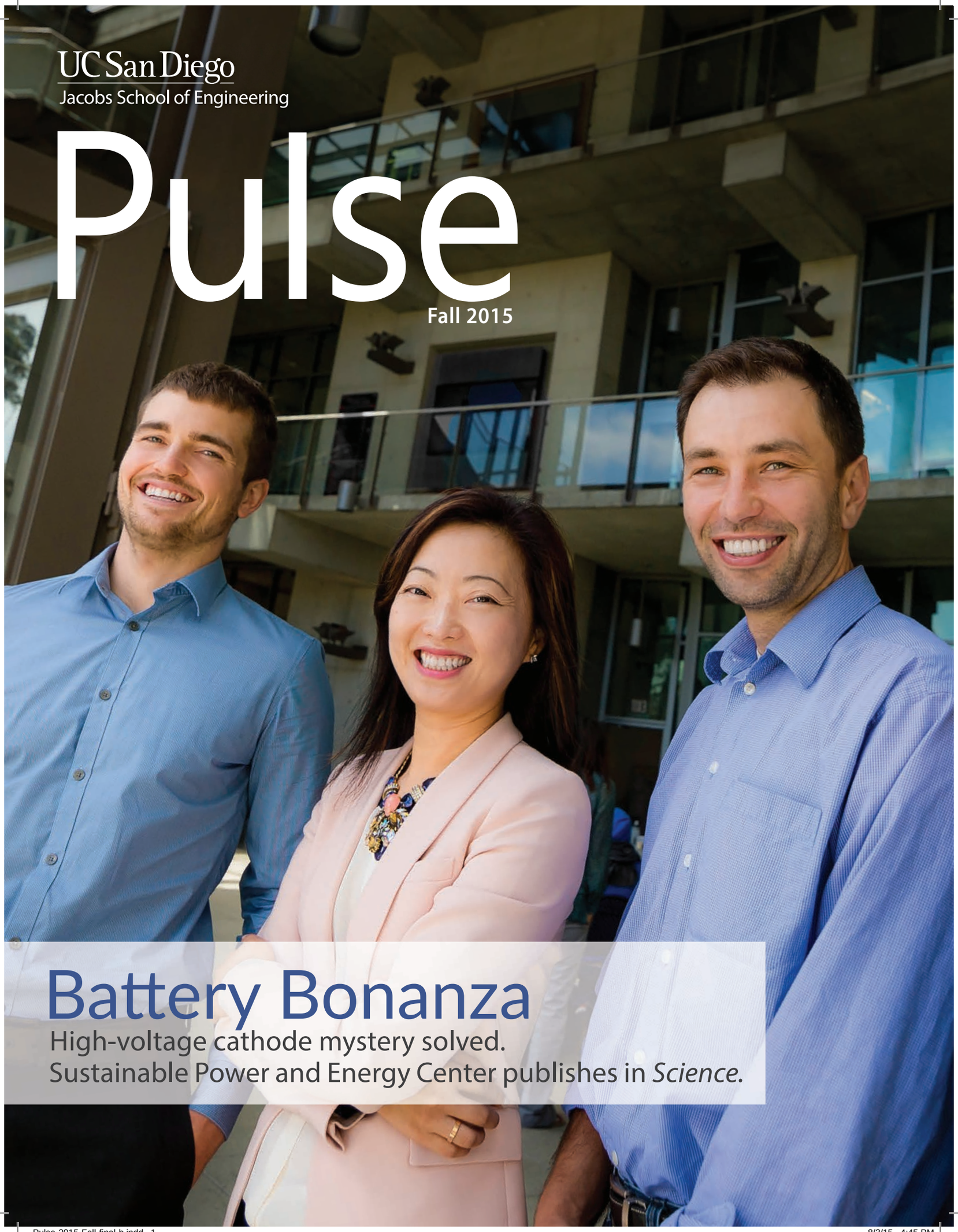
UC San Diego
Jacobs School of Engineering

Pulse

Fall 2015



Battery Bonanza

High-voltage cathode mystery solved.
Sustainable Power and Energy Center publishes in *Science*.

Experience Engineering

I am pleased to announce our new school-wide Experience Engineering Initiative. We will give each of our Jacobs School undergraduate students a hands-on or experiential engineering course or lab each and every year — starting freshman year.

All Jacobs School undergraduates are engineers from day one. Our new hands-on classes serve as "spring training" for future internships and full-time jobs. Early on, we must give our students many opportunities for "a-ha!" moments — experiences that help students generate the confidence and motivation they need to persevere and succeed in classes, internships and ultimately in engineering careers. In their first year, students should feel that they are meant to be engineers. They need experiences that translate into stories for family and friends about the exciting things they designed and built. With the Experience Engineering Initiative, we give our students these opportunities through increasingly difficult real-world challenges that require them to integrate theory and practice. From personal teaching experience, I know that these kinds of hands-on classes propel undergraduates to higher levels of excellence in their coursework, research and internships.

Our first set of pilot courses for the Experience Engineering Initiative launched this past academic year. You can read about two of these great classes on page four of this issue of *Pulse*. During the upcoming academic year, we will roll out more pilot classes and ramp up the number of students in these courses.

The Initiative complements our extensive opportunities for hands-on engineering through student teams, competitions and organizations; service projects; internship programs and more. By practicing hands-on problem-solving inside and outside the classroom, our students learn to integrate engineering theory and practice well before they enter the workforce as interns or new hires.

Experiential classroom education has been important to the Jacobs School for decades, of course. But now, for the first time, we are taking these courses school-wide through a systematic and comprehensive four-year framework. The Initiative aligns with our mission to train tomorrow's technology leaders — individuals who can implement engineering fundamentals in a team environment to solve problems facing society. And that's exactly what we are doing in classrooms and labs across the Jacobs School.

As Dean, my job is to optimize the maximum growth rate of our students' theoretical and practical knowledge. I look forward to sharing our progress on the Experience Engineering Initiative and complementary projects we are developing. As always, you can reach me at DeanPisano@eng.ucsd.edu.

Albert P. Pisano, Dean

Jacobs School of Engineering

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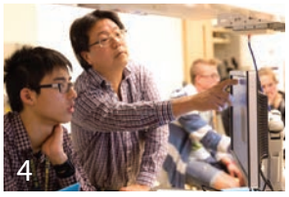
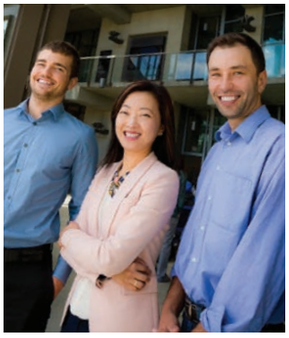




FRONT COVER

What is the secret to high-voltage batteries? Andrew Ulvestad (physics Ph.D. graduate), nanoengineering professor Shirley Meng and physics professor Oleg Shpyrko led a new study that offers an answer to this question (pg. 6).

