defending against hacks
A confession: I am an optimist. I am upbeat about our profession and most especially about engineering education in the U.S., even if I must immediately acknowledge that my vantage point is privileged.

You have certainly heard and perhaps share my concern that our country continues to lose manufacturing jobs to emerging economies in Asia and elsewhere. But the global reaction to the recent passing of innovator Steve Jobs tells us something. The leadership we haven’t lost is in the generation of ideas, of new technologies, of innovation and creativity. This is a separate and very important issue, one about which I have some data.

There is a national trend back to engineering. Penn Engineering has seen a 30 percent increase in applications every year for three consecutive years, more than doubling our pool. The economy has sent many young people back to school, and they are choosing engineering for their studies. Our master’s enrollments have doubled in two years and our doctoral numbers are also at an all-time high. We truly are “at capacity.” It feels good to be popular.

But the real story is not in the numbers, it’s in the passion and imagination of our students and faculty. The classroom experience is supplemented by countless design activities that punctuate the life of the School, within and outside of academics. PennApps, a marvelous “hackathon,” the Robocup, the IGEM synthetic biology competition, the “Robodeo” (yes, a rodeo of robots!), the DMD projects, the electric car and the PennVention activities of the Weiss Tech House, just to name a few. And, of course, we have those unlikely but very real Rube Goldberg devices everywhere. These collective celebrations of innovation are the results of enthusiastic teams of young people who are using technology to make things better. I read them as the best possible homage to Steve Jobs.

Now, as always, there are reasons to worry about the state of our country and of the world. The condition of engineering as a profession is not one of them.
A United Front Against Cancer

By Janelle Weaver

Cancer accounts for nearly a quarter of all deaths and is the second most common cause of mortality in the United States. Since President Richard Nixon declared a “War on Cancer” by signing the National Cancer Act 40 years ago, five-year relative survival rates have risen, but the proportion of the population that dies from cancer each year has grown by about 13 percent. Billions of dollars worth of cancer research has produced fragmented knowledge about the causes of the disease, and relatively few breakthrough therapies.

In response to this crisis, the National Cancer Institute has recently turned its attention to mathematics and the physical sciences to foster a more comprehensive and quantitative understanding of the complex disease. In 2009, the agency launched a dozen Physical Sciences-Oncology Centers to encourage interdisciplinary initiatives. “We need to bring in new approaches and perspectives from other disciplines,” says Ravi Radhakrishnan, associate professor of Bioengineering. “That’s where my lab fits in.”

Since joining the Penn faculty in 2005, Radhakrishnan has been developing mathematical models that integrate multiple spatial scales, from molecules to tissues, to examine how cells become malignant. Understanding cancer at these diverse levels is crucial for accurately predicting disease progression and treatment success, he says.
Given that cancer is so complex, a multi-pronged strategy is needed to combat the disease. Instead of using theoretical means to probe the molecular underpinnings of cancer, Andrew Tsourkas, associate professor of Bioengineering, develops innovative diagnostic tools. “Because Ravi and Andrew cover different parts of this broad research area, their concerted research effort is that much stronger,” says David Meaney, Solomon R. Pollack Professor and Chair of Bioengineering.

**Tailored Treatment**

A variety of cancers are associated with mutations in genes that code for the ErbB family of proteins, which activate a chain of chemical reactions within the cell when certain molecules bind to them. Radhakrishnan models how these mutations can result in excessive signaling that causes cells to survive longer and divide uncontrollably.

Several approved drugs inhibit ErbB activity, but their effectiveness depends on the specific ErbB mutations patients have. “Cancer therapeutics are not one-size-fits-all, so clearly there is a need for personalized approaches,” Radhakrishnan says. By modeling the ways in which these mutations affect cellular responses to medications, he hopes to generate insights that will advance the development of individualized treatments.

“The most immediate contribution of Ravi’s work will be to help us understand why drugs work for some but not all people,” Meaney says. “This information could then be used to figure out the best ways to design a drug or therapy from scratch.”

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Defeating Death

Another project in the lab involves modeling how tumor cells thrive under adverse conditions. These rapidly dividing cells deplete oxygen and other nutrients from their surroundings, but they survive by shutting down non-essential pathways and conserving their resources. “It’s like when your computer crashes and you start it in safe mode,” Radhakrishnan says. “It still functions, but it operates only a small number of core processes.”

When this happens, some proteins are encapsulated by vesicles and degraded for energy, and this process may destroy signals that would otherwise instruct the cell to die. “The cell is essentially eating itself, but this allows it to survive a couple of weeks longer than normal,” he says.

Powerful Predictions

Radhakrishnan is now setting his sights on other proteins implicated in the disease, and he also plans to confirm his model predictions by collaborating with biologists and clinical scientists to perform experiments using animal models of cancer and tissue samples from patients. If the clinical relevance of these models is verified, they could help identify proteins that should be targeted by novel drugs.

Over the next ten years, Radhakrishnan envisions that this work, in addition to the efforts of other cancer modelers, will lead to the refinement, validation and widespread use of the “oncosimulator,” a software tool that incorporates various types of data and models to optimize patient-specific treatment plans. “If we get to
the point where these models become very predictive, I can't even imagine how that will change the way we think about therapies."

Tracking Down Tumors

While Radhakrishnan studies molecular events that underlie a range of cancers, Andrew Tsourkas is focusing on prostate cancer, the second most common cancer among men in the United States. It is often detected based on rising blood levels of a protein called prostate-specific antigen (PSA), which does not provide enough information to distinguish cancer from benign conditions, such as inflammation or infection. The benefits of PSA screening may not outweigh the risks associated with follow-up tests and treatments, and it might not save lives.

