BioScience Research Collaborative is open for business

Hub links Rice researchers with neighbors in Texas Med Center

Construction on Rice University’s BioScience Research Collaborative (BRC) was completed this summer and its interior gives an open and modern feel as it provides ample space for some of the best research minds in the world to work together and solve a broad spectrum of complex problems in science and medicine.

The BRC is the largest building project Rice has ever undertaken. The 477,000-square-foot facility features a 280-seat auditorium, rooms for seminars and conferences, and eight floors of research labs equipped for cutting-edge, theoretical, and computational investigations.

“We are very excited about the collaborative and the impact it will have on the future bioengineering research and education,” said Jennifer West, chair of the Department of Bioengineering. “With this move, researchers and doctors from various disciplines and institutions can work more closely as they conceptualize, develop, and test practical biomedical technologies.

New lab-on-a-chip technology diagnoses heart attack by testing saliva

Next generation medical device enters clinical trials

When someone is having a heart attack every second counts, and getting the right emergency medical care immediately plays a critical role in surviving a heart attack and gaining full recovery.

This year, emergency medical-technicians and a multi-institutional team of dentists, physicians, and researchers led by Rice University biomedical engineer John T. McDevitt are testing a new “nano-bio-chip” system that diagnoses heart attack by testing a person’s saliva. This program was recently designated by Popular Science with the Best of What’s New in the Medical Device Category and has also been selected by the Science Coalition as one of the Best Advances of the Year.

“Obvious signs of heart attack, or acute myocardial infarction, are sudden and intense chest pain, however, often times symptoms are nonspecific and people don’t get the medical help they need until it’s too late,” explains McDevitt, who initially developed the concept for the nano-bio-chip technology in 1996 and launched a microchip-based research program at the University of Texas (UT) at Austin.

“There is a great need for a point-of-care diagnostic device that works as a companion test to the ECG, or electrocardiogram, because the ECG misses about one-third of the heart attacks and patients are not treated aggressively in these early stages after they seek treatment.”

McDevitt’s goal has been to develop a noninvasive biochemistry test that works as a companion to the ECG to more rapidly rule in and rule out heart attacks. Using many of the same micro-

The blue nano-bio-chip is made of silicon and in its center is an array of protein-sensing microbeads that provide a quick yes-no answer to heart attack in as little as 10 to 20 minutes. The researchers hope to use much cheaper stainless-steel circular chips (background). The nano-biochip is also being programmed as a cell-based test for cancer and HIV/AIDS. (Photo by Glen Simmons)
The Department of Bioengineering at Rice University has had many exciting developments this year, and we are poised for continued growth and enhancement of our programs. Our graduate program is ranked 7th among bioengineering/biomedical programs in the nation by U.S. NEWS & World Report’s 2009 rankings; our undergraduate program is currently ranked 9th. Rice is a leading institution in competing for government and private research funding, with $13.9 million dollars in research expenditures for our department in the last fiscal year.

Expanding the flow of basic, applied, and translational research and opportunities for multidisciplinary training requires space. The BioScience Research Collaborative (BRC), the largest building project Rice University has ever undertaken, is the new home for the Department of Bioengineering. The new facilities are phenomenal, and will allow us to expand our faculty in the coming years and facilitate highly collaborative, multi-institutional projects between investigators at Rice and Texas Medical Center.

To cultivate the skilled scientists and engineers needed to create tomorrow’s innovations, we equip our students with conceptual and technical expertise as well as create unique opportunities to apply this knowledge. For our undergraduate students this includes:

- New pedagogical methods and teaching standards that broaden students’ problem solving skills and scientific and technological literacy through real-world problems and inquiry-based learning;
- Continuing to expand our collaborative culture that integrates teaching and laboratory research early in a student’s career;
- Fostering engineering and cross-discipline design experiences, opportunities to compete, travel abroad, and carry out practical ideas to their intended point of application; and
- Cultivating strong oral, visual, and written communication skills.

These ambitions have become a point of distinction. The undergraduate program has been consistently ranked among the nation’s top 10 bioengineering/biomedical engineering programs, and our students are sought after by leading graduate and medical school programs, as well as companies seeking technical leadership skills.

This spring we conducted our first alumni survey to document alumni accomplishments and assess the quality of the undergraduate program. We gratefully acknowledge their continued dedication to the program, and will use their valuable input to further refine the department’s educational objectives.

As the department seeks to build partnerships that identify important problems, develop and translate bioengineering solutions, and train the next generation of leaders in bioengineering, short courses, symposia, and events have become a tremendous venue for students and researchers alike.

In August, the Center for Excellence in Tissue Engineering, Department of Bioengineering, and Institute of Biosciences and Bioengineering hosted the 17th Annual Advances in Tissue Engineering Short Course. Attendance included more than 100 participants from 14 countries.

Please join us at the 7th Annual Computational & Theoretical Biology Symposium, December 4-6, 2009. The event will feature invited talks on various theoretical methods of statistical mechanics that are being developed and applied to study the collective properties of biological systems.

The department is proud to host the 2011 Tissue Engineering International & Regenerative Medicine Society (TERMIS) North American Regional Conference. The event will integrate a global perspective to topics in education, interdisciplinary, basic and translational research in tissue engineering and regenerative medicine.

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The Rice BIOE NEWS is a biannual publication of the Department of Bioengineering. It is sent to alumni, faculty, students, and friends of the university. Some photos and content are courtesy of Rice University Photography Services and Department of News and Media Relations. Please send comments and story ideas to bioeng@rice.edu.
BioScience Research Collaborative is open for business (Cont.)

and devices that benefit people in Texas and around the world.”

Nearly all of Rice’s Department of Bioengineering has completed the move into the BRC. And over the next few months, the Institute of Biosciences and Bioengineering, Beyond Traditional Borders, Rice 360°: Institute for Global Health Technologies, the Texas-UK Collaborative Research Initiative and the Institute of Biosciences and Bioengineering, Beyond Traditional Borders, Rice 360°: Institute for Global Health Technologies, the Texas-UK Collaborative Research Initiative and the Institute for Global Health Technologies, the Texas-UK Collaborative Research Initiative and the Center for Biological and Environmental Nanotechnology will complete the transition. The Gulf Coast Consortia, which represents researchers in six Texas Medical Center institutions, will move to the BRC by early next year.

