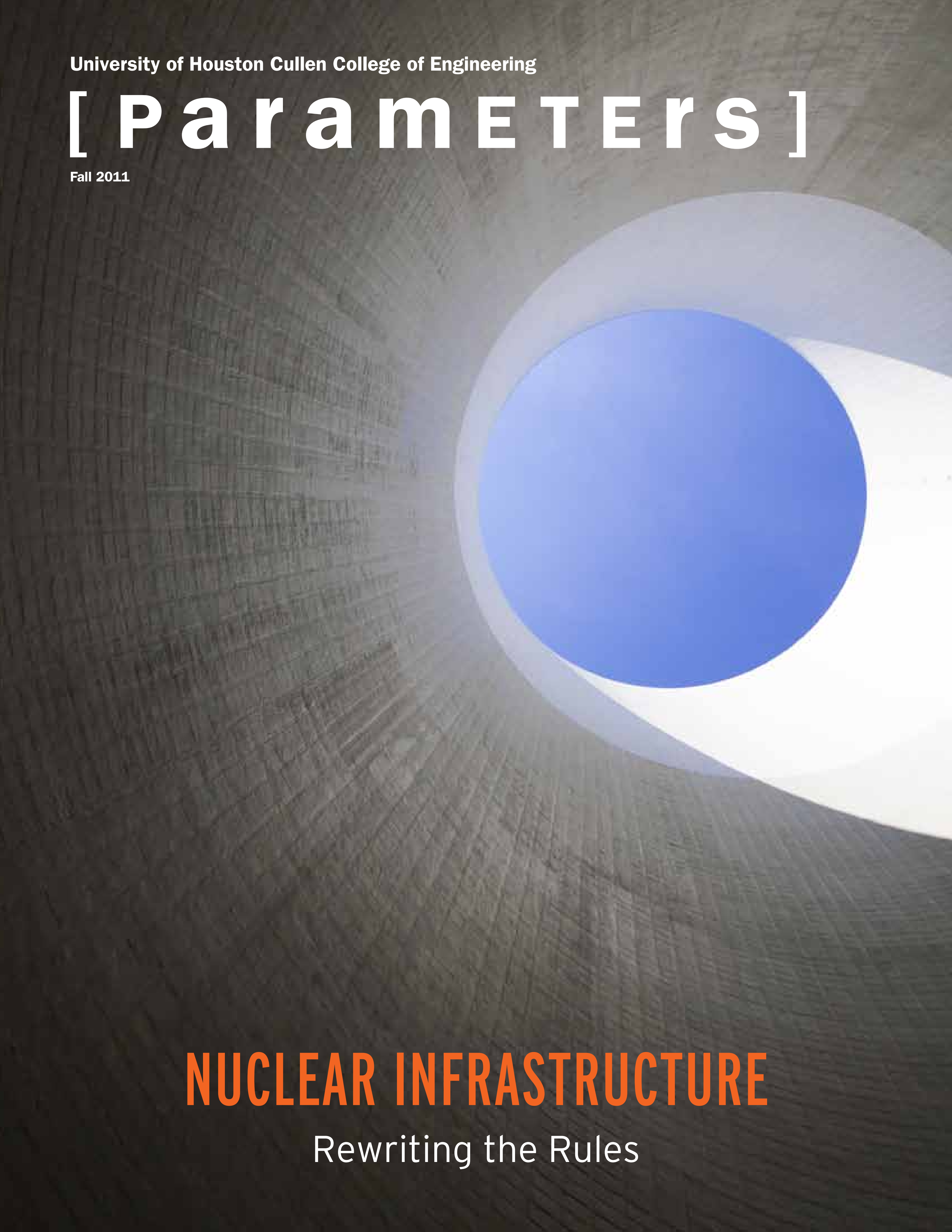
University of Houston Cullen College of Engineering

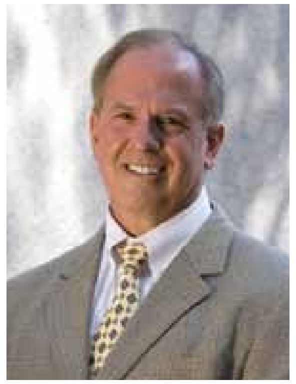
[ParameTErs]

Fall 2011



NUCLEAR INFRASTRUCTURE

Rewriting the Rules



A substantial part of the University of Houston Cullen College of Engineering's strategic plan is focused on the continual advancement of our educational and research programs along with the ongoing growth of our academic community. We have set aggressive goals to meet these objectives, which have been underscored by UH's drive to become the next Tier One university in the state of Texas. The growth and support of our engineering program at UH has been on a constant upward trajectory—a definite sign of our ambition and determination to be a top program nationwide. Good things are definitely happening at the University of Houston!

In addition to our quantitative growth charted numerically over the next couple of pages, we are excited to share information about some of the great things affecting the quality of our programs as well. This summer, our petroleum engineering facility at the UH Energy Research Park was renamed the ConocoPhillips Petroleum Engineering Building thanks to a major gift from the company. In addition, our growing Petroleum Engineering Program welcomed Dr. John Lee to UH. A member of the prestigious National Academy of Engineering, Dr. Lee is the first tenured faculty member in petroleum engineering and one of nine new faculty members we welcomed to the college this fall.

As part of our overall mission to be a program of relevance and impact to the Greater Houston community, the Cullen College has launched several certificate programs to provide advanced training for industry professionals. These programs have developed out of an ongoing emphasis from Houston industries for UH to provide training to their employees. Our new certificate program in subsea engineering—the only such program in the nation—continues to expand and gain momentum, while our Department of Chemical and Biomolecular Engineering is on the verge of launching advanced training programs in chemical engineering focused on process engineering, safety, operations and management, and process analysis. Both of these certificate programs will have a master's degree component in the near future.

In addition to a new Honors Engineering Program, we have developed an undergraduate program for students wishing to major in engineering. Our new Pre-Engineering Program will give students a chance to academically prepare to enter our college, increasing the probability of their success. We expect to see significant interest in this newly offered program.

In this issue of *Parameters,* we highlight growth in a particular area of research: nuclear infrastructure. Rapidly becoming an area of interdisciplinary strength in our college, our researchers have recently garnered major grant funding to study everything from determining how to strengthen the infrastructure surrounding nuclear power plants to better monitoring the structural health of these facilities following disaster events. These researchers are internationally known for their computational work involving materials as well as their experimental work testing the viability of these materials. We are excited that UH is emerging as a leader in yet another major area of research impact for our nation and our world.

Warm regards,

Joseph W. Tedesco

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

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

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FEATURES

PARAMETERS - FALL 2011

ON THE COVER

Nuclear Infrastructure

The view from the inside of a nuclear power plant cooling tower. The nuclear power sector is entering a period of tremendous growth, with construction either set or proposed for hundreds of new plants in the coming years. Investigators with the University of Houston Cullen College of Engineering are conducting structural and materials research to make these facilities as strong, long-lived and resilient as possible.

Lead News

Cullen College Driving

TIER ONE GROWTH

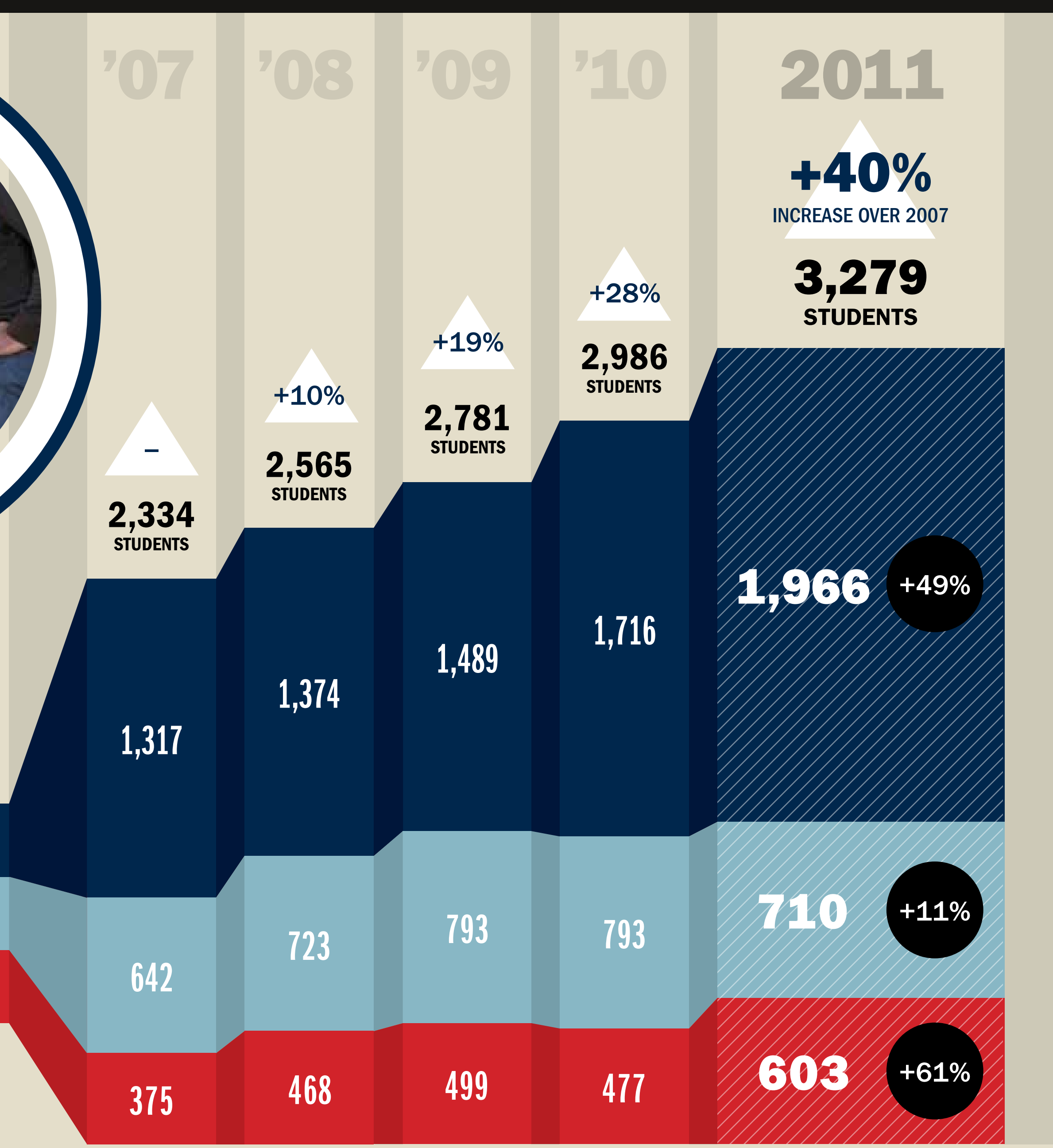
Earlier this year, the Carnegie Foundation for the Advancement of Teaching placed the University of Houston in its top tier of research universities, the most significant accomplishment to date in UH's journey to Tier One status.

The UH Cullen College of Engineering has played an important role in this journey. Over the past few years it has posted huge growth in nearly every metric that matters, from enrollment to faculty count to research expenditures.

"When the college announced its strategic plan for 2008 to 2013, we set ambitious goals for ourselves. Thanks to the hard work of our faculty and staff, we are well on our way to achieving these goals. I look forward to the college reaching even greater heights in the coming years."

