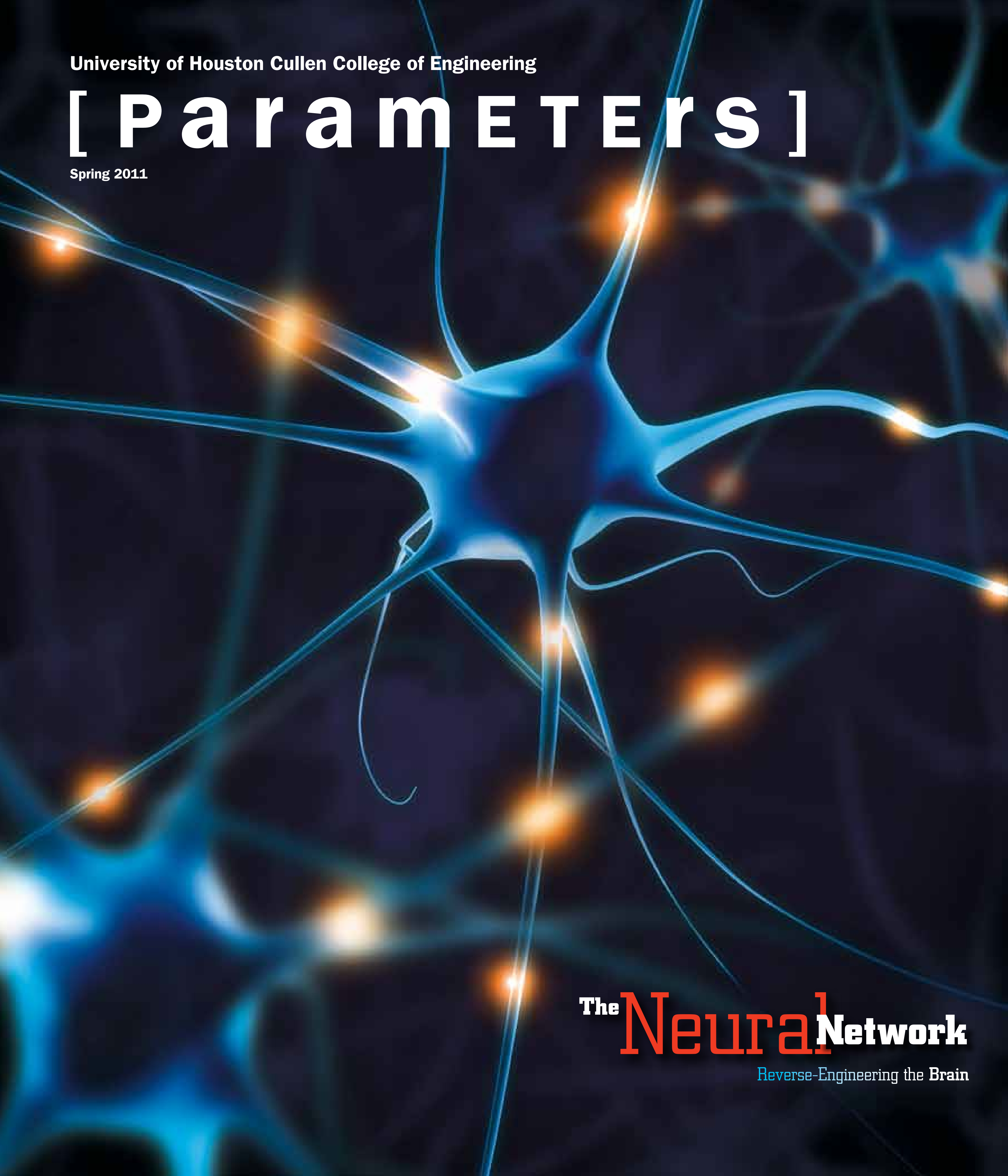
University of Houston Cullen College of Engineering

[Parameters]

Spring 2011



A major milestone has been reached on the University of Houston's Tier-One journey. In January, the Carnegie Foundation for the Advancement of Teaching categorized UH as a research university with "very high research activity." The highest classification given to research universities, the Carnegie ranking places UH in the company of other top-tier research institutions across the country. We have made tremendous progress in a very short amount of time due to the unwavering vision of our leadership and the ongoing diligence of our faculty and students in pursuit of excellence. UH is definitely on the move and will continue making strides toward these strategic initiatives.

At the UH Cullen College of Engineering, we continue to focus on core areas of research growth in addition to expanding academic areas of great national interest. In particular, we have played a significant role in the UH Energy initiative and the developing UH Energy Research Park. Our petroleum program recently moved into the research park, providing more space for the rapid growth of our new undergraduate program and our existing master's program.

The demand for this program has been incredible. We also continue to experience great interest from the energy industry in the Greater Houston area for other key programs. In response to the workforce development needs of these industries, we've launched a subsea engineering certificate program and are working to establish a master's program in this area. The first and only subsea engineering program in the country, our program will offer specialization in the design and maintenance of equipment, tools and infrastructure utilized in offshore petroleum operations, and therefore fulfilling a great educational need of this energy-centered region.

In this issue of *Parameters,* we highlight a growing network of neuro-engineering researchers at the Cullen College, which is part of UH Health. For many years, the college has been building expertise across disciplines in this major thrust area of biomedical engineering. In 2010, we were fortunate to recruit Metin Akay, a renowned expert in the neuroengineering sciences, as the founding chair of our new biomedical engineering department. Most recently, we recruited Badri Roysam to lead our electrical and computer engineering department. Featured in this issue, Badri is leading a multi-institutional effort to improve the viability of neural implants for medical applications. These two individuals bring a wealth of expertise in neuroengineering science that further elevates this research area to prominence within the UH Health initiative and throughout Houston's burgeoning medical community.

This research excellence provides ongoing scholarship for our academic programs, giving our students a top-tier education in a major metropolitan area. What's captivating is the fact that our students routinely mirror this excellence in their studies, in student competitions, in service and other leadership activities and as individuals. We could not be more proud of our Cullen Community for their commitment to UH, engineering education and the profession.

Warm regards,

Joseph W. Tedesco

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Elizabeth D. Rockwell Dean and Professor

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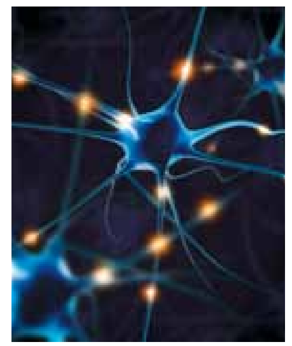


The Neural Network

Reverse-engineering the brain is one of the National Academy of Engineering's Grand Challenges of the 21st century. For years, a network of researchers at the Cullen College have been investigating the brain and developing tools to better solve neuro-related problems.

FEATURES

PARAMETERS - SPRING 2011

Petroleum Engineering EXPANDS TO RESEARCH PARK

The University of Houston Cullen College of Engineering's undergraduate Petroleum Engineering Program is now in full swing with a growing enrollment, a dedicated building and generous ongoing support from the petroleum industry. The program was launched in the fall of 2009 in response to "the great crew change," a reference to the many members of the petroleum industry's workforce who have recently retired or are expected to do so in the coming years. Facing a shortage of skilled workers, several companies in the sector approached the Cullen College about helping them meet their needs for new petroleum engineering talent.

"Houston is the center of the petroleum industry for the entire world, so the University of Houston is the ideal place for this type of program," said Tom Holley, director of the Petroleum Engineering Program.

It should come as no surprise, then, that many companies and organizations in the petroleum sector are generous supporters of petroleum engineering at UH. Major donors include Devon Energy, Marathon Oil, Southwestern Energy, El Paso Corporation and the Society of Petroleum Engineers, Gulf Coast Section, among others. In addition to corporate sponsorship, the program has received substantial donations from individual benefactors, including Beth Madison, founder and president of Madison Benefits Group Inc.

"The University of Houston has been extremely fortunate to have strong support from the petroleum industry," said Holley. "These very generous gifts are shining examples of leadership and are especially noteworthy in light of the current economic climate."

Gifts to the program have been used to refurbish and equip the program's dedicated space at the University of Houston Energy Research Park. The building, which opened to students on January 18 of this year, boasts three classrooms, three undergraduate teaching laboratories, a computer lab, three faculty and graduate research laboratories, faculty and student offices, and a student lounge.

Given the undergraduate response to the program, the building will be put to good use. At the end of its first full academic year, 2009-2010, undergraduate enrollment totalled 20 students. Today it stands at nearly 100. The program's long-term goal is to graduate 50 students with a bachelor's degree in petroleum engineering each year. This is on top of the 80 students currently pursuing the Cullen College's existing and highly regarded master's program in petroleum engineering.

Even with all this momentum, there is still a lot to be done to fully establish the undergraduate petroleum engineering degree program, Holley said. With the program only in its second year, the curriculum and courses for junior- and senior-level students must be fully developed, endowed professorships must be funded and faculty recruited.

"We've made a lot of progress in the past year with this program, but there's still much that has to be done," said Holley. "Given the incredible support we've received from the university and the Houston community as a whole, I'm confident that this will soon develop into a world-class petroleum engineering undergraduate program."

