FOCUSING ON ENERGY RESEARCH ~ IMPROVING SYSTEMS AND PROCESSES ~ REUNION & HOMECOMING

Rensselaer

Alumni Magazine~Fall 2012

DREAM LIGHTING

THE LIGHTING RESEARCH CENTER HAS DEVELOPED INNOVATIVE LIGHTING SOLUTIONS FOR BOEING'S NEWEST AIRCRAFT

Incoming students who make up the Class of 2016 visited campus for Student Orientation in July and August. Students attended information sessions, met with academic advisers, and registered for classes. They also had the opportunity to meet new classmates, interact with faculty and student leaders, and become familiar with campus facilities.

Rensselaer

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ON THE COVER:
Nadarajah Narendran, director of research at the Lighting Research Center. Photo by Mark McCarty.

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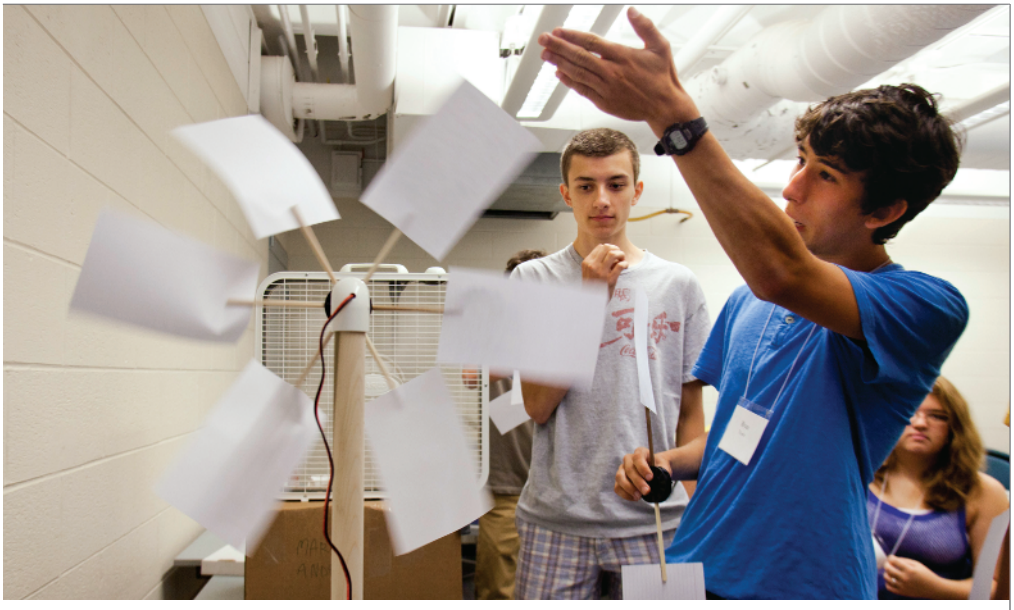

SCOTT BARROW

Students of all ages took part in Summer@Rensselaer programs on campus. See page 6.

FEATURES

DEPARTMENTS

SCOTT BARROW

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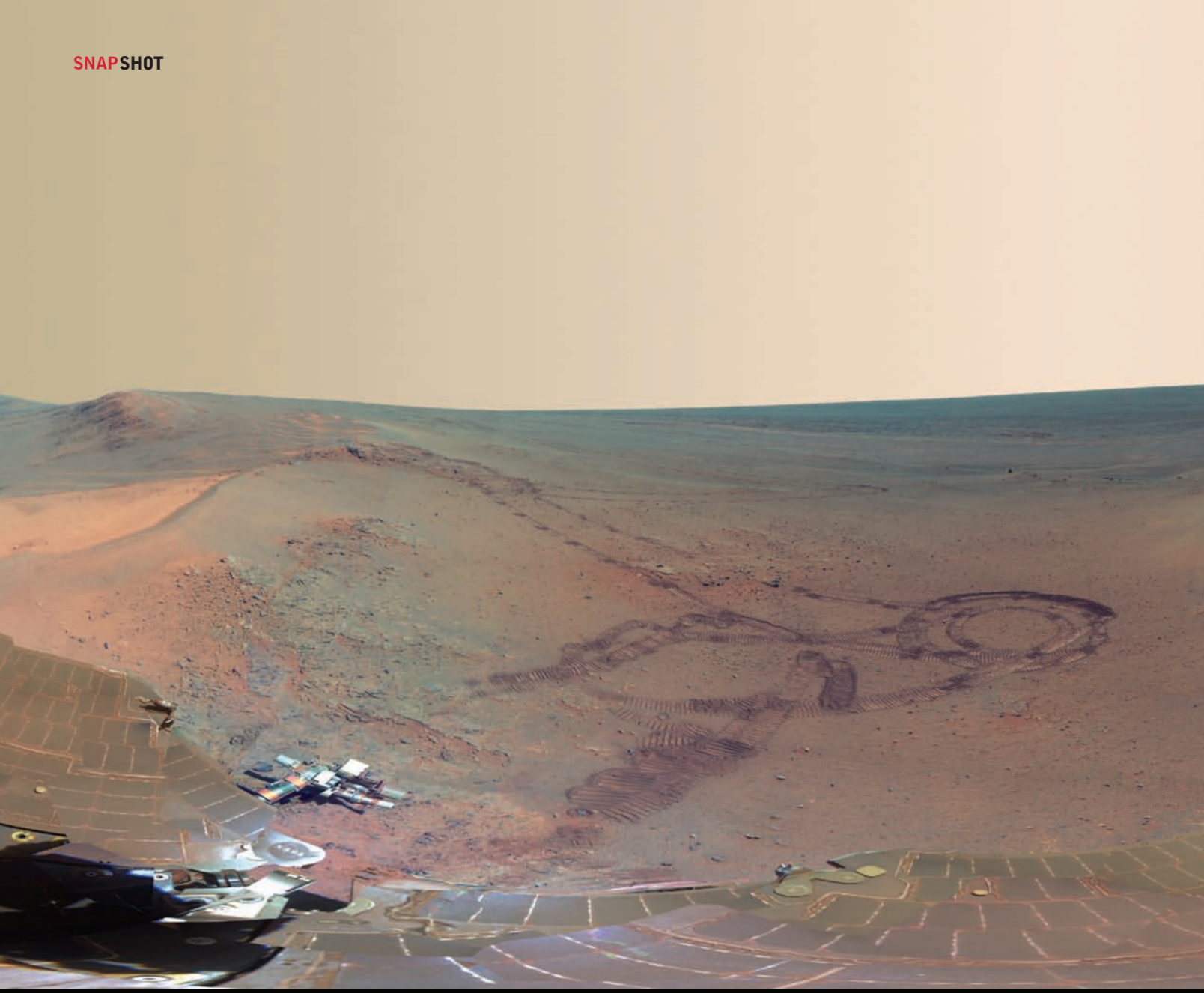


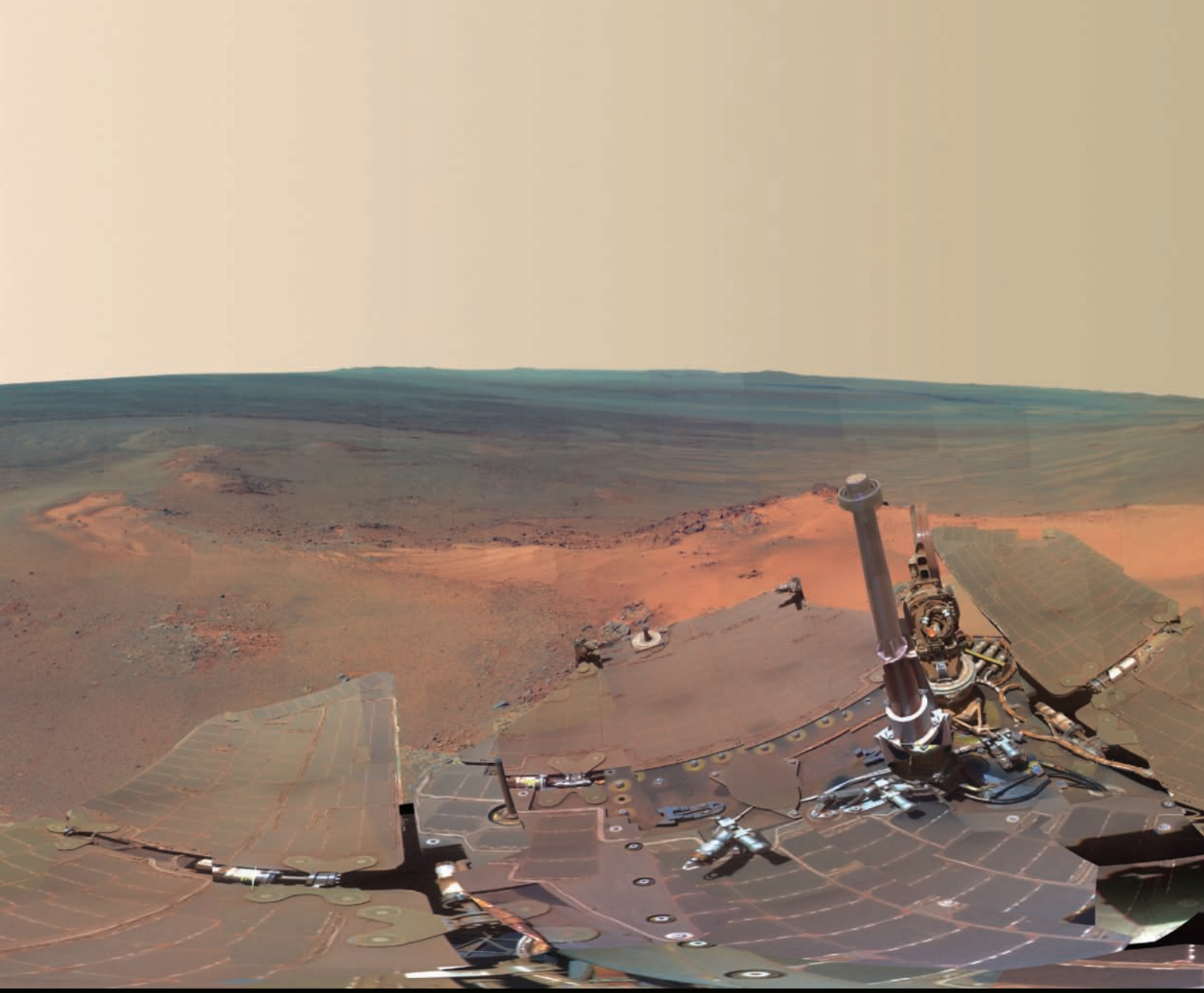
Mars Rover Returns Pictures of Red Planet

In July, NASA revealed a spectacular new 360-degree panoramic image of Mars' surface, taken by a camera on board the Mars rover Opportunity. The image is made up of 817 separate pictures taken by Opportunity's panoramic camera.

Opportunity was one of two rovers sent to Mars in 2003 for a mission originally expected to last just three months. While Opportunity's sister craft, Spirit, stopped functioning in 2010, Opportunity is still going strong.

More than a dozen Rensselaer alumni took part in that Mars Exploration Rover mission. Several of them are involved in the current mission, the Mars Science Laboratory, named Curiosity. Opportunity has spent more than eight years exploring the Red Planet. The image shows a full-circle view of Mars near a spot called "Greeley Haven," where Opportunity spent four months during the Martian winter.

Greeley Haven was named after Ronald Greeley (1939-2011), a member of the Mars Rover team who taught planetary science at Arizona State University.



In July, NASA released this image, which combines photos taken by the panoramic camera on the Mars Exploration Rover Opportunity.

Laurie Leshin, dean of Rensselaer's School of Science, was also part of the team that built Curiosity. Leshin, who joined Rensselaer from NASA, was a colleague of Greeley's at Arizona State University.

"Ron Greeley has been a mentor and dear friend throughout my career," she says. "He was my first geology professor and gave me my first academic research job. He loved exploring the solar system, and equally loved engaging students in his quest for knowledge. It is entirely fitting, and a wonderful tribute, that the Mars Exploration Rover team named Opportunity's most recent winter resting spot Greeley Haven. Ron will be sorely missed by planetary scientists, but his legacy will live on through his work, his students, and this special place on Mars."

Leshin and several alumni who were part the team that built Curiosity will be on hand at Reunion & Homecoming Weekend in October, where they will share stories about the engineering behind the project and the science behind the study of its findings.

The pilot "Mandarin Project" developed a research base for teaching languages in an immersive environment.

Partnering Across Disciplines

Reaching across disciplines is a major path to insight and innovation

We live in a time of abundant information of unprecedented dimensions. Our ability to generate and store data gives us more information than the human brain can process. With advanced instrumentation and sensors, we are becoming masters of observation.

But as information becomes easier to obtain, the ability to analyze that information, to see patterns in the numbers, is more precious. The analysis of data collected from instruments like the Large Hadron Collider or the Hubble Space Telescope is a task that requires hundreds of scientists, years of time and energy, and supercomputers capable of petaflop speed performance.

And when the findings from these great scientific endeavors are confirmed, we reach the most vaunted step in the process: applying them to the common purposes of life.

Of course, this is the founding mission of Rensselaer. And in seeking to achieve it, we have learned that sharing knowledge and working across disciplines is a potent approach. From our earliest years as an institution, transdisciplinary collaboration has been a hallmark of Rensselaer. Founded as an engineering school, Rensselaer became a *polytechnic* institute by virtue of the addition of science to the curriculum. Over the years, we have extended our reach with architecture, business, and the humanities, arts, and social sciences.

This fall, we extend that approach as we launch a new research center that draws on all our diverse pools of expertise. The Center for Cognition, Communication, and Culture will focus on the intersections and interdependency of these fields in the context of contemporary research, technology, and society. Interdisciplinary research will draw on the arts, design, engineering, humanities, the sciences, and social science. Work is under way to create a space for this unique new center at the Curtis R. Priem Experimental Media and Performing Arts Center.

The center's mission is intentionally broad, but already core research areas, and even a few intriguing projects, are emerging.

The core research areas are: large-scale collaborative virtual reality environments; cross-modal data displays and intelligent user interfaces; intelligent agents and cognition, communication, and culture; culturally inspired and culture-driving educational and enabling technologies; and new cultures. Each holds enormous potential for practical application.

The first research area, large-scale collaborative virtual reality environments, already has spawned a project that is generating much excitement on campus. Funded with a Rensselaer Office of Research seed grant, the project titled "Emergent Reality Lab: The Lost Manuscript" uses a mixture of narrative, game design, and augmented and virtual reality to teach Mandarin Chinese.

The "Mandarin Project," as it is known around campus, immersed students in a fictional mystery, set in Beijing, surrounding a book that has been missing for centuries.

The Center for Cognition, Communication, and Culture's mission is intentionally broad, but already core research areas, and even a few intriguing projects, are emerging.

Over the course of eight weeks, using a combination of virtual and augmented reality environments, students "visited" a series of locations around Beijing, including the Forbidden City, a traditional tea house, and a police station. In each of the locations, they gathered clues to solve the mystery by mastering course content.

Ultimately, the students learned more Chinese in eight weeks than they would have learned in a full semester of conventional language instruction. The experiment in pedagogical innovation involved researchers in computer science, art, and communication and media.

The pilot project developed a research base for teaching languages in an immersive environment. The same group of researchers soon will be working to improve the immersive experience they are able to create with their work in the Emergent Reality Lab, a new platform for research in immersive environments—including virtual reality, augmented reality, and mixed reality—currently under construction.

A summer internship program, held in advance of the center launch, also hints at the diversity of research interests that will come together through the new center. Graduate research included developing a hearing system for the HUBO humanoid robot, a digital music instructor capable of evaluating a performance and suggesting improvements; a Web-based tool that teaches math using elements of skateboarding; and a computer-controlled performance piece that adjusts to audience response.

Of course, transdisciplinary discussions and collaborations are not restricted to new centers and formal settings. Reaching across the boundaries of academic fields is something people of the Rensselaer community do as part of their daily routines. It happens spontaneously, and it also is designed into our campuses, which encourage informal get-togethers and expedite serendipity.

Such collaborations are demanding, but they promise great benefits. You can expect Rensselaer to work at the leading edge.

Future of Computing Is Here

At the end of the article on the Watson computer system ("One Giant Step for Computing," Spring 2012), there is a quote from all-time *Jeopardy!* champion Ken Jennings: "I for one welcome our new computer overlords."

In 1982, I heard IBM fellow James Martin speak at a computer conference about the future of computing. He made several predictions that have since come true. In his conclusions, he said that by 2025 humans would have trouble arguing with machine decisions.

Ken Jennings doesn't know how right he is.

BOB STURM '68
Oakland, Calif.

Concrete Argument

Thank you for the great article on Fenway Park. Having grown up in southeastern New England, I've been a Red Sox fan for years. I did find a small issue to take, though; that of the use of the word "cement" in at least three places when referring to "concrete." This is common in consumer publications, but should not have found its way into print in an engineering journal. The third instance actually said the engineer's daughter was checking on "cement drying." I doubt that she used that term, and if so, it should have been in quotes. Concrete does not dry, it cures. I think all engineers understand that, and that cement is only a component of the structural material concrete.

My family has always known that distinction, as well as the other "thorn in my side," the use of the term "tin foil" in place of "aluminum foil." I believe there was very little tin foil manufactured after the start of World War II, as tin was a critical material for the war effort.

The aluminum industry employed me during all my work since graduation from RPI, and is presently a large factor in supporting me in my retirement.

ALBERT PARKER '64, P.E. (RET.)
New Bern, N.C.

Polybahn West?

It's always a joy to read a new issue of *Rensselaer*. This time, the letter from Paul Shatsoff ("Connecting Campus to Downtown")—suggesting a funicular railway from downtown Troy to the RPI campus—immediately caught my interest.

I don't know whether there's room for a funicular in present-day Troy—certainly it wouldn't do to replace the beautiful Louis Rubin Memorial Approach—but Mr. Shatsoff's idea reminded me of a funicular in Zurich, Switzerland, called the UBS Polybahn. In a few minutes' time, it whisks passengers from a streetcar junction point named Central up to the ETH Zurich, the renowned technical institute from which Albert Einstein graduated in 1900. Wikipedia has more about the UBS Polybahn.

Polybahn: What a great name for a funicular to Rensselaer Poly! Troy might call its funicular Polybahn West. Perhaps a proposal for such would be a worthy thesis for a Rensselaer student majoring in civil, mechanical, or electrical engineering, or even a team of students pursuing those majors.

STEVEN SMITH '50
Camden, Maine

Mars Rover Connections Continue

This is in regards to the Alumni Connections article in the Spring 2012 issue ("Mars Rover Has Ties to Rensselaer"). The article lists Rensselaer alumni who have been involved in the Mars Science Laboratory mission to send the Curiosity rover to Mars.

I was the mission design and navigation manager for the Curiosity rover mission. I managed a team of 10 people at the NASA/Jet Propulsion Laboratory that performed trajectory design for the Earth launch, interplanetary transfer, and Mars atmospheric entry phases of the mission; developed the launch/arrival strategy; performed interplanetary navigation accuracy studies; and analyzed options for critical data communications during the Mars atmospheric entry, descent, and landing phase of the mission.

Previously, I was the navigation team chief for the Mars Exploration Rover mission that landed the twin Spirit and Opportunity rovers on Mars and the deputy navigation team chief and mission design manager for the Galileo mission to Jupiter.

LOUIS D'AMARIO '68
Providence, R.I.

Thanks for the Memory

While reading the 1949 Class Notes (Spring 2012), I was surprised and delighted to see my father's name mentioned by Christopher MacDermot. My dad was Bill Bahr. I was deeply touched to see my father's name and read Mr. MacDermot's kind words. RPI and the friends he made there meant a lot to my dad. It is wonderful to know that he has not been forgotten by his friends from RPI. Thank you, Mr. MacDermot.

ALISON BAHR TAYLOR
Ann Arbor, Mich.

We'd love to hear from you! To provide space for as many letters as possible, we often must edit them for length. Address correspondence to: Rensselaer *Magazine, Strategic Communications and External Relations, Rensselaer Polytechnic Institute, Troy, NY 12180; email to alum.mag@rpi.edu; or call (518) 276-6531.*

AT RENSSELAER

ACADEMIC OUTREACH

Summer School

For the last seven years, Rensselaer's Academic Outreach Programs office has offered numerous summer programs that focus on science, technology, engineering, and mathematics disciplines. This summer, elementary, middle, and high school students—along with college students and K-12 teachers—immersed themselves in a variety of credit courses, academic short courses, enrichment programs, and sports camps, including hockey, football, and basketball development camps for boys and girls.