The realization that leaders in academia, engineering, research and health care are united under one roof attracted two new prominent faculty members this year to the department.

Bioengineers at Rice University have teamed up with physicians at UT M.D. Anderson Cancer Center to design, fabricate, and ultimately test an ultra-slim optical imaging device called the Integrated Optical Needle (ION).

Built through the support of a five-year Research Project Grant (R01) from the National Institutes of Health, the ION integrates advances in nanotechnology and miniature optical instruments to pinpoint the cellular and molecular hallmarks of cancer in hard-to-reach tissue locations.

The microprobe is the smallest imaging instrument Assistant Professor Tomasz Tkaczyk has built. Tkaczyk is a co-principal investigator on the project with Rebecca Richards-Kortum, the Stanley C. Moore Professor of Bioengineering and professor of electrical and computer engineering at Rice. The system will be tested through UT M.D. Anderson surgeon Ann Gillenwater.

The ION features a high-performance miniature microscope objective that when inserted into a small-gage hypodermic needle about 1.3 mm across, it delicately advances through deep tissue to capture images through the distal tip with sub-cellular resolution and in real time.

Once complete, the ION will use the targeted contrast agents, or vital stains, developed in the Richards-Kortum laboratory to yield 3-D profiles of cellular and molecular-specific biomarkers of cancer in vivo.

Since 2003, Tkaczyk and Richards-Kortum, have co-led several multidisciplinary efforts with colleagues at the University of Arizona, Mount Sinai Medical Center, the UT Health Science Center at Houston, University of Texas, and the British Columbia Cancer Agency to develop a slate of optical imaging systems that are inexpensive, portable, and provide point-of-care diagnosis.

To learn more about the BRC and its research efforts, visit www.rice.edu/brc.
New lab-on-a-chip technology (Cont.)

fabrication procedures popularized by the electronics industry, the nano-bio-chip is made using photolithography methods, and in its center is an array of protein-sensing microbeads. The novel chemical sensing microchip, which is about size of a dime, fits into a larger rectangular shaped lab-card that when slid into a toaster-sized analyzer provides a quick yes – no answer in as little as 10 to 20 minutes.

The saliva-based diagnostic system is currently being tested in ambulances in San Antonio, and through a multi-site clinical validation project through three medical and dental schools at the University of Kentucky, University of Louisville, and the UT Health Science Center San Antonio.

Recent activities have led to an expansion of this program to include Christie M. Ballantyne, M.D., professor of medicine, Baylor College of Medicine and director for the Center for Cardiovascular Disease Prevention, at the Methodist DeBakey Heart Center.

“In addition to the ECG, physicians diagnose heart disease by testing for biomarkers in the blood, which when compared to a saliva test, takes precious time and laboratory resources,” McDevitt adds. “Interdisciplinary efforts in oral health research and clinical data collection are expanding our ability to develop highly sensitive and specific tests to quantify several molecular biomarkers for heart attack, thus removing some of the inefficiencies related to rapid and accurate diagnosis of acute myocardial infarction.”

While most chip systems are dedicated to a single-test modality, the microbeads developed by McDevitt and collaborators act as chemical processing units that display a matrix of four targeted protein markers to indicate whether a person is sick or not sick.

Through three years of guided research, the researchers have identified 13 unique salivary proteins as promising cardiac biomarkers from a pool of nearly 200 possibilities. So far, the device has been tested by more than 200 patients, 100 of whom were heart-attack victims. Studies conducted at each of the medical schools have compared ECG, and salivary multiplexed tests. The results yielded sensitivity and specificity values in the range of 90-100 percent, suggesting that select biomarker combinations on the nano-bio-chip exhibit outstanding heart attack screening capabilities. This work was published this July in the journal Clinical Chemistry.

Coronary heart disease and cancer are labeled ‘silent killers’ because a series of molecular events must occur deep within the body long before obvious clinical manifestations take hold. Through a $6.1 million grant from the National Institute of Dental and Craniofacial Research, McDevitt and collaborators will also be extending their next-generation salivary and cancer diagnostic devices into dentist offices to detect and monitor individuals at risk for future coronary heart disease and cancer.

McDevitt, the Brown-Wiess Professor of Chemistry and Bioengineering, co-founded LabNow in 2002 in Austin, TX based on the CD4 microchip technology developed in his laboratories that provides simple, rapid, and affordable methods for counting white blood cells in HIV/AIDS patients. The immune function nano-bio-chip device has successfully completed human trials in Boston hospital settings and in an HIV reference laboratory in Botswana, Africa. The fully developed technology was featured at the July 2009 HIV meeting in Cape Town South Africa.

McDevitt’s research has been generously supported by the NIH, the Bill and Melinda Gates Foundation, the Welch Foundation, the Doris Duke Charitable Foundation, the NSF, the Office of Naval Research, and others.

Lead investigators on the saliva-diagnostics, or CARDIUS (Cardiac Arrest Rapid Diagnostic Information Using Saliva), project have included: Nick Christodoulides and Pierre Floriano, senior scientists at Rice; Chih-Ko Yeh, B.D.S., Ph.D., professor of dental diagnostic science, and Spencer Redding, D.D.S., professor and chair of the Department of Dental Diagnostic Science at the University of Texas Health Science Center at San Antonio; Craig Miller, D.M.D., professor of oral medicine, Michael J. Novak, B.D.S., L.D.S., Ph.D., professor of periodontics, and Jeff Ebersole, Ph.D., Alvin L. Morris Professor of Oral Health Research and director of the Center for Oral Health Research, at the University of Kentucky; and Denis Kinane, B.D.S., Ph.D., associate dean for research and enterprise and the Delta Endowed Professor, at the University of Louisville.

The image above left shows a healthy patient whose saliva contains only modest amounts of the targeted proteins for coronary heart disease, while the image above right reveals significant increases in intensity of the captured proteins providing evidence of the presence of an active heart attack. (Photo by Pierre Floriano)
Uncovering the dynamic interactions of key hearing protein
Rice, Baylor research wins new NIH grant and ARAA supplement

Rice bioengineer Rob Raphael and his collaborator Fred Pereira from Baylor College of Medicine were recently awarded a new $1.75 million R01 grant from the National Institutes of Health to study prestin, a motor protein essential for proper auditory function.