Cover photo: Erik Jepsen / UC San Diego Publications

BACK COVER

Contextual Robotics Forum, October 30th 2015

BROKEN BONES

Professor Robert Sah with bioengineering students

Fractured and broken ankles can be lots of fun...if you're a bioengineering student. A new pilot course for the Experience Engineering Initiative at the Jacobs School challenges first-year bioengineering majors to problem solve like seasoned engineers.

This spring, first-year bioengineering students produced 3-D printed models of fractured ankles using 2-D images from real patients.

"As it stands, many doctors still use 2-D or paper images to help them decide how a fractured bone should be repaired. Having a 3-D model will enable them to make more accurate decisions," said first-year bioengineering undergraduate Marisa Keller. She was part of a team of engineering students working on a project conceived by bioengineering professor Robert Sah (pictured), a world-leader in cartilage repair and tissue engineering. The students took part in a pilot course for the new Experience Engineering Initiative at the Jacobs School (see Dean's column, pg. 2). The project challenged teams of freshmen to define an ankle fracture based on CT scans of normal, fractured, deformed and degenerate bones. The students generated models of the ankles in the CT scans using a 3-D printer and evaluated the accuracy of their work against the 2-D image.

"I knew the university offered endless research opportunities and a leading education, especially in bioengineering; but I never thought I could have the amount of exposure that the class offered this early on in my academic career," said freshman Julie Yip.

This early access to real engineering challenges is precisely the point of the Experience Engineering Initiative.

"Here at the Jacobs School, we are exceptionally good at instilling in our undergraduates strong engineering fundamentals. We are now more than doubling down on our efforts to pair the fundamentals with the practice of engineering," said Albert P. Pisano, Dean of the Jacobs School. "Engineering is nuanced. When students experience the nuances — the gray areas — they inevitably construct mental frameworks on which to hang the engineering fundamentals that will be coming their way fast and furious."

Other teams from the same pilot course focused on brain-body-machine interfaces and on developing Ebola treatments using limited resources.

Mechanical engineering undergraduates are also part of the pilot phase of Experience Engineering, by way of updated robotics classes.

In spring 2015, students designed and built robots to move items from a staging area into the correct recycling bin.

"Our students are free to print motor mounts, gears, pulleys, ball casters and anything else they can think of," said Daniel Yang, a mechanical engineering graduate student and TA for the class. Early on, one group chose to print a modified motor mount with the hope of increasing the speed at which their robot performed its task.

"The idea came to us while we were solving a linear slider problem on a lecture assignment," said Delta Caraulia, a first-year mechanical engineering major. "We realized that if we modified the width of the part, we could reduce the amount of friction: the wider base better supports the moments in the part and reduces the normal forces and friction in the bearings."

The class is co-taught by mechanical engineering professor Nate Delson, a pioneer in hands-on engineering education, and Michael Tolley, a mechanical engineering professor working on bioinspired robotic systems, including soft and self-folding robots.

IDEA Scholars

The first cohort of IDEA Scholars graduated in June.

Scholars program boosts graduation rates of students historically underrepresented in engineering.

Over the past four years, when the going got tough, bioengineering major Ismael Munoz knew he could always rely on his fellow IDEA Scholars for encouragement and a sense of community. "I see my peers doing crazy awesome projects and that motivates me to excel," he said. "We encourage each other."

Munoz wants to become a neuroscientist and is now well on his way to realizing his dreams. He and 15 of his classmates at the Jacobs School of Engineering were part of the first class of IDEA Scholars. The program is designed to increase retention and graduation rates for students underrepresented in the field of engineering, including low-income and first-generation students, women, and students coming from low-performing school districts and underserved communities.

"We tell them: we're here to see you through to graduation, to help you realize your dream and make it come true," said Michelle Ferrez, director of the IDEA Student Center at the Jacobs School.

Building and maintaining a sense of community is key, according to mechanical engineering professor Olivia Graeve, the incoming faculty director of the IDEA Student Center. "They have the sense that they belong to something bigger than themselves," she said.

When all 16 of the first cohort of IDEA Scholars graduate by summer 2016, the IDEA Scholars program will have retained all but six of the 22 students it started out with. Two of the six remaining students in the program switched from engineering to another STEM major. The other four students are pursuing engineering degrees closer to home.

IDEA Scholars take part in the residential Summer Freshmen PrEP program so that on their first day of classes, they can already see familiar faces among their fellow students. All IDEA Scholars enroll in the ENG 1-3 class series to learn time management, study skills and engineering research methods. They also attend technical workshops on topics such as programming with Python and MATLAB and designing with CAD. Incoming IDEA Scholars are mentored by upperclassmen in the program and give back to the community by getting involved in outreach programs.

The IDEA Scholars program has now grown from 22 to 50 students per year, and the goal is to expand it further. "The model is scalable," said Ferrez.

When undergraduate research, mentorship by faculty and peers, and student-cohort building are combined, overall academic success and engineering student retention rates increase, especially for underrepresented students, first-generation students and women, explained Ferrez.

In addition, these kinds of programs positively impact students' career decisions, including the choice to go to graduate school, she said.

"We look forward to growing our IDEA Scholars Program in order to serve more students, further diversify the engineering talent pipeline and have a greater impact on engineering student retention," said Ferrez.

LEARN MORE: idea.ucsd.edu

Ismael Munoz worked in the lab of bioengineering professor Todd Coleman.

Research centers are transforming the Jacobs School

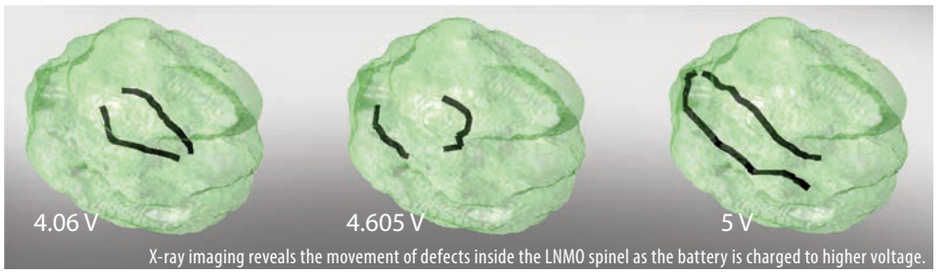
New centers encourage industry, faculty and students to collaborate and innovate to tackle tough problems for the public good.

The Jacobs School of Engineering has launched three new "agile" research centers so far in 2015. This adds up to a total of five new research centers launched at the Jacobs School in the last year and a half. Additional centers are on the way.

Each center builds on existing excellence at the Jacobs School and provides a platform for research collaborations between industry and multidisciplinary engineering teams at UC San Diego. Each center is built around a research vision that addresses big challenges facing society that no individual professor or lab could take on alone.

When faculty work together across disciplines and with industry partners, their students get opportunities to see challenges from multiple perspectives. This helps with their research and prepares them for the engineering work environment.

"A great engineering school is a relevant engineering school. Our faculty are working together like never before to address crucial issues that advance the public good and cannot be tackled by research labs working independently," said Albert P. Pisano, Dean of the Jacobs School. Read about all the new centers here: bit.ly/jacobsresearch



X-ray imaging reveals the movement of defects inside the LNMO spinel as the battery is charged to higher voltage.