Through "Summer@Rensselaer" and other departments on campus, offerings continue to expand. This year, classrooms came alive with students taking part in an aerospace engineering summer career exploration program, a computer game development academy, a chemistry and medicine summer scholars program, and an architecture career discovery program, as well as creative writing workshops, robotics engineering programs, and much more.

To learn more, visit summer.rpi.edu.

Marc Destefano taught the summer computer game development academy.

Scott Barrow

KRIS QUA

Research conducted at Rensselaer addresses some of the world's most pressing technological challenges—from energy security and sustainable development to biotechnology and human health.

SCHOOL OF ENGINEERING RECOGNITION

"World's Best Engineering Schools" Include Rensselaer

RENSSELAER HAS BEEN NAMED ONE OF THE top engineering schools in the world. Industry-focused website *Business Insider* ranked Rensselaer fourth on its list of "World's Best Engineering Schools." The rankings were based on surveys of engineers, professionals, and entrepreneurs working at technology companies.

"Rensselaer's engineering programs are held in very high esteem among the academic and scientific communities. We have long been recognized for the quality of our academic programs, the unique experiences we afford our students, and the ability of our graduates to make significant contributions early in their careers. This latest ranking provides clear evidence of the value placed on our world-class engineering programs by the companies that hire our graduates," says David Rosowsky, dean of the School of Engineering. "We are immensely pleased to be recognized by *Business Insider* as one of the best engineering schools in the world."

Business Insider asked survey respondents to rate how valuable degrees from different engineering schools are to the future careers of graduates. Rensselaer placed fourth with a score of 4.16 out of 5, behind Stanford University, the Massachusetts Institute of Technology, and the top-ranked California Institute of Technology. Rounding out the top 10 were: University of California, Berkeley; Carnegie Mellon University; Cornell University; Georgia Tech; Harvard University; and Princeton University.

Survey results show the two most important factors in choosing an engineering school are the skills and knowledge acquired in school (74 percent), and the brand value of the school (19 percent).

The survey identified IBM, Cisco Systems, Intel, Microsoft, and Oracle as key employers of Rensselaer graduates.

Today, 3,000 undergraduate students and 700 graduate students are enrolled in the School of Engineering, and 70 percent of incoming first-year engineering students were in the top 10 percent of their high school graduating class. The School of Engineering's seven academic departments offer 30 different degree programs.

Research conducted at Rensselaer addresses some of the world's most pressing technological challenges—from energy security and sustainable development to biotechnology and human health—and the School of Engineering's 165 faculty members are at the leading edge of their fields. The engineering faculty's annual research expenditures total more than $50 million.

"Rensselaer's engineering programs are held in very high esteem among the academic and scientific communities. This latest ranking provides clear evidence of the value placed on our world-class engineering programs by the companies that hire our graduates."

INTERNATIONAL RECOGNITION

President Named to British Royal Academy of Engineering

PRESIDENT SHIRLEY ANN JACKSON HAS BEEN ELECTED as an International Fellow of the prestigious Royal Academy of Engineering.

Announcing the 2012 Class of Fellows, Sir John Parker, GBE FREng, president of the Royal Academy of Engineering, said, "We welcome our new fellows—the collective expertise and vision of the best engineers is what drives our ambitious agenda and makes so many good things possible."

According to the Royal Academy, President Jackson was chosen for her "research and leadership experience in industry, education, and government as well as her expertise in high-energy physics." She is one of only four International Fellows in the 2012 Class.

"Selection as an International Fellow of the Royal Academy of Engineering is only for those at the pinnacle of engineering achievement," says retired U.S. Court of Appeals Senior Circuit Judge Arthur Gajarsa '62, chairman of the Rensselaer Board of Trustees. "President Jackson has left her mark in engineering and related fields throughout her career, whether at Bell Labs, in the nuclear energy arena, or more recently focusing locally, nationally, and globally to harness scientific discovery and technological innovation to spark the economy and to meet the grand challenges and opportunities of our time. The Rensselaer community benefits from and is extremely proud of President Jackson's achievements."

She was chairman of the U.S. Nuclear Regulatory Commission from 1995 to 1999, and currently is a member of the President's Council of Advisors on Science and Technology, co-chairs the President's Innovation and Technology Advisory Committee, and is a member of the U.S. Department of State International Security Advisory Board.

She also is a member of the U.S. National Academy of Engineering, the American Philosophical Society, and a fellow of the American Academy of Arts and Sciences, the American Physical Society, and the American Association for the Advancement of Science.

ALUMNI HALL OF FAME

Fenway Park Design Was a Home Run!

Rensselaer alumni joined with the Boston Red Sox and baseball fans to celebrate the 100th anniversary of Fenway Park and to honor Alumni Hall of Fame members Frank and Kenneth Osborn, who played a key role in designing and building the storied ballpark. The Rensselaer Alumni Association hosted a special behind-the-scenes tour for alumni, members of the Rensselaer community, and members of the Osborn family in April at Fenway Park. President Shirley Ann Jackson and David Haviland '64, former vice president for institute advancement and former dean of architecture, both spoke at the event.

Helen Dickey Curtis, oldest of Kenneth Osborn's 20 grandchildren, also spoke.

Frank C. Osborn graduated from Rensselaer in 1880, and in 1892 founded the civil engineering firm that would become Osborn Engineering. His son, Kenneth H. Osborn, graduated from Rensselaer in 1908 and joined the family company shortly thereafter. Both were civil engineering majors.

Kris Qua

In 1911, Osborn Engineering was among the team of contractors hired by the Red Sox organization to build the new ballpark in Boston's Fenway neighborhood. Osborn Engineering helped design and build the park's grandstand in steel and concrete. The company built the concrete foundation and reinforced steel columns of the park's right field pavilion. The company also played a significant role in the major renovations of Fenway Park in 1933 and 1934, under the leadership of Kenneth Osborn. A facelift of the stadium was already under way when a fire struck on Jan. 5, 1934, and ravaged most of the ballpark's wooden features. The burned wooden stands along the outfield were replaced with concrete structures.

Osborn Engineering became the nation's foremost designer of large sports stadiums, and pioneers in the use of reinforced concrete and structural steel. In addition to Fenway Park, the company designed Yankee Stadium in 1923, Philadelphia Stadium in 1924, and Chicago White Sox home Comiskey Park in 1925. Other notable Osborn Engineering stadiums include those on the campuses of Purdue University, Oberlin College, and the University of Notre Dame.


Andrew Chung

Student members of Engineers for a Sustainable World take a break with Michael Jensen (far right), faculty adviser and professor in the Department of Mechanical, Aerospace, and Nuclear Engineering.

ENGINEERS FOR A SUSTAINABLE WORLD

Extreme Makeover

Members of the student group Engineers for a Sustainable World (ESW) and other students spent the spring semester transforming a used 20-foot steel shipping container into a safe, comfortable, and transportable bedroom for orphaned children in Haiti.

The student team designed and built the sustainable bedroom, which will provide secure living quarters, shelter from the weather, and reliable electricity for 11 orphans and their caretakers. Several Rensselaer seniors worked on this project for their capstone design class in the O. T. Swanson Multidisciplinary Design Laboratory.

The sustainable bedroom was shipped to Haiti on May 25. A team of Rensselaer students planned to travel to Croix-des-Bouquets, Haiti, in August to install the bedroom at the Orphanage of Good Will and train the caretakers on upkeep and maintenance.

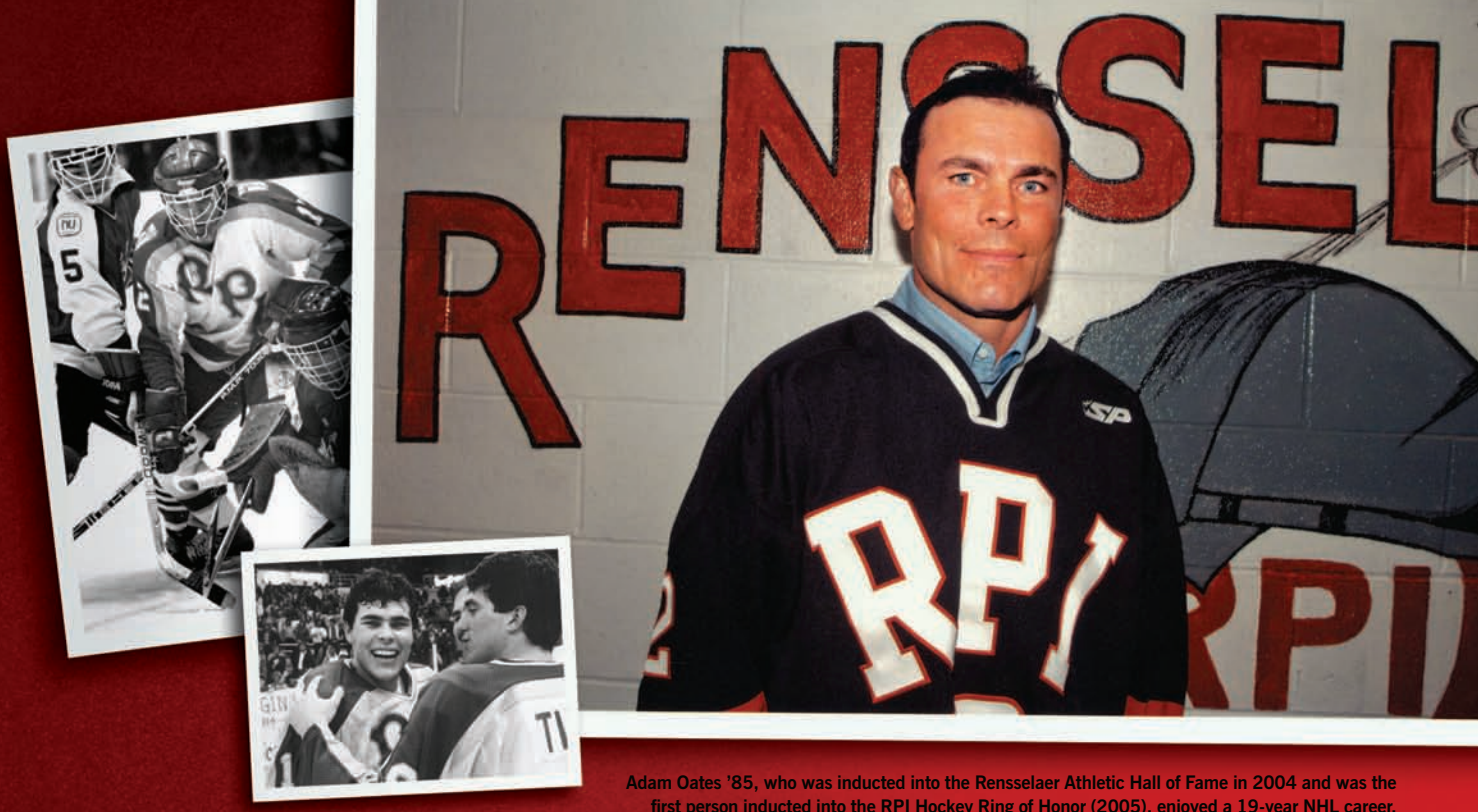
"This is an outstanding example of engineering students taking what they learn in the classroom, and applying it to the creation of solid, globally minded solutions that will have a tremendously positive impact on the lives of 30 orphans in Haiti."

"For this project, we're using the engineering smarts we've learned at Rensselaer to develop a sustainable solution for a very real, pressing need at the Orphanage of Good Will," says Andrew Chung, president of ESW at Rensselaer, who is dual majoring in mechanical engineering and design, innovation, and society. "Additionally, by exploring the conversion of used steel shipping containers into housing structures, we hope to spread awareness of recycling these abandoned containers for use in developing countries and disaster-prone regions of the world."

The ESW team designed the sustainable bedroom to leverage the cooling ability of reflective paint, shading, and natural and active ventilation to ensure a comfortable environment. The electrical system uses roof-mounted solar panels donated by General Electric to power the bedroom's ventilation system, lights, and wall outlets.

"This is an outstanding example of engineering students taking what they learn in the classroom, and applying it to the creation of solid, globally minded solutions that will have a tremendously positive impact on the lives of 30 orphans in Haiti," says Michael Jensen, ESW faculty adviser and professor in the Department of Mechanical, Aerospace, and Nuclear Engineering. "It's been a pleasure to work with these great students. Their enthusiasm and hard work on this altruistic project have been wonderful."

To learn more about the Rensselaer Engineers for a Sustainable World, go to esw.union.rpi.edu.



Adam Oates '85, who was inducted into the Rensselaer Athletic Hall of Fame in 2004 and was the first person inducted into the RPI Hockey Ring of Honor (2005), enjoyed a 19-year NHL career, scoring 341 goals with 1,079 assists for 1,420 points in 1,337 contests.

NATIONAL RECOGNITION

Hockey Hall of Fame Adds Adam Oates '85

June 26 was a banner day for Adam Oates '85. First the former Rensselaer hockey standout was named head coach of the Washington Capitals; then he capped a monumental day in the history of Rensselaer hockey as he became the first Engineers player to be chosen for induction into the Hockey Hall of Fame. Oates is one of four former NHL greats to receive the nod this year and will be inducted into the Hall of Fame at the 2012 Induction Celebration on Nov. 12 in Toronto.

"Growing up, I was a guy who was kind of overlooked," Oates told the Hockey Hall of Fame upon hearing the announcement. "I was fortunate to have the opportunity to go to RPI and have the time for my game to mature. This is a tremendous honor and I look back and realize how lucky I was to have great coaches to help me along the way."

In his three years at Rensselaer (1982-1985), Oates had 66 goals and 150 assists for 216 points in 98 games, helping the Engineers to an overall record of 85-19-1 and to win the 1985 NCAA Championship. Rensselaer, which was 35-2-1 in 1985, also won the ECAC Championship in 1984-1985. Oates led the team in assists all three years (33, 57, 60) and was first in points as a sophomore (83) and junior (91). He set numerous school records, including assists (60 in 1984-85) and points (91 in 1984-85) in a season and assists in a career.

"Since he joined the NHL after the 1985 championship season, Adam Oates has had an outstanding career, both as a player and assistant coach," says President Shirley Ann Jackson. "To see those achievements recognized by being named a head coach in the NHL, and being elected to the Hockey Hall of Fame on the same day, speaks volumes about his prominence in the game. We are proud of Adam, and we wish him much success as he begins his new career as a head coach with the Washington Capitals. He is a great example of the Rensselaer spirit, on and off the ice."

Oates, who was inducted into the Rensselaer Athletic Hall of Fame in 2004 and was the first person inducted into the RPI Hockey Ring of Honor (2005), enjoyed a 19-year NHL career, scoring 341 goals with 1,079 assists for 1,420 points in 1,337 contests. He exceeded 100 points in a season four times, including a career-high 142 points with the Boston Bruins in 1993.

A five-time NHL All-Star Game participant and an NHL Second Team All-Star in 1991, Oates retired ranked fifth all time in NHL history in assists (currently 6th) and 13th in points (currently 16th). Additionally, Oates played five years for the Capitals from 1997-2002, serving as both captain and assistant captain. He is also one of two former Rensselaer players to coach in the NHL, joining goalie Kevin Constantine '80, who posted a combined record of 161-155-60 at the helm of San Jose, Pittsburgh, and New Jersey from 1993-2002.

CHEMISTRY AND CHEMICAL BIOLOGY

Scientists Unlock Some Key Secrets of Photosynthesis

New research led by chemists in the Baruch '60 Center for Biochemical Solar Energy Research at Rensselaer is seeking to detail the individual steps of highly efficient reactions that convert sunlight into chemical energy within plants and bacteria.

In a paper published in the Royal Society of Chemistry journal *Energy & Environmental Science*, the scientists—led by K.V. Lakshmi, assistant professor of chemistry and chemical biology and scientific lead at the Baruch '60 Center—have provided important information on a specific portion of the photosynthetic process called photosystem II. It has been a major challenge to directly observe the individual steps of the solar water-splitting reaction that takes place in photosystem II, Lakshmi says. This finding provides new foundational research into how plants efficiently convert energy from the sun and could help inform the development of a new, highly robust, and more efficient generation of solar-energy technologies.

"The photosynthetic system of plants is nature's most elaborate nanoscale biological machine," says Lakshmi. "It converts light energy at unrivaled efficiency of more than 95 percent compared to 10 to 15 percent in the current man-made solar technologies. In order to capture that efficiency in solar energy technology, we must first tackle the basic science of photosynthesis by understanding the chemistry behind its ultra-efficient energy conversion process in nature."

The new research focuses on the first of two photochemical reactions that plants use to convert solar energy into chemical energy. Specifically, the researchers studied the binding and activation of the substrate water molecules in the catalytic site of photosystem II, a protein complex in plants and cyanobacteria that uses photons of light to split water molecules. The protons and electrons resulting from this split are then used by the plant to fuel the remaining systems in the photosynthetic process that transforms light into chemical energy.

Lakshmi was joined in the research by Rensselaer students Sergey Milikisyants, Ruchira Chatterjee, and Christopher Coates, as well as Faisal H.M. Koua and Professor Jian-Ren Shen of Okayama University in Japan.

ENGINEERING

New Manufacturing Innovation Learning Lab Introduced

Rensselaer has unveiled the new Manufacturing Innovation Learning Lab (MILL). Focused on educating the next generation of manufacturing leaders and pioneers, MILL builds upon the successes of its predecessor, the award-winning Advanced Manufacturing Laboratory (AML).

"The evolution from AML to MILL reflects changes in the field and in the marketplace. Industry is looking for future leaders who are versed in time-tested manufacturing techniques, yet experienced and fluent in micro, nano, bio, and other leading-edge manufacturing technologies," says David Rosowsky, dean of the School of Engineering. "Advanced manufacturing is essential to reinvigorating American innovation and to creating high-paying jobs across all technology sectors. The MILL positions Rensselaer and its graduates to make bigger, bolder contributions toward these important national goals."

Located in the George M. Low Center for Industrial Innovation, MILL is a forward-looking manufacturing learning environment. Leveraging the instructor expertise and industry-grade equipment in MILL, students taking *Introduction to Engineering Design*, the new *Manufacturing Processes and Systems I* and *II*, and senior capstone design courses can practice and master manufacturing processes. In these classes, students undergo the same design, process engineering, technical documentation, and rapid prototyping used in industrial research and development teams.

Looking forward, MILL will be an important foundation for infusing micromanufacturing, nanomanufacturing, and other advanced manufacturing technologies into the Rensselaer undergraduate engineering curriculum and graduate student experience. Additionally, MILL will enable new course work and advanced study on robotics systems development, manufacturing systems simulation, and emerging machining technologies. The School of Engineering expects to establish new undergraduate and graduate courses focused on these areas.

"Not just anyone can get a job at a leading high-tech manufacturing company. To succeed, thrive, and become a leader at these companies, you need to know the ins and outs of how to make stuff quickly, smartly, and competitively. This is precisely what Rensselaer teaches undergraduate students in the MILL," says Sam Chiappone, manager of fabrication and prototyping in the School of Engineering.

MILL's predecessor, the AML, was established in 1980. For the past few years, several student teams using the AML and taking the related course, *Advanced Manufacturing Lab*, have won or placed high in the American Society of Mechanical Engineers (ASME) Student Design and Manufacturing Competition held at the ASME annual conference. Rensselaer students won top prize at the competition in 2011, 2010, and 2009.

This year, graduating seniors who studied in the AML over the past two semesters have secured manufacturing-related jobs at Apple, Boeing, Pratt & Whitney, RBC Bearings, and many other top-tier employers.

Jill Evans

President Jackson was joined by local and state officials, area business leaders, members of the Rensselaer campus community, and representatives from the project development team at the ribbon-cutting ceremony.

Martin Benjamin

COMMUNITY

Chasan Building Renovation Brings History Back to Life

Beginning in the mid 1800s, the Chasan Building at the intersection of Fourth Street and Broadway served as the site for an iron storehouse, a public school, and a series of light industrial ventures before the building was used for commercial and retail businesses in the early 20th century. After more than 150 years of residing on an architecturally diverse streetscape in the center of the city of Troy's historic district, the Chasan Building was the site of a ribbon cutting in May at which Rensselaer and Columbia Development Companies unveiled the project that has converted the building into office space for the Rensselaer Institute Advancement team.

"The Institute is a committed, long-term partner in the revitalization of downtown Troy," says President Shirley Ann Jackson. "The adaptive re-use of the Chasan Building is an important step in continuing the renaissance of downtown Troy—a renaissance that the university is proud to help catalyze."

