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California Institute for Telecommunications and Information Technology

Calit2

Volume 12 | Issue 1 | Fall 2016

University of California, Irvine

Carnivorous **Coup**

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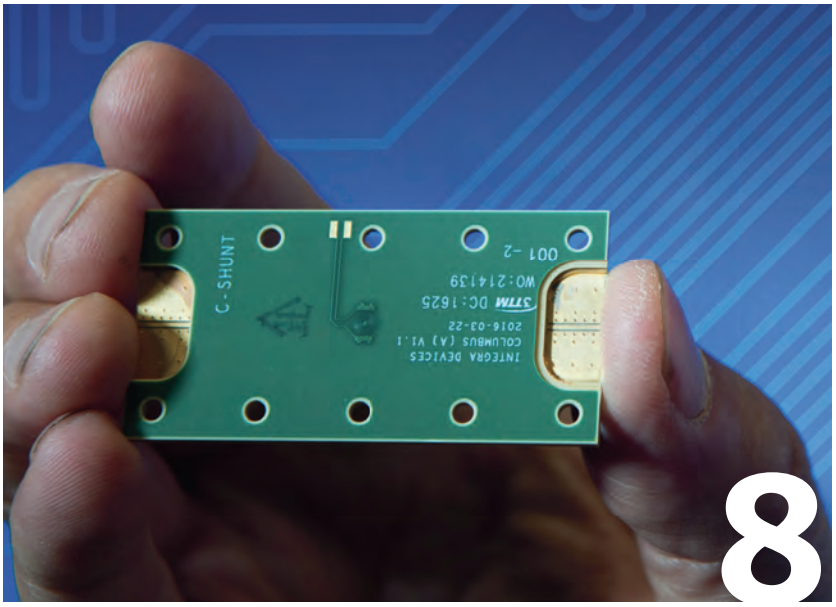

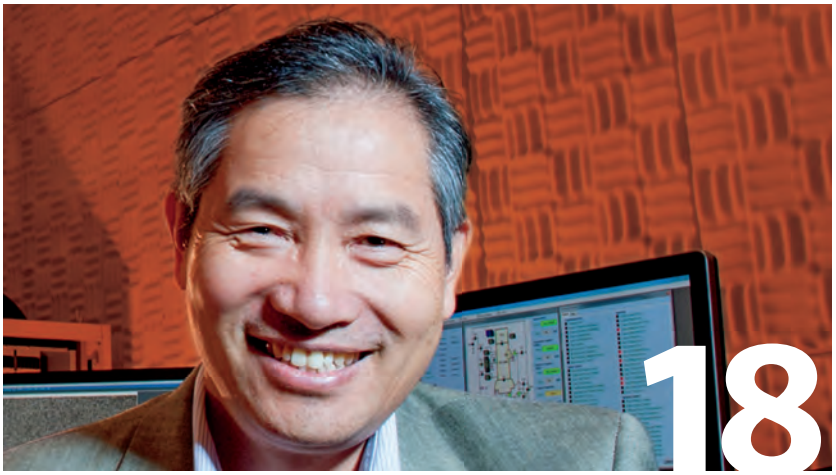

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Volume 12 | Issue 1

Interface is published semiannually by UC Irvine's Calit2 Communications Department.

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Publisher: Mike Delaney, Meridian Graphics

On the cover: *Drosera capensis, commonly known as the cape sundew, uses a sweet sticky secretion to snag insects on long tentacles. Calit2 researchers are using powerful computational tools to sequence and study the genome of the carnivorous plant.*

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a year's worth of oxygen for 20 people

SAVES 17,128 gallons of water
enough for 1,016 eight-minute showers

SAVES 28,560,000 BTUs of energy
power for the average household for nearly four months

ELIMINATES 116 pounds of waterborne pollutants

ELIMINATES 1,895 pounds of solid waste
enough to fill more than 400 garbage cans

ELIMINATES 3,731 pounds of greenhouse gas

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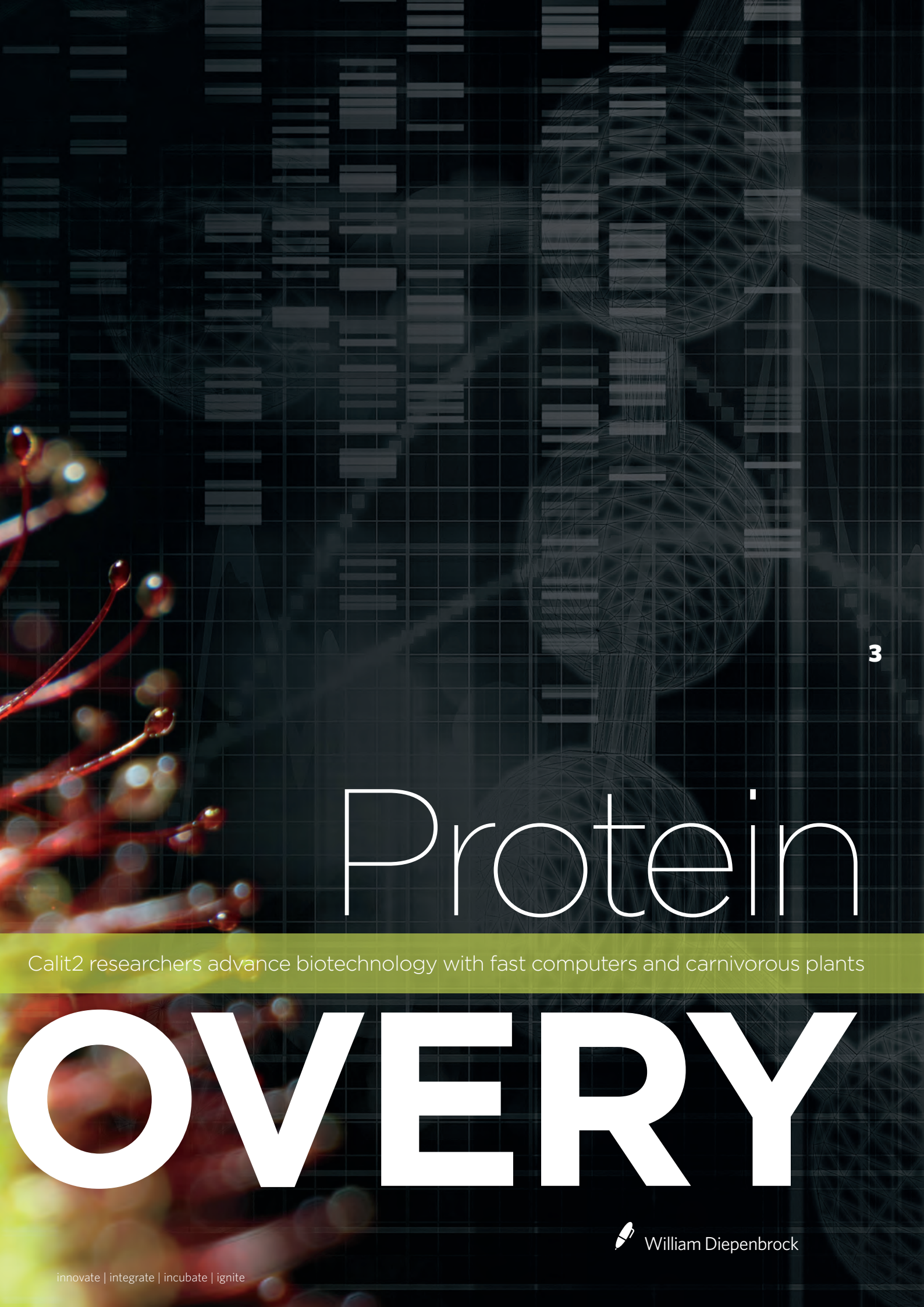

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Protein

Calit2 researchers advance biotechnology with fast computers and carnivorous plants

OVERY

William Diepenbrock

Hundreds of brutal, efficient killers crowd Carter Butts' home, bringing grim death to any unwise enough to venture into range. But fear not. These are magnificent bug-eating plants that populate nearly every continent.

Drosera capensis, commonly known as the cape sundew, also replicate human digestive processes under extreme circumstances. So Butts, a UC Irvine sociology and statistics professor, and his research colleague Rachel Martin, a UCI associate professor of chemistry, molecular biology and biochemistry – and a fellow carnivorous plant enthusiast – wondered: why not pull one into their lab and see what it could teach humans?

The result: An 18-month project to sequence and study the genome of Drosera capensis, the first of its family and the third carnivorous plant ever to be sequenced.

They chose the cape sundew, in part because it drew Charles Darwin's special attention in his 1875 book on insect-devouring plants. The 194 species of sundew use a sweet sticky secretion to snag insects on long tentacles. Other tentacles move to trap bugs and sessile glands digest them.

Butts and Martin overcame hurdles in extracting DNA, analyzed genomic sequences with tools typically used in sociology and explored novel enzymes that break down proteins – and which could provide significant medical benefits to humans.

"Carnivorous plants are neat," Martin says. "Nobody knows exactly what proteins and enzymes they possess. They started out trying to kill insects to protect themselves from being eaten. This has evolved six separate times into mechanisms for trapping insects and using them for nutrients."

Their discoveries, reported in two recent peer-reviewed journals, show the magnificent killers may be equally extraordinary in what they can do for humans – erasing biofilms from medical instruments and safely battling stubborn fungal infections, for example.

Environmental challenges faced by the plants suggest they have creative ways of surviving, according to Butts.

"It's a lot harder for a carnivorous plant to eat things than it is for us," he says. "You can't heat up the environment to make the enzymes go faster and you have to compete with bacteria and fungus and other creatures that are also trying to eat your food. For them to survive, they need to have really effective and interesting properties."

Butts and Martin, already collaborators on a National Science Foundation project focusing on proteins, created their project under the aegis of Calit2 – where Butts has his lab.

The institute provides for multidisciplinary research – in this case, pairing Butts' methodology training and Calit2's computational resources with Martin's keen understanding of biochemistry.

"My work has mostly been on studying social networks, simulation methods and statistical methods," Butts says. "This whole arena was an entirely new direction for me. We adapted a technique that I previously used to study individual life histories, believe it or not, to look at proteins."

The team quickly ran into challenges. First, Butts and Martin needed to extract usable DNA – a challenge because plants excrete substances that mask their DNA when chopped up.

"A lot of the genome-sequencing techniques and the techniques for collecting the DNA are optimized for human studies because the driving force for a lot of this is medicine," Martin says. "I mixed and matched techniques till I came up with one that actually worked. UCI's Genomics High Throughput Facility was very helpful in checking whether the genome was good enough to sequence."

The effort took about three months, followed quickly by creation of the sequencing data – where technical developments have shortened the process to about a week.

"We took advantage of next-generation sequencing technology – which has reduced the cost and time quite a lot – to get usable reads," Butts says. "That takes the extracted DNA, breaks it into little tiny pieces, and then uses a machine to read out the DNA sequences of these little pieces. You get a puzzle that has hundreds of millions of pieces and you have to put it together, which is a computational challenge."

CalIt2 provided key resources during this step.

"It requires access to high-performance computing, which was something I have in my lab and I was able to bring to bear on the problem," he says.

The team reviewed gigabytes of data to figure out how to organize the puzzle pieces into readable sections of genome.

"There's no universal strategy that always works. You experiment with

"We found all this great stuff from only the first carnivorous plant that we've looked at, and there are numerous kinds of plants and lineages."

modifying the techniques and try different strategies. We went through quite a number of assembly algorithms and strategies for processing and cleaning the data until we found something that finally worked," Butts says.

"We believe we have about 90 percent of what's there. That's pretty good for an initial assembly, and that means what we have is good enough that we can start to find proteins and do other kinds of studies of the organism with fairly high confidence," he adds.

The data yielded a rich trove of information.

"It really is exciting to have this huge basket of stuff, and realize there are treasures in there. You just have to figure out how to get them out," says Butts.

Martin quickly identified 44 protein sequences, far too many to economically produce. Using molecular modeling, they helped target the most novel and exciting sequences. She focused on proteins that may work as anti-fungal agents, producing three in her lab. Two are called chitinases because they generate enzymes that digest the chitin in bug exoskeletons.

"This is a very valuable agent to use as an antifungal because you can use it to poison fungus and not humans, since humans don't have chitin," she explains.

Martin also has created a protein-specific insert, a sub-sequence of a protein that cleaves off after the protein is made. It is itself an enzyme whose functions may include defense against pathogens and cleaning cell walls.

