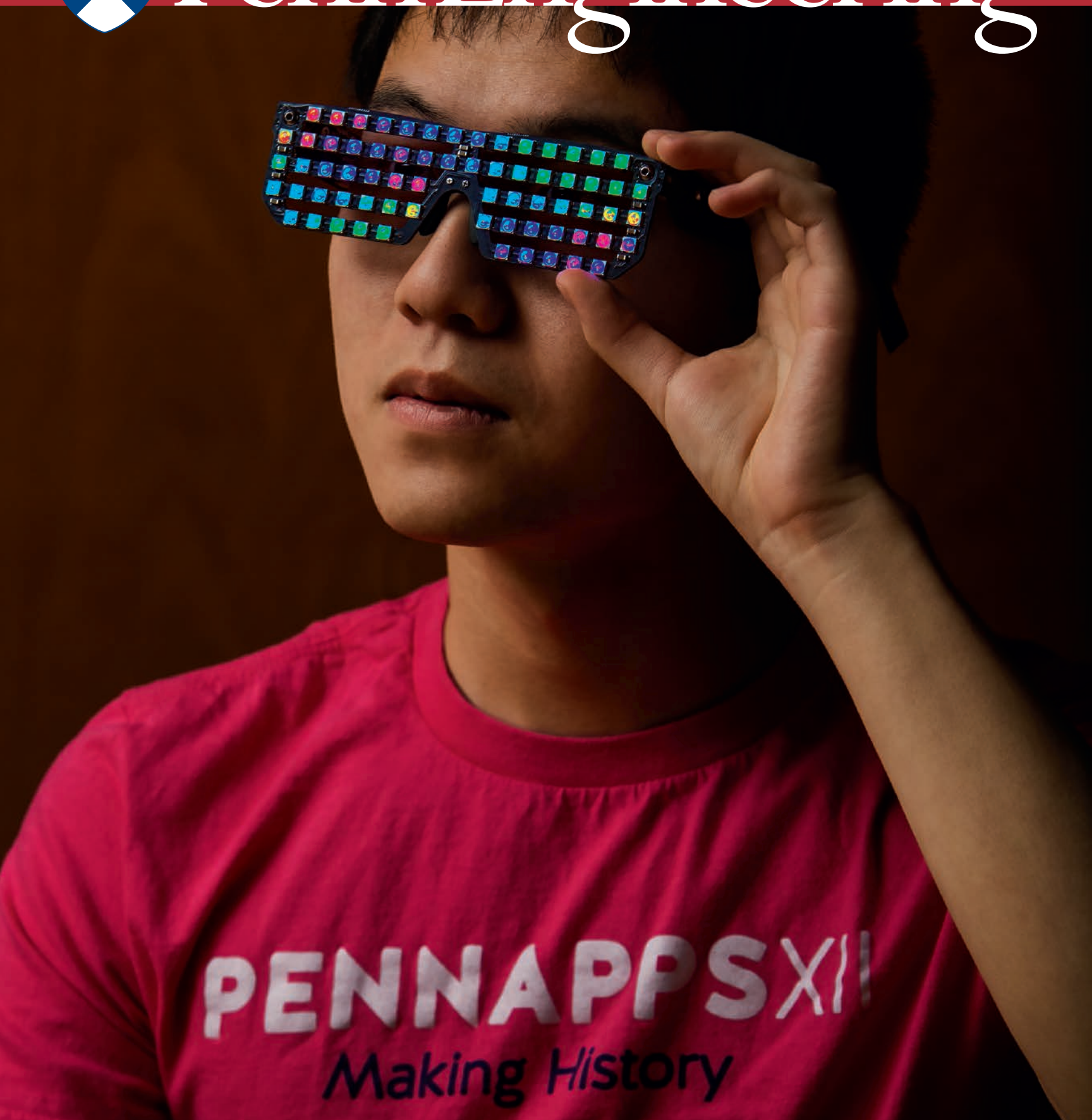


Penn Engineering



WEL... CENTER
PENNAPPS XII

**PENN
APPS**

COMCAST
NBCUNIVERSAL
Penn
Engineering

xfinity

PENNAPPS XII
Making History



#PennAppsXII

PENNS XII
COMCAST NBCUNIVERSAL

twilio PLAIN ebay Demand nest MLL





PennAppsXII

PennApps, the world's largest student-run hackathon, has grown from an event for a handful of Penn students to one including more than 2,000 hackers from around the world. With record-level participation for PennApps XII, Penn Engineering partnered with title-sponsor Comcast to secure a change in venue to Philadelphia's Wells Fargo Center. Pictured is the PennApps Expo, where members of the public toured the arena floor to mingle with some of the world's brightest minds and to try out some of the weekend's hardware and software products.

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University of Pennsylvania
School of Engineering and Applied Science

PENN'S CULTURE OF INNOVATION,
WITH ITS ORIGINS IN THE INVENTIVE
GENIUS OF THE UNIVERSITY'S
FOUNDER AND AMERICA'S FIRST
ENGINEER, BENJAMIN FRANKLIN, IS
FLOURISHING AS NEVER BEFORE.

Penn Engineering Magazine

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Eat sleep <code/> repeat

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VIJAY KUMAR
Nemirovsky Family Dean

#PennEngineeringPride

As I write my first letter for this magazine, I've served as the Nemirovsky Family Dean for just over four months. I'm not new to Penn nor to Penn Engineering. Indeed, I joined Penn Engineering as an assistant professor 28 years ago.

In that time, as a teacher, a researcher, the director of the GRASP robotics laboratory and as a department chair, I thought I had seen and gotten to know everything about Penn. I knew we had brilliant colleagues, incredibly smart and savvy students, and a supportive administration that truly appreciates Penn Engineering's role on campus. What I had not realized or experienced in the way I have in the last 127 days is the extent of the Penn Engineering network and the institutional loyalty of our alumni. No matter where I go, people know Penn and Penn Engineering and are eager to connect.

You know who you are—the hundreds who reached out to congratulate me when the deanship was

announced; the people I've met every week in these last few months who offer their significant financial support to our students and faculty in the form of scholarships and endowed chairs; and our incredible Board of Overseers who thoughtfully advise and generously support the initiatives of the School. I have found this outpouring of enthusiastic support to be powerful, exhilarating and inspiring.

This robust support, of course, has allowed us at Penn Engineering to concentrate on our dual mission of creating, integrating, and disseminating knowledge and delivering an engineering education that prepares our students to become global leaders in technology-based fields. We are developing a strategic plan for growth that will allow us to realize our mission and take Penn Engineering to the next level of prominence and excellence. I look forward to sharing this plan with you in a future issue. 🇺🇸

Harlan Flagg

The Hot-rodding Trailblazer

Los Angeles may be well known for its pervasive car culture, but Harlan Flagg (EE'04) has set his sights on turning the gas-guzzling city into an electric motorcycle mecca. With beautiful weather all year long and its permissive law-enforcement stance toward lane splitting, L.A. is the perfect place to test-drive this concept.

In 2009, Flagg founded Hollywood Electrics to make this dream a reality. The dealership is the world's leading electric motorcycle retailer and performance parts manufacturer. For the past six years, the store has carried the largest selection of electric vehicles in the world, and sales have grown every year since it first opened. "We have a worldwide customer base, not just buying our motorcycles, but also our performance products," Flagg says. "The industry has gone from selling a few hundred units to several thousand units in just a couple of years, and there's still a lot of opportunity for growth. It's an exciting time."

FOLLOWING HIS PASSION

Flagg's enthusiasm for electric motorcycles may have been destiny. His father, who was also an electrical engineer, always had motorcycles in the garage, so Flagg picked up the passion while growing up in L.A. Later, as a student at Penn, he worked at a motorcycle shop restoring old bikes in his free time. But after graduating in 2004, Flagg followed a traditional path, building prototype cameras while working at a company that designs imaging devices.

During that time, Flagg continued to tinker with vehicles in his spare time and even teamed up with his dad to convert a BMW car to electric power. That experience, among others, sparked his interest in electric vehicles and convinced him to quit his job in 2008 to follow his true passion. Flagg hopped on a cruise ship with his then-girlfriend (now wife) and worked on his business plan while the couple sailed around the world. "I saw a golden opportunity, because no one else was doing it. When we opened our shop six years ago, we were getting in pretty early, at the beginning of the electric motorcycle industry," Flagg remembers. "I wanted to position myself as a leader in the industry, and now we are the top electric motorcycle retailer in the world."









IN THE SADDLE

The first time Flagg rode a motorcycle, he never wanted to be trapped in a car again. He had the same feeling of freedom when he first rode an electric motorcycle, but this time the experience had an extra dimension. “There’s something about silently whizzing along on an electric bike that makes you feel like a superhero, like Batman,” Flagg remarks. “It’s like you’re slung out of a slingshot with the instant torque of an electric motor, with full acceleration right off the bat, zero to 60 in three seconds. It’s an incredible feeling.”

“THERE’S SOMETHING ABOUT SILENTLY WHIZZING ALONG ON AN ELECTRIC BIKE THAT MAKES YOU FEEL LIKE A SUPERHERO, LIKE BATMAN,” FLAGG REMARKS.

