Penn Engineering

Service Learning

Early this summer, a team of students from Penn's chapter of Engineers Without Borders (EWB) traveled to the Guatemalan village of Tzununa to address critical sanitation needs. The crew labored alongside local masons and homeowners to construct latrines for the village.

While the outcome of improving the overall wellbeing and hygiene of the community may seem obvious to the outsider, the project included a critical health education component. Though it was hard, physical work, opportunities for student engagement with the community in which they were working enriched the service learning experience exponentially.

CONTENT

Penn Engineering / Fall 2016

University of Pennsylvania
School of Engineering and Applied Science

"WHEN ON PENN'S CAMPUS, YOU CAN TAKE MANY PATHS. LEARNING TO DECIDE FOR YOURSELF, AFTER TAKING INPUT FROM THOSE YOU TRUST, IS AN ASPECT OF MY PENN EDUCATION THAT HELPED ME TREMENDOUSLY."

Penn Engineering Magazine
alumni@seas.upenn.edu
215-898-6564
www.seas.upenn.edu

Vijay Kumar
Nemirovsky Family Dean

George W. Hain III
Vice Dean, External Affairs
Development and Alumni Relations

Joan S. Gocke
Director of Communications
Editor

Design
Kelsh Wilson Design

Photography
Kelsh Wilson Design
Lamont Abrams
John Carlano
Michael Moran/OTTO

VIJAY KUMAR
Nemirovsky Family Dean

Technology as a Liberal Art

I feel fortunate to be a technologist. I feel even more fortunate because I am the dean of Penn Engineering at the University of Pennsylvania, one of the world's finest institutions where the liberal arts are elevated and taught together with the professional disciplines.

Above all, Penn aims to produce leaders who will change the world for the better through their chosen fields. Whether the challenge is food security, water shortages, malnourished children, clean energy, more efficient transportation networks, or fighting infections and pandemics, it is difficult to imagine solutions that do not require technological innovation. It is important that we, as engineers, ensure that there is technological literacy in the next generation of leaders from all disciplines, just as we want our engineering graduates to be skilled communicators and multifaceted thinkers.

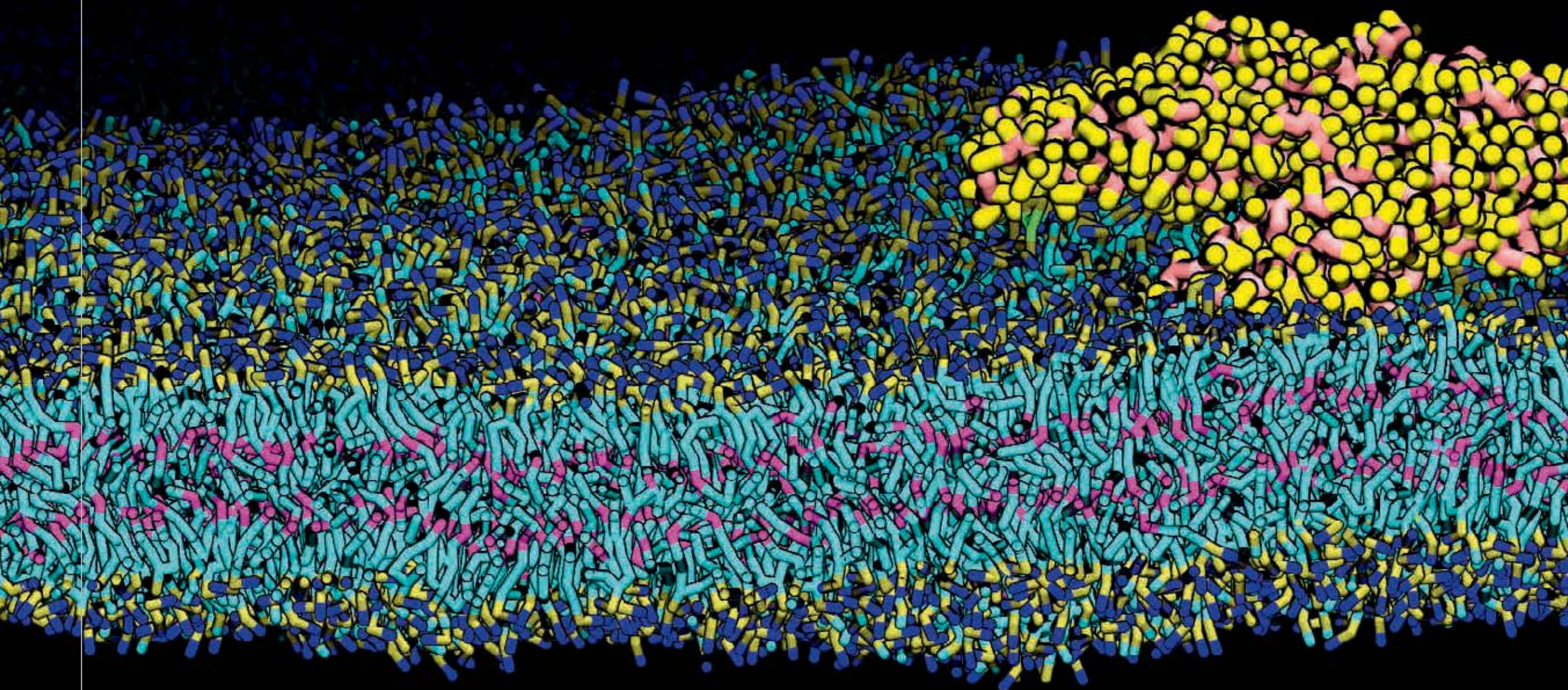
When Benjamin Franklin was outlining the basis for what would eventually become the University of Pennsylvania, he was far ahead of his time when he insisted that students be educated in what was "most useful and most ornamental." I argue that today the two cannot be separated. According to the Association of American Colleges and Universities (AACU), a liberal education is about developing strong and transferable intellectual and practical skills. Should it not include learning about technology to empower individuals and prepare them to deal with complexity and change?

We are on the cusp of a transformation in higher education. Open opportunities for learning, such as those afforded by Coursera (in which Penn was a founding partner), will continue to break down the traditional borders that used to confine disciplines into their individual buildings, labs and campuses. Lines are being blurred, and students want programs that allow them to combine philosophy with computer science and bioengineering with art.

Institutions like Penn are well positioned to make this happen. The liberal arts count among their alumni leading social scientists, economists, historians and policy makers, and will soon include those trained in engineering.

Why Cells Go Rogue

Prediction Tools for Better Cancer Outcomes



Ravi Radhakrishnan designs and continually refines computer models, illuminating fundamental mechanisms of central importance in biological engineering relevant to cancer research.

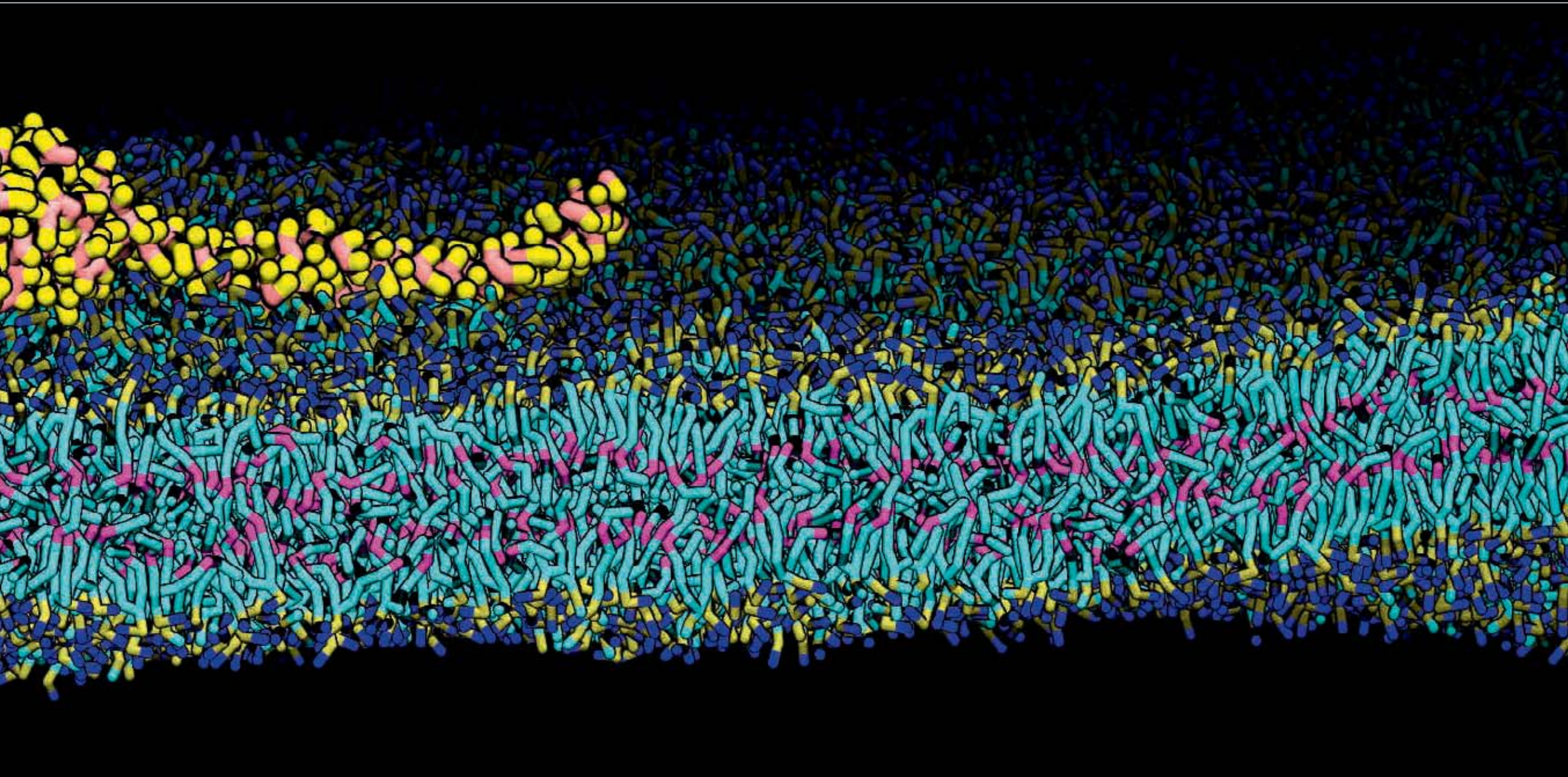
On a daily, often hourly basis, at a pace that reflects the urgent need for this information, his lab integrates new data and poses questions to chemists, cell biologists, pharmacologists and oncologists. "I am continually engaging with these communities of researchers," says Radhakrishnan, professor in Bioengineering and in Chemical and Biomolecular Engineering. "The most central paradigm in our lab is to make sure that the theory and models that we construct actually interface with all of these collaborators and different scales in a meaningful way."

