Reid Wiseman ’97, a NASA astronaut currently stationed aboard the International Space Station (ISS), on a video call with students, faculty and alumni in the concert hall of the Curtis R. Priem Experimental Media and Performing Arts Center (EMPAC) this past October. Wiseman talked about the current state of the space program, gave insight into daily life on the ISS, and reflected on the ways his Rensselaer education put him on a path toward his ultimate career ambition – space travel. Wiseman graduated from Rensselaer in 1997 with a bachelor’s degree in computer and systems engineering.
This past year marks CBIS’ 10th anniversary. We are proud of the breakthrough work by our world-class faculty and students. Our contributions in protein engineering and separations, regenerative medicine, biomaterials, and bioinformatics point the way to exciting new avenues for future exploration. And our new multi-laboratory capabilities in stem cell research provide unique opportunities to combine cell biology, biomedical engineering, chemical engineering, and informatics research.
As the new Dean of Engineering I am pleased to present the Spring/Summer 2015 issue of the School of Engineering magazine. The magazine provides a window into the many exciting activities in both education and research that make the School of Engineering at Rensselaer truly an intellectually vibrant place.

Rensselaer has a long history and excellent reputation in technological education. Our faculty are leading many initiatives that will collectively define the modern engineering education for the 21st century and place the school at the forefront of it. Such education will include, for example, organic integration of new technology into classrooms, more effective ways of delivering content, access to maker-tinker-inventor spaces for students, as well as exposure to new ideas and cultures through study-abroad and other experiences. As you read the magazine, I hope you will get a sense for some of these activities. I expect to report much more on this front in the coming year.

The magazine focuses on many examples of truly interdisciplinary research activities that are fundamentally changing the way we think about human health, well-being, productivity, and safety. You will notice articles on research that spans a spectrum from the molecular to the human level, combining advanced computation with state-of-the-art experimentation. This research is addressing a range of important challenges, from diagnosis of birth defects, development of artificial pancreas to fight type-1 diabetes, and 3D printing of human skin, to using advanced computation and virtual reality to train surgeons in virtual surgery environments. The magazine also highlights activities at the intersection of advanced materials and lighting happening in our Smart Lighting Engineering Research Center. And finally, I hope you will take note of our growing strength in the (bio) imaging area in the article on omni tomography.

As we look forward to celebrating the 200th anniversary of Rensselaer in 2024, we in the School of Engineering are proud of our illustrious history and our strong reputation. We are also proud to be an important part of the transformation that is happening on the Rensselaer campus with exceptional new faculty and growing body of outstanding students. We thank you for your continued support of Rensselaer and invite you to visit us to experience the transformation first hand!

Best wishes,

Shekhar Garde

“I am honored and excited to lead the school at this important time. By striving for quality and excellence in research and education, building bridges across various schools at Rensselaer, cultivating and celebrating diversity, and promoting the accomplishments of our faculty, students, and staff, we will continue to elevate the impact and the transformational nature of engineering at Rensselaer.”
Chemical engineering was the fourth engineering course to be added to the curriculum, in 1914, following civil, mechanical, and electrical. “The object was to give a course which would better prepare a young graduate to take up work leading to the management of industrial plants than would any of the engineering courses or the course in science already established,” according to History of Rensselaer Polytechnic Institute, 1824-1914, written by President Palmer Ricketts.

Dean Garde’s research focuses broadly on understanding the role of water in biological structure-function, and specifically on the hydration and water-mediated interactions using statistical mechanical theory and molecular modeling and simulation tools. He has published over 90 peer-reviewed papers in leading scientific journals, which have been cited over 6000 times (per Google Scholar). He has given 130 invited talks at leading universities, industries, and international conferences, including many keynote lectures. He has received several awards including the CAREER Award by the US National Science Foundation (2001), School of Engineering Research Award (2003), Rensselaer Early Career Award (2004), and the 2011 Robert W. Vaughan Lectureship at California Institute of Technology. He was elected a Fellow of the American Institute of Medical and Biological Engineers (2014) and American Association for Advancement of Science (2015).

Garde is also one of the leaders of a unique animation movie project called the “Molecularium”, which aims to excite the younger generation about the world of atoms and molecules. He has pioneered integration of data from large-scale molecular dynamics simulations into a Disney-Pixar style animation world. He is a co-executive producer of the Molecularium I-MAX/3-D-IMAX movies – Molecules to the MAX, which are currently being distributed nationwide. In 2011 he was honored with the Explore-Imagine-Discover Award by the Children’s Museum of Science and Technology, in the Capital District of Albany, NY. The Nanospace portal of the Molecularium project received ‘Best of the Web’ award in Education by Center for Digital Education in 2013.
From skin you can print to lighting that thinks, Rensselaer researchers usher in the future of well-being

HEALTH & HUMAN SAFETY

WHY OUR DESCENDANTS WILL LIVE BETTER THAN WE EVER DREAMED OF
WHY OUR DESCENDANTS WILL LIVE BETTER THAN WE EVER DREAMED OF

From skin you can print to lighting that thinks, Rensselaer researchers usher in the future of well-being.

If you’re like most people, the two sides of your body are not identical. This left-right asymmetry develops in the womb, and no one knows how.

A lot is riding on the answer—since a glitch in the development can mean severe birth defects.

That’s what motivates Leo Wan to solve the mystery. And unlike most researchers in this specialty, who focus on animal or human tissues, Wan and his team have gone several levels smaller.

“We decided to tackle the problem at a cellular level, in vitro,” said the assistant professor in Rensselaer’s Department of Biomedical Engineering. “This gave us significant advantages in discovering important molecular mechanisms and screening for factors that influence left-right asymmetry.”

Plumbing Chirality’s Depths

One critical factor may lie in the fact that cells have chirality (or left-right asymmetry) too. “Our most significant contribution so far has been the discovery of intrinsic cell chirality on micropatterns with defined boundaries,” he noted. This finding should shed light on the micro-level mechanisms behind the asymmetry of organs in the human body—as well as factors that could disturb those mechanisms and lead to birth defects.

The past year has seen substantial progress on two related fronts. In one investigation, Wan and his team tested whether they could use cell chirality to measure toxicity. “Cells have to have normal functions for their chirality to show up,” Wan explained. “In a toxic environment, those normal functions are impaired, and the chirality will be lost or even reversed.” The experiment found that exposure to certain nanoparticles in fact erased the cells’ chirality—also indicating that prenatal overexposure to those nanoparticles might lead to birth defects in human chirality.

Another line of research may address dextracardia, a severe defect in which the heart points toward the right (instead of toward the left, as it normally does). Wan is focusing on the role of cell chirality in the eventual direction of the cardiac tube—the precursor of the embryonic heart.

“The cardiac tube starts as a straight tube along the midline of the embryo,” Wan explained, “and subsequently rotates and bends to the side. We used cardiac cells from mice to study their intrinsic directional bias. One ongoing study focuses on how the adhesion force between cells could potentially contribute to the formation of chiral cellular structure—and therefore the improper looping of the cardiac tube.”

Next Steps and Impact

Wan has already formulated plans for the next phase of his research. He will focus on developing multiscale in vitro models for left-right asymmetry, which has only been studied in vivo to date. He wants to examine whether in vitro cell chirality shares signaling pathways and putative proteins with the progress of left-right symmetry breaking. And if all goes well, his lab will conduct the first-ever experiments attempting to link intracellular cytoskeletal dynamics, single-cell chiral behavior in polarization and migration, and multicellular chiral development in 2D and 3D.