The Chasan Building serves as an example of the Greek Revival style, and has managed to retain its integrity of location, setting, association, materials, workmanship, feeling, and design. In addition, Chasan is a contributing building in the Central Troy Historic District that was listed on the National Register of Historic Places in 1986.

The building underwent a complete renovation and modernization, including a new roof, historic replica windows, restored exterior masonry, and the reconstruction of the original circa-1850 arched carriageway opening that will serve as the new main entrance to the building.

Rensselaer acquired Chasan and the nearby Proctor's Theatre in 2002 at the request of state and local officials to steward the properties and to help develop an effective, sustainable redevelopment plan. Since then, Rensselaer has invested nearly $1.5 million in the stabilization of Proctor's Theatre and stewardship of both buildings. Last fall, Rensselaer announced an agreement with Columbia Development Companies to assume ownership and begin work on Proctor's Theatre and Chasan.

"Columbia Development is committed to helping redevelop, in a responsible manner, the historic fabric of Troy," says Joe Nicolla '79, a partner in Columbia Development Companies. "This project is especially gratifying to several of our project team including Tom Keaney '94 (Columbia Development), Kevin Gleason '78 (BBL Construction Services), and Kurt Woodward '75 and Greg Seleman '72 (Woodward Connor Gillies & Seleman Architects), as we are all graduates of RPI and are privileged to be working with our prestigious alma mater. "

LIGHTING RESEARCH CENTER

Exposure to Light Could Benefit Alzheimer's Patients

Individuals with Alzheimer's disease and related dementias (ADRD) often sleep during the day and are awake at night. The situation can turn life-threatening if they leave their homes and wander around outside. This irregular sleep schedule and night wandering, and the consequent burden on their caretakers, is a primary reason individuals with ADRD are placed in more controlled environments such as nursing homes. A new study from the Lighting Research Center at Rensselaer lays the foundation for the importance of tailored light exposures as a viable treatment option for the reduction of sleep disturbances in older adults and those with ADRD.

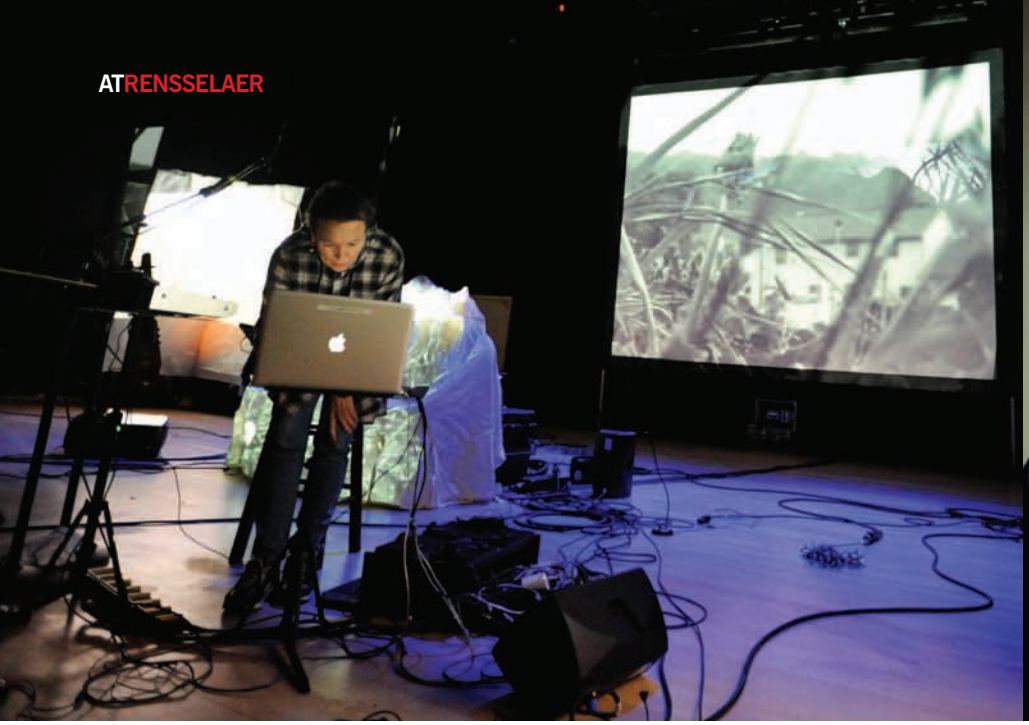
Funded by a grant from the National Institute on Aging, the study is the first to collect circadian light exposures in individuals with ADRD. Results of the quantitative study show that individuals with ADRD experienced lower light levels, exhibited lower activity levels, and had greater disruption to their natural circadian rhythms than healthy older adults. The findings also show that people with ADRD experience lower levels of light exposure and greater levels of circadian disruption during the winter.

"This is the first field study to examine the synchrony between the circadian light pattern and the activity response pattern to assess circadian disruption," says Mariana Figueiro, associate professor and director of the Light and Health Program at the LRC, who led the study. "Measurements revealed that those with ADRD experienced more circadian disruption than healthy older adults."

Growing evidence indicates that circadian disruption by irregular light/dark patterns is associated with reduced quality of life and increased risk of disease.

"Biology is driven by circadian rhythms at every level, and light is the main stimulus for synchronizing the circadian system to the solar day. By quantifying an individual's light/dark exposure pattern, we can prescribe 'light treatments' promoting circadian entrainment, thereby improving health and well-being," says Figueiro.

To collect data for the study, the research team used a Dimesimeter, a dime-sized device developed by the LRC, to record how much photopic and circadian light individuals are exposed to and whether they are active or resting.



Laurie Anderson first came to EMPAC as a resident artist in 2009 to complete work on *Delusion*, a work commissioned by the Vancouver 2010 Cultural Olympiad.

EMPAC

Laurie Anderson Named Inaugural Distinguished Artist-in-Residence

LAURIE ANDERSON HAS BEEN NAMED THE inaugural distinguished artist-in-residence at the Curtis R. Priem Experimental Media and Performing Arts Center for a three-year term beginning in 2012.

As one of America's foremost contemporary artists, a persistent experimenter at the intersection of performance, media, and technology, and an inventor of tools and instruments, Anderson is an ideal match for EMPAC's exceptional research and production environment for adventurous new work. The residency provides Anderson with wide access to space, technology, and support for creative experimentation, but as important, brings the artist into ongoing dialogue with students and faculty.

Anderson first came to EMPAC as a resident artist in 2009 to complete work on *Delusion*, a complex series of stories about longing, memory, and identity commissioned by the Vancouver 2010 Cultural Olympiad. At EMPAC, she found the ideal working environment to try new ideas and integrate the diverse, multidisciplinary elements of the work, including music, visuals, altered voices, and electronic puppetry.

"It's such a great honor to be the first EMPAC distinguished artist-in-residence," says Anderson. "Working with the crack technical and production teams and having access to EMPAC's spectacular spaces and resources is such a dream. I'm incredibly grateful for this opportunity."

The distinguished artist-in-residence is an expansion of EMPAC's extensive project-based residency program, which supports the creation of new works and research. It marks the first time an artist has been invited for an extended time unrelated to a specific project, with the express goal of sharing the artist's creative practice with a technology-focused campus and the community through lectures, work-in-progress demonstrations, Web documentation, workshops, and more.

"With EMPAC, Rensselaer has made an incredible commitment to bridge new technology with new artistic development and to bring together the engineering and scientific world with the experiential and creative approaches of the arts."

EMPAC Director Johannes Goebel sees a unique opportunity in this collaboration. "With EMPAC, Rensselaer has made an incredible commitment to bridge new technology with new artistic development and to bring together the engineering and scientific world with the experiential and creative approaches of the arts," he says. "Laurie Anderson will bring her deeply rooted experience in using technological tools in her artistic work to the campus community."

Since 2005, EMPAC has provided residencies to more than 100 projects with over 400 participating artists, both established and emerging, creating ambitious experimental, time-based work that crosses artistic disciplines and often intersects with the sciences and humanities.

One of America's most renowned performance artists, Anderson creates genre-crossing work that encompasses performance, film, music, installation, writing, photography, and sculpture. She is widely known for her multimedia presentations and musical recordings and has numerous major works to her credit, including *United States I-V* (1983), *Empty Places* (1990), *Stories from the Nerve Bible* (1993), *Songs and Stories for Moby Dick* (1999), and *Life on a String* (2001), among others. She has had countless collaborations with an array of artists, from Jonathan Demme and Brian Eno to Bill T. Jones and Peter Gabriel.

TETHERLESS WORLD CONSTELLATION

Automating the Search for New Technologies

Scientists at Rensselaer have begun work on a new Intelligence Advanced Research Projects Activity (IARPA) project to develop computer systems that help quickly identify emerging ideas and capabilities in technology. The research is part of the IARPA Foresight and Understanding from Scientific Exposition (FUSE) program under a team led by BAE Systems that includes Brandeis University, New York University, 1790 Analytics, and Rensselaer. Rensselaer has received $510,000 to fund its initial phase of the larger collaborative research project.

The current process to scan the horizon for new technologies is done primarily with human hands and minds. The process is time consuming and exhaustive, often only finding a technology well after it has become engrained.

The computer and Web scientists within the Tetherless World Constellation at Rensselaer, led by Constellation Professor Deborah McGuinness, will work with the FUSE team to help automate portions of the technological process of identifying emerging technologies. The team seeks to develop computational programs that will quickly analyze millions and even billions of pages of text for the emergence of new technological and scientific trends. The end result will be a new tool that can quickly scan collections of text in multiple languages for arising ideas. The Rensselaer focus is on making the process transparent and actionable.

"No one can keep up with the massive amount of data currently out there even in one language, let alone in many different languages," McGuinness says. "This will allow us to look at a far greater number of documents in less time to understand the significant trends that are out there." Once identified, these trends can then be better studied and seized upon for further development and investment by human analysts, McGuinness says.

The initial program will filter a huge assortment of published scientific, technical, and patent literature. The new system seeks to detect patterns or signatures that are indicative of the emergence of a new idea, capability, application, or even an entirely new field of study. The system then prioritizes these patterns and nominates areas for analytic exploration, according to McGuinness.

The research makes meaningful connections between the various information found in its search, a skill that most search engine technologies significantly lack, McGuinness says. And it must do all this a million times over in mere seconds. By doing so, the system can augment the work of human analysts in their search for new technologies around the world.

"We need to take this massive amount of largely unstructured data and give it a defined structure for the analysts," McGuinness says. "Further, we need to provide systems that tell users how they came to conclusions in order to allow users to understand when and how to act on the information."

McGuinness is joined in the research by co-principal investigator and Constellation Professor James Hendler.

RIGHT: MARK MCCARTY/LEFT: TIM KNOX

JULIE TRACY

LALLY SCHOOL OF MANAGEMENT AND TECHNOLOGY

10th Anniversary for Chinese Alumni

For many of us, our educational roots were the foundation for future opportunities to impact the world. Looking back on that time can provide great insight and appreciation.

In fall 2002, a group of 20 executives from Chinese software development companies came to the Lally School of Management and Technology for a one-semester, graduate-level certificate program titled *Management of Software Development Firms*. This program was sponsored by the China International Talent Exchange Foundation to improve the management of Chinese software companies.

During that program, the executives learned the latest management concepts, strategies, and methodologies from Lally School faculty in order to refine their entrepreneurial skills and abilities. As an integral part of this program, they also interacted with American information technology firms, learned about American culture, and created network opportunities.

In June 2012, to commemorate and celebrate the 10-year anniversary of their participation in this certificate program, the alumni returned to Rensselaer and the Lally School for a two-day visit hosted by a group of Lally School MBA students.

Also included was a visit back to campus and a chance to return to the Lally School in the Pittsburgh Building. Lally School Dean Tom Begley greeted and spoke with the alumni, along with several members of the Lally School faculty, including Pier Abetti, clinical professor; Jeff Durgee, associate professor; and Tom Triscari, clinical associate professor.

The alumni, led by Hongbo Jiang, chief executive officer of Dalian Zhonglian Computer Co. Ltd., expressed their gratitude for their professors, shared what they had learned inside and outside of the classroom during the program, and provided highlights of their career achievements over the past 10 years.

"The memories of 10 years ago are still very strong, and we are delighted to get a chance to meet here again," says Jiang. "We hope to continue our experience with Rensselaer after this visit as well."

MAKING A DIFFERENCE

First Endowed Athletics Coach Leads Women's Soccer

Rensselaer Women's Soccer Coach Cord Farmer bears the distinction of being the first endowed coach in Rensselaer Athletics history.

Tom Killips

As the beneficiary of an anonymous gift, Farmer's position is funded for women soccer players for generations to come. "The endowed coaching position is a great step for the athletic department," says Farmer. "Endowments for coaches make our funding go farther and enable us to compete with some of the bigger schools. It's a source of pride for the team to know that a donor has invested in women's soccer with an endowment. Everyone wants to work a little harder to honor that kind of commitment."

Farmer helped guide his Engineers team to a solid 8-7-2 record during the 2011 campaign. In his three seasons at the helm, 10 of his players have garnered year-end All-Liberty League recognition, while 47 student-athletes have been named to the conference's All-Academic squad.

Farmer was an assistant coach with the University of Wisconsin's women's soccer team prior to arriving at Rensselaer.

"I was excited that Rensselaer made a commitment to hire me as a full-time coach for women's soccer," says Farmer. "I looked at the other Division III soccer schools and saw that Rensselaer fit very well with their high academic standards. I thought that the soccer program at Rensselaer had room to grow and the sky's the limit."

Farmer was also attracted by the new East Campus Athletic Village (ECAV). "I know that the facilities for the academic side for our student-athletes are phenomenal, so ECAV represents a giant step to bring athletics up to the same standard," he says. "When the alumni return, you can see a little envy, but also pride in the new athletic resources."

Farmer particularly enjoys working with the athletes at Rensselaer. "I think Rensselaer athletes are as dedicated as any Division I athletes that I have met," says Farmer. "The first day of practice is like Christmas for me, because 99 percent of the team has been working on their skills and I can see a difference on the field.

Tom Killips

"I think Rensselaer athletes are as dedicated as any Division I athletes that I have met," says Cord Farmer, who bears the distinction of being the first endowed coach in Rensselaer Athletics history.

"I am really honored to fill the first endowed coaching position at Rensselaer," says Farmer. "Hopefully, this will serve as the kindling for the fire, so that others will step up and endow other coaches at Rensselaer."

TECHNOLOGY COMMERCIALIZATION

Recent Breakthroughs

The DaySwitch®

An automatic, energy-saving device invented by Andrew Bierman and Russ Leslie of Rensselaer's Lighting Research Center works by turning on and off electric lights in the home or office using a microprocessor that connects to a luminaire. The processor receives signals from a self-commissioned, mountable photosensor. The photosensor uses a unique algorithm to control illuminance at the task pane making the photosensor more accurate than current market technologies. Light energy consumption can be reduced by up to 30 percent and commercial customers can be recompensed in as soon as one year after installation. The device can be used in existing or new light fixtures and installs without additional wire runs or ballast replacement rendering it easy to install, low-cost, and effective.

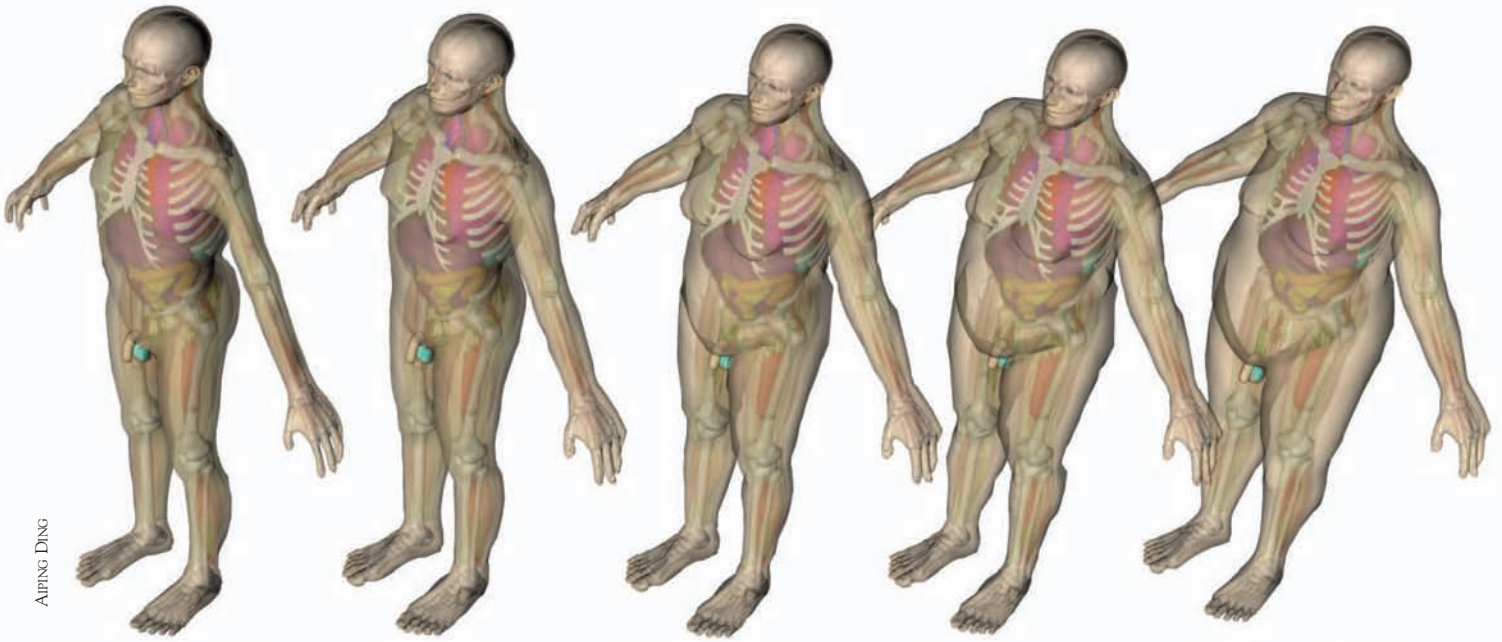
Mark McCarty

New Material for Protein Purification

A highly efficient protein purification material using electrospun cellulose fibers has been developed by researchers in Rensselaer's Center for Biotechnology and Interdisciplinary Studies. The novel electrospun cellulose fiber mat incorporates hydroxyapatite nanoparticles resulting in increased surface area and is capable of adsorbing proteins overcoming similar commercial products' drawbacks of fragility under high packing pressure and limitations to surface area due to microparticle formation. The highly efficient mats can be used as membranes in spin columns and can be desorbed by washing with salt or phosphate buffer.

Transparent Silicone-Based Nanocomposites Increase Light Efficiency

A thermodynamically stable dispersion technology resulting in thick, transparent, high-refractive index silicone nanocomposites that increase the light efficiency of LEDs and improve the emitted light color quality has been invented by researchers in Rensselaer's Smart Lighting Engineering Research Center. The nanocomposites could be processed as transparent bulk material with high filler loading, which is essential for novel optical, magnetic, and biomedical applications. This composite successfully achieves homogeneous dispersion of nanofillers within silicone, which minimizes the loss of transparency due to scattering. The composites can be used in optical, optoelectronic, magnetic, and biomedical applications.



AIPING DING

Normal weight | Overweight | Obese level I | Obese level II | Morbidly obese

MECHANICAL, AEROSPACE, AND NUCLEAR ENGINEERING

"Phantoms" Make Medical Imaging Safer for Overweight Individuals

MOST MEDICAL IMAGING EQUIPMENT IS NOT DESIGNED WITH OVERWEIGHT and obese patients in mind. As a result, these individuals can be exposed to higher levels of radiation during routine X-ray and CT scans.

A new study is the first to calculate exactly how much additional radiation obese patients receive from a CT scan. Research results show the internal organs of obese men receive 62 percent more radiation during a CT scan than those of normal weight men. For obese women, it shows an increase of 59 percent.

New technology developed at Rensselaer by nuclear engineering expert X. George Xu could help solve this problem. Xu's research team created ultrarealistic 3-D computer models of overweight and obese men and women, and used computer simulations to determine how X-rays interact with the different body types. These models, known as "phantoms," can help empower physicians to configure and optimize CT scanning devices in such a way that minimizes how much radiation a patient receives.

"Radiation exposure is cumulative over a patient's lifetime. The risk associated with a radiation dose from a single CT scan is relatively small when compared with the clinical benefit of the procedure," says Xu, head of the Nuclear Engineering Program and a professor in the Department of Mechanical, Aerospace, and Nuclear Engineering. "But patients are increasingly undergoing multiple CT scans and other radiation-based procedures, which can lead to unnecessary radiation risk. Regretfully, our study shows that obese and overweight patients can be exposed to an even greater level of radiation. Our new study brings us one step closer to minimizing radiation exposure and mitigating this risk to patients."