Radhakrishnan, a member of the National Cancer Institute's (NCI) Physical Sciences Oncology Center at Penn, works at the interface of chemical physics

RADHAKRISHNAN AND HIS TEAM UNDERSTAND THE FUNDAMENTAL BIOPHYSICS AND MATHEMATICS AND HOW TO INTEGRATE THESE INTO PREDICTIONS AND INSIGHT FOR LEADING-EDGE EXPERIMENTS.

and molecular biology. His lab develops computer models that synthesize fundamental laws of physics and biology with *in vitro* experimental and patient-specific genomic data. As data is continuously added, these computer models have become increasingly more quantitatively accurate and useful for cancer screening and diagnostics, clinical decision-making about therapeutics, and development of next-generation therapeutics (such as nanocapsules that can deliver cancer medication to diseased cells only, without harming adjacent healthy cells).

A molecular simulation of a protein (yellow) using thermal waves to help bend a cell membrane into different shapes.



Dennis E. Discher, Robert D. Bent Professor in Chemical and Biomolecular Engineering and principal investigator of the Oncology Center, notes that, "NCI realizes you're not going to answer everything with genetics, even when doing all the sequencing you want. Other scientists in our center are experimentalists with strong theory backgrounds, so there's a robust interplay with Ravi's group. Ravi and his team understand the fundamental biophysics and mathematics and how to integrate these into predictions and insight for leading-edge experiments."

INTEGRATING DATA

"I see the potential of our approach to be truly transformative and to touch a large class of people and patients," says Radhakrishnan, whose lab may well be the first to design computer models that integrate data at the scale of individual atoms and electrons, utilizing data sources ranging from membranes, proteins, cells, tissues, organs, mice, individual patients and large cohorts of patients with cancer.

"Ravi's methods have made people sit up and take notice," says Mark A. Lemmon, co-director of Yale University's Cancer Biology Institute. His ongoing collaboration with Radhakrishnan and Yael Mossé, a pediatric oncologist at The Children's Hospital of Philadelphia, has generated a comprehensive computational model of key gene mutations of importance to the treatment of neuroblastoma, a childhood cancer.

"We routinely get urgent requests from clinicians around the world who need to know whether their patient's specific mutation would respond to a drug targeting that mutation," says Lemmon. "The dream is that a clinician would pick up an iPhone and plug in the neuroblastoma mutation. With what Ravi has developed, in principle it could be that simple."

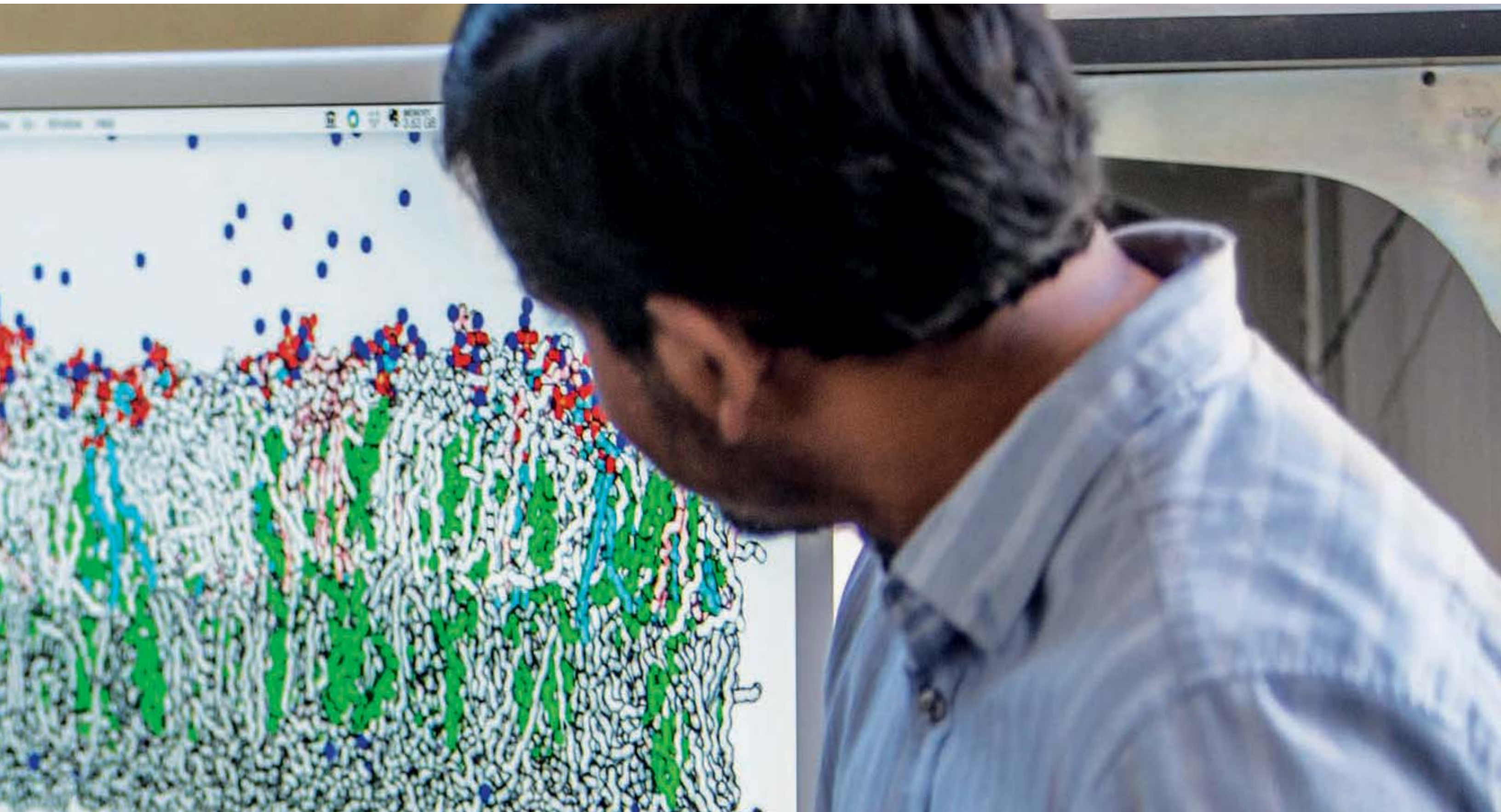
WHALE SOUNDS

Even as he generates insights relevant to patient care, Radhakrishnan's lab also investigates cancer-relevant properties in proteins that are a thousand times smaller than a single cell. Radhakrishnan and recent doctoral graduate Ryan Bradley co-authored a paper in July's *Proceedings of the National Academy of Sciences (PNAS)* in which they explain their crucial new insights about the mechanisms that individual proteins use to signal each other across long distances: They use undulations of thermal waves to spur proteins on faraway cell membranes to form capsules that perform basic necessary cellular functions such as metabolizing, migrating and proliferating.

"A cell starts to become a 'rogue' cell as these capsules malfunction," says Radhakrishnan. A cancer tumor is a cluster of these rogue cells. "Just as whales talk to one another through sound waves in the ocean, similarly proteins can feel the presence of neighbors from fairly far away via these elastic waves. Such learnings of fundamental biophysical interactions can be carried forward and applied to future technologies for cancer diagnostics and could also inform drug design. For example, can we artificially create nanocapsules filled with drugs using small molecules to shut off certain proteins, and also shuttle those drugs to where you need them the most? That's something we can start designing based on these findings."

THESE FUNDAMENTAL SCIENTIFIC INSIGHTS MAY BE THE UNDERPINNING FOR A NEW FORM OF CANCER DIAGNOSTICS.

Radhakrishnan's lab is now working to design and optimize "nanocarriers" to potentially deliver cancer medication to diseased cells only. "Our platform takes into account all of the chemical or physical aspects that determine whether a nanocarrier will go to a particular location or not," says Ramakrishnan Natesan, postdoctoral fellow in Radhakrishnan's lab



Ravi Radhakrishnan (center) and doctoral students Ryan Bradley (left) and Ramakrishnan Natesan (right) discuss results from a simulation of highly charged signaling molecules moving in a cell membrane.

and first author of a paper published in May in the journal *Royal Society Open Science*. "Proof of concept is in that paper. Now we're exploring the relevance of this finding to many different therapeutic drug-delivery scenarios."