"This is something the plant seems to be using as an antifungal or anti-bacterial agent. We're really excited about catching that in the lab," she says.

The duo has more genomes in the pipeline, too. And Martin and Butts are excited to explore what they may discover from other carnivorous plants.

"We found all this great stuff from only the first carnivorous plant that we've looked at, and there are numerous kinds of plants and lineages. So we're really excited about comparing what we found here to what's going on in other carnivorous plants," Martin says. "We expect to see a lot of similarities, because things evolve in similar directions to get the same function, but there is no reason it has to be exactly the same."

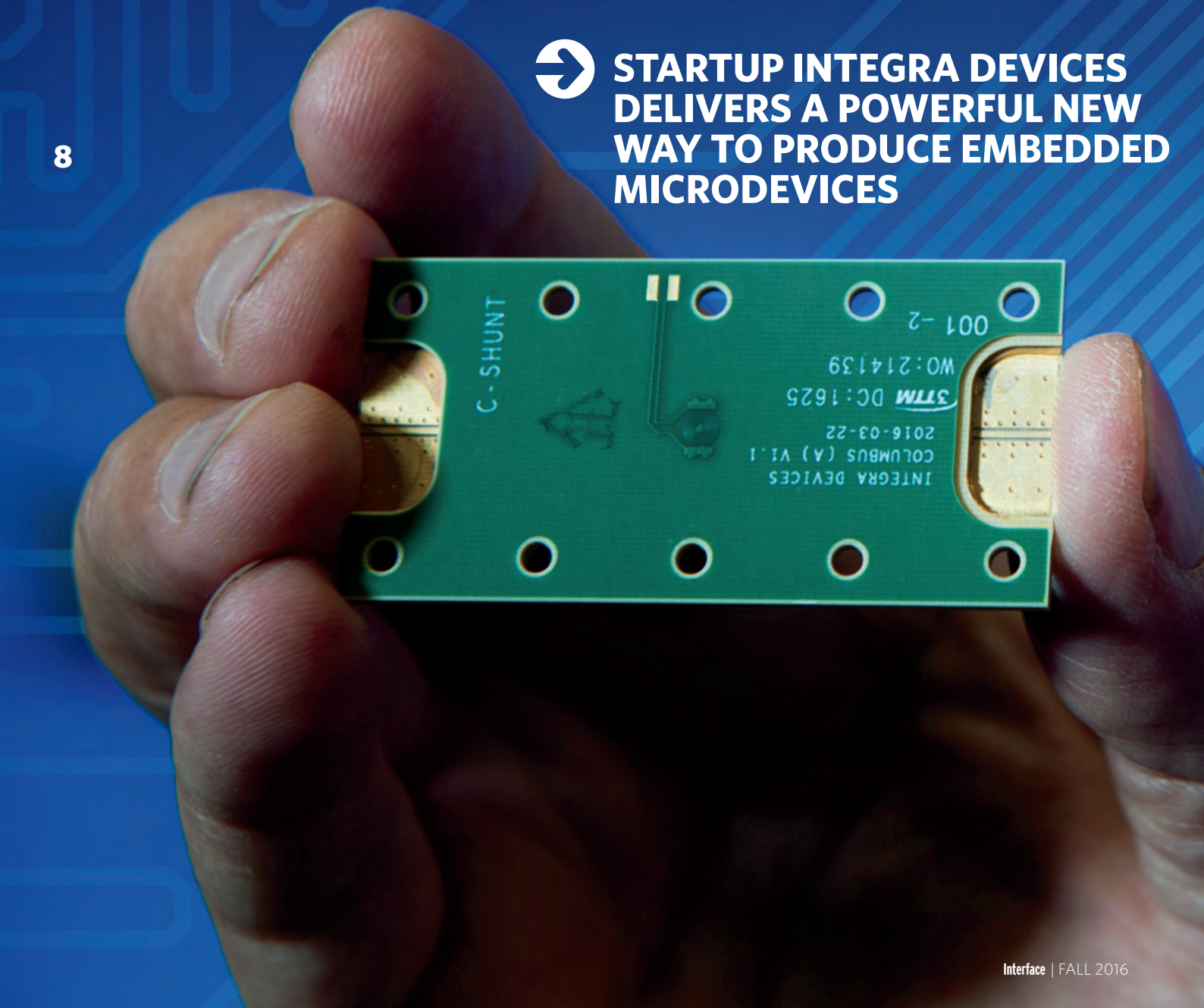
Butts wants to continue developing the methodology that allowed the duo to go from genomic source code to the model of proteins and enzymes that has guided their experiments.

"This is a really valuable innovation," he says. "We are trying to model more kinds of proteins, to model proteins under different conditions and to be able to predict more things about their structure and function.

"If we're going to harness the fruits of the genomic revolution, we need to be able to dramatically improve our ability to speed that source-code-to-final-product process. A lot of people have put a lot of work into pieces of that, and we're building on that work. We think the time is right to be able to put all those pieces together."

INNOVATIVE INTEGRA

STARTUP INTEGRA DEVICES DELIVERS A POWERFUL NEW WAY TO PRODUCE EMBEDDED MICRODEVICES



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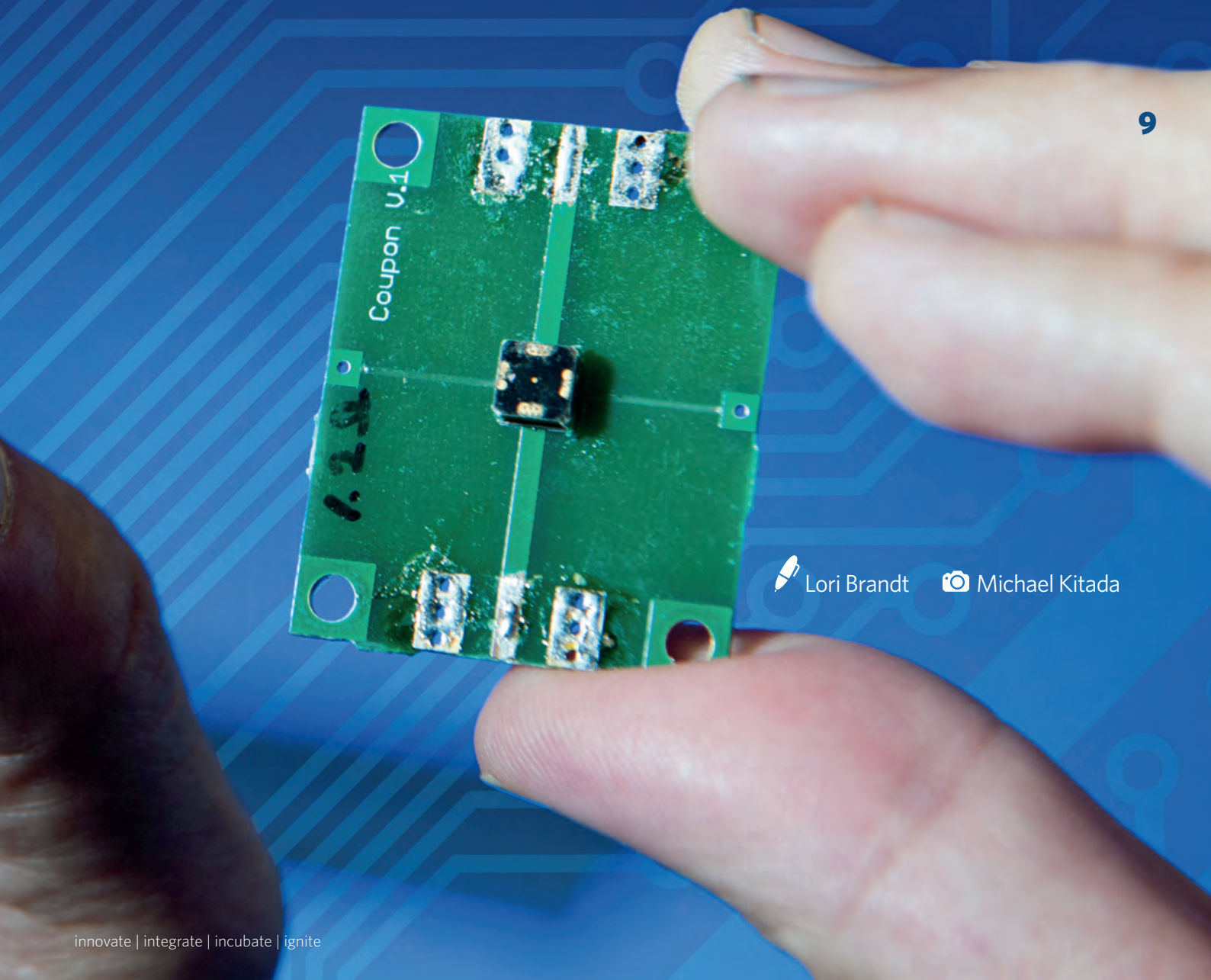

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Lori Brandt Michael Kitada

It's no wonder Mark Bachman has a spring in his step these days. Recently retired from UC Irvine's engineering faculty, the technology visionary and Internet of Things (IoT) evangelist has joined forces with two veteran high-tech industry entrepreneurs to found Integra Devices, a startup company with an eye toward the future.

Located in Calit2's TechPortal, the 1-year-old company is leveraging a newly patented manufacturing process for advanced 3-D microsystems (devices, sensors, relays, actuators). The technique, an alternative to silicon manufacturing, is well-suited to meet the high-frequency, high-speed and high-performance demands of fifth-generation (5G) communication networks and the Internet of Things.

During his 15 years as an electrical engineer at UCI, Bachman conducted research on microelectromechanical systems (MEMS), nanotechnology and micromanufacturing, working with Calit2 Director G.P. Li to establish the Integrated Nanosystems Research Facility (INRF) and BiON clean rooms. He is now applying that research to bring high-value products to industry. Integra Devices has licensed two patents from UCI, and is in the process of licensing several others, commercializing the manufacturing process and designs for a line of products.

As Integra Devices' senior engineer for research and development, Spencer Chang spends a lot of time in the Calit2 Microsemi Lab, where he tests advanced sensors.

"Most people use silicon technology to build really small things," says Bachman, Integra Devices chief technology officer. "Professor Li and I figured out a way to make high-performance microdevices using other materials like plastics, metals and ceramics for instance, and we can put them all together in a single package."

This technique, called Amalga, stacks the materials in laminate substrates as opposed to the flat monolithic process of silicon fabrication. It enables the miniaturization of devices and the integration of various materials, as well as allows the components to be embedded in substrate or printed circuit boards.

The method can be applied to many markets and applications, and it's a much more cost-effective approach than silicon. Bachman says the manufacturing technology does not require expensive capital equipment or clean rooms. "Most can be done by retrofitting existing electronics manufacturing shops," he says. "Same tools, same people. It's an opportunity to upgrade to an advanced manufacturing process."

With private investor funding and Lockheed Martin as its first customer, Integra Devices has chosen a line of radio frequency (RF) electromechanical relays as its first product and has partnered with three local manufacturers.

"There are certain things that silicon cannot do," says Paul Dhillon, Integra Devices executive vice president of sales. "Miniaturized, high-power electromechanical RF/microwave relays have been the holy grail for miniaturization. [Our approach] is something that has never been done until now."

With the IoT gaining momentum, there will be billions of devices connected to each other: automated cars, smart homes, mobile phones and wearable sensors, along with things that haven't been invented yet. Microrelays, switches and smart antennas will be crucial to help users, devices and sensors all communicate for a smarter, more efficient society.

Once the company's approach is validated for microrelays, it's an incremental step to apply it to other devices, according to Integra Devices CEO James Spoto. "Mark can build all kinds of interesting microdevices in standard PCB manufacturing technology, with some obviously secret-sauce additions," says the former semiconductor industry engineer and executive. "We'll be going after the things that aren't well done in silicon; RF devices, flow sensors, audio sensors and actuators are a few examples."

Integra Devices' technology and products will help to meet the need for miniaturization driven by growing 5G, IoT, virtual reality, unmanned vehicles (drones), self-driving cars and wearables markets.

Bachman believes his company could help transform the microelectronic industry by bringing manufacturing back to the U.S. "The new 5G standard is a whole new ball game, it demands high-frequency and quality performance; conventional devices are not going to cut it. Smart antennas and microrelays, which can rapidly reconfigure themselves, will be a big deal in 5G."