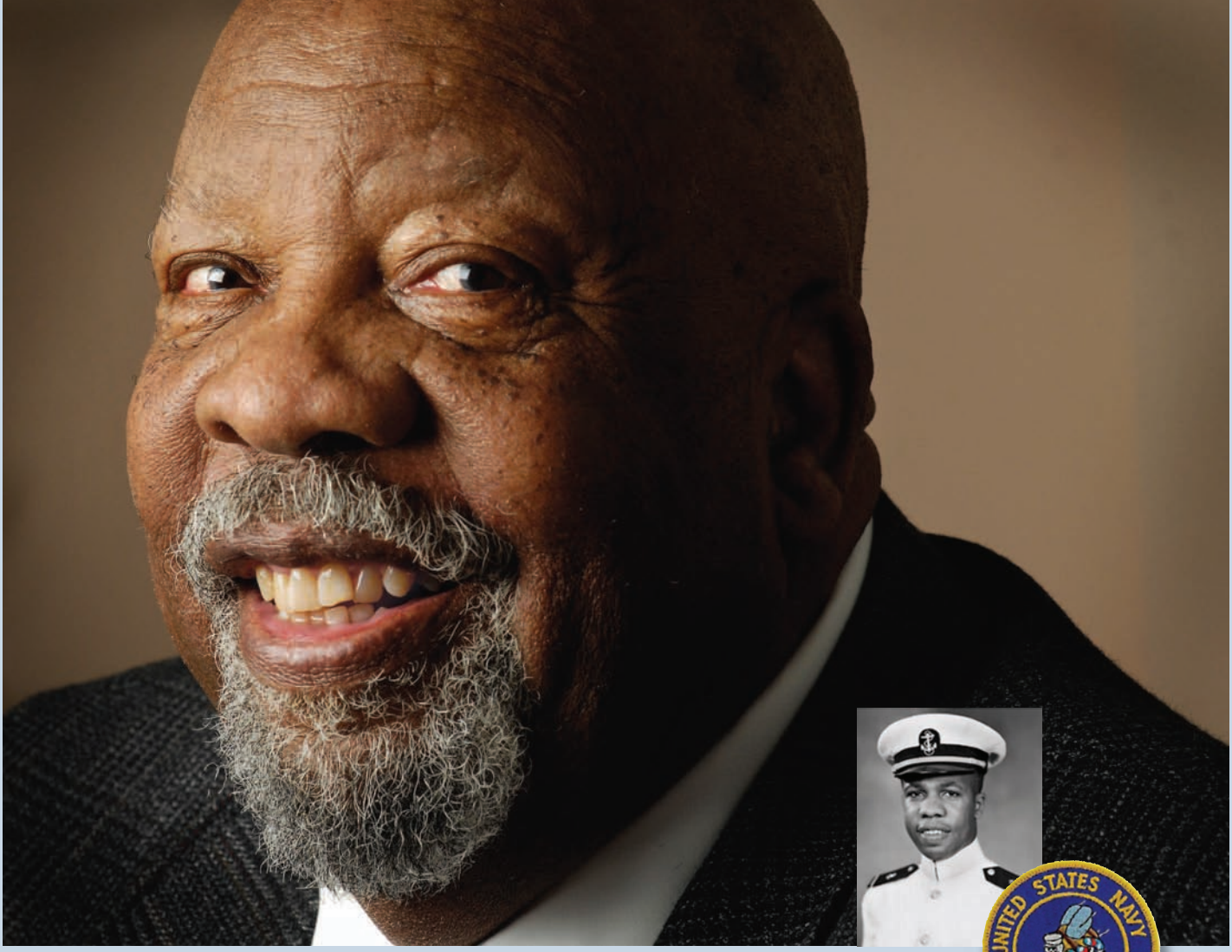
"Our study shows that obese and overweight patients can be exposed to an even greater level of radiation. Our new study brings us one step closer to minimizing radiation exposure and mitigating this risk to patients."

Currently, if technicians use normal equipment settings to perform a CT scan on an obese patient, the resulting images are blurry as the X-ray photons have to travel further and make their way through layers of fat. As a result, technicians generally adjust the equipment to a more powerful setting, which produces a better image but exposes the obese patient to additional radiation. These new phantoms will be part of a forthcoming software package, VirtualDose, developed by Xu and his team. VirtualDose aims to enable the creation of a personalized, ultra-realistic phantom of any patient undergoing a CT scan.

The program takes into consideration a patient's individual characteristics, including age, sex, height, weight, and even if a woman is pregnant. By entering these data into the software, VirtualDose quickly creates a phantom that accurately models the patient's internal organs.

These phantoms will allow physicians and researchers to compare the radiation doses a patient will get from different CT scanner settings, and then choose the most appropriate configuration.

VirtualDose also will enable physicians to keep a highly accurate record of how much radiation patients are exposed to over their lifetime. California recently became the first state in the United States to require radiation dose records for patients undergoing CT examinations.



André F. Chung/The Baltimore Sun

Wesley Brown distinguished himself as the first African-American to graduate from the U.S. Naval Academy before earning his civil engineering degree at Rensselaer in 1951.

IN MEMORIAM

Wesley Brown '51: A Legacy of Courage, Service, and Inspiration

By the time he came to Rensselaer, Wesley Brown '51 had already made history as the first African-American to graduate from the U.S. Naval Academy. For the rest of his life, in the Navy and elsewhere, Lt. Cmdr. Brown encouraged others to persevere and break similar barriers.

Brown died of cancer May 22 at age 85. His death was noted throughout the nation, and his life and legacy were celebrated both by those who knew him and those who benefited from his sacrifices.

"Wes Brown exemplified everything that we want Rensselaer graduates to aspire to," says Rensselaer Board of Trustees Vice Chair Adm. R.J. Zlatoper '63. "He broke new ground in the Navy and in engineering in a way that changed the nation."

More than 250 attended a memorial service for Brown at the Naval Academy June 6. Mourners included top military officials, the first African-American female graduate of the academy, and others who followed Brown as trailblazers. To many of them, Brown served not just as an example but also as a source of support.

"AMERICA IS STRONGER BECAUSE OF WES BROWN. MORE THAN 60 YEARS LATER, WE CONTINUE TO REAP THE BENEFITS OF HIS CONTRIBUTIONS. IN TRUE RENSSELAER FASHION, WES BROWN CHANGED THE WORLD."

Brown entered the Naval Academy in 1945, long before the civil rights era. He chose the Navy in part because, as he wrote in a 1949 article in the *Saturday Evening Post*, "... I learned that the Navy primarily is an engineering institution, and engineering has always been my dish."

Five African-American men had been admitted to the Annapolis military college before Brown. All five left within a year, unable to withstand the prejudice and relentless hazing. But Brown was determined to persevere. He was commissioned June 3, 1949, 16 months after President Harry S. Truman desegregated the armed forces.

During Brown's four years as a midshipman, he purposely lived alone, concerned that a roommate might be taunted or ostracized simply for being associated with Brown. He was given excessive demerits in an effort to run him out of the academy. Fellow midshipmen refused to sit with him, and he was prevented from joining the choir. Brown did, however, make the track team, running both track and cross-country.

In interviews conducted decades later, Brown acknowledged that he was tempted to drop out almost daily. But small gestures of support helped him endure. Among those who encouraged Brown to persevere was an upperclassman and cross-country teammate, Jimmy Carter, who would go on to be president.

Phil Hoffmann/U.S. Naval Academy

Blake Marvin

Wesley Brown (above) joins with U.S. Naval Academy officials in the ribbon-cutting ceremony at the dedication of the Wesley Brown Field House in 2008. Named in his honor, the state-of-the-art facility is home to the Naval Academy's athletic teams. Brown stands in salute with Admiral Michael G. Mullen (below right) during the playing of the national anthem.

Ricky Carioti/The Washington Post

Brown's first assignment was at the Boston Naval Shipyard. He then came to Rensselaer to earn his bachelor's degree in civil engineering. Classmate Ted Baglin '51 remembers Brown as "a good guy, always with a smile and sense of humor. I look back and realize that I had the privilege of spending a brief period with this man who overcame great obstacles and actually carved a significant niche in this country's history."

From Rensselaer, Brown went on to a 20-year career in the Navy Civil Engineer Corps, advancing to the rank of lieutenant commander. He served in the Korean and Vietnam wars and put his engineering skills to work around the world, building houses in Hawaii, roads in Liberia, a naval air station in the Philippines, a nuclear power plant in Antarctica, and a desalination plant at Guantanamo Bay, Cuba.

After retiring from the Navy in 1969, Brown worked in construction engineering for the New York State University Construction Fund at Stony Brook University, the Dormitory Authority of the State of New York, and the University Planning Office at Howard University. He retired from civilian employment in 1988.

In 2008, the Navy dedicated the Wesley Brown Field House in his honor. At the time, the building was the first and only Naval Academy facility named for a living alumnus. During the dedication ceremony, Adm. Mike Mullen, chairman, Joint Chiefs of Staff, cited Brown's "four years as a midshipman, when he was expected to complete none, his 20 years as a Seabee, and his continued life of civil service and example ... tearing down the walls of prejudice, not just for African-Americans but for all minorities. It was his noble calling, and it was his service and his contribution of citizenship, that led to long-lasting change in our Navy and in our nation."

Zlatoper echoed those sentiments after learning of Brown's death. "America is stronger because of Wes Brown," he says. "More than 60 years later, we continue to reap the benefits of his contributions. In true Rensselaer fashion, Wes Brown changed the world."

HUMANITIES, ARTS, AND SOCIAL SCIENCES

Department Name Change Reflects Wider Scope

President Shirley Ann Jackson has announced an important change in the name of a department in the School of Humanities, Arts, and Social Sciences (HASS).

"After extensive review and deliberation by Dean Mary Simoni and the HASS faculty, the Department of Language, Literature, and Communication will change its name, and now be recognized as the Department of Communication and Media," President Jackson said, in a memo announcing the change. "This change will enable the department to continue its tradition as an internationally recognized department for interdisciplinary education, research, and theory development, while looking to its future through a new perspective."

HASS Dean Mary Simoni says the new name is more representative of the true scope of the department's work.

"This change reflects the greater integration of emerging 21st-century forms of communication—digital, social media, graphic, visual—in the program," Simoni says. "Faculty and students within the Department of Communication and Media look to the full range of media, both traditional and technological, in creating a powerful message through their work."

For almost 60 years, Rensselaer faculty and students have explored the relationship between communication and technology. In 1953, Rensselaer established the world's first master of science program in technical writing. In 1965, the Institute established the Ph.D. in communication and rhetoric.

The new department name encompasses the wide range of disciplinary perspectives within the department, which include writing for new media environments, digital rhetoric, cultural studies, human-computer interaction, multimodal communication, graphic design, media studies, and computer-mediated communication.

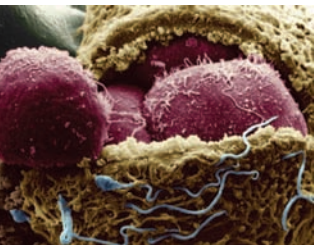
The new name facilitates promising research partnerships across the Institute in areas such as the visualization and sonification of complex data and multimodal communication, and creates a strategic alliance, under *The Rensselaer Plan*, with the Institute's signature research thrusts in computation and information technology, and media, arts, science, and technology.

BIOTECHNOLOGY

New Stem Cell Facility Opened

Groundbreaking research to advance the application of stem cells to address critical injuries and diseases is taking place at the Rensselaer Center for Stem Cell Research, a new center funded by New York state that was officially opened in June.

The center was launched by President Shirley Ann Jackson, New York State Department of Health Commissioner Nirav Shah, and Jonathan Dordick, director of the Center for Biotechnology and Interdisciplinary Studies (CBIS) and the Howard P. Isermann '42 Professor of Chemical and Biological Engineering. They were joined at the ribbon cutting by Glenn Monastersky, CBIS operations director and biomedical engineering professor of practice. Monastersky is also principal investigator under the $2.45 million grant awarded to fund the new center, from the New York State Stem Cell Science Program (NYSTEM).



"The opening of the Rensselaer Center for Stem Cell Research marks a milestone on the path toward this important area of exploration, which promises so much in terms of alleviating disease and improving health," says President Jackson. "At the center we will work at the frontiers of this promising discipline in collaboration with New York state and investigators from across the region.

According to Dordick, the new center continues to place CBIS and the research conducted there on the leading edge of efforts to harness advances in biotechnology to address 21st-century health challenges.

"Ranging from our work on the blood anticoagulant drug heparin to solutions to fighting some of today's 'super bugs' to important advances in understanding Alzheimer's disease, we are focusing our efforts on scientific advances that will ultimately open the doors to new cures for traumatic injuries or treatments for long-term conditions and diseases," Dordick says. "Now, working with our partners at New York state and other researchers in the region, we will expand our work on stem cells to help the medical and scientific research communities advance efforts to better understand those cells and how they can be used in medicine."

"The center that we have designed, funded by the NYSTEM award, will provide unique and valuable research platforms for stem cell researchers throughout upstate New York," Monastersky says.

ARCHITECTURE

Colorful Student Project Benefits Food Pantries

A group of School of Architecture students raised more than $2,000 and collected more than 1,600 cans of food for area food pantries in the second annual Capital District CANstruction event.

CANstruction—a nonprofit organization committed to ending hunger—organizes regional competitions in which local residents build and exhibit structures built entirely of cans of food. The structures raise awareness (and food) for food pantries. Following the exhibition, the structures were disassembled and the cans donated to local food pantries.

The Rensselaer team, the only student team in an event dominated by architecture and engineering firms, won the award for "Best Use of Labels," one of four awards given among the 14 teams, according to Tyler Hopf, a fourth-year student and captain of the Rensselaer team.

"It was great to represent RPI, win an award, and donate so much to a great cause," Hopf says.

The theme of this year's CANstruction project was animals, and the students' 10-by-10-by-8-foot structure—shaped and patterned like a peacock—was on display along with other entries at the New York State Museum this spring.

The Rensselaer team members are: Emily Mastropiero, Cady Guyton, Rachel Medina, Katie Brust, Hyatt Tortorella, Tyler Hopf, Sarah Goldfarb, Julia Grabazs, Alex Dorn, and Cat Callaghan. Mark Mistur, associate dean of architecture, also participated.

Architecture students collected more than 1,600 cans of food and $2,000 for their display. When the exhibit ended, the food was donated to area food pantries.


HAJELA


HENDLER


KORATKAR


AMITAY


DE


GERHARDT


BRENEMAN


DANON


INTES


LIAN

PRABHAT HAJELA, an experienced academic and administrative leader, has been appointed provost. A professor of aerospace engineering and vice provost, Hajela served as acting provost since Jan. 1, 2012. As vice provost since 2005, Hajela has been instrumental in helping Rensselaer maintain its leadership position in undergraduate education. An expert in complex system analysis and design in the presence of uncertainty, Hajela has published more than 270 papers and articles in the areas of structural and multidisciplinary optimization, and is an author/editor of four books.

JAMES HENDLER has been named the new head of the Department of Computer Science. Hendler is a senior constellation professor in the Tetherless World Constellation. He joined Rensselaer in 2007 after two decades at the University of Maryland, where he served as director of the Joint Institute for Knowledge Discovery and co-director of the Maryland Information and Network Dynamics Laboratory. The Computer Science Department is renowned nationally and internationally for its work in areas such as bioinformatics, computational science and engineering, computer vision, database systems, networking, parallel computing, pervasive computing, robotics, semantic web, software design, and theoretical computer science.

NIKHIL KORATKAR, a nanomaterials expert, has been named the John A. Clark and Edward T. Crossan Professor of Engineering. Koratkar joined the Department of Mechanical, Aerospace, and Nuclear Engineering in 2001 as an assistant professor. He was named associate professor in 2006 and full professor in 2009, and currently holds a joint appointment as a full professor in the Department of Materials Science and Engineering. His research is positioned at the intersections of nanotechnology, energy, and sustainability.

MICHAEL "MIKI" AMITAY, an aerospace engineering and fluid dynamics expert, has been named the James L. Decker '45 Endowed Chair in Aerospace Engineering. Amitay joined Rensselaer in 2003 as an assistant professor in the Department of Mechanical, Aerospace, and Nuclear Engineering. He was named an associate professor in 2008 and full professor in 2011. His research focuses on the development of flow control techniques to boost the performance of aerial and underwater vehicles, as well as to increase the efficiency and lifespan of wind turbines and buildings.

SUVRANU DE, a computational mechanics expert, has been named head of the Department of Mechanical, Aerospace, and Nuclear Engineering (MANE). De joined MANE as an assistant professor in 2002, became an associate professor in 2007, and a full professor in 2011. In 2010, he was named director of the Rensselaer Center for Modeling, Simulation and Imaging in Medicine. MANE is the largest department at Rensselaer, with more than 1,100 undergraduate students, 150 graduate students, and 36 tenured or tenure-track faculty.

LESTER GERHARDT, professor of electrical, computer, and systems engineering, has received the Benjamin Garver Lamme Award and Medal from the American Society for Engineering Education (ASEE). He was honored for his "combined contributions to the art of teaching, contributions to research and technical literature, and achievements that contribute to the advancement of the profession of engineering college administration." Awarded since 1928, the Lamme Award is regarded as the highest honor bestowed by the ASEE. Gerhardt's primary research focus is digital signal processing with an emphasis on image and speech processing.

CURT BRENEMAN has been named head of the Department of Chemistry and Chemical Biology. Breneman has been with Rensselaer since 1989. Breneman has written more than 85 academic papers and 15 book chapters, and has presented over 250 invited lectures. Throughout his career, he has served as a consultant to many companies, including General Electric, Eastman Kodak, Google, and multiple pharmaceutical and drug discovery companies. He was named a fellow of the American Chemical Society in 2011. He is also the director of the Rensselaer Exploratory Center for Cheminformatics Research.

YARON DANON, a professor in the Department of Mechanical, Aerospace, and Nuclear Engineering, has been named director of the new Gaerttner Linear Accelerator (LINAC) Center within the School of Engineering. The primary research thrust of the center is obtaining nuclear data for use in a variety of applications, ranging from the design of nuclear reactors and analysis of criticality to radiation damage and new nuclear medicine technologies. The Gaerttner LINAC Center is part of the Rensselaer Nuclear Engineering Program, which is among the oldest in the nation.

XAVIER INTES, assistant professor of biomedical engineering, has won a Faculty Early Career Development Award (CAREER) from the National Science Foundation (NSF). Intes will use the five-year, $400,000 award to further his research into a promising non-invasive biomedical imaging technique to help identify and treat cancerous tumors. The CAREER Award is given to faculty members at the beginning of their academic careers and is one of NSF's most competitive awards, placing emphasis on high-quality research and novel education initiatives.

JIE LIAN, assistant professor of mechanical, aerospace, and nuclear engineering, has won a Faculty Early Career Development Award (CAREER) from the National Science Foundation (NSF). Lian will use the five-year, $500,000 award to further his research into the design of nanomaterials for use in nuclear energy systems. The CAREER Award is given to faculty members at the beginning of their academic careers and is one of NSF's most competitive awards, placing emphasis on high-quality research and novel education initiatives.

LIGHTING UP the AVIATION INDUSTRY

WHEN THE BOEING COMPANY AND THE FAA NEEDED TO DEVELOP INNOVATIVE, EFFICIENT LIGHTING SOLUTIONS, THEY TURNED TO RENSSELAER'S LIGHTING RESEARCH CENTER

BY JODI ACKERMAN FRANK

The Dreamliner is a sleek, next-generation Boeing 787, a long-range twin-engine jetliner equipped with much of what the latest technology has to offer. The aircraft's modern carbon composite frame is at least 10 tons lighter than its traditional counterpart. It is also the most fuel-efficient commercial jet in the global market. Perhaps the most attractive aspect of the Dreamliner, though, is the interior—most noticeably the cabin—where passengers are greeted by a spacious domed entryway that's illuminated by dramatic overhead lighting, which resembles an infinite blue sky.

Passengers can dim or lighten the electronic shading embedded in the windows with the touch of a button. Along the sidewalls, subtle LED fixtures provide full-color spectrum lighting, and upgraded reading lights dot the spaces where the 200 or so seats are situated on either side of the aisle.

Nadarajah Narendran, LRC director of research and principal investigator of the partnership established between the LRC and Boeing.

Mark McCarty

Entering the Dreamliner, passengers are greeted by a spacious domed entryway that's illuminated by dramatic overhead lighting, which resembles a blue sky. Passengers can dim or lighten the electronic shading embedded in the windows with the touch of a button.