“All of these ideas are potentially transformative in nature,” Wan explained. “They are designed to address long-term debates on left-right asymmetry with novel approaches. My hope is that they will unveil one of the ultimate mysteries of biology—enabling us to develop new diagnostic and screening tools for birth defects.”

SWEATING THE SMALL STUFF

Leo Wan seeks to solve a biological mystery—and fight birth defects—on the cellular level.
SHAPING FUTURE CAREERS,
PERFECTING THE ARTIFICIAL PANCREAS

for B. Wayne Bequette and his collaborators research is essential to the fight against Type 1 diabetes
A child is sleeping. Her blood sugar drops into hypoglycemic range. She needs attention now. Fortunately, she’s wearing a continuous glucose monitor, and the alarm goes off. Unfortunately, everyone sleeps through it.

B. Wayne Bequette’s latest advance is designed to make this a non-issue. His team’s “low glucose suspend” system is the next step in their long line of solutions that, together, will contribute substantially to a novel closed-loop artificial pancreas for people with Type 1 diabetes.

“Millions of people stand to benefit from this technology,” said Bequette, a professor in Rensselaer’s Department of Chemical and Biological Engineering. “With a closed-loop artificial pancreas, they will no longer need to serve as their own ‘control loop’ and can spend more time focusing on the rest of their lives. And better regulation of blood glucose has been shown to reduce long-term complications such as eye diseases and nerve damage.”

Protection for Sleepers

The artificial pancreas—the result of a multidisciplinary collaboration of researchers at distinguished universities, health research centers, and other institutions—consists of three principal components: a glucose sensor, an insulin infusion pump, and a feedback controller. Bequette’s expertise in sensors and controls has made him an invaluable contributor to these aspects of the pancreas.

It was Bequette’s lab, in fact, that came up with a predictive alarm in the first place. “One of the major concerns for parents of children with type 1 diabetes is the risk of hypoglycemia while sleeping,” he explained. “We developed algorithms that could predict when an individual was at risk of going hypoglycemic, and then provide an alarm in advance so that the individual could take a glucose tablet or drink some juice.”

Because loud noises do not always wake up caregivers, however, Bequette’s team needed to take another step—and the low glucose suspend system was born. The system automatically shuts off the insulin infusion pump on the artificial pancreas before hypoglycemia occurs.

Preliminary outcomes have been promising. “The results from our initial in-hospital studies were dramatic enough to justify outpatient studies, where individuals took the system home and used it overnight,” he said. “To date, we have completed over 2,000 nights of outpatient tests, and the results clearly show a reduction in hypoglycemic risk.”

Bequette’s research extends in many other directions as well. His team is investigating how to extend the suspend system to include hyperglycemia, controlling glucose to an acceptable range between low and high levels. New algorithms are designed to detect sensor signal anomalies that may occur, for example, when the sleeper rolls over on the sensor. Most recently, his team developed a closed-loop system for 24/7 regulation of blood glucose, without requiring meal or exercise knowledge. While the initial platform required a laptop computer, the current NIH-funded project will control the system via smartphone.

“My interest in research is the number one diabetes when his sister was diagnosed with it in the 1970s. “However, when I first came to Rensselaer, I made it across campus to meet many of the faculty members in systems and control. Soon a biomedical engineering Ph.D. student asked me to be on his dissertation committee. His topic, drug infusion control, was new to me, but as a result I began to collaborate on biomedical engineering projects. This in turn led to proposals for the NSF and started me on a path towards the diabetes research I am conducting today.”

“Chemical Engineers Can Do Anything”

An invaluable by-product of Bequette’s research is the number of postdoctoral researchers and graduate students he has mentored since his diabetes work began 10 years ago. Two of the postdocs in particular have advanced the research: Fraser Cameron developed the algorithms behind the alarms and controllers, and Nihat Baysal focuses on the signal anomalies.

As part of Bequette’s mentoring, he stresses that chemical engineers can “do anything,” and their careers may take them to places they never imagined. He should know: his research interests run the gamut from fuel cell control to the smart grid and “internet of things.”

“I stress to graduate students, particularly those considering an academic career, that I never mentioned biomedical engineering research topics during my search for a faculty position,” recalled Bequette, who first became interested in Type 1 diabetes when his sister was diagnosed with it in the 1970s.

This research is supported by:

NIH National Institute of Diabetes and Digestive Diseases
Eric Ledet has thrice been honored with prestigious teaching awards—and for good reason.

SHAPING FUTURE CAREERS, ONE EXPERIENCE AT A TIME
A CONVERSATION WITH ERIC LEDET
If, as a Rensselaer student, you visited a South African township, watched live surgery from the classroom, or worked on projects months after the assignment was over because they energized you so much, you were probably a student of Eric Ledet.
Ledet’s initiatives to create unique undergraduate experiences have drawn accolades, including the Trustees Outstanding Teacher Award in 2013, the Class of 1951 Outstanding Teaching Award in 2011, and the School of Engineering’s Excellence in Education Award in 2007. More important, these experiences have influenced students’ career paths and achievements well beyond graduation. One look at the experiences will tell you why:

- **Three times, Ledet has taken a small group of students to South Africa to visit the country’s poorer citizens and identify projects to improve their lives.**
- **In his Clinical Orthopedics and Contemporary Research course, students routinely watch live surgery being performed at Albany Medical Center, dialoguing with the surgeons in real time.**
- **Over the past seven years, students have collaborated with the Center for Disability Services on roughly a dozen projects—from devices for children with disabilities to the prevention of pressure sores.**
- **Ledet’s undergraduates have taken part in Global Engineering Teams, an initiative of universities from five continents whose students collaborate across boundaries on engineering problems.**

Why have you focused so much of your effort at the undergraduate level?

For undergrads, experience is just as important as knowledge. If students can apply knowledge from the classroom in a firsthand experience, it helps them understand that knowledge in a completely different and deeper way. Plus, a big part of undergraduate education is trying out a whole bunch of different things and seeing what inspires you. Having gone to South Africa and worked on a project that’s made a difference can change the way you approach your career.

Can you share an example of that?

In 2013, one of our students went to South Africa as part of a Global Engineering Team. She worked with students from all over the world on a project related to oral hygiene and impoverished people in coastal Africa. The team reported out at a conference in Germany, and their work was done. But this student and a South African colleague have continued to work on the project. They have a patent pending for their solution, and they ultimately want to distribute it through NGOs. It’s so gratifying to have that kind of impact on students. That’s what we’re here for.

How did these projects get started?

What amazes me is how all of these projects have flowed together. In 2009, Dr. Jackson traveled to Stellenbosch University in South Africa; later, on a reciprocal visit, one of the Stellenbosch professors asked if he could meet with me. We connected both personally and professionally, and six months later—when he was back in the U.S. for a conference—we spent two days brainstorming ideas about collaboration. Out of that came our first trip to South Africa.

Tell me about that first trip.

I experienced so many things: from the most beautiful natural vistas I’ve ever seen to some of the most disturbing living conditions I’ve ever seen. We took part in a rural nurses’ program that brought us into the townships—where we stuck out not just because of our skin color, but because we had shoes. The adults kept their distance, but the kids followed us around, first two, then six, then a horde. One of our students made a face at the kids, and the kids made faces back. The one word we had in common was baboon, so when one of our students said “baboon,” the kids started acting it out. By the end of the day, the kids were hanging all over us, and our students were in tears.

Did the trip have a lasting impact?