X-ray vision looks inside batteries

New study reveals a secret to high-voltage batteries.

Batteries of the future will need to do more than charge faster, last longer and cost less — they will also need to work well at high voltages. This attribute is crucial for batteries used in high-power applications such as electric cars. However, most of today's lithium-ion batteries do not operate above 4.2 Volts because their cathodes cannot survive higher voltage levels. So far, only one cathode material, called an LNMO spinel (a crystalline solid composed of lithium, nickel, manganese and oxygen atoms), is known to function at up to 4.9 Volts. But the reasons for its high-voltage performance have remained a mystery. A team of researchers led by nanoengineers and physicists at UC San Diego recently offered an answer to this question in the journal *Science*.

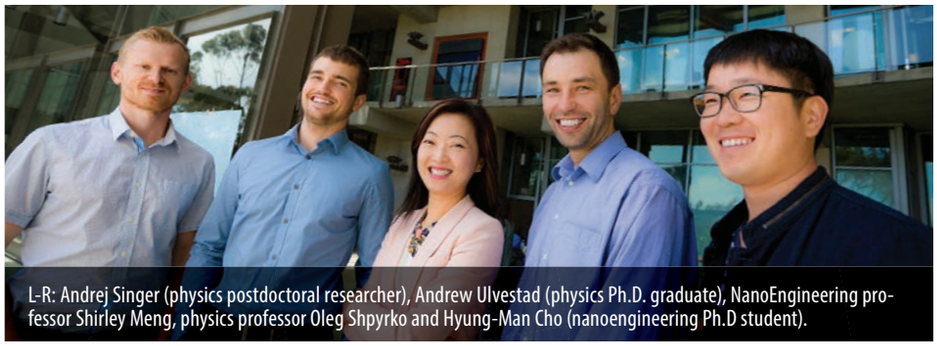
Using a combination of laser-like X-ray beams and novel phase retrieval computer algorithms, the team reconstructed high-resolution 3D images of the LNMO spinel — at the nanoscale level — and watched how the cathode material behaved while it was inside a charging battery. Analyses of the images revealed the movement of defects within the cathode material. The defects are irregularities in the material's otherwise highly ordered atomic structure.

The team discovered that the defects are stationary when the battery is at rest. But when the battery is charged to high voltage, the defects move around within the cathode material. According to the researchers, this is a significant finding because it shows that the LNMO spinel has a unique way of responding to the strain that is induced at high voltage.

"Materials typically respond to strain by cracking. Our experiments show that this material handles strain by moving the defects around while the battery is charging," said nanoengineering professor Shirley Meng, who is also Director of the Sustainable Power and Energy Center (pg. 7). These findings could help battery developers design high-voltage cathodes for lithium-ion batteries.

"From the perspective of a battery materials researcher, this study also points to the exciting possibility of 'defect engineering' for battery materials. This would involve designing new battery materials that have specific 'defects' that improve performance," said Meng.

"These new imaging methods that allow us to look inside the battery — while it is operating in real time — will be important not only for energy storage materials, but also for many other applications, novel materials and devices," said physics professor Oleg Shpyrko.


L-R: Andrej Singer (physics postdoctoral researcher), Andrew Ulvestad (physics Ph.D. graduate), NanoEngineering professor Shirley Meng, physics professor Oleg Shpyrko and Hyung-Man Cho (nanoengineering Ph.D student).

Sustainable Power and Energy Center

SPEC.UCSD.EDU

From theory to microgrid, we innovate.

Better solar panels and wind turbines are important to help ensure a low-carbon future. But they are not enough. The energy from these intermittent sources must be stored, managed, converted and then accessed when it's needed most. And the cost of future battery systems that will do this work needs to drop. This is where the new Sustainable Power and Energy Center comes in.

The Center collaborates across academic disciplines and works directly with industry partners to solve key technical challenges that are holding back distributed-energy storage and generation, as well as accompanying power-management systems. Center researchers just published a breakthrough that could lead to rechargeable batteries that function at record-breaking voltages (see opposite page).

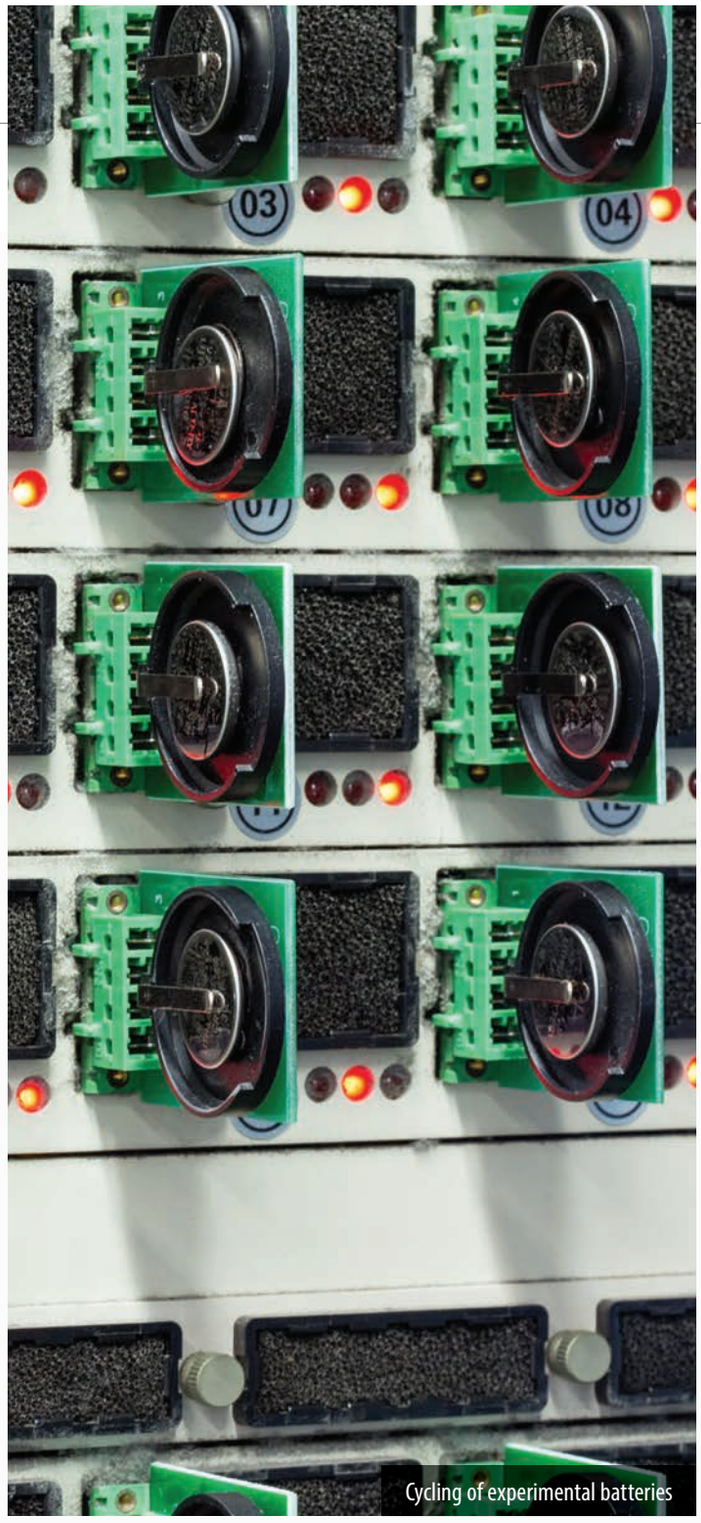
Many industry areas such as electric vehicles, microgrids, photovoltaic panels, wind turbines and wearable sensor devices stand to benefit from the Center's work.

