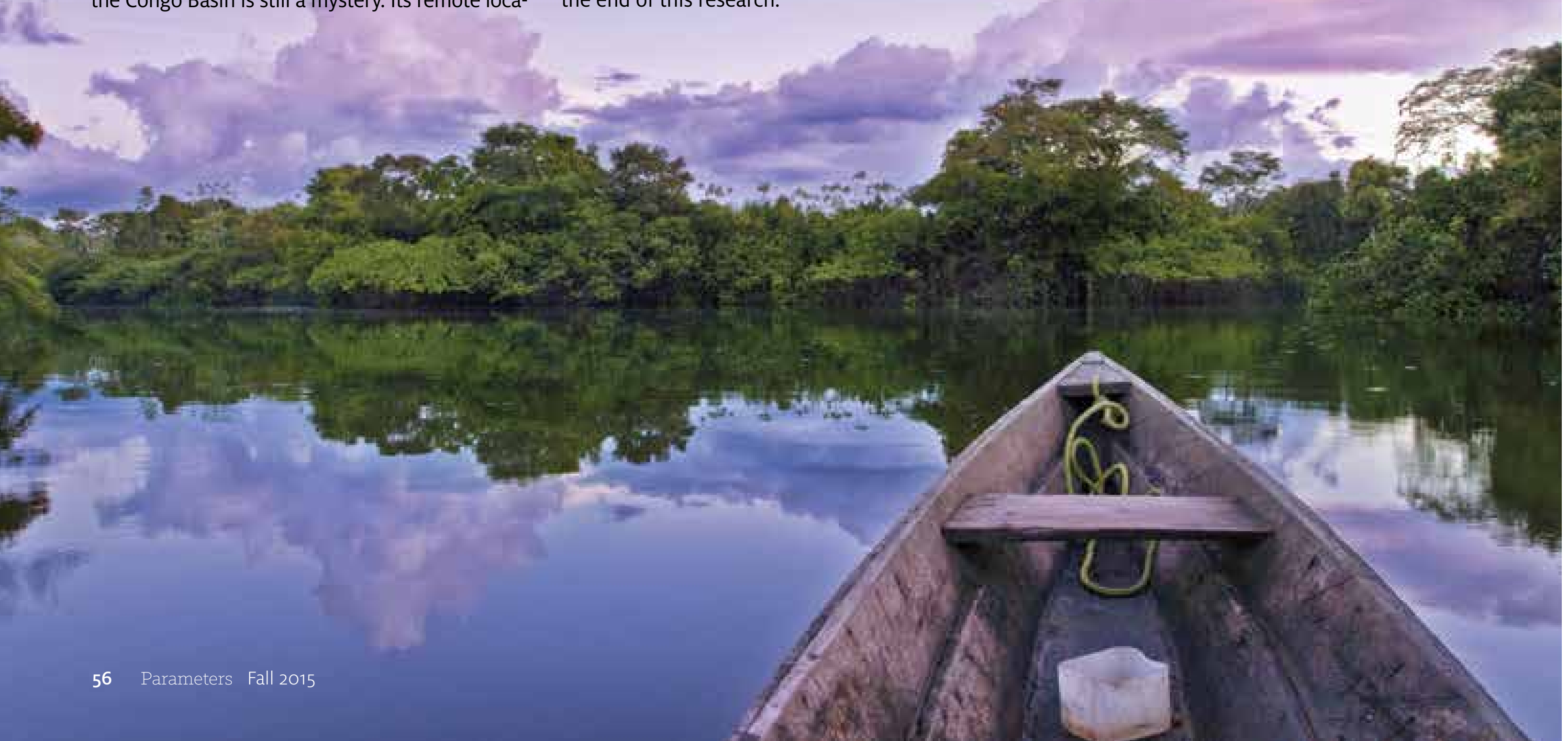
Moreover, because the floodplains of the Congo Basin receive most of its water from upland runoff rather than the river itself, damming projects along the Congo River may not have as much as an environmental impact in the wetlands as it would in the Amazon Basin.

This insight is particularly significant considering hydropower generation projects proposed in the Congo Basin, such as the Inga dam. The so-called Grand Inga project has the potential to provide power to almost the entire African continent, generating twice the power of the Three Gorges Dam in China. The proposed dam would be located about 30 miles from the mouth of the Congo River, where powerful waterfalls and rapids are located.

"This work can help regulators make important decisions about hydropower generation projects in vital basins such as the Congo," Yuan added.

Yuan said she hopes to continue her research in her career after graduation from the Cullen College, but remains open to job prospects in industry as well. "I received a lot of guidance from Dr. Lee. He is very supportive and I learn a lot from working with him," Yuan said. "I feel well prepared for what might be next [after completing my Ph.D.], so I am quite open to career options."

Yuan added that receiving the NESSF fellowship was one of the highlights of her academic career. "I am very honored and grateful I got the fellowship this year," she said.



SCHLUMBERGER FOUNDATION HONORS MECHANICAL ENGINEERING PH.D. WITH FELLOWSHIP

The need for female professionals in STEM industries is overwhelming, and the data is similarly dismal for underrepresented minorities, according to the 2015 National Science Foundation report "Women, Minorities and Persons with Disabilities in Science and Engineering." **Himani Agrawal,** a Ph.D. student studying mechanical engineering, just won a fellowship to help change those statistics.

Agrawal was awarded the Schlumberger Foundation Faculty for the Future Fellowship, an award for female Ph.D. and post-doctoral students from developing countries studying science, technology, engineering and math (STEM) subjects. The fellowship, valued at $50,000, is only awarded to 5-6 percent of applicants who apply from around the world, and applicants must illustrate a commitment to inspiring young women to pursue studies in STEM. This is the first time a University of Houston student has been awarded the fellowship.

The fellowship application included five rigorous rounds and an interview with the Schlumberger Foundation Board of Trustees.

"This fellowship means a lot to me," Agrawal said. "I'm hopeful the support of the Schlumberger Foundation will help me a lot in getting a post-doc position after I finish my Ph.D." She added that part of her academic success has come from outside the classroom. "You can't focus only on academic excellence, you must also focus on extracurricular activities, especially outreach." Agrawal is a graduate committee member of the Society of Women Engineers UH chapter, a group which hosts several outreach events throughout the year.

Learn more about the Schlumberger Foundation at https://www.fftf.slb.com.

UH ENGINEERING STUDENT GAINS FRONT-ROW SEAT FOR ENERGY POLICY AND POLITICS

Chemical engineering student **Jami Summey-Rice** spent last summer in Washington, D.C., as one of 14 students nationally selected for WISE (Washington Internships for Students of Engineering).