Oh, yes. For the students, it was a revelation. On the grand spectrum of privilege, they tend to cluster toward one end, and during the trip they encountered people far down the other end. Some came home and said, “I’m really lucky.” Others came home and said, “I’m really lucky and I want to do something.” That’s what leads to projects that outlive the original assignment.

Speaking of that, didn’t the South Africa trip lead to a new project with the Center for Disability Services?

Yes, it did. One of the biggest needs we saw on the trip was the great challenge for people with physical disabilities in a developing country. The students on the first trip identified this as their top priority. Now for years, our students have worked on projects for the Center for Disability Services (CDS). In this case, we needed their expertise. We said, “You have substantial knowledge in this area. Can you help us?”

The presenting issue was that South Africans who spend a lot of time in wheelchairs end up with pressure sores that are both painful and prone to infection. When we described this to our colleagues at the Center, they said, “Actually, that’s a problem here too.” So it became the perfect partnership, and the Center sponsored a Global Engineering Team to address the issue. The team cycle ended, but the students are still working with the Center on this. They wanted to go beyond the program’s finish line and get to the point where they were helping people—here and in Africa.

By the way, our participation in Global Engineering Teams came out of our collaboration with Stellenbosch too. After the first trip, my colleague at the university suggested we join that effort to give our students broader experience with interdisciplinary international teams. That’s the main goal of the Global Engineering Team consortium, which the University of Berlin established in 2004.

How do you recruit students for these projects? And how do you go about planning the experience?

I do an open solicitation. This is where I’ve seen the impact of the South Africa experience:
recently I asked a class of 95 students if they might be interested in going on the next trip, and 94 said yes. I ask interested students to submit an essay, and I base my selections on the essays I receive.

As for planning: beyond the typical itineraries and such, I make a point of leaving my experiences for undergrads as open-ended as possible. In many aspects, I don’t know how they’re going to go. That allows the students to shape the experience, for the experience to evolve on its own, and for the unexpected to happen. It’s unique and new and different, for the students and for me.

Let’s talk about something else that, if not unique, is certainly extraordinary: the “telesurgery” in your classroom.

One thing I bring to the biomedical engineering classroom is my time in a clinical environment. I ran the orthopedic research program at Albany Medical College. So I’ve seen how essential it is for my students to understand the clinical setting. After all, if they’re going to develop new technology that touches the clinical world, they have to know what the clinical world is all about.

So I asked my colleague Richard Uhl, MD (’80), head of orthopedic surgery at Albany Medical College, for help designing a course on the state of the art in clinical topics. We concluded that the best way to expose students to clinical settings was to get them into the OR, and the best way to do that was via a live two-way feed at a classroom equipped for the purpose. Feeds from the cameras in the OR—on the surgeon’s headlamp, on the endoscope, etc.—were broadcast to the students in real time. They could ask questions, and the surgeons would answer when the progress of the surgery permitted it. As a result, students didn’t just see the clinical environment; they learned the clinical language. I am convinced that this knowledge will make them good designers in the future.

What kind of impact has this had?
I give my students questionnaires to get feedback on initiatives like this. In one of them, I asked, “Do you talk about the live surgery in your job interviews?” Ninety percent of them said yes. And that includes the pre-med students who took the class.

What’s next for you?
Some of our alums from a major orthopedic company asked me how they could support the Clinical Orthopedics course. They have committed to sending their own simulators and implants to Rensselaer for our use—so students can actually “do” simulated hip surgery firsthand. This doesn’t just acquaint them with the clinical setting; it immerses them in it.

I will continue to solicit support for the South Africa experience as well: as you can imagine, it’s an expensive proposition for both the students and the institute, so outside support is key. And in everything, I will keep trying to deliver open-ended, experiential learning that engages students thoroughly and stays with them well into their careers.

No description of Eric Ledet’s work would be complete without a mention of South Africa. A rural nurses’ program in South African townships has exposed Rensselaer students to a life vastly different from their own. One of Ledet’s students traveled to the country in 2013 to take part in an oral hygiene project. And a collaboration with the Center for Disability Services is working on solutions for pressure sores experienced by African people in wheelchairs.
LIGHTING SYSTEMS THAT THINK

…and improve your health, and warn you of hazards, and transmit video, and…

Center Director, Dr. Robert Karlicek and his colleagues at Rensselaer’s Smart Lighting Engineering Research Center (ERC). The center is one of just 17 in the United States that the National Science Foundation established.
“We envision a future in which lighting systems will know what we need without our telling them. There will be no light switches, no voice commands, nothing.”

That’s not all Bob Karlicek envisions. There’s also the light-based internet, indoor GPS to help you find your way in an unfamiliar building, and the ability to identify unsafe situations in a senior living facility.

No wonder they call it smart lighting.
Karlicek and his colleagues at Rensselaer’s Smart Lighting Engineering Research Center (ERC) are exploring the components of such a system now. The center is one of just 17 in the United States that the National Science Foundation has established to, according to its website, “integrate transformational academic engineering research and education to stimulate increased U.S. innovation in a global context.”

Rensselaer's ERC aims to serve as the “one-stop shop” to usher industry into the future of lighting. And what a future it is.

To the Limits of Light
The pace of smart lighting developments is all the more noteworthy because of the contrast with the last 100 years. “Lighting research essentially took the 20th century off,” said Karlicek, the ERC’s director and a professor in the Department of Electrical, Computer, and Systems Engineering (ECSE). “Incandescents were perfected in the 1920s, flourescents in the 1950s. Now, ultra-reliable LED lighting is setting the stage for market saturation, and manufacturers are looking for the next big leap with new lighting technology and services. We believe that leap is smart lighting.

The goals in every phase of research are the same: significant advances in energy efficiency, human health, and productivity. The path to meeting these goals is populated with all kinds of eye-opening advances, including:

The light you need, when you need it.

Imagine this: you take two steps into a familiar room and your lighting system adjusts the light based on time of day, current conditions, number of people in the room, and your personal preferences—preferences that the system itself will have figured out. Sensors would even gauge your mood at the time and fine-tune lighting conditions accordingly.

The root of this innovation involves making light color-tunable, an avenue of research that the ERC is pursuing. “Human circadian rhythm adapts to natural changes in light,” Karlicek explained. “By tuning indoor light to the circadian rhythm as well as other factors, we can help people sleep better, speed the recovery of hospital patients, and improve health overall.

“The last thing people worry about is adjusting the lighting in a room to their needs. If the lighting can make that adjustment, it can enhance the well-being of people and so optimize their productivity.”

The productivity benefit could apply in countless settings. Color-tuned lighting could improve performance in schools, offices, manufacturing plants, and just about anywhere people work. Athletes can use color-tunable light to reduce jet lag during road trips. Neither is the benefit restricted to humans: lighting systems could read the health and age of a plant, as well as the phase of the growing season, and then automatically tune the light to optimize growth and productivity.

Information at light speed.

“We are running out of radio frequency bandwidth for the wireless internet,” Karlicek observed. “So we are looking at light-based communication, which is more regulated and so has almost infinite bandwidth.”

It’s hard to imagine the full range of possibilities. Take the indoor GPS, which you will appreciate if you have ever tried to find a loved one in the hospital, or the housewares aisle in your local big-box store. Low-frequency light wavelengths transmit data to a GPS unit, pinpointing key locations and enabling people to move through buildings more efficiently.

A corollary of this application may be even more important. Through time-of-flight sensing, a smart lighting system could identify objects—their size, their distance, and other factors—based on the time it takes for the light to return to the source. Such a design could be used to highlight unsafe situations in their living surroundings, or even alert staff at senior living facilities when a resident has fallen. On a similar front, smart lighting systems could also detect the presence of biohazards in a room by sending out a UV pulse to search for contamination when the lighting system knows that the room is not occupied.