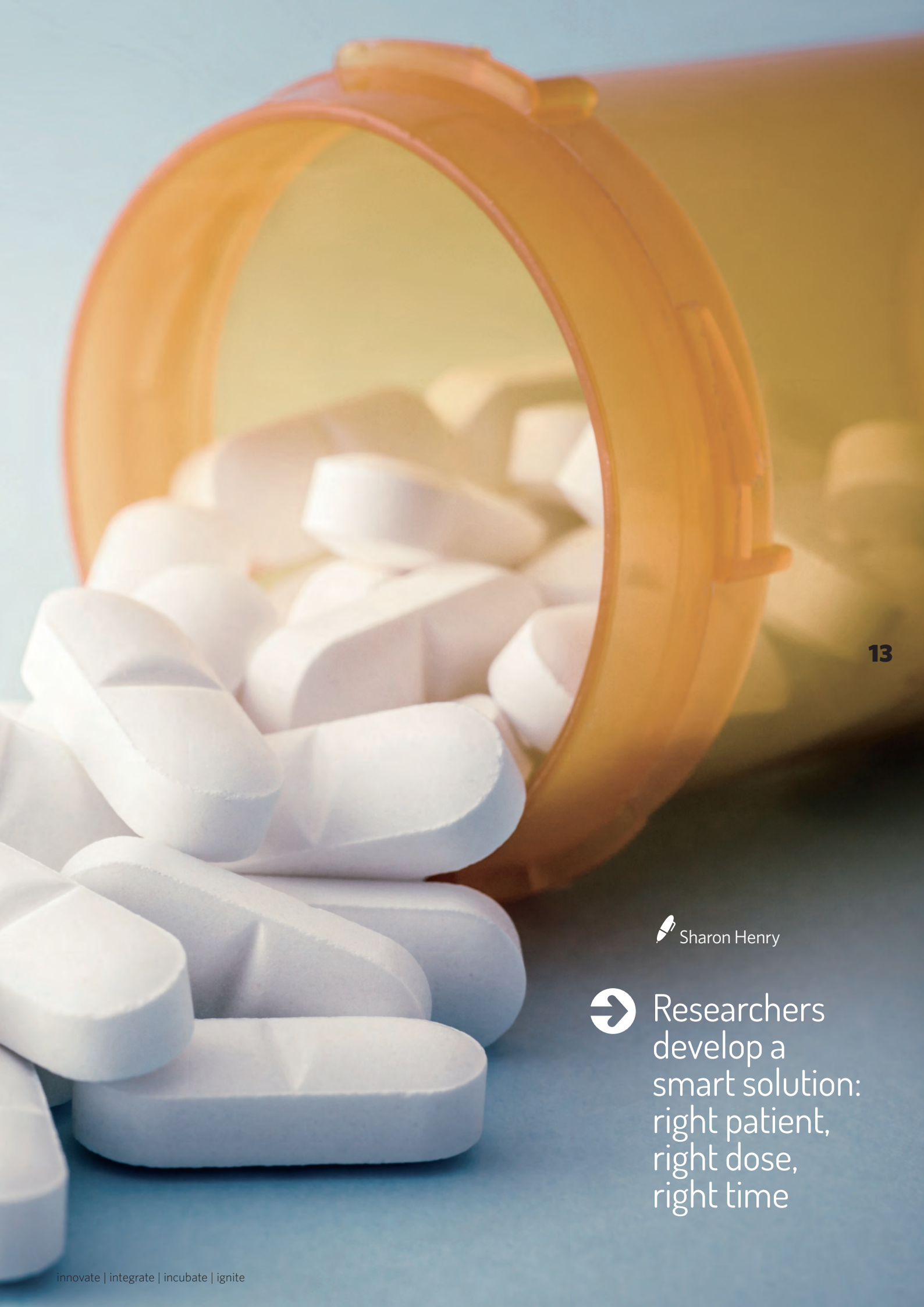
Spoto, who has guided two previous startup companies through to successful exits, says the goal at Integra Devices is to build the company to significant revenue within four to five years. "Having Mark, the principal inventor on the technology, involved in the effort is a huge value."

The company recently hired two new employees – Sourabh Dhillon in business development and Spencer Chang ('14), a recent UCI biomedical engineering graduate – bringing its total workforce to five. They have one more year in Calit2's business incubator before they'll have to find another office location.

"I appreciate access to TechPortal's physical space and Calit2's excellent resources such as the electron microscopes and clean rooms," said Bachman. "But our main excitement in working at Calit2 is engagement with world-class research faculty, staff, students and industry partners."

Integra Devices Chief Technology officer Mark Bachman (left) and CEO James Spoto believe their company is well situated to meet the high performance demands of 5G and the Internet of Things.

Looking for the Next FIX



Sharon Henry

Researchers develop a smart solution: right patient, right dose, right time

Dr. Solomon Liao admits to often encountering a dirty, little family secret not uncommon to physicians who prescribe opioid medications.

"I cannot tell you how many patients we've had ... grandmothers who have cancer and their grandsons are stealing their medication," he says. "Another patient openly tells us the daughter is stealing her father's pain medicine. It's really tough. These patients ... want family members to be around them, yet they do not want relatives stealing their medicines."

Liao is director of Palliative Care Services at UC Irvine's School of Medicine. Last year, he, along with radiation oncologist Dr. Randy Wei and anesthesiologist and pain specialist Dr. Padma Gulur, assembled an interdisciplinary team of doctors, pharmacists, statisticians and Calit2 engineers to develop a medical device designed to reduce prescription opioid abuse and perhaps change the way medicine is prescribed and dispensed.

The device, a smart pill dispenser called PICARD (Patient Initiated Controlled Analgesic Recording Dispenser), uses IoT (Internet of Things) technology to store, record and dispense prescription medication. Drug-usage data collected from PICARD can be analyzed to help physicians deliver a more patient-centric prescription – maximizing effectiveness while reducing side effects and over-prescribing that can put patients at risk for abuse.

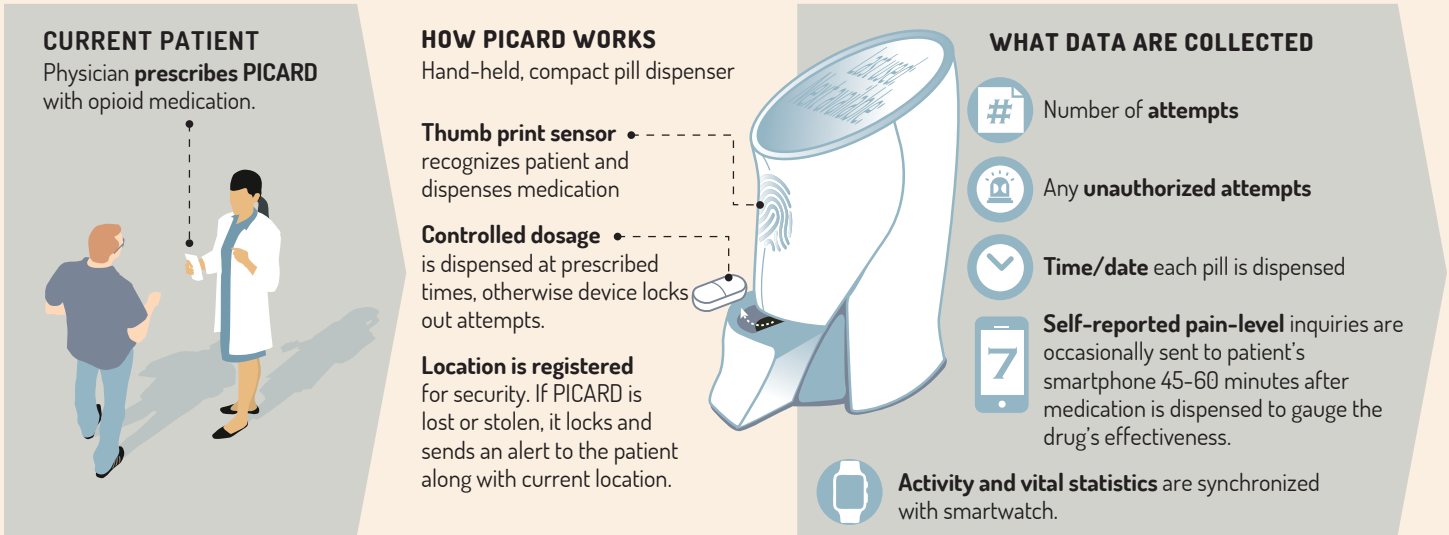
Wei defines it simply as: "The first device that ensures medications, especially opioids, are being dispensed to the right patient, at the right dose and at the right times as prescribed."

Following surgery or treatment for injury, patients often are discharged from the hospital with a surplus supply of pain medication.

"In the hospital, we are so strict about pain medications for patients, but when they go home we give them

Smart pill bottle: The right patient, the right dose, at the right time

PICARD (Patient Initiated Controlled Analgesic Recording Dispenser) developers envision creating an ecosystem that will ensure prescription opioid drugs are correctly dispensed to a patient while tracking a drug's use and effectiveness. Precise dispensation data also will give physicians better insight to adjust or change a prescription.



90 pills of highly addictive and lethal prescription opioids without safeguards or supervision," Wei says. "That doesn't make sense for a controlled substance."

Opioids – drugs that include prescription painkillers such as Percocet, OxyContin and Vicodin – reduce pain by increasing levels of dopamine, the feel-good hormone in the brain. As the brain becomes accustomed to the dopamine, more and more is needed to maintain results, which can lead to addiction.

From 1999 to 2010, the number of deaths involving opioids more than quadrupled in the U.S., according to the Centers for Disease Control and Prevention. A disturbing report released last year by the U.S. Drug Enforcement Administration said drug overdoses are now the leading cause of injury death in the U.S., ahead of motor vehicle accidents and firearm fatalities.

The PICARD prototype, built on a 3-D printer Calit2 researcher Linyi Xia keeps in her office, is a chunky yellow block, about the size of a chalkboard eraser.

> "When you consider all the money we waste on medications that are thrown away, if we spent even a fraction of it on technologies like this, patients and society in general would be better off."

WHAT HAPPENS TO THE DATA
Clinical data stored in a secure **HIPAA* compliant cloud** is accessible via patient's electronic medical record or secure mobile app.

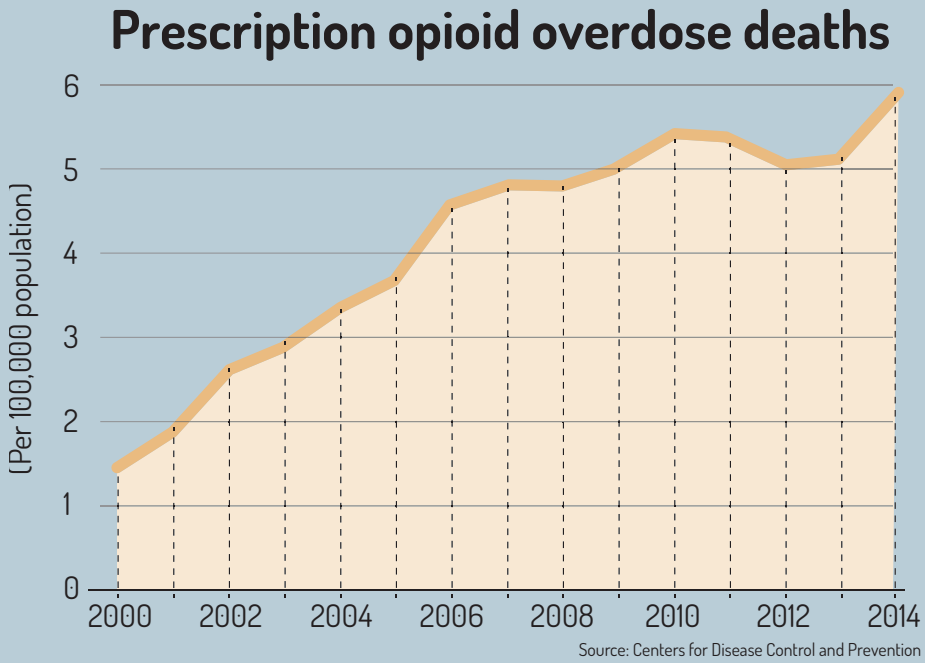
Database
Stores and maintains data.

Back end
Manages data and provides access to client.

Data visualization
Physician can review and share monitored data with patient:
- Number of opioids dispensed
- How effective drug has been at reducing pain level
- Whether drug use was same, less or greater than the previous month
- To what degree pain and/or opioid use have affected daily activity

HIPAA-compliant cloud network
Collecting aggregated, anonymous clinical data of each case study allows continuous building of a data archive for big data analytics.