SCREENING CELLS

Over the past decade, patient- and tumor-specific genetic screening and cell-based immunotherapy have dramatically changed and improved cancer treatment outcomes. "Yet for certain cancers, notably pancreatic and liver cancer, there aren't 'smoking gun' mutations like you see in lung cancer and neuroblastoma," says Lemmon. "Another approach is to look at the physical state of the organ, the injury to the pancreas and structure of the liver, for a predisposition to cancer. We're trying to understand how variations in cellular stiffness change the biochemistry of gene regulation. These fundamental scientific insights may be the underpinning for a new form of cancer diagnostics."

"We've shown that we can predict conditions for membrane bending with high accuracy based on the exact chemistry and presence of proteins," says Bradley. "Now we're trying to understand how physical forces such as stiffness of the environment outside the cell can modulate the cell's behavior."

"We're still a ways away from the goal of measuring cellular stiffness in every cancer patient, an experimental technology not yet approved for clinical use," adds Radhakrishnan. "We are building the case that this might be what we have to do. Our research indicates that genetic sequencing and cellular stiffness screening may be equally important, especially in cancers of the soft tissue. The real questions now are whether measuring stiffness at a cellular level is economical and can lead to precise diagnosis. That remains to be seen. But there's promise."

By Jessica Stein Diamond

Karen Winey, TowerBrook Foundation Faculty Fellow and chair in Penn Engineering's Department of Materials Science and Engineering (MSE), meets with students in the Singh Center for Nanotechnology.

Karen Winey

At the Helm of Materials Science

To excel in materials science research, you need curiosity about the microscopic building blocks of matter, and the creativity to design radical new properties on which to build the next technologies. Fortuitously, Karen Winey, TowerBrook Foundation Faculty Fellow in Penn Engineering's Department of Materials Science and Engineering (MSE), has a long-proven career in doing both.

"I have been deeply involved in the department since arriving in 1992, and am extremely proud of our extraordinary breakthroughs in science and engineering across a broad spectrum of materials, from metal to inorganics to polymers. I am equally proud of our history of service to the University and the scientific community, our highly regarded educational programs and our extremely accomplished alumni," says Winey. "Now, with my new responsibility as department chair, I'm excited about developing additional research and educational opportunities in order to expand and share knowledge about materials related to energy storage and conversion, sustainability and infrastructure, health sciences and electronic and optical devices."

"Karen's unique blend of professional achievements and personal qualities makes her a strong choice for heading the department," states Vijay Kumar, Nemirovsky Family Dean of Penn Engineering. "I am confident her experience, scholarship, insight and vision will drive this program into the future."

ENHANCING COLLABORATION

Winey and her fellow materials scientists are forward thinkers. They look for connections between the underlying structures of materials, the properties of materials and how processing conditions can manipulate a material and its performance. Winey is now applying that mindset to advance the department's already far-reaching trajectory.

"I am following Peter Davies, who chaired MSE for 14 years and whose list of accomplishments is considerable. He was an early advocate of dedicated facilities for nanoscience, eventually resulting in the construction of the Singh Center for Nanotechnology. He also identified, early on, that nanoscience would be appealing to undergraduates," she remarks. "Under his guidance, our department has become scientifically stellar, and I intend to continue that momentum."

Chief on her list of near-term initiatives for the department includes bringing additional faculty on board to enhance its research portfolio and academic offerings. "New faculty serve to strengthen our undergraduate curriculum and master's programs and to broaden what is available to doctoral students," she states. "I want to hire people who will bring unique skills that will augment the existing departmental and School-wide research initiatives."

CHIEF ON WINEY'S LIST OF NEAR-TERM INITIATIVES FOR THE DEPARTMENT IS BRINGING ADDITIONAL FACULTY ON BOARD TO ENHANCE ITS RESEARCH PORTFOLIO AND ACADEMIC OFFERINGS.

This is especially exciting as MSE continues to strengthen its research scope in the area of health science. "Many of our faculty are already working in this arena to build understanding and improve health. For example, body tissues have complex mechanical properties and we are developing mathematical models to describe these intriguing properties, so as to control or monitor tissue health. We are also designing structured coatings that can hinder cell growth and thereby prevent infection," she notes.

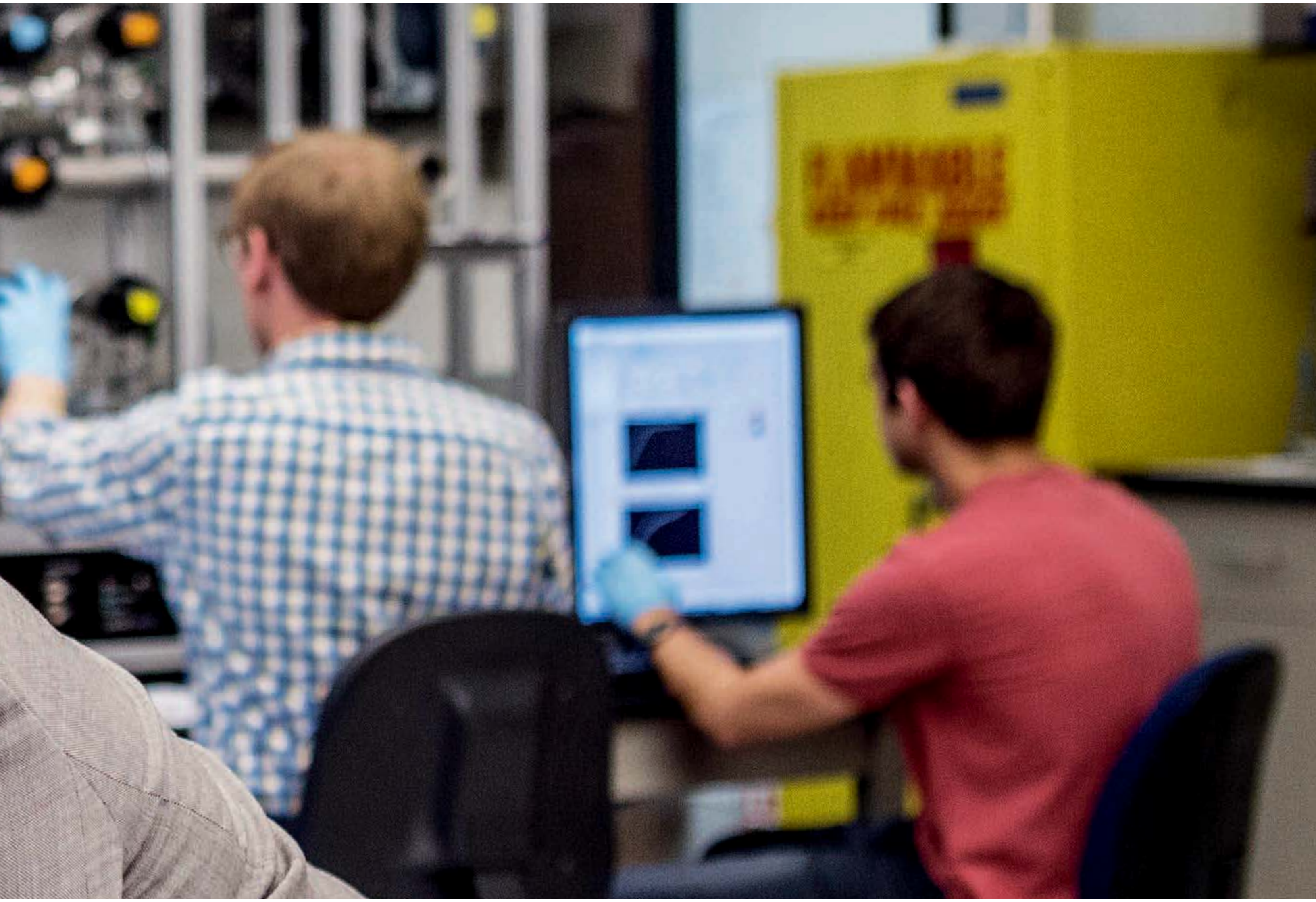
FUEL FOR INNOVATION

Collaboration is often the fuel for innovation in MSE. The department has long been affiliated with the Laboratory for Research on the Structure of Matter and was the catalyst for building the Nano/Bio Interface Center. MSE faculty are also engaged with the Penn Center for Energy Innovation, the Penn Institute for Computational Science and the recently formed Center for Engineering MechanoBiology.

“I consider collaboration key to the advancement of our department and our science,” says Winey, whose own research brings together partners in academia, national laboratories and industry for innovative discovery. Early in her career at Penn Engineering, she pioneered a technique to disperse carbon nanotubes, a building block of nanotechnology, in polymers. She also experimented with their orientation to learn how changes in position affect their electrical properties. “I was fortunate to work with nanotubes as they were just becoming available. Their potential when combined with polymers really fascinated me,” she recalls.

Building on that fasciation, today Winey investigates two aspects of polymers. In polymer nanocomposites, her group focuses on polymer dynamics in the presence of various nanoparticles and other types of nanoscale confinement. “Polymer motion is significantly impacted by nanoparticles and we are building a fundamental understanding of this to enable easier processing and broader use of polymer nanocomposites,” she explains.

In functional polymers, Winey’s work has identified new nanoscale structures. “We are now testing the mechanical and transport properties of these new structures to evaluate their potential value as self-healing polymers or as membranes in batteries or fuel cells.”



Winey works with Demi Moed, MSE junior and Rachleff Scholar, to load a polymer onto the brass heating element of a broadband dielectric spectrometer to measure ionic conductivity.