Those in law enforcement also see the appeal. More than 50 police departments now use electric motorcycles, which afford officers the opportunity to quietly move in on suspects. These vehicles also have the advantages of low emissions and low cost of operation, requiring no gas and little maintenance. Plus they can be powered by diverse, domestic renewable energy sources, reducing dependence on foreign oil while supporting our national economy. “It’s the perfect solution for a

lot of people, whether you’re concerned about the environment, commuting costs, or sending money overseas to buy foreign oil,” Flagg says. “We’re running out of reasons to not go electric.”

Electric motorcycles have even caught up with gas-powered bikes in terms of speed and power. Two years ago, an electric motorcycle set the fastest overall time in the motorcycle division at the Pikes Peak International Hill Climb. The Hollywood Electrics team also made waves at the event. To prepare for the race, they enhanced the performance of a standard Zero electric motorcycle by reducing heat to the air-cooled motor and maximizing battery discharge. The trick worked: the team won first place in the production electric motorcycle class in 2013 and has successfully defended its title ever since.

But at least a few remaining obstacles keep these impressive vehicles from being widely adopted. For one, there is a need for additional fast-charging stations to make long-distance riding more practical, Flagg says. And there’s the challenge of convincing people to make the switch. “It’s a new industry and a niche market, so a lot of people have not been exposed to electric motorcycles or are not interested in trying them,” Flagg says. “Getting more people in the saddle is one of the most satisfying parts of my job.” 🍵

By Janelle Weaver

Brain Quest

Charting Complex Terrain Within Neurons

Promising insights into how brain cells are formed, how brain development goes awry and mechanisms in degenerative brain disease are emerging from a lab on the fifth floor of Skirkanich Hall.

“As we generate maps of how the genetic sequence, the DNA, folds and coils into complex 3-D structures inside the nucleus of brain cells, we’re exploring an aspect of genetics that has not yet been examined,” says Jennifer Phillips-Cremins, assistant professor in Bioengineering, who joined Penn’s faculty in early 2014.

As her lab develops the first-ever maps of 3-D genome folding patterns inside neurons, Cremins advances her hypothesis that “how genetic material folds is intricately associated with how genes are expressed and how the brain ‘wires up’ during early development.” Her ultimate goals are to uncover new mechanisms for how the brain works, use that knowledge to better understand the onset and progression of disease, and then someday find ways to reverse-engineer that knowledge to control precisely how genes are expressed so they don’t get dysregulated in disease.

Amid a buzz of excitement about yet-to-be-published discoveries, Cremins describes the key finding in her most-cited paper in *Cell*: “We uncovered evidence that 3-D genome folding patterns change in dramatic ways as stem cells from the early embryo turn into brain cells during early development. Now we’re focused on understanding what these three-dimensional patterns mean for brain function and disease.”

CURIOSITY AND COMPASSION

Cremins recently received the 2015 NIH New Innovator Award for her novel research techniques and aims. In early 2015, she also received an Alfred P. Sloan Research Fellowship as an emerging scientific leader, following her designation in 2014 by the New York Stem Cell Foundation as a Robertson Investigator, an honor bestowed on the world’s preeminent stem cell scientists.

Curiosity and compassion drive Cremins’ experimental focus on neurodegenerative diseases like Alzheimer’s, and neurodevelopmental diseases such as Fragile X. “I recently became interested in underlying mechanisms regulating brain development during the earliest years of life and how that development goes awry, ultimately leading to debilitating neurological diseases,” she notes.

“AS WE GENERATE MAPS OF THE GENETIC SEQUENCE, WE’RE EXPLORING AN ASPECT OF GENETICS THAT HAS NOT YET BEEN EXAMINED,” SAYS PHILLIPS-CREMINS.

Her interest in brain dysfunction began during her first job as a caretaker for an individual with Alzheimer’s, which was also her grandfather’s diagnosis years later. “Then, near the time when I started my lab at Penn, I also introduced my own son into the world,” she recalls. “I have watched in wonder and awe as my son grows and acquires advanced cognitive processes and abilities. I strategically picked Fragile X because I wanted to help children with devastating brain disease and intellectual disabilities in particular. There are 20 or more diseases with the same trinucleotide expansion mutation problem as Fragile X, including Huntington’s disease and many of the ataxias. We hope the mechanisms we study will matter across many neurodevelopmental diseases.”

Cremins hopes to someday develop techniques that go beyond screening for genetic errors to also block the recurrence of key mutations. “My goal is to gain new knowledge that can be used to develop new strategies to prevent neurodevelopmental diseases altogether instead of treating symptoms.” For neurodegenerative diseases, she likewise hopes to find ways to block early steps in the cascade of errors within the genome so the full onset of the disease is blocked from progressing.



JENNIFER PHILLIPS-CREMINS
Assistant Professor in Bioengineering



Jennifer Phillips-Cremins (foreground) studies genome architecture heatmaps with doctoral students Heidi Norton and Jonathan Beagan. These maps give researchers a snapshot of how genes and other important segments of DNA interact with each other in 3-D space.

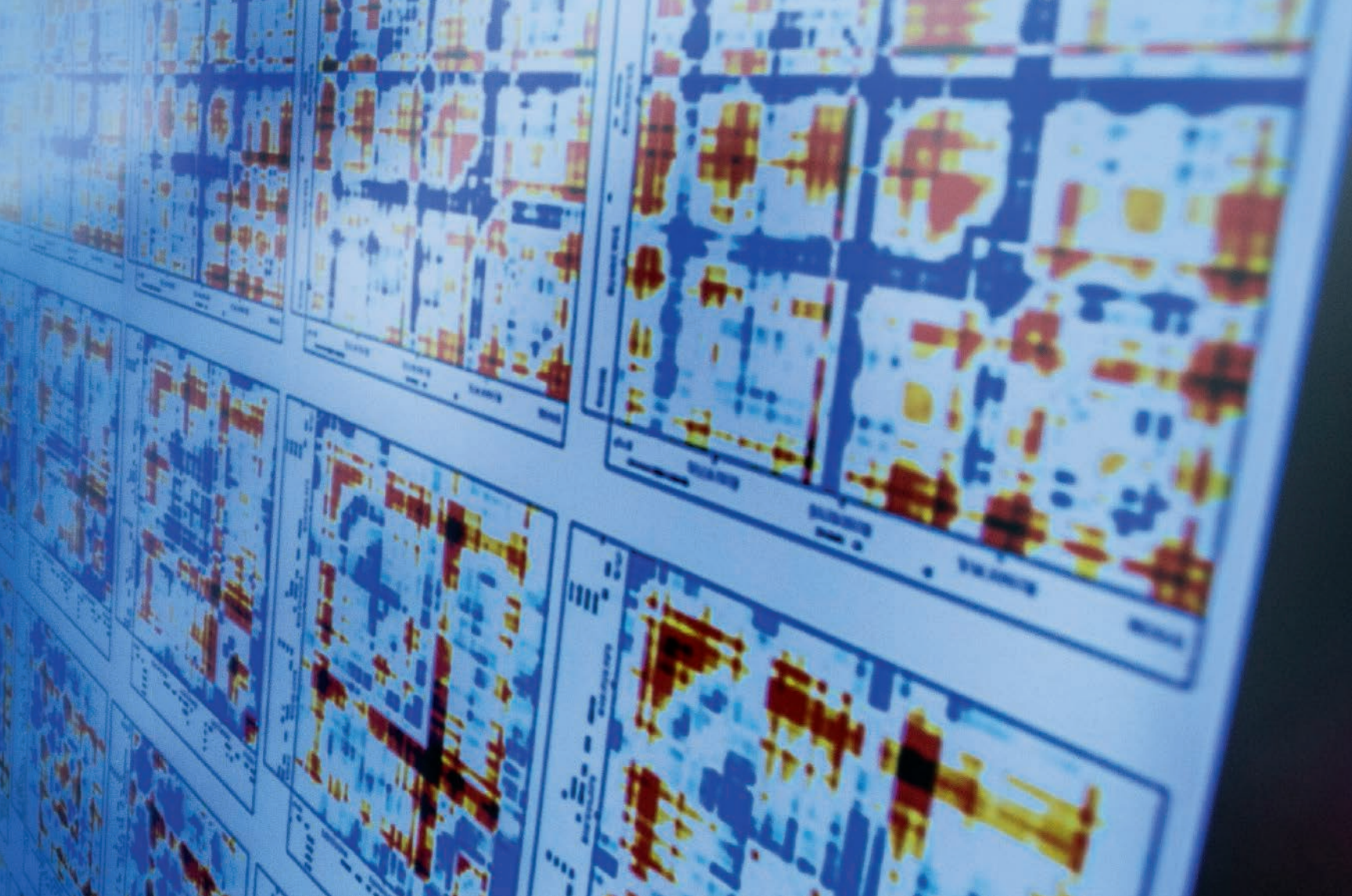
She's forthright that her high-risk research goals may or may not come to fruition during her career. Such caution mixed with optimism reflects the legacy of the mapping of the human genome in 2001, when early hopes were deflated by gene therapy failures. The next wave of related discovery focused on epigenetic switches that regulate gene expression, trigger cell differentiation throughout the body from conception to end of life, and respond to environmental cues such as nutrition, exercise and stress—an elegant synthesis of nature-nurture.