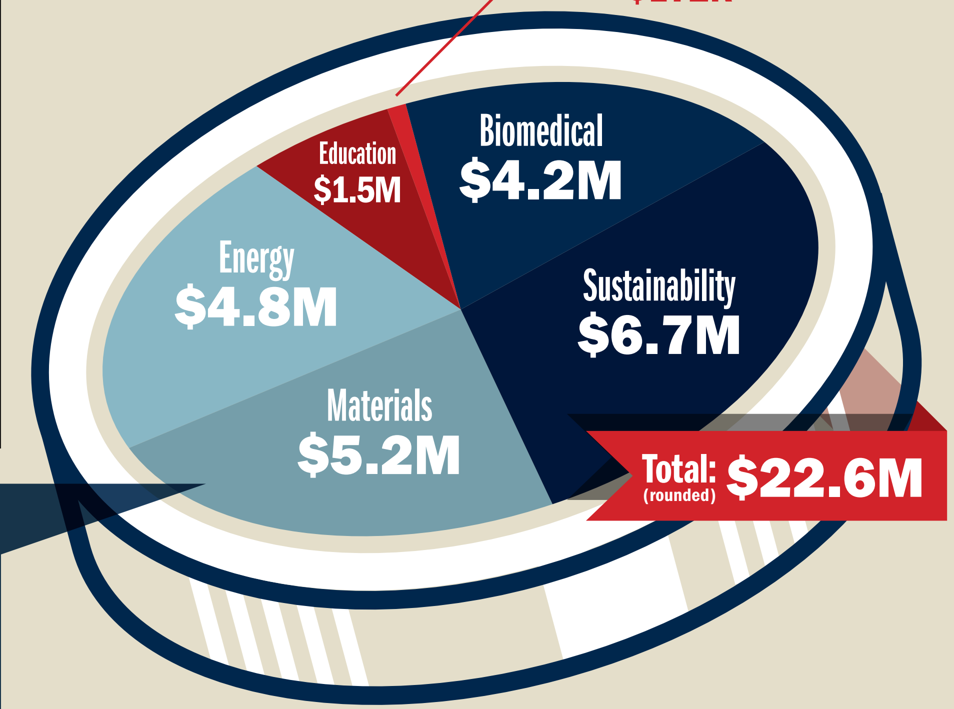
- Joseph W. Tedesco
Elizabeth D. Rockwell Dean and Professor of the Cullen College

Explosive Growth in Enrollment 2007–2011



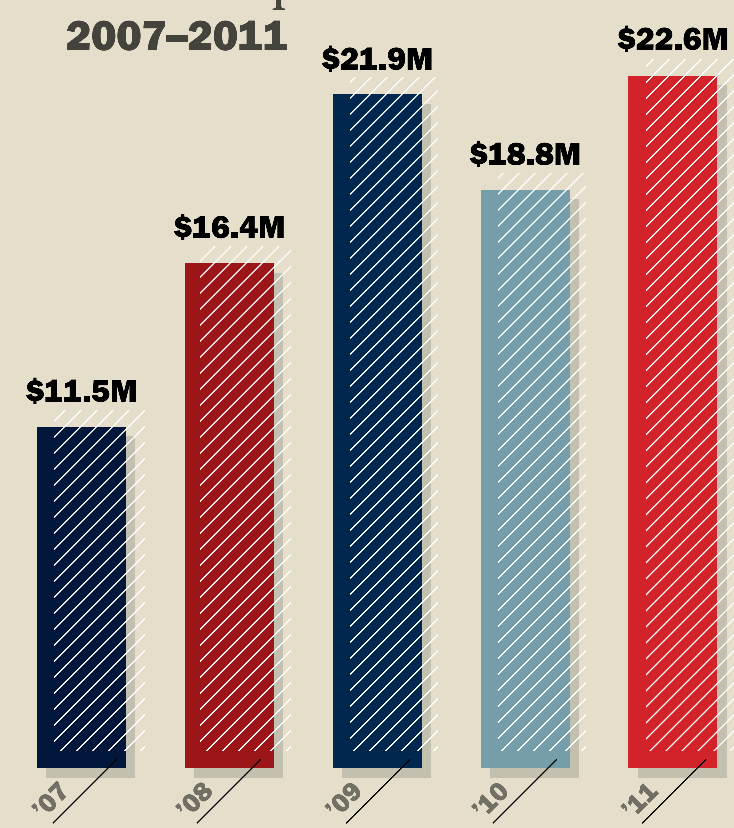
*Not Freshman

Research Expenditure Breakdown, 2011



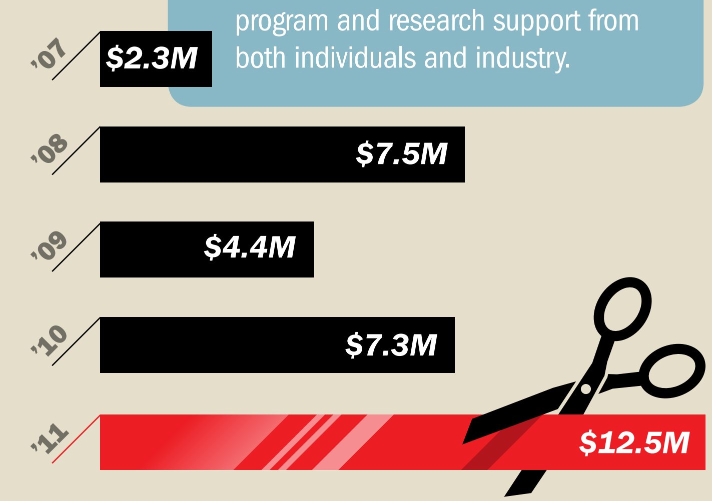
Research – The UH Cullen College of Engineering's research portfolio continues to grow and diversify, with annual expenditures for all four major research thrust areas – energy, biomedical engineering, materials and sustainability – falling within 18% and 30% of the total for fiscal year 2011.

Research Expenditures 2007–2011



Financial Support, 2007–2011

Gifts – Financial support to the UH Cullen College of Engineering has grown tremendously over the last five years across a diversity of funds, including student scholarships, chairs and professorships, gifts-in-kind, and program and research support from both individuals and industry.



9 New Faculty Join Cullen College

One of the key components to achieving Tier One status is having a Tier One faculty. Since the fall of 2007, the UH Cullen College of Engineering has grown its tenured/ tenure-track faculty count from 87 to 105. This fall, alone, the college welcomed nine new faculty members, including two associate professors and one member of the National Academy of Engineering. The research and educational efforts of these individuals will help the Cullen College achieve its goal of ranking among the top 50 engineering programs in the country.

John Lee, Ph.D.

Hugh Roy and Lillie Cranz Cullen Distinguished University Chair and Professor of Petroleum Engineering
Ph.D. Chemical Engineering, Georgia Institute of Technology

The Cullen College has signed one of the country's most respected petroleum engineering academics as the first tenured faculty member in its Petroleum Engineering Program. John Lee joined the college this fall from Texas A&M University, where he served as the Regents Professor of Petroleum Engineering and held the L.F. Peterson Chair in the Harold Vance Department of Petroleum Engineering. Lee's work on oil and gas reserves regulations and unconventional gas reservoir production forecasting has earned him respect throughout the engineering community and petroleum industry. He is a member of the National Academy of Engineering and the Russian Academy of Natural Sciences. He was an Academic Engineering Fellow and honored with the Law and Policy Award by the U.S. Securities & Exchange Commission. He is an Honorary Member of SPE and AIME.

Ravi Birla, Ph.D.

Associate Professor of Biomedical Engineering
Ph.D. Biomedical Engineering, University of Michigan, Ann Arbor

Birla's research focuses on the creation of 3D cardiovascular constructs, including bioengineering 3D cardiac patches, using stem cells to support the formation of cardiovascular tissue construct, developing cell based cardiac pumps, and developing scaffold-free technology to support 3D heart muscle formation.

Ashutosh Agrawal, Ph.D.

Assistant Professor of Mechanical Engineering
Ph.D. Civil and Environmental Engineering, University of California, Berkeley

Agrawal, who previously served as a research assistant professor with the college's mechanical engineering department, is currently researching surface tension in patch-clamp experiments, incipient plasmolysis in E. coli, membrane-membrane adhesion, and estimations of adhesion energy.

Bora Gencturk, Ph.D.

Assistant Professor of Civil and Environmental Engineering
Ph.D. Civil Engineering, University of Illinois at Urbana-Champaign

Genturk's research interests include advanced materials for civil engineering applications, sustainable construction, vulnerability assessment of structures and the development of new experimental methods.

Lars Grabow, Ph.D.

Assistant Professor of Chemical and Biomolecular Engineering
Ph.D. Chemical and Biological Engineering, University of Wisconsin, Madison

Grabow uses computational methods to understand and predict chemical processes that occur on solid-gas and solid-liquid interfaces. In particular, his work focuses on heterogeneously catalyzed reactions relevant for energy production, energy storage, pollution mitigation and the production of useful chemicals.

Faculty Growth (Tenured/Tenure-track)

2007–2011

'07	'08	'09	'10	'11
87	91	95	100	105

William Epling, Ph.D.

Associate Professor of Chemical and Biomolecular Engineering
Ph.D. Chemical Engineering, University of Florida

Epling's research focuses on understanding and engineering the reaction process on and along a catalyst surface. This encompasses the preparation of novel catalyst materials, the fundamental characterization of catalyst surfaces; developing new analytic techniques, processes or devices; and preparing or manufacturing pilot-scale samples for testing and application. All of this results in in-depth fundamental catalyst knowledge that is translated into practical, industrially relevant applications.

Hyongki Lee, Ph.D.

Assistant Professor of Civil and Environmental Engineering
Ph.D. Civil Engineering, Ohio State University

Lee researches questions in Earth sciences through distinctly different satellite geodetic instruments. His long-term goal is to establish a research program centered on developing a variety of geodetic methods and algorithms, and applying them to scientific research and engineering applications of the hydrosphere, the cryosphere, the solid Earth, the oceans, and their complex interactions. This includes establishing a research group that monitors natural hazards, including floods, hurricanes, earthquakes and volcanoes.

Mo Li, Ph.D.

Assistant Professor of Civil and Environmental Engineering
Ph.D. Structural Engineering, University of Michigan, Ann Arbor

Li's research involves creating, assessing and implementing advanced material technology for repairing existing and designing next-generation engineered structural systems, focused on three areas: extending structural service life and durability under combined environmental and mechanical loading conditions; enabling distributed multimodal self-sensing capabilities for structural health monitoring; and improving system resilience and environmental sustainability. Her research extends to assessing economic, environmental and social impacts caused by technological and economic changes at different scales.

Kalyana Nakshatrala, Ph.D.

Assistant Professor of Civil and Environmental Engineering
Ph.D. Structural Engineering, University of Illinois at Urbana-Champaign

Nakshatrala's research interest is mathematical formulation and analysis, and developing computational techniques for problems in structural, solid, and fluid mechanics. Applications include degradation/healing of civil and aerospace structures and materials, geosciences and bio-mechanics. Specific topics include multiscale and stabilized finite elements and numerical upscaling techniques; nonlinear continuum mechanics and thermomechanical constitutive modeling; coupled problems and fluid-structure interaction; theory of interacting continua; computational fluid, solid and structural mechanics and applied mathematics; and high-performance computing.

ConocoPhillips Makes Major Gift to UH Energy Research Park

(L-R) Cullen College Dean Joseph W. Tedesco; former UH System Board of Regents Chair Carroll Robertson Ray; Carin S. Knickel, vice president of human resources for ConocoPhillips; Ron Harrell, chair of the UH Petroleum Engineering Advisory Board; UH System Chancellor and UH President Renu Khator; and Chair of UH Chemical and Biomolecular Engineering Ramanan Krishnamoorti.

The University of Houston Cullen College of Engineering's Petroleum Engineering Program marked a major milestone with the official dedication of its new headquarters, the ConocoPhillips Petroleum Engineering Building.

The building is located at the University of Houston's Energy Research Park, a 74-acre space just minutes from UH's central campus. When fully developed, the park will serve as the center of the university's energy–related research and education.

The building was made possible thanks in large part to a gift from Houston-based ConocoPhillips, which made a $1 million gift commitment to UH and the Energy Research Park in 2011 and intends to follow up with gifts of $1 million in both 2012 and 2013.

At the ribbon cutting ceremony, Joseph W. Tedesco, Elizabeth D. Rockwell Dean of the Cullen College, thanked ConocoPhillips "for this incredible gift, one that is mutually beneficial to the UH Energy initiative and our Petroleum Engineering Program as well as the ever-growing energy community in the city of Houston."

The facility, which opened to students in January 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.

The new building is the first to have an official grand opening at the Energy Research Park, noted UH System Chancellor and UH President Renu Khator. With continued support from individuals and industry, the park could well become a major asset for the city of Houston and for the global energy sector, she said.

"One day, this place, this Energy Research Park, could have the same vitality, the same innovation, that you find in the Texas Medical Center. This could be the hub where public, private and academic sectors merge together to create something that cannot be created without that kind of synergy."

New Chair of Industrial Engineering Appointed

The UH Cullen College of Engineering named **Gino Lim** the new chair of its Department of Industrial Engineering, effective May 16. A Hari and Anjali Agrawal Faculty Fellow with the department, Lim earned his Ph.D. in industrial engineering in 2002 from the University of Wisconsin – Madison. He then worked as a postdoctoral researcher in that university's computer science department before joining UH in 2004.