THE MSE CULTURE

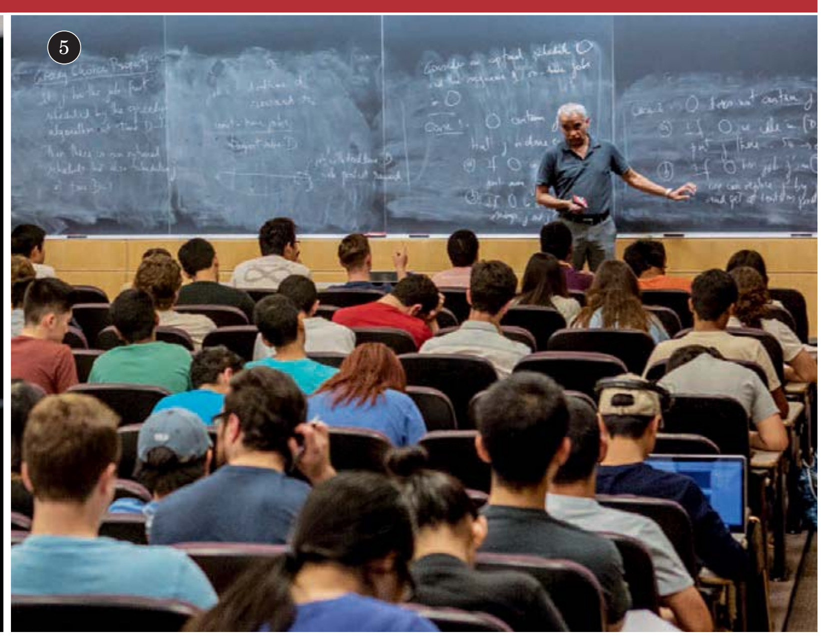
Winey's new role as chair wasn't so much a career goal as it was a logical next step in developing the science she is passionate about at the university she loves. "I have a collaborative mentality when it comes to my science and this department," she says. "It matters to me that MSE thrives. I can't insulate myself and my research from its wellbeing, nor would I want to."

The desire to advance materials science and the department is shared by her colleagues. "I think that a multidisciplinary approach is really the materials science culture. We're not just interested in building our own labs and forwarding our personal research; we are building a thriving scientific community."

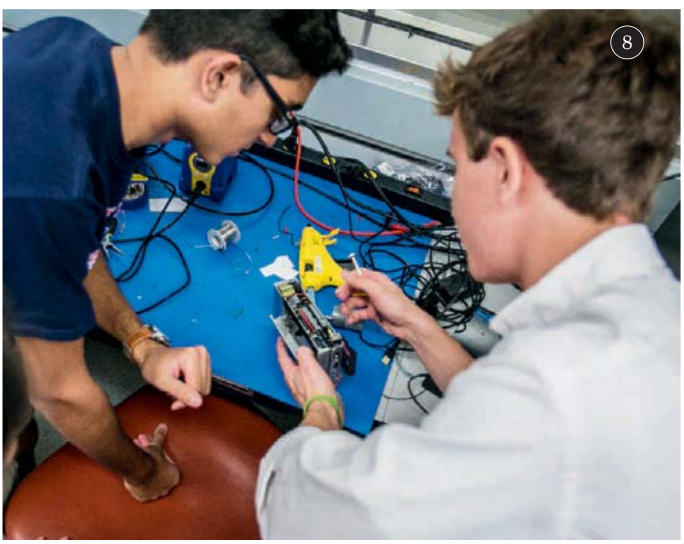
Science and academia are where Winey feels most at home. "I love the intellectual challenge of expanding what the world knows. Maybe I could have done that in a corporate environment, but I really love the rhythm and stimulation of the university atmosphere." She is just as passionate about teaching and dedicating the time it takes to help students have their individual "a-ha" moments. "That can happen in the classroom, but more often it happens during office hours when we just talk and ask questions of one another," she states. "And that collegiality pervades throughout the classroom, the labs and the entire department. It's what enables us to effectively extend and transfer knowledge and innovation."

By Amy Biemiller

On Our Camera Roll



1. A stunning string of first-place trophies is displayed by the 2016 Penn Electric Racing team. **2.** Undergraduates in EAS 101 experiment with sensors interfaced to an Arduino controller board. **3.** A quiet study space is always available in the "Fish Bowl." **4.** Penn Engineers enjoy a spectacular fall day outside the Towne Building. **5.** Sampath Kannan, Henry Salvatori Professor and chair of Computer and Information Science, takes questions in CIS 320, *Introduction to Algorithms*.



6. Cyclists find an active and welcoming community at Penn. **7.** Technician Jing Peng prepares a sample for diagnostic testing in the Micro and Nano Fluidics Lab. **8.** Electrical engineers work on a prototype design project in the Detkin Lab. **9.** A hub for engagement, students collaborate with faculty and peers in the technology-rich Forman Active Learning Classroom. **10.** Taking time between classes to catch up on emails and coursework in the lobby of Levine Hall.

Target: Zika

A Low-Cost Diagnostic for Developing Nations

As viruses go, Zika is ruthlessly efficient. Since 2015, when Brazil reported its first few cases, the illness has moved with astonishing speed, infecting millions of residents throughout Central and South America, and more recently, the continental United States.

In most patients, its symptoms are mild: bloodshot eyes, skin rash, flu-like exhaustion—but in pregnant women, the consequences become far more severe. When the virus emerged in Brazil, so too did hundreds of newborns with microcephaly (an abnormally small head and brain), a condition that can cause a lifetime of developmental problems. In nearly every case, the afflicted baby's mother had contracted Zika during pregnancy.

Despite its devastating effects on newborns, testing for the virus can be a major challenge in developing nations where infrastructure is often in disrepair, says Haim Bau, professor in Mechanical Engineering and Applied Mechanics (MEAM).

"Most of the labs in those areas that can identify Zika are not located in close proximity to a patient, and systems for transporting samples from patients aren't well developed," he says. "That means samples can be degraded during shipping, or the results might not make it back to the patient."

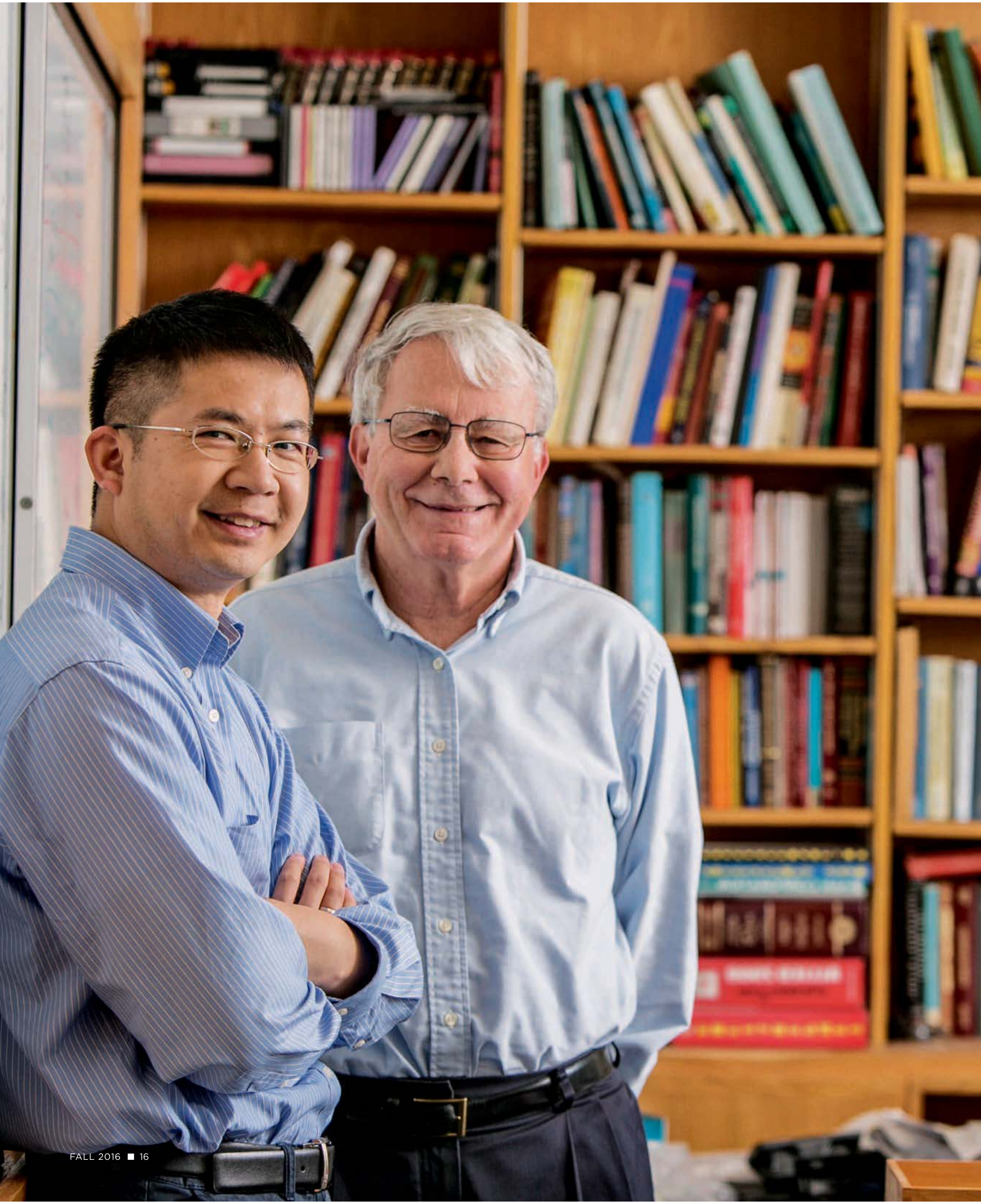
Rather than shipping samples to distant labs, Bau is working on a device that lets rural clinics test for the disease directly. Earlier this year, he collaborated with Changchun Liu, research assistant professor in MEAM, to create a prototype that they're hoping will give doctors a new tool in the fight against Zika. The device they've created is roughly the size of a soda can, and provides a diagnosis in the field without the need for a lab, electricity, or even a trained technician.