CHROMATIN CARTOGRAPHER

In early 2015, the human epigenome was mapped for the first time in linear form, not as it exists within actual cells. Cremins' lab focuses on that next frontier: creating 3-D maps showing how the genetic sequence (roughly two meters in length when stretched out end-to-end) fits inside the

nucleus, which is about the size of the head of a pin. Discoveries occur when patterns of spatial proximity between distant sections of chromatin (a complex of DNA, RNA and histones) are linked to regulation of gene expression for a particular type of neural cell. Form informs function, says Cremins, offering two metaphors: how an airline flight map shows key hubs of activity where lines join cities connected by frequent travel, and how a particular knot pattern is tied for a specific use and purpose.

Her lab's biggest discovery since coming to Penn occurred in early 2015. Doctoral student Jonathan Beagan observed that when a somatic (mature) cell is reverse-programmed to a pluripotent cell (capable of becoming several different cell types), it retains traces of the 3-D genomic folding configuration of its mother cell. This result may yield clues to new ways to prevent or reduce side effects of therapeutics and to engineer cells for desired characteristics.



“When I observed 3-D genome folding memory for the first time,” remembers Beagan, “that moment of discovery was thrilling.”

REMEMBER THIS MOMENT

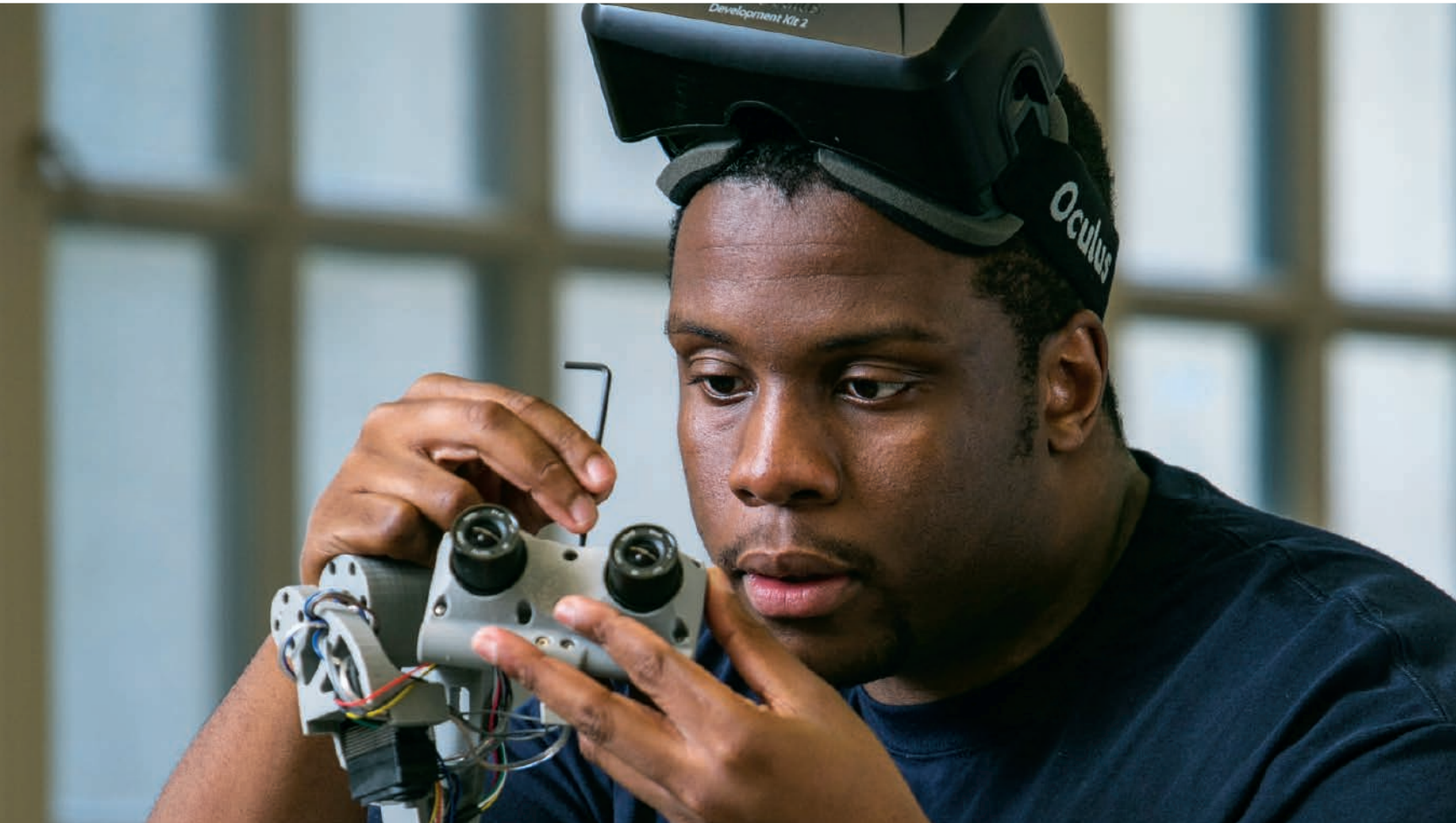
Heidi Norton, also a doctoral student in the Cremins lab, likewise describes a not-yet-disclosed breakthrough. “I showed the data to Dr. Cremins and she said, ‘This is huge! You should remember this moment because they come along rarely in science.’”

Discoveries like these may soon occur with greater frequency in the Cremins lab, which currently has \$4.1 million in funding, including recent funding through the NIH 4D Nucleome Common Fund initiative. Cremins and her team of ten graduate and undergraduate students, computational scientists and research technicians, in collaboration with Arjun Raj, assistant professor in Bioengineering,

and Gerd Blobel, professor in Pediatrics at the Children’s Hospital of Philadelphia, all work to cross-train one another. They aim to combine “wet lab” and “dry lab” skills in molecular and cellular experimentation plus coding, computation and data analysis.

“Beyond the biology, there’s a complex data science component to our work: how to analyze a massive amount of data and how to appropriately use statistical principles to find patterns in big data and interpret the biological significance of the patterns correctly,” says Cremins. “Watching my students grow into talented and purposeful multidisciplinary researchers who collaborate to make discoveries is inspiring. They’re equipped to make a big impact on the future with the depth and breadth of skills needed to integrate and drive biological discovery.”

By Jessica Stein Diamond



99% Perspiration

Hands-on Innovation at Penn Engineering

Penn's culture of innovation, with its origins in the inventive genius of the University's founder and America's first engineer, Benjamin Franklin, is flourishing as never before. President Gutmann's *Penn Compact 2020*, the University's renewed strategic plan, identifies innovation as a guiding principle, and Penovation Works, a 23-acre South Bank property adjacent to campus, has been developed to further advance technological and scientific research, discovery and entrepreneurship.

At Penn Engineering, hands-on innovation has long been a touchstone. A look into labs throughout the School finds students producing objects from 3-D printers, experimenting with haptic surgical devices, launching quadrotors into flight, and manipulating materials that can only be observed through an electron microscope.

Student-run innovation initiatives are not to be outdone. PennApps has quickly grown from its founding in 2009 to become the largest student-run hackathon in the world; over Labor Day weekend, 2,000 computer coders set up camp in Philadelphia's Wells Fargo Center, forming teams whose aim was to quickly develop never-before-seen software and hardware. Another recent event organized by students, the Penn Innovation Conference, was held in October, offering students participatory skill-development workshops, panel discussions and the opportunity to engage with entrepreneurs and technology experts.

THE RIGORS OF SENIOR DESIGN

No Penn Engineering graduate ever forgets his or her Senior Design Project, a two-semester course



At Penn Engineering, hands-on innovation has long been a touchstone. Daleroy Sibanda, master's student in Robotics (far left), completes repairs on DORA, a telepresence robot that creates an enhanced sense of situational awareness for the user; the Penn Electric Racing (PER) car competes on the track in Lincoln, Nebraska (middle); and Mechanek is an enhanced head and neck support device intended for the safety of race car drivers (right).