When lighting systems can see where their photons are going and sense changes in their environment, they will be able to connect to other smart systems—smart watches with biofeedback, smart thermostats and home security systems, and others. This connectivity will open a wide range of new services and features to improve comfort, safety, and quality of life.
Meanwhile, the combination of video and smart lighting has already increased well-being in a clinical setting. “New regulations require the presence of windows in ICUs, but many ICUs have no opening to the outdoors,” explained Partha Dutta, the ERC’s deputy director and also a professor of ECSE. “So we stationed a camera on the roof of St. Peter’s Hospital (in Albany) and transmitted a ‘virtual window’ into their ICU (shown above). The surrounding lighting adjusts automatically as the outside light changes.” This helps patients orient to the external world, which has been shown to shorten their hospital stays and accelerate their recovery at home.

On the Global Stage

Industry is beginning to take note of this research. Such companies as Philips, GE Lighting, Osram Sylvania, Dow Corning, Seoul Viosys, and Acuity have signed on as members of the ERC. Their interest, and that of other industry leaders, reinforces Karlicek’s assertion that “smart lighting is attracting a lot of attention, and we are starting to carve out a global leadership position as to what smart lighting is going to be.”

And what precisely will it be when all is said and done? ERC researchers address that question with some a very basic question of their own. “Our purpose, in a nutshell, is to look at all the possible benefits of smart lighting—for energy efficiency, for information technology, for the human factor—and determine evolutionary endpoints for our research. In other words, what valuable things can we make lighting systems do that they don’t do now?”

No matter how quickly smart lighting research proceeds, someone is going to have to keep it going for years to come. Hence Illumineering.

Researchers at Rensselaer have created the Illumineering curriculum to prepare both undergraduates and graduate students for careers in smart lighting. The webinar-based format includes content from a wide array of disciplines: not just engineering and science, but also architecture, health, business, and the social sciences. A modular approach allows industry partners and others to add their own contributions, providing “real world” knowledge for students.

According to ERC director Bob Karlicek, Illumineering addresses a significant gap in engineering education. “Believe it or not, many engineering students don’t even know what a lumen is,” he said. “This kind of curriculum can expose them to a promising range of knowledge and career opportunities that they may never have heard of before.”

There should be interest on the Rensselaer campus, if student activities are any indication. The Smart Lighting Sustainability Club brings together a multidisciplinary group of undergraduates who collaborate with Rensselaer’s facilities directors to identify possible lighting improvements on campus. Club members have been involved in several redesign projects, which (in addition to the gains in energy efficiency) provide needed exposure to the first wave of solid state lighting.
“Our work involves the creation of immersive virtual environments to help surgeons gain and sustain proficiency in various procedures, while coping with all the stressors and distractions one would face in the live operating theatre. It is, in essence, a virtual replication of the OR.”

Suvarnu De, director of the Rensselaer Center for Modeling, Simulation and Imaging in Medicine (CeMSIM)

If you’re going in for surgery next week, you may want to skip the next two paragraphs.

According to a recent estimate in the Journal of Patient Safety, up to 440,000 people die in the hospital every year from preventable medical errors—the rough equivalent of three Boeing 777s crashing each day. Some of those errors happen in surgery. The reasons vary: a dearth of training in specific procedures, psychomotor and cognitive missteps, the distractions and stresses that pervade every operating room in the world, and others.

“All machines make errors,” said Suvarnu De, director of the Rensselaer Center for Modeling, Simulation and Imaging in Medicine (CeMSIM). “We humans are much more complex than the most sophisticated machines. So, even though surgeons are trained to reduce errors, errors do occur. In a multitasking environment such as surgery, increased attentional overlap increases the chances of error. The key to the next generation super-surgeon is significant reduction in surgical errors.”

To achieve that goal, De and other CeMSIM researchers have leveraged virtual reality to develop immersive environments. The research has the potential to make an impact on one of this century’s Grand Engineering Challenges, as defined by the National Academy of Engineering (NAE).

Addressing an Urgent Need

Conditions within the surgical profession have made virtual surgery invaluable. Some widely used procedures require little or no special certification. Residents, no longer allowed to work unlimited hours, do not get as much exposure to as many situations as they may need. Surgical procedures themselves are not standardized and may lack built-in safety measures.

All of this highlights the urgent need for surgeons to practice techniques without any risk to patients. Surgery simulations are one solution, yet to date most simulators have focused solely on hand movements and motor skills. De’s research looks at a much bigger picture—the entire operating room (OR) environment.

“Our work involves the creation of immersive virtual environments to help surgeons gain and sustain proficiency in various procedures, while coping with all the stressors and distractions one would face in the live operating theatre,” De said. “It is, in essence, a virtual replication of the OR.”
Virtual worlds could make surgery far safer—and do much more besides

**Building Proficiency in Common Procedures**

That mission has led CeMSIM’s research into a wealth of overlapping directions:

- **Intubation** occurs anytime general anesthesia is part of the procedure—yet anesthesiologists have very little opportunity to attain proficiency outside of the patient-centric apprenticeship model. For a difficult airway situation, “If intubation is not done quickly and accurately, the patient dies,” De said. For this reason, De’s lab is developing a totally immersive virtual environment for honing intubation skills, in which fundamental variations in the virtual patient’s anatomy may be introduced to present users with complex intubation scenarios.

- The **Fundamentals of Laparoscopic Surgery (FLS)** comprises a few basic procedures that all surgeons must know and be proficient in to be Board-certified in surgery. The current evaluation process, though, can be cumbersome and provides little feedback. In response, De and colleagues are developing the VBLaST (Virtual Basic Laparoscopic Skill Trainer), which enables surgeons to hone their skills and receive instant feedback. Ongoing large-scale multi-center trials have shown the effectiveness of this system compared with conventional evaluation.

- **Electrosurgery** allows for more precise dissection than traditional scalpels and eliminates bleeding during incision. The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) has developed an online didactic program on the Fundamental Use of Surgical EnergyTM (FUSE)—but the key word is didactic. “There is no hands-on component of FUSE that allows the surgeon to understand the consequence of using electrosurgical tools,” De said, “so SAGES asked us to develop a virtual simulation tool.” In VEST (Virtual Electrosurgical Skill Trainer), surgeons don 3D glasses to bring a 2D simulation to life.

- Since endoscopy has become a widespread approach to surgery, many have wondered whether even the outside instruments used in the procedure might be eliminated entirely. In natural orifice translumenal endoscopic surgery (NOTES), as the name implies, every aspect of surgery takes place within the body cavity in question—requiring at most one small incision in the umbilicus. This led De to the invention of a virtual environment to simulate such procedures. The NOTES simulation uses cognitive task analysis to divide each step into very small substeps, enabling surgeons to pinpoint and work on specific areas for improvement.

Many brain surgeries require exquisite control and immense concentration, in addition to technical mastery. Surgical treatment of arteriovenous malformations is one of the most complex procedures involving brain vasculature. De’s group is working with a company to develop the first simulation system for this surgical procedure.

**Answering the Need for Real-Time Computing**

Virtual surgical environments, by definition, must be interactive on two levels—visual and haptic (touch)—which presents De’s lab with yet another challenge. “For real-time graphics, an update rate of 30 frames per second is adequate,” De explained. “However, a much higher update rate is necessary to provide smooth haptic sensations. This calls for extremely agile algorithms.” To create that agility, CeMSIM has devoted efforts to the development of real-time computational algorithms that, combined with the latest hardware, enable real-time computing on a standard PC.