> DESPITE ITS DEVASTATING EFFECTS ON NEWBORNS, TESTING FOR ZIKA CAN BE A MAJOR CHALLENGE IN DEVELOPING NATIONS.

LAB-ON-A-CHIP

To use the device, caregivers take a small sample of saliva, blood, stool or urine from a patient and place it onto a small plastic cartridge. Tiny channels and porous membranes inside help to concentrate and filter the sample's content, acting as a miniature "lab-on-a-chip," automating processes that normally are done by several different benchtop machines.

Roughly the size of a soda can, the device created by Bau and Liu provides a diagnosis in the field without the need for a lab, electricity, or even a trained technician.



Zika isn't the only disease that Changchun Liu (left) and Haim Bau have tackled. They're currently expanding their "lab-on-a-chip" work to create diagnostics for HIV and other viruses, providing low-cost tools for doctors in developing nations.

"Instead of having a human or even a robot carry a sample from one lab machine to another, we put all those operations onto the chip, and it transfers the material from one operation into another," Bau says. "It eliminates an expert from the process, so even minimally trained or even untrained personnel can carry out these sorts of analyses and get relatively quick results."

IF YOU CAN DETECT THE DISEASE QUICKLY IN A CLINIC, YOU CAN POTENTIALLY ASK PATIENTS TO LIMIT THEIR CONTACT WITH OTHERS.

If specific Zika genes are present in the sample, a special dye already inside the device changes color, giving doctors a clear indication that the patient's results are positive. In all, the whole process takes only about 40 minutes.

"That speed is important," adds Liu. "If you can detect the disease quickly in a clinic, you can potentially ask patients to limit their contact with others. It could give clinicians a powerful way to help prevent the spread of the virus."

GETTING WARMER

Right now, Liu says, the most reliable way to confirm the disease is through a process called Polymerase Chain Reaction (PCR), which can sniff out tiny amounts of genetic material from the Zika virus and multiply it millions of times. As new copies of the virus' genes accumulate, they eventually reach high enough levels to be seen and identified by technicians. The catch, however, is that PCR uses carefully controlled cycles of heating and cooling to make those copies, and so relies on sophisticated (and often expensive) lab equipment.

To get around that problem, Bau and Liu have focused on a relatively new detection method called "Reverse Transcription Loop-Mediated Isothermal Amplification" (RT-LAMP). It's a mouthful of a technique, but it has a few key advantages. Like PCR, it homes in on nucleic acids, giving incredibly accurate test results, but does so at a fixed temperature rather than using computer-controlled cycles. That may seem like a small distinction, but it means that the process no longer needs complex lab equipment. Instead, it can be run on a surprisingly small and low-tech heat source.

"We use a method similar to how soldiers cook military rations in the field," says Bau. "It's a chemical reaction that creates heat by mixing water with magnesium alloy." The reaction takes place next to a block of paraffin wax that absorbs excess heat as it slowly melts, keeping the temperature stable. Simple materials like these have the added benefit of keeping costs down. Each device, he estimates, would cost only a few dollars to make.

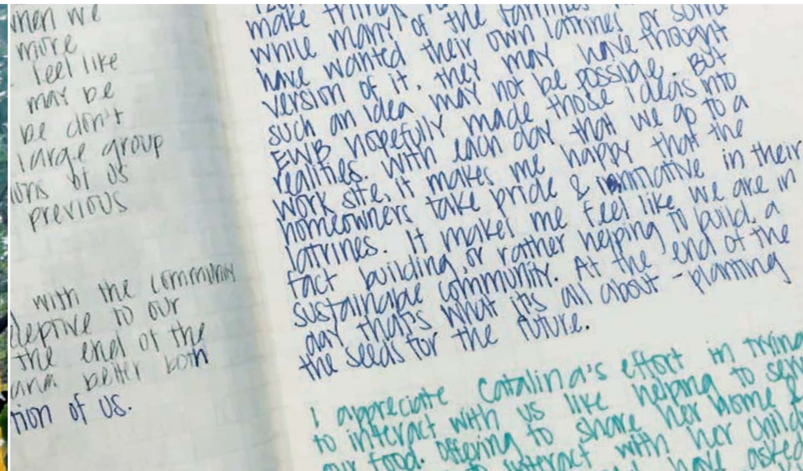
THINKING BIG

Zika isn't the only disease that Bau and Liu have tackled. They're currently expanding their "lab-on-a-chip" work to create diagnostics for HIV and other viruses, providing low-cost tools for doctors in developing nations. "There's a real need, especially in the developing world, for these diagnostic products. We're driven to solve real-world problems that are affecting the life and health of many individuals around planet," says Liu.

Bau and Liu's focus on tackling health issues worldwide has attracted a wide range of students at all levels, from undergraduate to doctoral, to their labs. In one case, they've even engaged a junior in high school. "He wrote us an email wanting to get involved, and he's really exceeded our expectations," says Bau.

That's not entirely surprising, given that Bau's unofficial mantra for students is to "think big, work hard, and get it done," a challenge that his lab meets on a daily basis. "We like challenges, and being engineers, we like to solve problems," he says. "That's what engineers do."

By David Levin



Global Engagement Through Service Learning

In her opening remarks to the Class of 2020 at this year's Convocation, President Amy Gutmann urged incoming students to make academic and social choices at Penn that "complement who we are becoming rather than merely reflect who we already know ourselves to be." "Differences," she emphasized, "are the key."

This advice would, no doubt, resonate strongly with Penn Engineers Sylvester Tate, senior in Computer Engineering; Christelle Nayandi, sophomore in Chemical and Biomolecular Engineering; and Alfa Lopez, sophomore in Mechanical Engineering and Applied Mechanics, who each chose to enroll in courses centered on service learning abroad. Ocek Eke, director for Global and Local Service Learning Programs at Penn Engineering, notes that a certain "fearlessness" and motivation to "step out of the box" are notable characteristics of these aspiring engineers and world citizens.

Eke, along with service program faculty and student leaders, is charged with ensuring that the students' spirit of adventure is protected by meticulous reconnaissance and preparation; student safety is deemed "paramount." All potential service learning sites are rigorously assessed for feasibility and security. Destinations last summer for the Penn Engineering students accepted into global outreach courses included Rwanda (Gashora Program), Ghana (Appropriate Point of Care Diagnostics) and Guatemala (Penn chapter of Engineers Without Borders).

Service Learning programs at Penn Engineering afford students the opportunity to both use their engineering skills to provide immediate impact in project locales and to learn about other cultures and reflect on their experiences in a meaningful way. Above: Sylvester Tate, senior in Computer Engineering, worked in Rwanda to install solar lights on a previously unlit campus of a girls' school.

WORLD CITIZENS

The overall aim of the Global Service Learning Program is "to improve human lives through sustainable engineering in all corners of the world." Coursework includes both classroom assignments and lectures on the Penn campus and practical experience in the field. Among the student outcomes are understanding and applying knowledge taught in courses, and engagement, curiosity and reflective practice to foster critical thinking.

Reflective practice seems to have come naturally to Sylvester Tate. In his list of personal goals set for the trip to Rwanda with nine other Penn Engineers, he wrote, "Be open to learning new ways and customs. Everyone you encounter is a teacher." He also aspired to be unafraid of the unknown and, in fact, to "chase after it until it becomes well known."

Under the guidance of Jorge Santiago-Aviles, associate professor in Electrical and Systems Engineering, and others, the group was charged with several projects. Tate's primary project was the installation of solar lights around the previously unlit Gashora Girls Academy of Science and Technology (GGAST) campus. The school is in a rural location, and students would often be frightened to leave their rooms because they could encounter nocturnal wild animals. Tate served in a project management role where he unpackaged and tested the lights to ensure that all 22 functioned properly. He then worked with the team to ensure that the lights were installed at the correct locations.

Christelle Nayandi, sophomore in Chemical and Biomolecular Engineering, traveled to Ghana through Penn Engineering's Appropriate Point of Care Diagnostics (APOC) program to learn about issues surrounding diagnosis of pediatric tuberculosis (TB).

The group also aimed to provide water to an existing water purification system at a community health clinic, which does not have a source of water to purify during the dry season. *(Editor's note: This project is greatly in need of funding. In order to implement the system, additional piping must be purchased. To help, please go to: gofundme.com/WaterForGashora).*

In his capstone paper written about his work in Rwanda, Tate described the GGAST girls as "brilliant" and possessing an "unparalleled zeal for education." "I was honored," he wrote, "to be among a group of people who will actually change the world."

MEETING CHALLENGES

Meanwhile, Rwandan-born and raised Christelle Nayandi had made her way to Kumasi, Ghana, through Penn Engineering's Appropriate Point of Care Diagnostics (APOC) program. Excitedly, Nayandi opened her travel journal with, "I can finally check one thing off my list: visiting a West African country!" She was about to spend a month based at the Kumasi Center for Collaborative Research in Tropical Medicine (KCCR).