The program began in 1980 to prepare future engineers for leadership roles in guiding science, technology and public policy. The interns spent nine weeks meeting with government officials and technical advisors to better understand how engineers can contribute to legislative and regulatory public policy decisions.

Summey-Rice, a junior in chemical engineering, is also minoring in petroleum engineering as well as energy and sustainability. The energy and sustainability minor is an interdisciplinary program based in the UH Honors College but open to all students.

Those classes have cemented her interest in policy issues.

"I'm fascinated by energy policy. I'm fascinated by sustainability," she said. "I realized I do have aspirations outside engineering."

The interdisciplinary nature of the program held special appeal, tapping into her concern that conventional education programs often "force people to be right-brained or left-brained."

"That doesn't set us up for solving the big problems," Summey-Rice said. "We need both."

WISE is guided by faculty member-in-residence Kenneth J. Lutz, a former Congressional fellow for U.S. Sen. Ron Wyden, who now teaches a course he developed on the smart grid at the University of Delaware.

In addition to meetings and field trips, WISE interns are required to write a paper on a topical engineering-related policy issue. Summey-Rice focused on the economic and environmental implications of high-speed rail versus air travel.

That's topical, as organizers try to build support for a high-speed rail between Houston and Dallas.

"We hate the airlines but we don't have another option," she said, explaining the allure of high-speed rail for many people.

Summey-Rice is currently vice president and a candidate for president of the UH chapter of the American Institute of Chemical Engineers, which sponsored her internship. The interns, each sponsored by a cooperating engineering society, received housing at George Washington University, paid by the sponsoring society, and a $2,100 stipend.

She is also a member of the Society of Women Engineers, the UH Energy Association and Omega Chi Epsilon, the honor society for chemical engineering students, as well as an initiate of Tau Beta Pi, the engineering honor society.

Summey-Rice will graduate in Spring 2017 and hopes to work in the energy industry. Ultimately, she hopes to move into policy work after building a strong background in the industry.

STUDENT ACCOLADES:

- Electrical and computer engineering students **Erick Saucedo, Steven Do** and **Aman Fatma** won the first place prize at the 2015 Mercury Remote Robot Challenge hosted by Oklahoma State University by building a remote bot that performed a myriad of commands in the dark.

- Chemical and biomolecular engineering students **Rui Li, Yuying Song** and **Melanie Hazlett** received poster awards at the 2015 Southwest Catalysis Society's spring symposium.
- Mechanical engineering students competing in the American Society of Mechanical Engineers South Texas Section University Technical Competition won several of the category awards. See the full list of awards below:
  - In the undergraduate research category, **Alan Garcia, Ethan Windish, Daniel Camacho** and **Mitul Patel** won with their Cameron-sponsored capstone design project, "Cold Temperature Effects on Elastomers."
  - Ph.D. student **Sonika Gahlawt** won the graduate research category with her presentation, "Understanding Elastic and Flexure Behavior of Half-Heusler Thermo-electric Materials."
  - "Quadcopter," a capstone design project by **Carlos Arocha, David Marquise, Sarmed Omran** and **Quentin Walker,** won the undergraduate design category.
  - **Ala E. Omrani** also received an award in the subsea engineering category for "Hydromechanical Modeling to Cope with Gas Volume Fraction during Artificial Lift."

STUDENT ATTENDS ARGONNE TRAINING PROGRAM ON EXTREME-SCALE COMPUTING

A Ph.D. student at the UH Cullen College of Engineering was one of only 65 participants selected to attend the Argonne Training Program on Extreme-Scale Computing (ATPESC) funded by the U.S. Department of Energy's Office of Science.

Civil engineering student **Justin Chang** traveled to St. Charles, Illinois from August 2-14 for the intensive two-week training program, which provided hands-on training on the key skills, approaches and tools to design, implement and execute computational science and engineering applications on current supercomputers and the HPC systems of the future.

"I was delighted to have found that I was chosen considering how selective this training program is," Chang said. "This program will let me stay up to date with the latest technologies, trends and innovative ideas within the high performance computing community."

Chang's advisor, Kalyana Nakshatrala, a civil and environmental engineering assistant professor, said that although civil and environmental engineering and high performance computing may not seem so compatible, the fields often go hand in hand. "Highly sophisticated computer modeling is necessary for many civil and environmental engineering projects," Nakshatrala said.

Take Chang's research, for example: as a doctoral student at UH, Chang developed sophisticated computer models and numerical methods for subsurface flow and transport modeling. Satish Karra, a staff scientist in the Earth and Environmental Sciences Division of the Los Alamos National Laboratory who worked with Chang last summer, said that Chang's "state-of-the-art algorithms…are vital for our group's research in modeling aspects of carbon sequestration, groundwater contamination, hydraulic fracturing and nuclear waste disposal."

"It feels incredible to have come from a civil engineering background and still be selected for this two week crash course on important topics in extreme-scale computing," Chang said.

Last March, Chang received the U.S. Department of Energy's Office of Science Graduate Student Research (SCGSR) Award. The SCGSR program provides supplemental awards to support part of a graduate student's thesis research to be conducted at a DOE laboratory. Chang will be at the Los Alamos National Laboratory (LANL) in New Mexico until next January to write scientific code and study the computational efficiency of these numerical methods on state-of-the-art high performance computing (HPC) systems.

Chang said that completing the ATPESC program before traveling to LANL to complete his graduate student research is a huge boost to his education and his research.

"ATPESC gave me excellent exposure on how the technologies are moving towards extreme-scale computing and how my codes can be adapted to this change," he said. "I believe that this training program will give me the essential knowledge and the required skill set, thereby boosting my background in HPC needed for my research."

UH TEAM WINS THE TEXAS ENERGY INNOVATION CHALLENGE

Graduate students from the University of Houston won top honors in the Texas Energy Innovation Challenge with a plan to harness geothermal energy to treat water produced during hydraulic fracturing.

The competition, held last May in Austin, featured five teams of graduate and professional students from across the state, tasked with researching and developing the most creative and cost-effective use for water produced from the hydraulic fracturing of wells.

As the first-place winner, the UH team won $10,000 in scholarship funding. Each team was made up of graduate students from engineering, business and law; the other teams were from Texas A&M University, the University of Texas at Austin, UT-El Paso and Texas Tech University.