*Health Insurance Portability and Accountability Act



Xia, a specialist in embedded systems, co-leads a student team with Sergio Gago-Masague, a Calit2 project scientist, to design and implement the product's electrical/mechanical system and user interfaces.

PICARD will be sleek and compact, not much larger than a typical pharmacy pill container, but with a thumbprint sensor and LED screen top. The design for the device's spring-loaded dispensing mechanism was influenced by Pez dispensers and gumball machines, Gago-Masague says.

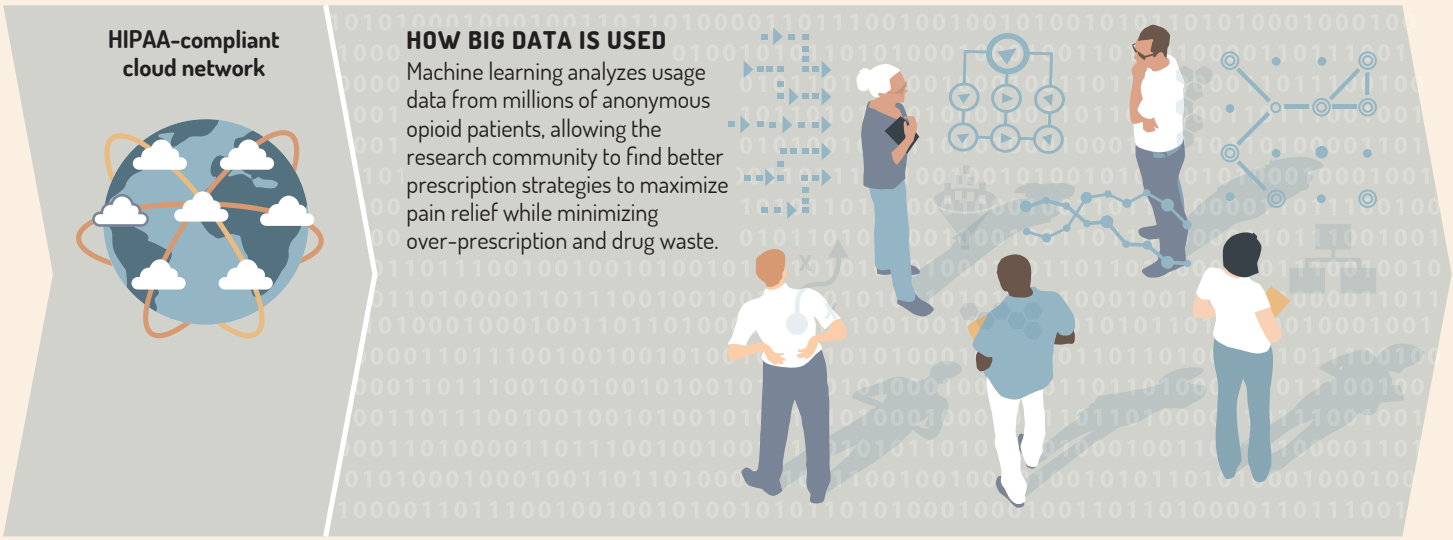
When a PICARD sensor recognizes a patient's thumbprint and confirms it's time to dispense medication, a single pill moves from the pre-loaded cartridge into the dispenser slot. "The idea is these cartridges will be disposable, like your printer cartridge," Xia said.

With grant support from the UCI Institute for Clinical & Translational Science and the NIH Clinical & Translational Science Award, the team is working to complete its prototype and is collaborating with oncologists, geriatricians and internists to start PICARD's clinical trials. Ultimately, researchers expect the smart pill bottles – which they hope to be cost-effective and widely used – will improve pain management and reduce hospitalization, E.R. visits and opioid-related side effects.

Gulur, who directs UCI's Health Pain Management Services, also leads SafeRx OC, a local coalition committed to reducing prescription drug abuse and overdose deaths. She believes PICARD can be especially helpful for patients with known addiction issues who also have genuine pain.

Liao agrees that the device has value beyond prescription opioid management. "We have people with

"The larger, broader concept is to collect patients' usage data and use it to change how physici



memory impairments from Alzheimer's and strokes who forget to take their pain medication," he says, adding that the device could be utilized for blood thinners, and heart, diabetes and blood pressure medications.

"When you consider all the money we waste on medications that are thrown away, if we spent even a fraction of it on technologies like this, patients and society in general would be better off," Liao says.

"The larger, broader concept is to collect patients' usage data and use it to change how physicians prescribe opioids," Wei says. "It's not just the dispenser we're building, it's the ecosystem."

He envisions a future where doctors prescribe opioids based on individual need. "There's a smart artificial algorithm that will tell you this patient only needs 10 pills instead of 90," he says. "There's no longer all this medication that goes to waste or is stolen by family members or friends. That's our big vision."

TECHNOLOGIES FOR HEALTHY AGING

According to a report by the Orange County Healthy Aging Initiative, the OC is home to over 3.1 million people and is the sixth most populous county in the nation.

In 2016, 13.5% of the county's population is 65 and older. This number is projected to nearly double by 2040, when almost one in four residents will be 65 or older. In collaboration with non-profit organizations, health care professionals and seniors, Calit2 is working on several projects that will provide powerful personal tools to assist in healthy aging activities.

Join us Thursday, Nov. 10, 2016 to:

- Learn more about the fastest growing population of the Internet – baby-boomer seniors who want to be fully wired;
- Hear about a new digital community collaboration platform that offers a unique twist on social networking;
- See interactive and engaging electronic game-based solutions for healthy living;
- Meet a UCI startup company that is developing fun and effective products for clinic and at-home therapy;
- Discover what the near future holds for the healthy aging market and how to get involved.

Registration is required: **www.calit2.uci.edu** for complete details

ans prescribe opioids," Wei says. "It's not just the dispenser we're building, it's the ecosystem."

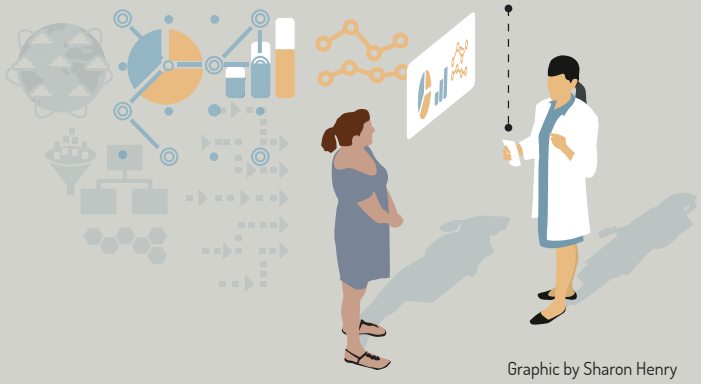
HOW HEALTH CARE IS TRANSFORMED

Precision medicine
Predictive analytics are used to identify how well a patient will respond to treatment based on an individual's specific medical condition and preferences, rather than using the "one-size-fits-all" practice for prescribing medications.

Telemedicine
If a patient is taking too many opioids or taking medication incorrectly, a nurse practitioner can check in with the patient.

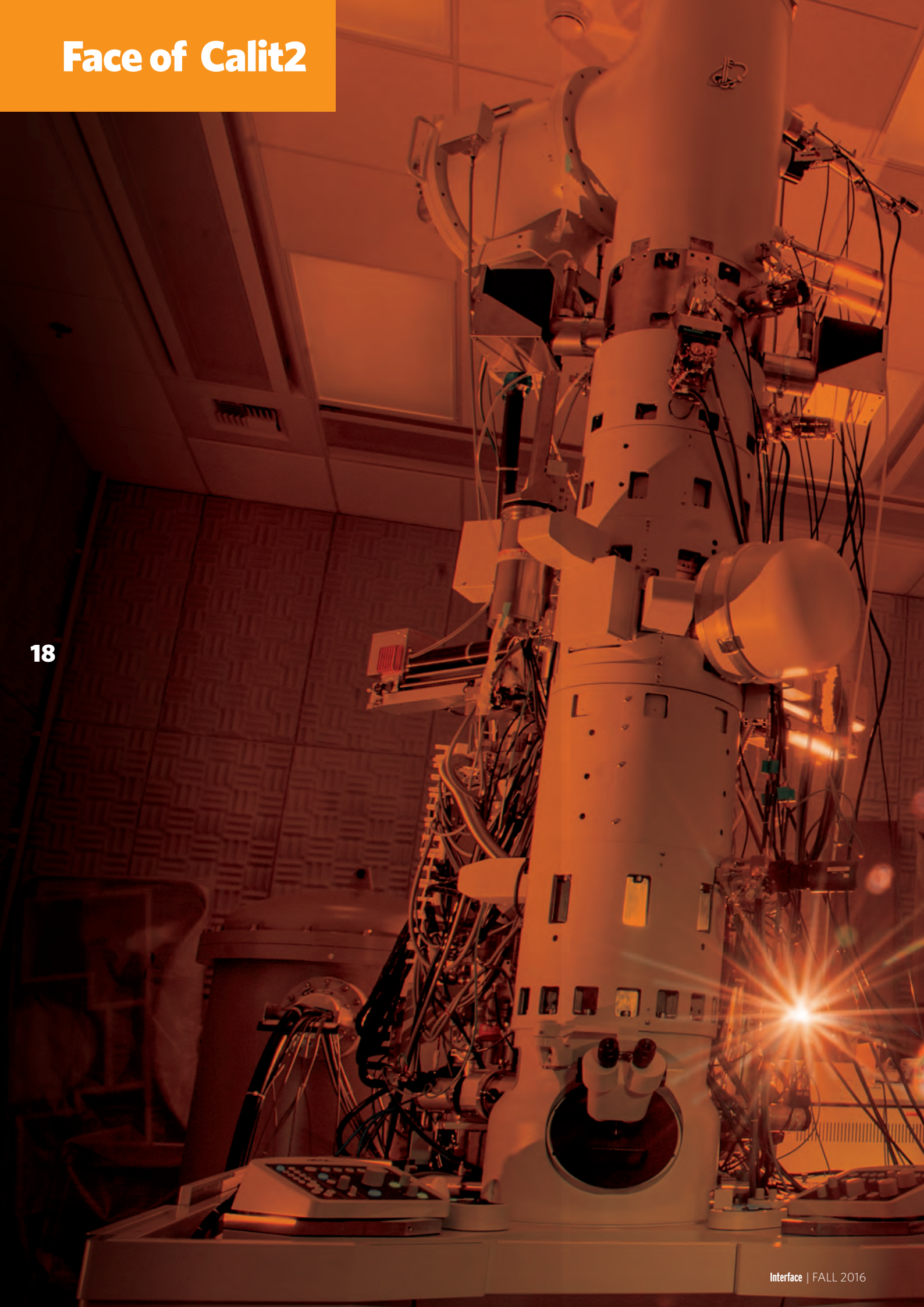
FUTURE PATIENT

Physician is equipped to deliver a more patient-centric prescription that maximizes the medication's effectiveness while lessening side effects and over-prescribing that could lead to opioid addiction.



Graphic by Sharon Henry

Face of Calit2



GOAL GETTER

TENACIOUS IMRI FACILITIES DIRECTOR KNOWS WHAT HE WANTS AND MAKES IT HAPPEN

Anna Lynn Spitzer
Michael Kitada

Growing up in rural China, Jian-Guo Zheng's life was less than idyllic.

His beloved father, a well-liked village tailor, died when Jian-Guo was only eight. His mother, a peasant farmer with no formal education, remarried a couple of years later, and although his stepfather was kind, Zheng recalls the stigma of losing the family's patriarch. "The concept of family is very important in China. Our whole family was looked down upon. Even when my stepfather joined the family, he was considered an outsider."

Still a child himself, Zheng suddenly was saddled with family responsibilities: division of property, home repairs and refereeing family squabbles. "It was a lot of pressure," he says of those years. "I had white hairs when I was only 13. It was unfortunate to experience these things as a child, but it made me grow up quickly."

School, though, was a respite from the stress. "I was very happy in school and really enjoyed it," Zheng says, "because I did very well and the teachers were kind."

Nothing made his mother happier than her son's success in school. Her own childhood responsibility for tending her siblings and helping on the family farm precluded an education; she carried that regret into adulthood. "She talked about not having the chance to go to school, especially when I played a little too much," says Zheng of his mother, who, even today, at 89, cannot read and can write only her own name. "When I was young, my mom always told me that she will support my efforts to go to school however she can."