Many of these new cabin features are a result of advanced lighting technology and design. The Rensselaer Lighting Research Center (LRC) has played a central role in Boeing's ability to successfully incorporate this new state-of-the-art aircraft lighting that is already enhancing the airline passenger experience.

"Boeing's focus was to find ways to take the passenger flying experience to the next level, and lighting is a big part of that," says Nadarajah Narendran, LRC director of research and the principal investigator of the partnership established between the LRC and Boeing.

The LRC and Boeing partnership began in 2005, when the world's largest aerospace manufacturer was searching for collaborators to assist in the development of innovative, efficient lighting solutions for its commercial aircraft.

The LRC leads the globe in university-based research and education devoted to sustainable lighting. Since 1988, it has built an international reputation for its expertise in advanced lighting technologies, application demonstrations, and product testing and evaluations. As world-recognized specialists in the field of vision science, LRC researchers also focus on how light affects visual perception, cognition, and overall human health.

"There are experts around the world who specialize in these different areas, from

"THE WORK OF THE LRC HAS PLAYED AN IMPORTANT ROLE IN HELPING BOEING ADVANCE AVIATION THROUGH THE EFFECTIVE USE OF LIGHTING TECHNOLOGY."

Wanda Denson-Low '78

technology packaging and design to human well-being," Narendran says. "What sets us apart is our nearly 25 years of experience in all of these areas and successfully weaving these elements together."

"The LRC takes a multidisciplinary approach, and therefore provided a fresh perspective in the development of our lighting system," says Randy Camp, senior lighting engineer at Boeing.

In partnership with Boeing, LRC researcher Jean Paul Freyssinier '03, along with other researchers, evaluated traditional aircraft interior lighting designs and developed specifications for new lighting concepts. The LRC also developed a number of lighting designs, which were then used as a basis for the work conducted by Boeing engineers and designers.

LED LIGHTING LEADS THE WAY

LED lighting is a key element in Dreamliner's cabin. Boeing has targeted this type of solid-state lighting because of the technology's potential for significant weight reduction and lower maintenance costs over traditional light sources.

LEDs, or light-emitting diodes, are made from semiconductor chips, the size of sand grains. They are covered with mini-plastic lenses and connected to an electrical circuit. Unlike incandescent bulbs (which include traditional household light bulbs and halogen lamps), LEDs don't have a filament that burns out easily. They also can last more than 50 times longer than the incandescent bulb if designed correctly, and they demand far less electric power to produce the same amount of light.

LEDs also can emit virtually any color of light without the use of filters, and in many cases, they offer better quality light and deliver it more efficiently. The color of the LED light depends on the material from which it is made. A blue LED, for example, is most commonly composed of indium gallium nitride. One way to create a white LED is to combine a blue LED with a

yellow phosphor. For decades, colored LEDs have been used as simple indicator lights for TVs, phones, radios, and other electronics. Over the last several years, however, white LEDs have become bright enough to replace the standard incandescent light bulb in many everyday uses.

Despite the many promising applications of LEDs, assisting Boeing in turning solid-state lighting into standard aviation lighting for the Dreamliner was a monumental task. For one thing, the type of LEDs used on the aircraft did not exist when Boeing and the LRC embarked on their partnership seven years ago.

"The technology was not quite ready at that time, so we had to explore and combine various off-the-shelf technologies—and 'dream up,' if you will, alternatives that Boeing could possibly use during the concept design stage. Then we had to evaluate them," says Narendran.

The LRC research team's first task was to acquire a comprehensive understanding of the benefits, drawbacks, and perceptual differences of LEDs and how they could be best integrated into the cabin area of the new aircraft. LEDs are inherently different from other forms of light sources. For example, LEDs are easily affected by temperature changes.

Realizing the complexity in the practical application of this technology, LRC researchers explored the dynamics of LEDs in nearly every aspect, from the brightness of their light and their thermal management mechanics to how they affect human circadian rhythms. They conducted lab experiments, created mock-ups of aircraft interior, and tested new lighting concepts and prototypes on volunteer participants.

"We wanted to know if an LED lighting system would be able to produce adequate light," Camp says. "The Lighting Research Center reviewed the overall LED industry and provided the technical recommendations needed for an LED system to meet our interior lighting requirements."

LEDs have been efficient and long-lasting as indicator lights in electronics for decades, but using them to create stable high-quality white light for general lighting purposes presented new challenges.

One issue that had to be worked through was how to dissipate the heat produced through the LED and its circuitry. While LEDs may be cool to the touch, the internal part of the device can quickly overheat when high current passes through the junction, causing irreversible damage. Heat buildup is a byproduct of using high-power LEDs for white light, and that heat must be removed in order to maintain good performance over a long period.

To address this challenge, LRC researchers explored different lightweight heat-sink concepts. Heat sinks are designed to "catch" the heat that's released through the back of the LED device. The researchers found that a metallic heat sink, attached to the back of an LED fixture, can be designed to serve as a reflector to direct the light beam while drawing the heat away from the LED.

"We showed Boeing a couple of simple lighting options and then offered specifications so Boeing's design team could develop new solutions," Narendran says.

RIGHT LIGHT AT THE RIGHT TIME

It is well-known that light exposures regulate our biological or circadian rhythms that repeat themselves about every 24 hours, including the sleep-wake cycle. But, on long air flights, these cycles can become disturbed and become out of sync, the reason that many passengers experience jet lag.

"Our circadian rhythms are governed by retinal exposures to light and dark. Short-wavelength (blue) light is the most potent, so by controlling the timing and duration of blue light exposure, we can adjust the biological clock to different time zones," says LRC Director Mark Rea, who specializes in visual and circadian processes related to lighting. "We can also activate the brain at night with long-wavelength (red) light, much like a jolt of caffeine, without affecting the biological clock at all."

In other words, using the right light for the right time of day can enhance a person's comfort level and alertness. Use the wrong lighting, however, and a passenger's favorable flying experience could fly out the window. Equipped with this knowledge,

USING THE RIGHT LIGHT FOR THE RIGHT TIME OF DAY CAN ENHANCE A PERSON'S COMFORT LEVEL AND ALERTNESS. USE THE WRONG LIGHTING, HOWEVER, AND A PASSENGER'S FAVORABLE FLYING EXPERIENCE COULD FLY OUT THE WINDOW.

Rea and LRC colleague Mariana Figueiro '98 offered recommendations, including defining which colors could benefit passengers most during a flight and also how window shading can add to a superior flying experience.

"There are some simple guidelines you can follow to prevent jet lag," Figueiro says. "Say you're flying from New York to Paris, and the plane is ready to land. The first reaction might be to open the shade and look outside. But that's probably the worst thing you can do for jet lag. You want to protect yourself from light as you're landing in Paris."

The attractive electrochromic windows in the Dreamliner are 60 percent bigger than in traditional airplanes as a way for passengers to reconnect to the flying experience. With five different tint settings at their fingertips, passengers can control the amount of light that comes through the window. The airline crew has ultimate control over the windows from a central point.

The color of light produced by the versatile LED system on the upper walls and ceiling also can be controlled by crew members, who can then provide the most optimal environment for passengers during different stages of a flight. For instance, a sunset might be simulated around dinnertime. Or, during landing a sunrise might be composed that slowly alerts passengers of their arrival time—a much gentler approach than switching on standard fluorescent lighting in full force.

"The great thing about LED lighting is that it can be 'tuned' to different colors, unlike traditional light sources," Figueiro says. "The idea is that using the right light during the right time of day can enhance or hinder a person's well-being."

"Boeing is proud of its partnership with RPI and its Lighting Research Center," says Wanda Denson-Low '78, Rensselaer trustee and senior vice president of Boeing's Office of Internal Governance. "The work of the LRC has played an important role in helping Boeing advance aviation through the effective use of lighting technology. The use of LED lighting in Boeing commercial aircraft is helping to improve the overall passenger experience and reduce aircraft maintenance costs."

A NEW ERA OF CREATIVITY

The Dreamliner, the first midsize airplane capable of flying long-range routes, completed its first commercial flight, from Tokyo to Hong Kong, last fall. Since then, 843 Dreamliner orders have been placed by 57 airline companies from around the world.

Already the Boeing aircraft has earned international accolades over the past year by such prominent organizations as the American Institute of Aeronautics and Astronautics and the National Aeronautic Association. This spring, the Dreamliner was recognized by the European Institute for Creative Strategies and Innovation, which gave Boeing its top award. Awards are given to companies or organizations whose ideas and products help advance society. The jury of judges was impressed by Boeing's creative research and development methods, which included input from international passenger organizations, university studies, and industry experts.

This is the first time the organization has recognized an aviation company with such a prize. Last year, the institute gave the grand prize to French Director Jacques Perrin for the movie *Oceans*.

"Boeing's focus in designing the airline cabin was all about aesthetics for a great passenger experience," says LRC Associate Director Russ Leslie, who led the lighting design team in the Boeing-LRC partnership.

To produce the effect of the blue-sky dome in the Dreamliner's entryway, Leslie's design team studied the works of various artists, including James Turrell, who is well-known for his experiential pieces that explore light and space. Based on such artwork, the team focused on how to make the ceiling more spacious using color and in the design of the overhead bins.

"We worked hard on how the framing of the luggage bin area would allow you to see the ceiling and then came up with a defined wash," Leslie says. "It can be a very saturated blue, and when it's in that mode, it really does seem like you're staring into a blue sky. You can't tell whether that's a

half a mile or just a few feet above you."

"The LRC played an important role in the overall lighting and interior architecture development of the Dreamliner's cabin," Camp says. "When the design process was complete, we knew how the lighting and architecture would work together for the passenger cabin illumination. The blue sky lighting has a dramatic effect and was precisely what we needed to introduce a new airplane to the market."

In addition to working with Boeing, the LRC has conducted notable work for the Federal Aviation Administration (FAA) over the last decade, providing important insights and guidance that have been driving changes in aviation lighting across the United States and the world.

In 2005, the LRC was selected to join the FAA Centers of Excellence program, created to solicit partnerships with world-class academic institutions and industry to coordinate research and development in aviation technology. Academic institutions are selected on a competitive basis. The LRC was called to apply its expertise in technology, visual performance, and application of LEDs in airfield lighting. In particular, the FAA was interested in the potential of LEDs to replace existing incandescent lighting on airfields.

"At the time, solid-state lighting was a new light source," says Donald Gallagher, the FAA visual guidance program manager for airport safety research and development. "Even in our own agency, there was a lot of speculation that LEDs couldn't match up to the standards of incandescent lighting. Our work with the LRC was to show the facts of what LEDs are really capable of."

Since that time, the LRC has conducted lab and full-scale field studies in collaborations with the FAA, universities, and industry specialists to determine how new LED technologies can be applied to runways, taxiways, approaches, and other airfield areas.

In its work with the FAA, the LRC has been shedding light on improving visibility in remote airfields. In Alaska, for instance, dozens of tiny airfields serve as points of landing in areas that cannot be easily accessed by road. For reasons ranging from cost and an unreliable grid or generator power to damaged light bulbs due to harsh weather, many of these landing areas do not have proper lighting to help pilots land safely. In fact, Alaska has the highest aviation accident rate in the nation, according to the Alaska Department of Transportation & Public Facilities.

"Safety is not just a lighting issue, but the FAA wanted to look into ways that better visual cues could help pilots land safely in rural and remote airfields," says Narendran, also the principal investigator of the LRC's work in the Centers of Excellence program.

The LRC team—Andrew Bierman '89 and Zongjie Yuan '07, along with Rea—developed prototype airfield light fixtures, which were placed at the corners of runways in flight tests in Florida, Alaska, and North Dakota. The LRC and FAA collaborated in these field studies with Embry-Riddle Aeronautical University in Florida, along with the University of North Dakota and the University of Alaska to confirm the accuracy of the new metrics.

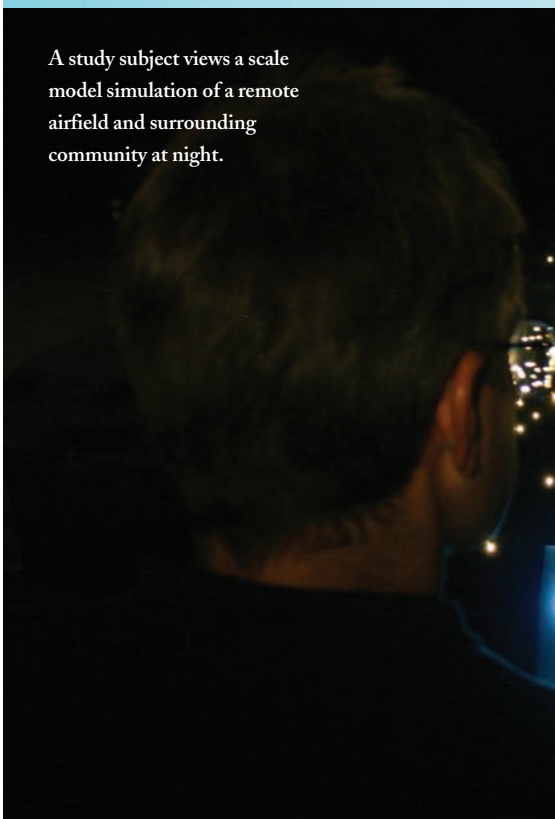
In 2010, the FAA remote airfield lighting team installed a lighting system, designed and built by LRC and FAA researchers, at a small airport in the native village of Napaimute in Alaska. In November of the same year, the value of the lighting system became clear. A pilot, en route from McGrath to Aniak, was able to land with confidence at Napaimute's airfield to pick up a critically ill resident well after sunset because the pilot could see the outline of the runway from several miles away.

INITIATING NEW LIGHTING STANDARDS

A key challenge in replacing traditional incandescent lighting with LED technology in airfields is that the type of light emitted from each source is different. Filters are used to produce colored light in incandescent lamps. The colored light from LEDs, however, is produced by the light source itself. As a result, the spectrum of the light produced by the two technologies is remarkably different. Chromaticity standards (based on the quality of a color related to its hue) for "aviation white" were established in the 1960s based on incandescent light sources. Therefore, even though white LEDs offer

"SAFETY IS NOT JUST A LIGHTING ISSUE, BUT THE FAA WANTED TO LOOK INTO WAYS THAT BETTER VISUAL CUES COULD HELP PILOTS LAND SAFELY IN RURAL AND REMOTE AIRFIELDS."

Nadarajah Narendran



A study subject views a scale model simulation of a remote airfield and surrounding community at night.

Prototype airfield fixtures developed by the LRC were used in flight tests in Alaska and North Dakota to validate laboratory results. Placed at the corners of a runway, these fixtures helped to confirm the optimum spectrum, intensity, flash rate, and distribution for airfield lighting.

better visibility and color recognition, the existing boundary for aviation white excludes certain ranges of white that LEDs produce.

"Only a small subset of commercially available white LEDs meet the current chromaticity requirements for aviation white, making it difficult to adopt this energy-efficient technology for airfields," Narendran says.

To tackle the issue, LRC senior scientist John Bullough '91 led a team of researchers and conducted several studies to reformulate the chromaticity boundaries that people perceive as white and for other colors as well. These newly formulated color boundaries are now being considered in airfield lighting standard revisions.

"Obviously, everyone wants to save energy. But more important, we noticed that LED lighting gave a better visual signal to pilots, so adopting new standards in order to better integrate LED technology is a critical part of advancing airfield lighting systems," Gallagher says.

One way that the LRC is initiating new lighting standards is through its work with runway guard lights. These flashing yellow lights are used to help pilots detect the presence of taxiway and runway intersections. Busy airports typically construct taxiways, marked pavement along which aircraft taxi to or from a runway, to allow aircraft to leave the runway at higher speeds so that another plane can land or depart more quickly.

In a multistage project, LRC scientists conducted lab and field studies to understand and compare lighting parameters between incandescent lamps and LEDs. Researchers also studied how LED lights appear to pilots in certain weather conditions compared to halogen lamps.

The project encompassed collecting reaction times and visibility data from participants tested in a lab setting that simulated a scaled-down airfield under different visibility conditions. The results showed that for all the weather conditions studied, the existing requirements for the light intensity (perceived brightness) of halogen bulbs are sufficiently noticeable to pilots.

To maintain the same perceived brightness in LEDs, however, the researchers had to reduce the light intensity by more than 60 percent, among other changes, which in the end resulted in good news: LEDs provided better visibility than incandescent lamps while significantly cutting energy demand. To confirm the lab findings, the LRC conducted a field experiment at the Schenectady County Airport in Glenville, N.Y. New specifications for LED runway guard lights were developed based on this and other research.

Last year, the FAA funded Embry-Riddle to conduct the last stage of the three-year research project—a large field evaluation at Daytona Beach International Airport to validate the previous findings. Built using the new specifications, LED runway guard light fixtures were installed at the airport.

"Embry-Riddle faculty collected the data and found that their research replicated everything we had simulated in the lab and at the Schenectady airport," Narendran says.

INTERNATIONAL COMMUNITY TAKES NOTE

Last fall, during an International Civil Aviation Organization (ICAO) conference, hosted by Rensselaer on campus, the FAA shared these and other LRC research findings with ICAO representatives. A specialized agency of the United Nations, the ICAO sets international aviation standards and regulations.

Among suggested changes to several standards, including color boundary guidelines, the FAA shared a new formula for calculating the most effective intensity (perceived brightness) for the LED flashing signal fixtures.

"Our ICAO working group accepted our recommendations, with some minor changes," says Gallagher, who added that these color-boundary changes already have been added to FAA airfield regulations.

"We are very enthusiastic in our collaborations with the aviation industry in realizing the undeniable potential for solid-state lighting," says Narendran. "Every time we can demonstrate the possibilities and benefits of new types of lighting, we take another step in creating a positive legacy for society."

"ENERGY SECU
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—PRESIDENT SHIRLEY ANN JACKSON

ENERGY AND THE ENVIRONMENT

THE CENTER FOR FUTURE ENERGY SYSTEMS IS DEVELOPING NEW ENERGY MATERIALS, DEVICES, AND SYSTEMS TO OVERCOME OUR RELIANCE ON FOSSIL FUELS. BY WINNIE YU

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NIUM."

Source: U.S. Energy Information Administration, International Energy Outlook 2011

Seven billion. That's how many people are currently competing for the world's dwindling supply of fossil fuels. By the year 2050, the world population will soar to a staggering 8 to 10 billion, all competing for even less of the existing fossil fuels.

Skip Dickstein / Times Union

No doubt, we live in a world that demands a lot of energy. Energy to power our vast and complex technologies. Energy to sustain a growing population. Energy to support a rising standard of living. At current rates, global energy consumption is expected to double by the middle of this century.

The growing demands for energy have made us increasingly reliant on fossil fuels—coal, oil, and natural gas—and created a dependency that puts our nation at political risk. The explosion in energy consumption also has spawned a parallel concern about the environment, in particular the release of carbon dioxide emissions into the atmosphere. These emissions, scientists know, are causing severe damage to an increasingly fragile environment.

"It is clear that achieving a sustainable global energy framework, capable of meeting the energy needs of citizens, without causing irreparable environmental damage, will require continuing technological advances that modify our current production and use of energy," says President Shirley Ann Jackson. "It is a given that, at least in the long term, there will be no single 'solution' to providing abundant, clean, and inexpensive energy for the global community. Rather, there likely will be a mix of solutions."

President Jackson calls the need for an adequate supply of affordable, accessible, sustainable energy "the overarching issue of the 21st century."