To address this problem, Tsourkas is devising new methods to improve the detection of cancer using non-invasive, high-resolution magnetic resonance imaging (MRI). This approach can be useful for discovering tumors, which produce a distinct MRI signal compared with healthy tissue. During exams, patients are sometimes injected with a metal called gadolinium because it accumulates in tissue with abnormal vasculature and has magnetic properties that amplify the signal in these areas. Still, either the metal doesn't specifically mark tumors or the signal is too weak to result in a reliable diagnosis. “That has been a huge limitation, and I think we’ve taken a big step toward eliminating the problem,” Tsourkas says.
To strengthen the signal enough to notice small tumors, Tsourkas has designed nanoparticles that carry a large amount of gadolinium. In most cases, gadolinium is attached only to the outer layer of the nanoparticle because the signal is stronger when the element is in contact with water. By contrast, Tsourkas’ nanoparticle has a highly porous outer shell that allows water to flow through and surround extra gadolinium on the inside. Because these nanoparticles intensify the signal, they could facilitate the early detection of cancer.

Tsourkas is further tailoring these nanoparticles to detect prostate cancer by coating them with F77, a unique antibody that selectively binds to molecules on the surface of prostate cancer cells at both early and late disease stages.

The next step is to test the safety of this technology in animal models of cancer, and then possibly in human clinical trials. If approved, the nanoparticles would help clinicians make accurate diagnoses, select appropriate therapies and monitor their efficacy. Tsourkas hopes that clinicians will be able to choose from a variety of nanoparticles targeted for different types of cancer, or even other categories of diseases.

“It’s well known that one of the best ways to treat cancer is to find it when it’s just beginning to form in the body,” Meaney says. “A lot of what Andrew does really focuses on this general area of early detection, and that’s one way I think he’ll create an impact.” ☕
Keegan Dubbs (MSE’13) had never heard of engineering when her high school physics teacher suggested she pursue it in college. She had always loved math and science, but engineering? At home she mentioned the possibility to her dad, whose surprised reaction now makes her laugh.

“He thought I was talking about being a train engineer,” she says. Now a junior at the School of Engineering and Applied Science, Dubbs recalls her first look at Penn. “I loved it. I was completely sold after visiting.” A native of Minneapolis, MN, Dubbs fell hard for the vibrant, urban campus. Despite her unfamiliarity with engineering and the East Coast, she took a leap of faith.

Today, Dubbs is pursuing a major in Materials Science and Engineering and a minor in Engineering Entrepreneurship. During the past two summers, she had positions at companies both large and small. In 2010, she worked at Medtronic, the biomedical engineering powerhouse in Minneapolis, and this past summer at Hydros, a Philadelphia startup company (www.hydrosbottle.com) launched by alums from Penn Engineering and Wharton. At Hydros, she helped market an innovative plastic reusable water bottle with a built-in filter. Profits from the sale of this product help to bring clean drinking water to communities around the world.

“I chose engineering because I knew it would be challenging,” Dubbs says. “Engineering teaches you how to think. You can approach any problem and apply the skills you’ve learned to overcome obstacles.”

**Winning Combination**

During her sophomore year, Dubbs joined the Engineering Deans Advisory Board (EDAB), a group of engineering students who meet with deans and senior administrators to present initiatives targeting both
Dubbs’ major, Materials Science and Engineering, focuses on designing more useful materials, such as polymers, metals, glass and ceramics, for a host of applications.
academic and social aspects of the School. So far, their projects have included a new survival guide for freshmen (Surviving the Seven SEAS) and an informal networking event for upperclassmen to meet alumni and engineering professionals.

Linda Lipski (MSE’13), a classmate and president of the Engineering Student Activities Council (ESAC), describes Dubbs as “very hardworking and fun-loving.” Dubbs admits that if anyone’s cracking jokes at EDAB meetings, it’s usually her. “I’ve always had a very strong work ethic, but I don’t take myself too seriously.”

Collaboration Among Women

Women in engineering at Penn are in the minority: 33 percent of Penn Engineering undergraduates are women, which is higher than the national average of 19 percent. That’s not all bad, women students note. In fact, it can be exhilarating. “I love it. I feed off of that,” Dubbs says. “It distinguishes you from the crowd. I feel this pride in being a female engineer.” Lipski agrees. “Women attracted to engineering really want to be there.”

In large part, women students feel their smaller numbers feed their competitive spirit and encourage collaboration. Michele Grab, director of the Advancing Women in Engineering program, outlines how the School works hard to attract and retain women, offering them social and academic support. “We want women to feel they have just as much voice in the room.”

Far-reaching Materials

Dubbs’ major, Materials Science and Engineering, focuses on designing more useful materials, such as polymers, metals, glass and ceramics, for a host of applications. Examples include strengthening the shell of smart phones so they won’t break when (inevitably) dropped, or creating the first major airliner fuselage (Boeing 787 Dreamliner) that is polymer-based, not aluminum-based, making it lighter and more fuel efficient, notes Karen I. Winey, professor of Materials Science and Engineering.

Winey, who is also Dubbs’ advisor, notes that a materials science engineer “can have an impact in many areas,” which appeals to students like Dubbs. In her classroom last year, Dubbs was “enthusiastic and engaged in the curriculum.”