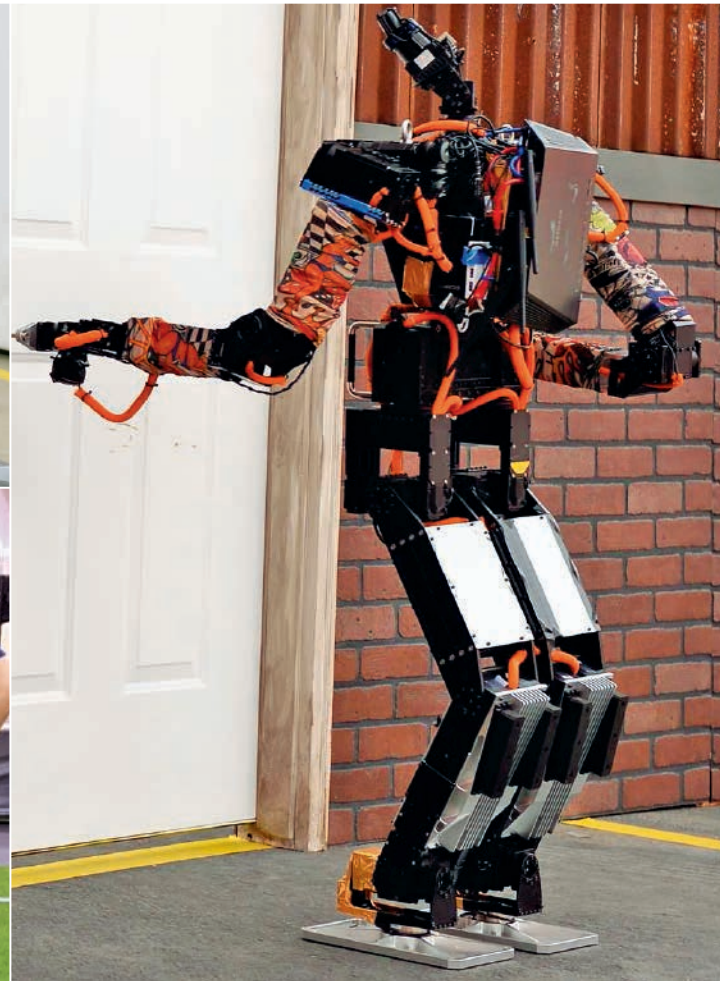
sequence that challenges students to create novel solutions to real-world engineering problems. Throughout the year, students acquire skillsets that include team building, time management and budgeting, in addition to designing and fabricating. On top of an often heavy senior-level course load, the design sequence is academically rigorous, culminating in year-end Departmental and School-wide presentation contests.

Senior Design teams also often vie for honors at the annual Cornell Cup, an embedded design competition sponsored by Intel and hosted by Cornell University. The Cup's mission is to "empower student teams to become the inventors of the newest innovative applications of embedded technology." Last spring, Penn's Mechanical

Engineering and Applied Mechanics (MEAM) projects BionUX (haptic feedback for prosthetics), DORA (a high-end telepresence system) and Mechanek (an enhanced head and neck support device for race car drivers) impressed the judges. The MEAM teams brought home three out of the Cup's seven first place prizes.

A DYNAMIC CLASSROOM

A new approach to the craft of classroom teaching has been introduced at Penn Engineering. A large portion of the second floor of the Towne Building has been transformed into changeable hubs for interactive learning, creating a new dimension for pedagogy and performance. The Forman Active Learning Classroom is designed to promote



The PER chassis undergoes stringent testing (top left); Team THORwIn (Tactical Hazardous Operations Robot with Intelligence) wins the Louis Vuitton trophy (bottom left); THORwIn activates a doorbell (right).

dynamic collaboration and communication among participating students, with professors engaging in the mix and providing input.

Two flights down in Towne, one can find the Penn Electric Racing (PER) workshop, which garages REV1, the team's electric race car and winner of top honors at the 2015 Society of Automotive Engineers (SAE) International competition held over the summer in Lincoln, Nebraska.

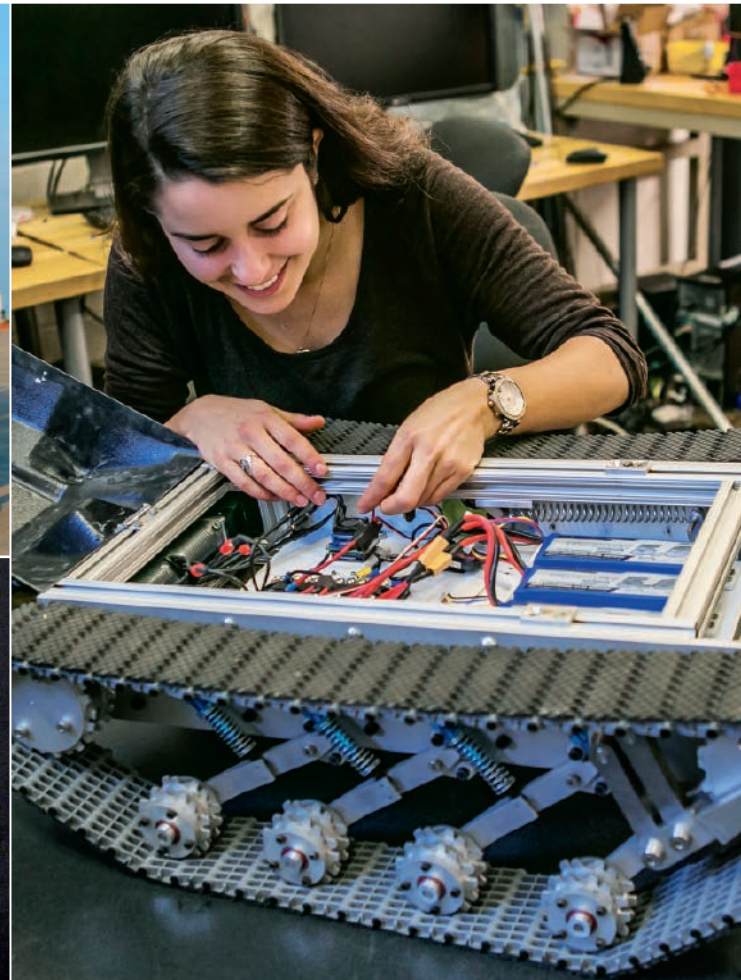
WHEN EVERYONE IS PRESENT,
NEW IDEAS ARE BOUNCED AROUND
AND ADAPTIVE TECHNIQUES ARE
EMPLOYED AND EVALUATED.

It is in extracurricular team-occupied spaces like this one that a whole different kind of ingenuity manifests itself, observes PER's chief engineer Adam Farabaugh. PER is currently close to 30 members strong, and

while students from various disciplines contribute to different aspects of the enterprise, the teamwork ethic is essential to their success. When everyone is present and hard at work in the shop, new ideas are bounced around and tweaks and adaptive techniques are employed and evaluated efficiently. In this inclusive environment, newer team members become engaged and energized.

CLOSING THE DESIGN CYCLE

PER affords team members the opportunity of seeing the full engineering process completed, rather than having "one shot" at solving a problem, as is often the case in a curricular lab. Farabaugh, a 2015 MEAM graduate working on his master's in Robotics, notes that as they prepare their SAE car for the racetrack, students are "closing the cycle: turning testing and evaluation into redesign, and repeating the cycle *ad infinitum*." His take on learning from trial and error in the workshop is that, in and of itself, failure isn't the instructive experience, as much as "coming back from a failure and succeeding the next time is."



The Penn Electric Racing team poses with seven first place trophies (top left); DORA allows users to explore and engage in remote locations (bottom left); Ilana Teicher, MEAM'17, checks the wiring on her final project in Integrated Product Design (right).

This cycle of “test-evaluate-redesign-repeat-repeat-repeat” would resonate strongly with Steve McGill, doctoral candidate in his research with the GRASP Lab’s Tactical Hazardous Operations Robot with Intelligence, or THORwIn. When asked about his experience with innovation through his work with adult-size robots, McGill repurposed Thomas Edison’s well-known aphorism about genius: “Innovation,” according to McGill, “is 1 percent inspiration, 99 percent perspiration.”

