engineering news

School of Engineering

FALL 17

SANTA CLARA UNIVERSITY

DEAN'S MESSAGE

Photo: Adam Hays

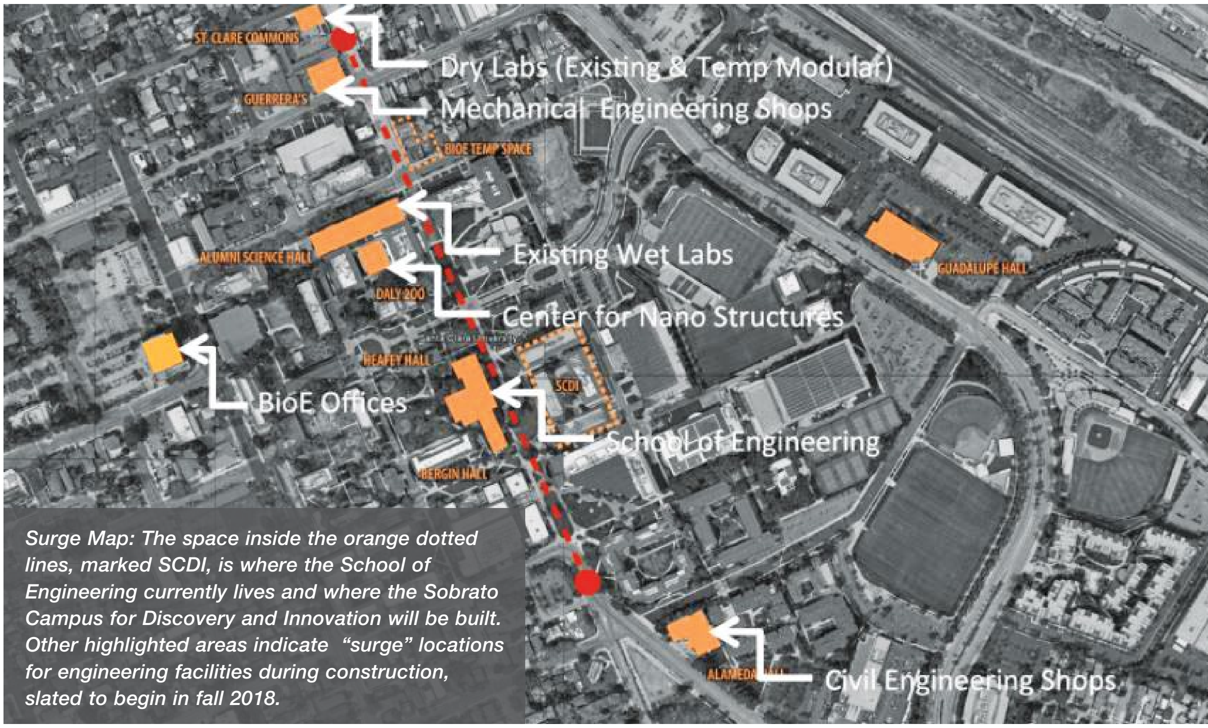
Fall Quarter is upon us! On behalf of the School of Engineering, welcome to our first newsletter of the year. As the new dean of the School of Engineering, I am absolutely thrilled to be one of the newest Broncos on campus. From the beautiful campus, to the many helpful and kind students, staff, and faculty that I have been fortunate to have met, to the many exciting academic, extracurricular, and research programs I'm learning more about, all I can say is: I am proud to be a Bronco!

We have been busy at work this summer on many details regarding the Sobrato Campus for Discovery and Innovation (the STEM building), the future home of the School of Engineering, scheduled to open in 2021. You can keep up with the new STEM building progress at **scu.edu/stem**. In addition, we have been hard at work designing many new laboratories and classrooms that will serve our School during the "surge" period while the Sobrato Campus is under construction beginning in fall 2018.

One thing will never change: Our dedication to being THE Jesuit University in Silicon Valley and everything that time-honored tradition represents.