At UH, Lim has been an investigator on grants totaling more than $8 million, with more than $2 million of that coming to UH and the balance to collaborators at other institutions. His research currently includes partnerships with several institutions in the Texas Medical Center to optimize their patient and room scheduling, including The Methodist Hospital, The University of Texas Health Science Center and The University of Texas MD Anderson Cancer Center. Lim's research also includes evacuation planning for major urban areas.

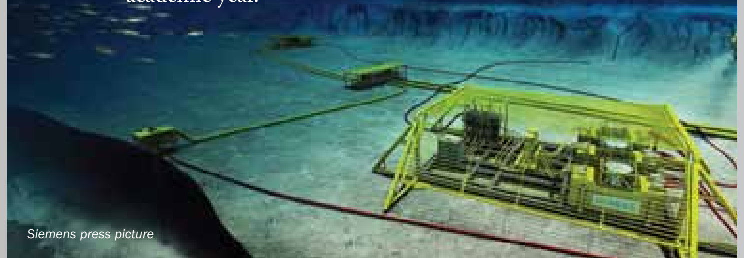
As chair, Lim said his five-year goals include working with his faculty to significantly increase external funding and scholarly activity. He also hopes to make the department one of the top 25 in the nation according to the *US News & World Report* rankings. The department has moved steadily up that list in recent years and now stands at 38, he noted.

KBR Makes Gift to Subsea Program

Engineering, construction and services firm KBR has made a $50,000 donation to the UH Cullen College of Engineering's new Subsea Engineering Program.

The program focuses on the design and installation of underwater infrastructure used in offshore petroleum exploration and retrieval. It is the first and only dedicated subsea curriculum in the United States.

The gift, made in partnership between KBR and its subsidiary Granherne, will support four industry professionals serving as adjunct faculty members in the program. These individuals have been designated KBR Lecturers in Subsea Engineering for the current academic year.



Siemens press picture

DOE Supporting Wind Turbine Research

Venkat "Selva" Selvamanickam, M.D. Anderson Chair Professor of Mechanical Engineering, will lead a research team charged with developing a low-cost superconducting wire that could be used in future wind turbines.

The group, which includes SuperPower Inc., the U.S. Department of Energy's National Renewable Energy Laboratory, Tai-Yang Research and TECO-Westinghouse Motor Company, has been awarded $3.1 million by the DOE to perform this work.

"This grant will be used to produce a high-performance superconducting wire to build a light, high power and high efficiency wind turbine generator. Superconducting wire enables us to build wind generators with power ratings at 10 megawatt and above, which are suitable for offshore wind power plants," Selvamanickam said. "The use of high-power generators can reduce installation, maintenance and capital costs of the turbine and the wind power plants."

"While conventional generator windings are made of copper wire, with a superconducting wire, it is possible to pass hundreds of times more electric current than a copper wire," he added. "But the cost of superconducting wire is currently very expensive. Our goal is to develop a low cost superconducting wire that will make superconducting wind generators become more practical for widespread use."

Litvinov Named Director of Materials Engineering

Dmitri Litvinov, John and Rebecca Moores Professor of Electrical and Computer Engineering, has been named director of the Cullen College of Engineering's Materials Engineering Program.

The graduate program, which offers both a master's and a Ph.D. track, focuses on engineered materials and their processing for a wide range of engineering applications, from renewable energy to biomedical engineering to information technology. Specific areas include solar cell materials, superconducting ceramics for energy applications, materials for biosensing, magnetic materials for data storage and processing, and composites for aerospace engineering and wind-energy applications.

As an interdisciplinary effort, current faculty of the Materials Engineering Program include members of the college's mechanical, chemical, and electrical and computer engineering departments, with plans to expand with faculty from biomedical engineering and civil and environmental engineering who are interested in participating in the program. Materials engineering faculty and students also collaborate with researchers in the University of Houston's College of Natural Sciences and Mathematics.

ENGINEERING extras

Princeton Review Recognizes UH

» The University of Houston has been named one of the nation's best institutions for undergraduate education by *The Princeton Review,* the widely known education services company. It has chosen UH for inclusion in the recently-published edition of its popular annual guidebook, "The Best 376 Colleges: 2012 Edition."

Former President of India Visits UH

» The University of Houston welcomed former president of India A.P.J. Abdul Kalam to its campus in August. Kalam, who served as president from 2002 to 2007, met with officials and toured many of the university's top research facilities, including the UH Nanofabrication Facility.

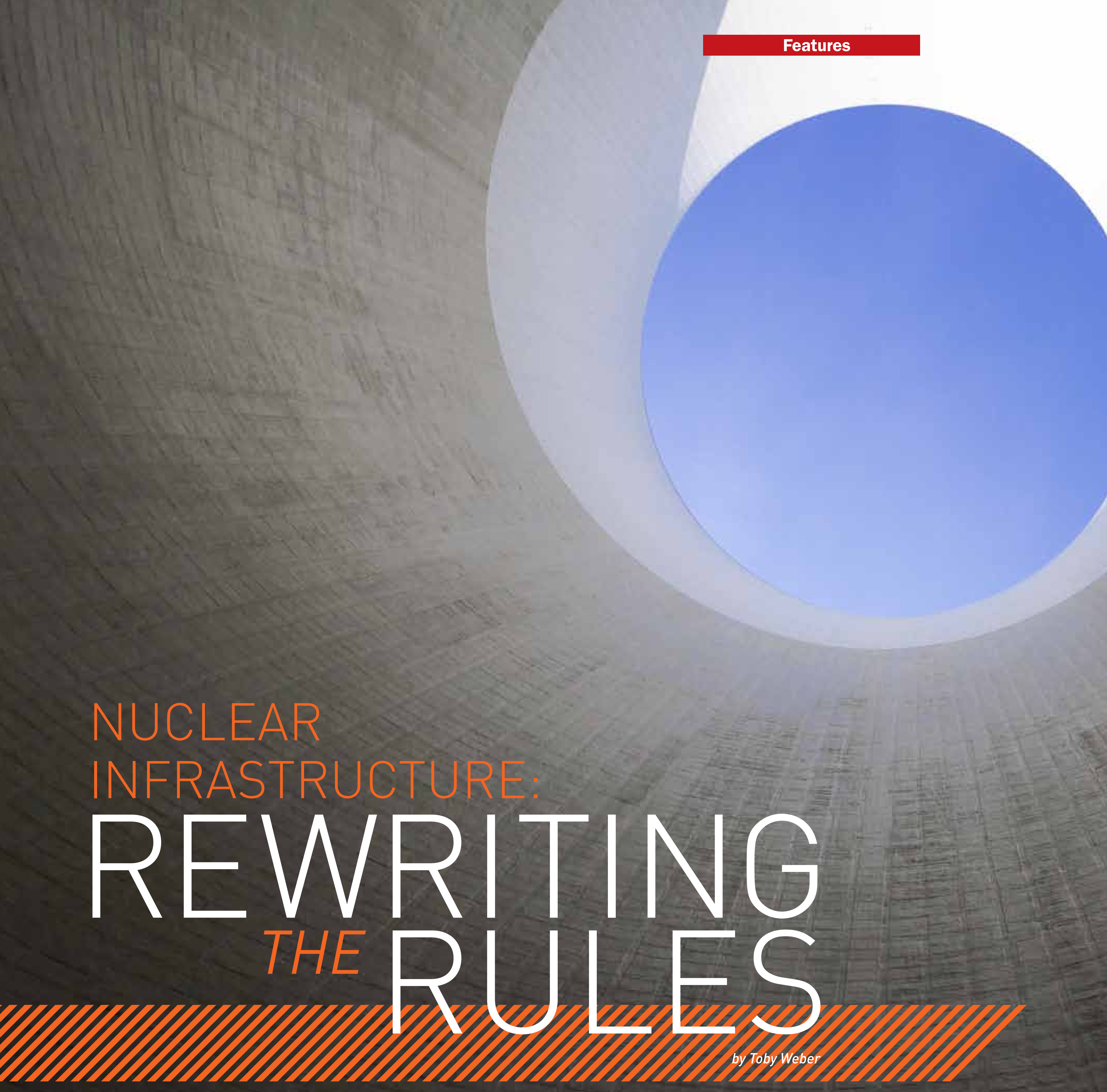
Professor Part of Oil Spill Study

» Ramanan Krishnamoorti, professor and chair of chemical and biomolecular engineering, is part of a major multi-institutional, $112.5 million grant awarded by the Gulf of Mexico Research Initiative Research Board to study the effects of the 2010 Deepwater Horizon oil spill. The effort is geared toward the development of new tools and technology to respond to future spills and improve mitigation and restoration efforts.

Marathon Oil Donates Rig Model to Cullen College

» Marathon Oil Company has donated a scale model of their North Sea Brae B platform to the college. The 14-foot-tall rig model was a fixture at Marathon for a couple of decades and is now located in the foyer of the one of the college's academic buildings. The Brae B rig itself was installed in 1987 over a period of 67 days and weighs some 72,000 tons. Marathon has been instrumental in providing support for the Cullen College; in particular, the company was the first corporate donor to make a major gift to the new undergraduate Petroleum Engineering Program in 2008.

cullen college news @cullencollege



NUCLEAR INFRASTRUCTURE: REWRITING *THE* RULES

by Toby Weber

NUCLEAR POWER is in a time of transition.

The events at the Fukishima Nuclear Power Plant in Japan earlier this year have caused many countries to rethink or even abandon the technology. Meanwhile, countries like China are in the midst of such rapid economic growth that nuclear is the only practical way for them to meet their future energy needs. No matter what, they will almost certainly end up building scores of more plants in the coming years.

Regardless of which route a country chooses to take, all can agree that nuclear plant infrastructure should be as durable and resilient as possible. At the University of Houston Cullen College of Engineering, researchers are literally rewriting the rules on how to design nuclear plant infrastructure in order to withstand greater loads and monitor infrastructure health.

Kaspar Willam and Ashraf Ayoub are using computer simulations to determine how concrete reacts to the high radiation levels and temperatures inherent in nuclear reactors, and aim to integrate these findings into structural analyses of nuclear plants.

Thomas Hsu, a giant in the reinforced concrete community, organized a hugely successful international nuclear infrastructure conference that took place in late 2010, and is now editing a book that will be the most up-to-date manual on how to design nuclear plants.

Gangbing Song is remaking the way nuclear plants are maintained. While visual inspections are a primary means of ensuring the health of plant infrastructure, Song has developed a far more reliable piezoelectric-based sensing system that, with a push of a button, can provide a full report on the health of plant's infrastructure.

Also studying structural materials is Yashashree Kulkarni, who is exploring the affects of high radiation on nanotwinned metals and how to optimize these metals for use in applications where they will be exposed to such conditions.

And finally, Yi-Lung Mo recently won a Department of Energy grant to develop a new class of foundation/base isolation system for nuclear power plants. Instead of providing improved strength and ductility to withstand loads, this system will cause seismic waves to literally bounce off the structures without causing any serious damage.

SPANNING THE GAP

photo by TBS Photography

"[We're] evaluating the structural response through three-dimensional load simulations, in particular under the effect of temperature, radiation and multiple hazards."

There's a serious shortcoming in the large swath of structural research, and a pretty obvious one at that.

Many investigations focus on one of two areas: materials (concrete or steel, for example), or structures (buildings, bridges, etc.). That approach can make sense based on individual researchers' areas of expertise. But it creates a gap that doesn't exist in the real world, where the properties of the material and of the structures are in constant interaction.

While researchers performing structural analysis often integrate material properties into their models, having experts on materials and structural analysis collaborate in a single investigation can help researchers make the biggest possible contributions to their fields.

That's a good description the partnership formed by UH Civil Engineering Professors Ashraf Ayoub and Kaspar Willam. The two are combining their expertise to conduct "multiscale" research that integrates the most up-to-date findings on material properties into computer models of various types of structures, including planned studies of nuclear power plants.

Willam, a member of the National Academy of Engineering, is an internationally recognized authority on concrete behavior. Much of his research involves using computer models to determine the multi-axial material properties of concrete under different environmental and mechanical effects.

"Concrete is a mixture of several components," said Willam. "It combines dense aggregates that are embedded in a cement paste matrix. They all have their own properties, which lead to mismatch of their responses under different stresses."