THE OVERALL AIM OF THE GLOBAL SERVICE LEARNING PROGRAM IS TO IMPROVE HUMAN LIVES THROUGH SUSTAINABLE ENGINEERING IN ALL CORNERS OF THE WORLD.

In Kumasi with 15 other Penn students and accompanied by Eke, Miriam Wattenbarger, senior lecturer in Chemical and Biomolecular Engineering, and Penn Medicine professor Harvey Rubin, Nayandi's focus was on point-of-care diagnosis of pediatric tuberculosis (TB). Visits to Ghanaian hospitals and rural medical centers revealed the challenges of diagnosing and treating TB in areas without the equipment and techniques readily available in more economically advantaged areas.

Alfa Lopez, sophomore in Mechanical Engineering and Applied Mechanics, was part of the Penn Engineers Without Borders (EWB) crew working to implement a sanitation project in the Guatemalan village of Tzununa.

The APOC team was advised and instructed in all things Ghanaian by five students from the Kwame Nkrumah University of Science and Technology (KNUST), where the group also attended lectures. They soon became aware and sensitive to the sending and receiving of subtle cultural messages, and were careful, for instance, not to wear all red and/or black clothing—the colors signify that the wearer has suffered the loss of someone close to them.

INVALUABLE GIFTS

Alfa Lopez summed up her service learning experience in Guatemala as, "Life-changing. For sure."

Of Guatemalan heritage herself, Lopez had only visited the country as a tourist and sightseer. As a way of fulfilling her personal mission to help the people of her roots, Lopez signed up with the Penn chapter of Engineers Without Borders (EWB) for a project in the Guatemalan village of Tzununa.

It was hard, physical work. The Penn EWB crew of 12 students, two student leaders, Eke, faculty member J. Anthony Sauder, and a graduate student all labored alongside local masons and homeowners to construct latrines for the village. While the outcome of improving the wellbeing and hygiene of the community by way of latrine usage may seem obvious to the outsider, the project included a critical health education component. To ensure the project's sustainability, it was necessary for the team to understand and address any cultural resistance to it.

Awed by the community members' energy and pride in their work, Lopez wrote in her reflection journal of the "many invaluable gifts" she received from the people of Tzununa. As with Tate and Nayandi, Lopez's engagement with the community in which she was working enriched the service learning experience exponentially. It only remains to be seen how each of these students will continue to grow, as both engineers and as global citizens.

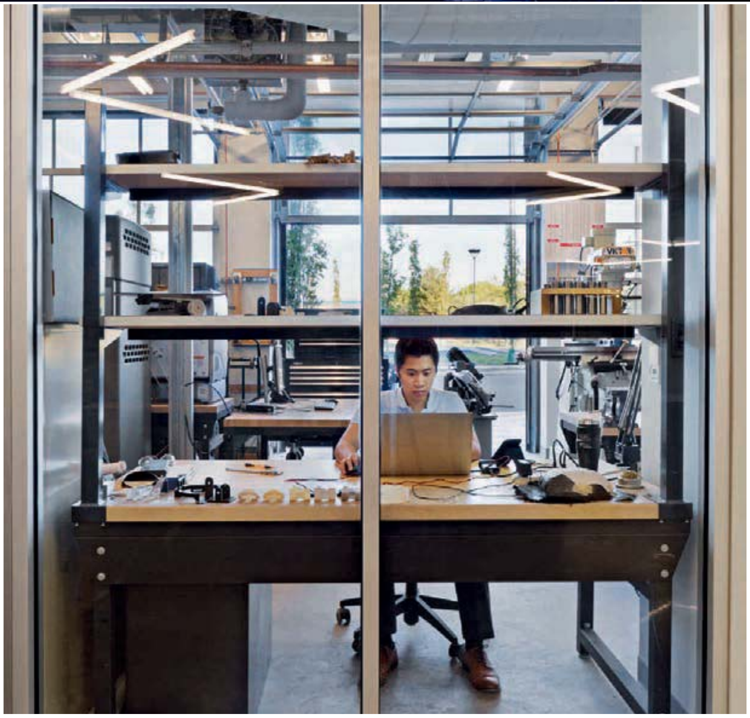
By Patricia Hutchings

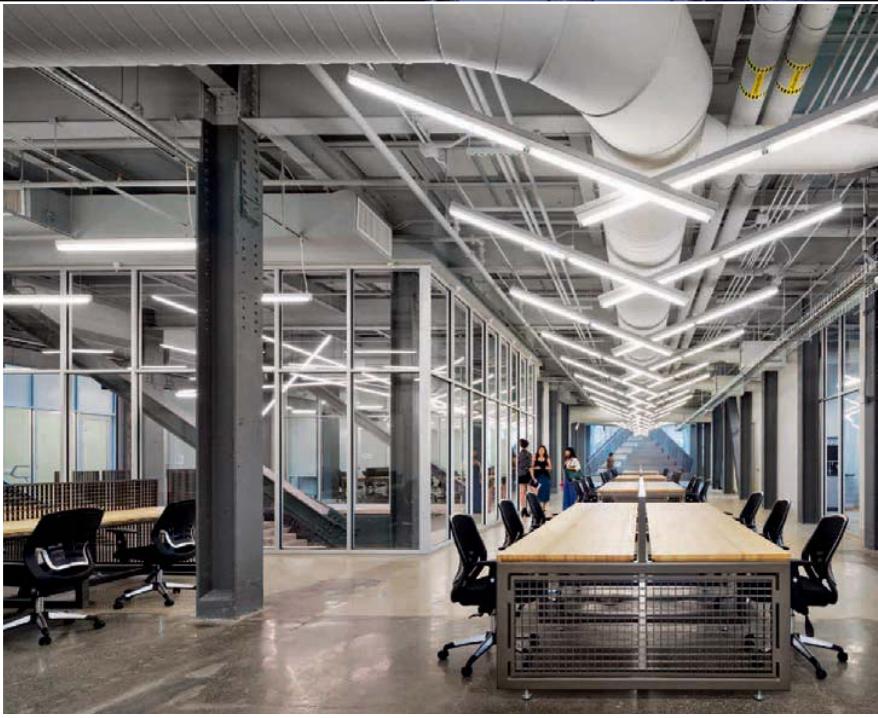
Pennovation

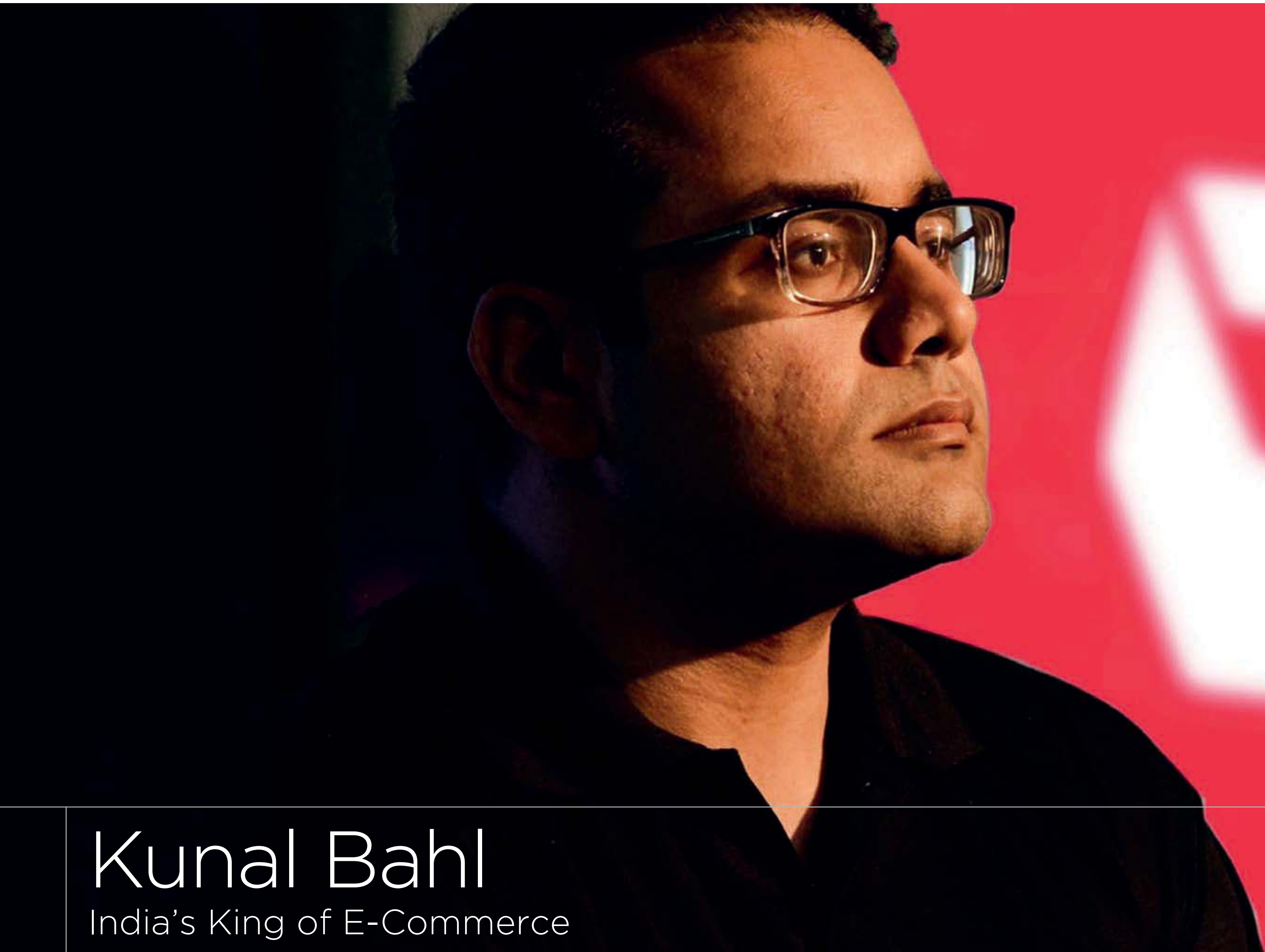
The Pennovation Center, the new hub for Penn's innovation, entrepreneurship and technology transfer efforts, celebrated its Grand Opening in October 2016. Originally a DuPont laboratory, the three-story, 58,000-square-foot building has been completely transformed to foster new connections between Penn researchers and industry members by putting wet labs, co-working desks, meeting spaces and corporate offices in close proximity. New companies born from these interactions can rent "startup garages" on the first floor as they grow their nascent businesses.