“Real-time computing enables all of our virtual surgery work,” De said. “In fact, our biggest contributions involve the algorithms to boost simulation speed.”

The software research highlights another aspect of De’s work: it takes words like multidisciplinary and collaborative to new levels. CeMSIM researchers investigate not only medicine, biomedical engineering, and computer science, but also robotics and psychology. And De collaborates with many of the world’s most distinguished research hospitals, medical schools, and associations like SAGES. All these large-scale research activities are supported through multiple research grants from the National Institutes of Health.

**Meeting the NAE Grand Challenge**

Clearly, De’s research could transform the quality of surgery around the world, producing better-trained, more experienced surgeons and a dramatically lower error rate. As invaluable as that contribution is, De has his eye on an even broader goal: enhancing virtual reality in general—one of the 14 Grand Challenges identified by the National Academy of Engineering.

“Enhancing virtual reality is a key to so many aspects of the future,” De said. “Airline pilots already use it to increase their proficiency. I see it extending to training at chemical and nuclear plants, to artists, to any number of industries. Our work, then, is not just for surgery, but to address the Grand Challenge as a whole.”

De knows the scale and complexity of this pursuit, which is why rigor and persistence are integral to his research. To illustrate this during a recent interview, he snatched a tissue from a box on his table and began waving it in the air.

“How precisely does the tissue move? The electrons and protons in the tissue are interacting with each other and resulting in this motion,” De explained. “Nature does this effortlessly. Can you replicate it in a computer in real time? Not now, not ever. If we cannot replicate this simple motion virtually, how can we perfect virtual reality in more complex situations? So we should not be complacent just because we can solve a bunch of advanced partial differential equations on massively parallelized supercomputers. Perhaps the basic language in which mathematics expresses physics needs to transform. The Grand Challenge has been issued, and we must continue to strive toward meeting it.”
No matter how hard you try, you can’t bring a whole levee to campus.

That simple fact illustrates a wider problem that has bedeviled engineering schools for years. Some projects (like fieldwork on a levee or assembly of a full-scale airplane prototype) are simply too big for the average campus, which makes it difficult for students to get the hands-on experience they must have to excel in their discipline.

Tarek Abdoun, Victoria Bennett, and their team have hit upon a novel solution—and the National Science Foundation has taken notice.

The NSF recently recommended funding for the development of Geo Explorer, a “mixed reality and mobile” (MR&M) game that brings students into the field without their ever leaving Troy. The game forms the cornerstone of a hybrid course module that includes actual lab testing, virtual field testing, theoretical system design, and practical experience in the design and virtual inspection of flood protection systems.

“To the best of my knowledge, this idea is unique in geotechnical engineering education,” said Abdoun, the Thomas Iovino Chaired Professor in Civil and Environmental Engineering, who also serves as Associate Dean for Research and Graduate Programs. “It’s more comprehensive and more integrated than previous attempts at MR&M. We believe it can overcome the long-standing logistical barriers to student fieldwork and practical training in college.”

Geo Explorer puts students through every step of field testing, from locating the site to inspecting the levees and assessing their health. Students use their mobile devices to play the game, downloading field data, receiving messages from game characters, and collaborating with their classmates.

That is the mobile part of mixed reality and mobile. For the reality part, students use pre-arranged soil samples for physical testing in the lab, then upload the results to the game.

Geo Explorer is easily adaptable to all facets of the course experience. “Students’ homework would be in the game environment; if they complete the corresponding mission in the game, they’ve done their homework,” Abdoun said. “We can complement the homework with in-class simulations. Students could engage the game in teams, with each taking a specific role.”

Engineering students are not the only people who could benefit from Geo Explorer. According to the project summary, a demo version of the game will be released for use at the New York State Museum and in an elementary school with a high percentage of students in underrepresented groups. Bennett will also coordinate gaming sessions in a free academic summer program for middle schoolers.

The impact of the project—reaching so many age and experience groups with such a novel idea—could reverberate throughout geotechnical engineering education, and well beyond. “The proposed game has the potential to transform the way we teach geotech,” Abdoun wrote. “Ultimately, the use of MR&M games should result in a better trained, globally minded workforce.”

The project builds on game modules developed by Deltares, an independent institute for applied research in the field of water, subsurface, and infrastructure. Abdoun and Bennett’s partners include Casper Harteveld (Northeastern University), Usama El Shamy (Southern Methodist University), Flora McMartin (Broad-based Knowledge, LLC), and Joseph Tront (Virginia Tech). Geo Explorer will be initially aligned with the learning outcomes associated with courses at Rensselaer and SMU, after which it will be adapted for courses at Manhattan College and California State University, Fullerton.
OMNI-TOMOGRAPHY: ONE CONCEPT FOR EVERYTHING

A pioneer in medical imaging pursues his field’s holy grail

Ge Wang, John A. Clark and Edward T. Crossan Chaired Professor of Engineering
Engineers are often reluctant to use the word breakthrough.

It smacks of marketing hype. Most advances in engineering are incremental. The history of technology is littered with self-proclaimed breakthroughs that turned out less than spectacular.

But believe this: Ge Wang is in pursuit of a breakthrough.

Wang’s major field of research, medical imaging, features an array of technologies: CT, MRI, positron emission tomography (PET), and others. Each is invaluable for certain aspects of healthcare. Each has substantial limitations. “If we could combine all these modalities in one unit, and capture all data in one scan,” noted Wang, “we could do much better imaging than what we can today.”

Until recently, that was a big if — too big for serious consideration. But it is precisely what Wang is pursuing.

Cracking the Interior Problem

Breakthroughs are not new for Wang, who came to Rensselaer as the John A. Clark and Edward T. Crossan Chaired Professor of Engineering in 2013. He and his colleagues introduced the field of bioluminescence tomography in 2004. Their resolution of the debate over fan-beam spiral CT technology (vs. traditional “step-and-shoot” CT imaging) drove its rise to prominence as the dominant paradigm. Most notably, in 1991, Wang was the lead author of the first papers on the algorithms for spiral (helical) cone-beam CT imaging — the technology that, today, enables 100 million CT scans every year in hospitals worldwide.

Even with these advances, CT imaging still faced a stiff challenge with the enigmatic name of “the interior problem.” Traditional CT methods could not circumvent the problem, the root of which is data truncation — a loss of desirable global perspectives about local regions of interest (ROI) that are the focus of most medical investigations. The missing nonlocal data often result in images that are far less than perfect. As Wang wrote in a paper with his research partner, Hengyong Yu, in 2012, “When a traditional CT algorithm is applied for local reconstruction [of the image] from truncated data, quantitative accuracy is lost in a reconstructed image, compromising its diagnostic value significantly.”

The interior problem had baffled people for decades. Some researchers tried to solve it with beams targeted to the ROI, but their algorithms fell short in significant ways: providing only approximate reconstructions of the ROI, or capturing only significant boundaries in the image. Wang and his collaborators set to work on an entirely different solution: interior tomography for the theoretically exact, practically accurate CT imaging of an ROI using only data that directly involve the ROI. The breakthrough was made possible via rigorous analysis and novel utilization of general knowledge on images (for instance, the fact that images are piecewise-regular as described by polynomials).