Hydraulic fracturing uses sand, water and chemicals, pumped at high pressure into a well, to fracture the dense rock formations and release oil and natural gas, with millions of gallons of water returning to the surface along with the oil or gas. There is a growing desire to recycle or reuse that water, although the cost has kept many companies from doing so. Most inject the water into disposal wells.

But concern about disposal wells – studies have linked wastewater disposal to small earthquakes, and many shale plays are in water-scarce regions – has spurred a search for new ideas.

The competition was sponsored by Power Across Texas, with a panel of judges from the energy industry.

UH team members, using the name GeoThermH2O, proposed to harness geothermal energy from decommissioned wells to reduce the cost of water treatment.

Team members include **Amin Kiaghadi** and **Rose Sobel,** both Ph.D. candidates in environmental engineering, Shanisha Smith, a lawyer who just completed a Master of Law degree, and Varun Sreenivas, an MBA student specializing in energy finance and the energy supply chain.

Faculty advisors included Hanadi Rifai, professor of civil and environmental engineering; Zachary Bray, assistant professor of law; Radha Radhakrishnan, clinical assistant professor in decision and information sciences; and Konstantinos Kostarelos, associate professor of chemical and biomolecular engineering. Executives from Houston-based Rockwater Energy Solutions served as industry mentors.

The team's research found that while membrane and distillation technologies provide the highest quality water treatment, both require huge amounts of energy, making treatment more expensive than disposal.

Under their plan, a closed loop system using a small volume of freshwater would be recirculated in the decommissioned well to power a desalination unit, capable of cleaning and recovering about 70 percent of the water. That treated water could become an inexpensive, drought-resistant source of water for agricultural and nonpotable municipal use.

The team also called for tax credits for water recycling and increasing the cost of disposal as a way to spur the use of the new technology.

MECHANICAL ENGINEERING STUDENTS EARN COVETED NASA RESEARCH FELLOWSHIPS

Two Ph.D. students in the Cullen College's department of mechanical engineering received highly coveted NASA Space Technology Research Fellowships. The fellowships will cover the cost of their education from August 2015 to August 2016.

Andrew Robertson (advisee of Ken White) and **William Walker** (advisee of Haleh Ardebili) both received the prestigious fellowships. According to mechanical engineering department chair Pradeep Sharma, no Cullen College student has earned the status of NASA Space Technology Research Fellow in decades – let alone two in a single year.

For the past three years, Robertson has been working closely with White to study the bonding mechanisms in structural coatings. Structural coatings are used to preserve a variety of industrial, marine and commercial structures and components. The weakest part of any structural coating is the strength of the bond made with the substrate, and Robertson said that studies focusing on this area are particularly relevant for space applications.

"This topic is important to NASA because of their extensive use of coatings," Robertson said. "Rather than being applicable to only one type of coating, my research can be applied to any kind of coating to maximize its functionality and that's why I believe my application was selected."

In addition to the relevance of this research to NASA, White said Robertson was chosen to receive the fellowship because of his aptitude in explaining his work.

"I feel that the NASA selection committee recognized his intellectual capacity and maturity in presenting his research topic," White said.

Having the opportunity to work on research with real-world applications throughout his undergraduate and graduate student career has helped to set him apart as an engineering student, White said. "I have seen his creativity grow in response to the challenges of his advancements through our program, first as a fast track undergraduate, then as a first-time graduate student," he said.

Working with Ardebili, Bill D. Cook Assistant Professor of mechanical engineering, Walker's project focused on the thermo-electrochemical analysis of lithium-ion (Li-ion) batteries for space applications.

"This is a critical topic because the batteries currently used in the International Space Station and for other space related applications are transitioning to lithium-ion batteries, and the evaluation of their safety and thermal, electrochemical performance is imperative," Ardebili said.

Walker is developing computer models to predict the thermal performance of lithium ion batteries during nominal operations and during thermal runaway scenarios. Walker carefully designs experiments to complement his computer models with real world results. Together, Walker and Ardebili published their results in the *Journal of Power Sources* in 2014 and plan to publish a second paper in the near future.

"His NASA fellowship is very well-deserved and will allow him to focus his time and efforts on this critical research for space applications," Ardebili said.

Walker agreed with Ardebili, adding that the fellowship will allow him to become an expert in the use of lithium-ion batteries for space applications.

"I was selected to take coursework and research hours that will enable me to become an expert in testing and analyzing thermal aspects to lithium-ion batteries with respect to understanding and preventing thermal runaway and thermal propagation," Walker said.

FOUR CHEMICAL ENGINEERING GRADUATE STUDENTS WIN KOKES TRAVEL AWARDS

Four graduate students from the Department of Chemical and Biomolecular Engineering at the UH Cullen College of Engineering received prestigious Kokes Awards to attend the 24th North American Catalysis Society (NACS) meeting held in Pittsburgh, Penn. last June.

From Left: Hieu Doan, Manjesh Kumar, MengMeng Li, Yang Zheng

The winning students were **Hieu Doan, Manjesh Kumar, Yang Zheng** and **MengMeng Li.** Out of 200 student abstracts submitted, only 110 received Kokes Awards.

The Kokes Travel Award program of NACS aims to encourage undergraduate and graduate students to attend and participate in the biennial NACS conference. This award allowed Doan, Kumar, Zheng and Li to travel to the conference free of charge and covered the costs of their student conference registration fee and hotel accommodations, as well as providing a travel allowance.

The North American Meeting (NAM) of the Catalysis Society is widely recognized as the premier research conference for heterogeneous catalysis, homogeneous catalysis, electro-catalysis and photo-catalysis. Held every other year, NAM draws crowds of more than 1,100 attendees and features plenary lectures, keynote addresses by leaders in the catalysis field, awards and hundreds of oral and poster presentations.

Hieu Doan

Doan, who is advised by chemical engineering professor Lars Grabow, was a co-author on a paper published in the journal *Science* that revealed the secrets behind gold's unexpected oxidation activity. In addition to the prestige of publishing this research in a major journal, Doan was one of only five researchers selected to present his poster as a "Hot Topic Talk" at the Gordon Research Conference last January.

Doan's research poster on gold's oxidation activity was also presented at the NAM24.

"It's an honor to be chosen for this award and I really enjoyed meeting with some of my peers and collaborators as well," Doan said.

Doan's poster outlined his research determining why gold, one of the least reactive of all metals, performs so well as a catalyst when oxidizing carbon monoxide (CO) into carbon dioxide (CO_2). The collaborators on this project were Bert Chandler, Johnny Saavedra, and Christopher Pursell at Trinity University in San Antonio.