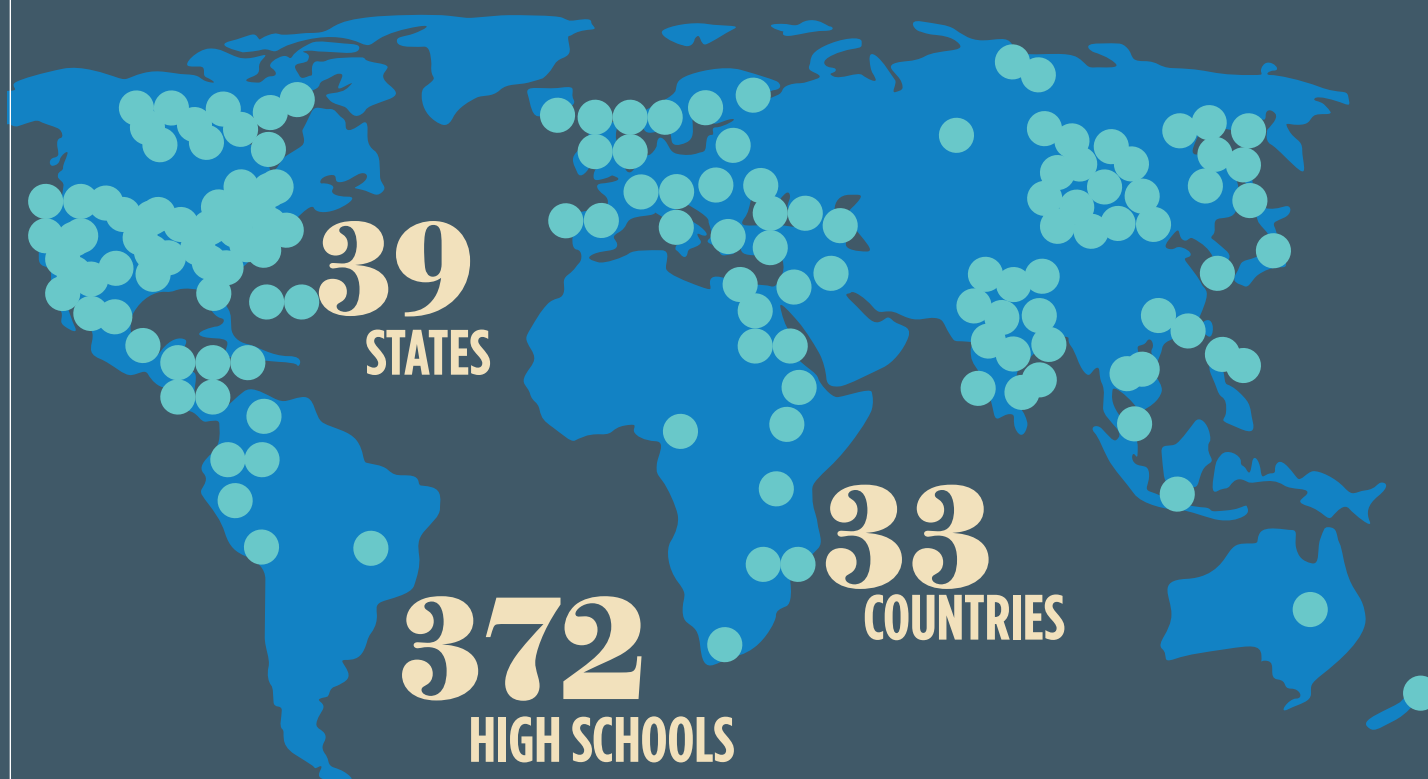
Led by McGill and in collaboration with UCLA, Team THORwIn won first place and top technology trophies in the AdultSize Humanoid League from last summer’s Robot Soccer World Cup (RoboCup) in Hefei, China. League winners since 2011, hardworking Penn teams have steadily implemented the necessary enhancements in hardware, electronics and power, software architecture, vision and locomotion control to keep them at the leading edge.

McGill notes that the GRASP Lab’s researchers come from many disciplines, including medicine and psychology, and that “in this collaborative environment, we are able to cultivate seeds of imagination and inspiration for next-generation technology, including methods for humanoids to provide disaster relief.”

Daniel Lee, director of the GRASP Lab and faculty advisor for Team THORwIn, adds that some of the lessons learned from hands-on group endeavors are hard won. Team-centered engineering projects are undertaken in an environment quite different from that of the classroom, where students are expected to do homework by themselves and hand in their own work. Team members must divide their workload, and difficulties may arise, he explains, “because personalities really come out in stressful situations.” Just as in the post-graduation workplace, Lee concludes, “getting things done sometimes involves more than technical skills.” ▾

By Patricia Hutchings

Penn Engineering Class of 2019 Fast Facts



AVERAGE SAT
2223

SAT MATH 764

SAT CRITICAL READING 724

SAT WRITING 735

ACT MATH 34

% UNDERREPRESENTED MINORITIES



PENN



NATIONAL AVERAGE

% WOMEN



PENN



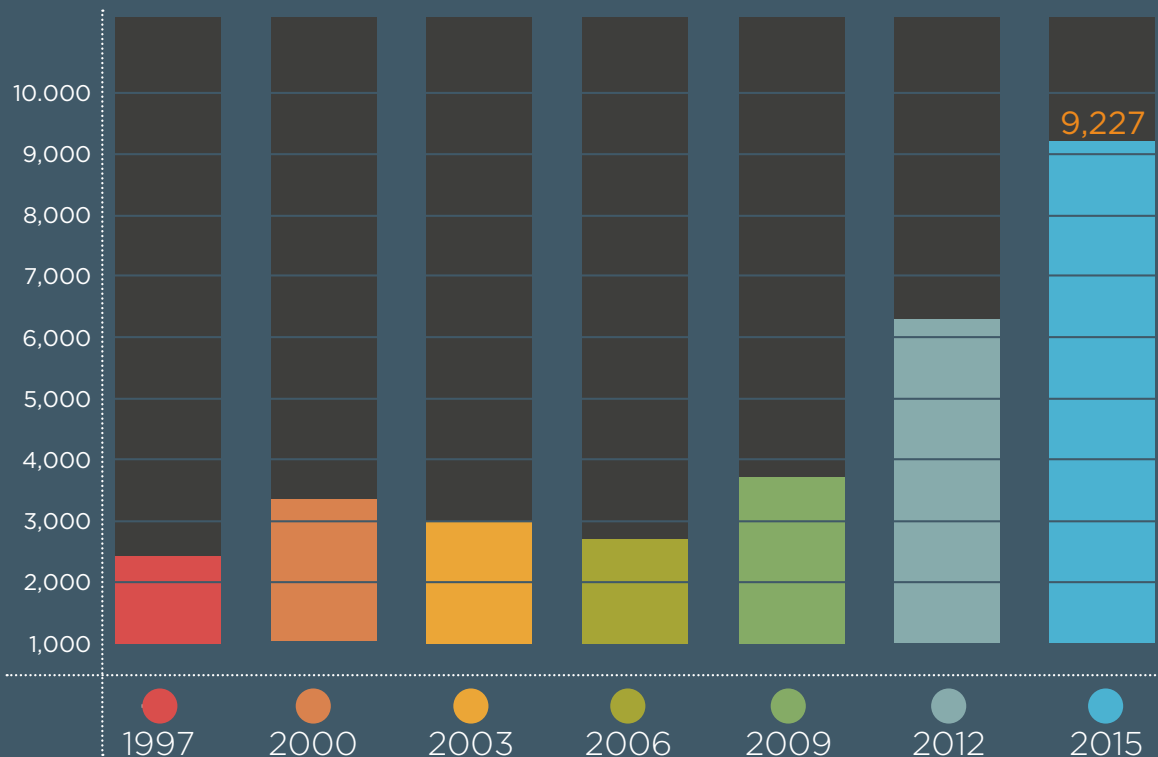
NATIONAL AVERAGE

9,227

APPLICANTS

PENN ENGINEERING IS THE MOST SELECTIVE UNDERGRADUATE SCHOOL AT PENN, WITH **421** STUDENTS ENTERING THE CLASS OF 2019.

APPLICATION GROWTH



Breaking New Ground

In the digital age, information is a double-edged sword. The ability to collect and study troves of user data helps companies to build better services and enables scientists to make important discoveries. But when mining large datasets, researchers risk exposing sensitive personal information.

Aaron Roth, the Raj and Neera Singh Assistant Professor in the Department of Computer and Information Science (CIS), believes that with smarter tools, we can do “big data” science while protecting individual privacy. “We’re used to thinking of privacy as this goal that’s inherently at odds with analyzing data,” notes Roth. “But privacy and data usefulness are surprisingly aligned with each other.” Through his foundational work on “differential privacy,” Roth is building algorithms that researchers can use to analyze large datasets without revealing the identities of individuals. He’s discovering that these algorithms don’t just ensure privacy, they help researchers arrive at more robust conclusions.

GETTING STARTED

When Roth began graduate school at Carnegie Mellon University, the issue of online data privacy was just beginning to garner national attention. One of the first major security breaches occurred in 2006, when AOL released “de-identified” search logs of hundreds of thousands of users to benefit academic researchers. The well-intentioned move became a scandal when *The New York Times* tracked down one of the supposedly anonymous web searchers, and showed how individual users could be identified from the data. As the number of large data breaches grew, security researchers began asking what could be done. “People wanted a way of sharing data while having a guarantee that someone wasn’t going to come along and re-identify the data later,” Roth says. Several

research groups at the time then proposed the idea of differential privacy, which aimed to address these exact problems.

ROTH IS BUILDING ALGORITHMS THAT RESEARCHERS CAN USE TO ANALYZE LARGE DATASETS WITHOUT REVEALING THE IDENTITIES OF INDIVIDUALS.

Roth’s doctoral thesis, the first on the subject of differential privacy, attracted the attention of CIS faculty member Michael Kearns, who encouraged him to apply for a position at Penn. “I likened our recruitment of Aaron to recruiting Kobe Bryant out of high school,” says Kearns, National Center Professor of Management and Technology. “I knew it would be fantastic to have him here.” If anything, Roth has managed to exceed those high expectations since arriving at Penn in 2011, collaborating with researchers across academia and industry to lay the theoretical groundwork for the nascent field of differential privacy. Roth’s achievements have earned him numerous honors, including a Sloan Research Fellowship, an NSF CAREER Award and a Yahoo Career Advancement award. “It’s so rare to find someone at such a young age who’s not just doing great research, but doing great research in a field he helped to create,” notes Kearns. “I’m having the time of my life working with him.”