At the same time, the Center trains and mentors students to become tomorrow's workforce for green and advanced energy. UC San Diego's world-renowned microgrid serves as a real-world test bed for the work, which is rooted in thoughtful analyses of the economics of distributed energy.

Interfaces are the "demons" in energy devices

"Devices for energy storage and conversion live and die at materials interfaces, and yet materials behavior at crucial interfaces is often a mystery. Our research teams have developed unique expertise to design, control and characterize energy-materials interfaces like never before. We work from the atomic level up through nano, micro and macroscales. Through the synergy of interfacial science and engineering, we are uniquely positioned to design, predict and characterize what is occurring — sometimes in real time — at key materials interfaces."

— **Shirley Meng, Ph.D.**
Sustainable Power and Energy Center Director



Cycling of experimental batteries

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- THEORY AND COMPUTATION
- MICROGRID TESTING
- MANUFACTURING AND INTEGRATION
- CHARACTERIZATION AND DIAGNOSIS
- SYNTHESIS AND FABRICATION
- ECONOMIC EVALUATION

Center for Visual Computing

VISCOMP.UCSD.EDU

Revolutionizing the way we capture, image and display the visual world.

Researchers at the Center for Visual Computing are researching and developing a future in which photograph-quality images can be rendered instantly on mobile devices. A future in which computers and wearable devices have the ability to see and understand the physical world just as humans do. A future in which real and virtual content merge seamlessly across different platforms.

"Our goal is to make significant, long-term contributions to visual computing and imaging technologies," said Ravi Ramamoorthi, computer science professor and Center director.

The opportunities in robotics, communication, health and medicine, city planning, entertainment, 3-D printing and more are vast — and emerging quickly. To pursue these kinds of research projects, members of the Center bring together computer graphics, augmented and virtual reality, computational imaging and computer vision.

The immersive virtual and augmented-reality test beds at UC San Diego's Qualcomm Institute are an ideal laboratory for the Center's software-intensive work, which extends from the theoretical and computational to 3-D immersion.

It's a very exciting moment to develop research that could make a big impact, explained Center member Zhuowen Tu, a professor in the Department of Cognitive Science. "It's about sensors, data, applications, large-scale computing, representations and machine learning algorithms. We will bring them together like never before."

Unbuilt Courtyard House by Ludwig Mies van der Rohe.
This rendering demonstrates how photon mapping can simulate all types of light scattering.

MOBILE VISUAL COMPUTING AND DIGITAL IMAGING

- New techniques to capture the visual environment via mobile devices
- Improved computational imaging and computer vision in the wild
- Advanced rendering on a variety of mobile platforms

INTERACTIVE (AUGMENTED) DIGITAL REALITY

- Achieving photograph-quality images at interactive frame rates to enable the rendering of digital reality in real time
- Seamless rendering and mixing of real and virtual content in real time

UNDERSTANDING PEOPLE AND THEIR SURROUNDINGS

- Computer vision systems with human level understanding of gestures, scene semantics, activities and groups of people
- Medical, biological and city-planning applications

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CHO Systems Biology Center

CHO.UCSD.EDU

Training next-generation engineers to program cells to make drugs.

Living cells serve as "factories" that churn out more than $140 billion in protein-based drugs annually. These biological factories, especially Chinese hamster ovary (CHO) cell lines, produce pharmaceuticals for people with arthritis, autoimmune diseases and much more.

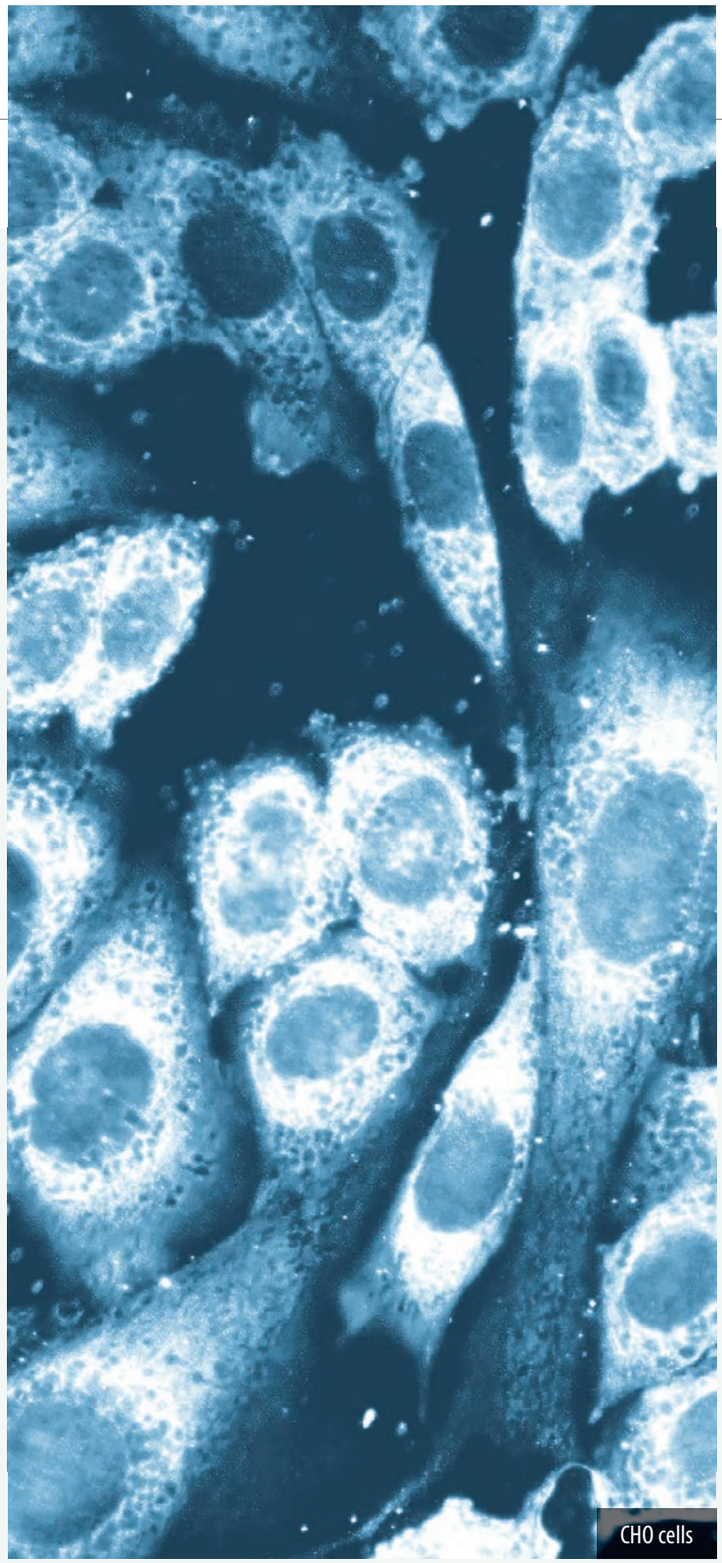
Thanks to recent advances in systems biology and CHO research, including many breakthroughs made at UC San Diego, bioengineers can now control a wide range of properties of these protein-based drugs — properties that determine safety, efficacy and production cost. But there is much more work to do.