Together, the team discovered that the reason for gold's unexpected oxidation is water.

Doan is currently in his final year as a doctoral student at the University of Houston. After graduation, Doan plans on pursuing a career in the oil and gas industry.

Manjesh Kumar

Kumar has been working closely with advisor Jeff Rimer for over three years to find better methods for growing zeolites, which are crystalline materials that are used as adsorbents and catalysts in a variety of chemical processes. Zeolites span applications from gasoline production to additives for laundry detergent – not to mention thousands of other commercial and consumer products.

But despite the importance of these materials in many chemical and industrial processes, the ways in which these crystals are synthesized are not well understood. Kumar's research focuses on finding better ways to rationally design zeolites in order to improve the materials' performance and reduce the costs and trial-and-error associated with their synthesis.

Kumar was selected to give an oral presentation on his research at the NAM24 meeting. His research group published a paper titled, "A Facile Strategy to Design Zeolite L Crystals with Tunable Morphology and Surface Architecture," in the prestigious *Journal of the American Chemical Society* in 2013. He presented some of his recent research work on effective morphology control of commercially relevant zeolites like Mordenite and SSZ-13 and its potential growth mechanism.

Kumar plans to look for a research position in the oil and gas industry after earning his Ph.D. "I would really like to continue on the research path I started here at UH," Kumar said.

Yang Zheng

Zheng has spent most of his career as a doctoral student working side-by-side with Mike Harold, chair of the chemical and biomolecular engineering department, and Dan Luss, Cullen Professor of Engineering. Harold and Luss are both renowned experts in the field of chemical reaction engineering, with one area of focus being the treatment of emissions from engine exhaust.

"I am so proud to work with them," Zheng said. "I receive great guidance from them as a Ph.D. student."

So far, Yang has three peer-reviewed publications with co-authors Harold and Luss based on his doctoral research in respected catalysis and chemical engineering journals like *Applied Catalysis B: Environmental* and the *Chemical Engineering Journal*. One of the benefits of working closely with Harold and Luss is access to the University of Houston's Center for Clean Engines, Emissions and Fuels, or TxCEF, one of the world's leading research centers for advancing the discovery and adoption of new engines, fuels and emission reduction technologies.

Zheng's research focuses on the discovery of novel automotive emission control systems for reducing nitrogen oxide, or NOx, from diesel engine exhaust. Specifically, Zheng is looking into combining two existing NOx reduction technologies to achieve better control of harmful emissions for diesel engines.

So far, results from Zheng's research shows that using dual layer catalysts consisting of an LNT catalyst (or lean NOx trap) and an SCR catalyst (or selective catalytic reduction) with rapid hydrocarbon pulsing effectively reduces NOx in diesel engine emissions with less ammonia slip.

Zheng plans to graduate this year and hopes to continue his current research on automotive emission control systems.

MengMeng Li

Li also works closely with faculty advisor Mike Harold to research NOx reduction systems for diesel engines. However, Li's work focuses on using sequential catalysts to selectively reduce NOx in diesel engine emissions. In this system, the first catalyst enables the generation of ammonia, which is used by the second catalyst to eliminate the NOx.

"The idea is to reduce NOx by 50 percent with the lean NOx trap, then to produce as much ammonia as possible for downstream selective catalytic reduction to achieve complete NOx removal," Li said. This method of reducing NOx emissions in diesel engines could potentially be much more cost effective than current emission reduction systems.

Although Li's research results have been promising so far, the system she's studying is still very new and widely debated, she said.

Li has spent the last three years conducting research at TxCEF sponsored by private industry, including Honda Inc. "I had the opportunity to work closely with industry throughout this research," Li said. "It was very helpful for me to interact with industry and learn what their needs are and what their standards are. I think having that experience helped me with the poster presentation."

Li, who is currently in her third year as a Ph.D. student, said she was pleasantly surprised to receive the Kokes Award so early in her career as a doctoral student. "I really didn't expect to get it," she said. "I am honored and very excited."

STUDENTS, FACULTY TEAM UP TO BRING NEW TECHNOLOGIES TO MARKET

As an undergraduate, **Christopher Holly** and his teammates had more experience writing papers and waiting tables than wooing investors, but they caught on quickly.

They won $15,000 at the Baylor New Venture Competition last spring, the result of being willing to adapt, pulling an all-nighter as they rewrote their pitch to address early questions. The prize money paid to incorporate their fledgling business, Zeolytic Technologies Inc., with money left over.

The energy startup offers a zeolite created by **Jeffrey Rimer**, Ernest J. and Barbara M. Henley Assistant Professor of chemical and biomolecular engineering, which can maximize catalyst performance as refiners turn crude oil into transportation fuels.

Holly and his partners, **Jared Beale**, **Nick Brannon** and **Torri Olanski**, are part of an innovative program at the University of Houston's Wolff Center for Entrepreneurship, pairing business students with University researchers. The students develop plans to turn a faculty-created technology into a viable business.

The program, a partnership between the Wolff Center and the UH Division of Research, serves several purposes. Instead of textbook case studies, students work with real technologies, devising business plans and competing for start-up funding. Faculty inventors also receive help commercializing their research.

"The [Wolff Center] program at UH provides an excellent opportunity to transform ideas and inventions developed in the laboratory into commercial technologies," Rimer said. "This cannot be accomplished unless you have a team of highly motivated and innovative students pushing their business plan forward, which we do."

There are six major business plan competitions – the Zeolytic Technologies team went to California for Chapman University's California Dreamin' competition in late April – and their popularity is growing.

"They're catching fire as startups see them as a source of funding," says Ken Jones, director of undergraduate programs at the Wolff Center, part of the Bauer College of Business.

Most of the competitors are graduate students, but UH sends undergraduates, Jones said. This is the third year UH has paired students with researchers; students launched a business, REEcycle, after last year's competition tour, during which they won more than $100,000 and the three top awards at the National Clean Energy Business Plan Competition, sponsored by the U.S. Department of Energy.

REEcycle now operates out of the new Innovation Center incubation space at UH's Energy Research Park, using a method developed by Allan Jacobson, Robert A. Welch Chair of Science and director of the Texas Center for Superconductivity at UH, to recycle rare earth elements critical for powering cell phones, wind turbines and other clean energy technologies.

REEcycle CEO Casey McNeil was named to Forbes magazine's "30 under 30" list of movers in the energy world, and he and his teammates competed again in business plan competitions last spring.