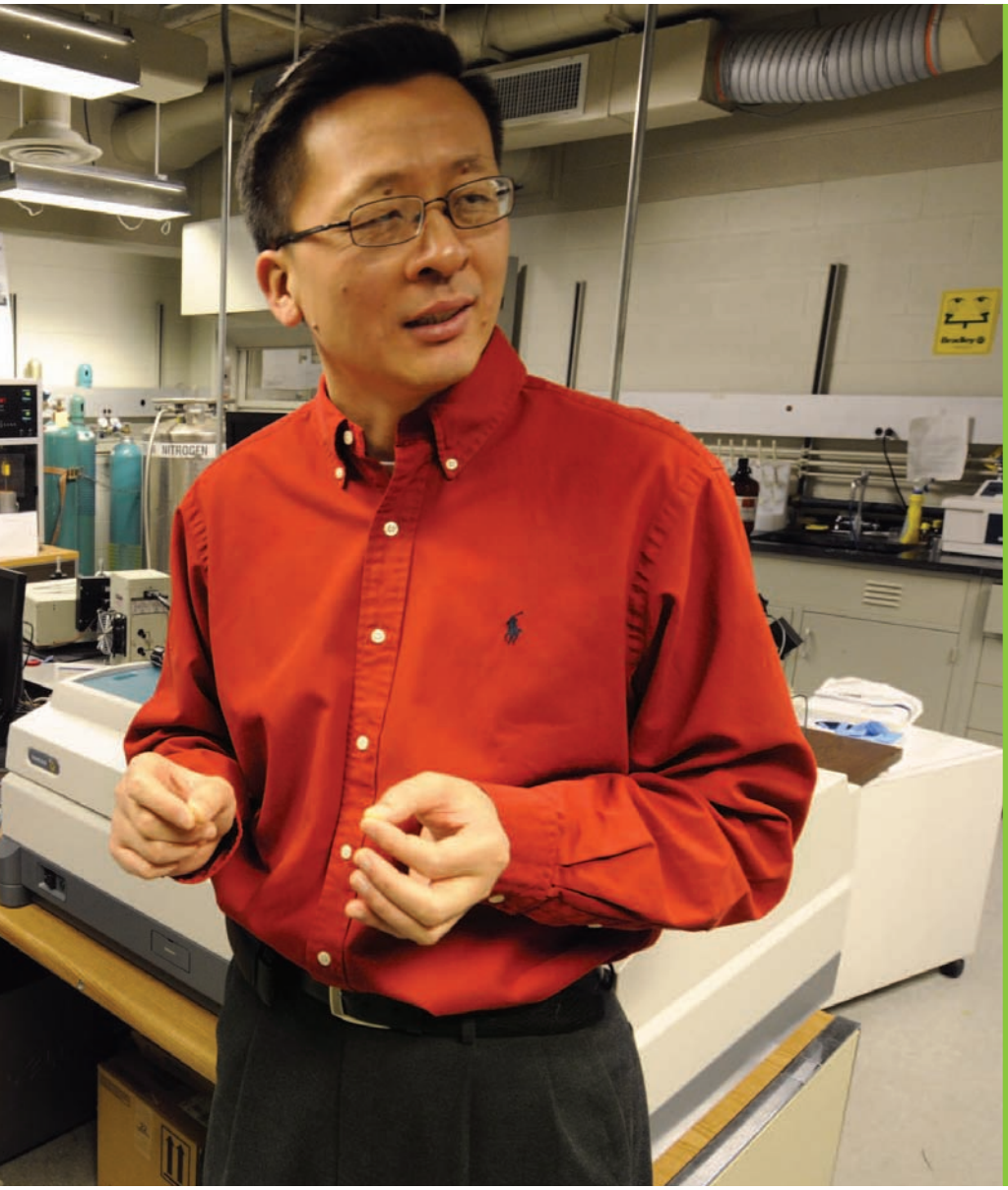
"Energy security is the 'space race' of this millennium," she says. "The global nature of these challenges provides a measure of the urgent need to advance discovery and innovation to resolve them."

At Rensselaer, that type of innovation rests with the Center for Future Energy Systems (CFES). Created in 2005, the center is one of 15 university-based Centers for Advanced Technology in New York. As the only CAT that focuses on energy, the center is also referred to as the "Energy CAT."

Rensselaer operates the Energy CAT in partnership with Cornell University in Ithaca. The center has its office on the 8th floor in the George M. Low Center for Industrial Innovation. The center's material and device characterization lab is located on the same floor. Another key facility of the center, the distributed generation system test bed, is in the Jonsson Engineering Center.

The research at CFES is devoted to exploring energy and the environment, a dual theme that has global and political implications, says Jian Sun, director of CFES and a professor in the Department of Electrical, Computer, and Systems Engineering. Energy, environment, and smart systems is one of the key research thrusts at Rensselaer. At the heart of the research is the urgent need to overcome our reliance on fossil fuels.

"Our dependence on fossil fuels has to change," Sun says. "Most of our energy



"OUR DEPENDENCE ON FOSSIL FUELS HAS TO CHANGE."

—JIAN SUN, DIRECTOR OF CFES AND A PROFESSOR IN THE DEPARTMENT OF ELECTRICAL, COMPUTER, AND SYSTEMS ENGINEERING

Martin Byrne, associate director, and Jian Sun, director

consumption, including electricity and transportation, is fossil fuel-based, and that has national security implications."

One solution, he says, is with the development of renewable energy sources. "We need to increase our use of renewable energy such as wind, solar, and others," Sun says. "Renewable energy is the key to displacing fossil fuels. How do we more efficiently harvest sources like wind and solar? How do we design more efficient wind turbines and solar panels, and integrate them into the utility infrastructure we have today?"

At the same time, society needs to be aware of the environmental impact of our energy use. Already, we are experiencing climate change caused by greenhouse emissions from motor vehicles and power plants, Sun says. "That's why energy and the environment go hand in hand," he adds. "A lot of environmental issues are related to how we use energy."

The way we use energy is also an important factor. "We have to be more efficient in how we use energy at home, in offices, manufacturing, and in transportation," Sun says.

The Business of Energy

The mission of the CAT program is to spur technology-based applied research and economic development in New York. Fulfilling this mission requires close ties and collaboration with the industry, particularly New York state companies. "Industry collaboration is essential," Sun says. "Our success is measured by our economic impact, the number of jobs we create, and our ability to attract investments." The state, he says, is especially fond of partnerships formed with small companies.

Industry partnerships can develop in

different ways. To facilitate that, CFES has a full-time business development expert, Martin Byrne, associate director of the center, whose primary responsibility is to connect CFES researchers with the industry. Whether it's a small startup company or a large, well-established corporation, the goals remain the same: to help companies develop the resources and know-how to create new energy technologies.

Another end goal of these partnerships is economic growth in New York state. And indeed, that growth has been achieved. Since its inception, CFES has created more than 100 manufacturing jobs in the energy sector and infused $62 million into the state's economy. CFES also has secured $21 million in research grants and $6.7 million from the state's Division of Science, Technology, and Innovation (NYSTAR).

In addition to research and technology development, CFES provides its industry partners with other forms of services, including the development of business plans, access to the center laboratories, the preparation and submission of joint funding proposals, and the identification of state and federal funding opportunities.

Together with its industry partners, CFES has spawned dozens of research projects. These projects last as short as three months or as long as five years. The projects have engaged faculty members and students across all schools on the Rensselaer campus. "Energy is a problem you try to solve with all different kinds of technologies," Sun says. "It's the nature of the problem that requires contributions from many different disciplines." Featured below are just a few of the projects that have been developed through CFES.

Power in the Wind

Wind energy is the fastest growing segment of renewable energy technologies. In the U.S., there are more than 47 gigawatts of installed capacity, accounting for more than 20 percent of the world's installed wind power. Worldwide, there are 238 gigawatts.

Not surprisingly, wind energy is a key area of focus at CFES, where researchers are working to enhance turbine blade design, testing synthetic jets to reduce vibration and fatigue load, and looking for ways to improve efficiency and compatibility of the electric interface with the utility grid.

Wind energy is a key area of focus of the center, where researchers are working to enhance turbine blade design, testing synthetic jets to reduce vibration and fatigue load, and looking for ways to improve efficiency and compatibility of the electric interface with the utility grid.

Working with GE Global Research, CFES is developing advanced control techniques for wind turbines connected to weak power grids. "The high impedance of a weak power grid may cause harmful resonance with the wind turbine that leads to poor power quality and instability," Sun says. "The control method we are developing uses real-time measurement of the grid impedance to adaptively modify the behavior of the turbine such that it can work with a variety of power grids."

In a separate but related project, CFES is also looking at large-scale wind farms for offshore applications. That project is being supported by the National Science Foundation, the Department of Energy, and the Stanford Global Climate and Energy Project.

"Aside from the complex construction and harsh environment, offshore wind farms also face many electrical engineering challenges," Sun says. "An offshore power system is ultimately a weak grid, and integrating a large number of dynamic turbines into such a grid is not an easy task by any measurement."

Working also with GE Global Research, CFES is investigating alternative system architectures for offshore wind farms that can fundamentally solve some of the problems of today's systems.

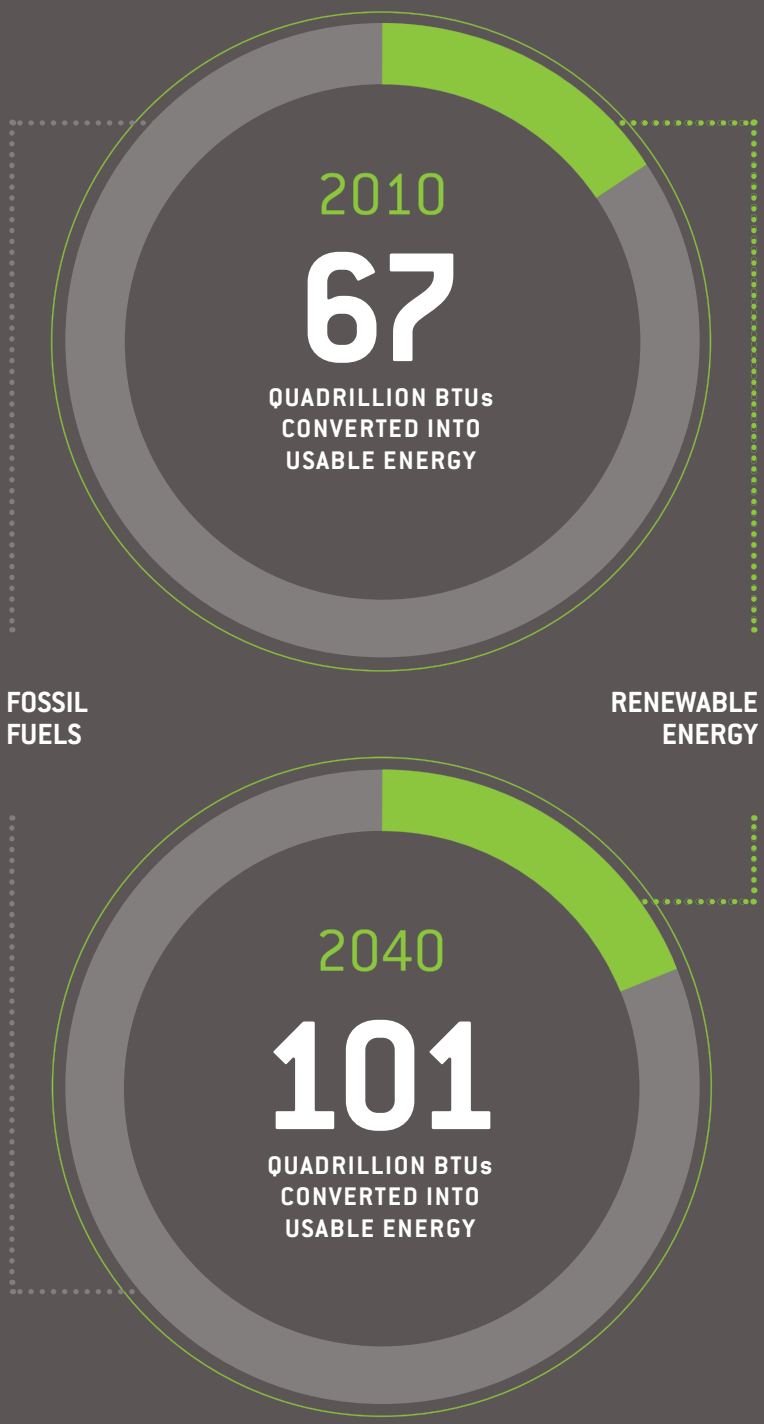
A Different Power Grid

Harnessing the power of wind is one thing. Making it available to consumers in a reliable and cost-effective way is another. After all, the best geographic areas for generating green power are often far removed from the highly populated and industrial areas that need the power. Transporting the renewable power is just as important as the method for harvesting it from wind and the sun.

Today's power grid is built on a small number of large power plants that are centrally controlled, and a unidirectional power distribution network that brings electricity from the power plants to the consumers. Renewable energy generation, on the other hand, is widely distributed

The research at the Center for Future Energy Systems is devoted to exploring energy and the environment, a dual theme that has global and political implications. At the heart of the research is the urgent need to overcome our reliance on fossil fuels.

RENEWABLE POWER SOURCES CONVERTED INTO USABLE ENERGY



ExxonMobil Outlook for Energy: A View to 2040

and highly variable. "When a large portion of electricity is coming from such distributed and intermittent sources, the nature of the power grid changes, and that calls for different ways to control and operate the grid," Sun says.

That's why another critical area of research at CFES is the integration of renewable energy into the power grid. To support the research in this area, CFES has developed a distributed generation test bed that can emulate future distribution networks with renewable sources connected to it. The test bed has been developed with funding from NYSTAR, and has been instrumental in attracting research funds from different sources.

The ability of today's power grid to transfer power over long distance—for example, to move wind power generated in the Midwest to the coasts—is limited by the impedance of the power lines. High-voltage direct current (HVDC) transmission can overcome this limitation and is also a viable option for offshore wind applications. With support from the National Science Foundation, the U.S. Department of Energy, and the Stanford Global Climate and Energy Project, CFES is investigating the so-called multi-terminal HVDC technologies for both bulk power transmission and offshore wind applications. The center is also expanding its distributed generation test bed to provide hardware-in-the-loop and real-time simulation capabilities for such HVDC systems.

An important partnership for CFES research in the power grid area is with the newly funded NSF Engineering Research Center (ERC) for Ultra-Wide-Area Resilient Electric Energy Transmission Networks (CURENT). The CURENT ERC is led by the University of Tennessee, and Rensselaer is a key partner. The Rensselaer campus director is Joe Chow, professor of electrical, computer, and systems engineering, and an expert on power system operation and control.

Lighting Up the Future

CFES researchers are working with the Rensselaer Smart Lighting Engineering Research Center (ERC) and the Lighting Research Center (LRC) to develop novel semiconductor materials, lighting devices,

and integrated systems to harness the power of smart lighting. The effort is being spearheaded by Bob Karlicek, the director of the Smart Lighting ERC, and Nadarajah Narendran, director of research at the LRC.

Narendran has pioneered several technologies that improve the energy efficiency of white light-emitting diodes (LEDs), which is a fast-growing solid-state lighting technology. Along with his colleagues at the LRC and in collaboration with CFES, he has steered those concepts and technologies to the marketplace by directing technology and product commercialization efforts with industry in general and New York state industry in particular.

Among the key projects has been the development of ideal encapsulation materials that improve the efficiency and life of white LEDs; the development of high luminous efficacy green LEDs based on novel high efficiency phosphor and remote phosphor technologies; and the development of accelerated test methods to understand factors that affect LED driver life. The work at LRC has been done in partnership with numerous companies including Auterra/Applied Nanoworks, Evident Technologies, and RPC Photonics.

The Smart Lighting ERC has a comprehensive research program that tackles all aspects of smart lighting technologies, from basic materials, to sensing and advanced control, to system integration. One particular project Karlicek is overseeing is the replacement of inefficient lighting on parts of the Rensselaer campus with controlled LED lighting as a first step to the development of much more advanced lighting systems, or smart lighting. This project is being led primarily by teams of students and the Rensselaer physical facilities office.

"The intent is to target areas where significant energy savings are possible with state-of-the-art LED fixtures, add novel control systems to minimize light use when it is not needed, and monitor the energy savings," Karlicek says.

Lighting, he says, currently accounts for 30 percent of the total electrical energy used on campus. The ultimate goal is to reduce that energy consumption by creating smart lighting systems and smart grids that can communicate with each other as lighting needs and energy availability change from moment to moment. During a high peak energy demand, for instance, the grid could tell the lighting system to dim down 15 to 20 percent to conserve energy.

"Working with CFES, we're going to use this as an example of how building and lighting systems can work together," Karlicek says.

Ultimately, he says, the program will tie into more extensive work with CFES on grid and building energy management. "Combining Smart Lighting with CFES programs and other campus initiatives for energy efficiency, we expect that improving lighting design and efficiency will have a big impact on Rensselaer's electrical energy consumption and set the stage for wider use of these energy savings methods," Karlicek says.

Researchers have created the darkest material made by man. It absorbs more than 99.9 percent of light and could be used to boost the efficiency of solar energy conversion.

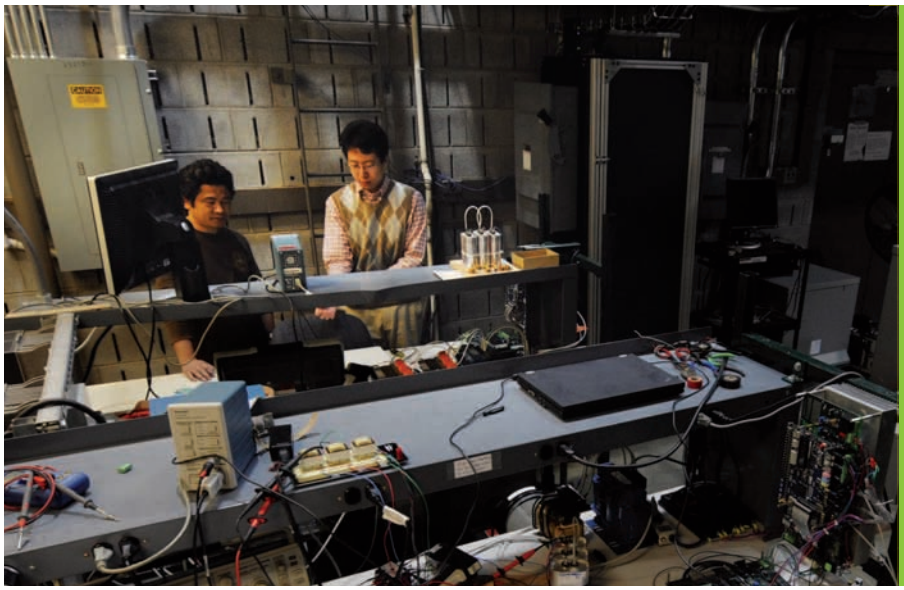
Tracking Sunlight

When it comes to tapping renewable energy sources, scientists need to look no further than nature. Take the sunflower, for instance, a perfect example of phototropism, in which the plant grows toward sunlight, traps the light, stores it, and uses it for energy later on. Or consider the alpine buttercup, a heliotropic wonder that grows close to the ground, tracks sunlight, and stores it in its petals.

Studying these plants has allowed scientists and architects at the Center for Architecture Science and Ecology (CASE), another important CFES partner, to develop the Integrated Concentrated Solar Facade (ICSF). The solar tracking system concentrates sunlight on a high-efficiency solar cell, capturing the resource as both electric and thermal energy that can be redistributed for lighting in large buildings, and heating and cooling in a variety of building types including offices, factories, and apartment complexes, says Jason Vollen, associate director of CASE and an associate professor of architecture. "The Integrated Concentrated Solar Facade will lower lighting costs, cooling costs, and heating costs, both initially and throughout the building life cycle," he says.

Vollen says the ICSF uses a combination of natural resources and those available in the built environment to provide energy—in this case, lighting—to an architectural structure. "This project epitomizes the idea of our approach, which is that we view all the bioclimatic forces in the built environment as valuable resources," he says. "That's very atypical of how buildings have been thought of in the past. In the past, contemporary approaches, even systems, were sequestered from each other. A large part of our jobs was to create a strong barrier between the inside and the outside of a building. Our job now is to

Skip Dickstein / Times Union



To attract more students to energy-related research projects, CFES recently created the *Energy Scholars Program.*

capture the energy, transform it, store it, and redistribute it so that you can make the energy more useful."

To do this, they use bioanalysis, a practice that Vollen describes as "learning from nature."

"We ask the question, 'How would nature solve this problem?'" Vollen says. "In the case of the solar tracking facade, there are many plants that already know how to do this."

CASE collaborated with HeliOptix, a company in New York City, to develop the facade, a project that began 10 years ago under the efforts of Anna Dyson, professor of architecture and director of CASE. The technology was demonstrated at the Syracuse Center of Excellence and also tested in New York City at CASE's Wall Street location.

The ICSF was funded through CFES and involved the expertise of Rensselaer's engineering and scientific communities as well as CASE. "It was truly a collaborative effort," Vollen says.

Other CFES Efforts

Though the bulk of the work at CFES involves New York state companies, the center also works with companies nationwide and internationally when the research fits the expertise of the center and the energy and environment research thrust.

One such area is electric transportation. Sun, for instance, has been working with Boeing on power electronics technologies for more electric aircraft. His recent work in this area includes electromagnetic interference modeling and mitigation, high-frequency power conversion, and aircraft electric power system modeling and simulation. Meanwhile, Paul Chow, another professor of electrical, computer, and systems engineering, has been working with Toyota to develop wide bandgap semiconductor devices for electric vehicle applications.