Willam's earlier work includes explorations of how concrete performs under rapid heating and drying, an effect very much in play at nuclear power plants. Spurred by the search for the technical explanation behind the destruction of the World Trade Center, in 2009 he and his collaborators published a 200-plus page report outlining their research into concrete spalling, a phenomenon where the surface of concrete basically explodes under rapid heating.

Their findings indicated that two factors are likely at work. In one, water in the pores of the concrete mix heats and expands, causing internal pressure. The other likely culprit is restrained thermal strain, where high heating near the surface of the material causes a large increase in compressive stress and potential local instability.

More recently, Willam has received funding from Oak Ridge National Laboratory to review the effects of high nuclear radiation levels on concrete — information that should help provide a starting point for future projects.

This is where Ayoub comes in. A researcher whose areas of expertise include structural modeling, his goal is to integrate Willam's findings on concrete properties into global structural models, which makes these analyses even more realistic and compelling. He plans to build multiple models of nuclear power plants. Through computer simulation he will expose these plants to the previously mentioned stresses due to temperature and radiation, as well as hazards such as earthquakes, wind and man-made impact.

"When you create a model, you subject the structure to certain loads and see how it responds, what kind of internal forces and deformations occur," said Ayoub. "What we're doing here is basically evaluating the structural response through three-dimensional load simulations, in particular under the effect of temperature, radiation and multiple hazards."

By comparing how these structures react to these loads and stresses, Ayoub and Willam should be able to help develop new multi-scale modeling techniques for nuclear plants. Developing a systematic way to apply these findings is another job altogether, however.

Fortunately, Ayoub and Willam have embraced that task. Both sit on Committee 447 of the American Concrete Institute, charged with creating a post-processing module that allows structural designers to customize their work for nuclear power applications. Currently, no such module exists.

"This is an extra post-processing module to take the output data and convert them into meaningful design quantities," Ayoub said. "This is guidance for industry engineers that is missing in the literature."

That guidance — guidance that grows in part out of a "multiscale" collaboration that considers nuclear plants' unique properties — should pay off in the form of new nuclear plants that are designed more safely and better able to produce power reliably.

LEADING THE INFRASTRUCTURE FIELD

photo by Todd Spoth

In 1986, Thomas Hsu received a grant from the National Science Foundation. With a team of graduate students and technicians, he took that funding and, in two years, built an absolute beast of a machine. More than 80,000 lbs. of metal, pipes and tubing.

That machine, the Universal Element Tester, remains the most advanced tool of its kind to this day. It uses a set of 40 jacks to exert up to 1,000 tons of pressure in each of four different directions. Thanks to a sophisticated electronic control program, it can apply practically any type of load, including compression, tension, torsion, shear, bending and their combinations.

And what, you may ask, does the machine test? Concrete panels, aka, walls.

"We pretty much have the world's best equipment to test walls," said Hsu.

While walls may seem simple to the uninitiated, any civil engineer worth his slide rule knows they're actually very complex. A column, for instance, only deals with one-dimensional stresses in the vertical direction. Walls however, bear stresses in two dimensions (horizontal and vertical) on a daily basis, and even three dimensions in certain unfortunate circumstances, such as earthquakes. How these stresses interact with and affect each other is a serious and complicated topic, and one that was little understood when the UET crushed its first concrete panel more than 20 years ago.

While most structures wouldn't even be structures if it weren't for walls, in nuclear power plants they do a lot more than just keep the wind out and the air conditioning in.

"Any building you're in usually has lots of columns and beams. Stack them all up and you get a building," said Hsu. "But in a nuclear power plant there are nuclear reactor vessels, pressure vessels, and a lot of pipes, valves and other things that you don't want to move, because a leak can be very dangerous. Since walls are very rigid, nuclear plant designers rely on them more than they do in a normal building."

> "We pretty much have the world's best equipment to test walls."

This makes understanding the dynamics of walls vitally important to nuclear power plant infrastructure. Through his work on the UET, Hsu has become one of the world's leading authorities on the behavior of concrete walls and, by extension, how to build a nuclear plant. Just one year ago, in fact, he and fellow Civil Engineering Professor Y. L. Mo published the book "Unified Theory of Concrete Structures," which synthesized roughly 25 years of two- and three-dimensional concrete panel research.

That book, and the decades of research and service it represents, has made Hsu a pillar of the reinforced concrete research community. Last year, he put this authority to good (and now seemingly prescient) use by organizing and chairing the International Workshop on Infrastructure Systems for Nuclear Energy.

The workshop truly was an international meeting, Hsu noted. Held in Taipei, Taiwan, it featured presentations from many of the top nuclear infrastructure researchers from United States, Asia and Europe. The choice to hold the conference in Asia was quite deliberate, said Hsu.

Most of the nuclear power plants that will be built in the next couple of decades will be built in Asia, with China alone expected to construct hundreds more plants in the coming years.

"You need to have the best people in the world working on this issue," said Hsu. "We work with top international institutions and experts to share and advance knowledge and to reach across national and generational divides."

With 33 presentations and roughly 120 attendees, the conference received positive reviews all around, Hsu said. More important, though, is that the event served as the catalyst for the formation of multiple research collaborations.

Hsu himself is a participant in one of these collaborations, in fact. Working with investigators at the National Center for Research on Earthquake Engineering (NCREE), he is using the conference presentations as the basis for a book on nuclear plant infrastructure. Hsu spent this summer in Taiwan editing the publication, which should weigh in at 500 to 600 pages when it is published next spring.

"When it comes out it will be the most up-to-date, advanced guide for building infrastructure of nuclear power plants," Hsu said.

STRUCTURAL MONITORING

Gangbing Song has developed and is now testing a piezoelectric-based system that can instantly provide reports on the health of entire pieces of infrastructure.

Binoculars should be for bird watching, *not preventing nuclear catastrophe.*

Surprisingly, though, they're used for both. One of the primary ways nuclear plant operators monitor the health of their infrastructure is visual inspection. And that often boils down to someone using a pair of binoculars to look for cracks in the hard-to-reach pieces of infrastructure.

At the University of Houston Cullen College of Engineering, a research team led by Professor of Mechanical Engineering Gangbing Song is developing a system, in collaboration with Yi-Lung Mo from the college's Department of Civil and Environmental Engineering, that brings infrastructure monitoring into the 21st century in collaboration.

Song's system is based on a series of smart aggregate sensors. These aggregates are surprisingly humble looking, consisting of two wires wrapped in a single piece of insulation and connected to a black cube small enough to be carried in a pocket.

Inside each cube lies a strip of piezoelectric material. Piezoelectrics have the unique ability to convert mechanical energy to electrical energy and vice versa. Compress or bend a piezoelectric and it will generate an electrical charge; jolt it with electricity and it will move. Piezoelectrics are used in everything from lighters, which use the spark generated by mechanical energy to ignite the lighter fluid, to cell phones, which rely on piezoelectrics for their vibrate function.

This mechanical-to-electrical conversion lies at the heart of Song's smart aggregate system. Under Song's plan, the aggregates are placed in the actual concrete of a piece of infrastructure, such as the containment domes that serve as the final barrier against the release of radiation in the case of a disaster.

Plant operators will send an electrical charge to one aggregate through one of its wires, causing the aggregate to vibrate. The wave created by that vibration will then travel through the structure and register with all the other aggregates, which will translate that mechanical energy into an electrical signal. "When the structure is healthy, we will record these signals and use them as a reference. When we run a test later, we can compare the results. If there's a dramatic change, we know something has happened," said Song.

photo by TBS Photography

Cracks that form in structures, for instance, will alter or even halt wave propagation. Aggregates near a crack would register a change in how the wave is traveling through the structure, altering plant operators to the existence and rough location of a problem. The system can even be used to alter operators to larger troubles, said Song. Based on a close reading of the waves recorded by the smart aggregates, plant operators would be able to tell if water has filled a crack, which could be a sign that radioactive material is leaking into ground water.

The smart actuators could also be used to measure the force of an impact or earthquake at a nuclear power plant. Since regulators worldwide require that these plants be built to withstand loads up to a set point, such a calculation could give an immediate big picture view of a nuclear plant's infrastructure after a disaster.

"If a vehicle hits the structure, we'd be able to tell the level of force from the impact. And if there's an earthquake we'd be able to tell the force-level applied to the structure at different locations," said Song.

Given that this system quickly and easily provides a detailed look at infrastructure health, it could be particularly valuable at decommissioned nuclear power plant sites, noted Song. One of the less-costly options for decommissioning these plants is to bury them in feet of concrete, preventing spent nuclear fuel from causing any harm as it slowly decays over the course of decades and longer.

Of course, there are still several hurdles that must be cleared in order to make all of this a reality. One of the biggest is simply managing the data. With aggregates likely to be placed every few yards, a large structure could easily have thousands of them.

"We have a lot of aggregates, so how are we going to quickly process all the data they provide, especially in large-scale implementation? That's one of the most significant challenges," Song said.

Notably, Song will have the opportunity to wrestle with this problem, at one of the world's most important nuclear sites. Thanks to a recent grant from the U.S. Department of Energy, Song will conduct meso-scale tests of his smart aggregates in partnership with Savannah River Nuclear Solutions, a privately run facility charged by the federal government with converting uranium into nuclear fuel and storing spent nuclear fuel from reactors around the world. The tests will be conducted at Florida International University's Advanced Research Center.

If those tests are successful, there could be just a few years between now and the implantation of a new system for monitoring nuclear infrastructure health, and putting the binoculars in their case once and for all.

NANOTWINNING METALS

While concrete is the most relied on material for nuclear power plant infrastructure, it is by no means the only one. These facilities rely on a great number of other materials, from copper and steel to ceramics and polymers. And all of these materials must be able to withstand the loads and strains imposed on nuclear energy generation and storage facilities.

Yashashree Kulkarni, assistant professor of mechanical engineering at the Cullen College of Engineering, is exploring the ability of one relatively new class of structural materials, specially fabricated "nanotwinned" metals, to withstand prolonged exposure to high radiation. Her findings could help determine if they are suitable for use in nuclear power plants and storage facilities. She is the sole principal investigator on a recent three-year, $228,431 grant from the National Science Foundation to conduct this research.

"We know that nanotwinned metals provide ductility and strength. The question is whether there is a perfect way to fabricate these metals that could also lead to radiation resistance," said Kulkarni. "If so, that's an ideal combination of properties."

To understand how this combination could be achieved, it's best to first understand the makeup of nanotwinned metals.

Copper, gold, aluminum and similar metals are composed of individual crystalline grains that are typically a few micrometers large. Material failure by irradiation can occur when the atoms within these grains become dislodged due to heat or radiation. If the dislodged atoms migrate to the surface of the metal they will cause the material to swell. They can also clump together, resulting in brittleness, while the voids left by the dislodged atoms can aggregate, forming the beginning of cracks.

The properties of these materials are determined by how the individual grains are organized. The grains lie at different orientations pointing in different crystallographic directions. The interfaces, or grain boundaries, between these grains can serve as sinks for dislodged atoms and vacancies, and as barriers for defects such as dislocations, effectively increasing the strength of the material.

Through her research, Kulkarni is seeking to maximize these desirable properties, as well as fine-tune the materials to enhance ductility and withstand high radiation, by arranging not just the grains but by creating "nanotwins" within each individual grain.