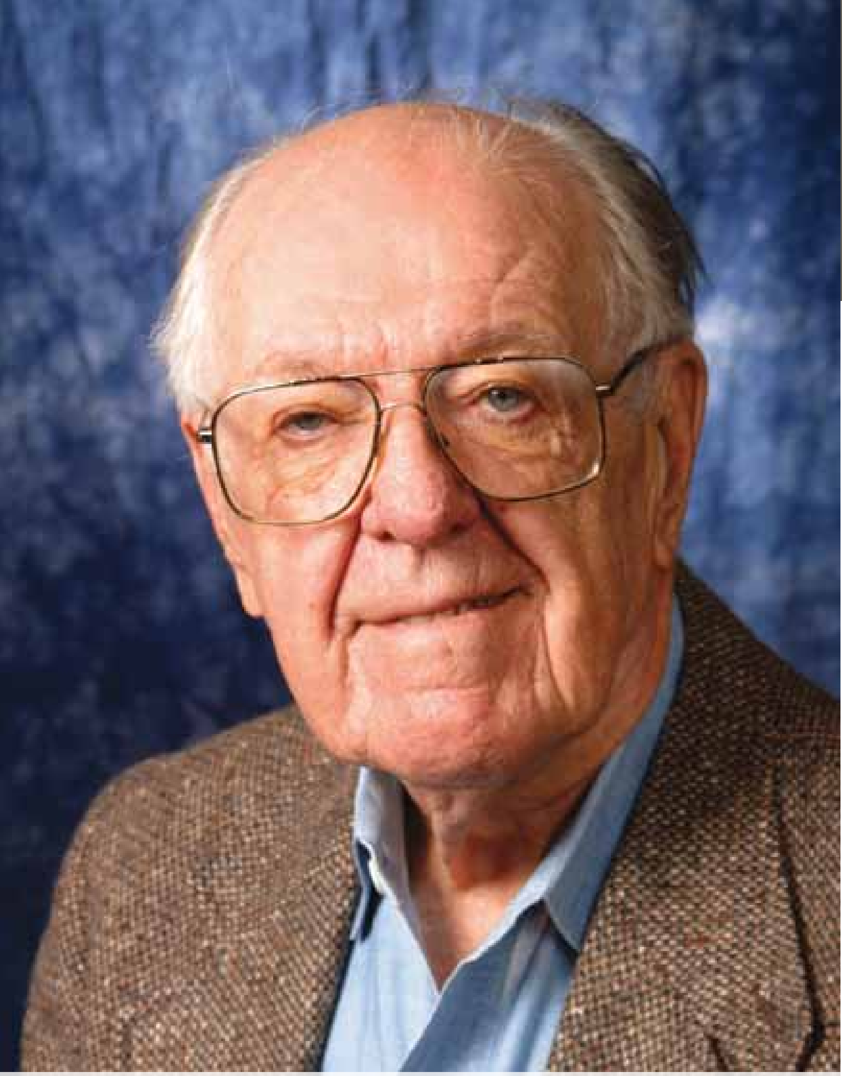
Holley Establishes SCHOLARSHIP FUND

Tom Holley, director of petroleum engineering at the Cullen College, and his wife Nancy, have made a major gift to the program in support of student scholarships.

This gift, along with anticipated matching funds from Shell Oil Company, where Holley worked for more than 27 years, has allowed for the creation of a $51,000 endowed scholarship fund in honor of Trilochan Padhi, a renowned geophysicist and one of Holley's mentors at Shell.

The fund will support annual $1,000 scholarships for two petroleum engineering students. Holley said he hopes others who have worked with Padhi and wish to honor him will donate to the fund in order to support additional students.

In addition to supporting student success, Holley noted that this gift shows that individuals can make real, lasting and important contributions to the program. "It's not always about companies," he said. "Individuals can do things, too. It is gratifying to Nancy and me to see the impact that a gift to this university has on the lives of students."



In Memorium

NEAL AMUNDSON, 1916-2011

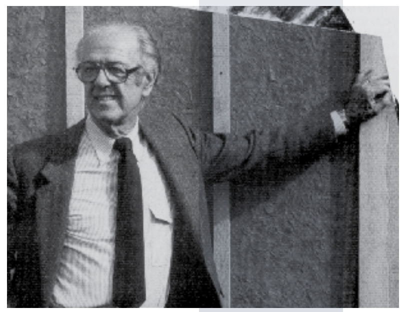
Neal Amundson, Cullen Professor Emeritus of Chemical and Biomolecular Engineering and Professor of Mathematics, passed away in February at the age of 95.

Widely regarded as one of the most prominent chemical engineering researchers and educators in the country, Amundson was a pioneer of chemical reaction engineering. His research contributions to the field included analyzing and modeling chemical reactors, separation systems, polymerization and coal combustion.

Just as important as his research, though, was his impact on chemical engineering practice and education.

Amundson took over leadership of the University of Minnesota's chemical engineering program in 1949. At that time, chemical engineering education across the country was focused on industrial processes, with students expected to memorize facts about these processes and show their ability to perform them in the lab. Amundson changed that. In a move that would be copied across the world, he redesigned the curriculum to focus not on empirical information but on modern scientific methodology and tools. He pioneered the use of mathematical modeling and advanced solution techniques to predict the behavior of complex chemically reacting systems and processes.

"Neal was one of the leading chemical engineering researchers in the country and took what used to be a rather empirical approach to research and introduced new methods of scientific study that were adopted by chemical engineering programs across the nation," said Dan Luss, a Cullen Professor of Chemical Engineering at UH, who earned his Ph.D. from Amundson at the University of Minnesota in 1966.



Amundson was regarded as "The Father of Modern Chemical Engineering" by his peers.

Amundson's efforts led the University of Minnesota's chemical engineering department from relative obscurity to the top-rated program in the country. His addition to the University of Houston in the mid-1970s helped launch chemical engineering at the Cullen College into the top 10 nationally during the early 1980s.

Amundson was an elected member of the American Academy of Arts and Sciences, the National Academy of Engineering and the National Academy of Sciences. He was a recipient of the NAE Founders' Award and holds honorary doctorates from the University of Minnesota, University of Notre Dame, University of Pennsylvania, University of Guadalajara and Northwestern University. At the University of Minnesota, the building that houses the Department of Chemical Engineering and Materials Science was named "Amundson Hall" in his honor and the UH Department of Chemical and Biomolecular Engineering named its annual lecture series for him. In addition, he was honored by UH with the Esthel Farfel Award, the highest faculty award given at the university.

University of Houston Earns Tier One Ranking

The Carnegie Foundation for the Advancement of Teaching has categorized the University of Houston as a research university with "very high research activity," the highest classification given to research universities and the equivalent of Tier One status.

"I give the credit to our faculty, our staff, our students and our Board of Regents who have been so supportive the last two or three years," said UH President Renu Khator. "But, at the end of the day, great communities build great universities. It is a compliment to the city and the state and to our fabulous delegation members, our legislative leaders who believed this was an important initiative."

UH now becomes the third public university in Texas in the top-tier group, joining The University of Texas at Austin and Texas A&M University. Khator said the Carnegie designation will bring greater visibility to Houston and lead to more economic development for the region and sustained research productivity from UH.

College Performs Well in Latest NRC Rankings

The UH Cullen College of Engineering excelled in the National Research Council's rankings of Ph.D. programs. Using the median for all rankings, the college's chemical engineering doctoral program placed 18th in the nation out of 106 ranked programs in the study's S-ranking, which measures a program against criteria set by members of the discipline. With this ranking the program bested its counterparts at nearby institutions such as Rice University (48th) and Texas A&M University (43rd). The University of Texas at Austin was the only school in the region to rank higher.

The Cullen College's electrical and computer engineering doctoral program ranked 58th out of 136 ranked programs, putting the department very close to Texas A&M University (54th) and not far from UT Austin (41st).

The college's civil engineering doctoral program placed 63rd in the nation out of 130 ranked programs, well ahead of Texas Tech University (101st), the only ranked program among emerging research universities in the state. In addition, the department placed 42nd in the country in the NRC's research activity measure, ahead of both Texas A&M (45th) and UT Austin (56th).

Mechanical engineering's doctoral program placed 77th in the country out of 127 ranked programs. That put the program ahead of Texas Tech (110th), again the only ranked program among the state's emerging research universities. In terms of research activity, the department ranked 45th in the nation, ahead of UT Austin at 46.

ENGINEERING extras

Research Building Breaks Ground

» The University of Houston has begun construction on a new Health and Biomedical Sciences Center. When completed the six-story, 167,000-square-foot structure will house researchers from multiple departments across the university, including from biomedical engineering. By placing researchers from different specialties under the same roof, the university intends to foster more interdisciplinary research.

Subsea Certificate Offered

» The Cullen College has officially launched a Subsea Engineering Certificate Program, the first and only formal subsea curriculum in the country. The program was established in response to the petroleum sector's need for engineers with the specialized skills to design and maintain the equipment and infrastructure used in underwater offshore drilling. Program supporters include Cameron, FMC Technologies and GE Oil and Gas.

Willson Named AAAS Fellow

» Richard Willson, professor in the Department of Chemical and Biomolecular Engineering, has been named a Fellow of the American Association for the Advancement of Science, the world's largest general scientific society. Willson received the honor for making "distinguished contributions to biomolecular recognition sciences and its applications and for development of technologies for rapid characterization of catalysts and nucleic acids."

Industry Alloy Grant

» National Semiconductor, the world's largest maker of analog circuits, has given Assistant Professor of Electrical and Computer Engineering Stanko Brankovic a $166,000 grant from to develop new metal alloys for use in critical applications such as medical devices and aircraft. Brankovic will use the funding to support two graduate students and to build a new machine that uses infrared sensors to test the properties of alloys as they are created.

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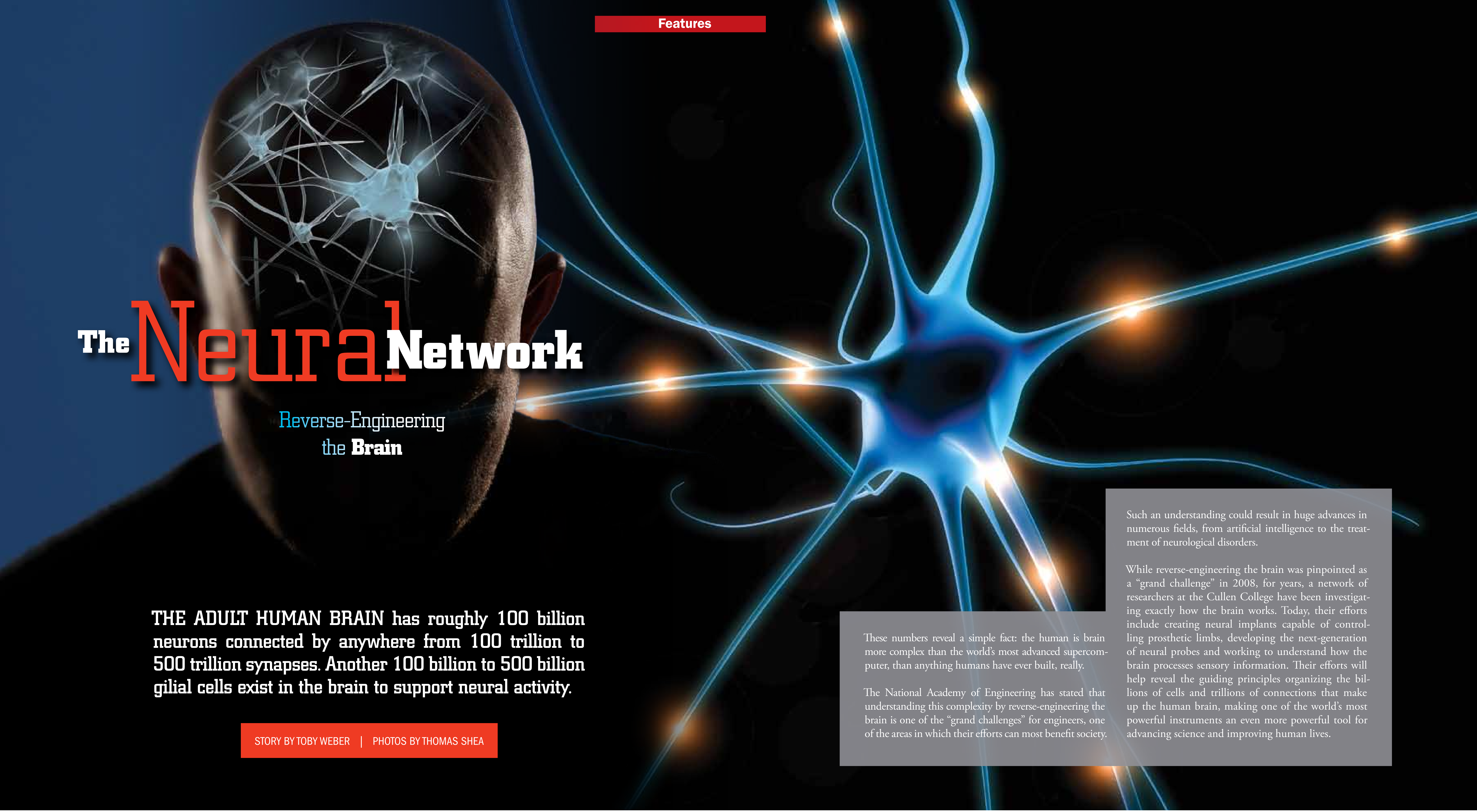