“Prestin is known to help amplify faint sounds and increase the ability to hear tones as it responds to changes in electrical potential by altering its shape,” said Raphael, associate professor of bioengineering and principal investigator on the project. “The big question is, ‘What is the molecular mechanism underlying this unique activity?’ ”

Prestin is found in the outer hair cells of the cochlea and is a transmembrane protein, which means it pokes through and is embedded in the outer covering of cells. And like many other transmembrane proteins, evidence suggests that prestin only becomes fully functional when it oligomerizes, or comes together in small groups.

On the seventh floor of the BioScience Research Collaborative, Raphael and his students are working to determine the functional significance of prestin-prestin interactions. The new five-year grant from the NIH’s National Institute on Deafness and Other Communication Disorders supports investigations into the molecular interactions that are responsible for prestin’s electromechanical activity.

Using sophisticated optical imaging and electrophysiological techniques, Raphael’s group will study how prestin responds to electrical stimulation and how membrane dynamics are altered when prestin is both by itself and in groups. Pereira’s group will use molecular techniques to mutate regions of the protein to determine which portions of the protein make prestin stick together and which are vital to its function.

“We want to characterize prestin’s functional unit and learn how it works to enable this remarkable and unique electromotile activity,” Pereira said.

When sounds reach the liquid-filled cochlea—the ear’s built-in amplifier—they pulse through the tunnels of the snail-shaped organ, bending tiny hair-like microvilli that energize a specialized type of cell found only in the cochlea, the outer hair cells. When energized, outer hair cells stimulate millions of prestin proteins to lengthen and shorten in a rapid-fire succession. The resulting movement of the entire outer hair cell, in turn, selectively amplifies sound frequencies, allowing the listener to perceive faint sounds that would otherwise be missed.

"Prestin is supposed to be a piezoelectric molecule that deforms in response to electrical signals, but prior studies have been limited to studying prestin’s electrical activity by measuring how it changes membrane capacitance,” Raphael said. "Nobody has investigated the corresponding mechanical deformation at the molecular level and observed the hypothesized nanoscale motions that occur when prestin is stimulated by voltage. We’re going to do that in a very systematic way."

This research could help answer key questions about human hearing and the causes of hearing loss and deafness. Raphael also added that, "A larger significance of this research is that prestin is a member of a family of highly conserved membrane transport proteins found in other parts of the body and mutations in these proteins are implicated in various diseases such as skeletal abnormalities and goiter.”

The American Recovery and Reinvestment Act (ARAA) recently provided an additional $300K in funding to accelerate the research and purchase sensitive optical equipment that will improve FRET measurements with fluorescence lifetime imaging microscopy (FLIM).
Investigations into how *Bacillus subtilis* ensures survival gains NSF funding

Joint efforts between Rice bioengineer Oleg Igoshin and University of Houston Assistant Professor of Biology and Biochemistry Masaya Fujita recently gained funding from the National Science Foundation.

Since 2008, the duo has been studying how soil bacterium *B. subtilis* senses nutritional deprivation and ensures survival by initiating a multistage differentiation process of sporulation. Sporulation is a costly and time-consuming task, and is only used as a last resort. To protect itself in times of uncertainty, the bacterium must carefully process environmental cues and decide whether or not to engage in sporulation.

Interestingly, only 50-60 percent of identical bacterium under identical conditions has been found to sporulate. The genetic basis of this complex “bet-hedging” strategy is a focus of the funded project.

Assistant Professor Igoshin will combine computational modeling and statistical analysis with the experimental data gathered in Fujita’s lab to decode signal processing mechanisms during sporulation. As a result, the researcher will get systems-level understanding of stochastic decision making in this model system.

The methods and models developed in this study have long-term application in addressing questions of cell differentiation decisions in higher organisms, and may provide new insights into food preservation processes and public health safety techniques, including development of new antimicrobial agents and vaccines.

Bioengineers probe the nanoscale to understand heart valve structure

*Grant supports investigations into heart valve tissue and disease*

Bioengineers at Rice University are investigating how continuous mechanical movement and dynamics of pressure and blood flow influence the biological function of heart valve tissues at macroscopic and microscopic levels.

Their aim, which is supported by a new two-year grant from the South Central Affiliate of the American Heart Association, is to use nano-indentation technology to study the behavior of cells and the extracellular matrix, and see how their complex interwoven structures respond to biomechanical environments.

“Heart valve tissue is made up of three layered structures. One layer has a lot of very organized collagen, which gives the valves strength. Another layer has a more gelatinous-like structure, and a third is more elastic,” explains Associate Professor Jane Grande-Allen. “Characterizing how this mechanobiological framework functions will help us understand and establish heart valve elasticity, durability, and tensile strength in tissue engineering applications.”

The investigations represent a new direction in the Grande-Allen group toward aortic heart valve research, but connect other heart valve research from three interrelated studies conducted by graduate students Hubert Tseng, Nikhil Gheewala, Elizabeth Stevens, and Chris Durst.

Using nano-indentation technology – a tiny probe 20 nanometers across that is housed in a scanning electron microscope – the group is measuring force and displacement as the probe presses into valve tissue to assess its material behavior in very, very localized areas of extracellular matrix.

The aortic valve tissues is a three layered structure. The collagen layer is stained yellow, the middle spongy layer contains glycosaminoglycans and is stained blue, and the lower elastic fiber layer is stained black.

The environmental electron microscope was enhanced in 2008 with an Institute of Biosciences and Bioengineering (IBB) Hammill Innovation grant shared between Grande-Allen and Jun Lou, assistant professor in mechanical engineering and materials science, to measure mitral valve mechanical heterogeneity.