Jacobson also created the technologies used by two additional Wolff Center teams – Carla and Purus – competing this spring: Carla is pitching a process to reclaim lanthanum, another rare earth element, from used catalysts, and Purus is working with Jacobson's technology to remove hydrogen sulfide and carbon dioxide from natural gas and biogas streams.

Jones said all entrepreneurship students are placed in teams and paired with a technology developed by a UH faculty member, although not all the teams go on to compete. Sometimes, for example, students determine that commercial prospects for a technology aren't good, or that it needs more work.

The real entrepreneurship work begins once they determine the commercial potential. "Whether it's zeolites or whatever, technology is pointless unless someone is willing to pay for it," Jones said.

Holly, who graduated last May, said he and his teammates are convinced Rimer's zeolite technology can go the course.

The technology provides a means of selectively tailoring the properties of zeolite materials to improve their performance in applications such as catalysis. "Its key advantages are its versatility – it can be applied to any zeolite structure – and its ability to tune catalyst properties in a way that cannot be matched by conventional zeolite synthesis," Rimer said, noting that it already has drawn attention from petroleum and petrochemical companies that use zeolites as commercial catalysts.

Holly said the students have formed a corporation and will work out of the Energy Research Park's Innovation Center.

> “[ENGINEERING IS A] WAY TO KEEP LEARNING INTERESTING THINGS.”

MECHANICAL ENGINEERING ALUMNUS HONORED WITH PRESIDENTIAL TEACHING AWARD

Mechanical engineering alumnus **Jonathan Claydon** was recently recognized as a state finalist for the 2015 Texas Presidential Awards for Excellence in Math and Science Teaching (PAEMST). The PAEMST are the nation’s highest honors, intended to recognize instructors who contribute to their communities as role models and leaders in the field of STEM education. The application process is arduous and requires nominees to submit a résumé, letters of recommendation, classroom video footage and an extensive narrative essay.

Claydon, who excelled in advanced math and science subjects like calculus and physics during his senior year of high school, was drawn to the UH Cullen College of Engineering because he saw engineering as a “way to keep learning interesting things.”

As an undergraduate student at UH, Claydon was a member of the Honors College, which he said strongly impacted his undergraduate experience. He found that the Honors Engineering Program provided him a “home base” within the University. In addition to living in one of the Honors College dorms on campus, he bonded with his classmates over long study sessions in the Honors Library and late-night peer tutoring sessions.

After receiving his bachelor’s degree in mechanical engineering, Claydon landed a job in the construction industry as a project engineer. However, after a couple of years in construction management, he realized the industry wasn’t for him and began to seek a new career that would be “more actively engaging during the day.” Enter, academia.

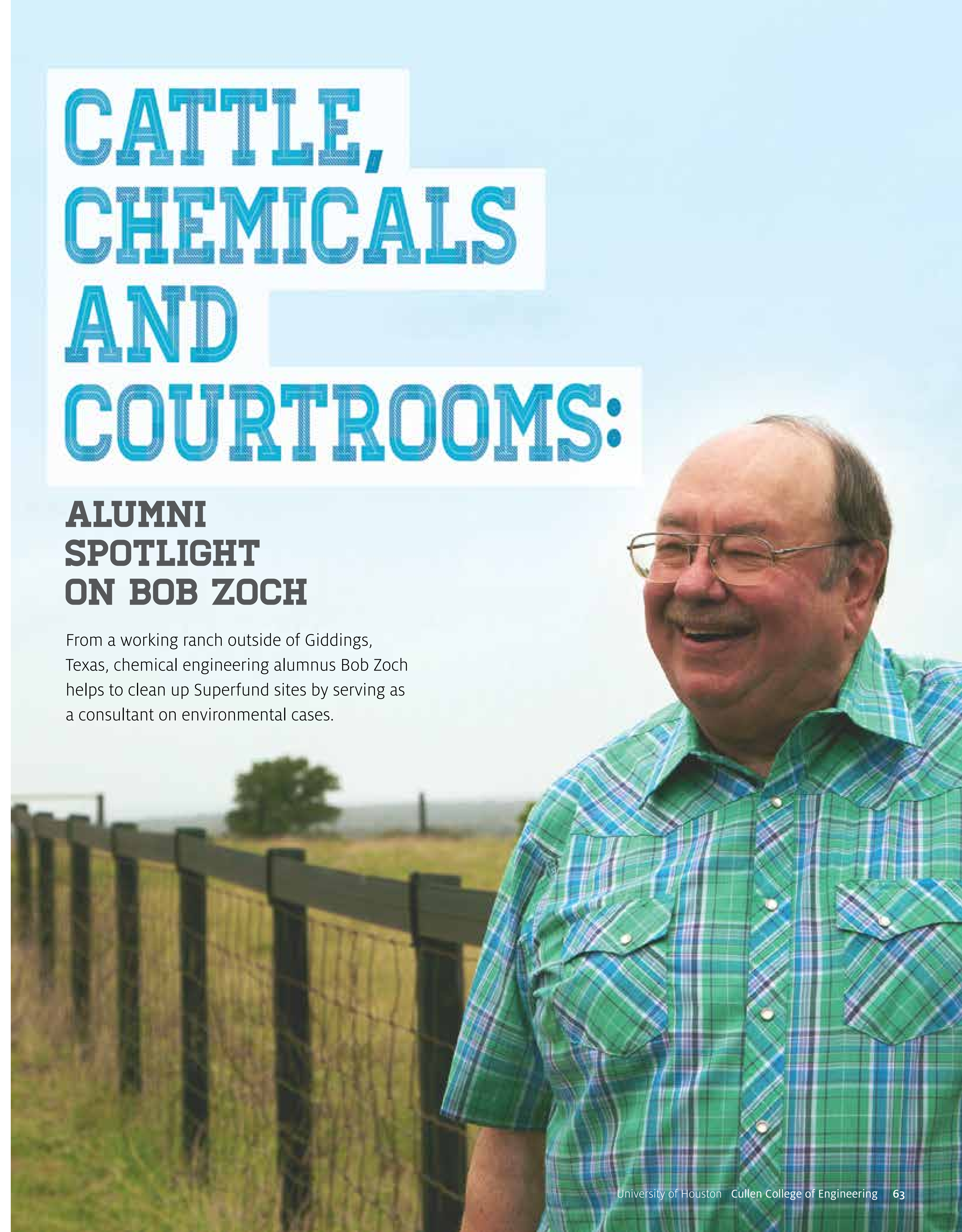
As Claydon was considering possible new career directions, he learned that a couple of his friends were exploring alternative teaching certifications. Claydon’s interest was piqued and he enrolled alongside them. Deciding which subject to teach was a “no-brainer,” Claydon said. Because of the extensive math classes he’d taken as an engineering student and his lifelong interest in the STEM (science, technology, engineering and mathematics) fields, Claydon enthusiastically jumped headfirst into teaching high school mathematics.