Luckily for Zheng – and his mother – China's political turbulence abated at just the right time. From 1966 to 1976, during the country's Cultural Revolution, education was stifled. Many middle and high schools were disrupted, and universities operated on reduced schedules, if at all. When the revolution ended in 1976, though, ambitious students like Zheng regained lost opportunity. "If the Cultural Revolution continued for a few more years, I would never have gotten the chance to go to university," he says.

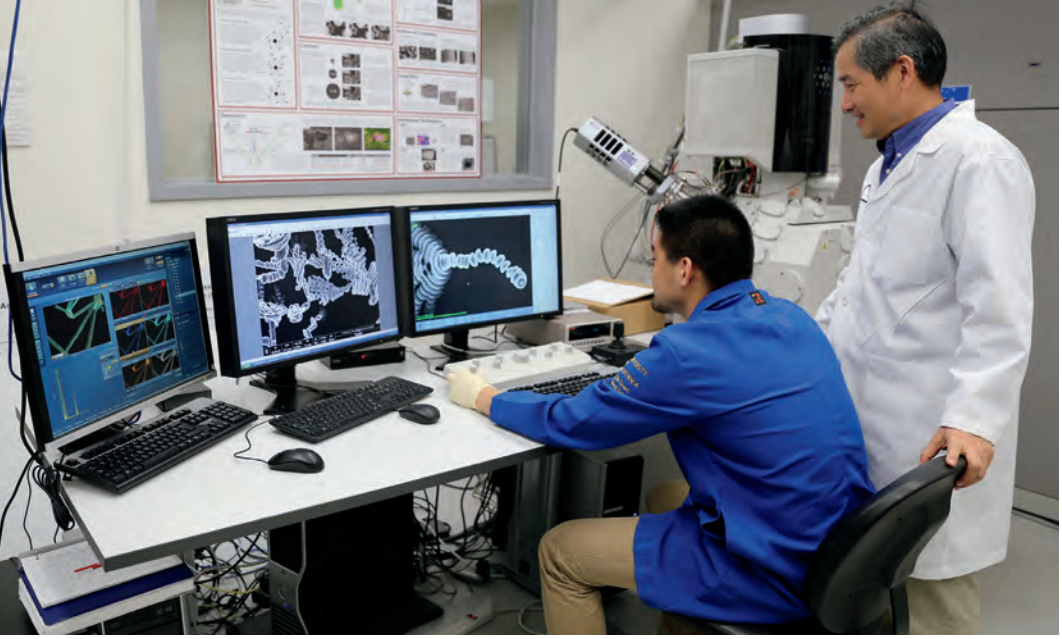
With the end of the revolution, millions of students now could compete for limited spots in the country's reopened universities. High-achieving pupils were chosen to take a national college-entrance examination. Zheng, number one in his class, was selected to sit for the first national exam in 1977, when he was a 15-year-old freshman.

He failed. "From 1968 to 1976, we hadn't learned much in our school," he says, shrugging.

Previous page: Zheng sits near one of the most advanced transmission electron microscopes in the world. Under his guidance, IMRI is advancing fundamental research and new technologies across scientific and engineering disciplines.

Below: Family is a top priority, and he visits his mother in China at least twice a year. Here, Zheng's wife, Lily Wu, and son, Xida, flank the family matriarch.

Right: Despite working long hours, Zheng finds time to work in his garden, play ping pong, visit the beach and take a walk every night.



Zheng oversees a user on the Magellan FEI, an extreme high-resolution scanning electron microscope.

As a sophomore, he tried again, borrowing books from family friends, learning from teachers and studying old textbooks around the clock. He aced the exam, with scores good enough to land him a spot in any of the country's universities. Unfortunately, however, preference that year was given to students who had already graduated.

So Zheng waited. The third time was the charm. In 1979, he was accepted to Nanjing University – one of China's best – in the physics department, which accepted only one of every few hundred applicants.

Now an expert in electron microscopy and director of facilities for UC Irvine's IMRI (Irvine Materials Research Institute), Zheng earned bachelor's, master's and doctoral degrees in solid state physics from Nanjing University, completed postdoctoral work in England, and today oversees millions of dollars' worth of high-tech materials characterization equipment.

Vision, patience, hard work and determination define him. Zheng knows what he wants and chases his goals insistently. When he felt he wasn't learning enough, he declined renewal of a productive guest scientist position in Germany; when he decided to improve his English and electron microscopy skills, he turned down a prestigious job offer in another German city.

Instead, Zheng wrote to Prof. John Steeds, a British microscopist and a Fellow of the Royal Society, to apply for a postdoctoral position. "Dr. Steeds was famous in electron microscopy, especially convergent beam electron diffraction, and that's what I wanted," says Zheng, who at the time, had worked in Germany for more than two years but whose wife and five-year-old son were still living in China. "I didn't care about a title; I didn't care about income. I knew his reputation and I just wanted to come and learn transmission electron microscopy and bring my family with me."

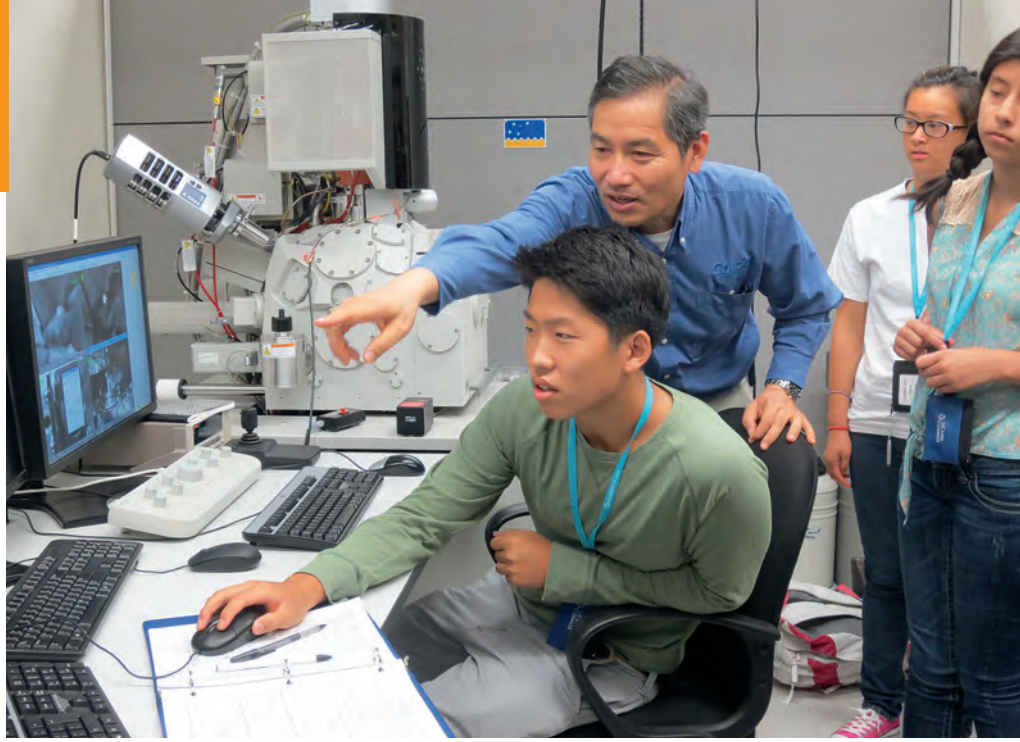
He got the position and a three-year contract in Bristol, England.

Zheng had written another letter before moving to England, this one to Northwestern University's materials science department. "They are one of the best in the world," he says.

That letter was never answered, but after working in England for several years, Zheng saw an online advertisement for a job at Northwestern's Electron Probe Instrumentation Center (EPIC).

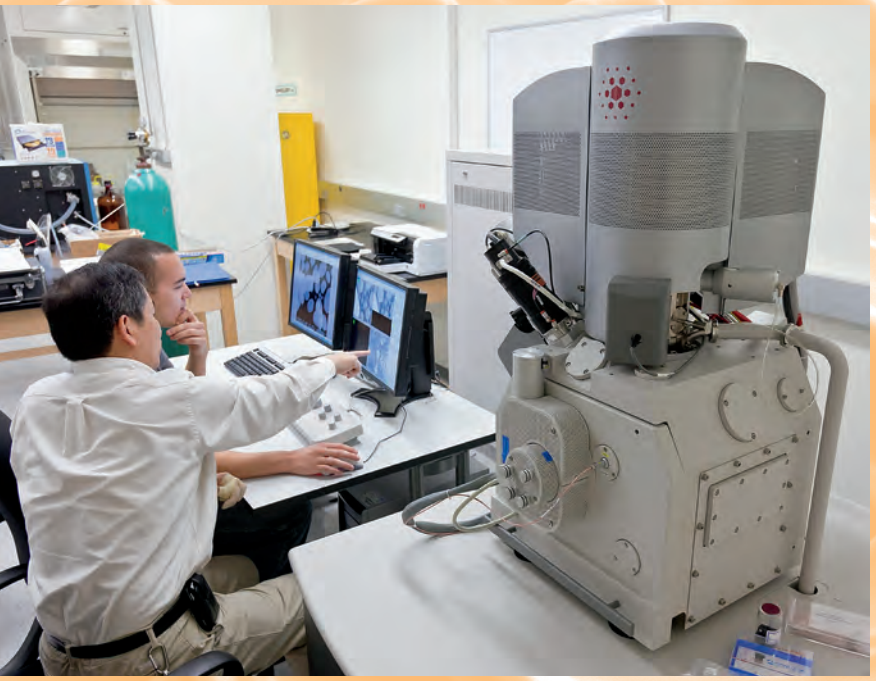
"I submitted my resume, and I got a phone call from the director, who asked, 'When do you want to come? We'd like to interview you.'" Zheng stayed at Northwestern for five years, managing EPIC, while doubling its usage and revenue in the process.

Then a friend told him about a job at Calit2 at UCI. A quick website search convinced Zheng that the job wasn't for him. "I'm a TEM guy and the TEM at Calit2 was older. I did not think UCI was the right place for me."



Right: Zheng views outreach activities as essential to overseeing the labs. Among his efforts: teaching high school summer program participants about scanning electron microscopy.

Below: Zheng has worked diligently to upgrade the campus's materials characterization capabilities. A new Quanta 3-D FEG scanning electron microscope/focused ion beam was installed in the Calit2 microscopy lab in October 2010; a month later, it was up and running, and ready for graduate student training.



A few months later, the friend prodded him again, telling Zheng he thought the job was a good opportunity. This time he decided to submit a resume and pay a visit to the campus. UCI Chemical Engineering and Materials Science Professor Albert Yee, who directed Calit2 at the time, told Zheng his goal was to improve the institute's materials characterization capabilities. "I was happy at Northwestern but it was a pretty established place," says Zheng. "Albert told me there was great potential here."

That was 10 years ago. The facility that Zheng was hired to oversee has grown from a few instruments to a world-class materials characterization center. IMRI encompasses several unique facilities: a surface science facility, a scanning electron microscopy facility, an x-ray diffraction facility and a new TEM center that houses four state-of-the-art TEMs.

Currently counting more than 350 registered users from academia and industry, IMRI houses several dozen highly sophisticated instruments, including the best in X-ray powder diffraction, scanning electron microscopy, transmission electron microscopy, X-ray photoelectron spectroscopy, ultraviolet photoelectron spectroscopy and auger electron spectroscopy in Southern California.

And, a new state-of-the-art center for sample preparation and property measurement is expected to open next year. TEMPR will provide thermal, elemental, mechanical, physical and rheological services, and will support materials discovery in physical sciences, biology, engineering and medicine.

Zheng is understandably satisfied. "My ambition was to have a world-class facility, and I think right now our facility is indeed world-class," he says. "I haven't done it alone but I have played a role."

His approach encompasses four goals: safety, including a safe environment and users properly trained on the equipment; user-friendliness – all machines are available, functional and well-maintained; astute staffing and competitiveness – instruments and staff can meet imposing research challenges; and sustainability, which includes substantial use of equipment and a long-term development plan. "If users need something, we should be able to achieve it here," he says simply.

"Jian-Guo does an incredible job running the

day-to-day operations," says Matt Law, UCI associate professor of chemistry, former faculty director of the Laboratory for Electron and X-Ray Instrumentation and current IMRI associate director. "His extraordinary dedication, knowledge, skill and hard work have been absolutely critical to the early survival and continuing growth, scientific impact and financial success of the facilities. We'd be in big trouble without him."