To translate the data gathered into tissue engineering applications, the Grande-Allen group is working with Jennifer West, one of Rice’s leading experts in the design and application of novel biofunctional and biomimetic materials. Grande-Allen and West, the Isabel C. Cameron Professor of Bioengineering, will use the data to emulate cardiac valvular development and evaluate the behavior of the cells in 3-D tissue engineering scaffolds.
Systems biology specialist Amina Qutub joins Rice
Engineering alum returns to expand bioengineering program

Amina A. Qutub has joined Rice University as an assistant professor of bioengineering. Qutub received a bachelor’s degree from Rice in 1999 graduating with top honors in Chemical Engineering. This summer she returned to her alma mater to launch a new research program in systems biology with long-term applications in cancer therapy; treatments for ischemia, multiple sclerosis, and Alzheimer’s disease; and increased understanding of cellular and sub-cellular organization in vascular biology.

A cell’s response to hypoxia underlies pathologies as diverse as arthritis, ischemia and cancer. It also determines in part how a stem cell differentiates, how neurons age, and how capillary networks grow. Qutub’s investigations will be based on three research platforms: biological systems modeling theory and design, hypoxic response signaling, and cerebrovascular systems biology.

As a postdoctoral fellow at the Johns Hopkins University School of Medicine, Qutub’s work in systems biology to understand hypoxic response and angiogenesis earned her a Ruth L. Kirschstein National Service Research Award. Under this fellowship, she worked in Aleksander S. Popel’s group to develop the first molecularly-detailed computational model to test angiogenic therapeutic strategies, targeting the hypoxia-inducible factor 1 (HIF1) pathway. Predictions of the HIF1α hydroxylation model have recently been experimentally observed and shown to shrink cancer tumor growth in vivo. The research has also been noted in several high-caliber peer-reviewed publications.

Qutub earned a doctorate degree in 2004 at the University of California at Berkeley/San Francisco through their jointly run bioengineering program. While in the lab of C. Anthony Hunt, professor of biopharmaceutical sciences and pharmaceutical chemistry, she created multiscale systems models to simulate mechanisms underlying neurological conditions and developed new methods in brain drug delivery. The research was supported by a Whitaker Bioengineering Graduate Research Fellowship.

Rebekah Drezek promoted to professor

Rebekah A. Drezek was promoted to professor in bioengineering and in electrical and computer engineering.

Drezek’s cost-effective, miniaturized, point-of-care optical technologies are showing tremendous potential for the early detection, diagnosis, and monitoring of disease in vivo. Developments include new optical spectroscopy and imaging instrumentation and molecular-specific optical contrast agents, experimental studies into the biophysical origins of measured optical signals, and computational modes of the interaction of light and biological tissue. Results of her efforts have been published in more than 70 papers and have led to six patents/patent applications.

Research from her highly productive Optical Molecular Imaging and Nanobiotechnology Laboratory has been supported by nearly $11 million in grants from the National Science Foundation, National Institutes of Health, Department of Defense Congressionally Directed Medical Research Program, Beckman Foundation, Welch Foundation, Coulter Foundation, Whitaker Foundation, and others.

In addition to her forte for cutting-edge research, Drezek is an inspiring teacher and mentor. To date, she has advised four postdoctoral fellows, 17 doctoral students, and more than 20 undergraduate students. Seven of her students have received prestigious awards, including two National Science Foundation fellowships, two National Defense Science and Engineering Graduate fellowships, a DOE Krell fellowship, a NNEMS fellowship, and a Beckman scholarship.

Notable awards Drezek has received include the MIT TR100Technology Reviews’ selection of 100 Top Young Innovators Award, the Association for the Advancement of Medical Instrumentation Becton Dickinson Career Achievement Award, and the Beckman Young Investigator Award. She has been an invited speaker on nanotechnology at the National Academy of Engineering (NAE) Frontiers of Engineering annual meeting. In 2008 she won, the American Society for Photobiology Research Award, the Rice University Charles W. Duncan Jr. Achievement Award and the University Presidential Mentoring Award, and was named fellow of the American Institute for Medical and Biological Engineering. This fall she will receive the Adolph Lomb Medal from the Optical Society.
Tissue engineers gather for Rice 'short course'

More than 100 participants from around the world attended the 17th annual *Advances in Tissue Engineering* short course August 12-15.

The convergence of some of the greatest minds in regenerative medicine is one of the event’s greatest assets. Each year, the four-day ‘short course’ is packed with information about the latest research on patient-specific therapeutics and is presented by top leaders in the field from academia, medical research, and industry.

Organized by Antonios G. Mikos since 1993, the 2009 event featured 30 invited speakers and 10 Rice scientists. Participants and speakers alike learned first-hand about a range of topics involving computational structural biology, cell migration, biomimetic strategies, nanotech approaches to treatment, and the clinical translation of tissue engineering practices.

“Regenerative medicine is a highly complex and rapidly expanding industry that depends on communication. The course’s open format is conducive to sharing knowledge and fostering research collaborations that link academe, medicine, and industry,” Mikos added.

OSA to present Drezek with Adolph Lomb Medal

The Optical Society (OSA) has awarded Rebekah Drezek the prestigious Adolph Lomb Medal for her work at the intersection of bioengineering, photonics, and nanotechnology.

OSA will formally present the award at its annual meeting, Frontiers in Optics, Oct 11-15, 2009 in San Jose, CA.

“OSA is honored to recognize Dr. Drezek as a talented young leader in the field of optics and photonics,” said Elizabeth Rogan, OSA executive director. “She has demonstrated tremendous foresight and ingenuity toward the development of molecular imaging technologies that fight cancer and improve the quality of life for a growing number of patients.”

Drezek, professor in bioengineering and in electrical and computer engineering at Rice, uses an interdisciplinary approach to develop cost-effective, miniaturized, point-of-care optical technologies that detect biophysical changes in tissue inside the body to screen, diagnose, and monitor disease.

Working with clinicians at UT M.D. Anderson Cancer Center, Drezek’s group has built optical systems for a variety of diagnostic and therapeutic imaging needs that range from early detection to guiding surgery to monitoring the efficacy of radiation therapy and targeted drug treatments. Several imaging technologies have progressed to clinical trials.

Additional work from Drezek’s Optical Molecular Imaging and Nanobiotechnology Laboratory is also making significant contributions to health care. Time-saving modeling tools optimize the design of optical systems and molecular imaging agents leading to more efficient approaches to clinical trials.