It didn’t take long before Claydon found that teaching offered him what he was hoping for with a career change. He said the field kept him engaged throughout the day, offered interesting problems and provided lots of interpersonal interaction.

When speaking about his approach to teaching, Claydon emphasized the importance of valuing students’ time, listening to what students have to say and building trust through mutual respect. Claydon said he encourages peer-to-peer discussion and prefers hands-on projects over content lectures. And, perhaps most notably, Claydon said he recognizes that students have lives beyond the classroom and tries to maintain a holistic view of their commitments.

Claydon is one of five Texas state finalists. The next stage of the process will take place on the national level, and the 2015-2016 PAEMST winners will be announced next year. In the meantime, when asked what it feels like to be a state finalist, he said he was looking forward to the start of the new semester to be able to tell his students, “Hey, we did it! It was worth it; it paid off.”

Watch a video of our interview with Jonathan at www.egr.uh.edu/alumnus-teaching-award-video.



CATTLE, CHEMICALS AND COURTROOMS:

ALUMNI SPOTLIGHT ON BOB ZOCH

From a working ranch outside of Giddings, Texas, chemical engineering alumnus Bob Zoch helps to clean up Superfund sites by serving as a consultant on environmental cases.

Technically, chemical and environmental engineer **Bob Zoch** (BSChE '68) has retired two times. The longest amount of time Zoch spent in retirement was two years. The shortest was only two weeks.

"I was going to retire again this year, but it didn't work out," Zoch chuckled. "I think I'm busier now than I've ever been in my life."

> "I REALLY FEEL LIKE I GREW UP HERE, AND I ALWAYS KNEW I WOULD COME BACK."

To be clear, when Zoch says the word "busy," he isn't using it as a pejorative term. There's a certain magic to the word when he says it – a magic that becomes more clear once you understand Zoch's innate ability to turn his passions into professions, and vice versa.

Zoch was born in Houston, Texas in 1945. As the oldest of his 154 first cousins, he was given the responsibility of helping his grandfather on the family farm near Giddings, Texas every summer from the time he was in kindergarten up until he went to college at UH.

Zoch now lives on the same land he farmed as a child, alongside his wife, Cindy, their Chihuahua, Tina, and over 2,000 acres of rolling hills dotted with horses, cattle and hay bales. "My son lives in a house down the way with his wife," Zoch said, pointing into the distance. "Some of my cousins are just down the road."

"I really feel like I grew up here, and I always knew I would come back," he said.

Living off of the land from a young age, Zoch said, helped shape his future as an environmental engineer. "It's no wonder I was attracted to this side of the profession. I grew up on a farm, was raised on this land. I think that's got something to do with why I got into the environmental business."

Zoch began his career in 1964 when he applied for the Cullen College's co-op program, which allows students to work for local companies and earn a salary while pursuing an engineering degree. Zoch worked by day at Marathon Morco, a petrochemical company in Dickinson, Texas, and attended classes at night. "My dream then was always to become a plant manager at a chemical plant," he said.

After graduation, Zoch worked his way up from senior engineer to process design engineer, designing several chemical plants before his dream of becoming a plant manager came true in 1970.

In the early 1970's, federal regulations on air and water pollution began coming down the pipeline, and Zoch was soon promoted to head of environmental control of the parent corporation. "We had some pretty intense problems in air and water pollution control," he said. "I was launched into environmental work from my education and experience in chemical engineering, and here I am today. I haven't let go of it yet."

In 1997, Zoch's second retirement began, this time lasting until 1999, when an old friend called Zoch for advice on a large Superfund case involving more than 110 companies. After serving as a consultant on the project, Zoch's phone began ringing more and more with consulting requests for environmental cases.

Zoch now works full-time as an independent regulatory compliance and litigation support consultant for companies involved in environmental cases. "I focus mostly on Superfund matters and major contaminated sites that need to get cleaned up and that somebody needs to pay to get cleaned up," he said. When asked if any interesting cases stand out in his memory, Zoch thought for several seconds before answering: "An interesting case?

> "I WAS LAUNCHED INTO ENVIRONMENTAL WORK FROM MY EDUCATION AND EXPERIENCE IN CHEMICAL ENGINEERING, AND HERE I AM TODAY. I HAVEN'T LET GO OF IT YET."

During this time, Zoch began to foresee issues with industrial waste management as the next big frontier for environmental regulations. "Back in those days," he said, "whenever an air or water pollution problem needed to be solved, a lot of companies were taking that stuff and dumping it onto the ground."

In 1974, Zoch left his full-time job to start his own environmental consulting company, forecasting that government regulation of industrial waste was just around the corner. "Unfortunately, those regulations didn't get finalized until 1980," Zoch laughed.

Zoch said he struggled to keep the fledgling company afloat for a few years until the Environmental Protection Agency's Hazardous Waste Permitting and Superfund programs were launched in 1980. From then on, Zoch's company, ENSR Corporation, was doubling in size every six months. In 17 years, ENSR Corp. grew from one employee to over 2,000, and dozens of office locations were opened around the world. Then, in 1990, Zoch sold the company to a German multi-national corporation and headed the U.S. affiliate of that corporation's technology commercialization business.

Three years later, Zoch retired for the first time. His retirement lasted two weeks before the consulting business called to him again.

All of them are interesting. That's why I got into the environmental business to begin with."

This is the point at which it becomes clear that for Zoch, the line between his passions and professions has blurred, if it ever existed at all. Zoch's jobs are his passions – his passions are his jobs. And the ranch style home he designed with Cindy and built on the same land he grew up on is a testament to this fact, a love letter to every passion he turned into a job.

In addition to working 60 hours every week as a consultant, Zoch oversees the ranch work carried out on his land. Zoch and Cindy raise cattle and horses and farm hay and corn. They recently added a few pecan groves to the land as well.

"It's a major commitment," Zoch said of running his own businesses. "It's not cheap and it takes time. That's the main thing – it takes time, it takes long hours, it takes sacrifice. But it's worth it. For me, it was worth it."

In addition to working long hours and making sacrifices to achieve the entrepreneurial dream, Zoch said his courses at the UH Cullen College of Engineering and his industrial employment through the college's co-op program helped him to get on the fast track to professional success.