The Neural Network

Reverse-Engineering the Brain

THE ADULT HUMAN BRAIN has roughly 100 billion neurons connected by anywhere from 100 trillion to 500 trillion synapses. Another 100 billion to 500 billion gilial cells exist in the brain to support neural activity.

STORY BY TOBY WEBER | PHOTOS BY THOMAS SHEA

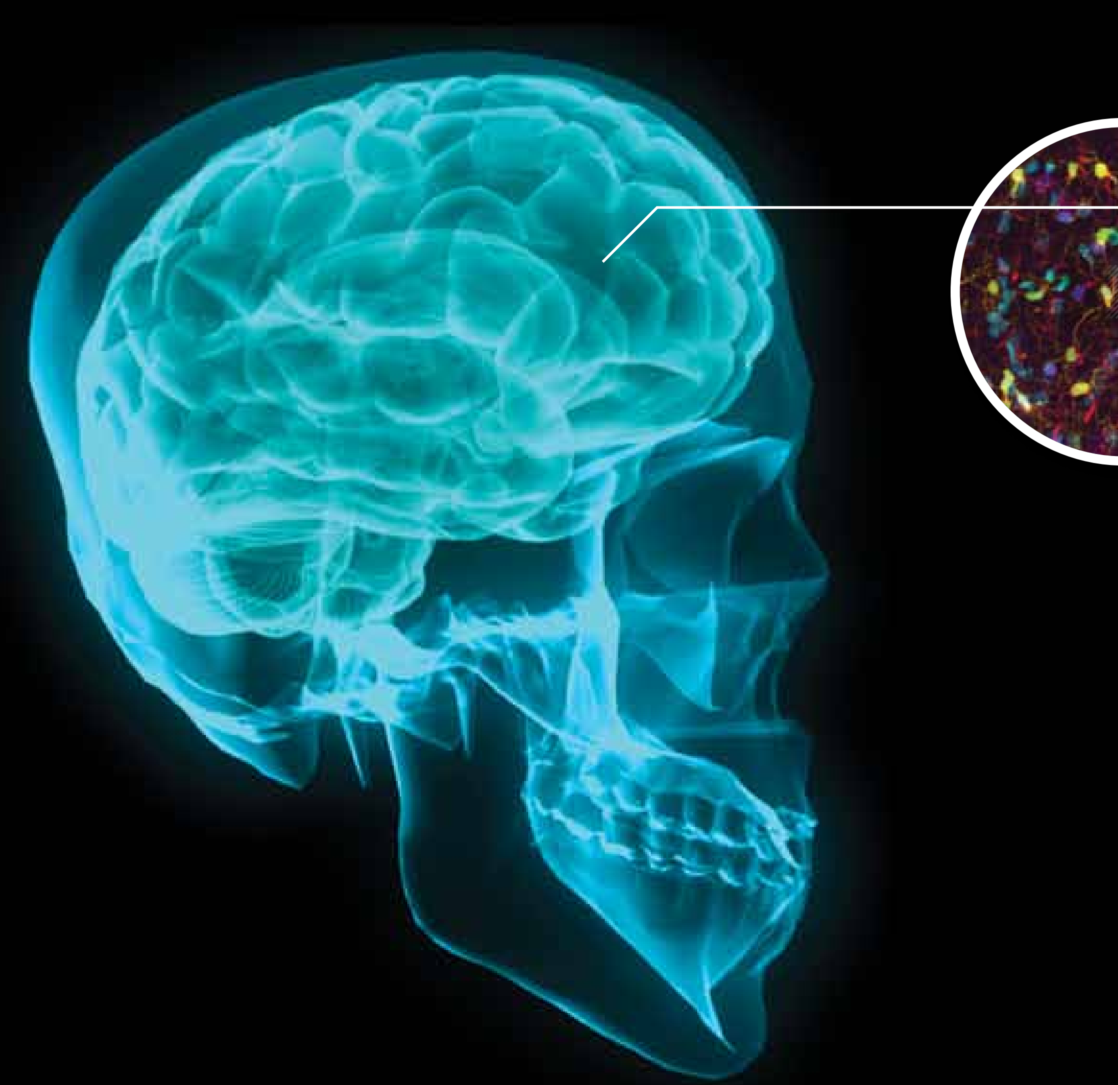
These numbers reveal a simple fact: the human is brain more complex than the world's most advanced supercomputer, than anything humans have ever built, really.

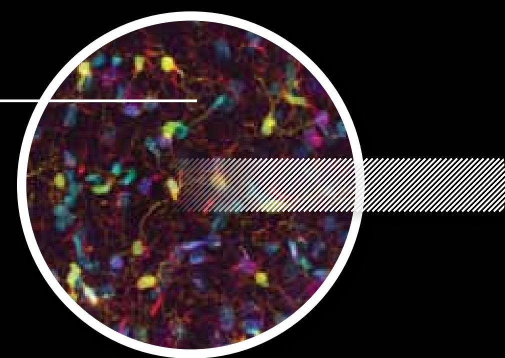
The National Academy of Engineering has stated that understanding this complexity by reverse-engineering the brain is one of the "grand challenges" for engineers, one of the areas in which their efforts can most benefit society.

Such an understanding could result in huge advances in numerous fields, from artificial intelligence to the treatment of neurological disorders.

While reverse-engineering the brain was pinpointed as a "grand challenge" in 2008, for years, a network of researchers at the Cullen College have been investigating exactly how the brain works. Today, their efforts include creating neural implants capable of controlling prosthetic limbs, developing the next-generation of neural probes and working to understand how the brain processes sensory information. Their efforts will help reveal the guiding principles organizing the billions of cells and trillions of connections that make up the human brain, making one of the world's most powerful instruments an even more powerful tool for advancing science and improving human lives.

Leading Collaborations





Deep Inside the Mind

The research team led by Electrical and Computer Engineering Chair Badrinath Roysam is using color-coded, three-dimensional images of brain tissue, like the one above, to determine exactly how and why neural implants fail over time. These images are translated into data that quantifies how each brain cell and cell type responds to an implant. The data is then analyzed for patterns that can explain device failure.

The human brain is staggeringly complex, the source of everything from abstract reasoning to involuntary activities like breathing. With roughly 100 billion neurons, each capable of firing up to 200 times per second, it is far more sophisticated than the most advanced, most powerful supercomputer.

Because of this complexity, overcoming the biggest neuroengineering problems often requires teams of experts all at the top of their fields. Badrinath "Badri" Roysam, chair of the Cullen College's Department of Electrical and Computer Engineering, is leading one such team. Consisting of researchers from four institutions, they have been charged by the U.S. Department of Defense's Defense Advanced Research Projects Agency (DARPA) with overcoming one of the most significant obstacles to the use of prosthetic limbs controlled by the user's mind: the failure of the neural implants that receive signals from the brain and then transmit them to the prosthetic limb.

According to Roysam, these devices, which can also be used to stimulate the brain, sample brain fluids or deliver medication, fail because the brain treats them like an injury.

Once a device is implanted, "the tissue begins remodeling itself right away," Roysam said. "It's called a tissue reactive response. Basically reactive cell types envelop the device to the point where it becomes completely isolated from the rest of the brain. At that point, it's basically ineffective." Typically these implants fail within two months, eliminating their value as long-term solutions for individuals who have lost a limb.

While researchers understand the fundamentals of why implants fail, the details of the process are not well known. How, exactly, do different brain cell types react when an implant is introduced? How do the reactive cell types make their way to the neural implant? And how does an implant's design affect the brain's response to it?

These are the questions this research group will seek to answer.

The work will begin at the University of Michigan, where Professor Daryl Kipke heads a team that specializes in fabricating neural implants. Kipke's group, as well as a company he leads, NeuroNexus Technologies, has the capabilities to build implants to nearly any specification such as different sizes and shapes or with different surface coatings.

After implantation, researchers led by Bill Shain from Seattle Children's Research Institute will take multiple images of tissue that will reveal how the different cells of the brain react to an implant. These won't be any standard images, however. Shain's lab is a world leader in a highly advanced imaging technique known as multispectral laser scanning confocal microscopy. In essence, this technique produces high-resolution three-dimensional images of brain tissue, with each different type of tissue and cell assigned a unique color.

These images will then be transmitted to the University of Houston, where Roysam's team will run them through a sophisticated and powerful software platform dubbed FARSIGHT. Developed by a collaborative team led by Roysam with the support of the National Institutes of Health, FARSIGHT will translate these images into data that quantifies the response of each individual brain cell and cell type to the implant.