With courses in subjects such as structural materials, quantum physics and nanotechnology behind her, Dubbs is looking ahead. She is thinking about pursuing an MBA, or her most lofty goal, a joint JD/MBA degree. “It’s always good to have that ‘shoot-for-the-stars’ attitude,” she says. Chances are, Dubbs will hit her target. ☝
After months of excavation and foundation work, the steel structure of the Singh Center for Nanotechnology is taking shape on the 3200 block of Walnut Street. Upon completion of the exterior work, the building will be wrapped in a refined “curtain wall” of glass and steel. The facility is expected to be one of the most advanced nanotechnology centers in the region, with completion slated for spring of 2013.

The $91 million Center, named for Penn alumnus, University Trustee and Engineering Overseer Krishna P. Singh, will feature microscopy laboratories, optics labs and a 10,000 square-foot, environmentally controlled clean room. Developed jointly by Penn Engineering and the School of Arts and Sciences, the building will also feature a courtyard, public galleria, a forum space and conference rooms.

Remaining naming opportunities include:
Walnut Street Plaza: $3 million
Research Laboratories: $150,000 to $1 million
Laser Laboratory: $350,000
Café: $250,000
Faculty Office Suite: $100,000
Study Areas: $75,000
Offices: $25,000-$50,000
Receiving Penn Engineering’s S. Reid Warren, Jr. Award for exceptional teaching is a mark of distinction, but to receive the prize in one’s first year of teaching at Penn is—to employ an adjective often used to describe recipient Robert Ghrist—amazing. It is the undergraduates themselves who cast the votes, a fact that especially pleases Ghrist, the Andrea Mitchell University Professor in the Departments of Electrical and Systems Engineering and Mathematics, who accepted the Warren Award in 2009.

Ghrist was recruited in 2008 as one of the University’s Penn Integrates Knowledge (PIK) Professors and holds appointments in the School of Engineering and Applied Science (Electrical and Systems Engineering) and the School of Arts and Sciences (Mathematics).

As an applied mathematician specializing in topology, the study of multidimensional abstract spaces and shapes, Ghrist develops and applies mathematical methods to solve engineering problems in robotics and sensor networks.

But above and beyond his eminent qualifications as an interdisciplinary researcher and scholar, Ghrist embraces the spirit of the PIK appointment as an opportunity to enhance communication and collaboration between the two schools. Importantly, he also brings to Penn a talent for inspiring awe and enthusiasm in the classroom. Comprehension, for the most part, seems to follow.
Literature as Life-changer

While some might see it as a gift, Ghrist understands teaching as his “calling” or “vocation,” in the true Latinate sense of the word. It must have come to him quite early—his first grade teacher told him she saw in him the makings of “an absent-minded professor.” As for leaning toward the engineering discipline early on, Ghrist reveals, “LEGOs were my friends.” It was a college literature course, however, that “absolutely changed [his] life.” He is passing the love along: the first two ‘settling down’ minutes of his engineering classes are spent reading from a favorite work.

As a lecturer he is as playful as he is thoughtful, and his ideas are transmitted with a contagious ease. It is no surprise that he is invited to speak and teach all over the world. His travel schedule was so rigorous over the summer of 2011—Utah, Zurich, Budapest, Ohio—that he described his “vacation” as “any time I was home.” The end of summer found him in Japan for a four-part lecture series; his plane touched down in Philadelphia just as the fall semester was about to begin.

Should you become curious about where in the world Robert Ghrist is and what in the world is on his mind, you can follow him on Twitter (@robertghrist). Here you will find life according to Ghrist in “one-forty or less,” as he describes this popular social media’s word limit. His aphoristic tweets range from cultural observations on the road to joyful culinary discoveries to lightning-quick reflections on the amusements of his four home-schooled children.
He also keeps his followers updated on his work-in-progress: *Funny Little Calculus Text (FLCT).*

*FLCT* is, well, not even Ghrist is entirely sure. Perhaps it is the “calculus anti-text.” Whatever it is, it bears no similarity to the dense and weighty calculus book many lugged around campus. Ghrist is creating, instead, a calculus text that students will actually read. Written in his own unique, calligraphic hand on a Fujitsu tablet PC, *FLCT* is colorfully and whimsically peppered with pop culture cartoons, literary references, and the author’s humorous asides on the material. Ghrist designed the text to add depth and understanding to the students’ high school catalog of AP Calculus knowledge.

**Setting Up Freshmen to Succeed**

Teaching students just out of high school is Ghrist’s passion, and he enjoys bridging math and engineering. (He is presently working on reforming the calculus curriculum in “engineering language.”) As he explains it, freshmen do not yet know what they “can’t” do and he loves “setting them up for success.” He throws the difficult Taylor Series at them on their first day and watches them rise to the challenge. This measure of difficulty also serves to “toughen them up,” Ghrist believes, and helps prepare them to successfully and confidently meet life on life’s terms.
But what of those students who are struggling? It’s hard to believe, but Ghrist once found himself in difficulty with his coursework. He explains that, for years, math and engineering solutions came to him easily and intuitively, and intuition, he believes, is a “dangerous gift.” He remembers the panic he felt in his junior year at the University of Toledo, when he “hit a wall,” and became lost. The hard-won wisdom he gained has informed Ghrist’s empathy for students experiencing similarly confusing academic dilemmas, and he is able to lead them out of the labyrinth, urging them to build new skills and to approach problems inductively.

Beyond the world of the structures and representations known to the rest of us as mathematics, lie unknown and unnamed regions now being observed and mapped by Robert Ghrist. The discoveries of this intrepid explorer fascinate his students and edify his peers and, at the University of Pennsylvania, all consider themselves fortunate to have a part in his remarkable journey.
The rise of computer technology meant to make our lives easier comes with a cost: the ever-growing risk of security and privacy violations. Companies evaluate their customers’ web browsing habits to target Internet ads, and “phishers” send fraudulent emails in an effort to procure credit card details from individuals who bank and shop online. Meanwhile, an application named Creepy allows users to track the locations of people based on geotagged photos uploaded to Twitter or Flickr.