The CHO Systems Biology Center partners with industry to train the next generation of cell-line engineers to leverage emerging genomic and systems biology tools to accelerate drug development. The Center also collaborates with industry to develop new resources and techniques that empower the biopharmaceutical industry to engineer and optimize CHO cell lines for drug development.

New Era for Systems Biology

"Here at UC San Diego we are uniquely positioned to train scientists in CHO cell design and expand the CHO cell engineering toolbox. For three decades, CHO cells have been the biopharmaceutical industry workhorse. While the modus operandi for controlling drug quality included randomly screening cells, our research teams at UC San Diego are helping to open an era of rational CHO cell engineering, with the release of CHO genome sequences, systems biology models and CRISPR tools. In the hands of innovative cell engineers trained in big data analytics and systems biology, these tools will enable the design of the next generation of CHO cells."

— **Bernhard Palsson, Ph.D.**
CHO Systems Biology Center Director


CHO cells

Unparalleled CHO Cell Line Resources

- GENOME SEQUENCES AND ANNOTATIONS
- METABOLISM AND GLYCOSYLATION MODELS
- CHO SYSTEMS BIOLOGY INSIDER INFORMATION
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- DEEP OMICS PROFILING OF ENGINEERED CELL LINES

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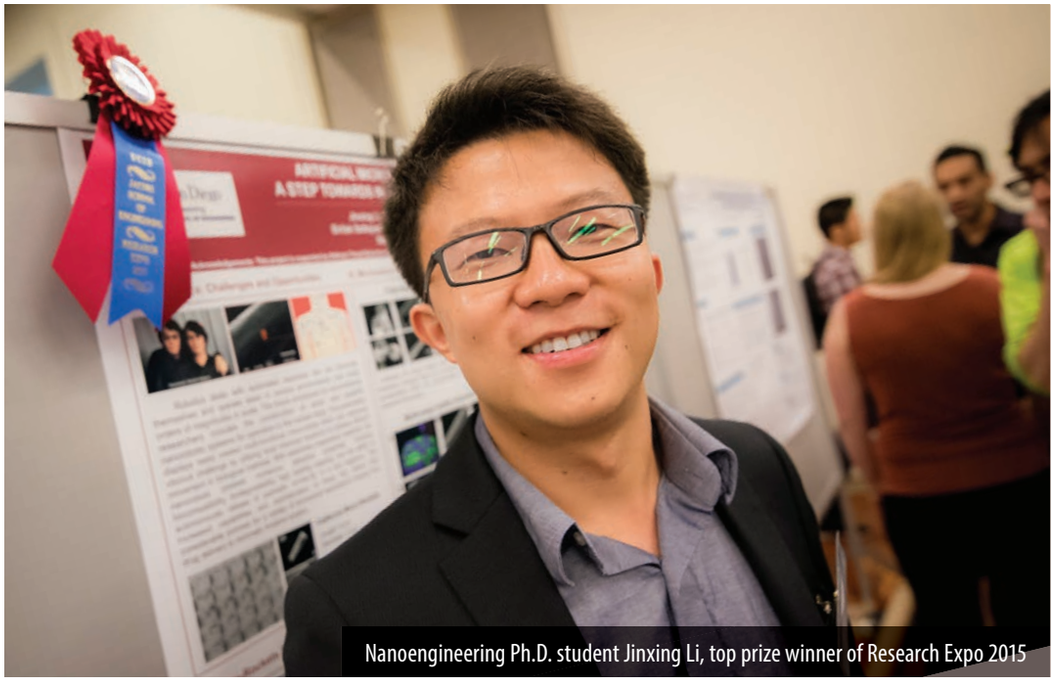
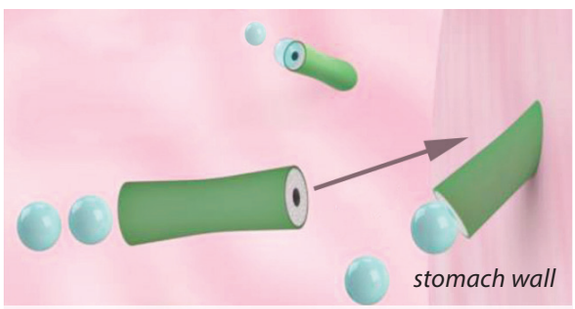

Nanoengineering Ph.D. student Jinxing Li, top prize winner of Research Expo 2015

Motors in a mouse

Micromotors for drug delivery go for a spin.

Tiny motors made primarily of zinc could one day deliver drugs both safely and effectively to specific locations inside the human body. Jacobs School nanoengineering researchers recently demonstrated an important step in this direction — the first published example of artificial micromotors deployed inside a living animal. Jinxing Li, a nanoengineering graduate student at the Jacobs School, won the grand prize at Research Expo 2015 for his research poster on this topic.

The micromotors deliver and release cargo within the stomachs of mice. The key to the movement of these motors lies in their zinc bodies, which react with stomach acid to generate a stream of hydrogen bubbles that propel the motors and enable them to swim around the stomach. In recent experiments, the motors traveled at a speed of 60 micrometers per second for up to three minutes. As an added bonus, the zinc motors are biodegradable. They gradually dissolve in stomach acid, releasing their cargo to the stomach wall and leaving no toxic traces behind.



Micromotors are propelled by hydrogen bubbles and swim to the stomach wall

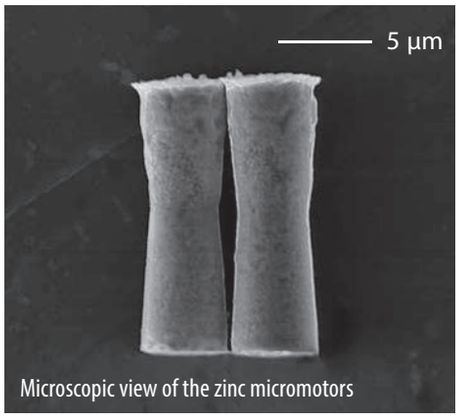
"We have been developing this technology for almost three years and this is the first time we put a nanorobot in a live animal and showed that it could effectively deliver payloads to a particular location," said Li. "This is a very exciting example showing that nanorobots can really work in vivo and benefit health science."

Li is part of a research collaboration between the nanoengineering labs of professor and chair Joseph Wang and professor Liangfang Zhang. The research, which was first published online in December 2014 in the journal *ACS Nano*, has generated global media attention.