The center is also taking steps to amp up the involvement of students, who are a key part of the work being done at CFES. To attract more students to energy-related research projects, CFES recently created the Energy Scholars Program. The program begins this fall and is open to students in their junior or senior years.

Selected students will receive a $3,500 stipend to work on an energy-related research project in collaboration with an industry partner. Energy Scholars are expected to stay in regular contact with a mentor from the sponsoring company and to visit the company at least twice. The program provides an additional $500 for project-related materials and travel costs.

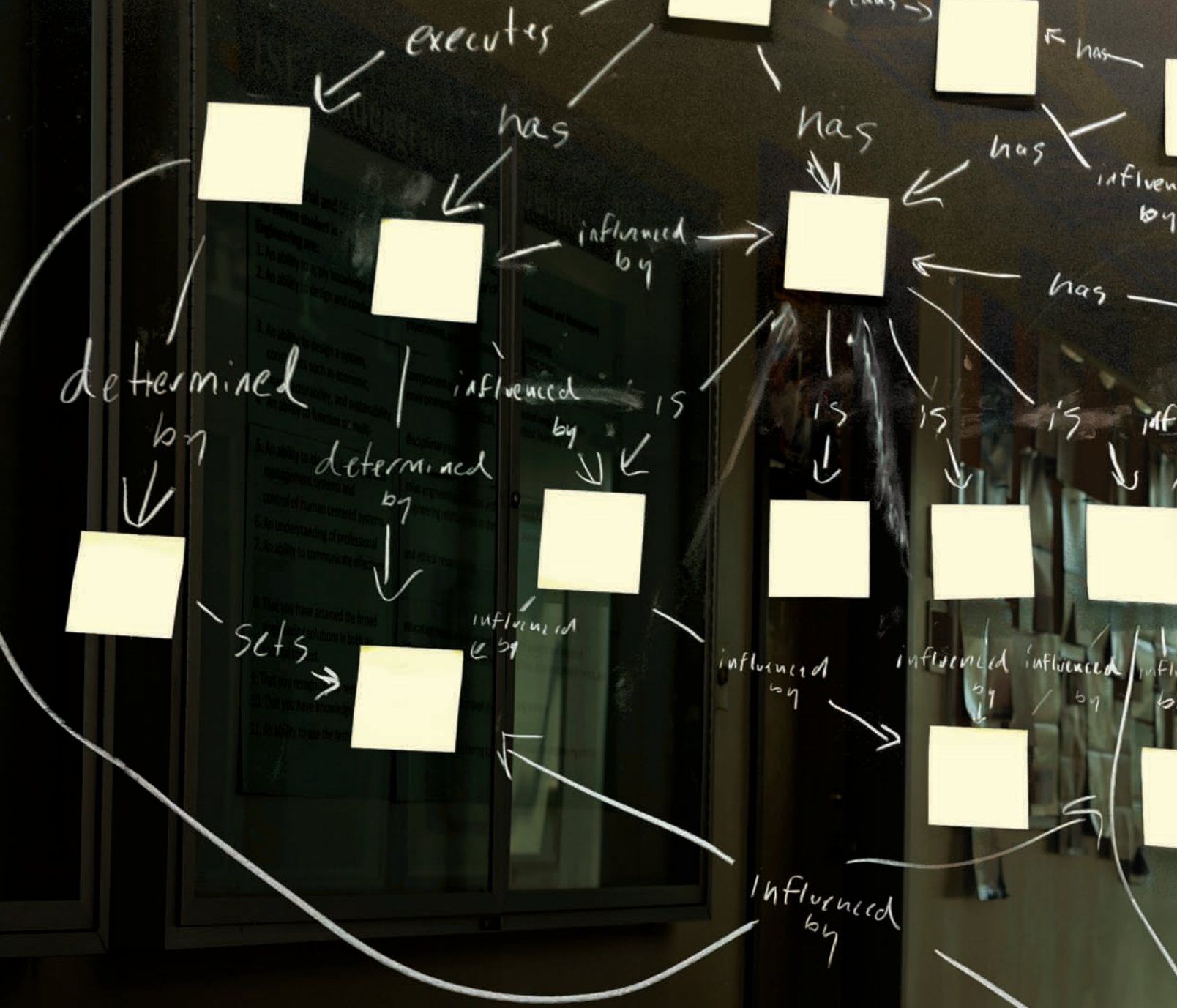
So far, the program has commitments for the support of eight scholars from seven companies including General Electric, the New York Power Authority, National Grid, and Corning Inc.

In 2015, CFES will undergo the mandatory redesignation process required of state CATs, which takes place every 10 years. "We need to position the center well to do that, identify our strengths, and project those strengths," Sun says.

Identifying the strengths was the objective of a strategic planning process that the center conducted in 2010. Five focus areas identified in that process were: wind energy, solar energy, energy storage, smart grid, and smart buildings. Several faculty working groups have been established to foster collaboration and project development in these areas. CFES also will continue to build partnerships with other research labs on campus including the Center for Automation Technologies and Systems (CATS), the fuel cell research lab, and the Computational Center for Nanotechnology Innovations.

Fortunately, funding for energy-related R&D remains viable and appears to be a priority on many levels, including the U.S. Department of Energy and the New York State Energy Research and Development Authority.

The current economic downturn has presented some challenges for working with the industry, particularly small companies. "We are hopeful that investment in energy technology remains a national priority," Sun says. "There is significant expertise and a lot of excitement about energy research on campus. CFES is devoted to helping New York state and the nation to grow a green economy by capitalizing on this expertise and interest."



ENGINEERING PR

LINK

DAVID MENDONCA AND JENNIFER RYAN, ASSOCIATE PROFESSORS OF INDUSTRIAL AND SYSTEMS ENGINEERING

OCESSES

Industrial and systems engineers make things work better.

When President Obama allocated billions of dollars to extend broadband Internet to millions of rural Americans, a Rensselaer-educated industrial engineer helped pinpoint where the underserved individuals lived. When a team of scientists from across the country decided to study the reliability of prosthetic implants used to aid brain-injured individuals, a Rensselaer industrial engineer analyzed the data collected.

BY JANE GOTTLIEB

PHOTOS BY MARK MCCARTY

When a coastal North Carolina community set out to learn how prepared it was for the next hurricane, a team of Rensselaer industrial engineering professors and students compiled voluminous data to see how, and if, utilities and emergency responders worked together.

"The final product is really enlightening. They pointed out some things that we normally don't get involved in," says Warren Lee, director of the New Hanover County Emergency Management Department. "Usually, AT&T comes and does its restoration. Progress Energy comes and handles its own. But I think that now we'd get much more involved in orchestrating their efforts to see that one is not hindering the other."

Rather than build structures or components like a civil or electrical engineer, the industrial engineer builds or improves a process for doing things—such as fortifying emergency response in New Hanover County, or developing the detailed maps to see precisely where Internet service is lacking.

At Rensselaer, industrial and systems engineering (ISE) is the smallest of the seven engineering departments. It tends to be unfamiliar to young people considering engineering careers. But it is also making an impact that outpaces its size.

Its faculty expends about $1 million a year in sponsored research, with an emphasis on supply chain delivery and civic disaster-preparedness. Grants come from the National Science Foundation, U.S. Department of Defense, Department of Homeland Security, various New York state agencies, and companies such as GlobalFoundries, which all require data in order to make crucial decisions.

And even in a weak economy, Rensselaer industrial engineering graduates enjoy a stellar job placement rate, impressive starting salaries, and career mobility. In the past two years, they have accepted positions at Procter & Gamble, IBM, General Electric, Microsoft, GlobalFoundries, Merrill Lynch, Sandia National Labs, and Lockheed Martin.

Charles Malmborg, ISE professor and department head, said that of the 43 students who graduated in May, at least 35 had jobs lined up.

"Employers place a tremendous value on our ISE graduates," says David Rosowsky, dean of the School of Engineering. "They are recognized as having a rigorous, broad-based, technical education and for their understanding of how complex systems impact individuals and organizations. When I visit with companies, they are very interested in what Rensselaer is doing in industrial and systems engineering."

Nearly every large corporation employs industrial engineers, or a full department, to develop solutions for operating faster, more reliably, and at a lower cost. They use computation, mathematics, modeling, social sciences, and the other branches of engineering to design or evaluate the gamut of systems human beings rely on, in transportation, public health, finance, entertainment, medicine, media, defense, manufacturing, emergency response, communications, and more.

Tracking use of social media is a concern; so is finding more environmentally sustainable methods to manufacture products and materials. So is figuring out how to position machines in a factory to maximize efficiency.

"When you walk in, everyone has a white suit on and everything is robotic and flying overhead at 50 miles an hour. I get to schedule how they move around," says Ryan Loggins '10, a Ph.D. candidate in industrial and systems engineering who works for microchip manufacturer GlobalFoundries in Malta, N.Y. "I am co-inventing a process that has never existed before."

Industrial engineers create the schedules that determine where professional teams play so that they face opposing teams the correct number of times, at both home and away venues. They might also be asked to figure out where, in the event of an earthquake, debris can be stored so that it is close to the hard-hit areas without posing a risk to the survivors. Or oversee credit card solicitation, or cybersecurity. Or, how the government can effectively use Twitter to alert the public of a terror threat.

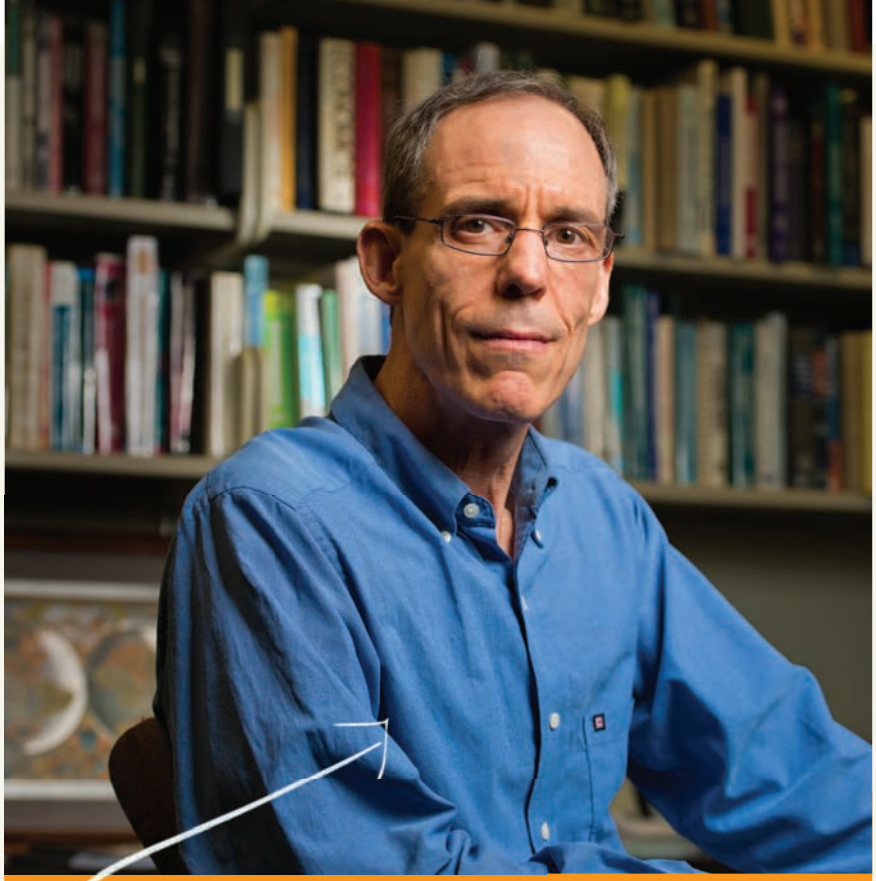
> "This is engineering... we are building things, systems for the best way of doing things. Our tools are applied math, computer science, and modeling."
>
> WILLIAM "AL" WALLACE

And because of the complex questions arising on all fronts, and because the tools of technology now make vast amounts of information available, their work is seen as vitally important from Wall Street to the Third World.

"One of the main things that made me pursue industrial engineering is that people with 'IE' degrees can go anywhere," says Paul Salasznyk '05.

At 30, Salasznyk has earned his bachelor's, master's, and doctoral degrees from Rensselaer. He works as an operations research manager at Computech Inc., a Bethesda, Md.-based contractor advising the Federal Communications Commission on where to spend billions of dollars to extend broadband. He is often courted by other companies. "I am helping organizations make critical decisions in a data-driven fashion," he says. "I can do this for the government or in an industry setting. This is not true of all types of engineers."

And yet, even though companies are anxious for the recipe of skills Salasznyk



> "The challenge to us is to explain how the total integrated systems perspective of industrial engineering, combined with our core skills in data science, computation, and mathematical analysis, can add value in all types of enterprises."

CHARLES MALMBORG

offers, his field is one the general public is largely unacquainted with. It is not easy to explain. And high school students are more likely to warm up to the tangible results of civil engineering than the concepts—adaptive supply chain theory or logistics—this branch looks at.

"Anyone who works in business, or has worked for a business and has seen a process that doesn't work very well, understands exactly what we do," says Associate Professor Jennifer Ryan, who conducts sponsored research in supply chain theory.

"But when you're young and don't have that kind of experience, it's a little bit harder to picture. We're engineers who are not designing a part or a machine. It's much more big picture."

UNDERSTANDING ISE

Despite its strong reputation, Rensselaer's program is under-enrolled, according to Malmborg. The undergraduate program, with room for 225 students, has 145. The master's and Ph.D. programs, with about a dozen candidates each, can accommodate more than twice that number. The trend goes beyond Rensselaer.

"Industrial engineers account for one in seven U.S. engineering jobs. But they represent fewer than 5 percent of engineers," Malmborg says. "The challenge to us is to explain how the total integrated systems perspective of industrial engineering, combined with our core skills in data science, computation, and mathematical analysis, can add value in all types of enterprises."

The program experiences a notable enrollment rise as students matriculate, suggesting that once they become acquainted with ISE, they are intrigued. Malmborg notes that an average of 10 to 12 freshmen enter Rensselaer's program, a figure that climbs to 50 to 55 by graduation. "They find their personal skills match up very nicely with IE," he says. "They are really strong in communication. They love math and computers but maybe aren't as enamored with the physical sciences."

Among them is Jessica Wong '12, who graduated in May. After attending the High School for Math, Science and Engineering at the City College of New York, she came to Rensselaer as an engineering student. Wong planned to pursue a dual degree in engineering and design, innovation, and society. But in her sophomore year she attended an open house hosted by the industrial systems and engineering department and was grabbed by what she saw as the "humanities side of engineering."

"It wasn't counting gears and looking at a motor. It was the logic—being able to coordinate operations," notes Wong. "It was a perfect fit. I changed my major."

The same year, she took part in an eight-month co-op at Estee Lauder's industrial engineering department on Long Island, which handles logistics of mixing the raw materials of cosmetics. The summer after her junior year, Wong did a paid internship with Procter & Gamble in Iowa City, viewing an entirely different manufacturing atmosphere.

Approaching graduation, she received an offer from Disney to work in a department that handles queue management. She declined, in favor of the offer from United Technologies Corp. to enter its highly selective program in operations leadership. Over the next two years, Wong will cycle through three of

the manufacturing conglomerate's units, which include Carrier, Otis, Hamilton Sunstrand, and Pratt & Whitney.

"I get to use such a big toolbox and it can be really creative. I can improve a process and do it however I want to get there," says Wong. "So many people don't know about it but if they did, they would definitely be interested."

EARLY FOCUS

Not that Rensselaer's industrial and systems engineering program is new. Since its creation in the 1930s as "management engineering," the program has vacillated between an identity as an engineering discipline and an engineering-based field within business. It has been housed within the Lally School of Management and Technology and the School of Engineering. An early focus was organizational administration and plant design. In the 1950s, the program stood out for being among the first of its kind to require computer programming course work.

In the late 1980s, it became its own interschool department, known as "decision sciences and engineering systems." The program pulled together faculty from the schools of management, engineering, and science.

"We called it a three-dean salad," recalls William "Al" Wallace '61, the Yamada Corporation Professor, who joined the faculty in 1965 and is the longest-tenured member of the industrial and systems engineering department.

In 2007 the program underwent an external review that concluded with a recommendation that the interschool hybrid be replaced with a more defined research and academic focus. "Decision sciences" became "industrial and systems engineering" and returned to the School of Engineering.

Wallace argues that the program is exactly where it belongs. "This is engineering," he says. "It's not one of our core sciences but we are building things, systems for the best way of doing things. Our tools are applied math, computer science, and modeling."

The difficulty in pinpointing and naming the field is not unique to Rensselaer. Industrial engineering is also known as, or overlaps with, management

"Industrial and systems engineering is attractive to students seeking a broad technological degree that will prepare them to go in many possible directions in their careers. Our ISE graduates are in high demand by some of the world's top companies and are commanding high salaries."

—DAVID ROSOWSKY

science, systems engineering, operations research, and decision sciences. In addition, industrial engineering students seated side by side in the same classroom are likely to have vastly different career interests from one another. They may enter law, global finance, industry, or work for a non-governmental organization.

"Industrial and systems engineering is attractive to students seeking a broad technological degree that will prepare them to go in many possible directions in their careers," says Rosowsky. "The ISE curriculum prepares students to work in companies and organizations across the spectrum of engineering disciplines. Our ISE graduates are in high demand by some of the world's top companies and are commanding high salaries."

David Mendonca, Ph.D. '01, an associate professor in the department, believes industrial and systems engineering will become more relevant to young people as they learn about the high job placement and myriad ways they can apply the field.

PATHWAYS TO SUCCESS

"I think one of the reasons that ISE has had a tough time gaining entree to younger students is that the pathways are not well defined," says Mendonca. "But with the pathways better defined, younger students are seeing promising futures for themselves in the field."

One of his undergraduate courses uses engineering techniques to gain insights about competitive sports. The sample group includes Rensselaer's own hockey and football players. Through extensive interviews and data collection, the students identify the factors that make the difference between winning and losing.

"They learn how you can bring analytic message to bear in understanding human performance using the core ISE skills," says Mendonca. "It's serious fun. They *love* it. I have done it twice as a special class and this time as a regular course. It was full before the second wave of registration. We don't need to tell them why they need to care. It's already interesting to them."

Mendonca is also exploring the theoretical links between improvisation in two very different realms: jazz performance and emergency response. He and several

colleagues are collecting data from musicians at Rensselaer's Curtis R. Priem Experimental Media and Performing Arts Center. Mendonca hopes the results can be used for training purposes.

"Our goal is to conduct cutting-edge research on why some organizations succeed or fail, but also to contribute to the development of training," says the professor, whose work was recently featured on National Public Radio.

Faculty members also pursue studies that look at factors that determine the long-term performance of life-enhancing devices, such as brain implant chips. Associate Professor Mark Embrechts is one of five principal investigators involved in a three-year, $5.2 million grant that involves faculty from other universities and medical centers. Others address problems in financial risk management, health policy, and threats to technology, such as the Internet.

Among the department's specialties is supply chain management, which looks at the best ways to move goods from raw material to the consumer. Jennifer Ryan, an associate professor who specializes in this area, says she became interested during graduate school as she saw how mathematics could be used to tackle tangible problems in manufacturing, transporting, storing, and distributing goods.

"We are able to identify particular mechanisms that work well with a company. It's important because chains are prevalent in all kinds of organizations," says Ryan, who uses both corporate and public funding.

She noted that getting a product to the market might require that a company manage thousands of different items in dozens of locations across the globe. Add to the mix the variables that cannot be predicted: How many of the items will be needed? By when? In addition, new-generation products are introduced continuously, requiring constant adjustments to the supply chain. Coming up with the best practices—such as having the right amount of inventory on hand—can save millions of dollars.

Ryan shares her findings with students and engages them directly in research. In March, she and two doctoral students completed a study funded by a $180,000 National Science Foundation grant to help companies manage their inventory of spare parts. Having the right replacements on hand can prevent protracted disruptions that can take place when sophisticated and expensive machinery is ordered.

Ryan's study analyzed data from sensors installed on the machines that can show when they might break. The equations they came up with from the sensor data can be used by companies to forecast their own demand for spare parts.

"The research supported two Ph.D. students who did dissertations on this topic," she says. "And in the long run, all of this research will find its way back into our courses."

ENGINEERING SOLUTIONS FOR DISASTER RESPONSE

Another area in which Rensselaer industrial and systems engineering students are deeply involved concerns how communities can prepare for and react to disaster, piece by piece. The September 11 attacks on the World Trade Center are among the significant examples of what can go wrong when separate systems fail to coordinate.