Since 1916, OSA has worked to advance the common interests of the optics and photonics field, providing educational resources to the scientists, engineers and business leaders and by promoting the science of light and the advanced technologies made possible by optics and photonics.
New textbook engages students in real-world problems

As the world becomes more interconnected, students are seeking opportunities to learn about problems of disease and health, and how science and engineering can be used to solve global health challenges.

*Biomedical Engineering for Global Health*, written by Rebecca Richards-Kortum, gives students a cohesive overview of how biomedical technologies are developed and translated into clinical practice.

Published by Cambridge University Press and expected to be available in late 2009, the textbook is written for students from all disciplines from non-science majors to biomedical engineers. The text integrates the biomedical data of the major diseases facing developed and developing countries with the recent technological advances and the economic, social, ethical and regulatory constraints that impact the development of new technologies.

“This book has grown through widespread collaborative efforts of colleagues at Rice and the Texas Medical Center, and was inspired by students from multiple backgrounds who are passionate about becoming part of the solution to global health issues,” Richards-Kortum said.

Outreach program blends science/engineering education

Howard Hughes Medical Institute provided funding to launch the Beyond Traditional Borders (BTB) initiative at Rice University in 2006. As part of the initiative, an outreach program was organized to prepare middle school and high school teachers as well as university educators to teach Bioengineering & World Health at their institutions.

The course quickly received approval from the Texas State Board of Education for state elective credit, and for the past four summers program leaders have worked with the Houston Independent School District to expand the number of educators teaching Bioengineering & World Health. Overall, the program has disseminated appropriately tailored teaching curriculum to 36 teachers from 24 schools and universities through an annual four-week workshop, impacting more than 1,600 middle and secondary school students in Texas.

Richards-Kortum, the Stanley C. Moore Professor of Bioengineering and director of Rice 360°: Institute for Global Health Technologies, uses actual case studies to show the development, assessment and global diffusion of new medical technologies, including new vaccines to prevent infectious disease, imaging technologies to improve early cancer screening and implantable devices to treat heart disease.

The core principle of the curriculum, which uses engineering design methods as a systematic and effective framework to guide students through the process of developing interdisciplinary solutions to health problems, is supported by homework problems and a project assignment designed to guide them in developing simple, robust, cost-effective technologies that are adaptable to a country’s needs.

The concept for the curriculum is a reflection of Richards-Kortum’s experiences as a leading researcher in developing low-cost miniature imaging systems to detect cancer, as a founder of the Beyond Traditional Borders (BTB) initiative, and as a professor of the course Bioengineering & World Health, which has been taught at Rice and the University of Texas at Austin since 2001.

BTB and Bioengineering & World Health are funded by the Howard Hughes Medical Institute to Rice through the Undergraduate Science in Education Program.

In 2008, BTB and the School of Biotechnology and Health at Tecnológico de Monterrey offered the course to 20 Houston and Monterrey high school and university students. The students began the course in Mexico with two weeks of study at the Tecnológico de Monterrey and two weeks of study at Rice followed.

In 2009, BTB and the University of Malawi hosted a two-week camp for 36 underprivileged female high school students in Malawi to promote enrollment in the sciences and engineering at the university level. The two-week program concurrently trained 18 teachers in the Bioengineering & World Health curriculum.

Mentored teaching fellowships are available for postdoctoral and graduate students from various disciplines to learn to teach the course. So far, over 15 graduate students and postdoctoral fellows have participated in the program.
As real as it gets
Senior design courses expand bioengineering pipeline

The senior design courses at Rice University’s Oshman Engineering Design Kitchen (OEDK) are expanding the number of experienced, innovative, and globally minded leaders entering the bioengineering pipeline.

Since 2004, more than 200 bioengineering students in 48 teams have completed a design project that has a real-world application in technology, global health, or space travel. Fifteen student teams have won regional and national awards at design competitions, and 15 students have left Rice with a patent application on their resume.

The brass behind the program is a network of Rice faculty advisors, clinicians at Texas Medical Center institutions, partners within the Beyond Traditional Borders initiative, leaders of the Texas Space Grant Consortium’s Higher Education Program, and Houston-area organizations/agencies that work with Professor Maria Oden to develop a slate of challenges for Rice students to put their imaginations and skills to work.

This fall, 20 projects were proposed for bioengineering seniors work in teams of 3-5 people to select and take their ideas from research, conception and prototyping to testing and marketing. But what makes the program truly stand out is teams can choose cross disciplinary approaches to produce a working prototype.

“Students initially find it challenging to work in such an interdisciplinary environment, but realize that collaboration, if done effectively, can result in better solutions,” said Oden director of ODEK and professor in the practice of engineering education.

Under the guidance of Rice faculty members and design challenge mentors students work through a guided process to understand the problem and assess the needs of the end product while considering FDA requirements, safety, ethics, cultural/contextual considerations, economic and infrastructural limitations, and intellectual property rights.

Senior design wins approval hands down

A team of bioengineering students working in the Oshman Engineering Design Kitchen at Rice University invented a device to measure intrinsic hand muscle strength that could one day revolutionize the diagnosis and treatment of hand injuries and neurological disorders, specifically carpal tunnel syndrome.

Developed by Jennifer Cieluch, Caterina Kaffes, Matthew Miller, Neel Shah and Shuai "Steve” Xu for their year-long senior design project, the new invention isolates a patient’s fingers to measure and catalogue the strength of specific muscles or muscle groups.

Gloria Gogola, an orthopedic surgeon at Shriners Hospital for Children in Houston, worked with OEDK Director Maria Oden to challenge Rice students to develop a device that tests and chronicles intrinsic hand muscle strength quickly, with little cost, and is adjustable for small hands or unusual morphologies. She then served as one of the team’s mentors throughout its development and is currently testing the device in her clinic.

The device called PRIME, which stands for Peg Restrained Intrinsic Muscle Evaluator, has three elements: a peg-board restraint, a force transducer enclosure and a PDA custom-programmed to capture measurements.

“This particular student group worked extremely hard on the project, and they went above and beyond the course requirements. They took this from a concept to an actual working, clinically useful device,” said Dr. Gogola.