SAFER AND SMARTER

When a researcher wants to answer a large number of questions about a dataset, the obvious thing to do is to query that dataset many times. But this strategy comes with a risk. “If I’m an algorithm, and I compute an answer on a dataset exactly,



AARON ROTH
*Raj and Neera Singh Assistant Professor in
Computer and Information Science*



$$\min \int_{-\infty}^{\infty} P(x) \cdot \log(P(x))$$

$$\sum P(x) = 1 \quad [>$$

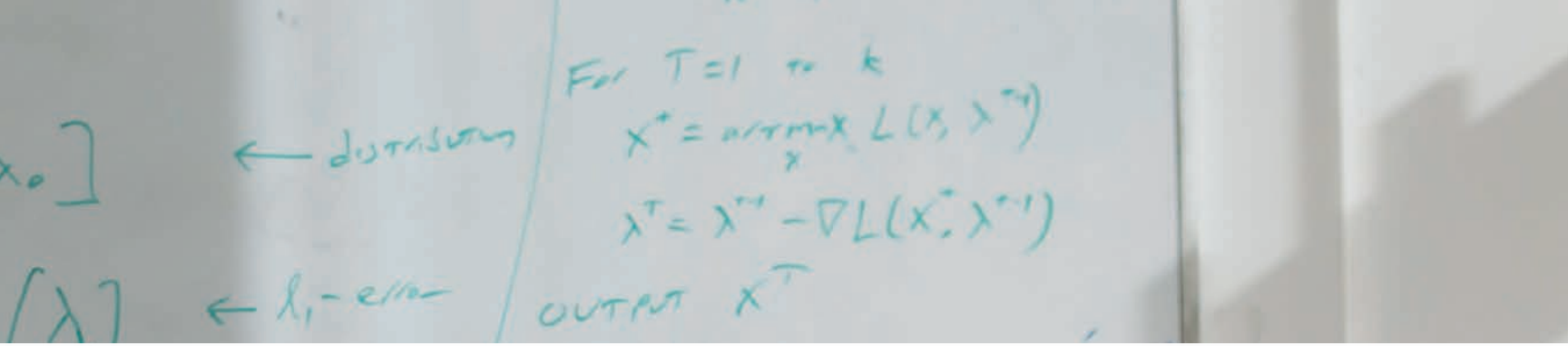
$$-a \leq \frac{1}{\epsilon}$$

$$P(x) \cdot \log(P(x)) + \lambda_0$$

$$+ \lambda_1 + \lambda_2$$

$$z =$$

$$\lambda_1 =$$



every time you ask a question, you'd eventually be able to reconstruct the dataset and find every individual," Roth says.

Instead, a differentially private algorithm will try to predict accurate responses by looking at the questions that the researcher has already posed and the answers that have been given, and guessing based on a large number of other datasets consistent with the results so far. "It turns out, from the answers I've given previously, information about the dataset is implied that might already determine the answer to the question you've asked next," Roth says. This strategy ends up giving a privacy guarantee, because the algorithm only has to look back at the dataset a small number of times.

"IN DATA PRIVACY, YOU WANT TO LEARN FACTS ABOUT THE UNDERLYING POPULATION WHILE NOT LEARNING MUCH ABOUT INDIVIDUAL MEMBERS OF THE POPULATION," SAYS ROTH.

While differentially private algorithms were conceived as a tool to protect individuals, Roth and his colleagues have made a surprising discovery during the course of their research: these algorithms can also protect researchers from the "false discoveries" that occur when a dataset is repeatedly mined for correlations.

One can imagine a medical researcher looking for correlations between smoking and lung cancer in a dataset of 250 individuals. Rather than learning idiosyncratic things about her study group, she'd like to use the data to make inferences about the general population. That goal turns out to be aligned with the goal of data privacy. "In data

privacy, what you want to do is learn facts about the underlying population while provably not learning very much about individual members of the population," Roth says.

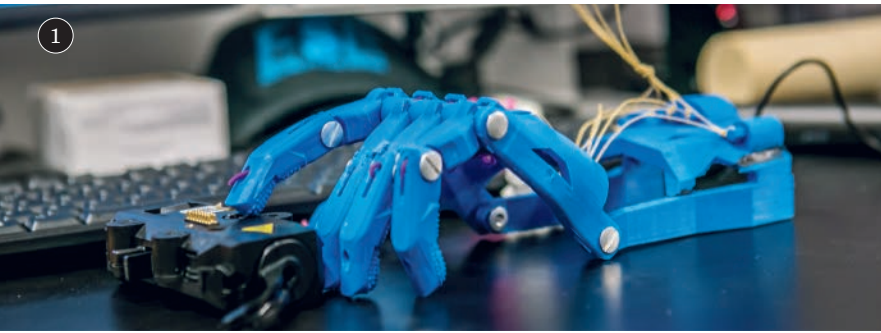
Together with researchers at the University of Toronto, Microsoft Research, IBM and Google, Roth published a study in *Science* this year outlining a method for testing successive hypotheses on the same dataset using differentially private algorithms. Disciplines ranging from cancer research to economics might in the future use similar methods to protect the privacy of study participants while ensuring statistically robust conclusions.

BUILDING NETWORKS

Roth's efforts to build a research field that bridges academia, technology and society are mirrored by his teaching and mentoring activities at Penn. During his short time at the University, Roth has built foundational courses for the Networked & Social Systems Engineering (NETS) program, an interdisciplinary major that teaches undergraduates to think scientifically about topics like the viral spread of content on Facebook and Search Engine Optimization. "Normally, a junior faculty member would come into a traditional existing department and teach courses that were already designed," Kearns says. "Aaron came in and designed an algorithmic game theory class for undergraduates from scratch. There existed no such course in the world at that level."

Roth enjoys teaching undergraduates, and also finds it gratifying to watch the intellectual development of his doctoral students. "All of my graduate students, by the time they are several years in, have become real colleagues and independent researchers," he remarks. "The transformation from when they started graduate school is really remarkable to see." ▾

By Madeleine Stone



On Our Camera Roll



1. A 3D-printed robotic hand is ready to work in Towne's AddLab. **2.** Gone are the days of classroom chalk and blackboards; presenting at the "whiteboard" is now the norm. **3.** Professor Michael Kearns and students hard at work in NETS 112, "Networked Life," held in Skirkanich Hall's Berger Auditorium. **4.** Focused and driven, a student's coursework is completed whenever there is a spare moment. **5.** Dean Vijay Kumar lectures at the Penn Wharton China Center in Beijing.



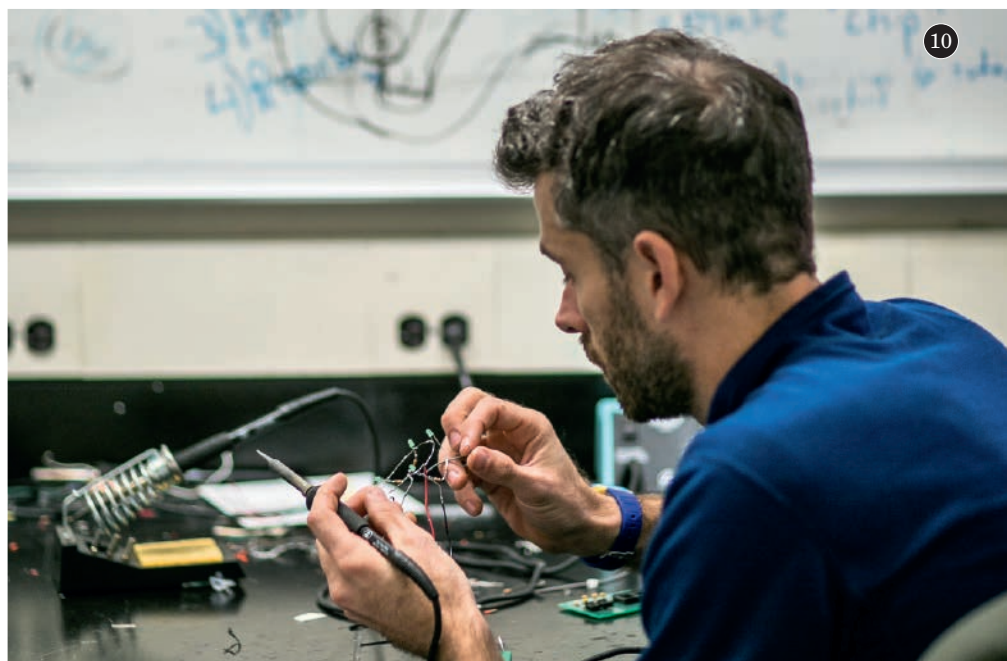
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9



7



10



8

6. Early risers in front of the Towne Building on a fall morning. **7.** Study spaces are filled to capacity in the Moore Building. **8.** Starting the day with a coffee and answering email. **9.** There is always time for laughter, even during midterms. **10.** Soldering in Mechanical Engineering's General Motors Educational Laboratory.

Science Nonfiction

Mapping a New Market for Robotics Technology



For Jonas Cleveland, it all started with *Short Circuit*.

At the age of 28, Cleveland (ROBO'14) works at the leading edge of robotics technology. He collaborates with some of the field's most well-known names and has cofounded an exciting new tech company that could revolutionize the process of automated navigation. However, as lofty as the circles in which he travels are today, the origins of his passion trace back to a slightly less academic source: the 1986 cult classic starring Ally Sheedy, Steve Guttenberg, and, of course, a robot. "I saw *Short Circuit* as a kid," says Cleveland, "and when I saw the robot Johnny Five come to life, I knew at that moment I wanted to be involved in robotics."