Technology can even endanger someone’s health, as demonstrated this August at the Black Hat Technical Security Conference. One of the keynote speakers showed that it’s possible to remotely control glucose monitors and insulin pumps to alter doses of the hormone.

“But I have both of these medical devices, I was quite interested in the hack,” says Jonathan Smith, Olga and Alberico Pompa Professor of Engineering and Applied Science in the Department of Computer and Information Science. “Personally, I turn off the wireless interface on my insulin pump, so there’s no way to attack me in that manner.” Smith is not only thwarting hacks that could affect his health, he’s also developing innovative strategies to prevent attacks that could sabotage personal computers and entire networks.

**Bot Blockers**

For a project funded by the Office of Naval Research, Smith collaborates with colleagues at Penn, Harvard and Princeton to shield networks against botnets – collections of computers controlled by a master for nefarious purposes. Botnets often originate from downloads of malicious software, such as spyware and adware.

In a common type of onslaught known as a denial-of-service attack, many computers send communication requests that collectively overwhelm a target computer. Not only can these barrages paralyze the machine and disable Internet sites, but they can also wreak havoc on financial activities and government services. “They create a lot of fear in the community because people worry that they’ll lose their connectivity when they need it for something important,” Smith says.

Smith and his team are devising ways to block downloads from websites that have infected machines in the past. Another tactic involves flagging abnormal
activity. “If you start seeing 10,000 messages come out of grandma’s computer, it’s probably not a sign that grandma is typing really fast and has had a whole bunch of coffee,” Smith says. “It’s probably a sign that her system has been taken over.” By deflecting unusual Internet traffic coming from specific nodes, it’s possible to keep botnets at bay.

Better SAFE than Sorry

To build a next-generation computer capable of resisting attacks, Smith is collaborating with Benjamin Pierce, professor of Computer and Information Science, and André DeHon, associate professor of Electrical and Systems Engineering, along with scientists at Harvard and Northeastern University. They are working on the Semantically Aware Foundation Environment (SAFE) initiative led by BAE Systems and funded by the Defense Advanced Research Projects Agency (DARPA).

Smith’s task is to protect machines from being hijacked by decentralizing the operating system and enforcing access restrictions. For instance, someone approved to use the printer is prohibited from running irrelevant programs, changing files or memory settings, or controlling network devices. This undertaking requires an overhaul of computer hardware, operating systems and programming languages, which traditionally have not been designed with security in mind, Smith says.

In another large initiative that started last year, Smith is helping to develop a safer Internet called Nebula. This network will consist of secure paths that transmit information to data centers, such as nodes that provide medical advice. This approach could reduce healthcare costs and lead to earlier diagnoses by encouraging the sharing of medical data among physicians and by preventing excessive tests, Smith says. “We try to bash away at the security and privacy problems that get in the way of people feeling comfortable using the Net for all of the tasks in their lives.”

Thinking Like the Enemy

Sometimes the best defense comes from understanding the enemy. To figure out how to improve face recognition systems, Smith is testing which disguises work best. In one experiment, the accuracy of one of these systems dropped from almost perfect to as low as 15 percent when images of faces were obscured with mirrored sunglasses, a scarf or a dark nylon stocking.

These findings can also be used to foil face recognition systems and deter invasions of privacy, such as attempts to predict social security numbers from pictures of faces. This example highlights the need for precluding large-scale, 100 percent accurate face identification, Smith says. “Sometimes the good guys are using the cameras, and sometimes the bad guys are. I want to be on the side of the good guys.”
On January 12, 2010, a magnitude 7.0 earthquake struck Haiti, killing hundreds of thousands of people and causing many others to go missing. In response to this tragedy, Google developed a web application called Person Finder, which allows individuals to post the status of relatives and friends affected by catastrophes. But there’s a catch: it requires Internet access, which is often not available in disaster zones.

During a 24-hour hackathon in June, Kevin Conley (ESE’12) came up with a solution. While in Silicon Valley for his summer internship, the electrical engineering student attended a Random Hacks of Kindness competition held at Google’s headquarters. At the event, company representatives gave talks about their products to encourage the participants to use them during the contest. While listening to a presentation about Person Finder, Conley realized that he could improve the program by making it accept text messages, which mobile phones can deliver by way of cell phone towers rather than the Internet.

“I had never worked on a team that large, so it was a challenge to get organized for tackling this kind of problem,” Conley says.

To demonstrate the finished product, the group instructed audience members to imagine that they were in a shelter after having survived a natural disaster, and to send text messages about their condition and whereabouts to a designated phone number. All of the messages appeared on the Google Person Finder website, and the judges were so impressed that the team won first prize.

The next month, Google showcased SMS Person Finder at a multinational meeting hosted by the State Department and explained how the innovation could help governments cope with catastrophes. “I hope that Google is able to work with us to incorporate it into the official Google Person Finder product,” Conley says.

Training Ground

As sources of inspiration for his hacking pursuits, Conley credits the biannual hackathon called PennApps, as well as ESE 350, the embedded systems and microcontroller laboratory course taught by Rahul Mangharam, Stephen J. Angello Term Assistant Professor of Electrical and Systems Engineering. While taking this course, which he dubbed “Introduction to Hacking,” Conley learned how to build gadgets as diverse as a Morse code transmitter and decoder, a simple telephone and a small elevator. “Kevin’s passion and enthusiasm became contagious among the students,” Mangharam says.
Karen Winey

Bringing Order to Nanoparticles

By Jana S. Moore
In the rollicking worlds of polymer composites and nanoparticles, Karen I. Winey, professor of Materials Science and Engineering, and her lab members help bring order while carving out new territory of their own.