PRIME won first place and $10,000 at IShow, an innovation competition for graduate and undergraduate students sponsored by the American Society of Mechanical Engineers. Then in late June, the team was named one of five winners in a student design competition sponsored by the NSF at the Rehabilitation Engineering and Assistive Technology Society of North America conference in New Orleans.
Bioengineering grad student earns Ruth L. Kirschstein NRSA fellowship
Award supports biomedical research in collective transport of kinesins motors

D. Kenneth Jamison has received a Ruth L. Kirschstein National Research Service Award (NRSA) from the National Institutes of Health for his investigations into intracellular transport processes and the collective function of motor proteins, such as kinesin and dynein.

Jamison’s award, which amounts to $62,000 over an 18-month period, supports his continued studies into the mechanics of how motor proteins collectively work and move. Greater knowledge of motor protein function will yield significant insight into how and why motor transportation sometimes malfunctions – creating conditions that impair normal cellular processes and are known to contribute to the onset of many neurodegenerative diseases.

“Within the highly crowded and viscous environment of a cell, motor proteins play a critical role transporting a diverse array of essential ‘cargos’ to their required destinations,” said Jamison. “By observing the biophysics of small groups of motor proteins with precisely known and controlled compositions, we hope to better understand the regulatory processes that control intracellular cargo transport under normal and diseased states.”

Jamison is a fourth-year graduate student in Assistant Professor Michael Diehl’s Macromolecular Systems Bioengineering Group at Rice University. To investigate the motility of motor protein systems, he spent the first two years of his graduate studies designing and constructing a fully-automated optical trapping instrument, which uses a near-infrared laser to attract microspheres for biological study.

For the past year, Jamison has been using the optical device along with new biosynthetic and protein engineering methods developed in the Diehl lab to attach motor assemblies composed of exactly two kinesin motors to the surface of polystyrene microspheres and manipulate these multi-component architectures to study their behavior against simulated cellular loads.

“There is not much more one can do to transport something in smaller units,” said Jamison. “Using this device I will measure motor protein activity with nanometer precision and explore their rich dynamic behavior under piconewton-sized forces. This research will tell us more than what motor proteins can do in groups; we will discover how they work, sense and communicate with each other to ensure that transportation needs are met and cells stay healthy.”

Senior design team cooks up winning device in national NASA competition

Team Taurus, a group of five senior bioengineering students has designed a device to help astronauts determine bone loss during long-term space missions of six months or more.

Charlie Foucar, Shannon Moore, Evan Williams, Bodin Hon, and Leslie Goldberg came up with a noninvasive device that measures the concentration of deoxypyridinoline, a bone marker found in urine.

The students’ learned of the success of their design during a videoconference that included NASA officials and judges and three other competitors from Virginia Tech to announce results of NASA’s third annual Systems Engineering Competition. Team Taurus shares the top prize, which included certificates, an invitation to a future space shuttle launch, and a cash prize of $3,500.

The team’s award-winning prototype has three stages: a collection unit that ties into the spacecraft’s waste disposal system, an immunoassay process that combines the urine with nanoshells and antibodies, and a photometer that reads the absorbance spectra of the combined solution and feeds a PDA running an analysis program personalized for each astronaut. Resulting data can be downloaded to NASA or analyzed on the spot.

Project adviser Maria Oden, director of Rice's design kitchen and professor in the practice of engineering, said, “Based on the hard work and tremendous success our students’ have had in applying their education and resources to build useful devices, leaders of the TSGC’s Higher Education Program are genuinely interested in the continued growth of our program and in our students’ future.”
Class of 2009 Graduate Degree Recipients

The Department of Bioengineering is proud to recognize the following 2009 graduate degree recipients, 14 of whom obtained a doctorate degree:

Janet Barzilla, Ph.D. (May ‘09)
Adviser: Dr. K. Jane Grande-Allen
Remodeling of the Extracellular Matrix Components of the Mitral Valve Due to Alterations in the Mechanical and Chemical Environments of the Tissue

Benjamin Daniel Elder, Ph.D. (Jan ‘09)
Adviser: Dr. Kyriacos Athanasiou
Optimizing a Scaffoldless Approach for Cartilage Tissue Engineering

Najumddin Juzer Gunja, Ph.D. (May ‘09)
Adviser: Dr. Kyriacos Athanasiou
Exogenous Stimulation of meniscus Cells for the Purposes of Tissue Engineering the Knee Meniscus

Ryan Matthew McGuire, Ph.D. (May ‘09)
Adviser: Dr. Robert M. Raphael
Electrophysiological Investigation of Prestin Function: Impact of Cysteine Replacement and Characterization of Self-Association During Voltage Stimulation

Melissa Knight McHale, Ph.D. (May ‘09)
Adviser: Dr. Jennifer L. West
Investigation of a Tunable Hydrogel Matrix and Pulsatile Flow Bioreactor for the Development of Small Diameter Vascular Grafts

Timothy J. Muldoon, Ph.D. (May ‘09)
Adviser: Dr. Rebecca Richards-Kortum
High-Resolution Imaging for Cancer Detection with Fiber Bundle Microendoscope

Roman Natoli, Ph.D. (Jan ‘09)
Adviser: Dr. Kyriacos Athanasiou
Impact Loading of Articular Cartilage: Effects, Computational Modeling, and Amelioration Thereof

Dawn Lynn Nida, Ph.D. (Jan ‘09)
Adviser: Dr. Rebecca Richards-Kortum
Development of EGFR-targeted Contrast Agents for In Vivo Applications

Ramdas Sunil Pophale, Ph.D. (May ‘09)
Adviser: Dr. Michael W. Deem
Zeolites to Peptides: Statistical Mechanics Methods for Structure Solution and Property Evaluation

Mohammed S. Rahman, Ph.D. (May ‘09)
Adviser: Dr. Rebecca Richards-Kortum
Low-cost Optical Imaging Systems for Early Detection of Oral Cancer

Darren Michael Roblyer, Ph.D. (May ‘09)
Adviser: Dr. Rebecca Richards-Kortum
Multispectral Optical Imaging for the Detection and Delineation of Oral Neoplasia