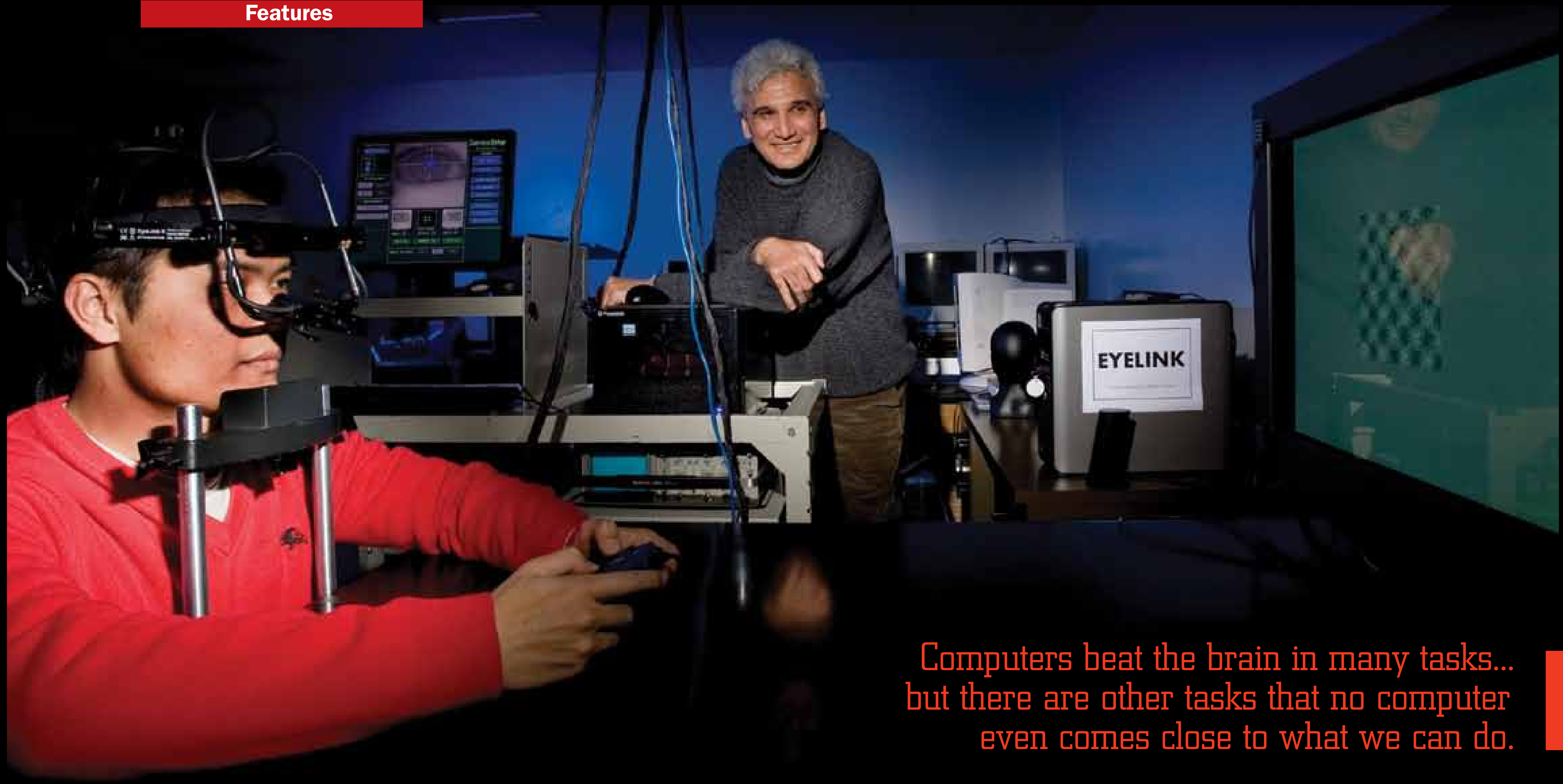
Researchers at Rensselaer Polytechnic Institute then take over. Using advanced pattern recognition software and techniques, Professors Kristin Bennett and Mark Embrechts will seek to identify the properties of the implants that spur the brain to isolate them, as well as which implant properties seem to hinder this process. Using this information, they will suggest design changes to the researchers from the University of Michigan, restarting the whole process.

In addition to making practical decisions on the direction of device design, data from each round of devices will be compiled, Roysam said, in order to determine the principles for developing better neural implants.

The group's research is supported by a DARPA grant for up to three years and up to $5 million. Given the talent assembled in this group of researchers, Roysam is hopeful that they will make advances in neural implant design that can help these devices last a lifetime.

"This is a dream team," Roysam said. "We have preeminent leaders in implant design, 3-D multispectral imaging, quantitative histology, and pattern recognition on our team. Ideally, we will be able to make great strides in the understanding of neural implant failure."

Bringing VISION into Focus



Computers beat the brain in many tasks... but there are other tasks that no computer even comes close to what we can do.

Using visual stimuli designed to test his hypotheses, Professor Haluk Ogmen (right) determines the reference frames the human brain uses to bring objects quickly into focus.

Here's an interesting visual phenomenon. Take out a video camera — or these days, a smart phone — hit record, and move it back and forth quickly. What you end up with is a blur. Now quickly swing your head up and down or side to side. Practically everything in your field of view stays focused.

The difference, obviously, is the brain. While the lens of the eye and the retina operate much like a camera, registering a three-dimensional scene on a two-dimensional surface, the brain uses a complex process to recognize and bring into focus objects that we barely glance at. Discovering the details of this process, the rules by which the brain lets us see the world clearly, is one of the major research thrusts of Haluk Ogmen, professor of electrical and computer engineering and biomedical engineering, and executive director of the UH Center for Neuroengineering and Cognitive Science.

According to Ogmen, the brain, working with the visual system, is able to keep focus through reference frames, which are essentially coordinate systems quickly formed by the brain. These frames are often based on something physical, such as a stationary object that allows humans to focus and identify a moving one — think of a car driving past a house. Reference frames can also be created out of something abstract. The knowledge of how a person moves, for example, allows us bring into focus in a split second anyone who walks in our field of vision.

Ogmen's research is trying to determine the rules for creating these reference frames. How, for example, does the brain register different movements to create reference frames? Are there different reference frames for objects that are close to us versus far away? What are the brain's rules for creating reference frames for objects of different sizes? And what role do these reference frames play in storing our visual experiences in our memory and retrieving them later?

To answer these questions, Ogmen creates visual stimuli that can fairly be described as optical illusions. "The idea," he said, "is to take a hypothesis and express it in a visual stimulus that has two opposite perceptual outcomes, one supporting the hypothesis and the second refuting it. By measuring the outcome, I can test my hypothesis about how the brain creates reference frames."

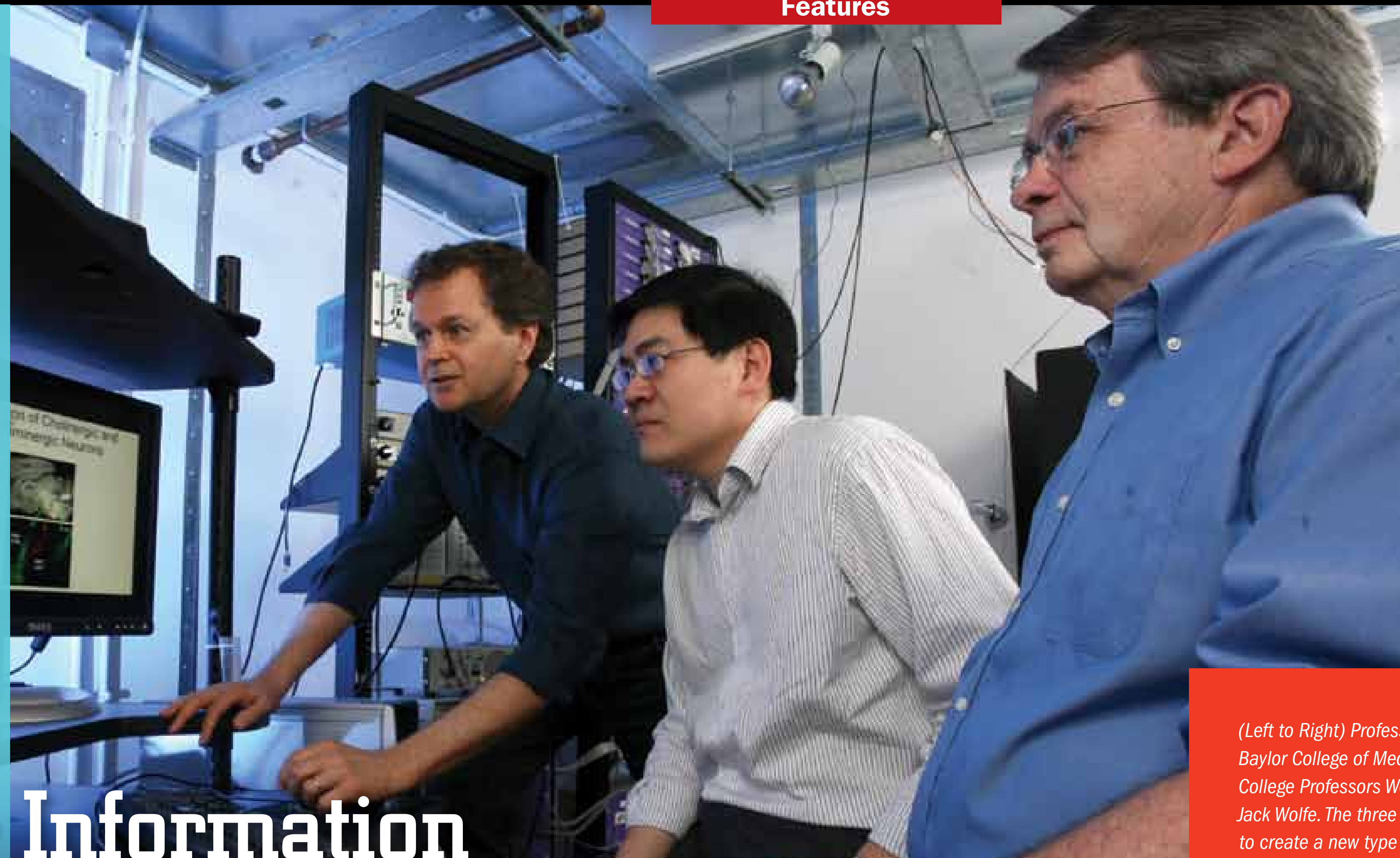
For example, one typical stimulus created by Ogmen and colleagues entails two images of three dark circles intermingled with white dots placed at different positions. Volunteer test subjects look at a computer screen that is quickly flashing these two images, one after another. They are then asked whether they see one particular dot as moving clockwise or counterclockwise around one of the circles. Their answers provide insight into how the brain allows us to keep moving objects in focus, such as the role of an object's rough motion, in forming reference frames.