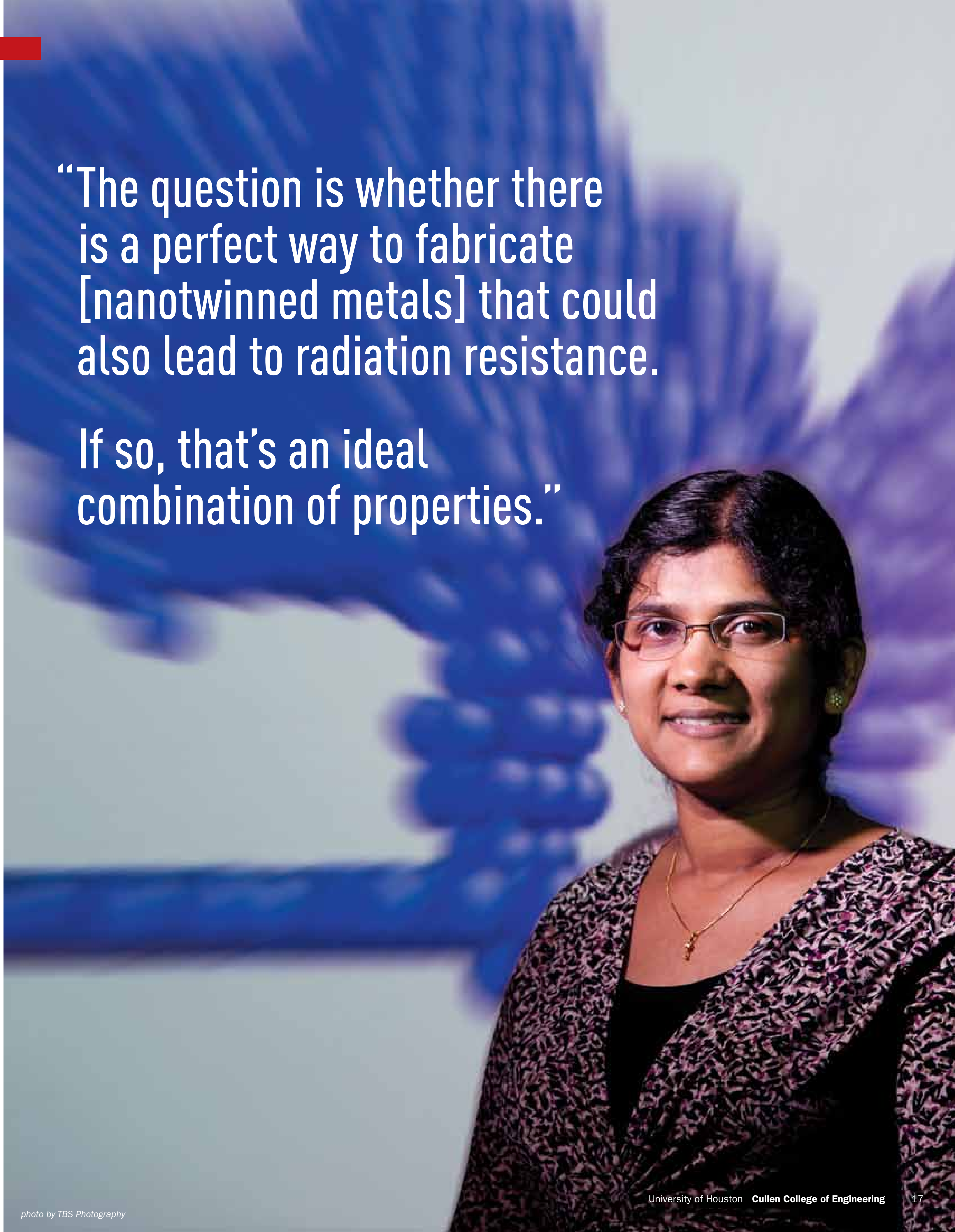
In nanotwinned metals, rows of atoms inside the grains are arranged in symmetrical pairs of mirror images (twins) stacked one on top of the other. The boundaries where the twins meet serve the same role within individual grains that the boundaries do between grains, providing strength ductility and resistance to crack propagation.

"The plane of the twin boundary is a very good plane for defects to move," said Kulkarni. "The dislocations that occur can actually move along this plane. They can then get absorbed into the boundary of the twins. The vacancies can also get absorbed. That provides some ductility, allowing these metals to accommodate some strain without leading to fracture."

While all this is well known, less understood is how high-energy radiation impacts nanotwinned metals, including its ability to dislodge atoms and create voids. Kulkarni will use computational analysis to examine how twin boundaries react to prolonged exposure to radiation and explore the limits of the boundaries ability to absorb defects.

Kulkarni will also look for ways to improve the properties of nanotwinned metals by modifying their structure. By tweaking the material's design, she hopes to achieve the above-mentioned ideal combination or strength, ductility and radiation resistance.

"The ultimate question in design is optimization," she said. "What should the optimal twin spacing be? What should be the twin size compared to the size of the grain? All these factors change the properties of the material. My research team and I will try to find the combination that provides the best mix of strength, ductility and radiation tolerance for different applications."



"The question is whether there is a perfect way to fabricate [nanotwinned metals] that could also lead to radiation resistance.

If so, that's an ideal combination of properties."

photo by TBS Photography

photo by TBS Photography

DEFLECTING THE THREAT

Nuclear power plants have to be able to take a punch. The stakes are just too high for them to literally crumble when they get hit.

That's why those who build these facilities utilize every advance in structural engineering to make new plants as strong and ductile as possible. It's a brawn versus brawn strategy, essentially.

But what if, instead of being designed to take a beating, these plants could be built to avoid that beating altogether?

That's essentially what Yi-Lung Mo, a professor in the Cullen College's Department of Civil and Environmental Engineering, proposes, at least for earthquake-induced loads. Thanks to a new base isolation system/foundation designed by Mo, seismic waves could end up literally bouncing off critical pieces of infrastructure such as nuclear power plants, preventing these facilities from being placed under any damaging load at all.

To understand this system, it's best to first start with a quick primer on traditional base isolation techniques that are applied to nuclear power plants.

These systems are typically composed of steel/rubber pillars (the conventional base isolators) placed into the ground that connect upward to the plant's foundation. Their job is to absorb the energy of an earthquake. As currently designed, though, these systems simply aren't able to handle the large deformations conventional base isolator suffer during large earthquakes. As a result, energy travels up through the base isolation system to the foundation and structure itself, where it can cause serious damage.

Mo's approach eliminates the use of a base isolation system distinct from the foundation, combining them into a single unit made of advanced materials.

This unit is based on the concept of periodic materials, an idea developed in the field of solid state physics. The theory holds that certain heterogeneous materials can be carefully engineering to be given a distinct frequency bandgap. This bandgap is essentially a frequency range; seismic waves that fall within that range literally bounce back to their source.

The heterogeneous materials Mo is using are nothing more than commercially available steel, rubber and concrete.

This system starts with a cylinder of solid steel that is enclosed in a layer of rubber. The two are then surrounded by concrete. That combination is then repeated to form the whole of a structure's foundation.

"We have one unit after another and another, all in a grid," said Mo. "As long as we can maintain that pattern, a seismic wave will reflect without traveling up the structure, no matter what direction it comes from."

Given that the bandgap covers only a set range of frequencies, one of the challenges of this effort is to develop a system with a bandgap that accounts for most seismic events. Mo's goal is to find the combination of grid design and material proportions to create a bandgap of between 0.5 hertz and 10 hertz — a range that includes almost all earthquakes, regardless of their actual magnitude.

"There's no direct correlation between a seismic wave's frequency and the magnitude of an earthquake," said Mo. " But what we're going to do should be able to reflect any magnitude — six, seven, eight, nine, 10 — as long as the frequency falls between 0.5 and 10 hertz."

Mo has already produced mathematical models that show the viability of this system. In August, he won a $538,000 grant from the U.S. Department of Energy's Nuclear Energy University Program to build and test scale models of this new system. He is partnering with researchers at The University of Texas who have access to mobile field shakers, as well as researchers at Prairie View A&M University and Argonne National Laboratory.

If successful, Mo believes this new approach is best suited for two recently proposed types of nuclear power generators: advanced fast nuclear power plants and some small modular fast reactors. If built, these new classes of nuclear power facilities would have significantly smaller footprints than tradition nuclear power plants, making this system more economically viable.

Nuclear power plants aren't the only facilities where this system could be useful, Mo pointed out. Hospitals, also critical and expensive pieces of infrastructure, could benefit from this technology, as could companies whose manufacturing processes require extreme precision, such as computer chip makers.

Still, nuclear power is the area where this could make the biggest difference in case disaster strikes, Mo said.

"Everyone has seen what happens when the infrastructure at a nuclear power plant fails," said Mo. "So we should take every step to make these plants as safe as they can be. This system can play a big role in that by isolating new plants from one of the most serious threats they face."

Paul Ruchhoeft

Associate Professor of Electrical and Computer Engineering

Education

Ph.D. Electrical Engineering, University of Houston

Career Overview

Ruchhoeft joined the University of Houston Cullen College of Engineering following the completion of a research professorship with the department in 2001. He also received an M.S. in electrical engineering from UH and a B.S. in electrical engineering from The University of Texas at Austin.

Ruchhoeft's cross-disciplinary research in nanolithography and nanofabrication has resulted in five patents and he has several pending patents for other bionanotechology developments. He has authored or co-authored more than 30 peer-reviewed journal publications and is conducting funded research with support from the National Science Foundation, the Alliance for Nanohealth, the Western Regional Center for Biodefense and Emerging Infectious Diseases (NIH), the state of Texas' Advanced Research Program, and the University of British Columbia.

A distinguished young alumnus of the UH Cullen College of Engineering, Ruchhoeft has also been honored as an outstanding teacher and researcher. He has been involved for many years in Research Experience for Teachers, a program funded by the National Science Foundation.

Research Interests

Most of Ruchhoeft's research interests are in the areas of nanolithography and nanofabrication. Specifically, he focuses on the development of a parallel printing process with nanoscale resolution using energetic helium ions and atoms and the development of new low-cost stencil masks used in the patterning process. Applications of this research include the formation of nanoparticles with engineered shape and composition; the development of rapid diagnostic tools using retroreflecting microparticles and surfaces; the direct patterning of antibody-coated surfaces; and the fabrication of large-area, periodic nano-scale patterns for use in infrared metal-mesh filter manufacturing and water filtration membranes.

photo by TBS Photography

Accolades

BIOMEDICAL ENGINEERING

Metin Akay delivered the keynote address titled "Global Healthcare Challenges and Opportunities," at the first Middle East Conference on Biomedical Engineering.

Kirill Larin has been named a senior member of SPIE, the international society for optics and photonics.

CHEMICAL AND BIOMOLECULAR ENGINEERING

Vincent Donnelly is the 2011 recipient of the American Vacuum Society's John A. Thorton Memorial Award. He will receive the honor during AVS' 58th International Symposium and Exhibition in November.

Demetre Economou received the W.T. Kittinger Teaching Excellence Award from the college.

Miguel "Micky" Fleischer received a Distinguished Engineering Alumni Award from the UH Engineering Alumni Association.

Raymond Flumerfelt received an Outstanding Teaching Award from the college.

James Richardson was honored with an Excellence in Applied Catalysis Award by the Southwest Catalysis Society, the local chapter of the North American Catalysis Society.

CIVIL AND ENVIRONMENTAL ENGINEERING

Abdeldjelil "DJ" Belarbi received the American Concrete Institute's Joe W. Kelly Award, an international award given to distinguished individuals for outstanding contributions in education relating to the broad field of concrete.

Mina Dawood received an Outstanding Teaching Award from the Cullen College of Engineering.

Thomas Hsu was recognized at the 2011 American Concrete Institute Annual Convention for 50 years of membership.

Hanadi Rifai was named a fellow of the American Society of Civil Engineers.

Jerry Rogers received the American Society of Civil Engineers Environmental and Water Resources Institute's 2011 Lifetime Achievement Award. He also received ASCE's 2011 Civil Engineering History and Heritage Award.

ELECTRICAL AND COMPUTER ENGINEERING

Betty Barr received a Teaching Excellence Award from the University of Houston. She also received a Career Teaching Award from the college.

Joe Charlson received an Outstanding Teaching Award from the UH Cullen College of Engineering.

Ji Chen received a 2011 Technical Achievement Award from the Electromagnetic Compatibility Society of the Institute of Electrical and Electronics Engineers.

Ovidiu Crisan received the Institute of Electrical and Electronics Engineers Region 5 Outstanding Student Branch Counselor Award for the second consecutive year. Region 5 is home to more than 90 IEEE student chapters in 13 states.

Diana de la Rosa-Pohl received an Outstanding Lecturer Award from the college.

Zhu Han and his two co-authors received the 2011 Fred Ellersick Prize Award for their paper on cognitive radio providers published in the April 2009 edition of *IEEE Wireless Communication Magazine*. The award honors the best paper in an IEEE communications magazine during the last three years. He also received an Excellence in Research and Scholarship Award at the assistant professor level from the University of Houston.

David Jackson was elected Secretary of the U.S. National Committee of the International Union of Radio Science, effective January 2012.

Dmitri Litvinov was named a John and Rebecca Moores Professor. He also received the Senior Faculty Research Award from the college.

Wei-Chuan Shih received the Best Poster Award at the Advances in Optics for Biotechnology, Medicine and Surgery Conference for his poster titled, "High Throughput Chemical Imaging of Living Cells."