This project was just one of more than 200 posters presented at Research Expo 2015. The five other departmental poster winners explored heart tissues on a chip; analyses of social media posts to prevent an increase in HIV infections; a W-band spatial power combiner with potential for millimeter wave imaging and enabling long distance communications among unmanned vehicles; resorbable scaffolds for bone implants; and testing of a new method to retrofit soft-story buildings to make them earthquake safe.

"You need to communicate your knowledge and wisdom to others. If humanity doesn't get behind it, it's not going anywhere." — Albert P. Pisano, Dean of the Jacobs School

During the Research Expo poster session, student presenters are judged on the quality of their work and how well they articulate the significance of their research to society. This dual challenge is a key component of the Jacobs School's mission to develop engineers with both the technical knowledge and leadership to drive tomorrow's innovation economy.



Microscopic view of the zinc micromotors

"There is an important lesson in all of this," said Jacobs School Dean Albert P. Pisano at the event's awards ceremony. "You need to communicate your knowledge and wisdom to others. If humanity doesn't get behind it, it's not going anywhere."

Read about all the winning posters and search poster abstracts online. Save the date: Research Expo 2016 is on April 16.

JacobsSchool.ucsd.edu/re

CWC 5G FORUM

NEXT-GENERATION WIRELESS SYSTEMS & APPLICATIONS

Move over 4G. The next-generation of wireless — 5G — is coming. But first, there is research to be done. UC San Diego is taking a leading role in preparing for the 5G age.

Engineers creating 5G technologies need to be in closer communication with one another and with the developers of future 5G applications.Two recent forums organized by the UC San Diego Center for Wireless Communications addressed these issues. The more recent event brought together experts from academia, industry and government to share insights, best practices and research questions pertaining to wireless systems and applications.

"This is a very unique forum because it gives us an opportunity to have conversations between people who are innovating in applications and people who are innovating in 5G technologies," said Sujit Dey, the director of the Center for Wireless Communications and a professor in the Department of Electrical and Computer Engineering.

Speakers discussed advances in wireless technology that will soon make it possible to download gigabytes of data in a second from our phones, allowing us to watch 3-D video or work and play in the cloud from our devices. 5G will also lead to improvements in augmented reality, industry automation, wearable devices, mission-critical applications including e-health apps, and self-driving cars.

Some of the biggest players in wireless applications and technologies — including more than 100 representatives from UC San Diego, Qualcomm, Nokia, Ericsson, Amazon, Yahoo!, Intel, Samsung, Mitsubishi Electric, Keysight Technologies, Symantec, SiBEAM, Kaiser Permanente and the City of San Diego — attended the two-day forum.

UC San Diego research teams are working on making some of these visions a reality. Electrical and computer engineering professor Gabriel Rebeiz, a leader in phased array technology research, has developed hardware for a new generation of automotive radar systems that Toyota is building into its new autonomous cars. These systems capture high-resolution images of areas approximately 100 meters around a moving car, which is useful for keeping safe distances from other objects.

Rebeiz recently collaborated with TowerJazz on a silicon wafer-scale phased array chip for 5G high-performance wireless communication systems. This array is the first of its kind: it has 256 high-efficiency antenna elements all integrated on the same chip; operates in the 56–65 GHz frequency range; and aims for high-speed communication, defined as greater than a 10-gigabits-per-second peak data rate.

Higher-performance and higher-speed systems for 5G will also require changes in the circuitry of silicon chips found in smartphones and other computing devices. The conventional analog circuitry in today's systems won't cut it, noted electrical and computer engineering professor Ian Galton. He explained that technology for 5G will need new analog circuit blocks that are more digital-like and that use extensive digital calibration. Galton's lab built such a chip that achieves state-of-the-art analog to digital converter (ADC) performance and is much smaller in area than the closest competing ADC.

Achieving high performance in next-generation devices and connections also comes with costs. According to Dey, the mobile networks will leave behind a much larger carbon footprint than wired networks.

"The overall consensus is about 50 to 60 percent of the energy is being consumed by base stations," said Dey. In addition, video and other demanding applications are draining mobile device batteries faster than ever. Dey is leading an effort to save power consumed by the base stations by switching off the antennas from time to time and sometimes leaving them idle. This strategy can also be applied to batteries. Systems can draw power from them in bursts — rather than continuously draining them.

"A challenge with using renewable energy like solar and wind is its intermittent nature," explained Dey. "By matching the energy consumption of the base station with the solar or wind energy generation, we can reduce grid power usage."

MORE INFORMATION ABOUT THE 5G FORUM AT:
5g.ucsd.edu

The 5G Forum encouraged conversations between enabling-technology pioneers and applications developers. (Pictured: electrical engineering professor Gabriel Rebeiz)

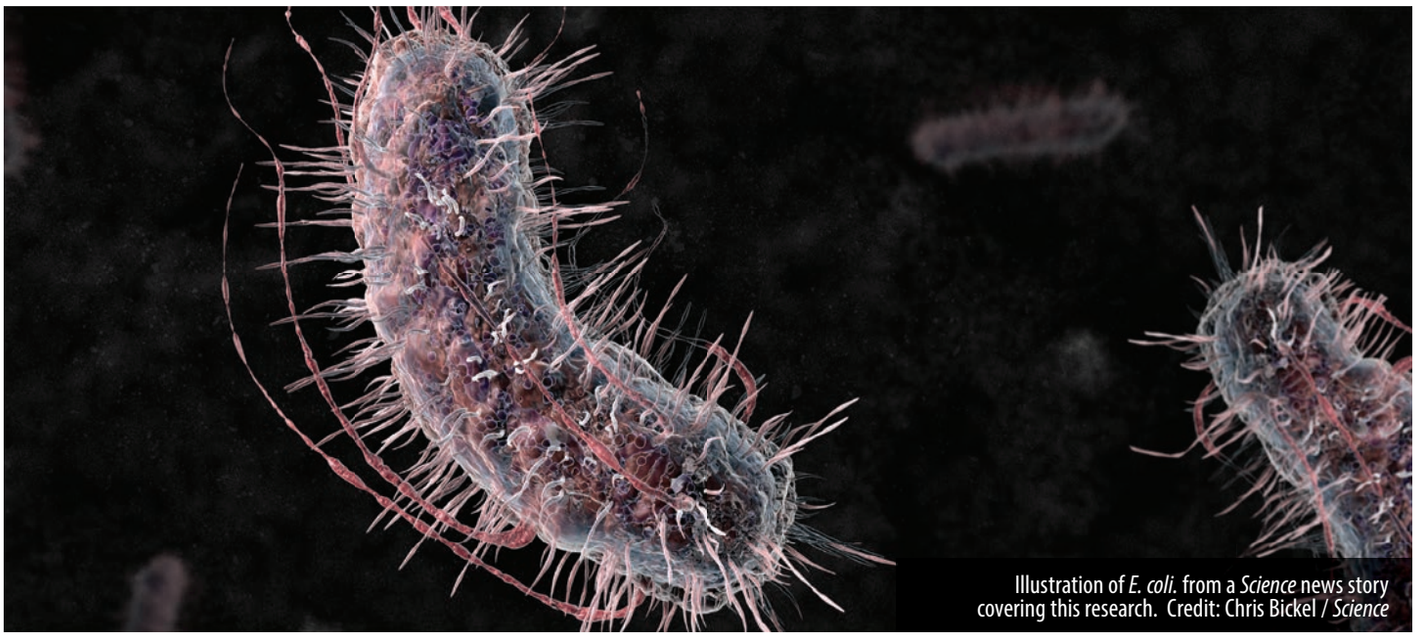


Illustration of *E. coli.* from a *Science* news story covering this research. Credit: Chris Bickel / *Science*

Programming probiotics

Bioengineers program probiotics for early detection of liver cancer metastases.