The Penn Engineering Research and Collaboration Hub, or PERCH, is one of the Pennovation Center's first occupants. Organized under inaugural director Daniel Koditschek, Alfred Fitler Moore Professor in Electrical and Systems Engineering, PERCH brings together three core research groups from Penn Engineering's General Robotics, Automation, Sensing and Perception (GRASP) Lab. Together, the Kod*Lab, the ModLab and the Multi-Robot Systems Lab, as well as researchers working in embedded systems and the Internet of Things (IoT), are situated above an incubator for spin-off companies, with an eye toward advancing new academic developments into the public pipeline.

PHOTOGRAPHY BY MICHAEL MORAN/OTTO







Kunal Bahl

India's King of E-Commerce

As a child growing up in New Delhi, Kunal Bahl (M&T'06) never imagined that he would one day launch a technology company that would transform the daily shopping experiences of millions of people.

Bahl got his start on this propitious path when he was accepted to Penn in 2002. As a student in the Jerome Fisher Program in Management & Technology (M&T), he was constantly challenged to leave his comfort zone. The unique combination of engineering and business curricula offered by the program helped Bahl to develop an appreciation for both of these critical aspects of building a successful technology venture.

"Dealing with uncertainty is something that students learn from the moment they step foot on campus for orientation," Bahl says. "Like in life and in business, when on Penn's campus, you can take many paths, and picking the path that you have passion for and that is also in your best interest is critical. Learning to decide for yourself, after taking input from those you trust, is an aspect of my Penn education that helped me tremendously."

It did not take long for Bahl's hard work and interdisciplinary learning experiences to pay dividends. In February 2010, Bahl and his best friend from high school, Rohit Bansal, launched Snapdeal, which quickly grew to become

India's largest online marketplace. The company's vision is to create India's most reliable and seamless commerce experience for buyers and sellers. Snapdeal now offers more than 50 million products for sale, from hundreds of diverse categories that include over 125,000 brands and retailers. Currently, Snapdeal reaches millions of users, including hundreds of thousands of sellers from 6,000 cities and towns in India.

"The ability to make a major impact for a large number of people, society, or the country has been one of the biggest driving forces for us," says Bahl, who is also Snapdeal's CEO. "We enjoy solving problems, and consistently bridging the consumption gaps drives us to work toward enabling more and more customers to have a great commerce experience. It is a great high to start a company; I think it is the most impactful way to spend our lives."

AS A STUDENT IN THE M&T PROGRAM, BAHL WAS CONSTANTLY CHALLENGED TO LEAVE HIS COMFORT ZONE.

PROVING SKEPTICS WRONG

The road to success did not come easily. When Bahl returned to India in 2008 after working for Microsoft for a short time, he and Bansal brainstormed about how they could best use their skills and experiences to improve the lives of millions of people. They launched a series of coupon businesses, but these ventures failed to generate enough money. The real breakthrough came in January 2010, when some of their merchants suggested that they launch an online version of the same thing. That's how the coupon site Snapdeal was born.

SNAPDEAL NOW OFFERS MORE THAN 50 MILLION PRODUCTS FOR SALE, FROM HUNDREDS OF DIVERSE CATEGORIES THAT INCLUDE OVER 125,000 BRANDS AND RETAILERS.

But within six months, the business was facing stiff competition from more than 50 other companies. At one point, Snapdeal was so cash-strapped that Bahl and Bansal had to pay team salaries out of their own pockets. So they went back to the drawing board, came up with a new business plan, hired top-notch employees, and raised more money. By mid-2011, Snapdeal had about 70 percent market share in the coupon business. While business was getting better, it was difficult to scale up. The real turning point was their trip to China at the end of 2011, which taught them that to grow big, Snapdeal had to become a marketplace.

"When Snapdeal began, online commerce was a nascent concept and we faced skepticism from various quarters," Bahl recalls. "Over the years, we have been able to give customers across the remotest regions of the country access to products and services that span the widest breadth of their consumption needs. At the same time, we have been able to fulfil the dreams of over 300,000 sellers in India, some of them first-time entrepreneurs, to grow a sustainable business."

GOLDEN YEARS

Moving forward, Bahl and Bansal will remain committed to building a rich and innovative online commerce ecosystem that creates more employment opportunities and has a significant impact on India's economy. All indications point to success in this endeavor. After all, Snapdeal was the first online marketplace to offer categories such as automobiles, real estate, cement and financial services, which no one had believed could be successfully sold online. "We fundamentally believe that anything which can sell offline can also sell online," Bahl says. "So hopefully you will also be able to buy a trip to the moon on Snapdeal in the coming years!"

To date, Snapdeal's wide-ranging, innovative products and streamlined services have earned the company numerous awards, funds from several major global investors, and partnerships with e-commerce giants such as Alibaba and eBay. Bahl himself has also garnered significant recognition from business elites. He currently serves on the board of the Indian Council for Research on International Economic Relations, which is one of India's leading economic think tanks. He was also named *The Economic Times* Entrepreneur of the Year in 2015, and earned a coveted spot on *Fortune*'s 2014 "40 Under 40" list.

But Bahl is not satisfied to rest on his laurels. "We want to continue to enhance the daily lives of a billion Indians through our products and platforms, whether they are consumers or merchants, all looking for access to fulfill their aspirations," Bahl says. "The next 25 years are going to be the golden years of India, and I can't wait to be a part of this incredible journey."

By Janelle Weaver

HONORS & AWARDS

Rajeev Alur, *Zisman Family Professor in Computer and Information Science,* was named a recipient of the 2016 Alonzo Church Award for Outstanding Contributions to Logic and Computation. This award is given by the ACM SIGLOG and others in recognition of an outstanding contribution represented by a paper or small group of papers within the past 25 years.

Portonovo Ayyaswamy, *Asa Whitney Professor of Dynamical Engineering in Mechanical Engineering and Applied Mechanics,* was named a recipient of the UCLA Engineering Alumni Professional Achievement Award. This award is given by the University of California, Los Angeles (UCLA) Henry Samueli School of Engineering and Applied Science and is one of the school's highest honors.

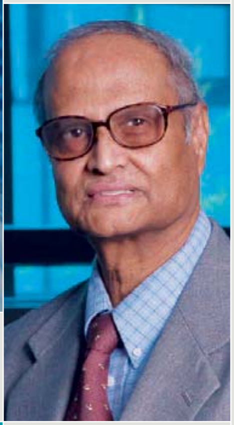
Danielle Basset, *Eduardo D. Glandt Faculty Fellow and Associate Professor in Bioengineering,* was named to the *Popular Science* 2016 "Brilliant 10," a list of the 10 most innovative young minds in science and engineering as, "The woman who reimagines how the brain works."

Nader Engheta, *H. Nedwill Ramsey Professor in Electrical and Systems Engineering,* was awarded an honorary doctorate from the University of Stuttgart in Germany in recognition of his achievements "in the field of plasmonics, metamaterials and nanooptics."

Sudipto Guha, *Associate Professor in Computer and Information Science,* was named a recipient of the 2015 European Symposia on Algorithms (ESA) Test-of-Time Award. This award is presented in recognition of papers from ESA Proceedings of the past 19-21 years.

Dan Huh, *Wilf Family Term Assistant Professor in Bioengineering,* was named a recipient of the 2016 *Analytical Chemistry* Young Innovator Award, which is given in recognition of the contributions of an individual who has demonstrated exceptional technical advancement and innovation in the field of micro- or nanofluidics in his or her early career.


Rajeev Alur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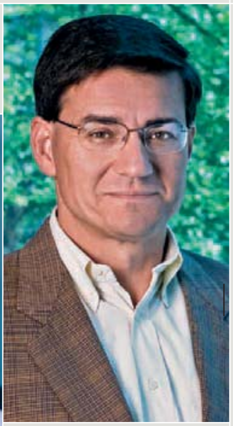


Pedro Ponte Castañeda

Vivek Shenoy

Yale Goldman

Santosh Venkatesh

Aleksandra Vojvodic

Stephanie Weirich

Pedro Ponte Castañeda, *Raymond S. Markowitz Faculty Fellow and Professor in Mechanical Engineering and Applied Mechanics,* has been named a recipient of the 2016 Warner T. Koiter Medal from the American Society of Mechanical Engineers (ASME) in recognition of his "world-leading development of theoretical tools of great power, elegance and practical importance for the analysis of the nonlinear response of composite materials."