INDUSTRIAL ENGINEERING

Qianmei "May" Feng received the Junior Faculty Research Award and an Outstanding Teaching Award from the college.

MECHANICAL ENGINEERING

Karolos Grigoriadis received the Abraham E. Dukler Distinguished Engineering Faculty Award from the UH Engineering Alumni Association.

Fazle Hussain was appointed as an honorary professor at Peking University, the only engineer to hold the distinction, and received the honorary title of dean of engineering at The Methodist Hospital Research Institute. He delivered Clarkson University's 2011 Distinguished Lecture titled "New Horizons in Engineering."

Javad Mohammadpour received an Outstanding Lecturer Award from the college.

Pradeep Sharma received an Excellence in Research and Scholarship Award at the associate professor level from the University of Houston.

Gangbing Song received the 2011 Faculty Award for Mentoring Undergraduate Research Students from the University of Houston.

A Salute to Three Longtime Faculty

Three University of Houston Cullen College of Engineering professors have retired this year, leaving a legacy of distinguished service dedicated to teaching and research. All three are UH graduates.

Betty Barr

Betty Barr, one of the college's first female faculty members, began her career in 1971 at UH as a linear algebra instructor, soon moving to the Department of Electrical and Computer Engineering to teach programming. Barr served an integral role in shaping the department's undergraduate curriculum, becoming the director of undergraduate studies in 1982. She has also served as the faculty advisor for the Society of Women Engineers and is best known as the mathematical problem designer for the slide rule competition at the annual Institute for Electrical and Electronics Engineers (IEEE) Chili Cook Off. Barr has been recognized numerous times for her outstanding career with honors such as the college's Career Teaching Award, UH's Teaching Excellence Award, the 2007 inaugural Provost Faculty Advising Award for Excellence in Undergraduate Academic Advising, the 2005 IEEE Region 5 Outstanding Engineering Educator Award, the 2005 Dukler Distinguished Engineering Faculty Award from the UH Engineering Alumni Association, the George Magner Academic Advising Award, and the Kittinger Teaching Excellence Award. Barr received her B.S., M.S. and Ph.D. in mathematics from the University of Houston in 1967, 1969 and 1971, respectively.

Charles Dalton

As an undergraduate at UH, Charles Dalton was offered a teaching assistantship with the Cullen College of Engineering, and was soon promoted to instructor in 1960. After completing his master's degree, he enrolled in a doctoral program at The University of Texas at Austin. During the second year of his Ph.D. work, he was offered a job in the UH Department for Mechanical Engineering, and spent a record 51 years as a faculty member in that department. He also served as an associate dean of the college for 18 years. Dalton's research focused on computational fluid dynamics. Along with one of his graduate students, he published the first calculations for vortex-induced vibrations, as well as the first calculations of the Honji Instability. Dalton is a three-time Cullen College of Engineering Outstanding Teacher Award winner. He has also received the Mechanical Engineering Professor of the Year Award, the college's Career Teaching Award and Kittinger Teaching Excellence Award, the Engineer of the Year Award and the Claude L. Wilson Award from the South Texas Section of American Society of Mechanical Engineers (ASME), and the Dukler Outstanding Faculty Award from the UH Engineering Alumni Association. Dalton completed his B.S. and M.S. in mechanical engineering at the University of Houston in 1960 and 1963, respectively, and earned a Ph.D. from The University of Texas at Austin in 1965.

Leang-San Shieh

Leang-San Shieh joined the Department of Electrical and Computer Engineering in 1971 as an assistant professor. He was promoted to associate professor in 1974 and professor in 1978. Since 1988, he has been the director of the Computer and Systems Engineering Program. Shieh has a prolific body of research in digital control, optimal control, self-tuning control and hybrid control of linear and nonlinear systems, with over 300 peer-reviewed journal papers, including a research monograph. He has directed 65 master's theses and 35 Ph.D. dissertations. Shieh is a senior member of IEEE and the American Institute of Aeronautics and Astronautics, and a registered Professional Engineer in the state of Texas. He has received the college's Dukler Distinguished Engineering Faculty Award, the Career Teaching Award, the Fluor Daniel Faculty Excellence Award, the Senior Faculty Research Excellence Award, the Kittinger Teaching Excellence Award and numerous Outstanding Teacher Awards from the college. He was also honored with the El Paso Faculty Achievement Award in Teaching and Scholarship from the University of Houston; the Honor of Merit from Instituto Universitario Politecnico, Republic of Venezuela; and a UH Teaching Excellence Award. Shieh received his B.S. from National Taiwan University in 1958, and M.S. and Ph.D. degrees from the University of Houston in 1968 and 1970, all in electrical engineering.

photo by Thomas Campbell

Professor's Bacteria "Slingshot" Finding Published in *PNAS*

Proceedings of the National Academy of Sciences has published an article on bacterial motility co-written by Jacinta Conrad, assistant professor in the Cullen College's Department of Chemical and Biomolecular Engineering.

The piece, published in the August 2nd issue and available online, describes a newly found method of motility using hair-like appendages called pili. Bacteria typically use pili to pull themselves in a given direction, but recent research has shown they can be used for other types of movement. Using sophisticated algorithms to track bacterial movement, Conrad and her collaborators found the organisms use pili to "slingshot" themselves in order to change their orientation and move in different directions.

They achieve this by having multiple pili pulling in different directions. Some pili then release from the surface, causing the bacteria to whip around into a new position. "You can think of it as pulling with multiple grappling hooks. If you let one go you'll re-equilibrate to the sum of the forces from those that are still attached," said Conrad. This method allows bacteria to move 20 times more quickly than if they simply used their pili to pull themselves along.

In addition to being extremely efficient, Conrad and her co-authors believe this quick movement helps thin the viscous polymer-water suspension bacteria produced prior to forming a biofilm, making it easier for them to move.

Conrad's co-authors on this article were senior author Gerard Wong, professor of bioengineering at the University of California, Los Angeles; and two members of his research group, Maxsim Gibiansky and first author Fan Jin.

photo by Thomas Shea

Professor Developing Injection-based Paralysis Treatment

Dong Liu, assistant professor with the Cullen College's Department of Mechanical Engineering, recently won a $390,000 grant from the National Science Foundation to develop an injection-based paralysis treatment.

When a spinal cord is damaged, the nerve fibers that transmit signals between the brain and the rest of the body can be too damaged to properly function, leading to paralysis. Liu's treatment will spur these fibers, called axons, to regrow across the damaged area.

At the heart of this new treatment are special iron oxide particles measuring approximately 20 nanometers. These particles have a unique property known as superparamagnetism. When they are exposed to a magnetic field, they themselves become tiny magnets, each with a north and south pole. Since these opposite poles are attracted to each other, the particles will naturally self-assemble into chain lattices along the direction of an applied magnetic field.

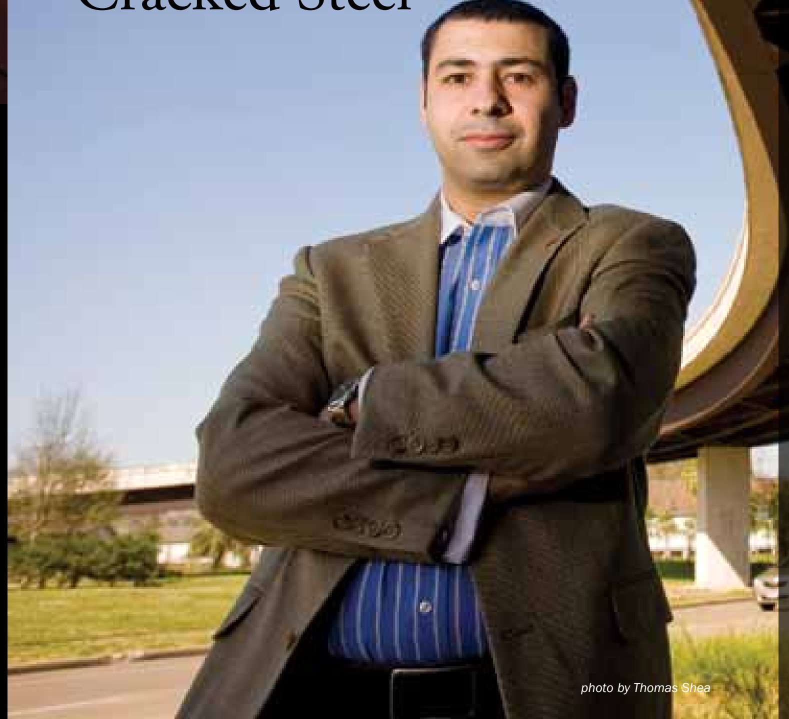
Liu encloses these particles in magnetoliposome, a lipid-based structure that is very similar in chemical makeup to the walls of stem cells. Magnetoliposome, however, has a positive charge, while the stem cells are negatively charged. The opposite charges draw the two together, while their chemical similarities allow the magnetoliposomes, along with the nanoparticles they contain, to easily pass through the cell wall.

"We let the stem cells engulf those liposomes. Since you have a magnetic force you can exert on the particles, if the particles are inside the cells you have a force you can exert on the cells and manipulate them, for example, to form a stem cell chain along a specific direction." said Liu.

Next, the modified stem cells are put in a solution and injected into the patient near the injured area of the spinal cord. Doctors then expose the area near the injection to a finely tuned magnetic field that should cause the stem cells to form a column that reconnects the two severed ends of the spinal cord.

Liu's collaborators on this grant are fellow Cullen College Professor Li Sun and researchers at The University of Texas Health Science Center at Houston. Their efforts began with seed funding from the Alliance for Nanohealth.

Professor Developing Patch for Repairing Cracked Steel



Mina Dawood, assistant professor of civil and environmental engineering, has received a three-year, $300,000 grant from National Science Foundation to develop a new method of repairing cracks in steel structures such as bridges.

Dawood's plans to mix fiber-reinforced polymers with shape-memory alloys to form a patch that compresses the crack tip, like a bandage pulled tightly over a cut. In doing so, these patches would dramatically slow or even eliminate crack propagation.

While the fiber-reinforced polymers will give the patches strength, the 'pre-stressing' effect will be achieved through shape-memory alloys, which can be manipulated at the molecular level to take on a specific shape when, for example, they are heated to a certain temperature.

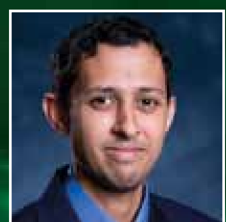
Dawood said a patch would likely be designed and fabricated offsite and then taken to a repair location. A repair crew would cover the crack with the patch, which would be held in place with a structural adhesive. When the bonding is complete, the patch would be heated with something as simple as a hair dryer. That heating would cause the patch to contract, pulling the two sides of the crack closer together.

In addition to being more reliable, this approach is also easier to implement than existing repair methods, noted Dawood. "You can imagine welding steel plates on the bottom of a bridge is not an easy task. These patches can be applied more quickly with less equipment and fewer workers."

Dawood has two primary collaborators on this project: Professor of Civil and Environmental Engineering Kaspar Willam; and Associate Professor of Mechanical Engineering Gangbing Song.

photo by Thomas Shea

Researcher Wins
NIH Vaccine Research Grant



Navin Varadarajan
Assistant Professor of Chemical and Biomolecular Engineering

A UH Cullen College of Engineering professor has received a grant to develop a new method of testing potential vaccines, and will use this approach to fight a virus identified as an emerging bioterrorism threat.

Navin Varadarajan, assistant professor of chemical and biomolecular engineering, won a two-year, $361,000 grant administered by the Western Regional Center of Excellence for Biodefense and Emerging Infectious Diseases Research and funded by the National Institutes of Health to test potential vaccines for the chikungunya virus. While rarely fatal, chikungunya causes arthritic symptoms so severe that some victims cannot even walk. Spread by mosquitoes, the disease's debilitating symptoms have led federal health and security officials to pinpoint it as a possible bioterrorism agent.

Not surprisingly, then, groups around the world are working to develop a vaccine for the virus, including a team from The University of Texas Medical Branch at Galveston and Tulane University with which Varadarajan is partnering. Varadarajan is testing the ability of potential vaccines developed by this group to spur the immune system to attack human cells that essentially have been taken over by the virus, becoming reservoirs for it to multiply.

When this occurs, the immune system produces CD8 T-cells that kill the co-opted cells. Since each CD8 T-cell is programmed to fight one particular disease, the vaccines being tested ideally will spur the immune system to produce CD8 T-cells that recognize only chikungunya-infected human cells.