Scientists at the Jacobs School and the Massachusetts Institute of Technology (MIT) have described a new method for detecting liver cancer metastases in mice. The approach uses over-the-counter probiotics that are genetically programmed to produce signals easily detectable in urine when liver cancer metastases are present. So far, the results indicate that genetically-programmed probiotics may be useful for detecting liver cancer metastases early on in the progression of the disease.

The metastatic spread of cancer is ultimately responsible for 90 percent of all cancer-related deaths, and liver metastases are particularly challenging for clinicians due in part to their small size and multiplicity. If metastases are detected early, patients have a much higher chance of survival. By using probiotics as a platform for early detection of liver metastases in mice, the researchers took advantage of the ability of certain bacteria to pass from the gastrointestinal tract directly into the liver and target tumors. Over the last 100 years or so, scientists have become increasingly aware of bacteria in environments previously thought to be sterile, such as tumors, indicating that bacteria are part of normal human physiology.

"It was discovered in the early 1900s that certain bacteria selectively colonize tumors," said Arthur Prindle, one of two first-authors on the study, who performed this research as a bioengineering Ph.D. student at UC San Diego. "No one knows for sure, but this could be due to the lack of immune surveillance and availability of nutrients inside the tumor — the bacteria can grow freely without the interference of the immune system."

Armed with this knowledge, the researchers set out to develop a simple method for detecting liver metastases using a mouse model for liver cancer and the widely used probiotic bacterium E. coli Nissle 1917 (EcN). This meant shipping off their probiotic to the study's other first author, UC San Diego alumnus Tal Danino at the Koch Institute for Integrative Cancer Research at MIT. The group engineered the bacteria to overexpress a LacZ gene reporter to test the idea that a probiotic taken orally would colonize metastases, something that was only previously demonstrated when bacteria were injected directly into the bloodstream. LacZ is a gene that encodes an enzyme that causes bacteria to appear blue when grown on a medium that contains its substrate. When inside an animal, the product of the enzymatic activity is excreted in urine and causes it to change color. If liver metastases were present, the urine of the mice turned red. UC San Diego bioengineering and biological sciences professor Jeff Hasty expects the new method will enable the detection of liver cancer at an earlier stage, increasing the chances that it will be treated successfully.

"There are multiple reasons to use probiotics in the early detection of cancer," said Hasty. "First, probiotic bacteria are susceptible to antibiotics, which enables their rapid removal from a patient's system once they've done their job. Second, probiotics will do what they do best — grow. That means that patients only need to be given enough probiotic bacteria to ensure that one bacterium arrives at its target location."

The researchers followed these mice for more than a year after oral delivery and found no deleterious health effects.

Tal Danino

Arthur Prindle

Materials science in the Amazon

Materials scientist Marc Meyers has studied everything from the structure of the toucan's beak to abalone shells. Over the years, he has drawn upon the Amazon, its fauna and flora, as a source of inspiration. This past year, he teamed up with engineering alumnus Jeffrey Lehmann for an expedition down the Roosevelt River, named after the American president who almost lost his life exploring it. In 1914, President Theodore Roosevelt co-commanded with Brazilian colonel Candido Rondon the first scientific expedition down the "River of Doubt," the trip bringing the former president to the verge of suicide and his party to near-starvation.

After more than a year of preparation, Meyers and Lehmann readied themselves with GPS and satellite image printouts of the states of Mato Grosso, Amazon and Rondonia, in Brazil. Dubbing their journey The Roosevelt River Centennial Scientific Expedition, in honor of their presidential predecessor, the group included Meyers, Lehmann and two Brazilian army colonels, Hiram and Angonese, with a vast knowledge of the Amazon. Together, the group would spend 23 days on the water, travelling and conducting research through the thickest jungles of the Amazon. Lehmann came back determined to make the river's entire 500 miles a World Heritage Site. He also plans to create a documentary film about his experiences in the Amazon. Col. Hiram already completed a book on the experience, and Meyers as well as Lehmann plan to do the same. Meyers came back with the seeds for a number of research projects (see right column).

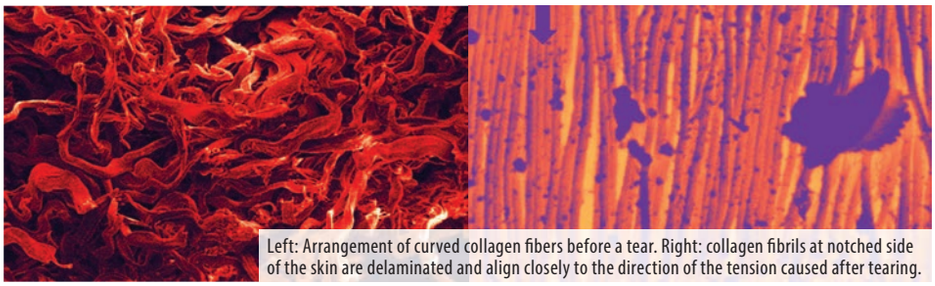
Measuring the piranha's bite

Lab notebook: A few future projects

- **The bite force of the piranha**
  The first scientific measurement of the fish's bite revealed its strength is surprisingly low. Graduate student Vincent Sherman is investigating why.
- **Rocks from Naivete Falls**
  The Amazon is rife with kimberlite, sometimes encasing diamonds. Studying the rock's properties will help determine how its deep channels resist erosion.
- **Structure of curassow feathers**
  Grad student Tarah Sullivan will test the strength of this amazingly light and strong material with SEM.
- **Crack propagation in exploding trees**
  Meyers will study whether these cracks reach the speed of sound, generating a sonic boom.
- **Fish scales**
  The trip yielded specimens of armored catfish, whose scales will be studied for bioinspiration in engineering concepts.

Why is skin so tough?

Engineers explain why skin resists tearing.



Left: Arrangement of curved collagen fibers before a tear. Right: collagen fibrils at notched side of the skin are delaminated and align closely to the direction of the tension caused after tearing.

Skin is remarkably resistant to tearing, even after it has been cut. A team of researchers from the Jacobs School and the Lawrence Berkeley National Laboratory (LBL) have explained why. Using powerful X-ray beams and electron microscopy, researchers made the first direct observations of the micro-scale mechanisms that allow skin to resist tearing. They identified four specific mechanisms in collagen, the main structural protein in skin tissue, that act together to diminish the effects of stress: rotation, straightening, stretching and sliding. "Straightening and stretching allow the uptake of strain without much stress increase, and sliding allows more energy dissipation during inelastic deformation. This reorganization of the fibrils is responsible for blunting the stress at the tips of tears and notches," said materials science professor Marc Meyers, who led the UC San Diego team that included graduate student Vincent Sherman.