Zheng's record speaks for itself. In his first year on the job, instrument performance and usage improved immensely, and revenue from the center was sufficient to cover costs; in his second year, revenue doubled, and during his third year, almost tripled. Today, users come from all over Southern California, and revenue has increased more than six-fold.

Another feather in Zheng's cap: the facilities are self-supporting; all instruments and services are maintained by user revenue. "This is a great achievement because not many facilities in the world do that," Zheng says.

"Immediately upon joining UCI, Jian-Guo went about rebuilding an arguably not-very-user-friendly facility – and a pretty ancient one – into one that became accessible to everyone," says Yee, who hired him. "He is now director of facilities for IMRI, a position he earned through sheer hard work and dedication."

UCI Executive Vice Chancellor and Provost Enrique Lavernia, himself a materials scientist, visited the facility soon after arriving on campus last year to express his support.

In the early years, Zheng sacrificed vacations, choosing instead to focus on his work. Even now, with additional staff to help ease the load, Zheng, who still works 10-hour days, prefers a hands-on approach. "Despite presiding over what is becoming the premier electron microscopy facility in Southern California and a good swath of the Southwestern U.S.," says Yee, "he remains humble and dedicated to the facility. it is a common sight to see him hunched over an inexperienced user, offering detailed guidance."

Adds Law: "Jian-Guo does what it takes to support our users, routinely working long hours, late at night, and on weekends to keep the operation humming along. As a result, he has enabled the research of at least a thousand students and postdocs, a hundred or so faculty, and scores of companies. That's a huge impact."

These days Zheng does get away a couple of times a year to visit his mother in China. "I have to make sure my job is taken care of, but at the same time, as a man, I have to take care of my mom and my small family. Without their support, I would not have been able to get to this point."

Family includes his wife, Lily Wu, and son, Xida (pronounced Sheeda), now 26 and a Caltech graduate living in New York City. Xida majored in chemical engineering, but decided instead to develop apps for social media. After some initial consternation, Zheng reluctantly gave his blessing. "I said, 'Fine, as long as you're happy, it's okay.' My idea is that no matter what you do, you do it well."

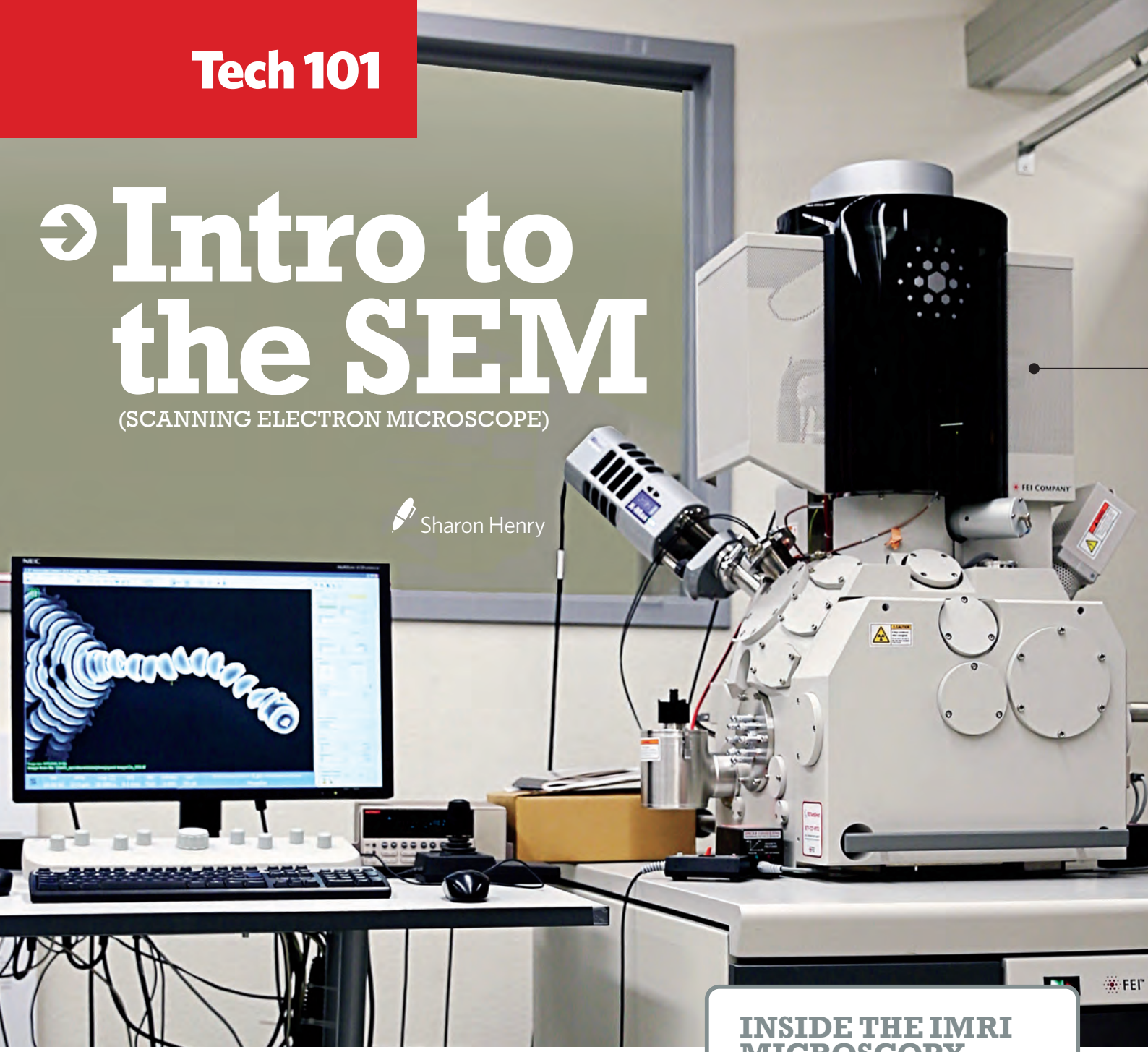
For Zheng, that includes being well-prepared, hardworking and most of all, zealous. "You have to do something you want to do, and go for it. Fame and money should not be the first thing we consider," he says. "I want to do something I'm really passionate about.

"When I see people happy, when they get the job done, when they publish their papers and our facility becomes very important to the university and to research ... that's the reward. That's why I came here."

Intro to the SEM

(SCANNING ELECTRON MICROSCOPE)

Sharon Henry



A SCANNING ELECTRON MICROSCOPE uses a beam of electrons to produce a digital image that reveals information about the materials in the specimen, including surface topography, chemical composition,crystalline structure and orientation.

An SEM can provide resolutions about 4,000 times better than a typical light microscope and 4 million times better than the unaided eye. This allows visualization of submicroscopic cellular particles as well as viral agents.

Because SEMs are sensitive to vibrations, they often are installed on the ground floor of a building.

The word microscope is derived from the Greek mikros (small) and skopeo (look at).

INSIDE THE IMRI MICROSCOPY FACILITY IN CALIT2

This **high-resolution SEM** is one of several state-of-the-art instruments the microscopy facility in the Calit2 building makes available to faculty, students and industry users on a recharge basis. Other equipment includes:

- Dual-beam SEM and focus ion beam
- High-resolution X-ray diffractometer
- Multipurpose X-ray diffractometer

These instruments can examine both organic and inorganic materials, crystal structure, orientation mapping and elemental measurement.

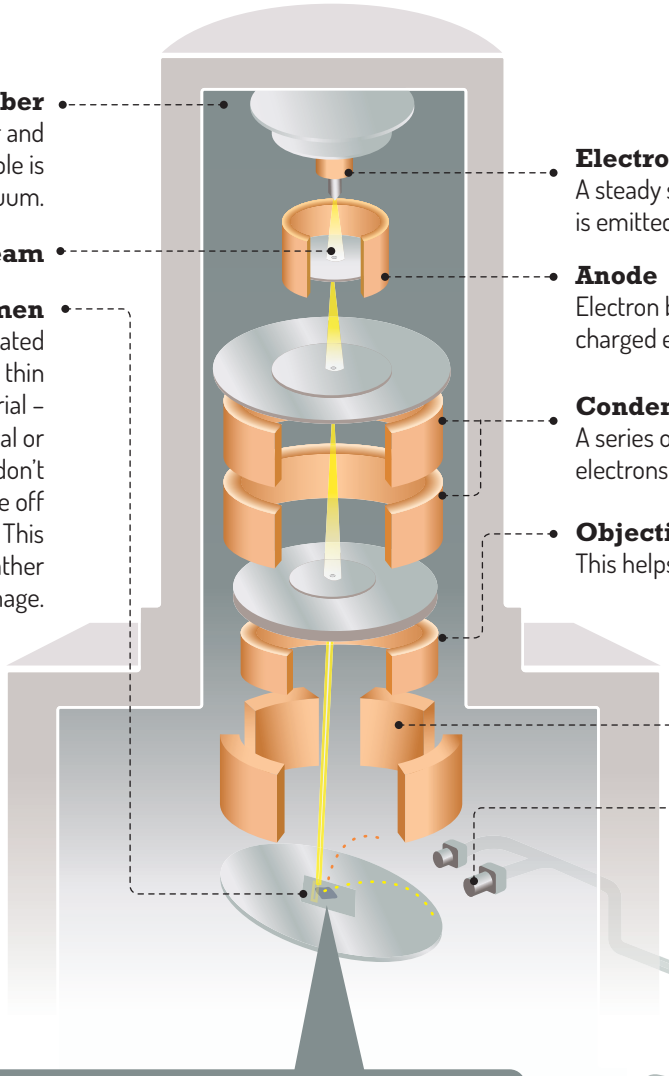
HOW A SCANNING ELECTRON MICROSCOPE WORKS

The SEM is used to investigate the microstructure and chemistry of a range of organic and inorganic materials. Here's how it works:

Vacuum chamber
To prevent interference by air and water molecules, the sample is placed in a vacuum.

Electron beam

Specimen
Most electrically insulated samples are coated with a thin layer of conducting material – carbon, gold or other metal or alloy – to ensure they don't gather a charge and give off too many electrons. This would produce a glow rather than an image.



Electron gun
A steady stream of high-energy electrons is emitted.

Anode
Electron beam is drawn toward positively charged electrode (anode).

Condensing lenses
A series of magnetic lenses focus the electrons into a tight beam.

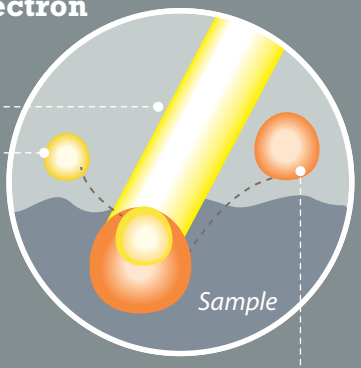
Objective lens
This helps focus the beam onto the sample.

Scanning coils
A set of coils moves the beam back and forth across the specimen.

Detectors
Detectors register electron current dispersed by the beam from the surface of the specimen.

What happens when the electron beam hits the specimen?

As the **electron beam** scans the specimen, different kinds of electrons are dislodged.



Secondary electrons
Atoms of the specimen absorb energy from the beam and give off their own electrons. These shallow electrons provide topographical information.

Backscattered electrons
These electrons are reflected from the surface, or from deeper within the specimen, to provide compositional information.

Table salt specimen

Monitor
Depending on the number of electrons that reach the detector, different levels of brightness are displayed on a monitor to create an image.