Upon his graduation from Union County Magnet School, a highly competitive high school focused on STEM fields, the Plainfield, New Jersey native

attended Carnegie Mellon University for his undergraduate work because "it's a great place to go if you want to do robotics." However, as he gained extensive technical expertise in robotics during his time at CMU, Cleveland also started to consider a second, percolating interest: entrepreneurship.

After briefly working as a researcher at Carnegie Mellon, Cleveland selected Penn for his graduate studies, a carefully measured move with an eye not only on the Robotics program's technical strength in robot perception, but also on the practical nature of the curriculum. "The program [at Penn] just does an incredible job of preparing people for industry," he says. "I saw the coursework here when I came to visit friends. They weren't only doing problem sets or papers, they were actually building things. That appealed to me."



COSY

STREET COURTYARD

CENTER

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NEWS



Pictured (left, clockwise) in the virtual map they've created, COSY team members and Penn alums Jonas Cleveland, Founder; Sagar Poudel, Developer; Kevin Cadette, Advisor; and Cody Phillips, Lead Developer. In order to explore places or events of interest, COSY's "beacon-free" technology enables any mobile device, from smartphones to robots, to provide turn-by-turn navigation and localization anywhere that GPS is not available.

Cleveland quickly made his mark in Penn's General Robotics, Automation, Sensing and Perception (GRASP) Laboratory, developing technology related to computer perception and artificial intelligence. "He has the mentality of a scientist," says Kostas Daniilidis, Associate Dean for Doctoral Education and Director for Online Education at Penn Engineering. "He always wanted to understand why something works. What differentiates him from other students was that he is very independent in formulating research questions. He really generated his own ideas and pushed through them during his time here."

INSPIRATION STRIKES

Cleveland had his research epiphany when a family visit to the American Museum of Natural History in New York turned into a squabble over the museum map and the family's location. "I remember thinking, 'Wow, this is a problem.' There had to be an easier way to figure out where you were and how to get where you were going, especially when you weren't outdoors with access to GPS. Then I realized this was really a robotics problem as well."

The robotic mapping concept became a focus of Cleveland's thesis work with Daniilidis and others in GRASP. After extensive research and progress, Daniilidis encouraged Cleveland to apply for the National Science Foundation's I-Corps program, a six-week business incubator offering guidance for and assessment of spinoff startup companies originating in NSF research. With Daniilidis on board as the technical mentor, Cleveland found his footing as the entrepreneurial lead on the I-Corps project. Ultimately, the collaboration led to a key patent and the cofounding of the LLC, Cognitive Operational Systems (COSY) in 2013.

RIFE WITH POSSIBILITIES

COSY has numerous avenues in mind for the real-world application of its technology. The first is a guidance application that can perceive and process its surroundings and offer directions to a person who is blind or otherwise impaired in crowded or challenging spaces where WIFI and GPS are unreliable. A trial run where a woman who is blind

was led through the crowds in Philadelphia's Suburban Station was a success. "That was a really big moment for us," he remembers.

The possibilities for COSY's technology do not stop there. Vijay Kumar, Nemirovsky Family Dean of Penn Engineering, and self-proclaimed "president of the Jonas Cleveland fan club," helped connect COSY with retail giant Walgreens, and the startup is now working on technology that will allow robots to cruise Walgreens stores at night and perceive, organize and process information about product placement on shelves.

CLEVELAND SELECTED PENN BECAUSE OF THE ROBOTICS PROGRAM'S TECHNICAL STRENGTH IN ROBOT PERCEPTION COUPLED WITH THE PRACTICAL NATURE OF THE CURRICULUM.

In August, the technology for this project earned a finalist's award for "Best Application Paper" at the annual IEEE CASE 2015 conference in Sweden. The extension of the process is also rife with possibilities, says Kumar. "Imagine a robot that tells you, when you are 95, where you've misplaced your keys, or where the remote is, or what groceries have been delivered and where they are," he says.

Now managing a small team at COSY, which is located in the new Pennovation Works site south of the main Penn campus, Cleveland is excited about the possibilities for both his company and the field in general. "The cool thing about robotics at this moment is that ideas that were once confined to science fiction are now becoming a reality," he notes. "The timing for us is pretty perfect."

With Cleveland helping to lead the way, it seems only fitting that a science fiction robot was where the whole process began. 🤖

By Eric McCollom



PennApps XII

HACKING ENTERS A NEW ARENA

Over its 275-year history, the University of Pennsylvania has been a beacon of innovation. It is fitting that the birthplace of ENIAC is also the host of PennApps, the largest student-run collegiate hackathon in the world.

Now in its sixth year, PennApps continues to grow and evolve, hosting a hackathon each semester. This fall's event included more than 2,000 participants, and despite the competitive nature of the event, there was a camaraderie among the attendees and an unexpected community-oriented mission. In past years, the hackathon has resulted in programs that run the gamut from entertaining to life-saving. "Last year, we had a team create an app that takes you through the steps of CPR," says Pranav Ramabhadran, M&T student and director of PennApps. "Imagine how helpful that could be in an emergency situation."

Tech companies have no trouble imagining possibilities, and that's partly why representatives from Facebook and Google walked the room for PennApps XII, scoping out the creations of potential future employees. This year, the "room" was actually the Wells Fargo Center, a move forced by a doubling of participants from just two years ago. Considering that this is the home of the Philadelphia Flyers and Philadelphia 76ers, it's hard not to feel PennApps is in the major leagues of international collegiate events.

The event, held between Friday, September 4th and Sunday, September 6th, began with a 6:00 p.m. kickoff of keynote speakers, including Leslie Chapman, a software engineer at Comcast, also a supporter of PennApps; John Maeda, design partner at Kleiner Perkins Caufield and Byers; and Vijay Kumar, Nemirovsky Family Dean of Penn Engineering. Matt Howard, vice director



Now in its sixth year, PennApps continues to grow and evolve, hosting a hackathon each semester. This fall's event saw more than 2,000 attendees travel to the Wells Fargo Center, a move forced by a doubling of participants from just two years ago.

of PennApps and a junior majoring in Computer Engineering, says it was the perfect way to amp up the crowd. "People were really blown away by learning about Dean Kumar's research into drones and seeing the videos," he notes. "It fit in well with everyone getting ready to create."

DESPITE THE COMPETITIVE NATURE OF THE EVENT, THERE WAS A CAMARADERIE AMONG THE ATTENDEES AND AN UNEXPECTED COMMUNITY-ORIENTED MISSION.

And, when 8:00 p.m. rolled around, they hacked, and didn't stop until 9:00 on Sunday morning.

Amidst the construction and chatter, Aasif Versi, in charge of hardware for PennApps, was most impressed by an even greater feeling of community this time around. "There is a sense of competition but also collaboration between the teams," says the junior, also majoring in Computer Engineering. "Some inexperienced hackers were accepted to the event and you can see that everyone is there to help them out. Need a screwdriver? Someone has one. A complex piece for a hack? If they don't need it, it's probably yours. I asked someone to help a high school team and it was their pleasure."

This year also featured a laboratory for participants, from microcontrollers to Oculus Rifts. In addition, this PennApps marked the first addition of "routes," which allowed participants to have a wider choice in terms of interests in which to compete. The six categories for this inaugural addition were Social and Civic Hacking, Design,



EdTech, Virtual Reality/Augmented Reality, Sports and Entertainment, and Humor. “By picking different themes, it allowed greater incentive for people to get more specific with their work,” Versi notes. “Yes, we had prizes, but a big reward for people was the recognition of finishing first in their chosen category.” Two of the routes also featured workshops. “The Design route had an overview of the subject, especially in the context of product design,” Ramabhadran says. “The Social and Civic route had individuals from the City of Philadelphia and Code for Philly going over the resources available and useful things to do when it comes to a civic hack.”

KEEPING THEIR EYES OPEN

When most of the Red Bulls had been consumed and the 9:00 a.m. hacking deadline had passed, all that was left to do was to pick a winner from the sleep-deprived faithful. Maybe not surprisingly, the grand prize went to another marvel related to a medical issue—an app which connects to smart-phones and enables input and output of Braille.

“I observed them in the middle of their work,” says Eloisa Jones, head of mentorship for PennApps and a junior majoring in Mechanical Engineering and Applied Mechanics. “You can see how advanced things are getting because they actually brought their own 3-D printer to speed up the process of their hardware hack. I didn’t expect that.”

PENNAPPS FOCUSES ON A FEELING OF INCLUSIVENESS, OFFERING A “CODING 101” EVENT SO EVEN THE ULTIMATE NEWBIE ISN’T LEFT BEHIND.

While PennApps is a competition, and a winner must be chosen, the real “W” goes to those who will benefit from the creations produced by this community. It’s the spirit of hacking that PennApps has made into a champion. 🍷

By Eric Butterman



Code of Connection

Since PennApps focused on a feeling of inclusiveness, even the ultimate newbie wasn't left behind. For many, an event called Code Weekend was their first foray into technological innovation. "It's a Hackathon 101 course and a Web Development 101 course mixed together," explains Pranav Ramabhadran, director of PennApps. "We hold it the weekend before the event in order to focus on simpler tasks, like making a website or an app. Our goal is to give everyone those skills by the end of the weekend." Ramabhadran says it's now so popular that they've become overbooked to the point where they only have a percentage of attendees in the actual room and must provide a livestream for the rest of the crowd in another room.