The advantages would be great. “Interior tomography allows an exact reconstruction from less data,” they wrote. “Less data are equivalent to lower radiation dose…. Interior tomography allows a smaller detector size, a faster frame rate and more imaging chains in a gantry space, all of which contribute to an accelerated data acquisition process.” The shorter the data acquisition takes, the better the time resolution will be, which is important for cardiac imaging, image-guided intervention, and other applications. Interior tomography also enables scanning of large objects or samples, which is critically important in such areas as X-ray phase contrast imaging and industrial non-destructive evaluation.

Making the Next Leap

But Wang and his collaborators had even more in mind. In a paper entitled “Towards Omni-tomography,” which appeared on PLoS ONE in 2012, they boldly extended the application of interior tomography from CT to the entire sweep of imaging modalities, introducing the general interior tomography principle and setting the stage for what they called “the holy grail of biomedical imaging”—the integration of multiple major tomographic scanners into a single gantry. “In this vision, one machine could provide all data to image cardiac and stroke damage, capture elusive functions and structures, and guide complex surgical procedures, among many other applications where traditional imaging modalities are insufficient.”

“We leapt from special interior tomography, involving CT only, to general interior tomography,” Wang explained. “It is, in a small way, analogous to Einstein’s special and general theories of relativity. That comparison speaks to how important omni-tomography could potentially be for the field of medical imaging. It is our grand unified theory.”

From Theory to Reality

Since their initial work on interior tomography in 2007, Wang’s team has been striving to turn the theory of omni-tomography into reality. A new goal of his lab is to explore multi-physics interactions in the omni-tomography framework. In one related project, his students are investigating whether X-ray excited nanophosphors could alter parameters observable by an MRI scanner. Wang hopes that omni-tomography will be not only important for simultaneous imaging in complementary mechanisms (such as CT-
MRI, CT-PET, and CT-SPECT) but also necessary for novel information from physical interactions.

If Wang has his way, this research will result in a prototype—and he is already working on it. Among other possibilities, he has developed a proposal to build a combined CT-MRI scanner, using the notion of omni-tomography on a small scale. The first use of such a machine will likely capture images of animals.

Wang’s contributions have received a great deal of attention from leaders in the imaging field. “Present-day hybrid or combined imaging modalities such as SPECT/CT, PET/CT, and PET/MR continue to show promise in providing information that influence patient management. Though combined, these imaging tests are acquired sequentially, which poses unique challenges,” noted Mannudeep Kalra, MD, a professor at Harvard Medical School and a radiologist with Massachusetts General Hospital. “As a clinical radiologist, I believe that omni-tomography will revolutionize radiology as a one-stop and one-shop imaging equipment. In my opinion, development of omni-tomography will impact diagnostic workup in both urgent and non-urgent situations, spanning from coronary artery diseases and strokes to liver diseases and musculoskeletal ailments.

From a technical perspective, the prospect of substantial radiation dose reduction for CT and significant time reduction for MRI with omni-tomography are groundbreaking.”

In other words, Wang is pursuing a breakthrough. And it may not be far off.

**Breakthroughs are not new for Wang...he and his colleagues introduced the field of bioluminescence tomography in 2004.**
“Right from the get-go, we were interested in fabricating human skin that could potentially be used as grafts in humans,” said Pankaj Karande, associate professor of chemical and biological engineering at Rensselaer. “Printed human skin has the potential to be significantly better than either donor skin or conventional models that use manual methods to mix cells and proteins.”

Karande and his research partner, Guohao Dai in Rensselaer’s Department of Biomedical Engineering, built their work on recent advances in 3D printing, including several proofs of concept involving the printing of human tissue. Together, they have optimized the printing parameters and biological factors to create living tissue that mimics in vivo human skin as closely as possible.

Better than the Original?
In some ways, it is better than in vivo human skin. Take its flexibility for skin grafts. “The skin fabricated with our approach is very good at retaining its form and structure,” Karande explained. “This is extremely important for its use in grafts. Current donor grafts and tissue-engineered skin grafts shrink upon grafting. The resulting scars at the graft margins are aesthetically undesirable but more importantly can limit functional mobility if the grafts are at joints such as elbows and knees.”
Consider also the fact that the printed tissue is, well, more than skin deep. “Current grafts available for skin wound healing and reconstruction are quite simplistic in that they try to re-create only the superficial skin tissue,” Karande said. “For a graft to survive on the host, it must have the blood vasculature available to it to supply nutrients and other essential ingredients.” Fortunately, Dai’s team has succeeded in printing blood vessels that not only channel blood flow but also cue the formation of new blood vessels—a key to the survival of the skin after grafting.

And then, as with any organ transplant, there is the high risk of rejection by the host. In a partnership with experts at the University of Pennsylvania, Karande is working to use stem cells from patients to create a “fully vascularized, full thickness, entirely autologous human skin graft.” Since the stem cells come from the patient, the chances of rejection by the patient’s immune system are generally lower.

From Immune Cells to Animal Testing and Beyond

For Karande’s lab, the next steps involve adding even more elements of natural human skin. Their attempt to incorporate hair follicles, for instance, addresses a challenge that has baffled researchers yet holds great promise for the aesthetics market. “Current strategies can be significantly improved upon,” Karande said. “There are many hurdles to overcome before this can be realized!”

Even more exciting, for Karande, is the incorporation of immune cells. “The skin is a rich immune organ and, as such, can be an interface for vaccination,” he noted. “This is why topical vaccines have always held great promise. But development has been slow since no one has been able to develop a relevant skin platform for testing that captures the immunology of the skin. If we can incorporate immune cells into printed skin, it will greatly accelerate the development of topical vaccines—with a potentially huge impact in epidemics and threats posed by infectious biological agents in bioterrorism incidents.”

The impact of printed human skin may be a boon for other species as well. Ethical concerns over animal testing have led to the investigation of other methods for evaluating various compounds. The reproduction of human skin could potentially lead to a “human on a chip” platform that would not only dispense with the use of animals, but also provide a platform more relevant to human physiology.

Though this may sound far off, Karande believes it is closer than we might think. “I envision that 3D fabrication of human tissues and organs will happen within our lifetimes,” he said. “This will be a significant step forward for organ transplants. Currently there is a large gap between organs needed for transplantation and available donors. It has unfortunately spawned illicit organ trade in developing nations. We hope that our work is a small step for a bigger humanitarian cause.”

The research of Guohao Dai looms large in the effort to fabricate human skin. Dai’s team has succeeded in printing blood vessels that not only channel blood flow but also cue the formation of new blood vessels—a key to the survival of the fabricated skin after grafting.
About Nancy DeLoye Fitzroy ’49

Nancy DeLoye Fitzroy was born in Pittsfield, Massachusetts, the youngest daughter of Jules Emile DeLoye and Mabel Burr DeLoye. Her father was a contractor and had a natural talent in the physical world. He made gliders at home and flew them from local hilltops and both he and Nancy’s mother encouraged her to excel in whatever she chose to do. Her first ‘engineering’ task was to build a record player from available parts. She became the first female student to study chemical engineering at Rensselaer and received her undergraduate degree in chemical engineering from Rensselaer in 1949. As a student, Nancy established the Rensselaer chapter of the Society of Women Engineers and served as secretary of the American Institute of Chemical Engineers. She was a member of RPI Players and Radio Players.

In 1950 Dr. Fitzroy was hired by Knolls Atomic Power Laboratory as an assistant engineer with the heat transfer group. In 1952, she became a development engineer for GE, initially working on the Hermes Missile Program and designing heat transfer surfaces for nuclear reactor cores. At GE, Dr. Fitzroy worked in a number of engineering and management capacities. Early in her career she was among the first engineers to work on the design of heat transfer surfaces in nuclear reactor cores. Subsequently she worked in corporate research and development where she consulted on technical problems in the field of heat transfer in gas turbines, space satellites, and other GE products. She remained with GE for thirty-seven years and retired in 1987.