Winey focuses on two research areas: designing and fabricating polymer nanocomposites with the primary goal of understanding their properties, and recording the nanoscale morphology in ion-containing polymers.

In both areas, which many believe hold the promise of revolutionizing day-to-day life, Winey has developed a reputation as a rigorous scientist. “Nanocomposites have suffered from messy experimental work,” Winey says. “Our work is distinguished because we pay equal respect to the polymers, particles, processes and properties.”

Uncovering Answers

Winey first attracted international attention in nanoparticle research a decade ago when she and two Penn colleagues developed a technique to disperse carbon nanotubes, one of the primary building blocks in nanotechnology, in polymers. She later followed with a question: Does the orientation of the nanotubes affect the electrical properties? Lab experiments showed that they did. She conducted simulation experiments, a hallmark of her rigorous techniques, to underscore the findings.

Winey believes the “why” of the chemical process plays a critical role. As her experiments show, nanoparticles make polymers move in unexpected ways, and understanding all components is crucial in taking a composite from the laboratory to the factory. “You need to dig in and figure out what is happening,” she says.

She has extended the approach to another first by the lab, the discovery that polystyrene studded with silver nanowires inexplicably switches from insulating to conducting with the application of a small voltage. When researchers cut off the voltage, the polymer returns to insulating, but not immediately in all cases. Winey and her team are now testing a hypothesis to explain the “reversible switching” phenomenon.

Because her lab seeks fundamental understanding, she hopes its work helps to close the gap between the predictions for nanoparticles and the relatively disappointing results of research so far. “No one has found the mechanical properties of a polymer nanocomposite anywhere close to what is predicted, and understanding that discrepancy is important to be able to move what we really measure toward the theoretical,” she says.
Professor Winey and Michelle Sherrott inspect a specimen holder for the JEOL 2010F scanning transmission electron microscope.

Peter K. Davies, professor and chair of the Department of Materials Science and Engineering, says that despite Winey’s emphasis on basic science, she remains focused on the primary goal of engineering research to make new products. “A key component of Karen’s work is doing fundamental science to a practical material to provide that sound basis that a production company could take to the next level,” he says. “She’s a tremendous scholar and a real engineer.”

World Leader in Imaging

Winey has developed a solid international reputation for her work. She has published more than 120 articles, holds five patents and serves as associate editor for Macromolecules, the field’s most frequently cited journal. Her colleagues consider her a world leader in ion-containing polymers, an area that could produce far better batteries and fuel cells than those in use today. In ion-containing polymers, her lab pioneered the use of HAADF STEM (or high angle annular dark field scanning transmission electron microscopy), a complex technique that allowed the researchers to image ionic aggregates for the first time.

The breakthrough has put the lab in high demand by scientists worldwide who want to know the morphology of new materials. “It’s like a triangle,” Winey says. “You have to have the material before you can measure the properties, and to understand the interplay
between chemical structure and properties, you need to know the morphology.” In 2009, Winey’s work with ion-containing polymers earned her a coveted National Science Foundation Creativity Award.

The highly complex equipment that Winey’s lab uses requires a precisely regulated environment. Winey looks with excitement to the opening of the Krishna P. Singh Center for Nanotechnology in 2013. The facility will not only accommodate the equipment the lab now uses, Winey says, but it also will catalyze the School to acquire new equipment that will help researchers go even further.

**Intellectual Curiosity**

After earning her doctorate at the University of Massachusetts in 1991, Winey undertook postdoctoral training at the AT&T Bell Laboratories in New Jersey. She chose academia over industry because Penn offered her more interesting opportunities. The benefits of Penn and interactions with students have made her grateful for her choice.

“The level of intellectual curiosity I get to follow is thrilling,” she says. “And you can’t do it without the students. I get great joy in seeing remarkable transformations in them as they immerse themselves in this research.”
FinePrint

Functional Products for a Paperless World

By Jennifer Hill

The spare and elegant layout of the FinePrint.com website reflects co-founders Jonathan Weiner (CS’85) and Mark O’Brien’s approach to their software designs and life itself. With the goal of making people’s lives easier, Weiner and O’Brien offer three products—FinePrint, pdfFactory and pdfFactory Pro—which enable users to seamlessly create, edit and enhance documents before printing, thus saving time, money and frustration. Customers can download the products for free and use them for as long as they wish before buying them. Enthusiastic responses to the products fill FinePrint’s website testimonials. “Creating functional products that people enjoy using makes my work and life rewarding and fun,” Weiner says.

A Simple Observation

Weiner’s idea for FinePrint came from the simple observation he made when he consulted for Fidelity Investments in the early 1990s: too much paper was being wasted. “We wrote manuals that were hundreds of pages long, printed 20 every week, and then threw them out,” Weiner recalls. He knew most organizations had the same problem because at the time, people couldn’t print only what they needed. Weiner remembered that at Hewlett-Packard (HP), his first job after graduating from Penn, he had used technology to print multiple pages on one sheet of paper. He decided to create a product with similar printing capabilities and pitched his idea to O’Brien, a former coworker and an expert at writing printer drivers. The pair began working nights, and in six months, Weiner and O’Brien created the first version of FinePrint. In 1996 they launched FinePrint Software, just as the Internet was taking off.