Vivek Shenoy, *Professor in Materials Science and Engineering,* and **Yale Goldman,** *Professor in Physiology and in Biochemistry and Molecular Biophysics in Penn Medicine and Mechanical Engineering and Applied Mechanics in Penn Engineering,* have been awarded a $24 million, five-year grant from The National Science Foundation (NSF) to establish a Science and Technology Center (STC) focused on engineering mechanobiology, or the way cells exert and are influenced by the physical forces in their environment.

Santosh Venkatesh, *Professor in Electrical and Systems Engineering,* has been appointed to the 2016-2017 Faculty Senate Executive Committee (SEC) of the University of Pennsylvania. On behalf of the faculty, members of the SEC and the various Senate committees engage in substantive investigation and consideration of matters of import within the University administration.

Aleksandra Vojvodic, *Skirkanich Assistant Professor of Innovation in Chemical and Biomolecular Engineering,* was named to the 2016 *MIT Technology Review* "35 Innovators Under 35" list under the heading, "A computation whiz speeds up the search for catalysts that will make green chemistry possible."

Stephanie Weirich, *Professor in Computer and Information Science,* has been named a recipient of the Microsoft Outstanding Collaborator Award from Microsoft Research (MSR). This award recognizes Weirich's collaborative abilities, which have had a "major impact on research at MSR, with practical outcomes that are used daily by thousands of programmers."

Mayur Naik
Associate Professor

Computer and Information Science

Ph.D. in Computer Science; Stanford University

Shivani Agarwal
Rachleff Family Associate Professor

Computer and Information Science

Ph.D. in Computer Science; University of Illinois, Urbana-Champaign

Linh Thi Xuan Phan
Assistant Professor

Computer and Information Science

Ph.D. in Computer Science; National University of Singapore

Eric Detsi
Stephenson Term Assistant Professor

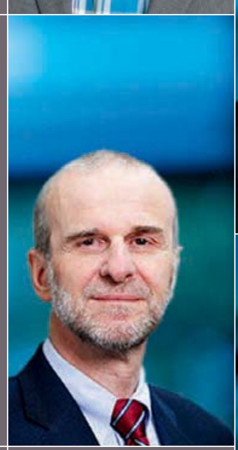
Materials Science and Engineering

Ph.D. in Applied Physics; Zernike Institute for Advanced Materials, University of Groningen, The Netherlands

Jordan Raney
Assistant Professor

Mechanical Engineering and Applied Mechanics

Ph.D. in Materials Science; California Institute of Technology



Manfred Morari
Distinguished Faculty Fellow

Electrical and Systems Engineering

Ph.D. in Chemical Engineering; University of Minnesota at Minneapolis

Aleksandra Vojvodic
Skirkanich Assistant Professor of Innovation

Chemical and Biomolecular Engineering

Ph.D. in Physics; Chalmers University of Technology, Sweden

Haralambos "Harry" Kritikos, *Professor Emeritus in Electrical and Systems Engineering,* passed away on July 2, 2016, after a long illness. He was a theorist in electromagnetism, and an outstanding teacher and advisor.

Dr. Kritikos was born in Tripoli, Greece, in 1933. He received all of his degrees in Electrical Engineering, earning bachelor's and master's degrees from Worcester Polytechnic Institute in 1954 and 1956, respectively, and a Ph.D. from the University of Pennsylvania in 1961. Following his doctoral studies, he was a member of the staff at The Moore School at the University of Pennsylvania, a Research Fellow at Caltech, and later joined the Penn faculty as an associate professor in Electrical Engineering in 1968.

Dr. Kritikos was a member of Sigma Xi, the international honor society of science and engineering, and was active in the IEEE, having been named an IEEE Fellow in 1988 and the recipient of both the IEEE Centennial and Bicentennial Medals.

Dr. Kritikos' early work was on diffraction and propagation of electromagnetic waves and the biomedical applications of electromagnetism. In more recent years, he was engaged in research on wavelets, symmetry and group theory with their applications to electromagnetic theory and antenna arrays. His office was always the center of animated discussion and he was beloved by his students.

Dr. Kritikos is survived by his wife Susanne (CGS'68, MSW'76); daughter Melissa Kaiser (C'95 ENG'95, WG'01); and grandchildren Teddy and Alex.

Sohrab Rabii, *Professor Emeritus in Electrical and Systems Engineering,* died at home on July 18, 2016. He was 78 years old.

Born in Ahwaz, Iran, Dr. Rabii came to the United States in 1958 on a study-abroad scholarship from the Iranian government. He earned a bachelor's degree in Engineering from the University of Southern California, then earned master's and doctoral degrees from the Massachusetts Institute of Technology (MIT). He did advanced study at MIT and worked briefly for the Monsanto Corporation.

Dr. Rabii joined the Penn faculty in 1969 as an assistant professor in what is now the School of Engineering and Applied Science. He became an associate professor in 1973. He was chair of the Department of Electrical Engineering from 1977-1982. In 1985, he received the Lindback Award for Distinguished Teaching.

Dr. Rabii was a researcher known for his contributions to the condensed matter theory of carbon-based materials, or what happens when carbon electrons and nuclei function in a condensed state. He was a senior member of the IEEE, a member of the American Physical Society and the author of over 160 journal and conference papers.

He retired in 2006, but remained an integral part of the Penn Engineering community, regularly attending lectures and faculty meetings. He escorted Penn students to Mali and Ghana, where they set up computer and electrical engineering labs.

Dr. Rabii is survived by his wife Susan B. Hunt; former wife Patricia B. Rabii; daughters Susan M. Zima and Elizabeth Rabii Cribbs; five grandchildren; three brothers; a sister and nieces and nephews.

Allie Rogers

Technology Entrepreneur and Engineering Mentor

A software engineer at heart, Penn Engineering Overseer Allie Rogers (M&T'87) turned a winning idea into entrepreneurial reality when he co-founded Triple Point Technology, a commodities trading software company, with Peter Armstrong (ENG'87) in 1993.

Since selling the company, Rogers has devoted his time to mentoring and investing in emerging companies while also supporting Penn Engineering in myriad ways. For Rogers, it always comes back to a desire to "build things" and improve upon what's come before.

What is the defining passion that drives your career?
I love to start with nothing but an idea and create the product, service and surrounding organization—to see that idea come to life and have value to others.

Of which accomplishments are you most proud?
The success at Triple Point and other ventures led directly to the personal success of hundreds of people I employed or invested in. The responsibility can be daunting but also heartwarming.

How has your experience at Penn Engineering informed your work?
Partnering to found Triple Point, even trying out such a venture, came directly from my M&T education. Everything I learned at Penn in terms of guiding the business side was hugely informative. At the same time, most of my working life has been devoted to management of software development, and I can trace all of those skills back to my computer science classes.

What are your current endeavors?
Even though I'm technically retired, I've been doing some angel investing with startups, mostly in the technology space. As it turns out, many of the organizations in which I've invested have connections to Penn. I also have an official operating role at one of my ventures, Trendalytics.

What is most rewarding about your work with Penn Engineering's Board of Overseers?
I like being part of the conversations about operations, growth, and attracting talent. It's informative to hear about faculty research and student opportunities.

Why has it been important for you to stay involved with Penn?
For members who are alums, being on the Board creates a nice connection between the alumni community and the School, because as alumni, we have a vested interest in ensuring that our school continues to be great and improve. Most of all, it's a wonderful way to give back.

By Elisa Ludwig

Penn Engineering Board of Overseers

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School of Engineering and Applied Science
University of Pennsylvania

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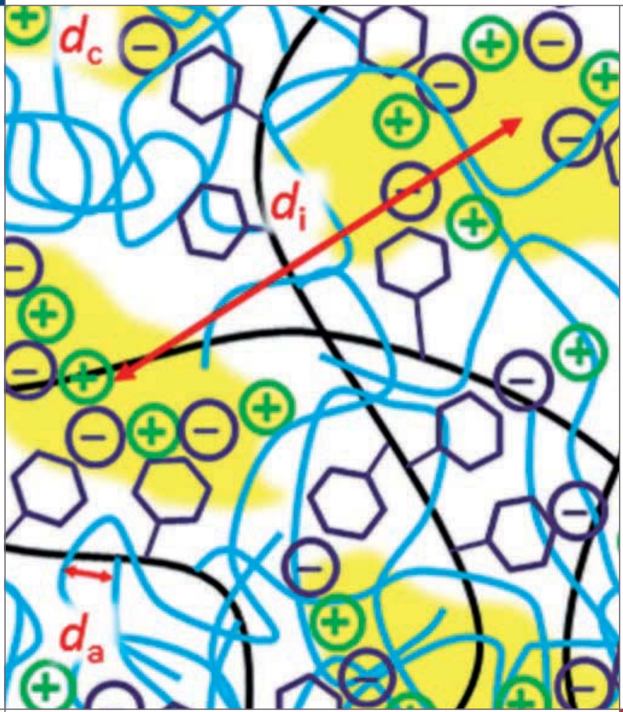

SAFER BATTERIES

Batteries need electrolytes that allow ions and not electrons to pass through them. If, says Karen Winey, TowerBrook Foundation Faculty Fellow and chair of Materials Science and Engineering, ions could be made to move through plastics, then solid polymer electrolytes could replace the flammable, and sometimes dangerous, liquid electrolytes currently used. The graphic (left) illustrates the work of Winey and her group, which used X-ray scattering to characterize the complex and hierarchical structure of such a polymer.

The red arrows indicate the characteristic length scales in the structure, which is a random copolymer (black line) with a long side chain (blue lines). The yellow regions denote the ionic aggregates wherein the cations (green) reside. It's these cations that the group wants to be able to move through the material.