"Applied perspective is really good to have, and I got that at UH, and it paid off," he said. "At the Cullen College, a lot of your engineering professors are working in industry or are consultants to industry, so they know what they are teaching their students. I wouldn't have gotten that much of an applied engineering education at Rice or Purdue."

Current engineering students at UH should take advantage of the college's proximity to Houston and flexible course schedules by working jobs and internships related to their major while pursuing a degree, Zoch said.

"UH is such a great school because students can take a lot of classes at night. I scheduled many of my classes at night or on alternating days, allowing for nearly full time work in the petrochemical industry," he said. "I would tell students to take extra time in college to get real world experience. I don't think I would have succeeded like I have without all of the professional experience I got while I was at UH."

ALUMNUS HOSTS STEAM OUTREACH EVENTS FOR HOUSTON STUDENTS

As the son of a migrant farm-working mother and an Air Force veteran father, **Reynaldo Guerra** said his path to pursue an engineering degree at the University of Houston came about by chance.

In his junior year of high school, Guerra was failing out of his math classes and, as a result, was kicked off of the basketball team. Motivated by his desire to continue playing basketball, Guerra said he began practicing his math skills as hard as he practiced his basketball skills. It didn't take long before Guerra realized he was not only good at mathematics – he actually enjoyed it.

"We are absolutely in need of engineers and scientists in this country, and especially in the city of Houston," Guerra said. "But when you go into some of the schools in low-income areas of Houston, you see that most of these kids have never met a scientist or engineer before. Some of them have never even heard the word 'engineering' in their lives."

Guerra graduated from the UH Cullen College of Engineering in 2003 with a bachelor's degree in mechanical engineering. As a student at UH, Guerra was involved in the student organization MAES, which then stood for Mexican American Engineers and Scientists. Guerra and his MAES classmates took it upon themselves to inspire more students into pursuing STEM careers by organizing events at Houston-area schools to introduce K-12 students to tough engineering concepts with fun, hands-on projects.

"We would try to be mentors to local elementary and high school students," Guerra said. "We wanted to get them excited about engineering and science and to try to get them to come pursue those fields at the University of Houston."

Since graduating from the Cullen College, Guerra has enjoyed a successful engineering career. He currently serves as the senior LNG proposal development engineer at Dresser-Rand, and has held previous positions at NASA, Accenture and ExxonMobil. But the drive to continue inspiring Houston students to pursue STEM fields never left Guerra, and he eventually reached out to his former UH classmates to reignite their STEM outreach efforts in local schools.

Guerra and his former classmates soon formed Camp STEMovation, a nonprofit organization dedicated to bringing STEAM (science, technology, engineering, art and mathematics) workshops and activities into Houston-area schools in low-income neighborhoods.

"The kids absolutely love it," Guerra said.

And it's easy to see why. Camp STEMovation held an event called "STEAM Extravaganza" at Rick Schneider Middle School last March, where students participated in five hands-on STEAM workshops with kid-friendly superhero themes.

The workshop that Guerra taught began by teaching students some basic engineering principles, then challenging the students to build "super hero lairs" using strips of card stock paper and scotch tape. The students' superhero lairs were then subjected to three tests.

In the first test, appropriately called "sky fall," Guerra holds the student's structure and drops it. For the second test, called "monster stomp," Guerra stands on the superhero lair on one foot. The third and final test is for the superhero lairs to survive being struck by an asteroid. "So we take two big, fat, college-sized textbooks and pretend they are asteroids. Then we drop them on the superhero lair," Guerra said.

The students are awarded points based on how well their superhero lair survived all three tests. They are also judged based on the aesthetics of their structure as well as how many materials they used to build it. The students with the most points at the end of the challenges won science kits and a trophy.

"You can see these light bulbs going off in these kids heads," Guerra said, adding that many of the students approached him during the event to ask him more about what engineers do, what you have to do to major in engineering and what types of jobs professional engineers can obtain. "So all of a sudden they go from not even having heard the word 'engineering' to this being an option for them."

More importantly, Guerra said programs such as Camp STEMovation help to inspire students to pursue STEAM careers at an early age.

"We're starting when they're young so they can be thinking about it as they go through their school career. The sooner you know about wanting to go into science or engineering, the better you can prepare yourself," he said.

Guerra said he doesn't plan to slow down on hosting STEAM events for local K-12 students anytime soon. In fact, he hopes to see Camp STEMovation's offerings grow in scope and frequency as time goes on.

"We have had principals come to us crying because a student that was classified as 'troubled' and wasn't engaged at all is suddenly inspired by an outside group that comes in and gets them excited about engineering and science," Guerra said. "We're creating experiences for these kids you can already tell will later have a profound impact on them. That's the most exciting part to me."

Watch our video of the STEAM Extravaganza at www.egr.uh.edu/alumnus-stem-outreach-video.

ASTRONAUT ALUMNA DELIVERS KEYNOTE ADDRESS AT IIE CONFERENCE

The largest industrial and systems engineering event of the year is the Institute of Industrial Engineer's (IIE) annual conference and expo, and this year's gathering hosted Cullen College alumna **Nancy Currie** as the keynote speaker.

Currie, a principal engineer at NASA, earned her Ph.D. in industrial engineering from UH in 1997. She was selected as a NASA astronaut in 1990 and flew on four space shuttle missions, logging a combined 1,000 hours in space. She is also an associate fellow of the American Institute of Aeronautics and Astronautics.

At the IIE conference, Currie discussed the importance of a rigorous systems engineering integration function in the design and operation of complex system. She also examined the role of the NASA Engineering Safety Center (NESC), which was established as a direct response to the 2003 Columbia accident, and how NESC is often asked to assist with significant engineering challenges.

The IIE conference and expo was held from May 30-June 2 in Nashville, Tenn.

NATIONAL OILWELL VARCO GIFT GROWS SUBSEA'S COMPUTING POWER

The mission of the UH Cullen College of Engineering is to serve the Greater Houston community by establishing innovative and industry-relevant engineering programs that help to drive the economy forward in the state of Texas. The Cullen College has succeeded at this mission in no small part due to the support of individual donors and corporate sponsors.

This was especially true for the Cullen College's subsea engineering program, which was established in direct response to industry workforce needs and with overwhelming support from leaders in the energy industry across the Houston region and around the world.

In an effort to bolster private support for higher education, the Texas Higher Education Coordinating Board established TRIP – the Texas Research Incentive Program. It provides state institutions funds that match private gifts or endowments at a certain percentage for the purpose of enhancing research activities.