This research currently focuses on simply determining what reference frames the brain uses and thew rules for creating them. As it progresses, though, Ogmen plans to explore what parts of the brain are at work in creating reference frames. Using functional magnetic resonance imaging, which reveals brain activity based on blood flow, he will determine the general locations of the brain that are at work in the formation of specific reference frames. Neuroscientists can then use that information to delve into the behavior of particular neurons or neuron groups.

This knowledge about how reference frames are formed, according to Ogmen, could aid in the creation of computer vision systems that can track and recognize more accurately objects in natural scenes, and even contribute to navigation systems developed by robotics experts.

"Computers beat the brain in many tasks, like large number multiplication and database searches," he said. "But there are other tasks that no computer even comes close to what we can do. In the area of navigation, the most powerful supercomputers cannot even match insects. So what's missing are the engineering design principles that capture the fundamentals of biological information processing. That's my goal as an engineer, to reverse-engineer vision, memory, and cognition and see how our brains and minds work."

Probing for Information



(Left to Right) Professor John Dani of Baylor College of Medicine with Cullen College Professors Wei-Chuan Shih and Jack Wolfe. The three are collaborating to create a new type of neural probe that can provide hundreds of times more information than existing devices.

In order to conquer the National Academy of Engineering's grand challenge of reverse engineering the brain, researchers must first have the tools to analyze how the brain works on the cellular level.

Professors Wei-Chuan Shih and Jack Wolfe in the Cullen College's Department of Electrical and Computer Engineering are teaming up with Professor John Dani in the Department of Neuroscience at Baylor College of Medicine to develop such tools. The neural sensing probes they are creating could yield several hundred-times more data than the probes currently used, helping to unlock information on the workings of individual neurons.

Today, Dani and other neuroscientists record brain activity with tiny probes that are about half the thickness of a human hair. Inserted into the brain, these probes detect electrical activity of these neurons.

Such probes are handcrafted by twisting together four fine wires, each with a sensing node at the end. By comparing how strongly an electrical signal registers on each of the nodes, the probes can identify the activity of a specific cell amid the background noise generated by nearby neurons. "These handcrafted tetrodes are the standard for brain studies that are deeper than a millimeter or so," said Wolfe.

While effective, these probes are far from ideal. If all four nodes are not equally sensitive to electrical activity, the probe will distort the perceived positions of neurons. And while these instruments are built one at a time, they are typically used in batches of 50 or more, making every experiment very labor-intensive. What's more, there is simply no way for these probes to sense any area other than near the tip of the probe. The next generation of probes, Dani says, must be able to sense multiple areas simultaneously.

At the heart of this team's new probe concept is a glass fiber substrate with hundreds of ultra-thin conductor lines that carry nerve signals from sensing nodes to signal processing electronics outside the skull.

With this design, the probe can have hundreds of sensing nodes and still be even smaller than a conventional tetrode. In addition, while stiff enough to be inserted into the brain, these probes will be flexible enough to shift with slow brain movements caused by breathing and other activities in free animals or humans. This flexibility is critically important since a stiff probe might cut or tear the brain.

One of the challenges of building this new probe is creating the conducting lines on the glass fiber's non-flat surface. To overcome this, the team is utilizing a technique developed by Cullen College alumnus John Randall during his time at MIT's Lincoln Laboratory in the 1980s. The process begins by etching a pattern of lines in a thin membrane to form a stencil mask. A beam of energetic helium ions — which eliminate the problem of diffraction caused by using beams of light — is then shot at the stencil mask. The result is an exact replica of the stencil on a resist covering the glass fiber substrate, ultimately yielding up to hundreds of conducting lines, each connected to a lone sensing node.

First, though, was the challenge of applying the resist uniformly over the strand of optical fiber. This problem was overcome thanks to the work of graduate student Dhara Parekh, who in 2008 developed a plasma resist deposition process with perfect uniformity. One of the other major obstacles was finding a way to consistently align the stencil mask to the glass fiber coated with the resist. This was solved last summer during one of the graduate student group meetings Shih and Wolfe hold with their graduate students every Saturday morning. It was a Ph.D. student, Mufaddal Gheewala, who contributed the simple solution: a jig that could align 50 probes simultaneously. This not only solves the problem of matching the stencil mask with the probe, but it also allows probes to be built in large batches, providing a clear path to mass-production.

The team is now developing additional features for this probe that turns it from a device that measures brain activity to one that can actually induce it. Combining optical modalities with a light-sensitive molecule introduced into research subjects, investigators will be able to stimulate a particular area of the brain on demand and then study the electrical response of nearby neurons. For Dani, whose research interests include addiction, the optical probe could be used to simulate the effects of particular drugs on the brain and then explore its electrical response to those effects.

"One of the limitations in neuroscience research is the ability to collect high-resolution data. Data is being lost in the background noise that we don't want to collect," he said. "By increasing the precision and accuracy with these new kinds of electrodes, we will be able to collect more data, new kinds of data that could potentially revolutionize the way we look at interactions between elements of the brain."

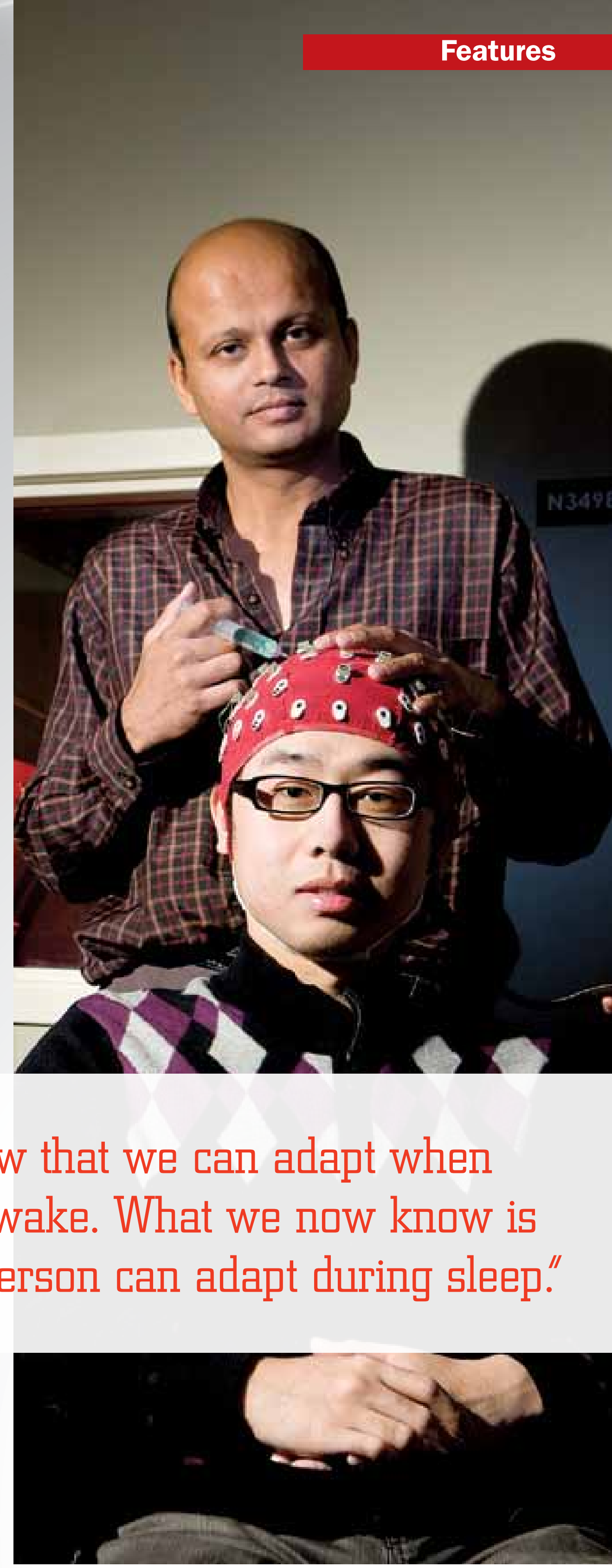
Making Sense of Things

Seeing and hearing are so fundamental to our day-to-day lives that most people don't even think about them. That would be like pondering the water that comes out of the tap, or our cars needing gasoline.

Just because we don't think about our senses doesn't mean the brain isn't hard at work when we see and hear. The mechanisms for processing the senses are in fact incredibly complex. They are also not completely understood. Professors Bhavin Sheth and Ben Jansen, both with the Department of Electrical and Computer Engineering, are among those conducting research to gain a better understanding of the brain's sensory processing mechanisms.

Sheth's research explores not just sensory processing in typical situations but in suboptimal conditions as well. Some of his work centers on whether and how the brain processes visual and auditory stimuli during sleep.

One of his most recent experiments explores the brain's response to colors during sleep. "We know that there's some visual adaption to colors that occurs when we're awake and that deadapts during sleep," said Sheth. "So we asked whether we could get de novo plasticity in sleep. In other words, could we make fresh impressions on a sleeping brain?"



"We know that we can adapt when we're awake. What we now know is that a person can adapt during sleep."

Sheth's experiment makes use of a well-documented phenomenon — one that we all have experienced at some time or another. During waking hours, staring at the color red for roughly a minute will result in seeing a non-existent green hue on other objects, and vice versa. If the staring is prolonged, between five and 20 minutes, the adaptation is durable.

Sheth, in collaboration with Scott Stevenson, a faculty member in the UH College of Optometry, set out to find whether the same occurs during sleep. The experiment utilized a device fitted over the eye of the subject and equipped with a green light bright enough to be seen through an eyelid. Subjects would get a full night's sleep wearing the device and, once awake, be asked to judge the "redness" of other colors and objects. The experiment showed that even during sleep, visual perception is skewed from green to red by the exposure to green light.

This result, Sheth readily admits, isn't extremely surprising. But what it reveals about the workings of the brain and the nature of sleep — a state in which most people spend one-third of their time — is very important. "We know that we can adapt when we're awake. What we now know is that a person can adapt during sleep. We've shown that during sleep, there are changes in brain circuitry and activity in response to external stimulation that are observable later during wakefulness."