In honor of one of Rensselaer’s most accomplished, active, and loyal alumni, Clarence E. Davies ’14, Rensselaer Polytechnic Institute established the Davies Medal for Engineering Achievement. On May 5, 2014, Dr. Nancy Deloye Fitzroy ’49 received the Davies Medal for her vision, leadership, and achievements in engineering that contributed considerably to the development of technology in heat transfer and its applications and her service as a strong voice for women in engineering which continues to have a profound impact today.
Dr. Fitzroy is considered a pioneer in mechanical engineering. She is the holder of several patents, author of more than 100 technical papers, and author of a handbook on heat transfer and fluid flow.

Dr. Fitzroy built a distinguished career at GE and her status as a national role model inspired younger generations of women to enter the engineering profession. Throughout her career she was active in professional societies and was the first woman to head a major national engineering society, the American Society of Mechanical Engineers, serving as president from 1986 to 1987. Nancy Fitzroy was elected a member of the National Academy of Engineering in 1995, is a member of the American Institute of Engineers, National Society of Professional Engineers, American Association of Engineering Societies (governor, 1987-89), Society of Women Engineers (honorary life member, chair 1972-73), Engineering Foundation of America, Whirly Girls (women helicopter pilots), Ninety-Nines (women pilots, president 1974-75), and the American Helicopter Society. In 2008, ASME honored the achievements of Dr. Fitzroy with an honorary membership. Dr. Fitzroy is an honorary fellow of the British Institute of Mechanical Engineering, the first woman to receive this honor; a fellow of the American Institute of Chemical Engineers, and is included in the Biographical Compendia: Smithsonian Institute and National Air and Space Museum. Dr. Fitzroy is a registered professional engineer in New York State.

Nancy met Roland Victor Fitzroy, a 1943 graduate of Union College, while working at GE and they were married in 1951. Roland Fitzroy served in the U.S. Army where he was selected for technical roles with the Manhattan Engineer District, the secret project that produced the first atomic bomb. His assignments included undercover espionage work, for which the Veteran's Administration recently conducted filmed interviews of Mr. Fitzroy's counterintelligence activities for historical documentaries. Mr. Fitzroy also had a distinguished 41-year career at GE, highlighted by the design of one of the nation's first inertial guidance systems for guided missiles. From 1946 to 1956, he was with the Project Hermes Guided Missile Division, and from 1956 to 1960 with the Propellant Utilization Project in the Rocket Engine Department. In 1960 he joined the Control Drive Mechanisms group at the Knolls Atomic Power Laboratory, where he teamed in the design and development of nuclear reactor operating components for various naval nuclear powered submarines. He retired in 1987.

Nancy and Roland both enjoyed flying. Roland piloted his own Cessna-310 “Nancy’s Fancy”, and Nancy is considered to be one of the first female helicopter pilots. Nancy also enjoys travelling, sailing, and skiing.

Dr. Fitzroy is considered a pioneer in mechanical engineering. She is the holder of several patents, author of more than 100 technical papers, and author of a handbook on heat transfer and fluid flow. Her contributions in the heat transfer field have led to improvements in: space reentry vehicles (heat shields, rocket engines (fuel use), nuclear submarines (cooling systems and shielding, nuclear reactors (cooling and shielding, household appliances (including electric motors), steam and gas turbines (electric power generation), and heat transfer physics. A natural role model for women in engineering, Fitzroy has been an active participant in activities designed to encourage women to seek careers in the profession.

At Rensselaer Dr. Fitzroy established the Nancy DeLoye Fitzroy ‘49 Scholarship, a fellowship awarded with first preference to a female graduate student pursuing an engineering degree at Rensselaer, and the Nancy and Roland Fitzroy Professor of Engineering faculty chair. She is a member of the Palmer C. Ricketts Society of Patroons.

In 1990, Rensselaer awarded her an honorary degree, a doctorate in engineering. She received an honorary degree, a doctor of science, from the New Jersey Institute of Technology in 1987.

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PAST RECIPIENTS

| Richard J. Bouchard ’58 | Walter H. Stowell Jr. ’59 |
| Frank D. Judge ’54 | Stephen E. Harris ’59 |
| Melvin L. Cohen ’65 | Sheldon Weinbaum ’59 |
| Thomas H. Lee ’54 | John E. Kelly III ’78 |
| Kenneth A. DeGhetto ’50 | James Mitchell ’51 |
| Van C. S. Mow ’62 | Martin Weinstein ’57 |
| Anthony J. DeMaria ’60 | Steven J. Sisson ’72 |
| Allan L. Rayfield ’65 | Marcian E. Hoff Jr. ’58 |
| Nicholas M. Donofrio ’67 | Hugo S. Ferguson ’56 |

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The prestigious Faculty Early Career Development Award (CAREER) from the National Science Foundation (NSF) 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.

Guohao Dai, Assistant Professor in Biomedical Engineering

Dai’s CAREER award of $440,000 is for the proposal ‘‘A Functional 3-D Vascular Tissue Engineering Tissue graft to Support Neural Stem Cell Self-Renewal.’’ His work will develop bioengineering technologies to create a functional perfused vascular network and study its interaction with neural stem cells around the vascular niche.

Ying Chen, Assistant Professor in Materials Science and Engineering

Chen’s CAREER award of $540,000 focuses on ‘‘Interface Deformation and Compatibility in Shape Memory Polycrystals,’’ which centers on the study and development of multifunctional ‘‘smart metals’’ known as Shape Memory Alloys (SMAs) informed by leading-edge interface engineering.

Onkar Sahni, Assistant Professor in Mechanical, Aerospace, and Nuclear Engineering

Sahni’s CAREER award of almost $500,000 is titled ‘‘Software Abstractions for Stochastic Embedding in Predictive Simulations on Extreme-Scale Cyberinfrastructure’’ and will investigate novel algorithmic and software elements and abstractions for stochastic embedding.

Johnson Samuel, Assistant Professor in Mechanical, Aerospace, and Nuclear Engineering

Samuel’s CAREER award of almost $400,000 for the project ‘‘Microstructure-Specific Machining Strategies for Bone’’ will investigate the fundamental effect of bone microstructural components on its machining responses.

IN MEMORIAM

Dr. Arthur E. Bergles, a former Dean of Engineering at Rensselaer and a worldwide leader in the area of heat transfer, passed away on March 17, 2014 at the age of 78. Dr. Bergles joined the Rensselaer faculty in 1986 as the Clark and Crossan Professor of Engineering and director of the Heat Transfer Laboratory. He went on to serve as Dean of Engineering from 1989 to 1992. After retiring in 1997, he remained active on the Rensselaer campus as the Clark and Crossan Professor Emeritus.

Prior to joining Rensselaer, Dr. Bergles was a faculty member at his alma mater, the Massachusetts Institute of Technology, where he earned his bachelor’s, master’s, and doctoral degrees. Later, he was on the faculty of the Georgia Institute of Technology and he also served at Iowa State University as chair of the Department of Mechanical Engineering and Anson-Marston Distinguished Professor of Engineering.

Dr. Bergles was recognized as a world leader in heat transfer and thermal science. He published more than 400 research papers, 26 books, and presented more than 400 invited lectures. He received many awards and considerable recognition for his work. Dr. Bergles was elected to the National Academy of Engineering (NAE) in 1992, and as a foreign member of the Royal Society of Mechanical Engineers in 2000.