"We hope to replicate these mechanisms in synthetic materials to provide increased strength and better resistance to tearing," said Robert Ritchie of LBL, where postdoc Wen Yang played a leading role in the synchroton measurements.

The researchers first established that a tear in the skin does not propagate or induce fracture, unlike other materials such as bone or tooth dentin, which are composed of mineralized collagen fibrils. Instead, the tearing or notching of skin triggers structural changes in the collagen fibrils of the dermis layer to reduce stress concentration. Initially, these collagen fibrils are curvy and highly disordered. In response to a tear, they rearrange themselves in the direction in which the skin is being stressed.

An engineer's journey to innovation

Gioia Messinger highlights the importance of small teams.

Gioia Messinger was 17 when she arrived in the United States from South America. She went on to earn a bachelor's in electrical engineering and a master's in computer engineering at the Jacobs School. For the first five years after graduation, Messinger worked as one of the only female engineers at a number of companies before moving on to a startup, where she was responsible for everything from market research to product launch. Soon after, she decided it was time for a change.

"I had worked with a number of consultants as an engineer, and I decided I wanted to try it," said Messinger. "The startup that I was working with asked me to come back as a consultant. I left on a Friday, and came back on a Monday having started my own business."

As a consultant, Messinger began managing both teams and projects.

"It required a lot of innovation," she said. "Things started shifting in my mind — I wanted to start innovating for myself."

As a result, Messinger's team participated in the development of the first cable modem and later began working with Kaiser Permanente and the Centers for Disease Control and Prevention (CDC) to conduct the largest population study by the CDC to date.

Gioia Messinger

"I came up with the idea to use touchscreen kiosks to collect data from patients," said Messinger. "Around that success, I was on the team that created the Pill Cam, a digital device that can be swallowed to take video and images of the intestines."

Messinger says she realized that innovation happens in pieces. "I always highlight the importance of working in small teams," she said. "I also want people to think about their job as a lifelong investment instead of a two or three year stand. It's critical that you enjoy your job, because innovation takes time."

Currently, Messinger serves as the Founder and CEO of LinkedObjects, a technology and strategy firm specializing in the Internet of Things. Until recently, she served as the founder and CEO of Avaak, Inc. (VueZone) which created simple, beautiful and connected cameras for your home.

Messinger told her story at a Gordon Engineering Leadership Forum at the Jacobs School in February.

Learn more: **bit.ly/gordonleadership**

Alumnus Mike Burton, an avid traveler.

Advice from a Groupon Engineer

Alumnus Mike Burton is Director of Mobile Engineering at Groupon and in charge of an app with 100 million downloads that generates more than half of the company's transactions. He recently talked to us about his career and the lessons he has learned. Excerpts below.

Advice for mid-career professionals: "One thing that has served me really well was getting into open source. I wrote a library for Android programming called RoboGuice and made it open source. It was a pain I encountered in my job and I wanted to solve it. Now Microsoft, Skype, Starbucks and Nike use it."

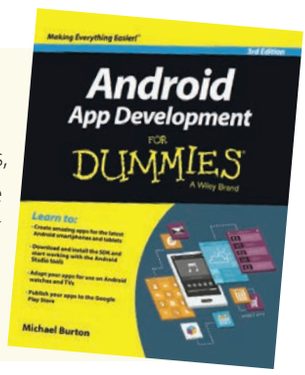
Advice for seniors or recent grads: "I always look for something about our candidates that really makes them stand out. What are they passionate about? What are they driven by? So I look for extracurricular activities, like robotics, captain of the debate team, personal apps they've built, it could be anything, but I look for different ways they demonstrate their passion."

On becoming an expert in Android app development: "I started out with server-side software. But at the same time, smartphones started taking off. The first Android phone had just come out. I knew Java, so this was a natural step for me. We were doing outsourcing contracts for other companies and that's how I got to program the Android apps for Digg, TripIt and OpenTable."

Burton's book

Featuring two sample programs, this book explores everything from the simple basics to advanced aspects of Android application development.

bit.ly/burtonsbook



$2 million gift from alumnus supports computer science undergraduate engineering education

We've all had a favorite teacher. Taner Halicioglu, a Jacobs School alumnus, had his in mind when he gave a $2 million gift to the computer science and engineering department at UC San Diego. The funds will help recruit, retain and support the professors and lecturers whose primary mission is to teach and mentor students.

"I want to give the Department of Computer Science and Engineering at UC San Diego the resources it needs to teach students and the ability to serve as many aspiring students as possible," said Halicioglu. "These teachers truly inspire students."

It was a lecturer who left the greatest impression on Halicioglu when he was an undergraduate majoring in computer science. He graduated from UC San Diego in 1996 with a bachelor of science and a passion for systems and data science. The lecturer was Keith Muller and he was working at ATT Labs while teaching here on campus.

"He always had an anecdote from his work life about why you wanted to know what he was teaching you," Halicioglu recalled. "I remember a good portion of the students stayed after class and talked to him."

Muller, who is now a Fellow and lead architect at Teradata, inspired Halicioglu to come back and teach in the department. Halicioglu currently teaches an undergraduate seminar in computer operations and production engineering, where he imparts some of the wisdom he has gained over the years working in the tech industry. His resume includes stints at eBay, Facebook and Blizzard Entertainment, the popular video game company that created World of Warcraft, StarCraft and Diablo.

The gift comes at a time of tremendous growth for the computer science department, now the largest in the University of California system, with close to 2,200 undergraduates enrolled as of fall 2014. The department is currently ranked 7th in the United States and 11th in the world, according to U.S. News and World Report.

"Today, we are celebrating our ability —thanks to this gift— to make a financial commitment to recognize the educators who engage and inspire our students," said Rajesh Gupta, chair of the Computer Science and Engineering Department at the Jacobs School.

Half of the gift will go to establish UC San Diego's first-ever endowed chair for a teaching professor. This chair is named after computer science Lecturer Emeritus Paul Kube.

The other half will go to attract and retain the best lecturers, allowing them to engage more with students, mentor them and develop new courses and programs. These lecturers build connections with undergraduates in many ways, but especially through the department's tutor program. The department now hires nearly 1,000 tutors every year, and many are returning students who have tutored before. Tutors are stationed in undergraduate labs, where they provide one-on-one and small-group mentoring.

"We are working hard to engage all of our undergraduate computer science and engineering students in hands-on or experiential education, starting in their very first year," said Albert P. Pisano, Dean of the Jacobs School. "I am sincerely grateful for this gift. It will help our computer science educators innovate in their classrooms and teaching labs."

Read more: bit.ly/csegift

Give back

You too can honor your favorite teacher by donating to the CSE Teaching Endowment Fund, the CSE Engineering Tutor Program or the Paul R. Kube Chair of Computer Science.

bit.ly/givetocse

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