One of Jansen's longtime research focuses is auditory processing, or how the brain registers and responds to sound. He is working with two groups in ongoing research projects — one of individuals with schizophrenia and one without — to understand the different ways in which they process sound.

Jansen conducts his tests using functional magnetic resonance imaging, or fMRI, an imaging technique that shows the oxygenation level of the blood flowing in the brain. Images that show increased blood oxygenation levels in particular areas indicate what parts of the brain are at work.

During the test, Jansen introduces the subjects to two sounds spaced half a second apart, measuring the responses to each sound. In individuals without schizophrenia, the brain typically exhibits a strong response to the first sound and a weaker response to the second. This is not surprising, he noted, since it is consistent with the ability to block out background noises and focus on a particular sound.

Individuals with schizophrenia, though, show a different response. While the reaction to the second sound was more or less equal for both groups, schizophrenic individuals had a much smaller response to the first sound. In fact, it was essentially equal to their response to the second sound. So instead of schizophrenic individuals having a difficult time blocking out background noise, as some have proposed, this test indicates that they tend to respond poorly to all sounds.

The next step of this research moves beyond observing to actually understanding what's happening. To that end, Jansen and Ph.D. student Xiaofei Du developed a complex mathematical model of the brain's auditory processing system. In applying this model, he has used as a starting point the dopamine hypothesis of schizophrenia, which holds that many symptoms of the condition are due to abnormal levels of the neurotransmitter dopamine in individuals suffering from schizophrenia. By both reducing and increasing dopamine levels in the model, "we got results that are indistinguishable from actual schizophrenia patients," he said. The findings will appear in an upcoming issue of *Neural Networks.*

Bhavin Sheth (left) and Ben Jansen (above) with the Cullen College's Department of Electrical and Computer Engineering both conduct research to uncover how the brain processes sensory information.

While this is not a conclusive proof of the dopamine hypothesis, it does help light possible paths for the treatment of individuals with the condition. "In the end, you want to use your knowledge to treat people," Jansen said. "If you understand what a disorder is all about you can develop drugs, surgeries or other therapies."

Qianmei (May) Feng

Assistant Professor of Industrial Engineering

Education

Ph.D. Industrial Engineering, University of Washington, Seattle, 2005

Career Overview

Feng joined the University of Houston Cullen College of Engineering as an assistant professor in 2005 following an appointment as a research assistant at the Pacific Northwest Agricultural Safety and Health Center at the University of Washington in Seattle. Since joining UH, she has received several honors, including a Highly Commended Award for her publications in the Emerald Literati Network and an Outstanding Teaching Award from the college. In 2010, she was also awarded a Brij and Sunita Agrawal Faculty Fellowship, established to honor promising junior faculty within the Department of Industrial Engineering. She is a member of the Institute of Operations Research and the Management Sciences (INFORMS), the Institute of Industrial Engineers (IIE), American Society for Quality (ASQ) and the Alpha Pi Mu Honor Society. She served on the editorial board for *Quality Engineering,* the *International Journal of Quality Engineering and Technology* and the *International Journal of Rapid Manufacturing.*

Research Interests

Most of Feng's research involves complex systems modeling, analysis and optimization, reliability engineering, quality control and improvement, applied probability and statistics, probabilistic risk and cost-effectiveness analysis and Six Sigma methodology.

Faculty Accolades

CHEMICAL AND BIOMOLECULAR ENGINEERING

Michael Harold has been named a M.D. Anderson Professor.

Peter Vekilov was named a fellow of the American Physical Society for his pioneering research in the areas of crystallization and protein aggregation.

Richard Willson was named a 2010 fellow of the American Association for the Advancement of Science for his distinguished contributions to biomolecular recognition sciences.

CIVIL AND ENVIRONMENTAL ENGINEERING

Jerry Rogers' paper titled "The New Town of Boulder City: City Planning and Infrastructure Engineering for Hoover Dam Workers" was one of 20 papers selected nationally for inclusion in the proceedings of a special symposium to celebrate the 75th anniversary of the Hoover Dam at the American Society of Civil Engineers annual conference.

Cumaraswamy "Vipu" Vipulanandan won the 2011 Most Valuable Professional award from the Underground Construction Technology Association and *Underground Construction* magazine for his outstanding contributions in education and research related to underground infrastructure construction and maintenance.

ELECTRICAL AND COMPUTER ENGINEERING

Stuart Long was named a Life Fellow of the Institute of Electrical and Electronics Engineers for his contributions to electromagnetics and the development of antennas for military and wireless communication applications.

INDUSTRIAL ENGINEERING

Ali Kamrani received a patent with Ford Motor Company titled "Method for Designing and Purchasing a Product."

MECHANICAL ENGINEERING

Kamel Salama was named emeritus vice president by the International Congress on Facture.

New Faculty

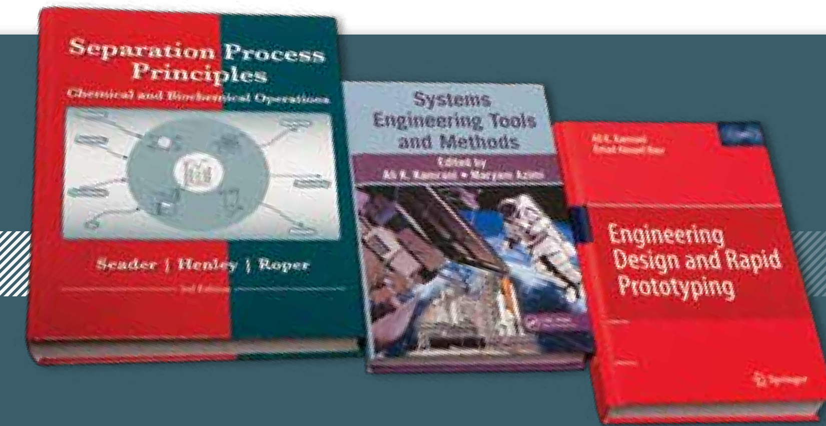
Patrick Cirino

Title: Associate Professor, Department of Chemical and Biomolecular Engineering

Previously: Associate Professor, Pennsylvania State University

Education: Ph.D. Chemical Engineering, California Institute of Technology, 2003

Research: Cirino's research interfaces chemical engineering with the biological sciences. He is interested in developing and applying protein and metabolic engineering tools to engineer microbes with improved biocatalytic properties, as well as pursuing fundamental understanding of metabolism and protein biochemistry. Biocatalyst design goals include more efficient microbial utilization of biomass for production of renewable fuels and chemicals, and enhanced biosynthesis of secondary metabolites.



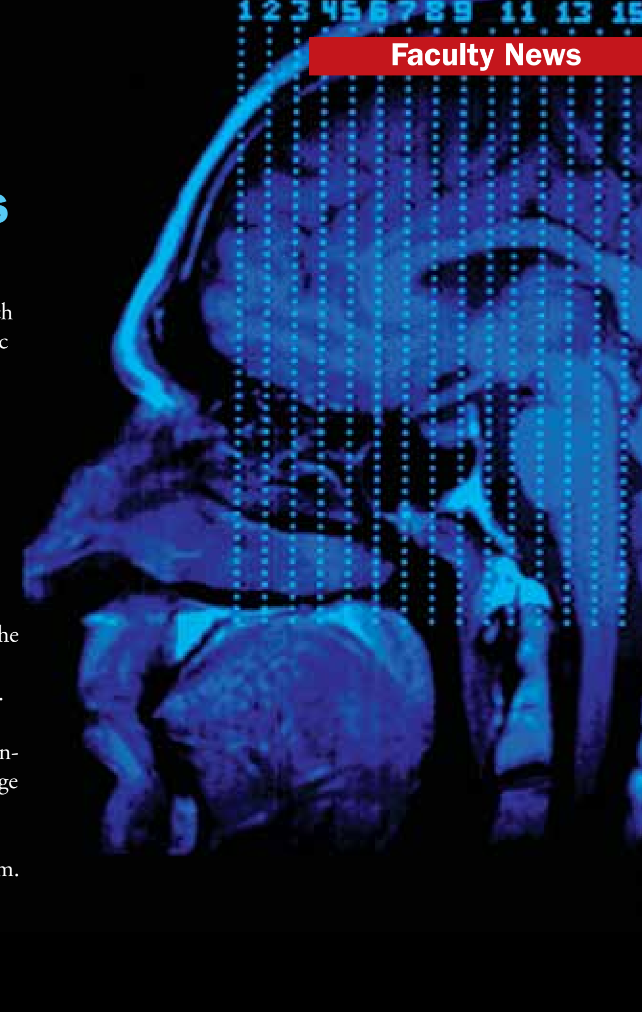
In Print

UH Engineering faculty recently published a couple of textbooks and one edited compilation that are widely used in engineering education. Ernest Henley, professor emeritus of chemical and biomolecular engineering, released the third edition of ***Separation Process Principles***, a text he co-authored with J.D. Seader and Keith Roper. The book is one of the best-selling texts for chemical and biochemical processes in the United States and is published by Wiley.

Ali Kamrani, associate professor of industrial engineering, also authored a text with Emal Abouel Nasr titled ***Engineering Design and Rapid Protoyping.*** Published by Springer, the text outlines methods and techniques for engineering design as it relates to modularity, rapid manufacturing and process planning. Kamrani also edited a book titled ***Systems Engineering Tools and Methods,*** a collection of chapters authored by more than 20 industrial and systems engineering faculty across the nation. The book published by CRC Press was edited by Kamrani's post-doctoral fellow Maryam Azimi.

Faculty News

Professor Developing **Color-Coded MRIs**



Cullen College Associate Professor of Mechanical Engineering Li Sun has won a $300,000 National Science Foundation grant to develop magnetic resonance imaging (MRI) technology that uses color to distinguish different types of tissue.

Sun's research centers around creating MRI contrasting agents out of a new breed of magnetic nanostructures.

"Current contrasting agents only adjust the grayscale of the image," said Sun." With these new contrasting agents, you can use magnetic frequency information to distinguish all the different tissue types by assigning them different colors."