Active in professional societies, Dr. Bergles was a fellow of the American Society for Engineering Education (ASEE), American Association for the Advancement of Science (AAAS), and American Institute of Chemical Engineers (AIChE), as well as a fellow, honorary member, and past president of the American Society of Mechanical Engineers (ASME). In addition to several honorary professorships and prestigious overseas fellowships, Dr. Bergles received honorary doctorates from the University of Porto in Portugal, Rand Africans University in South Africa, and the University of Rome-Sapienza in Italy.

Dr. Bergles was deeply committed to education and supporting the careers of young scientists. Over his career, he advised 82 thesis students. In honor of his retirement from Rensselaer, the Dr. Arthur E. Bergles Scholarship was established with gifts from friends, faculty, colleagues, and corporations. Additionally, the Bergles-Rohsenow Young Investigator Award in Heat Transfer is presented annually through ASME.
ENGINEERING FACULTY ARE DEEPLY COMMITTED TO THEIR SCHOLARSHIP, TO MENTORING AND GUIDING OUR STUDENTS, AND TO COLLECTIVE EXPLORATION AND DISCOVERY.

HERE ARE RECENT SELECTED FACULTY AWARDS AND NEWS HIGHLIGHTS.

PROMOTIONS

FACULTY PROMOTED TO FULL PROFESSOR

Matthew Oehschlaeger, Department of Mechanical, Aerospace and Nuclear Engineering

FACULTY PROMOTED TO ASSOCIATE PROFESSOR WITH TENURE

Matthew Oehschlaeger, Department of Mechanical, Aerospace and Nuclear Engineering

Mohammed Alnaggar, Assistant Professor

Peter Tessier, Associate Professor, Chemical and Biological Engineering

Xuegang (Jeff) Ban, Civil and Environmental Engineering

Pankaj Karande, Chemical and Biological Engineering

Liping Huang, Materials Science and Engineering

Cynthia Collins, Chemical and Biological Engineering

Yunfeng Shi, Materials Science and Engineering

Patrick Underhill, Chemical and Biological Engineering

CHAIRMED PROFESSORSHIPS

Peter Tessier, Associate Professor, Chemical and Biological Engineering, appointed the Richard Baruch M.D. Career Development Professor

Xie (George) Xu, Professor, Mechanical, Aerospace, and Nuclear Engineering, appointed the Edward E. Hood, Jr. Professor

NEW FACULTY

Civil and Environmental Engineering

Mohammed Alnaggar, Assistant Professor

Shun Uchida, Assistant Professor

Ali Tajer, Assistant Professor

Wencen Wu, Assistant Professor

Electrical, Computer, and Systems Engineering

Industrial and Systems Engineering

Materials Science and Engineering

Mechanical, Aerospace, and Nuclear Engineering

2014 Rensselaer Awards

Bimal Malaviya, Professor, Mechanical, Aerospace, and Nuclear Engineering, received the Rensselaer Alumni Association Outstanding Teaching Award

Michael Podowski, Professor, Mechanical, Aerospace, and Nuclear Engineering, received the Jerome Fischbach ’38 Faculty Travel Award

Johnson Samuel, Assistant Professor, Mechanical, Aerospace, and Nuclear Engineering, received the Class of 1951 Outstanding Teaching Development Grant
Daniel Walczyk, Professor, Mechanical, Aerospace, and Nuclear Engineering, received the 2014 School of Engineering Education Excellence in Assessment and Continual Improvement Award.

Richard Radke, Professor, Electrical, Computer, and Systems Engineering, received a 2014 School of Engineering Classroom Excellence Award.

Catalin Picu, Professor, Mechanical, Aerospace, and Nuclear Engineering, received a 2014 School of Engineering Senior Faculty Research Excellence Award.

Xuegang (Jeff) Ban, Associate Professor, Civil and Environmental Engineering received a 2014 School of Engineering Junior Faculty Research Excellence Award.

Pankaj Karande, Associate Professor, Chemical and Biological Engineering received a 2014 School of Engineering Junior Faculty Research Excellence Award.

Mark S. Shephard, Samuel A. Johnson '37 and Elizabeth C. Johnson Professor of Engineering, Onkar Sahni, Assistant Professor, Assad A. Oberai, Professor, Catalin R. Picu, Professor, and Antoinette M. Maniatty, Professor – all Mechanical, Aerospace, and Nuclear Engineering, received the 2014 School of Engineering Outstanding Team Award for "Development and Delivery of Advanced High Performance Computing Technologies".

David J. Duquette, John Tod Horton '52 Professor of Materials Science Engineering, received the 2014 School of Engineering Outstanding Professor Award.

Robert Hull, Henry Burlage Jr. Professor of Engineering and former head of the Department of Materials Science and Engineering, was named the first director of the Institute’s new Center for Materials, Devices, and Integrated Systems (cMDIS) at Rensselaer.

Linda Schadler, Russell Sage Professor in Materials Science and Engineering and former Associate Dean for Academic Affairs for the School of Engineering, has been named vice provost and dean for undergraduate education at Rensselaer.

Matthew Oehlschlaeger, Professor in Mechanical, Aerospace, and Mechanical Engineering has been named Associate Dean for Academic Affairs for the School of Engineering.

Pawel Keblinski, Professor in Materials Science and Engineering was named head of the Materials Science and Engineering Department.
Wayne Bequette, Professor, Chemical and Biological Engineering, was elected Fellow of the American Institute of Medical and Biological Engineers (AIMBE).

Shekhar Garde, Jack S. and Elaine S. Parker Professor and Dean of Engineering, was elected Fellow of the American Institute of Medical and Biological Engineers (AIMBE) and Fellow of the American Association for the Advancement of Science (AAAS).

Jose E. Holguin-Veras, William Howard Hart Professor, Professor, Civil and Environmental Engineering, Director, Center for Infrastructure, Transportation, and the Environment, was elected Fellow of the American Association for the Advancement of Science (AAAS).

Xie (George) Xu, Edward E. Hood Jr. Professor, Mechanical, Aerospace and Nuclear Engineering, was elected Fellow of the American Association for the Advancement of Science (AAAS).

Ge Wang, John A. Clark and Edward T. Crossan Chaired Professor of Biomedical Engineering was named Fellow of the American Association for the Advancement of Science (AAAS).

Qun (Leo) Wan, Assistant Professor, Biomedical Engineering, received the Basil O’Connor Starter Scholar Research Award from the March of Dimes Foundation and the National Institutes of Health (NIH) Director’s New Innovator Award.

Lucy Zhang, Associate Professor, Mechanical, Aerospace, and Nuclear Engineering, received a Japan Society for the Promotion of Science (JSPS) Fellowship.

Paul Schoch, Associate Professor, Electrical, Computer, and Systems Engineering, received the Woodie Flowers Finalist Award, Tech Valley NY Regional/FIRST Robotics Competition.

Richard Radke, Professor, Electrical, Computer, and Systems Engineering was recognized in ASEE journal Prism as one of 20 Under 40 faculty with demonstrated talent for teaching and real-world research.

Jonathan Dordick, Howard P. Isermann Professor, Chemical and Biological Engineering and Vice President of Research was named Fellow of the National Academy of Inventors (NAI).

Georges Belfort, Institute Professor, Chemical and Biological Engineering, received the Alan S. Michaels Award for Innovation in Membrane Science and Technology awarded by the North American Membrane Society.