Derek Jobst, who has served as a mentor for Code Weekend in the past, said it's an important chance not just to cater to engineering students but to reach out to students from many different schools. "We have great future business leaders and they may need a website if they start their own company, together," notes Ramabhadran. "We want to show that this knowledge is for anyone who wants it."

HONORS & AWARDS

Mark Allen, *Alfred Fitler Moore Professor in Electrical and Systems Engineering*, received the 2016 IEEE Daniel E. Noble Award for Emerging Technologies for “contributions to research and development, clinical translation, and commercialization of biomedical microsystems.”

Danielle Bassett, *Skirkanich Assistant Professor of Innovation in Bioengineering*, was named a 2015 Office of Naval Research Young Investigator. This program is designed to promote the professional development of early-career academic scientists both as researchers and instructors.

Scott Diamond, *Arthur E. Humphrey Professor and Chair of Chemical and Biomolecular Engineering*, received a five-year, \$3.7 million award entitled, “Blood Systems Biology” from the National Institutes of Health. The project will launch multiscale computer simulations of patient-specific heart attacks based upon the patient’s own blood biochemistry and their own coronary circulation obtained by radiological imaging.

Dennis E. Discher, *Robert D. Bent Professor in Chemical and Biomolecular Engineering*, has been named a Fellow of the American Association for the Advancement of Science (AAAS). Election as a Fellow of AAAS is an honor bestowed upon members by their peers, and Fellows are recognized for meritorious efforts to advance science or its applications.

Nader Engheta, *H. Nedwill Ramsey Professor in Electrical and Systems Engineering*, was named a 2015 National Security Science and Engineering Faculty Fellow. This program engages the next generation of outstanding scientists and engineers in the most challenging technical issues facing the Department of Defense. Engheta also received the 2015 IEEE Antennas and Propagation Society Distinguished Achievement Award.

Robert Ghrist, *Andrea Mitchell University Professor in Electrical and Systems Engineering and in Mathematics*, was named a 2015 National Security Science and Engineering Faculty Fellow. This program engages the next generation of outstanding scientists and engineers in the most challenging technical issues facing the Department of Defense.



Mark Allen



Danielle Bassett



Scott Diamond



Dennis E. Discher



Nader Engheta



Robert Ghrist



David Issadore



Raymond Gorte



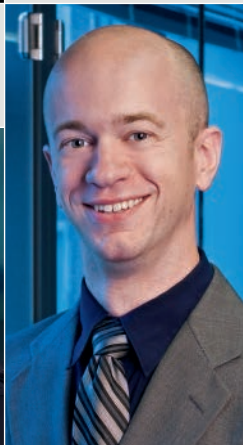
Jennifer Phillips-Cremins



Katherine Kuchenbecker



Beth Winkelstein



Robert Riggleman

Raymond Gorte, *Russell Pearce and Elizabeth Crimian Heuer Professor in Chemical and Biomolecular Engineering*, has been elected Fellow of the Electrochemical Society (ECS). The ECS aims to foster research, discussion, and practice in electrochemical and solid state science and technology.

David Issadore, *Assistant Professor in Bioengineering*, was selected to participate in the NAE's 7th Frontiers of Engineering Education Symposium. This symposium brings together some of the nation's most engaged and innovative engineering educators in order to recognize, reward, and promote effective, substantive, and inspirational engineering education.

Katherine Kuchenbecker, *Associate Professor in Mechanical Engineering and Applied Mechanics*, has been awarded the Class of 1940 Bicentennial Term Chair. The Chair was established by the Class of 1940 at its fiftieth reunion to recognize outstanding young professors at Penn. It rotates among the University's four undergraduate schools for five-year terms.

Jennifer Phillips-Cremins, *Assistant Professor in Bioengineering*, has been named to the 2015 class of New Innovator awardees by the National Institutes of Health. The award provides Phillips-Cremins \$2.4 million for the next five years to advance her work on the dynamics of the "3-D Epigenome."

Robert Riggleman, *Assistant Professor in Chemical and Biomolecular Engineering*, has been awarded a National Science Foundation grant to develop field theoretic models to predict the structure and properties of grafted nanoparticles positioned at fluid interfaces. Riggleman and his group will use these models to optimize the mechanics of the grafting architecture that allows nanoparticles to stabilize emulsions effectively.

Beth Winkelstein, *Professor in Bioengineering*, has been named Vice Provost for Education at the University of Pennsylvania. This position has primary responsibility for undergraduate and graduate education at Penn, developing and implementing policies that promote academic excellence, innovative teaching and learning and interdisciplinary knowledge across the University.

Dennis Discher Elected to National Academy of Medicine

Dennis E. Discher, *Robert D. Bent Professor in Chemical and Biomolecular Engineering*, has been elected to the National Academy of Medicine (NAM), one of the nation's highest honors in biomedicine.

The NAM was originally the Institute of Medicine, which was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected to the NAM by their peers for distinguished contributions to medicine and health.

Discher joined Penn in 1996 following postdoctoral work in computational biophysics as a U.S. National Science Foundation International Fellow at the University of British Columbia and Simon Fraser University. He received his Ph.D. jointly from the Universities of California, Berkeley and San Francisco, for studies of cell membrane physics and spliceform biochemistry.

Discher holds secondary appointments in Bioengineering and in Mechanical Engineering and Applied Mechanics and is a member of the Graduate Groups in Cell and Molecular Biology, Pharmacology and Physics. His research has focused on stem cell differentiation in relation to physicochemical properties of microenvironments, which differ greatly between tissues and in injury and disease. His group uses engineered polymer systems in studies that have extended to questions on drug carriers, particularly the roles of nanoscale features and immune system interactions.

Discher was awarded a Presidential Early Career Award for Scientists & Engineers (PECASE) from the National Science Foundation in 1999 and was elected in 2012 to the National Academy of Engineering (NAE). He is the Principal Investigator at Penn of an NCI-funded Physical Sciences Oncology Center, which fosters research into new physical principles in cancer development, and straddles the School of Engineering and Applied Science, the Perelman School of Medicine and the School of Arts & Sciences. Discher has authored more than 200 widely cited publications in journals that range from *Science* and *Cell* to *Physical Review Letters*, *Nature Materials*, and the *Journal of the American Chemical Society*.



Dennis Discher



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Robert Stavis

A Passion for Advancing Engineering and Technology



Overseer Robert Stavis (EAS'84, W'84) starts his day much like anyone else: with a cup of coffee and his iPad to get updates on what's happening in the world.

As a partner and leader of a financial services and education technology investment team at Bessemer Venture Partners in New York, Stavis finds his career exciting. He relishes the opportunity to identify and invest in new technology and technology-enabled businesses and then provide the guidance and insight in order to help them succeed. He's rarely at his desk, moving between startup offices, board meetings or sitting down with new prospects. But despite the hectic pace, he makes time for the things most important to him: family and community, including serving as an Overseer for Penn Engineering.

In the Q&A below, Stavis reflects on his time at Penn and his continued involvement in the University community, both as an Overseer and philanthropist.

How did engineering at Penn influence your current career?

My engineering education taught me how to ask deep questions and to fundamentally understand how systems work. I think about business processes and evaluate potential investments in a very engineering-focused way, and I credit the curriculum at Penn with a lot of my success.

How has being an Overseer changed your perspective?

As an Overseer, I've learned that fundraising is critical to supporting important research and this incredible institution. It has enhanced my understanding of how to best support Penn and has given me the tools to help explain this cause to others.

Is a dedication to philanthropy hard-wired in both you and your wife?

We each come from families in which giving back, both financially and through service, is very important. We are also both fortunate to be involved in strong communities, the Penn community, our community in Larchmont, NY, and even the early-stage startup community. As a result, we recognize that community strength doesn't happen on its own.

Is Penn a real touchstone for you and your family?

Yes. I met my wife Amy at Penn; we both took the same finance class. Penn is deeply enmeshed in our business and social lives, and our daughter is now a student at Wharton, so there's a family tradition as well.

What types of potential investments are you most excited about?

Across the universe of startups I focus on only a few areas: early-stage startups in financial services, the education space, and also the Internet of Things, which describes devices that connect to the Internet. I have a real passion for my work. The teams I get to work with are solving difficult and interesting problems, and it's great being able to work with talented, smart, passionate, driven entrepreneurs.

And if you hadn't gone into private venture investing?

I would've otherwise been an architect. It's a little like watching people build companies. I like the concept of getting a design down on paper and building something. 🏠

By Amy Biemiller

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ON THE COVER

THE WALKING RAVE

At PennApps XII, Jeremy Hong of Wright State University in Dayton, Ohio, hacked these digital shades so that the animations playing on their array of LCD displays sync with ambient music. Hackathons like PennApps challenge participants to push the limits of their hardware and software skills—in this case, to the benefit of DJs everywhere.