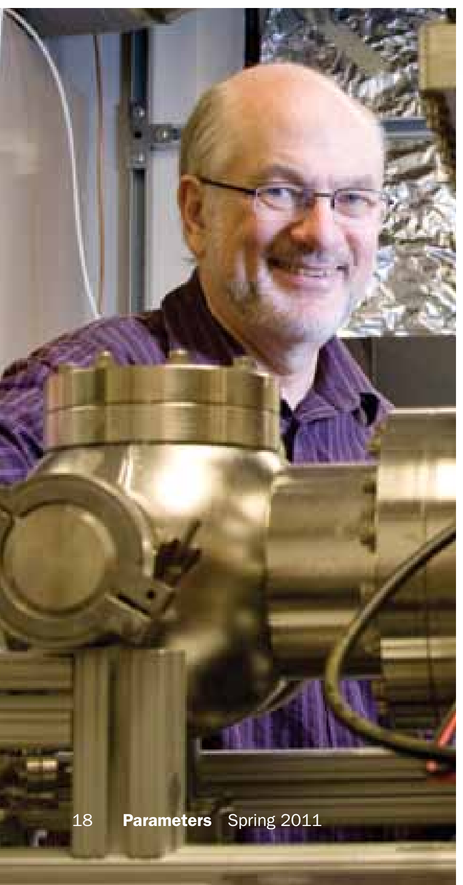
While most nanoparticles come in one of just a few standard shapes, such as nanospheres or nanorods, Sun's particles will be manufactured in irregular shapes similar to dumbbells or tubes. As a result, these particles have preset localized uniform fields that makes them respond to only a specific magnetic frequency.

The particles will then be coated in proteins that bond only with particular cell types, such as the cells that make up ligaments or specific internal organs.

In a clinical setting, these particles will be introduced into an MRI patient, most likely through an ingestible liquid or injection.

A patient's MRI machine can then be programmed to emit in rapid succession the frequencies that match the different types of nanoparticles in his or her body. As a result, the exact location of each particle, and hence, of the tissue it has bonded with, will be revealed.

The machine will then assign the each frequency a specific color, producing a full color image of the area being scanned by the machine, helping medical professionals know with certainty what an MRI image is showing them.



Plasma Reactions Paper **Featured on Journal Cover**

The Journal of Vacuum Science & Technology featured an article by Cullen College Professor of Chemical and Biomolecular Engineering Vince Donnelly on the cover of its January/February 2011 issue.

The paper "Plasma-surface Reactions and the Spinning Wall Method," outlined a new way to determine the behavior of atoms and molecules on the interior walls plasma chambers. Plasma chambers are used in many industrial processes, such etching silicon for integrated circuits. These processes are often slowed, however, by how plasma particles attach themselves to and react with each other on the surface of chamber interiors.

Understanding how these reactions occur will provide industry with a greater ability to control them and therefore better manage manufacturing processes. With that in mind, Donnelly has developed a chamber with a spinning cylinder serving as part of the chamber's interior. The cylinder always has one portion of its surface exposed

to the plasma and another outside the chamber.

During operation, the cylinder rotates at up to 50,000 times per minute. Using a mass spectrometer, Donnelly is able to analyze the particles that attach to the portion of the surface of the cylinder on the interior of the chamber just as that portion exits the chamber. Information uncovered includes how these particles react with each other and how they attach and detach from the surface.

"This process can be used to predict plasma operations in conditions that aren't currently being used, and contributes to overall knowledge of how these plasmas operate," said Donnelly.

Researchers Work to **Shorten Drug Development**

Michael Nikolaou

Professor of Chemical and Biomolecular Engineering

Vincent Tam

Associate Professor in the UH College of Pharmacy

Eliminating tens of thousands of manual lab experiments, two University of Houston professors are working toward a method to cut the development time of new antibiotics. While current practices typically last for more than a decade, a computerized modeling system being developed at UH will speed up this process.

Michael Nikolaou, professor of chemical and biomolecular engineering, and Vincent Tam, associate professor of clinical sciences, and are focusing on dosing regimens to reveal which ones are most likely to be effective in combating infection. It is hoped that pharmaceutical companies can then focus their tests on the most promising regimens.

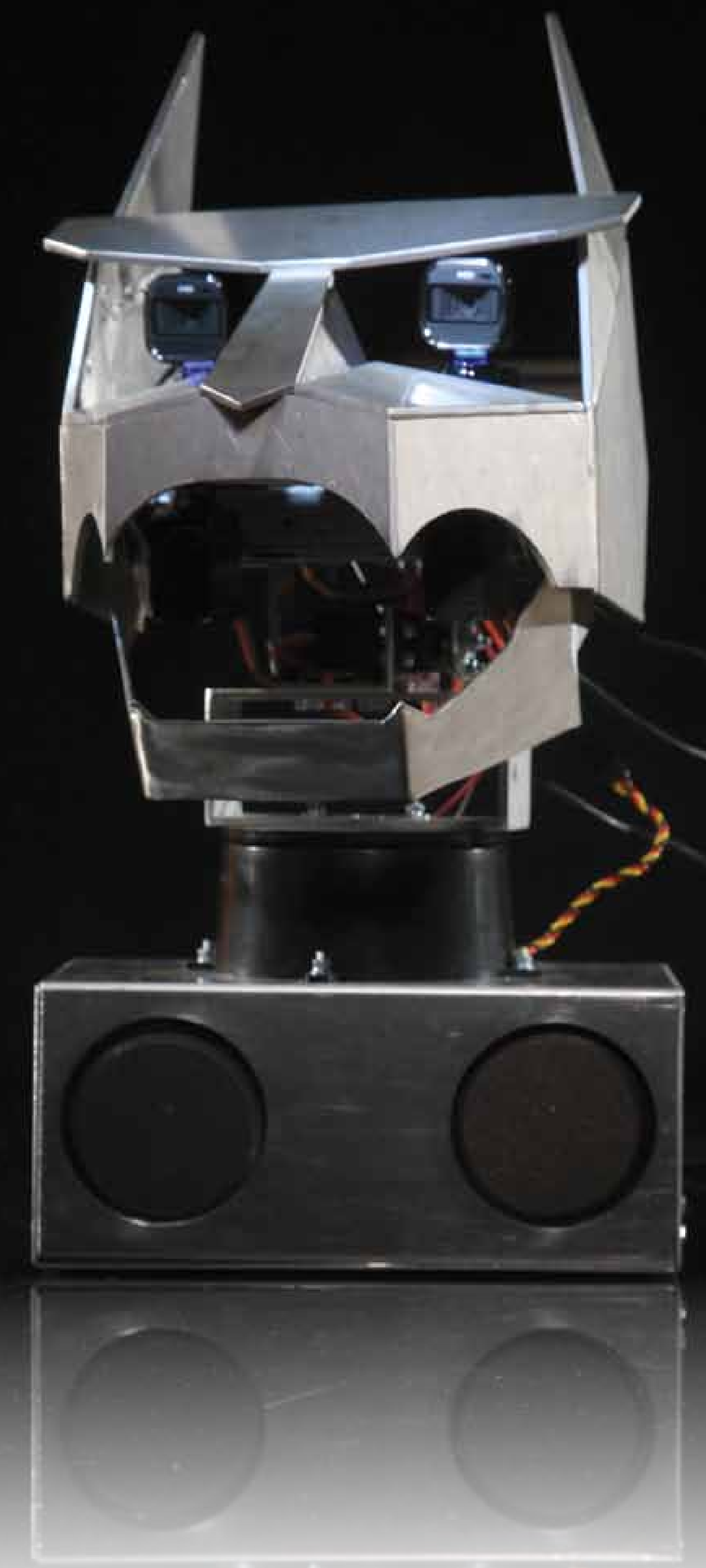
Their findings appeared in the Public Library of Science's journal, ***PLoS Computational Biology.*** The journal aims to further the understanding of living systems — from molecules to humans — through the application of computational methods. This article chronicles the results of a three-year endeavor that was initially funded by a $400,000 grant from the National Science Foundation.

"With microbial resistance to drugs increasing, there is a need to develop new antimicrobial agents rapidly," Tam said. "Our work proposes a new computational method that will provide quantitative insight to the interaction between certain antibiotics and pathogens. Through pharmacodynamic modeling, which studies the effects of drugs on organisms, our aim is to both help develop new antibiotics and optimize existing medications to curb the prevalence of drug-resistant bacteria."

The traditional approach to drug development involves a great deal of trial-and-error testing, such as empirically selecting a handful of dosing regimens for clinical investigations among hundreds of possibilities — only time will tell their effectiveness. Tam and Nikolaou, however, are employing computer modeling and simulation to project how bacteria would respond to different exposures of a drug, focusing on how much medicine a patient should take, how often it should be taken and for how many days. Subsequent investigations in clinical studies can then target those dosing methods that have the highest probabilities of success.

Tam, an expert on experimental therapeutics, and Nikolaou, with a background in computer-aided systems engineering, forged their collaboration through a seed grant from UH before they attracted external funding.

"Our approach gives us the ability to take extra variables into consideration in an attempt to develop a more robust computational tool that covers a wider spectrum of relevant scenarios in new drug development," Nikolaou said. "Some pharmaceutical companies are following our developments closely, and we are in the process of refining a model prototype in the form of a computer program to ultimately be used in a clinical setting."



Senior Design Yields

ROBO SHASTA

Four UH Cullen College of Engineering undergraduates have shown their Cougar pride by building a "Robo Shasta" for their senior design course.

The robot, designed to look like the head of the University of Houston's cougar mascot, can move, speak, track objects and perform basic arithmetic.

It was built by electrical and computer engineering students Marlon Belleth, Michael Canuz, Kyle Clifton and Major Jomah, who graduated from the Cullen College in December.

The inspiration for Robo Shasta came nearly two years ago, when Belleth and Canuz were members of the robotics team led by Professor John Glover. At one point, the team watched videos showcasing the work of robotics groups around the world. Seeing those videos convinced Belleth and Canuz that they were getting the skills and education needed to build a sophisticated robot of their own.

The self-directed nature of the project turned out to be a fitting way for the group to conclude their undergraduate education.

"We had to take the basics that we learned and then go out on our own and find the solutions to the problems we ran into," said Belleth. "There wasn't someone standing next to us telling us how to do it. So there was a lot of research, time and effort. That's really the point of the senior design class."

Undergraduate Recognized for Biomedical Research

Biomedical engineering junior Mohamed Mohamed captured first place in the Society of Mexican American Engineers and Scientists (MAES) Symposium 2010 poster competition by showcasing work performed in the Biomedical Optics Laboratory at the UH Cullen College of Engineering.

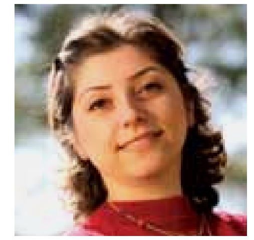
Mohamed has been working to quantify the permeability rates of lipoproteins, or cholesterol transporters, and other biologically relevant molecules through carotid tissue, the aortic branch supplying blood to the head.