William Jeffrey Triffo, Ph.D. (Jan ‘09)
Adviser: Dr. Robert M. Raphael
3-D Architecture of the Outer Hair Cell Lateral Wall as Determined by Electron Tomography

Anne Louisa Vnn de Ven, Ph.D. (Jan ‘09)
Adviser: Dr. Rebecca Richards-Kortum
Delivery of Molecular-Specific Optical Contrast Agents for Cancer Biomarker Detection in Live Cells and Tissues

Nafi Edward Yasar (May ‘09)
Adviser: Dr. Tomasz Tkaczyk
Integration of Sight, Hearing, and Touch in Human Cerebral Cortex

Keith Alexander Cordiner, M.B.E. (May ‘09)
Shang-Hsuan Lin, M.B.E. (May ‘09)
Wendy D. Mayes, M.B.E. (Jan ‘09)
Jireh Jon-Kai Yue, M.B.E. (Jan ‘09)
Kelly S. Horn, M.S. (Jan ‘09)
Jennifer G. Morton, M.S. (May ‘09)
Jun Shen, M.S. (May ‘09)
April Ann Smith, M.S. (Jan ‘09)
Cheng Zhang, M.S. (May ‘09)
Alumni News

Rice Bioengineering Department announces 2009 alumni awards

The Rice University Department of Bioengineering is pleased to announce its alumni awards for excellence in research, teaching, service, or significant contributions to the bioengineering industry, academia, or society.

The 2009 winners include: Scott L. Diamond, Distinguished Alumnus; Johnna S. Temenoff, Outstanding Bioengineering Graduate Alumna; Alonso Fuentes and Dania Daye, Outstanding Bioengineering Undergraduate Alumni.

Scott L. Diamond (Rice Ph.D. ’90) is the Arthur E. Humphrey Chair of Chemical and Biomolecular Engineering, and associate director and charter member of the Institute for Medicine and Engineering at the University of Pennsylvania. He also is founding director of the Penn Center for Molecular Discovery (PCMD) and director of the Penn Biotechnology Masters Program.

Diamond’s research at Penn specializes in cardiovascular therapeutic technologies in several key areas: mechanobiology, blood clot dissolving therapies and protein therapeutics, blood coagulation, drug discovery, and nonviral gene therapy, viral and lipoplex delivery. His laboratory has advanced chemical and biomolecular engineering methods with more than $23 million in research funding from the American Heart Association, National Institutes of Health, and the National Science Foundation.

Results of his research have been published in more than 125 high-caliber peer-reviewed publications. Diamond holds five patents/patent applications, and has received several highly prestigious academic and research awards.

Before joining Penn in 1997, he was a faculty member at the State University of New York for seven years. He received his doctorate in Chemical Engineering from Rice University under Larry V. McIntire in 1990, and bachelor’s degree in Chemical Engineering in 1986 from Cornell University.

Johnna S. Temenoff (Rice Ph.D. ’03) is an assistant professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech/Emory University. Her research focuses on developing functionalized biomaterials in a tissue engineering approach to regenerate orthopaedic tissue interfaces. Her novel engineering approaches to regeneration of tendon/ligament and its insertion points earned her an Arthritis Foundation Investigator Award in 2006 and an NSF CAREER Award in 2008. Temenoff’s research has been published in more than 20 peer-reviewed publications and she recently co-authored the textbook Biomaterials: The Intersection of Biology and Materials Science with Rice’s Professor Antonios G. Mikos.

Prior to joining Georgia Tech in 2005, Temenoff was a postdoctoral fellow in the Mikos Research Group. As a Whitaker Foundation Graduate Fellow, she earned a doctorate in Bioengineering in 2003 with Mikos serving as her adviser. Temenoff first became interested in biomaterials research while pursuing a B.S. in Biomedical Engineering from Case Western Reserve University in 1998.

Dania Daye (Rice B.S. ’07) gained early exposure to interdisciplinary research working in Professor Rebecca Richards-Kortum’s lab. She graduated magna cum laude from Rice and was elected to Phi Beta Kappa. Now a second-year candidate at the University of Pennsylvania’s MD/PhD program, she is pursuing bioengineering for her PhD with an emphasis on imaging sciences. Daye already holds a provisional patent on a technique she developed for noninvasive quantification of hepatic collagen concentration in liver fibrosis. Her research and education are supported by a Howard Hughes Medical Institute Gilliam Fellowship and a Paul & Daisy Soros Fellowship.

Alonso Fuentes (Rice B.S. ’05) is a flight project manager and payload systems engineer with Lockheed Martin in Houston, TX. Working in the company’s Space and Science Solutions division, he plans schedules and budgets as well as supports on-orbit session within Mission Control during biomedical experiments aboard the International Space Station. In the past two years he has earned five awards for working with peers to engineer practical solutions that exceed expectations. He is also working toward an M.B.A. at the University of Houston.

Photo by Christopher Smith
Rice bioengineering alumnae strive to make the world a better place
Vision and efforts supported by 2009 Fulbright Scholarships

Rice University bioengineering alumnae Abigail Watrous (B.S. ‘04) and Alicia Allen (B.S. ‘09) have been awarded Fulbright Scholarships to travel internationally and help improve the quality of life for others.

The grants supporting their quest are part of the Fulbright Scholars Program, the U.S. government’s flagship international exchange program to study, teach and conduct research in a foreign country. Prior to the 10-month internship, Watrous and Allen will participate in an intensive language enhancement course.

Abigail Watrous, a Ph.D. student in the University of Colorado’s (CU) Civil and Environmental Engineering Building Systems Program, is passionate about exploring green design, energy efficiency, and renewables. The Fulbright Scholarship will support her travels to Beijing, China and its rural communities to continue investigations into clean alternatives to coal for cooking and heating, and to develop hands-on teaching modules in renewable energy for Chinese and American elementary students.