Alfonso Ortega
Dean
School of Engineering

Surging Toward the Future



Surge Map: The space inside the orange dotted lines, marked SCDI, is where the School of Engineering currently lives and where the Sobrato Campus for Discovery and Innovation will be built. Other highlighted areas indicate "surge" locations for engineering facilities during construction, slated to begin in fall 2018.

With plans well underway for the ambitious new Sobrato Campus for Discovery and Innovation Center, STEM (science, technology, engineering, and mathematics) will be at the heart of SCU's campus. In preparation, engineering faculty, campus administrators, and architects have been feverishly working to ensure our engineering students' educational needs are met or exceeded during the construction process.

And what a process it will be! A year from now nearly all of the current engineering laboratories, classrooms, and offices will be razed, making way for the new construction. Termed "the surge project" (think powerful movement forward and upward), countless hours have been spent planning and deliberating the design, construction, and movement of programs into and out of temporary space and into their permanent homes. How will we do this while maintaining the excellence of our engineering programs throughout the duration of construction?

Recent major construction on campus has freed up a number of spaces for engineering's departments and programs, and great care has been taken to match the physical characteristics of temporary and permanent space to best align with program needs (i.e., high bay space for civil engineering, ample shop space for mechanical engineering, etc.). The result: a string of engineering surge spaces located in a corridor along The Alameda between Park and Fremont Streets, running right through the center of campus. This linear grouping will ease students' transition between classes and make wayfinding user-friendly for faculty and visitors, as well.

Construction on these surge facilities will be ongoing throughout this academic year, with move-in happening next summer. We will keep you posted on our progress as we surge toward an exciting future!

Watch our progress: scu.edu/stem

Delivering the Goods

While other students were spending the summer before their junior year escaping study, bioengineering major Grace Ling was immersed in it, looking for a way to eradicate cancer, cardiovascular ailments, and neurological diseases through a new method of gene therapy.

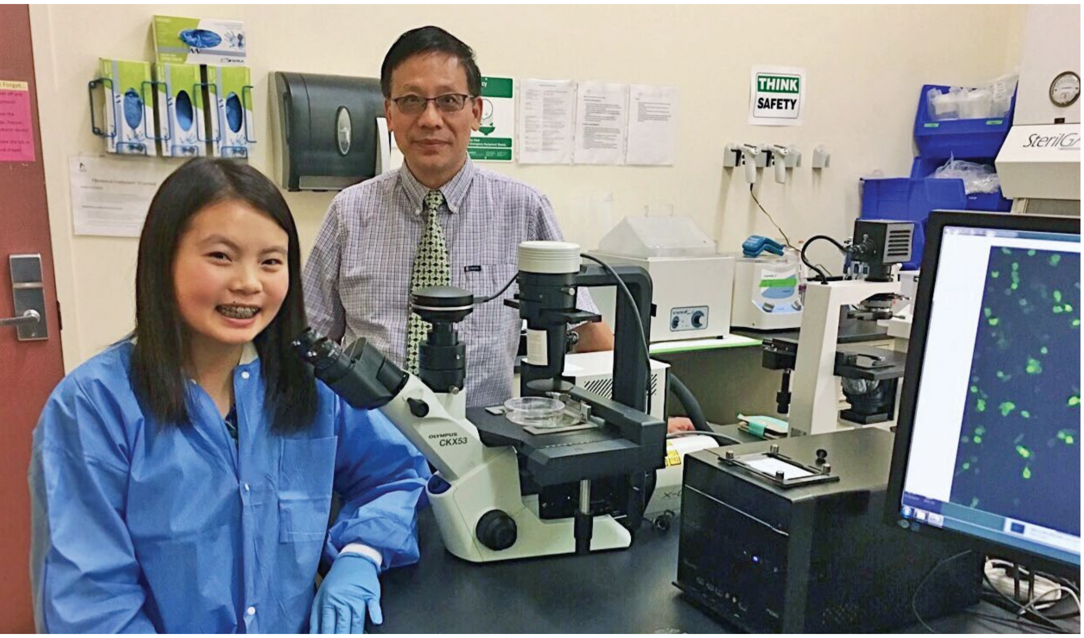


Photo: Heidi Williams

Grace Ling and Dr. Lu in the bioengineering laboratory.