Wallace has gained wide recognition since the 2001 terrorist attacks for his analysis of the interdependence of autonomous systems—transportation, power, water, communications, hospitals. His work shows the cascading effect of their overall failure to collaborate in both how they are built and how they respond to crisis.

For instance, the downed power lines in lower Manhattan paralyzed ATMs, making it impossible for people to get cash needed to sustain themselves. The city had back-up generators but there was no way to get the diesel fuel to them once roads became impassable. An electric generator might power a hospital but the water system for the same hospital might also lack the necessary back-up power, hindering patient care. Working with Wallace were Rensselaer professors Joe Chow, John Mitchell, Tom Sharkey, and David Mendonca, Wallace's former graduate student.

Their goals are to both help prevent disaster and make the systems work together more smoothly in the aftermath. They employed complex math and computer algorithms to construct working models of infrastructure interconnectedness. They have published several widely cited studies that map the tangled dependencies at the time of the attacks and during the arduous recovery. Their findings have led to additional interest and funding from the National Science Foundation. They also highlight those utilities that worked well under duress. Among these were Con Edison and Verizon, which successfully restored two interdependent infrastructures.

"Our eyes are on how to make our communities resilient," explains Wallace. "Are your ambulances close but not in the path of a hurricane? Do you have a way to get water? Do you have portable power lines that aren't in the way of your ambulances? Once you understand the importance of this, you try to do everything in your power to mitigate."

Partnering with the U.S. Department of Homeland Security and the University of North Carolina, the Rensselaer industrial and systems engineers developed prototype software that enables emergency response officials to physically see the interdependencies within the civil infrastructure system.

For Warren Lee, the emergency response director in New Hanover County, the work was an eye-opener.

He saw that not only don't utilities and other stakeholders historically think of the big picture, but that they are even reluctant to share information needed to coordinate crucial functions. (This stems, in part, from a fear of informing terrorists how to target their systems.) To negotiate such barriers, the Rensselaer group had to purchase some maps and make assumptions about where power lines and other services were located. New Hanover County was on their side.

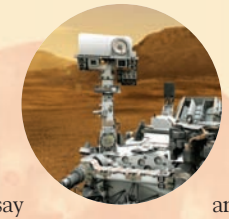
"Some of these people were really reluctant to release some of this information to a group of college students from New York," Lee says. "That's where we came in, to help leverage the support that's needed. Because we have been engaged in the development of this tool, it makes us look at the work in a whole new perspective."

NASA/Bill Ingalls

Mars Science Lab team members react to Curiosity's safe landing on Mars. Members of the team and Dean of Science Laurie Leshin will talk about the science behind the Rover and the study of its findings at Reunion & Homecoming.

Reunion & Homecoming: Exploring the "Red" Planet

Make plans to attend Oct. 5-7



When Reunion & Homecoming takes place the weekend of Oct. 5-7, some very special guests will be among the attendees. In fact, you might say they are "out of this world!"

Members of the team who built the Mars Rover Curiosity will share the science behind the construction and launch of the rover, as well as the study of its findings, at a special program on Saturday, Oct. 6. Also on hand will be Dean of Science Laurie Leshin, who came to Rensselaer from NASA and remains deeply involved in the development of tools to search for water and life on Mars.

The Mars Rover program is just one of the many fun, educational, and exciting offerings during Reunion & Homecoming weekend. On Friday, President Jackson will bring attendees up-to-date on the refreshed *Rensselaer Plan*. An all-new Physics Magic Show, with Aidyl Gonzalez-Serricchio '94, will make its debut on Saturday.

Milestone anniversary celebrations will include: 30 years of Science and Technology Studies; 40 years of the Arts Department; the Archer Center for Student Leadership Development's 20th anniversary; Lambda Chi Alpha's 75th anniversary; Alpha Phi Omega's 65th anniversary; and the Phalanx 100th anniversary celebration.

In addition, the weekend will include reunions for classes ending in 2 or 7, football and hockey games, a Back-to-Class program, tours, dinners, lunches, and more!

Contact your friends, classmates, teammates, Greek brothers and sisters, and encourage them to join you on campus for this very exciting, educational, and entertaining experience—worth the trip from any planet in the galaxy!

Visit the website at alumni.rpi.edu/reunion for a schedule of information, a list of who's coming, online registration, where to stay, and complete details on the various affinity group gatherings, or contact the alumni office at alumni@rpi.edu or (518) 276-6205.

ALUMNI NEWS

A Lost Ring Brings a Family Full Circle

Back in the spring of 2009, a class ring missing for more than 50 years was returned to its owner. Now, the owner of that lost ring will watch with pride as his grandson joins the Rensselaer family as a member of the Class of 2016.

Juan Gonzalez '49 (seated below) had lost the ring on a beach in San Juan while enjoying the day with his children. The ring remained buried in the sand until a FexEx pilot on layover in Puerto Rico discovered it as he combed the beach for treasure with his metal detector. The ring was returned to Gonzalez, and he was invited to return with his family to attend the Junior Ring Ceremony in 2011, and share his story with the Class of 2012.

Kris Qua

Accompanying Gonzalez was his grandson, Gabriel Kurtzman-Gonzalez, who took a tour of campus and visited with the admissions office. He must have been impressed, because Gabriel has enrolled as a member of the incoming Class of 2016—joining one of many legacy families who chose a shared Rensselaer education.

EVENTS CALENDAR

OCTOBER

11 Reception with President Shirley Ann Jackson. The Petroleum Club of Houston, Texas. Join area alumni for a reception and presentation of "Rensselaer at 200: Refreshing *The Rensselaer Plan*." For more details, contact Susan Haight at haighs@rpi.edu or (518) 276-6042.

25 Alumni Reception at AIPLA, Washington, D.C. Cocktails, hors d'oeuvres, and networking with alumni from across the country in the patent law, intellectual property, and licensing fields. For more information, contact Susan Haight at haighs@rpi.edu or (518) 276-6042.

NOVEMBER

9 Alumnae Reception at the Society of Women Engineers (SWE) Conference. Rensselaer alumnae in Houston, Texas, are cordially invited to a networking reception at the annual SWE conference. For more information, contact Susan Haight at haighs@rpi.edu or (518) 276-6042.

15 Alumni Reception at the Architecture Boston Expo (formerly Build Boston). Join other alumni in the building trades for this exclusive Rensselaer alumni reception. For more information, contact Kathy Kinsey at kinsek@rpi.edu or (518) 276-2832.

MILESTONES

Celebrating Milestones in Humanities, Arts, and Social Sciences

Reunion & Homecoming 2012 will include a celebration of two important milestones in the School of Humanities, Arts, and Social Sciences (HASS). The Department of the Arts will celebrate its 40th anniversary, and the Department of Science and Technology Studies will celebrate 30 years. Alumni from the School of HASS, along with all interested alumni and guests, are welcome to attend these events. Visit the Reunion & Homecoming website at alumni.rpi.edu/reunion for more information and to register.

The Department of the Arts is widely considered to be the first integrated electronic arts program within a research university in the United States. Founded in 1972, the department initiated the inclusion of electronic media in 1981. The department features an integrated and multidisciplinary approach to the arts with a focus on the use of experimental and electronic media in artistic creation and performance. The work of the department's faculty and alumni is represented internationally in museums, galleries, festivals, publications, and performances.

The department will showcase its faculty, students, and alumni at EMPAC during the weekend. Activities will include classical and experimental music concerts, a gaming arcade, interactive installations, sculpture and painting, and a new-media screening.

This sculpture is a gift to Rensselaer from Arts Professor Larry Kagan '68 and will be presented during the HASS celebrations.

The Department of Science and Technology Studies (STS), founded in 1922, is one of the oldest and most highly recognized programs of its type, and one of the few in the world that offers STS degrees from baccalaureate to doctoral levels. Degree programs emphasize the cultural, historical, economic, political, and social dimensions of scientific and technological society, with a focus on ethical and values issues. The internationally recognized faculty members have backgrounds in anthropology, history, philosophy, political science, social psychology, and sociology.

STS activities planned for the weekend include a departmental open house; overviews of programs in STS, sustainability, and design; a panel discussion on liberal arts education at Rensselaer; and a luncheon.

RAA VISA CREDIT CARD

The RAA Visa card is offered through a partnership with U.S. Bank. The card features no annual fee and your choice of benefits and rewards, and a percentage of every purchase goes directly to support the RAA. Visit alumni.rpi.edu/service for details.

RAA WORLDWIDE TRAVEL PROGRAM

Travel to exciting destinations with people who share your interests—fellow Rensselaer alumni. Trips for 2013 include an "Ancient Mysteries of the Americas" cruise from Miami to Lima, Italian Inspiration, the British Isles, Classic China and the Yangtze, and the Pride of South Africa. For more information visit alumni.rpi.edu/travel.

ALUMNI ATHLETIC TEAM COLLABORATION

The Office of Alumni Relations partners with many athletic teams to facilitate connections among students, coaches, and alumni. The office provides database services, support in planning milestone celebrations, and help in leveraging resources for major athletic event weekends. Visit the website at alumni.rpi.edu/teams, or contact Peter Pedone at pedonp@rpi.edu or (518) 276-6061 to find out more.

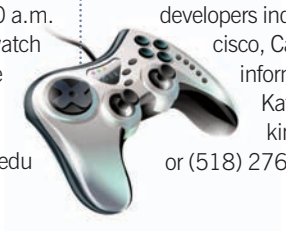
FEBRUARY

2 Big Red Freakout Ice House. This annual hockey tradition takes place at the Heffner Alumni House. Enjoy a delicious buffet dinner with other RPI hockey fans, get into the spirit with face painting by the Red & White Student Organization, and take a convenient shuttle to and from the Houston Field House. After the game, return for dessert and a reception with the team and coaching staff. For more information, contact Peter Pedone at pedonp@rpi.edu or (518) 276-6061.

2 Alumni Hockey Game. Troy campus. Men's ice hockey alumni are invited to return to the Houston Field House for the alumni game at 11:30 a.m. The public is welcome to watch as all your favorite players lace up for this fun annual event. For more information, contact Peter Pedone at pedonp@rpi.edu or (518) 276-6061.

MARCH

25 Alumni Reception at the Game Developers Conference. Attend this annual reception to meet other alumni in the game developers industry. San Francisco, Calif. For more information, contact Kathy Kinsey at kinsek@rpi.edu or (518) 276-2832.



Class Notes

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Attention: I am trying to find the oldest living graduate of RPI. You can send your update to lmahow@mindspring.com or at 109 Royal Garden Terrace, Madison, MS 39110. Can you help? Wonder if there are any other graduates above or near 100. Ever since **Izzy Warshaw** '23 passed away in 2007, we have not had any representative at Reunions past 95. If you can help me with this project, it will be greatly appreciated.

Heard from **Irv (Lucky) Goldstein**, fraternity brother and member of the Class of '41 (BA Chem.), who is professor emeritus, North Carolina State, Wood and Paper Science. After retirement, he is busy rearesing of his grandchildren and great-grandchildren. His wife passed away and he connected with his old girlfriend from Russell Sage in Troy, N.Y., after 72 years, meeting her again on Facebook. At 90 he is doing better than some not as old as he is.

Dick Trapp (Chem.Eng.) let me know that he is still involved with chemistry [illegible] a regional meeting of [illegible] August. Presently looking [illegible] had many skin lesions [illegible] dermatologist. I know Dick well as I was his fraternity house roommate for three years, and have visited him at his home in Massachusetts.

Bob Cox (ME) is still making trips to Michigan to go sailing on the many lakes in the area. He also took a ride in a corporate jet, piloted by his son, and saw the latest Garmin equipment (GPS). The founders of Garmin worked for Bob when he was CEO of King Radio. The GPS equipment is far superior to what they were making in the old days. He and his wife have had the usual problems of aging but it is better than the alternative.

Bob Hedemann (BAE), at 95, appears to be doing well despite a stroke about four years ago, which has slowed him down, although he still drives. He lives in Dothan, Ala., where his family was involved with baby furniture, and during the Second World War the firm made parts for several aircraft.

Send news to: Lou Skowick '39, 109 Royal Garden Terrace, Madison, MS 39110-2610; h: (601) 955-2265; lmahow@mindspring.com; website: www.lmahowick.com

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70th Reunion: Oct. 5-7, 2012

I received news of the death of **Edward N. Stevenson**. Ed and Doris were faithful attendees at five-year reunions, and Helen and I often pulled around with them.

I still can't see small print, as a result of the small stroke I suffered, but I can see catch enough to play bridge. My younger daughter took me to an overnight party on my birthday in February, and it was great. I'm considering attending Reunion in October, if someone can drive me to Troy.

Send news to: Ed Koenig, P.E. '42, 11 Stone Fence Road, Bernardsville, NJ 07924-1713; h: (908) 766-1117; tkob@dgtech.com

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Since the last issue of the alumni news, I've had a number of communiques and hope that this will continue. **Dick Schwartz** writes from Peru, N.Y., with a description of a very active life after retiring from the faculty of Binghamton University in 1995, involving community organizations, professional societies, mentoring, and musical performances. He gets occasional news from other '44 Eds, **Frank Hicks** and **John Van Doorne**.

Arnold Beckhardt retired to Vero Beach, Fla., after a very active career with IBM and is perhaps our only class novelist. Arnold has just published The [illegible] chronicling the activities of [illegible] Arnold's wartime activities [illegible] enjoyed the book.

With our class graduating in '43 there is a confusion in identifying some of our classmates. A letter from **Martin Lewis**'s widow Joan is an example. Martin passed away in 2011 after retiring from a career working on guided missiles, computer systems, and tire manufacturing. He graduated in August '44 and considered himself a member of our class. RIP.

And a final note: You will remember the chaos when Curtiss Wright Aircraft sent a swarm of Cadettes to RPI to study engineering topics that would equip them to perform various engineering tasks for that company. Twenty-four were listed in the 50th Reunion Transit and nine actually came to the reunion. A note from **Betty Anderson Scanlebrn**, one of the Cadettes, reported the passing of **Lenore Gurnsbrum Stalb**, a lovely lady and a member of our class.

Please keep sending me news of your activities, even if at this age they are down.

Send news to: L. McD. (Mac) Schelke '44, 24436 Waterview Drive, Worton, MD 21639; h: (410) 778-4955; macklyt@gmail.com

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These notes and space are reserved for the "career story" from **Richard Nickerson** '45 (ME) (BCEE). "I first went to RPI in September of 1941 - Class of 1945 - Dormitory Church II. I joined a great group in Navy ROTC and became a fraternity brother at Theta Xi. When war was declared in December of 1941, our schedule

Click to view Alumni/ae Notes and the complete Class Notes section (log-in required)

Rensselaer celebrated the 100th anniversary of

Kris Quia

Fenway Park, designed by the firm of alumni Frank and Kenneth Osborn, at an event April 28, featuring an exclusive tour of the facilities.

WRITE TO US!

We welcome contributions to "One Last Thing." Send personal essays of 750 words or less to alum.mag@rpi.edu.

"Knowledge and Thoroughness"

A look back at Rensselaer's pragmatic approach to education | *BY JEFF G. BOHN '68*

THROUGHOUT MY CAREER, I HAVE seen things go best for both projects and careers when proper knowledge was brought to bear and applied with thoroughness and diligence. It's not too much to say that the principal contributors to success in *any* endeavor are the personal qualities of knowledge and thoroughness.

I first encountered those words together in the seal of the college that shaped my professional life. The motto dates to 1904, when Rensselaer president and director Palmer Ricketts, Class of 1875, responded to a request from alumni for a crest they could display to represent the college. Into this crest Ricketts inserted two words that, as he later wrote, "seemed to cover two characteristics developed by the Institute course."

Amos Eaton, RPI's founding professor, believed that knowledge was incomplete without application and experience to perfect it. Founder Stephen Van Rensselaer agreed, and Eaton structured his courses with extensive laboratory experiments, field work, and classroom teaching by the students. Benjamin Franklin Greene, Class of 1842, continued and enlarged Eaton's vision. As director in 1851, he added "Polytechnic" to "Rensselaer Institute," reflecting his passion for a true *poly*-technic curriculum featuring a broad range of integrated, tightly focused courses that preserved Eaton's emphasis on application and experience.

It would take another half century before Charles Peirce, William James, and John Dewey developed a philosophy known as pragmatism that provided a theoretical framework for the educational approach Eaton, Van Rensselaer, and Greene had arrived at empirically.

Peirce, the founder of pragmatism, argued that the *effects* of an object are part of the *whole* of it. In other words, knowledge of an object is incomplete until it is experimented upon. James, interested in "truth," believed that "true ideas are those that we can assimilate, validate, corroborate, and verify." Dewey, the great educational theorist, wrote in 1903 that "…there is no way to know what are the traits of known objects… save by referring to the operations of getting, using, and testing evidence—the processes of knowledge-getting."

JIM BENEDUCI

From a student's perspective, the discussion relates to the difference between reading the chapter and doing the problems at the end, or the lab experiments. Every student has experienced the temptation to close the book at the end of the text and feel confident in his understanding of the subject. But every student also learns, eventually, that he only gains full knowledge of the material when he is challenged to "get, use, and test evidence," to experience the effects of boundary conditions, to see the meaning of a theory from different perspectives, to recognize dependent and independent variables, and to learn the art of making simplifying assumptions. It is in the dreaded assignments to prove, show, or derive that the real learning takes place.

In the engineering world, there is no greater instantiation of pragmatism's mandate to "know…the traits of known objects" than in verification testing of engineered systems. Every engineered object is unknown until it is tested, because it is about the object's *function* that we must gather knowledge. George Low '48, who served as director of spacecraft development for the Apollo program and later became president of the Institute, wrote in 1971 that "…the single most important factor leading to the high degree of reliability of the Apollo spacecraft was the tremendous depth and breadth of the test activity." Experimentation provided knowledge about how the systems functioned and assurance that the functions provided were the functions desired. Thoroughness in this is vital. Low wrote that there was "one overriding consideration that stands out above all the others: Attention to detail. Painstaking attention to detail…by all people, at all levels." Eaton, Greene, and Ricketts would have been proud of this tribute to knowledge and thoroughness!

Today's times are no more transformational than Eaton's. His pragmatic methodology remains valid. The fundamental objective remains to "apply science to the common purposes of life" by creating experience-intensive curricula fully to develop the necessary knowledge.

A contemporary of Dewey, English pragmatist F.C.S. Schiller, wrote in 1907 that, "In validating our claims to truth, we discover realities…and… transform them by our cognitive efforts, thereby proving our desires and ideas to be real forces in the shaping of the world."

How in keeping with Rensselaer's heritage, then, is the Institute's tagline, "Why not change the world?" With a pragmatic curriculum following Eaton and Greene, supported by the pragmatic philosophy articulated by Peirce and Dewey, we will indeed change the world: "knowledge and thoroughness" is change itself.

Jeff Bohn '68 majored in aeronautical engineering at Rensselaer and served as project manager for many aerospace, energy, and systems engineering programs in several organizations. He retired in 2007 as a Lockheed Martin Fellow after specializing in the development and integration of requirements for large aerospace systems. He lives in Malvern, Pa.






"Our intent was to have Rensselaer emerge re-energized, re-awakened, refocused. It meant that we had to imagine a different, bolder future for the Institute. We needed to recognize that, while building on its legacy and existing strengths, Rensselaer had to change."

President Shirley Ann Jackson

Renaissance at Rensselaer: A President, A Plan, A University Transformed

Written by national higher education writer Stephen G. Pelletier for the Institute, with a foreword by Dr. Paul Gray, Professor and President Emeritus, Massachusetts Institute of Technology, this book chronicles the extraordinary transformation of Rensselaer Polytechnic Institute that has occurred under the leadership of President Jackson under *The Rensselaer Plan*.

Available in hardcover and e-book format. Go to www.rpi.edu/transformed for details on downloading.

EMPAC 2012

CURTIS R. PRIEM EXPERIMENTAL MEDIA AND PERFORMING ARTS CENTER


ANTOINE TEMPE

Nora Chipaumire: *Miriam* OCT. 5 + 6


CHAD BATKA

Jennifer Koh: *Bach and Beyond* NOV. 30


LELAND BREWSTER

Laurie Anderson DISTINGUISHED ARTIST IN RESIDENCE 2012-2015

EMPAC is Rensselaer's international hub for contemporary art, performance, science, and technology. This dynamic center offers adventurous public events and performances in dance, theater, music, and the visual arts throughout the year. EMPAC is also a space where artists and researchers engage in new creative practice through its residency program.

For information on these and other upcoming events, visit **empac.rpi.edu**.

EMPAC Rensselaer

EMPAC 2012