Watrous is no stranger to using the engineering and design skills she has acquired to develop practical, effective, and affordable energy solutions both in the U.S. and abroad. At Rice, she conducted research in Jennifer West’s Laboratory for Biofunctional Materials/Cardiovascular Tissue Engineering and co-founded the Engineers Without Borders program. As a grad student at CU, she was a member of the award-winning 2005 Solar Decathlon team; and in 2007, earned grants from the National Science Foundation’s East Asia and Pacific Summer Institute and CU to spend a year at Tsinghua University in Beijing and travel to nine provinces to research biomass and renewable energies in rural communities. The experiences inspired her to write a children’s book about the basics of renewable energy titled Let’s Explore Energy. The book is available in English and Chinese.

Alicia Allen’s scholarship will take her to South Korea to teach English and share American culture with elementary students while taking in a culture that is entirely new to her. She is especially looking forward to the intensive language instruction in Korean that she will receive before being assigned a school.

Allen, a double major in bioengineering and French, also worked in the tissue engineering laboratory of Rice’s Professor Jennifer West. Much of her undergraduate research experience focused on vascularization, particularly the formation of blood vessels to develop smaller-diameter grafts for heart-bypass patients and create complex 3-D tissues beyond skin and cartilage. Through her one-year sabbatical from research, she expects the cross-cultural experiences gained from the Fulbright program will dramatically enhance her graduate education pursuits.

BIOE Alumni Class Notes

Please send alumni news to: bioealumni@rice.edu.

**Marty Bost** (Rice B.S. ‘07; Rice M.B.E. ‘08), an experiment support scientist at Wyle, is providing ground support for current science experiments on the International Space Station and building hardware for future experiments. Marty wrote, “I have to say, having the opportunity to work with Mission Control has been very exciting.” Marty also uses his artistic talents by participating in the annual Art on the Avenue fundraiser sponsored by Avenue CDC.

**Sheila Moore** (Rice M.S. ‘08; adviser Antonios Mikos) is currently working as a shuttle systems instructor for United Space Alliance at NASA’s Johnson Space Center. She prepares and presents lectures to astronauts, flight controllers, and instructors, on how to operate the space shuttle to ensure mission safety. Along with shuttle training, she works on the Constellation Training Program—NASA’s new program for human space exploration. In her personnel time, Sheila volunteers at Southwest Alternate Media Project (SWAMP) where she has been a board member since 2008 and works on the Fundraising Committee.

After finishing his graduate studies at Rice, **Eric Darling** (Rice Ph.D. ’04; adviser Professor Kyriacos Athanasiou) started a postdoctoral fellowship at Duke University with Professor Farshid Guilak. Recently, Eric received a K99/R00 Pathway to Independence Award from the NIH and subsequently took a faculty position as Assistant Professor at Brown University in the Department of Molecular Pharmacology, Physiology, & Biotechnology. The general focus...
Alumni News

Rice alumna wins Soros Fellowship for New Americans

Bioengineering alumna Dania Daye (B.S. ‘07) was selected to the Class of 2009 Soros Fellows from about 750 applicants. The second-year graduate student at the University of Pennsylvania’s MD/PhD program is also a Howard Hughes Medical Institute Gilliam Fellow.

Paul & Daisy Soros Fellowships are awarded to new Americans – resident aliens, naturalized U.S. citizens or those who are the children of two parents who are both naturalized citizens. The grants are intended to support individuals who are loyal to their country of origin but who will continue to regard the United States as their principal residence and focus of national identity.

Born 23 years ago in Beirut, Lebanon, Daye came to the U.S. when she was sixteen. Through the Soros Fellowships for New Americans, she will receive a $20,000 grant and half the cost of her graduate program tuition to pursue combined MD/PhD degrees in medicine and in engineering at the University of Pennsylvania.

Daye graduated magna cum laude from Rice and was elected to Phi Beta Kappa. She gained early exposure to interdisciplinary lab research working closely with Rebecca Richards-Kortum, the Stanley C. Moore Professor of Bioengineering and professor of electrical and computer engineering. Daye said the experience was influential in her pursuits on imaging sciences.

"In medicine, there often seems to be a gap between the physicians and the techniques that physicists and electrical engineers develop. With this scholarship, I am hoping to serve as a bridge between some disciplines that don’t regularly communicate,” Daye added.

Daye already holds a provisional patent on a technique she developed for noninvasive quantification of hepatic collagen concentration in liver fibrosis.

"Rice provided me with a number of opportunities to develop many fundamental skills in both research and patient care," Daye said. "I definitely look back at my experience in the lab through the Rice Undergraduate Scholars Program as one of the forming experiences that shaped the way I currently approach any research question in the lab. I would not be currently looking at filing a patent on one of my research projects from this summer, if it wasn’t for my undergraduate research experience at Rice."

Daye also served as the Rice Emergency Medical Service operations lieutenant, supervising 22 EMTs and maximizing the efficiency of the organization. Through the program she led an initiative that increased the number of public defibrillators on campus from four to 20.

"Being able to do this at the same time as research on campus tremendously shaped the way I look at science and medicine,” Daye said. "It allowed me to see them as two entities on a continuous spectrum, if not a continuation of one another. Medicine helps individual people while research helps people on a global level."

BioE Alumni Class Notes (Cont.)

of his research is to understand the relationship between the biological function of cells and tissues and their micro/nano-scale mechanical properties, in part by utilizing atomic force microscopy. In July 2009, Eric and Louise Organ (Rice Ph.D. ’08; adviser Professor Robert Raphael) were married.

Ailen Sanchez (Rice Ph.D. ‘06; adviser Professor Ka-Yiu San) has been with Genentech in San Francisco for four years. As a bioprocess engineer in the Late Stage Purification Division, her work involves the development and implementation of recombinant protein (i.e humanized monoclonal antibodies) purification at the laboratory, pilot plant and industrial scale using various separation unit operations. Her job supports the development, characteriza-

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Louise Organ-Darling (Rice Ph.D. ’08; adviser: Associate Professor Rob Raphael) is a postdoctoral fellow in Dr. Gideon Koren’s laboratory in the Cardiovascular Research Center (CVRC) at the Rhode Island Hospital in Providence, RI. Louise is supported by the CVRC’s new T32 Cardiopulmonary Research Training Grant (NHLBI), and her research in cardiovascular molecular pathobiology will focus on voltage-gated potassium channels in cardiomyocytes.

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