Funded by a School of Engineering Kuehler Undergraduate Research Grant, Ling was paid to work with her faculty advisor, Assistant Professor Bill Lu, researching the viability of using human cell-derived nano-vesicle exosomes for gene delivery. “Current therapies all use a virus to deliver genes for repair of mutations in targeted cells,” explained Lu, who holds an M.D. in addition to a Ph.D. “Even if it is not safe to treat the body this way, it is effective. For this research, we propose using human exosomes [cellular vesicles, or sacs] that function like and are the same size and weight as a virus, but can deliver genes safely.” Ling adds, “To do this, we have to get the therapeutic gene into a small vesicle exosome and then deliver it.”

That’s a tall order for an undergraduate, but her professor knows she can deliver. “The newer generation of therapies need a tremendous amount of engineering, but Grace is doing very well academically. She has motivation and has done a lot of groundwork leading up to this research,” said Lu.

“In my first year at SCU I contacted Dr. Lu to see if I could work in his lab,” Ling said. “I spent a lot of time learning lab protocols, and I also started going through tons of literature on exosomes, learning about their applications. Two types of genetic material can be used in gene therapy—RNA and DNA. Current research uses exosomes to deliver RNA, but RNA is unable to penetrate into the nucleus where all the genetic material is stored, so results are only effective for one generation. DNA delivery gets to the nucleus, but this exosome-based safe strategy has not been well explored, so that’s where we decided to focus our research.”

Over the summer, Ling ran experiments on how best to deliver DNA, testing a heat shock method where the DNA is encapsulated within the exosome and a PEI coupling method, where the genetic material is adhered to the exterior of the exosome, held in place with polymeric nanoparticles, essentially as a glue. “DNA and the membrane of the exosome are negatively charged and the nanoparticle PEI is positively charged so they are going to hold each other together,” she said. “We hope to see a higher effectiveness of DNA getting into the cell. I’m working on figuring out the best concentrate of polymeric nanoparticle for DNA coupling and am testing heat shock methods, varying the time and temperature to see which is best at loading DNA into the exosome.” To measure how much DNA reaches its target, green and red fluorescent proteins and luciferase, the enzyme that causes a firefly to glow, are added to the genetic material.

With the protocols established and tests underway, the next step will be comparing their results to those of virus-delivered gene therapies. “We hope to prove our hypothesis that exosomes, a human-secreted nano-vesicle, have the same gene delivery efficiency as viruses, but are safer for gene therapy,” said Ling, who is continuing to work on this project throughout the school year.

And a busy year for her it will be. Aside from her course work and this research, she is also a computer engineering minor, a member of Santa Clara’s cross country and track team, has a food art and lifestyle blog, and is designing “Cell-fie,” a biology-inspired virtual reality video game where players interact with and learn from characters like Nella Nucleus, earning the organelle’s particular powers—the ability to synthesize genes and repair mutations, in this case—along the way. Yes, it’s going to be a jam-packed year, but with admirable understatement, she says, “I like to stay busy!”

More on Cell-fie:
https://grace-ling.com/cell-fie

DISCOVERY CAN BE SO SWEET

You never know what gift might spark creativity or what glimmer of an idea might pay big dividends in the long run. When electrical engineering Adjunct Professor Allen Sweet was just 10 years old, his father presented him with a crystal radio set kit. As he built his first radio, he began demystifying the wonders of physics and engineering. Hearing the first very faint transmissions from his simple radio receiver, Sweet recalls, "I was in love!" Ever since that day, he has been building better and better—and smaller and smaller—radios over a career that has involved a lifelong love affair with telecommunications. Now, a discovery he made decades ago just might be about to hit the big time.