Printing Without Paper

Weiner and O’Brien’s timing couldn’t have been more fortuitous. For very little money, they put their new venture on the Internet and instantly gained a worldwide customer base. “We did no marketing,” Weiner says. “People found out about FinePrint by word of mouth.” Early customers welcomed the ability to do “a universal print preview” and print multiple pages onto one sheet. Spurred on by the effusive reviews, Weiner and O’Brien expanded FinePrint’s capabilities, enabling users to create letterhead, insert and remove graphics, and add watermarks and signatures to documents without having to print.

When Adobe allowed developers to make PDF applications in 2001, Weiner and O’Brien applied FinePrint’s technology to PDF creators and developed pdfFactory and pdfFactory Pro. With one click from any software, users could create and email PDFs, add or subtract the same features offered by FinePrint, and have instant, universal print previews.

Penn Engineering Paves the Way

Weiner credits Penn Engineering’s curriculum for giving him a solid foundation in computer science, making him an attractive candidate for employment at HP. “The career path I’ve chosen and created has been exceedingly rewarding,” Weiner states. “I followed my passion for software design, and it has led to a very satisfying life where my work doesn’t feel like work.”
For decades, heavy wooden boxes containing tarnished and worn instruments have been shelved in the basement of the Towne Building, their closed lids concealing the stories of the past and Penn Engineering’s history. In an ongoing series, we’ll be looking at some of these abandoned tools and, posing a riddle of sorts, asking readers to identify the object and describe how it may have been used.

The Tool
Sitting on a base of four adjustable feet, this instrument features a torsion arm strung on a wire. Suspended from the arm is a stirrup with a platinum ring that can be lowered onto a brass platform on which a cup is placed. On one end of the tool’s body is a measurement wheel with a manual adjustment dial. Versions of this tool, originally manufactured by Central Scientific Company, are still in use today. These instruments have multiple applications—one of which is in assisting environmental engineers. “This apparatus is now used very nicely for environmental reasons,” says Joseph Bordogna, Dean Emeritus of Penn Engineering. “The modern version is rugged, digital and extremely accurate. It’s applied to make sure that fields are being given the right amount of water from irrigation systems. It helps engineers avoid waste of a precious resource and ensures that food is being grown exactly as it should.”

The World Around It
To put this tool in a historic context, consider what was happening at Penn Engineering at the time it was being used: the graduate program in Chemical Engineering was newly introduced; undergraduate tuition and fees totaled $520, with an additional $35 for books; The Moore School was recently endowed by Alfred Fitler Moore; and the Differential Analyzer—the world’s largest mechanical computing machine designed to solve differential equations by integration using wheel-and-disc mechanisms—was close to completion. While the mystery object would eventually be upgraded with an electronic motor, its precision made it an indispensable tool for students studying the fundamentals of engineering concepts and conducting research in Penn Engineering’s labs.

Can you identify this tool and its purpose? If so, write to us at communications@seas.upenn.edu.
As final preparations for the Senior Design Competitions commence, students wander the halls at all hours of the night. Cheers of victory and groans of defeat emanate from every lab, robots roam the hallways, and coffee sales skyrocket to compensate for sleepless nights. Presentation day reveals nervous, exhausted students dressed in business finery, hoping to win the hearts of the judges. For most students it is a satisfying conclusion to their undergraduate career. But for a lucky few, the Senior Design Competition is an opportunity to apply research, academic training and problem-solving skills to solve real-world problems with timely and effective solutions.

Open-source Automobiles

Such is the case for the students working on AutoPlug, the 2009 brainchild of Rahul Mangharam, Stephen J. Angello Term Assistant Professor of Electrical and Systems Engineering (ESE) and director of the mLAB, a real-time and embedded systems laboratory. At that time, Mangharam was considering the future of a programmable car. Ever since, Penn Engineering students have been working to make AutoPlug one of the world’s most useful embedded systems devices.

That summer a team of undergraduates, including Kevin Conley (ESE’12), Teddy Zhang (ESE’12) and Gabe Torres (ESE’11), worked with Madhur Behl, a doctoral student in ESE, and Mangharam to develop the first capabilities for AutoPlug. According to the official website, AutoPlug is an open system and network architecture for Plug-n-Play services for third-party hardware devices and software modules. It allows vehicles to become extensible, customizable, and more integrated with evolving technology over the lifetime of the vehicle. The device enables car owners to enhance current capabilities, for example, engine performance and infotainment; add on functionality by using new safety sensors and on-road diagnostics; and customize a vehicle via an “Auto AppStore.” Thanks to the team’s hard work, AutoPlug won first prize at the 2010 World Embedded Software Competition held in Seoul, Korea.

The next phase of development became the focus for a Senior Design team supervised by Mangharam, as students sought to resolve one of the most vexing problems in the auto industry, Electronic Control Unit (ECU) failure. At last spring’s Computer and Information Science Senior Design Project Competition, Ross Boczar (ESE’12), Jason Suapengco (CIS’11), and Gabe Torres won first prize for their contributions to the AutoPlug system.
Remote-controlled Systems

The team explained that a modern luxury car uses as many as 70 different ECU processes, utilizing software which can exceed one million lines of computer code to manage the various operating systems within a car, such as anti-lock brakes, cruise control and other ECU systems. AutoPlug allows remote access to these vehicle systems, giving the manufacturer the opportunity to diagnose and repair system problems without the need to physically replace ECUs. Upgrades or replacements of the computer code which runs any system can be made remotely, greatly reducing the need for recalls. AutoPlug utilizes a Wi-Fi device such as a smart phone to install upgrades and repairs to your car much the way we update our computers. As Ross Boczar explained, “AutoPlug provides car manufacturers an easier way to diagnose and remotely upgrade vehicles on the road.”