His results verify the diffusion of low-density lipoprotein (LDL) into the inner lining of arteries, which is assumed to be the leading cause of atherosclerotic plaque formation. Atherosclerosis is a condition that develops due to the buildup of fatty substances inside arterial walls.

Utilizing a non-invasive imaging technique known as Optical Coherence Tomography (OCT), Mohamed was able to measure the permeability rates of lipoproteins such as LDL and high-density lipoprotein (HDL) in the tissue.

"What we were able to do here is verify this fact with a non-invasive method," he said. "In the future, we might be able to figure out how effective certain drugs are in preventing and treating atherosclerosis."

Graduate Students Win High Honors



Mona Meisami-Azad

The Association for Women in Science has given one of its three predoctoral 2010 Educational Awards to Cullen College graduate student Mona Meisami-Azad.

Meisami-Azad is working toward a Ph.D. in mechanical engineering under the guidance of Professors Karolos Grigoriadis and Matthew Franchek. Her studies and research focus on controls for complex engineered systems. This work has been applied to diesel engine after-treatment systems with the objective of reducing harmful emissions, as well as wind turbines, where the goal is to increase the energy capture while minimizing structural loads.

"These systems are actively controlled, where the measurements from a number of sensors are used to make a decision on how to manipulate actuating devices to ensure that a set of design objectives are met considering the design constraints," she said.

Meisami-Azad is on schedule to complete her Ph.D. by the end of 2011. Upon earning her degree, Meisami-Azad hopes to land a research engineering position in the automotive or energy industry. "I'm interested in a position in the research and development department of a large company," she said. "I'd like to be able to utilize the skills I acquire in my graduate studies and apply them in real-world applications including renewable energy systems."

Taraka Ravi Shankar Mullapudi

Taraka Ravi Shankar Mullapudi, a Ph.D. candidate in the Cullen College's Department of Civil and Environmental Engineering, won the Earthquake Engineering Research Institute's 2011 Student Paper Competition.

The award was presented to Mullapudi during the group's 63rd Annual Meeting, held in La Jolla, Calif., in February. Mullapudi presented the winning paper, "Seismic Behavior of RC Structures Subjected to Combined Loading Including Torsion," at the gathering.

The article explores the behavior during earthquakes of reinforced concrete members with eccentric loadings, asymmetrical geometries, and skewed and curved geometries with unequal spans and column heights. In seismic events, these concrete members are subjected to multiple combined loads, including axial, flexure, shear and torsion loads.

Mullapudi has developed an analytical model "to predict the behavior of structures under such loads, as well design them to resist against destructive earthquakes," he said.

This is just the latest honor Mullapudi has received during his time at the Cullen College. He has received two fellowships from the American Society of Civil Engineers and also won the best paper award for April 2010 from the ASCE's Texas Section. Mullapudi is pursing his doctorate under the guidance of Associate Professor Ashraf Ayoub.

Each year in celebration *of National Engineers Week, the Cullen College names the outstanding junior and senior students for every department and major. Out of this group of young scholars, the college chooses its overall Outstanding Junior and Outstanding Senior, two students whose work inside the classroom and out is truly exemplary. This year's honorees are mechanical engineering junior Ethan Pedneau and December 2010 civil engineering graduate Jessica Ngo.*

Outstanding Junior

Ethan Pedneau

Mechanical engineering major Ethan Pedneau has been named the Cullen College of Engineering's Outstanding Junior for the 2010-2011 academic year.

Pedneau, who hails from Pasadena, Texas, originally enrolled in the college planning to study chemical engineering. He switched to mechanical engineering as a freshman, however, because it appealed to his strengths. "My best courses in high school were art and mathematics. Mechanical engineering was the best way for me to apply those skills," he said.

Given his academic performance over the past three years, that was clearly the right choice. Pedneau boasts a grade point average of 3.753, and is an accomplished student researcher. Working with Ralph Metcalfe and Fazle Hussain, both professors in the Department of Mechanical Engineering, he has explored ways to overcome the problem of inconsistent energy production from wind farms in the Gulf of Mexico.

Utilizing wind data gathered by the National Oceanographic and Atmospheric Association, Pedneau's research team determined that by interconnecting wind farms throughout the Gulf coast, power generation would be "smoothed" to a predictable, dependable level. When one wind farm isn't generating enough power because of poor wind quality, another would generate enough to make up for it, they found. Further, their research indicates that hurricanes do not pose a major threat to offshore wind farms in the Gulf. Wind farms built to withstand up to a strong Category Three storm have only a 0.1 percent chance of being destroyed by wind each year. That figure, however, does not account for wave forces, a factor Pedneau and his group are currently calculating.

"The threat of hurricanes is very small, especially when compared to mechanical failure, grid failure and all the other things that can go wrong," Pedneau said.

Given his flair for research, it should come as no surprise that Pedneau is an active member of the Houston Undergraduate Research Network, a UH student organization, and hopes to hold a leadership role with the group during the next academic year. He is also a member of the Student Governing Board of The Honors College at UH, where he creates the artwork and posters advertising student events.

Looking ahead, Pedneau plans to pursue a graduate degree in mechanical engineering, most likely at the Cullen College.

Outstanding Senior

Jennifer Ngo

The Cullen College of Engineering's Outstanding Senior for the 2010-2011 academic year is Jennifer Ngo. Ngo, who came to UH on a full academic scholarship, graduated with a B.S. in civil engineering in December of 2010 with a final grade point average of 3.71.

During her time at UH, Ngo was active in the life of the college. She served as treasurer of the UH chapter of the American Society of Civil Engineers for two years, organizing and/or participating in events like the ASCE Chili Cook-off, its Habitat for Humanity volunteer efforts, and the group's semester kickoff parties.

Ngo was also a three-time member of the college's Concrete Canoe team. "I'm really active physically and I like to do outdoorsy stuff, so this was a natural fit for me," she said. Two of those teams won the regional Concrete Canoe competition and went on to represent UH at nationals.

In addition to her work with student organizations, Ngo went out of her way to build up her resume while still enrolled as a student. She spent a year as a research assistant on a Texas Department of Transportation-funded research project led by Kyle Strom, an assistant professor of civil and environmental engineering. She also completed two internships during her time at the college. The first was with United States Gypsum, a building materials manufacturer. The second internship, which she landed through the Engineering Career Fair, was with Spectra Energy, a natural gas pipeline and infrastructure firm.

After graduating in December, Ngo immediately began a position as a project engineer in the pipeline engineering department with Boardwalk Pipeline Partners, also a natural gas infrastructure company. In this role, she serves as part of a team that evaluates and selects the best routes for new pipelines. Once routes are finalized, her team selects a firm to engineer the pipelines themselves, as well as manages the construction process.

Given her academic achievements and clear commitment to professional success, it's not surprising that Ngo is considering pursuing an advanced degree, though one aimed at business rather than the lab. "I want to go back. Probably not for a masters in engineering, but for an MBA," she said. "I'm thinking that I'll go back about two years down the line."

Imitating Nature

Taken from *The Engines of Our Ingenuity*, Episode #1068

Dr. John Lienhard

People often ask me if invention copies nature. The answer's a surprise. We seldom manage to copy nature. She's too complex. Her secrets are too deeply buried. Our forbears were once in closer touch with organic nature. They knew the herbs of the forest and, without chemistry, they extracted medicines and processed chemicals from them. They used nature. But they made no attempt to copy her.

They might make ink from acacia tree gum, then extract coloring for it from the parasitic galls of an oak tree. Linseed oil, flaxen cloth or waxes — tanning, smelting, or adding color to stained glass. It all reflected an intimacy with the tastes and smells of the forest. We used nature. We didn't try to copy her.

As we synthesize cloth, paper, medicine, and oils, each step leads us further from the product nature provided. Now we process natural oils into plastics, minerals into glass, and organic fibers and chemicals into paper. In the very simplicity of our processes, we overlook nature's exquisite sophistication.

That's especially clear when we try to copy animal functions. Two-legged, or bipedal, motion poses insurmountable feedback control problems, so we simplify it. We separate propulsion from locomotion. We fit wheels on an ox- or engine-driven vehicle. Only in the last 35 years have we managed to make crude six-legged walking machines.

We did the same thing when we learned to fly. We couldn't combine lift with propulsion in a flapping wing. So we gave up, froze the wing in place, and drove the plane forward with a propeller. It was a crude solution for a hopelessly complex problem.

To invent the computer, we first had to despair of imitating the human brain. Now we very gradually try to endow our computers with the abilities that seem to lie within our own brains — neural networks, parallel processing, and fuzzy logic.

When we discover a new drug or glandular secretion, we first try to synthesize it. Then we introduce it orally or intravenously — not the way our own body would. Doctors and psychiatrists do repeated damage, along with much good, as they try to replicate the body's means for defending against disease and psychosis.

Another time, we'll talk about our attempts to copy the spider's web. Spider web strands have enormous strength and an array of qualities that we find in no manufactured material.

Technology's central task is expanding our reach — letting us travel faster and farther, heating and cooling us, extending our minds and our capacity for self-repair — pleasing our senses. And it always comes back to replicating what nature does more efficiently, and with layers of complexity that continue to baffle us.

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 2,600 episodes have been broadcast. For more information about the program, visit www.uh.edu/engines.*

It's okay to shoot electromagnetic current directly into the human brain.

The Food and Drug Administration has approved the use of devices to treat depression by either inducing or halting neural activity in targeted regions of the brain through such currents.

Existing devices, though, must be physically moved from place to place on a patient's skull, making the introduction of current slow and inaccurate. Three Cullen College professors — Ji Chen, Ben Jansen and Bhavin Sheth — are developing a new device, a dynamic EM coil, that eliminates these problems.

The device utilizes a grid pattern, with each intersection capable of generating current. Combining that with a mesh material, it will be placed directly on a patient's head, allowing for the quick and accurate introduction of current in any part of the brain. Through a computer interface, the device will also allow current to be sent into multiple areas simultaneously or in a desired sequence, giving researchers a valuable tool for investigating how various regions of the brain interact.

UNIVERSITY of HOUSTON | ENGINEERING

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Celebrating in style, the University of Houston community gathered in January to recognize its ascent to the top category of research universities, as evaluated by the Carnegie Foundation for the Advancement of Teaching. The foundation recognized UH as a home to "very high research activity," the highest classification it awards and the equivalent of Tier One status.