With a Ph.D. from Cornell University, Sweet became involved with telecommunications "way back, pre-cellular in the 1970s," where he whetted his appetite for the field by building components for long distance microwave transmissions. Over the years he worked at some of Silicon Valley's largest companies, becoming a radio frequency/microwave communications expert along the way and eventually starting his own consulting firm. "There were a lot of people doing new and unique things in the 1990s, and it was exciting helping clients find their way in wireless communications," said Sweet, who served as program chair for the very first conference on commercial uses of microwave technology held in Santa Clara, California, in 1994.

It was during the early 2000s that Sweet began working with the president of a small Santa Rosa company (Vida Products Inc.) on an invention so ahead of its time, they didn't quite know what they had. "With a Small Business Innovation Research grant sponsored by NASA we were able to lay some groundwork for advanced wireless communication and we patented certain aspects of our work, built some prototypes, found investors, but realized something was missing. The invention lay asleep while we tried to figure out the right way to take advantage of our discovery. At the time, we didn't fully understand the significance of our work," he said.

While this idea was percolating deep within his brain, Sweet began teaching graduate electrical engineering courses at SCU. Bringing decades of cutting-edge experience into the classroom, he teaches introductory and advanced courses in radio frequency integrated circuit (RFIC) design, while simultaneously continuing his research and consultancy that now includes laser scanners, fiber optics, high speed optical receivers, high efficiency 4G linear power amplifiers, and so much more.

Photo: Courtesy of Allen Sweet

Allen Sweet and Paul Wang conduct their research on 5G cellular technology in the Lawrence Berkeley National Laboratory's Nanotechnology Center.

In lieu of a traditional final, students in his class are challenged to create their own integrated circuit (IC). "I take them through the individual pieces of an RFIC throughout the quarter and at the end I give them the overall specs for a relatively large IC. It's up to them to find creative ways to put the bits and pieces together to tailor an end product for the customer." Different components and configurations have different weaknesses and strengths; taking advantage of those combinations is the challenge of the assignment. "It stretches them to be creative and think outside the box. Grad students are good at that," he added.

Capitalizing on the talent in his classroom, the professor has tapped one of his students, recent M.S. graduate Szu-Fan (Paul) Wang, to help him advance the field of nanotechnology. Now, nearly twenty years after patenting those ahead-of-their-time ideas, Sweet believes his inventions could unlock 5G cellular technology. "The worldwide cellular communications network is completely saturated," he said. "There is not enough spectrum available for all the necessary cell calls and data transmissions. It has reached the limit and people in the cellular network business need revolutionary change—fifth generation cellular technology that far surpasses 4G, operating at higher frequencies and at 10x data rate. Everything has to scale by a factor of 10." With excitement in his voice he adds, "My co-inventor and I are looking at what our discovery can contribute. We think it can not only contribute, it may be essential to the success of 5G."

To make their 12-year-old discovery viable today, they were invited to research minitiarizing the invention at Lawrence Berkeley National Laboratory's world-class nanotechnology center.

"We realized our device was too big to fit in a cellular handset. We need to make an integrated circuit out of it, but it's difficult to shrink all the pieces and parts down to the molecular level. The Lab invites people in to work on pet ideas that will help nanotechnology grow in new and different ways. Paul and I are working on how to grow a certain compound [called] YIG for use in the IC that is, at its root, a kind of gemstone called garnet. Adding other elements to garnet generates an extremely coherent, low noise signal based on spin precession occurring at the higher frequencies necessary for 5G. I think we're way ahead of the game at this; we can offer a factor of five increase in data rate using our signal sources," he said.

"We still need to get over a couple significant hurdles," he cautioned. "But we're getting ready to test, and if successful, it would be a great breakthrough!" Wouldn't that be sweet!