Using standard research techniques, isolating and studying CD8 T-cells is extremely challenging. These cells are only 10 to 20 microns across, less then a quarter the width of a human hair. Blood samples from subjects injected with the vaccine, however, are usually placed on plates that have wells that measure roughly six millimeters in diameter. Such a huge size disparity makes it extremely difficult to identify CD8 T-cells that are specific to a certain virus, and nearly impossible to isolate and study them.

Varadarajan, then, is developing a specialized polymer slide dubbed the microwell array. Roughly the size of a standard slide, it consists of approximately 85,000 individual chambers, each 50 microns by 50 microns — just the right size to isolate and study individual cells.

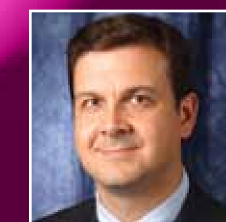
"If we shrink the container small enough so that its dimensions are similar to those of a single cell, we can achieve almost single-cell resolution. So within the same footprint, we can look at lots of cells," said Varadarajan.

Varadarajan will place a blood sample from a vaccinated subject on the microwell array. To identify which ones attack chikungunya, he will then introduce into the chambers cells that have been covered with pieces of the virus, spurring the CD8 T-cells that attack chikungunya into action.

He will then have a computer program analyze images of each individual chamber in order to identify the CD8 T-cells that are fighting chikungunya. Those cells will then be cloned by the millions, allowing Varadarajan to evaluate the effectiveness of these potential vaccines and provide guidance on vaccine development to his collaborators.

Developing New
"Platform" to Fight Malaria

Jeffery Rimer
Assistant Professor of Chemical and Biomolecular Engineering



Peter Vekilov
Professor of Chemical and Biomolecular Engineering

With resistance to existing antimalarial drugs on the rise, Jeffery Rimer and Peter Vekilov, both with the Cullen College's Department of Chemical and Biomolecular Engineering, have received a two-year, $150,000 seed grant from the U.S. Department of Defense to create an entirely new platform for developing medications to fight the disease.

This new platform will kill the malaria parasite by utilizing a quirk in the infection process.

Once introduced into a host, the malaria parasite enters the red blood cells and consumes hemoglobin by breaking the macromolecule into smaller constituents. One sub-unit of hemoglobin the parasite cannot use, however, is heme, which is highly toxic.

The malaria parasite combats this toxicity by neutralizing the heme. "It segregates the heme into little crystals about one micron in size. If the heme is sequestered in crystals it can't kill the parasite," Vekilov said.

Existing antimalarial medications presumably work by preventing the formation and/or growth of these heme crystals. As a result, heme molecules released by hemoglobin consumption are able to kill the parasite.

Exactly how these drugs prevent crystal formation is unknown, though. Vekilov and Rimer's work revolves around uncovering the process of heme crystal formation and then determining what kind of molecules could inhibit crystallization.

Vekilov believes that heme molecules attach to crystals at kinks, sites on the crystal surface that are favorable for the addition of new heme molecules. If this is in fact how heme crystals grow, Vekilov and Rimer will design "tailored inhibitors" that bond with the crystal surface and physically block the kinks, disrupting heme addition. Both believe this research will provide a deeper understanding of the type of molecules that could be the basis of new drugs.

photo by Thomas Shea

Professor Wins
Maritime Security Grant

Christopher Chung, associate professor of industrial engineering, has received a grant to develop a system to identify marine vessels as they enter sensitive areas.

The system will be based on Radio Frequency Identification (RFID), a technology that allows for automatic communication between a small electronic tag and an RFID reader. RFID is commonly used in industrial applications. By placing a reader at a warehouse's loading doors, for example, a company can automatically track tagged goods as they come and go.

Chung's idea, now funded by the U.S. Department of Homeland Security, is to integrate RFID tags into marine vehicle registration stickers. Authorities could then set up RFID readers around sensitive areas, such as ports, to identify ships that enter and exit. "If you have a vessel that comes into a port and it has no RFID signal, then you know there's something unusual about it. If a vessel goes into a restricted area and it has no tag on it, you know there's a potential situation," Chung said.

Chung will use the grant funds to evaluate system components such as RFID tags and antenna readers. In particular, he will look for components that are best suited for the maritime environment, such as tags that have good signal strength and antenna readers that can be integrated into flotation devices in order to cover large areas.

Chung is collaborating on this project with Lawrence Schulze, associate professor of industrial engineering at UH.

Grad Students Co-Author *Nature Materials* Graphene Paper

Two University of Houston Cullen College of Engineering graduate students co-authored a breakthrough article on graphene that was featured on the cover of the June 2011 issue of *Nature Materials*.

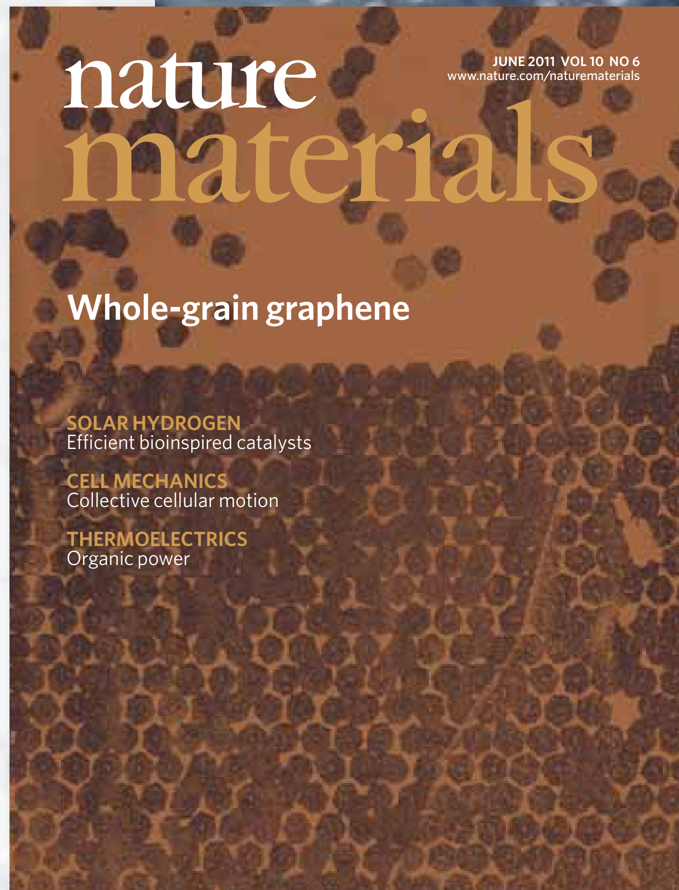
Wei Wu and Zhihua Su, both students in the Department of Electrical and Computer Engineering, contributed to the article outlining a method for creating single-crystal arrays of the graphene. They worked with first author Qingkai Yu, formerly a research assistant professor of electrical and computer engineering at the Cullen College and now an assistant professor at Texas State University, as well as UH Electrical and Computer Engineering Professor Stephen Pei.

Graphene is a one-atom-thick layer of carbon that was first fabricated in 2004. Single-crystal arrays of the material could be used to create a new class of high-speed transistors and integrated circuits that use less energy than silicon electronics.

But industry needs a reliable and defect-free method for manufacturing large quantities of single crystals of graphene. The development reported in *Nature Materials* marks a step towards perfecting such a method.

The paper outlines how single-crystal graphene arrays were grown on top of a copper foil inside a chamber containing methane gas using a process called chemical vapor deposition. The findings reported in *Nature Materials* demonstrated that researchers could control the growth of the ordered arrays. The researchers also were the first to demonstrate the electronic properties of individual grain boundaries.

The research was supported through a variety of funding sources, including the National Science Foundation, the U.S. Department of Energy, the U.S. Department of Homeland Security, the Defense Threat Reduction Agency, IBM Inc., the Welch Foundation, the Miller Family Endowment and Midwest Institute for Nanoelectronics Discovery.



UH IEEE Student Chapter Best in the Region, Again

UH Cullen College of Engineering students earned recognition for achievement in extracurricular activities and engineering competitions. For the fourth time in nine years, the UH Institute of Electrical and Electronics Engineers student branch received the Outstanding Large Student Branch Award for Region 5 — a region home to 90 IEEE student chapters across 13 states — at the 2011 IEEE Green Technologies Conference in Baton Rouge, La.

"We have received a lot of recognition in this region," said electrical engineering senior Jared Brayton, chairman of the UH Cullen College of Engineering student chapter of IEEE. "It's nice that people throughout our region know about UH electrical and computer engineering."

The award honors the chapter's efforts in fundraising, service projects, academic performance, social events and participation in IEEE initiatives. The group is active in providing local competitions for its members, outreach activities with area middle and high schools as well as non-profit organizations, and hosts an annual Chili Cook Off.

The group's long-time faculty advisor, Professor Ovidiu Crisan, was also honored as the IEEE Region 5 Outstanding Student Branch Counselor for the fifth time in 10 years. In fact, he was honored with this award for the second consecutive year.

"We're doing a great job," Crisan said. "The formation of our branch was good and we've had good student leadership. I hope to carry this forward."

UH Chem-E Car

EARNS TRIP TO NATIONALS

The University of Houston Chem-E Car team represented the Southwest region recently at the American Institute of Chemical Engineers' National Conference. The team of engineering undergraduates won second place at the AIChE Southwest Regional Conference, only edged out by a team from Mexico.

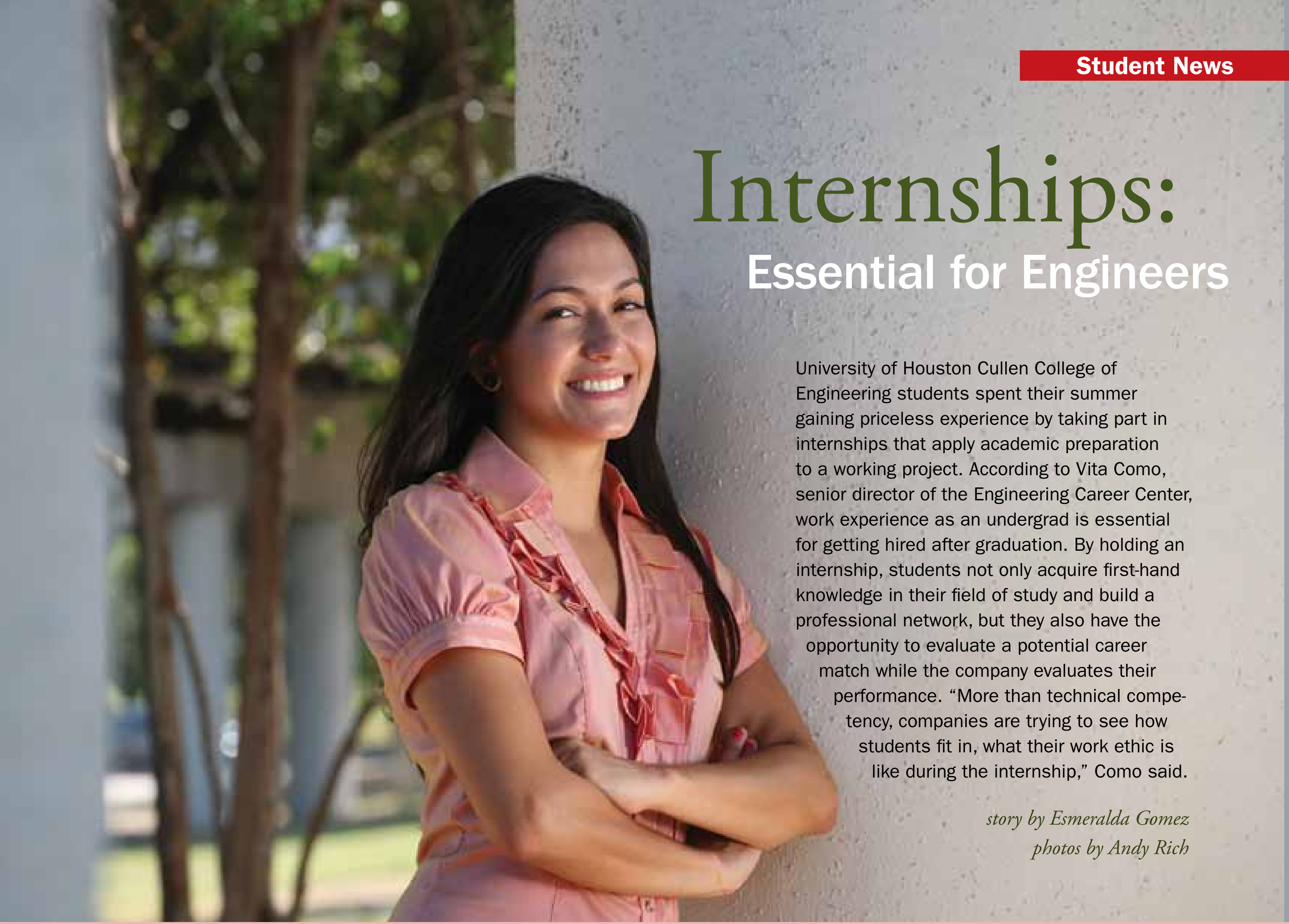
The challenge was to create a small vehicle powered by a chemical reaction that would meet distance and water weight requirements in a race. The Cullen College team designed a vehicle that was powered by a zinc-oxygen battery and has a stopping mechanism triggered by breaking a circuit. To break the circuit, the team used a magnesium filament placed in an acid dip.