National Oilwell Varco (NOV) supported the Cullen College with a $500,000 gift for the Cullen College's subsea engineering program, which will be paid in several installments. TRIP matched the first installment of $150,000 at 50 percent ($75,000) – with future matches to come as well.

The funds are already being put to use in the subsea engineering program, according to program director Matt Franchek. "[The money] NOV has given us, we're able to magnify that gift thanks to the state of Texas, and we're able to put it to use in the classroom for the students."

Specifically, the program has purchased several high-performance computing clusters available for student use. Additionally, the program purchased a significant amount of memory for the clusters to store their information on – and then refer back to as they perform more calculations. Franchek calls the infrastructure a "computational city," and it's available to all subsea engineering students.

For Franchek, the computers are more than just a tool – they're a pathway to a new method of engineering. "We want to see a computational approach to subsea engineering called analysis-led design," he said.

When subsea engineers design a structure, Franchek said, "they're doing lots of computations, and for these [structures] to grid out correctly and the computer to solve the code correctly, it's huge. The equipment we build can be 60, 70, 100 feet tall, so to simulate that is a big deal. Without the gift from NOV, we would never be able to do this." The new high-powered clusters are so powerful with computational calculations, Franchek said, that "when you hit return, you have to duck – the answer comes back so quick."

The clusters themselves are housed at the Energy Research Park (ERP), but students in the Cullen College can access them through the Dell workstations in the Engineering Computer Center.

Franchek says that the high-powered clusters are only the beginning of a long-term plan for the subsea engineering program to create a computational infrastructure capable of handling multiple, massive simulations and predict optimal designs that fit a given project. This, he said, will allow students to focus more seriously on which of the computer-designated optimal designs will work best in practice, and why.

ENGINEERING ALUMNI ASSOCIATION (EAA) GALA

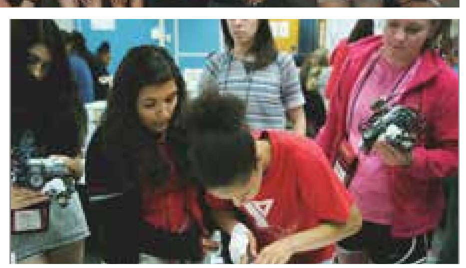


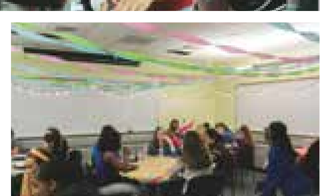




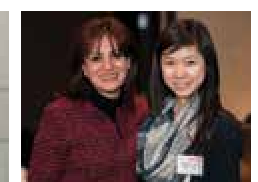
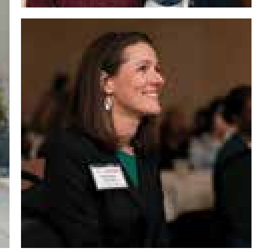
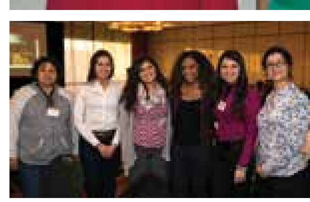

G.R.A.D.E. CAMP

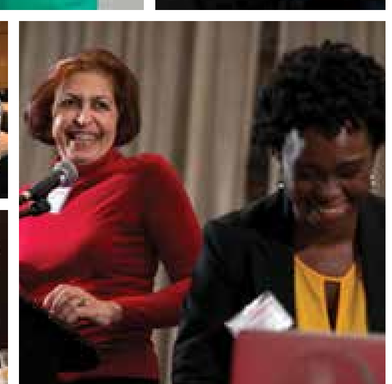






WOMEN IN ENGINEERING DAY EVENTS

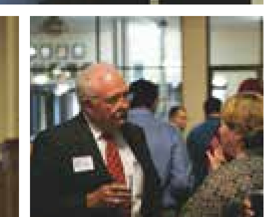







EAA ANNUAL MEETING AT THE SAINT ARNOLD BREWING COMPANY





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www.flickr.com/photos/CullenCollege

ENGINES OF OUR INGENUITY:

Taken from Episode 1050

John Lienhard

Excerpted from "The Brain Radiator"

"Braindance" is the odd title of Dean Falk's 1992 book on human evolution. She offers new means for dealing with the old issue of how modern humans finally emerged some 30,000 years ago. Falk begins 4.5 million years ago with the species Australopithecus, first discovered in South Africa in 1924.

In those days, paleontologists shied away from controversy with anti-evolutionists by classifying anything that might be our ancestor as human. That's how a major anti-evolution myth grew up – the myth that we couldn't find the missing link.

Australopithecus did walk on its hind legs. But there its humanity ends. Its brain was the same size as a chimpanzee's – about a third the size of yours. Falk believed the brain of that not-so-missing link was the key to the puzzle.

She found structures in Australopithecus's brain that were apelike, not human. Here was a creature who walked upright with hands free for 2 million years, yet it was endowed with the brain of an ape. The famous Lucy skeleton was one of these.

Then, a little over 2 million years ago, our ancestor's brain began growing. It took on the folds and creases of your brain or mine. A species called Homo habilis had a 40 percent larger brain. By 1.5 million years ago, Homo erectus was walking the hot plains of Central Africa with a brain more than double the size of Australopithecus's – who was still around, it seems.

Falk struggled to understand what had happened. Then, something emerged from her subconscious. One day her car mechanic had told her, "the size of your car's engine is limited by the capacity of its radiator to cool it." That was it! The brain is terribly sensitive to changes in temperature. It absolutely must be cooled in summer and heated in winter. But where is its radiator? Falk began studying the blood supply to ancient brains.

Sure enough: along with changes in brain size ran an evolving blood delivery system. When Lucy took to her hind legs, her head had to bear the brunt of the African sun. She began changing, very slowly. More holes appeared within humanoid skulls to provide access for more blood to cool the brain. The radiator of a Model-T evolved into the radiator of your Rolls-Royce brain.

It was 125,000 years ago that our brains reached their full modern size in, of all people, the Neanderthals. They began creating art, building huts, burying their dead and worshipping deities. They weren't toilet trained, it seems, but then – if you look at our lakes and rivers – maybe we aren't either. But now we had our radiator and now the real fun was about to begin.

The Engines of Our Ingenuity is a nationally recognized radio program authored and voiced by John Lienhard, professor emeritus of mechanical engineering and history at the University of Houston and a member of the National Academy of Engineering. The program first aired in 1988, and since then more than 2,800 episodes have been broadcast. For more information about the program, visit www.uh.edu/engines.

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