FANFARE

Nine UCI students with an interest in Internet of Things express their enthusiasm for participating in the UROP/Calit2 10-week summer undergraduate research fellowship program

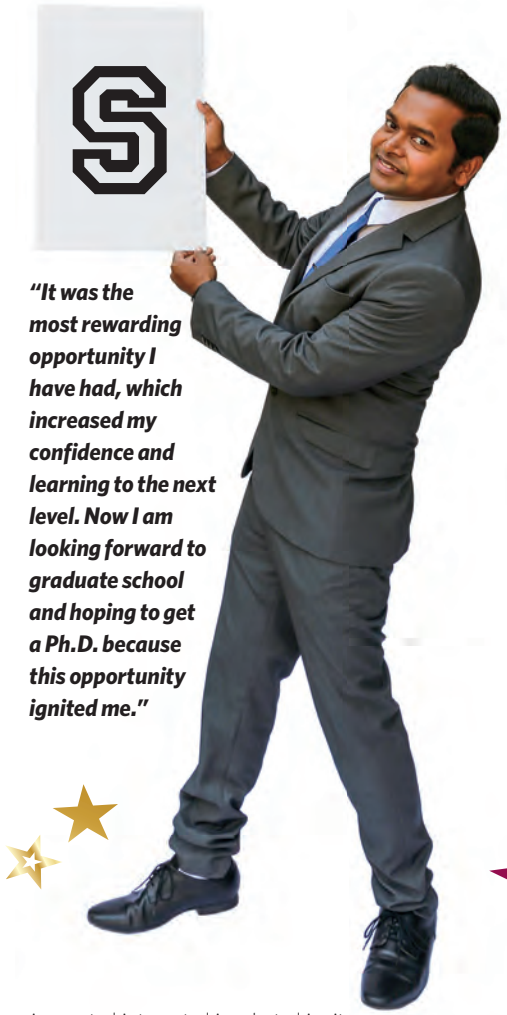
Shelly Nazarenus Debbie Morales

Project: Proabot Flotilla

Fellow: Asis Nath

Mentor: Simon Penny

Abstract: The goal of this project is to build a prototype for a fleet of inexpensive and environmentally friendly autonomous sailing craft – powered by sunlight and wind – for oceanographic and environmental research. The prototype is radio controlled, using a custom-control interface, two-way radio communication, and custom sensors and actuators. The final version will be linked to the Internet via satellite. In the prototype, the controller and boat both carry Arduino microcontrollers. Sail and rudder positions are given by the controller and managed by onboard sensor feedback. The first sensor suite includes a custom anemometer, wind-direction indicator, water-speed sensor and digital compass. Other sensors for collecting data such as turbidity, water chemistry, currents, temperature and radiation will be developed.



"It was the most rewarding opportunity I have had, which increased my confidence and learning to the next level. Now I am looking forward to graduate school and hoping to get a Ph.D. because this opportunity ignited me."

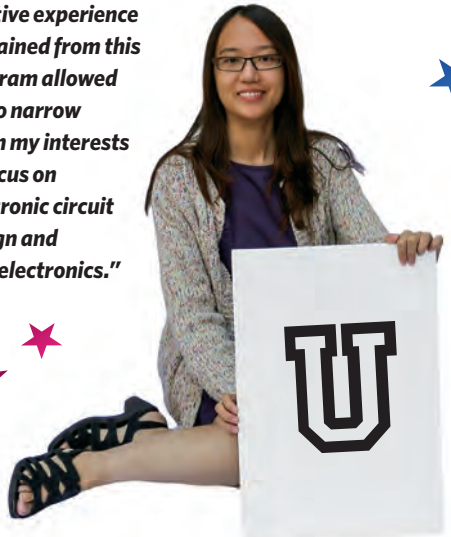
Project: Implantable Ocular Micro Pressure Sensor for Continuous Monitoring

Fellow: Ruthannah Wang

Mentors: G.P. Li, Mark Bachman, Sarkis Babikian

Abstract: Glaucoma, a medical condition caused by increased pressure within the eye, is the world's leading cause of blindness, with 70 million cases worldwide. Current methods of patient care have been inadequate for continuously monitoring the condition's development. In response to this need, this project explores two methods of designing an ocular implant with the ability to monitor eye pressure wirelessly and in real time. One is a radio-frequency resonator passive L-C circuit, which can be implanted in the eye, and consists of a micro inductor and a micro capacitor. The other method is an implantable passive optical sensor, consisting of a membrane with micro features. Scaled laboratory prototypes were fabricated for both types of sensors and tested inside a pressure chamber that was designed to represent a physical model of the eye with similar pressure conditions. Preliminary results suggest that both strategies yield easily interpreted data and generally are viable for a potential ocular implant design.

"Although I officially declared as an electrical engineering major prior to entering SURF-IoT, I was never sure of which specialization I wanted to pick within my major. The immensely positive experience I obtained from this program allowed me to narrow down my interests to focus on electronic circuit design and optoelectronics."



Project: MediCom

Fellow: Chifeng Wen

Mentors: John Billimek, Sergio Gago-Masague, Anmol Rajpurohit

Abstract: Medication adherence occurs when a patient takes his/her medications according to the prescribed dosage, time, frequency and direction. A breakdown in any one of these elements has the potential to result in unanticipated side effects and complications. Studies show that half of all patients do not take their medications as prescribed, more than one in five new prescriptions go unfilled, and compliance is lowest among patients with chronic illnesses. The MediCom project seeks to increase patient accountability by providing a comprehensive, intuitive and interactive multiplatform experience for patients to view and track their health data on computers, tablets and smartphones. The data is presented in user-friendly charts for patients and doctors, facilitating more informed decision-making regarding medication usage and effectiveness.

"This experience has been a great opportunity to put the principles I studied into practice. It creates the difference between knowing and understanding."

Project: A New AR Interface for Game-based Stroke Telerehabilitation

Fellow: Arzang Kasiri

Mentor: Walt Scacchi

Abstract: Augmented Reality (AR) is a means of human-computer interaction in which users perceive and interact with virtual objects juxtaposed with physical objects. In a prior study, AR game-based stroke telerehabilitation resulted in better outcomes compared to traditional game-based activity. The problem, however, was that the early AR version was too expensive to reproduce and not scalable. This project is developing version No. 2: a lower-cost, more scalable system through the use of IoT sensors, effectors and controllers. By using IoT technologies, the researchers created an affordable AR game that incorporates upper-extremity stroke rehabilitation exercises and movement gestures. The new version is being tested by stroke rehabilitation specialists.

Project: Algorithm to Effectively Feed Advertisements to Newsfeeds and Mobile Games

Fellow: Pablo Figueroa Lozano

Mentors: Amelia Regan and Dmitri Arkhipov

Abstract: While browsing through a given newsfeed or mobile gaming platform, there is a split-second decision that often goes unnoticed, but is integral to the user experience. A platform has to determine which particular advertisement is shown to a given user. This project focuses on writing and implementing code that determines which advertisement to show a user by implementing a metaheuristic algorithm that most effectively orders a set of given advertisements.

Project: TurtleBot with Qualcomm Snapdragon ARM CPU

Fellow: David Gogokhiya

Mentors: Solmaz Kia, Eli Bozorgzadeh

Abstract: Increasingly, mobile robots are used in applications such as rescue operations, and underwater and space exploration. However, for a swarm of robots to successfully accomplish its task, each robot must first determine its location in the environment. This project focuses on developing a robotic testbed for a robot-localization technique called cooperative localization, one of a number of promising algorithms for GPS-denied environments. The testbed consists of four mobile robots called Turtlebots, which were upgraded with Qualcomm Snapdragon ARM CPU-operating machines to increase control over the robots' computational and communication energy expenditures. The project is now focused on using Turtlebot's Kinect camera to take relative measurements from other robots in swarm operations to increase localization accuracy.

"My advice to incoming fellows is remember that failure is an important step to success. In fact, an important concept in design is to "fail faster." The idea being that most of your ideas will be duds, but every once in awhile, a rare and valuable one will show up. You want to hurry and find that one."

"My SURF-IoT experience was an enlightening fellowship that provided me with an immense appreciation for the work that is conducted by the faculty outside of the classroom. It was difficult, but it was incredibly rewarding."

"It was a great opportunity for me not just to learn something new and gain more experience in robotics, but also to improve my presentation skills."

Project: TagYourPlant

Fellow: Xin Hu

Mentors: Bill Tomlinson, Juliet Norton, Ankita Raturi

Abstract: People are producing and publishing a variety of local plant data on social media platforms, and hashtags are a useful mechanism for categorizing plants based on users' interests and observations, as well as for community participation. This work seeks to structure existing public plant datasets, improve access to communities of interest, and allow people to explore and learn more about native plants. TagYourPlant is a web application that mines plant pictures and hashtag data from two social media platforms: Twitter and Flickr. A dataset of approximately half a million posts was collected and processed. In contrast with plant data offered by academic or professional organizations, TagYourPlant provides relatable, concise and up-to-date data, making the search process social and visual.

"If you want to start your research journey, begin with UROP and SURF-IoT, one of the best opportunities and most welcoming and supportive programs around campus."

Project: Marching Cubes Made Tangible

Fellow: Aldrin Ryan Lupisan

Mentor: Jesse Jackson

Abstract: Marching Cubes is an interactive art installation comprised of 3-D printed construction units that engage participants through a playful interface enabled by media technology. The installation required a large number of 3-D printed blocks, so it provided an opportunity to optimize a printer farm. In this project, researchers created a farm, an array of 24 matching 3-D printers, with the goal of maximizing speed while maintaining an adequate finish. Two main parameters, infill and speed, were changed in the settings prior to printing. Both infill and travel speed determine how much filament is needed and how long a block takes to complete. The researchers ran various trials, adjusting the percentage of filament infill and the travel speed. Results were varied and failure came often. The project findings are important for the 3-D printing community since there are very few printer farms in existence that are rigorously tested at this rate. A detailed evaluation of successes and failures will be useful to similar future endeavors.

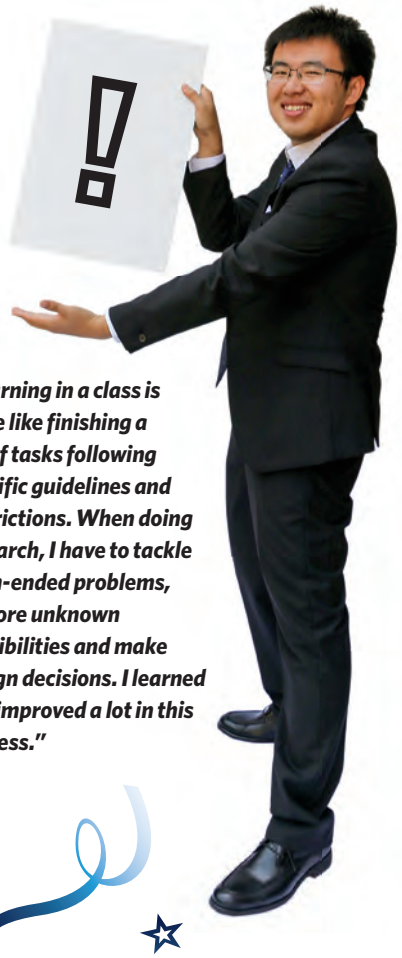
"Because of the experience and knowledge I've gained from participating in the program, I'd like to utilize aspects of IoT to help solve the problems we are currently addressing in my field of study, environmental engineering."

Project: News and Social Media Data Analytics using TextDB

Fellow: Zuozhi Wang

Mentor: Chen Li

Abstract: News and social media services such as Facebook and Twitter generate a huge amount of data on a daily basis. Many companies and organizations rely on this data to analyze user behaviors and make critical business decisions. These requirements bring many new challenges, including storage, search, analysis and visualization. This project studies ways to conduct text analytics on social media data, using state-of-the-art tools and techniques. As an example, researchers examined how to "extract information about Tweets mentioning Zika and their corresponding locations." The project is developing and using TextDB, a text-centric data-management system, to analyze news and social media data efficiently.



"Learning in a class is more like finishing a set of tasks following specific guidelines and restrictions. When doing research, I have to tackle open-ended problems, explore unknown possibilities and make design decisions. I learned and improved a lot in this process."

I'M SO HAPPY

REGULARLY SNAPPING SELFIES WITH YOUR SMARTPHONE AND SHARING PHOTOS WITH YOUR FRIENDS CAN HELP MAKE YOU A HAPPIER PERSON, ACCORDING TO COMPUTER SCIENTISTS AT THE UNIVERSITY OF CALIFORNIA, IRVINE.

In a first-of-its-kind study published just before back-to-school season, the authors found that students can combat the blues with some simple, deliberate actions on their mobile devices.

By conducting exercises via smartphone photo technology and gauging users' psychological and emotional states, the researchers found that the daily taking and sharing of certain types of images can positively affect people. The results of the study out of UCI's Donald Bren School of Information & Computer Sciences were published recently in the Psychology of Well-Being.

Brian Bell

UNIQUE STUDY FINDS TAKING AND SHARING SMARTPHONE

"Our research showed that practicing exercises that can promote happiness via smartphone picture taking and sharing can lead to increased positive feelings for those who engage in it," said lead author Yu Chen, a postdoctoral scholar in UCI's Department of Informatics. "This is particularly useful information for returning college students to be aware of, since they face many sources of pressure."

These stressors – financial difficulties, being away from home for the first time, feelings of loneliness and isolation, and the rigors of coursework – can negatively impact students' academic performance and lead to depression.