THE INTERNET OF YOU

The Internet of Things (IoT) is becoming ubiquitous in our lives—your electric car sends a text when it's fully charged, and your home's thermostat and lights can activate as you pull into the driveway, but what if your doctor could activate an insulin injection for you remotely, or send an ambulance to your home if alerted that your heartrate is dropping? Those are possibilities computer engineering's Assistant Professor Behnam Dezfouli and senior Angelina Poole are tackling as they work to enable existing WiFi infrastructures for medical applications.

Dezfouli has been active in this field of wireless sensor networks for over a decade (before it was known as IoT) and has designed various systems for smart agriculture, homes, and cities, but he found medical applications of IoT interest him most. "About two years ago, I developed a wireless system for collecting data from a patient's body and transmitting it to a hospital's proprietary wireless system, but I was always interested in using existing wireless infrastructure for these types of applications," he said.

For her part, Poole, who is also pursuing a bioengineering minor, was intrigued by the project because it touches on both the medical and computer engineering fields. "It's something that's closely related to what I want to do in the future. Implementing my knowledge of computer engineering in the medical field is of great interest to me," she said. Last spring, Poole applied and was awarded a Clare Boothe Luce Grant supporting women in engineering and since then she and her professor have been hard at work.

"Normally, to collect vital signs from a patient, many wires must be attached to the body," explained Dezfouli. "We want to remove those wires and create a small device to be worn on the body that connects with WiFi to collect data on a central aggregation point, such as a smart phone, which then transmits that data to the patient's own access point, or to the doctor's, or hospital's, and then to the cloud."

The two biggest problems with creating such a system? Making it energy efficient (so it doesn't drain the batteries of your iPhone while it is collecting your vitals), and ensuring data is delivered in a timely and reliable manner. To address these problems, the pair collaborated with engineers at Cypress and Samsung to develop different software installed on various devices, setting up a testbed for data communication between IoT devices and access points. "We're simulating the traffic pattern of different IoT systems or medical devices to measure how background traffic and concurrent use of the wireless infrastructure affects reliability and energy efficiency of these devices," Dezfouli said. "If you want to implement a wireless medical system in your home," Poole adds, "you don't want it to be affected by housemates streaming video or by interference caused by neighboring access points."

Poole works with a small team of graduate and Ph.D. students, transmitting packets of information and collecting data on signal strength, noise, and the time it takes to send a data packet. "Different medical devices have different sizes of packets or units of information, so to simulate what the network will be dealing with, we're varying the amounts of time, designing experiments about how to send information in ways that use the least amount of power," she said. "Right," Dezfouli chimes in, "if we're collecting samples from 10 different sensors, we need to know the best way to transmit the data—when the device should wake up and when it should sleep so that the minimum amount of energy is consumed. Collect, aggregate, transmit, sleep... repeat. We are determining the best traffic shaping strategy, and it's tricky because we have to measure the energy consumption for a very long duration, say a week."

Initial findings are due this fall with major results and a paper expected next spring. Poole is also working on a paper that reviews and investigates wireless technologies used for medical IoT systems. "As an undergraduate student, I think working on this project is an amazing opportunity. Having the chance to work with master's and Ph.D. students—to see how they question things and learn from the solutions they propose to existing problems has really opened my eyes to the possibility of pursuing a Ph.D."

Meanwhile, Dezfouli has been in discussion with folks at Kaiser about this research and they want to see a demo. "They need a robust in-home medical monitoring system. Hopefully we can demonstrate viability and apply for some grants to continue this work."

Photo: Nicole Morales

Angelina Poole '18 and Assistant Professor Behnam Dezfouli are developing an energy-efficient, wireless in-home medical monitoring system.