"It takes time for the filament to decompose in the acid," said team captain Walter Barta, a senior chemical engineering major. "The rate of that reaction depends on the concentration of the acid. So we change the concentration of the acid to change the amount of time that we want the car to travel."

During the competition, the teams were asked to have their cars travel 65 feet while carrying 400 milliliters of water. The Cullen College team came in second place, beaten only by the team from Mexico's Tech de Monterey. In addition, the Cullen College team came in first in the poster presentation section of the contest.

By placing in the top two in actual car performance, the Cullen College team earned the right to participate in the national competition. In addition to Barta, team members included William Payne, Tanya Rogers, Ed McDowell and K.C. Schuette. UH AICHE officers Abel Morales, Jorge Cubas and Allen Lo also contributed to the effort. Micky Fleischer, adjunct professor of chemical and biomolecular engineering, served as the team's faculty advisor.

photo by Thomas Campbell



Internships:
Essential for Engineers

University of Houston Cullen College of Engineering students spent their summer gaining priceless experience by taking part in internships that apply academic preparation to a working project. According to Vita Como, senior director of the Engineering Career Center, work experience as an undergrad is essential for getting hired after graduation. By holding an internship, students not only acquire first-hand knowledge in their field of study and build a professional network, but they also have the opportunity to evaluate a potential career match while the company evaluates their performance. "More than technical competency, companies are trying to see how students fit in, what their work ethic is like during the internship," Como said.

story by Esmeralda Gomez
photos by Andy Rich

Ashley Camacho discovered civil engineering while in high school. She had been involved with the National Hispanic Environmental Council (NHEC), an organization that encourages students to pursue a degree in a field related to the environment. "I learned a lot from a civil engineer who told me all about the different things he has accomplished with his degree," Ashley said. "When I took my first engineering course with Professor Zhu Han, I knew that this is what made sense to me, and what I enjoyed doing."

Ashley, now a senior civil engineering student at the UH Cullen College of Engineering, began her internship with the Texas Department of Transportation (TxDOT) in May. Within a few short weeks, Ashley had gained a collection of practical knowledge that complemented what she had learned in the classroom. She worked on a construction project that comprised a short stretch of I-10, not far from downtown Houston. Some of her tasks included concrete cylinder strength testing, documenting drilled shaft reports for the bridge columns and drawing bridge sketches to demonstrate work in progress. "Being out in the field and seeing the construction go from phase one through completion is eye-opening," Ashley said. "I have learned what it takes to build bridges, highways and frontage roads by interacting with the contractors, workers, structure designers and other engineers." Ashley credits the courses that she has taken at the Cullen College with preparing her for work in the field. "I have seen that it does not necessarily take a genius to create these bridges, rather it requires real common sense," Ashley noted. "You have to think about why things are a certain way, and consider what would happen under specific conditions." During her internship, Ashley also became aware of the most important factor in a successful construction workday. "Safety is the number one concern," she said. "Like my boss said, if you get hurt, I can't use you. He was joking of course, but everyone must take safety into account every step of the way."

Ashley's participation in the American Society of Civil Engineers (ASCE) led to her internship with TxDOT. "ASCE has helped open doors for me on so many levels," she said. "Without participating in ASCE, I do not think I would have had the opportunity to accomplish as much as I have."

The benefit of the TxDOT internship to Ashley's education and career is priceless. "Overall, I have enjoyed this internship more than I anticipated," she noted. "I am grateful that I was able to go on-site and get hands-on experience, and I appreciate the opportunity of seeing firsthand how our roads are built." After graduation, Ashley will seek a job that allows her to travel. "I am open to travel all around the world," she said. "This internship has helped steer me in a direction I am very excited to go, and I can't wait to see what the future holds for me."

Mikhail Alekseenko

Mikhail Alekseenko, who is majoring in petroleum engineering, interned with ConocoPhillips this summer. He worked on the chemical usage program, researching ways to optimize the company's chemical expenditures and ensuring the correct amount of chemicals are being pumped into the wells at the right time. "It's interesting to see the amount of chemicals that go into it, and how they interact with each other," he said. Mikhail spent two days a week in field operations, learning firsthand about the challenges that well operators face. His field experience complemented the data collection aspect of his project, in which he used proprietary programs to find out various factors that affect evaluation of well workover. Instead of assessing the characteristics of over 400 wells one by one, Mikhail devised a method of cross-reference in a spreadsheet to make decisions about chemical treatment in aggregate form. "It saved me a lot of time," he says. "If you go into parameters for each well, it would take you six months, if you're efficient." Mikhail viewed the internship with ConocoPhillips as a prolonged interview. "It's nice to see that all your hard work at school pays off in the internship," Mikhail said. "You are being rewarded with respect by fellow colleagues that appreciate the effort you've put into going to school, and it's a great experience that students need before they graduate."

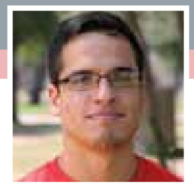
"More than technical competency, companies are trying to see how students fit in, what their work ethic is like during the internship," Como said.

Zaida Hernandez

From a young age, Zaida Hernandez was drawn to the craft of hands-on work: designing, building and fixing things to make them more efficient. Zaida, a sophomore majoring in mechanical engineering, interned at Johnson Space Center with the spacesuit development team, working with contractors on new technologies for everything from helmet to boots. One of her summer projects involved data analysis and comparison of a joint torque and mobility test done on two spacesuits. She also did Pro/E modeling of portable air backpack parts to determine packaging efficiency. Zaida looks forward to her future in engineering. "I am thinking about graduate school but I still haven't decided what type of engineering I would like to pursue," she said. "I would probably go to graduate school for aerospace engineering or mechanical engineering."

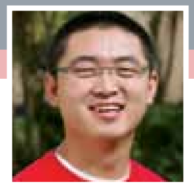
Anvesh Reddy Kunati

Anvesh Reddy Kunati is a graduate student working toward his master's in Industrial Engineering — Engineering Management. He joined Dell as an intern in Global Ops & Technology — Information Technology. His role was to define system requirement specifications, and provide the design and logic for implementation. "I'm very fortunate to work in an industry that is literally changing the world," he said. "The fact that I'm inspired by my work at Dell makes me proud to be part of such a dedicated, thriving global community." Long-term, Anvesh seeks to work as a business analyst in the area of supply chain and information technology, and would like to establish a consulting organization in the same area.



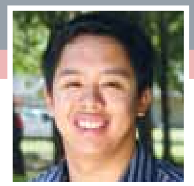
Gustavo Azevedo

Gustavo Azevedo, a junior electrical engineering major, spent his summer working with Baker Hughes Drilling and Evaluation (Inteq) in Oklahoma City. His project involved reservoir navigation systems (RNS), which receive survey readings from measurement-while-drilling (MWD) tools and produce a number of graphs that helps the RNS team determine which direction the driller should continue. "I am extremely happy about my project, especially because it is due to tools like this that directional drilling was able to revolutionize the oil and gas sector," Gustavo noted. "Working with Baker Hughes was a wonderful opportunity."



Pengfei Xiao

Pengfei Xiao is a senior chemical engineering major who received an internship at Shell through the spring Engineering Career Fair. As part of the production technology team, his project consisted of a competitive intelligence study to find out what competitors are doing with production operations. After the information collection phase, Pengfei then evaluated the data and made recommendations on how Shell can improve in that area. "The experience has been great," he said.



Nam-My Le

Nam-My Le is a sophomore electrical engineering major who interned at Texas Instruments. His tasks included analyzing static timing reports, using PrimeTime to fix hold and set-up violations, debugging non-equivalent compared points, and writing TCL/Perl scripts. Nam-My is excited about diverse opportunities in electrical engineering. "I can work in microprocessors one year, and on a wind turbine the next," he said. Nam-My is a member of the Honors Engineering Program, an Honors Ambassador, and the Student Governing Board Treasurer, as well as a member of IEEE, NSBE and SWE. After graduation, he would like to pursue a Ph.D. researching nanotechnology.

Collaboration

Taken from *The Engines of Our Ingenuity*, Episode #715

Dr. John Lienhard

I [once] read an odd book by Michael Schrage — *Shared Minds*. It's about collaboration. The book's too breezy and journalistic for my taste. But no matter! The guy's on to something. He draws the subtle line that divides communication and collaboration. That struck a nerve.

I try to communicate what I know and love about technology and invention in this series. I claim to write the series alone. And to the extent I do, that's communication, not collaboration.

Yet this series is pure and ongoing collaboration. For one thing, I treasure a few critical friends whom I trust absolutely. These people tell me, with unwashed candor, what they don't like about what I write. They don't waste time with politeness. They don't try to tell me how to fix things. They're effective because they share their subjective reactions with me.

I also have running encounters of another kind with several people. Each time we meet we continue a theme. These aren't so much conversations as they are probings. They spin out over months and years with an intimacy peculiar to shared ideas. I love these inquiries. So does Schrage. He says,

Two individuals create a set of shared experiences and understandings that are unique to them. They build contexts.

That takes work, and it pays huge dividends. All the great creative people have done it — Edison, Niels Bohr, Ben Franklin. They all had close, independent-minded colleagues. By words, drawings, equations, and carefully-shaped shared experience, they added the strength of other minds to their own.

Braque and Picasso — Crick and Watson! Did you know that Monet and Renoir painted side by side to create the shared experience that formed their artistic style? Afterward, they were able to grow off in their own directions.

How do we make that happen in our workplaces? First we recognize that collaboration is much more than just talk. Too much talk is didactic, competitive, one person informing another.

So we redesign workplaces to draw people into each other's orbits. We create common contexts. We're inventing blackboard-like software so we can share the design experience. Maybe we're learning to bring the scribbled napkin back to the workplace.

Yet real collaboration needs one thing more. True collaborators have a rare ability to seek out their own ignorance in front of another person. The key is trust. Schrage says,

The thing that matters most is that the collaborators possess mutual trust, the belief that they are adding value, and a genuine desire to create something new.

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 2,700 episodes have been broadcast. For more information about the program, visit www.uh.edu/engines.*

photo by Thomas Shea

Cleanroom *Collaborations*

The University of Houston recently held a ribbon cutting for one of its newest Tier One resources, the UH Nanofabrication Facility. The facility features a state-of-the-art cleanroom equipped with an extensive toolset for nano/micro device prototyping and characterization.

The facility is led by Dmitri Litvinov, professor in the Cullen College's Department of Electrical and Computer Engineering, who has organized the center around the principle of collaboration. It is open to researchers throughout the university, regardless of college or department, as well as those from outside institutions and businesses. This, he said, benefits research and encourages new partnerships.

"Having multiple users can quickly build up the knowledge base about what this equipment can do and how to do it," said Litvinov. "If you're attempting to do something new, you can just call up the other people who work in the same facility and ask if they have any insight. Those conversations can accelerate your research and can also lead to research partnerships."

Check it out online at **nanofab.uh.edu**

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Finding Fault in Real Time

A team of researchers with the University of Houston Cullen College of Engineering recently won a $400,000 grant from the National Science Foundation's Major Research Instrumentation Program to acquire an advanced digital image correlation system for the study of material failure. The investigators will work with the system's maker to develop real-time feedback capabilities, which will allow them to control the rate of material failure and gather more data from each experiment.

Check it out online at http://www.egr.uh.edu/news/0911/?e=mri