Data-driven Future

Future research directions include using the data acquired through AutoPlug as the car is driven in real-world conditions to improve the design of subsequent vehicles. According to Gabe Torres, AutoPlug is “not just a concept, not just a theoretical application, but actually something that could be used in a year’s time.”

AutoPlug won the judges’ decision that day. It was a project that perfectly embodies Penn Engineering’s educational mission to emphasize both theory and practice while forming intellectual linkages across a breadth of disciplines—the gold standard of a Penn Engineering education.
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The Engineering Alumni Society offers alumni many other great opportunities for getting involved with the School and the University at large. For more information, visit our website at http://www.seas.upenn.edu/alumni/alumni-society/index.php
“Serving with Dean Glandt and the rest of the Board is a way for me to focus my passion as well as give back to Penn,” Schlein says. “I can help to influence the innovators, which is highly pertinent to my day job. But I also get the benefit of learning from the Dean, a great educator and pioneer.”

Engineering the Entrepreneurial Pipeline

By Amy Biemiller

As a successful entrepreneur and venture capitalist, Ted Schlein (C’86) has a theory about how to create more jobs: educate more engineers. With a bird’s-eye view of the innovation economy as the managing partner for world-renowned venture capital firm Kleiner Perkins Caufield & Byers (KPCB), his theory is highly empirical.

“Consider that 20 percent of the gross domestic product of our country comes from venture-backed companies, and that most of the ideas for those companies come from engineers, and you can see why I am so enthusiastic about getting more engineers into the entrepreneurial pipeline,” he says.

Guiding Innovation

Discovering and financing innovation is one of Schlein’s passions. Another is a deep commitment to share his knowledge and experience with like-minded people. That’s why when the Board of Overseers asked this early-stage tech venture guru with a B.A. in Economics to join them six years ago, he quickly agreed.

He considers his commitment as an Overseer an opportunity to be involved in the development of engineers who will be professionally prepared to create applications, services and components that have the potential to become category defining companies.

“Serving with Dean Glandt and the rest of the Board is a way for me to focus my passion as well as give back to Penn,” he says. “I can help to influence the innovators, which is highly pertinent to my day job. But I also get the benefit of learning from the Dean, a great educator and pioneer. Working with him and learning about higher education is rewarding.”

Making the commitment to serve as an Overseer meant carefully considering how to squeeze in more hours out of most days. As the father of two teenagers and an avid outdoorsman, he credits keeping a balance with family, fitness and business key to making sure
one commitment doesn’t overshadow another. “If you are going to be good at what you do, you have to stay grounded. There is nothing like family to help with that,” he says. “Especially two teenage sons.”

**Entrepreneurial Excellence**

A regular lecturer at both Penn Engineering and Wharton, Schlein is generous in sharing his experience with students: how he established Fortify Software, a pioneer in the software security market and now a Hewlett-Packard Company; his days at Symantec when he led the company’s successful move into the software utilities market as well as the launch of its commercial anti-virus solution; and his insight from the vanguard of creativity as he leads KPCB’s investments into early-stage technology companies. He also encourages students to become entrepreneurs by helping them understand that collaborative relationships are vital.

“When I talk to the students at Wharton, I tell them to get over to the Towne Building and make friends with the engineers. I tell the engineers to welcome those opportunities in order to cultivate entrepreneurship,” he says. “Every successful startup needs the technical acumen engineers bring to the table.”

Collaboration and information sharing are vital in business as well as academia, says Schlein, who considers an interdisciplinary learning environment essential for any university interested in the title of “world class.”

“Penn has the best-of-the-best in terms of faculty, students, resources and alumni,” he says. “There’s a foundation in place that encourages interdisciplinary learning and collaboration; that knowledge sharing is a huge advantage. As Overseers, we are dedicated to harnessing that advantage in order to educate engineers who will be prepared to be the driving force of our economy.”
New Faculty

Kevin T. Turner
Gabel Family Term Associate Professor in Mechanical Engineering and Applied Mechanics

Ph.D. and Postdoctoral Fellow in Mechanical Engineering, Massachusetts Institute of Technology

Dr. Turner's research addresses fundamental and applied problems at the intersection of the fields of surface and interface mechanics and micro- and nanosystems. Surface and interface mechanics, which encompasses fracture, contact, and adhesion mechanics, plays a crucial role in determining the behavior of many micro- and nanoscale systems and manufacturing processes.

The Turner lab uses a combination of experimental measurements, analytical modeling, and numerical simulations to improve and realize innovative micro- and nanomanufacturing processes as well as to develop new approaches to measure the mechanical properties of interfaces at small scales. Dr. Turner's current work includes projects in semiconductor wafer bonding, microtransfer printing, tip-based nanomanufacturing, microfluidic devices for probing cell mechanics, and characterizing soft materials and interfaces.

Aaron Roth
Raj and Neera Singh Assistant Professor in Computer and Information Science

Ph.D. in Computer Science, Carnegie Mellon University; Postdoctoral Fellow at Microsoft Research

Dr. Roth studies the question of how algorithm design can be undertaken in settings in which either the data belongs to other self-interested parties, or the computation is to be performed by other self-interested parties. This requires studying the algorithmic foundations of data privacy and game theory.

In particular, Dr. Roth is interested in characterizing exactly what kinds of computations can be performed while satisfying strong information-theoretic privacy constraints, and in how selfish agents can be incentivized by these strong privacy protections to allow their data to be used. Dr. Roth approaches these problems from a background in theoretical computer science, but also interacts with privacy and policy researchers in both academia and government.
Honors and Awards

NEW CHAIR IN MECHANICAL ENGINEERING AND APPLIED MECHANICS

Professor Robert W. Carpick has been appointed Chair of the Department of Mechanical Engineering and Applied Mechanics (MEAM) effective July 1, 2011. “Rob brings leadership, deep scholarship, and passionate commitment to his research and teaching, loyalty to his students and colleagues, and integrity to this position. He will continue the trajectory of excellence in every aspect of MEAM, including the active outreach to underrepresented minorities and women,” stated Dean Eduardo Glandt.