Sustaining a Passion

At SCU we strive to inspire and develop entrepreneurial thinkers who will build a more just, humane, and sustainable world. It's a lofty goal, but we know we are succeeding when we see our students moving from theory to impact in the world. A shining example of engineering for good is electrical engineering alumnus Richard Navarro '10, M.S. '12, now a Google E-Team Operations Integrator—or sustainability engineer—with responsibility for the Bay Area, Europe, and Asia, who got his start in this field as the electrical lead on SCU's Third Place winning entry in the U.S. Department of Energy's 2009 Solar Decathlon. Navarro credits his Santa Clara education and hands-on experience working with a team of fellow undergraduates to design and build a fully functional sustainable home with giving him the confidence and chutzpah to take on grand challenges.

Still in his senior year, Navarro was first hired by Google as a Green Consultant, tasked with helping the company achieve LEED green certification. "It was one of the most challenging things," Navarro said, "because at the time I had no background besides the Solar Decathlon house in getting a green building certification out the door. It was a project that typically took two years, but we were able to do it in one. That was with me literally just learning on the fly, getting through each piece of the documentation, working with a number of teams, and…getting them to think about sustainability and how it really applies to them. Getting a building on Google's campus certified, getting people to think differently…. I felt like I had a huge effect. Taking what I learned from Solar Decathlon, bringing it to the campus here at Google, and then building a sustainability program on top of that—one that affects Google's global operations—it's crazy! That had a domino effect for how Google thought about sustainability for their operations."

While Navarro was driving a passion for sustainability, he was also becoming a more effective teammate. His Solar Decathlon experience had given him a great start, but at Google he was being exposed to different team cultures that required deeper empathy and understanding. So, as he was pursuing his master's degree in sustainable engineering, he completed a graduate minor in science, technology, and society (STS). "The STS minor has great courses focused on working with global cultures and how gender functions in the workplace, and just learning about how technology affects society. I knew I could get the technical stuff, but there's so much more out there," he said.

One of his favorite courses was Building Global Teams, which "unraveled so much" about situations he was facing at work. "Being able to float in between cultures and different work styles is super important," said Navarro. "No matter how 'American' a global company like Google is, there is still a lot of local culture embedded. I totally respect that, and now I have a roadmap to help navigate it. Marian Stetson-Rodriguez, who taught the course, was so dead-on to all the roadblocks I was facing, and it was super helpful and relevant."

These days, Navarro works with colleagues around the world looking for opportunities to be more sustainable—reducing waste, reusing water, and running Google's buildings at the highest level of efficiency. "One of the big issues we're focused on recently is inner air quality and examining how the indoor environment affects the Google employees," he said. "As much as my role is in sustainability, it's also in health and wellness. And that's super challenging, but—especially as an engineer from Santa Clara—I'm used to solving big problems, to tackle them, to be curious.

"The coursework and community I built at Santa Clara definitely shaped the kind of teammate I am at Google. Google is very important as well because they've allowed me to explore. I couldn't have asked for anything better, going from Santa Clara to Google. It was like a match made in heaven!"

Photo: Charles Barry

Richard Navarro, shown here working on SCU's 2009 Solar Decathlon house, credits that experience with his success at Google.

What's it really like being a young engineer boosting the sustainability of Google's operations globally? Read the full interview at: scu.edu/engineering/Navarro

John Thomas '86 Named San Francisco City Engineer


Photo: Courtesy of John Thomas

John Thomas '86 has been named San Francisco's City Engineer and deputy director for infrastructure. Throughout a 30-year career with San Francisco Public Works managing billion-dollar projects ranging from subways to hospital renovation, he has often faced challenges that pushed him out of his comfort zone, but he credits his profession with helping him through. "A civil engineering career teaches you to learn and study and respond. It has given me the confidence and tools to deal with problems as they arise," he said.

Thomas said he is grateful for the world-changing career path civil engineering has afforded him. "Civil engineering impacts society on a broad scale. At the outset, some projects' goals are incredibly transformative and inspirational. Once they are achieved you just think, 'Wow, that's amazing!' I grew to love what I do for a living and its potential upside."