"The good news is that despite their susceptibility to strain, most college students constantly carry around a mobile device, which can be used for stress relief," Chen said. "Added to that are many applications and social media tools that make it easy to produce and send images."

The goal of the study, she said, was to help researchers understand the effects of photo taking on well-being in three areas: self-perception, in which people manipulated positive facial expressions; self-efficacy, in which they did things to make themselves happy; and pro-social, in which people did things to make others happy.

Chen and her colleagues designed and conducted a four-week study involving 41 college students. The subjects – 28 female and 13 male – were instructed to continue their normal day-to-day activities (going to class, doing schoolwork, meeting with friends, etc.) while taking part in the research.

But first each was invited to the informatics lab for an informal interview and to fill out a general questionnaire and consent form. The scientists helped students load a survey app onto their phones to document their moods during the first "control" week of the study. Participants used a different app to take photos and record their emotional states over the following three-week "intervention" phase.

Subjects reported their moods three times a day using the smartphone apps. In evening surveys, they were asked to provide details of any significant events that may have affected their emotions during the course of the day.

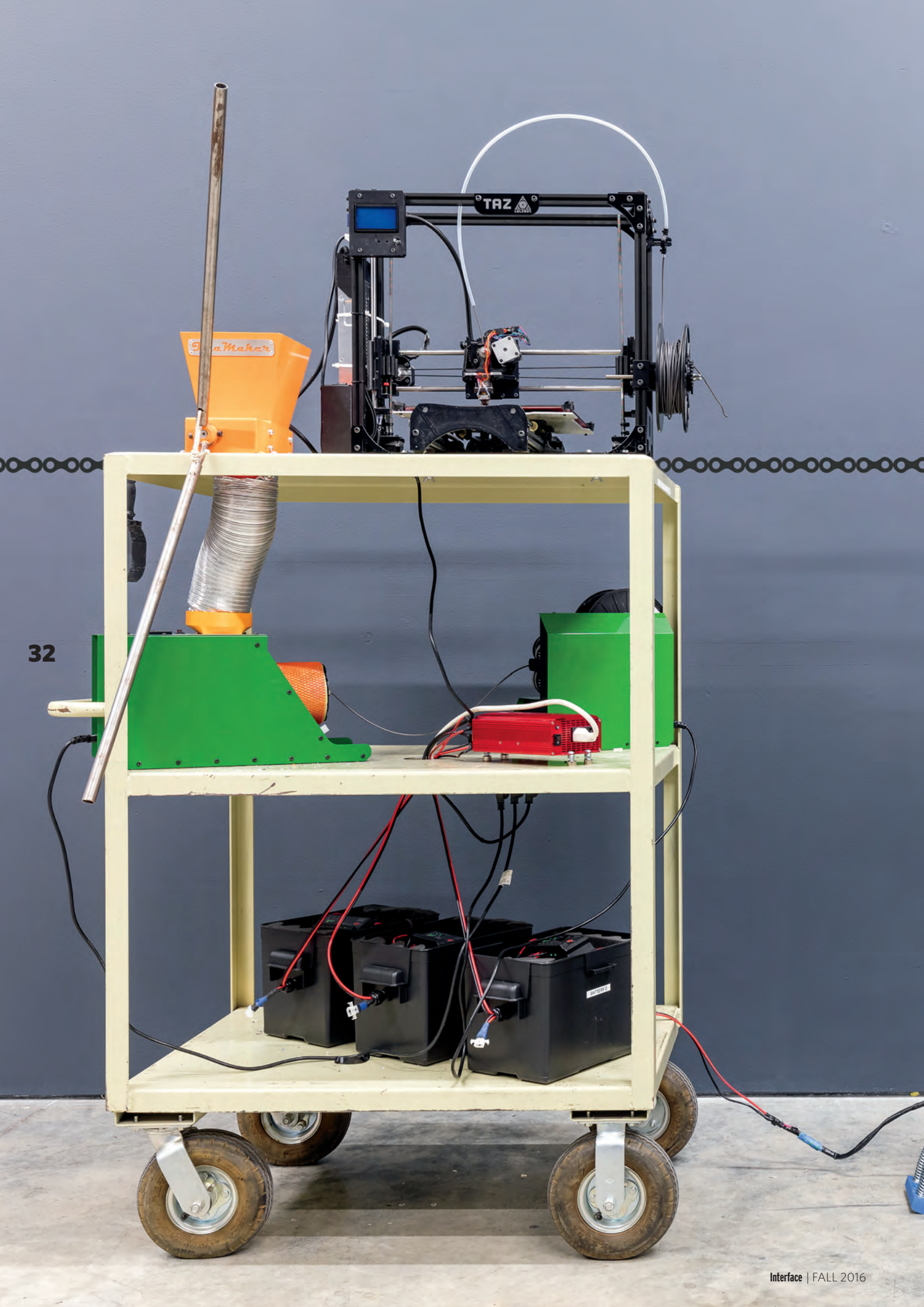
The project involved three types of photos to help the researchers determine how smiling, reflecting and giving to others might impact users' moods. The first was a selfie, to be taken daily while smiling. The second was an image of something that made the photo taker happy. The third was a picture of something the photographer believed would bring happiness to another person (which was then sent to that person). Participants were randomly assigned to take photos of one type.

Researchers collected nearly 2,900 mood measurements during the study and found that subjects in all three groups experienced increased positive moods. Some participants in the selfie group reported becoming more confident and comfortable with their smiling photos over time. The students taking photos of objects that made them happy became more reflective and appreciative. And those who took photos to make others happy became calmer and said that the connection to their friends and family helped relieve stress.

"You see a lot of reports in the media about the negative impacts of technology use, and we look very carefully at these issues here at UCI," said senior author Gloria Mark, a professor of informatics and Calit2-affiliated researcher. "But there have been expanded efforts over the past decade to study what's become known as 'positive computing,' and I think this study shows that sometimes our gadgets can offer benefits to users."

"Our research showed that practicing exercises that can promote happiness via smartphone picture taking and sharing can lead to increased positive feelings for those who engage in it."

PHOTOS BOOSTS POSITIVE FEELINGS


TAZ

Pedal POWER

A team of art and engineering students shares a creative drive for sustainability awareness

Anna Lynn Spitzer
Jesse Colin Jackson

Tucked into an inconspicuous space in one of UC Irvine's arts buildings is a potential game-changer: a why-didn't-I-think-of-that model that its creators hope will redefine environmental awareness and help reduce the world's surfeit of plastic waste.

The ambitious prototype is the brainchild of six very determined undergraduate students from different disciplines who worked together day and night for a year to create it, and their faculty mentor, an engineer-turned-architect-turned-artist.

Calling themselves S.P.A.M. (Specialists in Plastic Additive Manufacturing), the students are fine-tuning a mobile, bicycle-powered, closed-loop 3-D printer station that recycles its own waste.

It works like this: up to three riders pedal bicycles to power the cart-mounted operation; the system sends the energy to a generator, then to a battery, which stores it, and finally to an inverter. There, the DC power is converted into AC, which drives the 3-D printer. If the batteries are completely drained, it takes about an hour of moderate cycling by three riders to generate enough power to start the system. Additional pedaling will keep it running.

In addition to its human-powered energy stream, though, this system earns its environmental bona fides by recycling previously printed products. It grinds them into fragments, melts the plastic and extrudes it back into 3-millimeter plastic filament, spooling it to print the next job.

The project was conceived during last year's U.S. Department of Energy Solar Decathlon. UCI environmental engineering undergraduates Will Amos and Aldrin Lupisan – who met in their dorm freshman year – were on Team Orange County in the national competition to design and build energy-efficient houses. They were charged with designing a "Tool Room of the Future," which included a 3-D printer, for the team's house.

"During the Solar Decathlon, we talked often about this concept [but] we didn't have the proper time or resources to actually put the idea into action," Amos says.

Mechanical engineering undergraduate Amihan Amargo also was on Team Orange County, where she met Amos and Lupisan. Unbeknownst to the three budding engineers, Jesse Colin Jackson, a UCI arts professor with an undergraduate degree in civil engineering and expertise in additive manufacturing, was on the contest's faculty steering committee. Jackson was in possession of newly available lab space, and after meeting the undergrads, offered them a home for their project.

Then he introduced the engineering students to three like-minded arts students – Tina Chau, Aaron Hilado and Eunji Russ – and helped the new group obtain support from UCI's Undergraduate Research Opportunities Program and Calit2 Multidisciplinary Design Program (MDP).

"I had an existing research agenda in additive manufacturing, and the group wanted to put an additive manufacturing room in the Solar Decathlon house, so it evolved from there," Jackson says. "These students are not my graduate students; they didn't enroll to be part of the lab. It's a collective of people with common interests who want to tackle projects together."

A few members of last year's S.P.A.M. team graduated this year, but several new members are signing on, and the group

Three arts students joined three engineering students to become S.P.A.M. (Specialists in Plastic Additive Manufacturing); their first project is a human-pedal-powered mobile, sustainable 3-D printing system.

Previous page: Arts student Aaron Hilado demonstrates the closed-loop 3-D printer station that recycles its own waste.

> "We have reached a milestone ... a place where it works well enough to be able to describe what we've done, but we'd like to engineer it to work better on a practical level, which is quite a few more additional steps."

will continue its quest for sustainability. Its ultimate goal: recycling all of the lab's waste material. "It's a work in progress," says Jackson.

Amos, Lupisan and their new recruits will spend another school year honing the innovative system. Anticipated updates include the addition of wind and solar power, a feedback system to provide stats on how much power is being generated and synching the extractor and spooler to keep the system humming along efficiently.

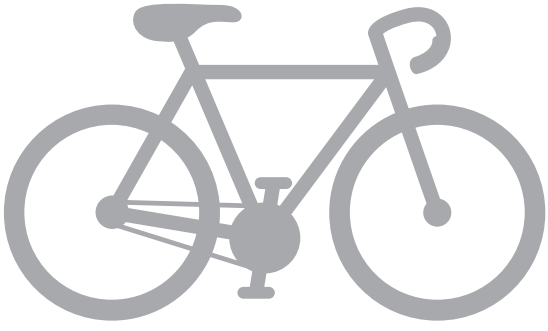
Team members say MDP, with its multidisciplinary emphasis, is a plus. "I've never really worked with engineers before," says artist Chau. "What one person lacks, the other makes up for. It was a really interesting experience to see how everyone's grown and changed for the better."

Amargo majored in mechanical engineering and minored in digital art. "Art students and engineering students do things differently, so it's nice to have different approaches."

S.P.A.M.'s efforts are reverberating well beyond UCI. The project is featured in "The 3D Additivist Cookbook," an e-book available later this year. Additionally, members have hauled the cart to area high schools, a TEDx event and other venues to share its message of environmental responsibility.

"We have reached a milestone ... a place where it works well enough to be able to describe what we've done, but we'd like to engineer it to work better on a practical level, which is quite a few more additional steps," says Amos, who was named one of six national winners of the 2016 Brower Youth Awards recognizing outstanding young leaders in the environmental movement.

For Jackson, the goal involves more than the next upgrade, cautioning that research goes beyond problem-solving. "Solving suggests that you're done, and none of these projects is ever done," Jackson says. "It's about asking new questions – we're more interested in asking new questions than we are in arriving at solutions."



A Parting Shot

Tiny batteries have made big news lately, much to the chagrin of a certain cell phone manufacturer.

So UC Irvine's invention of a nanowire-based electrode could be particularly timely, maybe even leading to batteries that don't require replacement.

Miniscule nanowires have been coveted by scientists for use in batteries because they are highly conductive and have a large surface area that's good for storing and transferring electrons. But the fragile filaments grow brittle quickly from repeated discharging and recharging (known as cycling), causing them to crack.

By encasing a gold nanowire in a manganese dioxide shell and covering the apparatus in a tough gel, researchers have created a device that can be recharged hundreds of thousands of times without cracking. They think the gel plasticizes the metal oxide in the battery, giving it flexibility and preventing damage.

"The coated electrode holds its shape much better, making it a more reliable option," says lead researcher Mya Le Thai, a chemistry doctoral student.

The findings were published in the American Chemical Society's "Energy Letters."

Under the direction of Professor G.P. Li, Calit2@UCI develops IoT technology-based innovations in a multidisciplinary research environment. By integrating academic research with industry experience, the institute seeks to benefit society, incubate new technology companies and ignite economic development. Calit2 focuses on the digital transformation of healthcare, energy, the environment and culture.

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