One example? The Embarcadero project—begun when San Francisco's elevated freeway was damaged beyond repair in the 1989 Loma Prieta earthquake. Thomas oversaw a complete overhaul of a waterfront district full of abandoned railroad tracks and decrepit remnants dating back to World War I. The resulting "grand boulevard" with light rail is a favorite thoroughfare among tourists and residents alike. "When tens of thousands of people are out enjoying the promenade, it's exciting to see all the effort come to fruition," Thomas said.

Allowing the people, rather than cars, to "own the city" is something Thomas aspires to. "We're adapting to a changing world. How do we take a small city with a growing population and increasing density and still have mobility? We have to look ahead for ways to adapt," said Thomas, who commutes daily on his bike and Caltrain.

Adding to transportation and mobility challenges are an aging infrastructure—"our water and sewer systems are over 100 years old," he noted—along with the projected effects of climate change and sea level rise. "We don't have the same problems Texas and Florida have had with Hurricanes Harvey and Irma," Thomas admitted, "but in San Francisco we have our own set of risks—king tides, earthquakes. We have to make sure solutions are in place and the capacity is there to respond effectively. As a native of the City of San Francisco, it is a great honor to be in this dynamic, constantly evolving role and to be given the opportunity to have an impact on the city and the projects we take on—and hopefully make things better than when I started!"

SEPEHRBAND AWARDED NSF GRANT

Curious, inquisitive, dogged, persistent… all fitting words to describe Panthea Sepehrband, mechanical engineering assistant professor. She's also crazy intelligent, funny, supportive, and generous—but we'll save those for another time. Recently, Sepehrband was awarded $328,975 in NSF Grant Opportunities for Academic Liaison with Industry (GOALI) funding to investigate how ultrasonic bonding occurs at the atomic level. But getting that funding was anything but easy.

The award is a testament to Sepehrband's persistence. When she came to SCU from Canada in 2012, she was just starting her research in wire bonding—the technique used to interconnect integrated circuits and their packaging during semiconductor fabrication. "Ultrasonic vibration is essential for various solid-state bonding techniques used in the consumer electronics, defense, automotive, and aerospace industries," she explained. "We know this process works, but we don't know why or how; I wanted to find out."

Curious as to whether her research would also be of interest to industry, she put a Google alert on her computer using the buzzword "wire bonding" and soon found herself at a workshop talking with as many people as she could, testing the waters. "The research matches well with my background, but I wasn't sure if it was worth pursuing for industry," she recalled. Turns out the folks at Kulicke & Soffa (K&S), a leading provider of wire bonding machines for micro packaging, were very interested. Enough so that they donated a machine for her lab, sent an installer, and trained her students on its use. Since then, Sepehrband and K&S have been working together on a mechanism of bond formation.

Prior to this collaboration, Sepehrband and her co-PI, mechanical engineering Adjunct Professor Calvin Tszeng, had begun submitting NSF funding proposals, with limited success. "Coming from Canada, I had no experience with NSF," Sepehrband said. "It's very easy to get small amounts of funding in Canada; but here it is very competitive because you are vying for bigger money. I had to spend a lot of time learning how to apply for funding. I attended workshops, learned how to write proposals, bugged the NSF program officer at any conference I attended, and eventually was invited to review proposals. It was a long process of learning and building a network here in the United States."

A 2013 proposal uncovered another roadblock. "Initially, reviewers questioned the capability of SCU to conduct this level of research," she said. "So over the past four years I've used any means I could to build up a strong foundation. I've obtained 14 internal grants from the School of Engineering and the Department of Mechanical Engineering, ranging from under $5,000 to $170,000 to outfit my lab and to support student researchers from undergraduate through postdoc. With these funds, I've been able to add a nanoindenter for measuring and testing very small volumes of mechanical properties.

"The School and my department have been very generous, and I'm so grateful for their support. I also tapped into SCU's Center for Nanostructures, using their equipment for analysis. All this made it very clear to the reviewers—upon the fourth submission—that SCU can definitely conduct this level of research!" she added, with a laugh.

Having built the foundation and landed the funding, the three-year research project is off and running. The work is divided into three sections: atomic scale modeling conducted by Ph.D. students; experimental analysis and materials characterization performed by undergraduates and graduate students; and finite element analysis. "The nice thing about this project is that it has multiple levels of complexity," said Sepehrband, "so we can have Ph.D., M.S., and undergraduate students working on various aspects of the research. Calvin will advise graduate students on finite element modeling, and Henri Seppaenen from K&S will serve as a general advisor. The close collaboration with an industrial partner provides a unique learning environment for the students, preparing them with relevant experience that is closely aligned with the needs of Silicon Valley's microelectronics industry," she added.

Based on the combination of modeling results and experimental analysis, Sepehrband and Tszeng plan to create a new workshop for university outreach activities promoting STEM fields among K-12 and underrepresented students. "It's exciting to get the younger generation interested in materials science and engineering," Sepehrband said. "I'm still amazed at this bonding; I can't wait to figure out why and how it happens!"

Photo: Courtesy of Nicole Morales

Panthea Sepehrband oversees the research of Ph.D. student Milad Khajehvand and undergraduate Jamie Ferris.

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The Jesuit University in Silicon Valley

Photo: Courtesy of SCU Engineers Without Borders

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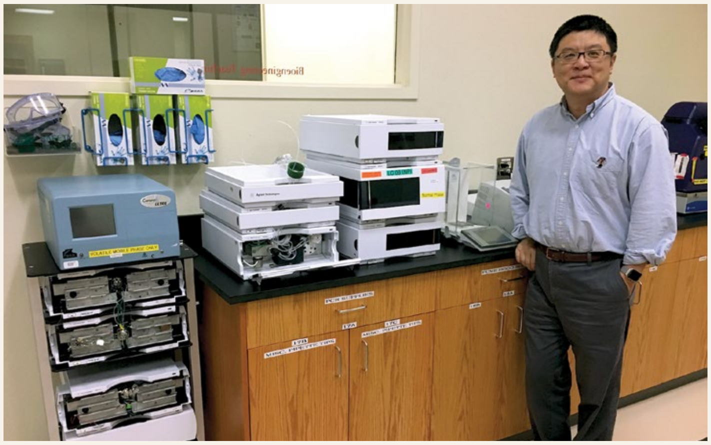
GENENTECH'S GENEROSITY BENEFITS BIOENGINEERING

The Department of Bioengineering recently received an Agilent high performance liquid chromatography (HPLC) system, complete with advanced molecular separation and detection modules and top-of-the-line microbalance for departmental teaching and research from Genentech, a world leader in pharmaceutical discovery and development for the treatment of serious or life-threatening medical conditions.

Photo: Heidi Williams



Complex new tools for high-level bio-tech research give Associate Professor Jonathan Zhang's students real-world experience.

"In SCU's bioengineering program, the theme is 'engineering toward therapy,'" bioengineering Associate Professor Jonathan Zhang said. "Students in our program learn about and research protein engineering and protein drug discovery. Not only will this new equipment help us teach more efficiently, it will also give our students experience working on the same equipment Genentech is using now. Students appreciate the curriculum more when they can see a direct tie to their career aspirations. Having the same hands-on experience with high-end, sophisticated equipment being used by a Silicon Valley biotech icon for biomolecular analysis makes it very clear what they are working toward," he added. The equipment has a replacement value in the neighborhood of $180,000.

Moving to the next stage of collaboration, talks are underway to form a strategic partnership between Genentech and the Department of Bioengineering to include research and internship opportunities. "Taking advantage of the strategic location of SCU at the center of Silicon Valley," said Zhang, "we are also in talks with other bio- and medical high tech neighbors such as Agilent, a leading biodevice company located right in our neighborhood. Even though our bioengineering department is relatively new, it is one of the strongest in the Bay Area and we are gaining in reputation locally and internationally," Zhang said. "It is exciting to see doors opening for us with these industry leaders."

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