Dr. Carpick joined the faculty of Penn Engineering in 2007. He received his bachelor’s degree in Physics from University of Toronto and his master’s and doctorate degrees in Physics from University of California, Berkeley, in 1994 and 1997, respectively. Dr. Carpick conducts research at the intersection of mechanics, materials, and physics. He is an expert in experimental nanomechanics and nanotribology (friction, adhesion, and wear). His lab has developed novel advanced scanning probe microscopy tools, used to investigate the fundamental nature of materials in contact. Dr. Carpick has done seminal work on nanoscale characterization of friction for many important materials, including ultra-thin organic films, solid single crystal and thin film surfaces, as well as ultra-strong carbon-based material and polymeric materials.

Dr. Carpick is a Penn Fellow, and the recipient of numerous awards including the ASME Burt L. Newkirk Award, R&D 100 Award, ASEE Outstanding New Mechanics Educator Award and an NSF CAREER Award.

Ben Taskar, Magerman Term Assistant Professor in Computer and Information Science, has been awarded a National Science Foundation CAREER Award for his research “Computation and Approximation in Structured Learning.” CAREER Awards are the NSF’s most prestigious honor in support of junior faculty who exemplify the role of teacher-scholars through outstanding research and excellent education.

Arjun Raj, Assistant Professor in Bioengineering, is the recipient of the 2011 NIH New Innovator Award for his proposal “A Comprehensive Spatial Picture of Transcription in the Nucleus.” The award, providing $1.5 million over five years, supports the development of new imaging tools to reveal how the physical organization of the genetic code determines how the cell reads the code itself. These methods will be a “nuclear GPS,” allowing researchers to visualize genetic organization in single cells.

Nader Engheta, H. Nedwell Ramsey Professor in Electrical and Systems Engineering, will receive the 2012 IEEE Electromagnetics Award for “contributions to electromagnetic theory and applications of metamaterials and nanoscale optics.”

Susan S. Margulies, George H. Stephenson Term Chair and Professor in Bioengineering, has been awarded a $6.7 million, five-year National Institutes of Health grant to conduct preclinical trials to treat pediatric traumatic brain injury.

Katherine J. Kuchenbecker, Skirkanich Assistant Professor of Innovation in Mechanical Engineering and Applied Mechanics, has been named a PopTech Science and Public Leadership Fellow for her work in haptics.

Jonathan Fiene, Senior Lecturer and Director of Laboratory Programs in Mechanical Engineering and Applied Mechanics, is the recipient of the 2011 Academic Champion Award from the Association for Unmanned Vehicle Systems International.

Warren Seider, Professor in Chemical and Biomolecular Engineering, is the 2011 recipient of the Van Antwerpen Award for Service to the American Institute of Chemical Engineers.

Kenneth Laker, Professor in Electrical and Systems Engineering, is being celebrated by the IEEE for his pioneering, sustained and thoughtful leadership of digital publication.
On October 13, 2011, Penn Engineering presented the Harold Berger Distinguished Award to Steven Chu, U.S. Secretary of Energy. In his lecture, “How Innovation Has Changed the World,” Secretary Chu outlined current and past challenges facing the human race, such as a growing population and the resulting need for increased agricultural production, and how each challenge has been met and overcome through innovation of new technologies and products.

Steven Chu has devoted his recent scientific career to the search for new solutions to our energy challenges and stopping global climate change—a mission he continues with even greater urgency as Secretary of Energy. He is charged with helping implement President Obama’s ambitious agenda to invest in alternative and renewable energy, end U.S. addiction to foreign oil, address the global climate crisis and create millions of new jobs. Secretary Chu is co-winner of the 1997 Nobel Prize for Physics for his work in methods to cool and trap atoms with laser light. During his visit to Penn Engineering, Secretary Chu also met with engineering students who presented projects dealing with alternative energy technologies.

The Harold Berger Distinguished Lecture and Award, named in honor of the Honorable Harold Berger, is awarded biennially by the School of Engineering and Applied Science to a technological innovator who has made a lasting contribution to the quality of our lives. Special emphasis is given to the societal and economic significance of an advance.
**John (Jack) E. Fischer.** 72, Professor Emeritus of Materials Science and Engineering and world leader in the science and engineering of carbon-based materials, died on June 28, 2011, after a decades-long battle with complications from polycystic kidney disease.

Cited as one of the world's top 20 scientists in the field of nanotechnology, Professor Fischer's seminal studies provided the basis for many advances in battery and energy storage technologies. Throughout his career, he authored more than 400 scientific papers; received numerous awards that included a fellowship from the American Physical Society; presented more than 200 invited lectures at national and international meetings; and mentored dozens of young undergraduate, graduate and postdoctoral scholars.

"I know we are all grateful to have had the good fortune to serve as Jack’s colleagues and to have known him as a friend. Jack was a great human being and a giant in our field, driven by a love of science and a joy in mentoring young scholars. He will be sorely missed," said Peter K. Davies, chair of the Department of Materials Science and Engineering.

"Jack was not only a fine scientist with a great deal of imagination and boundless energy, he was a great human being," said Sohrab Rabii, Professor Emeritus of Electrical and Systems Engineering. "His memory will always be with us."

Dr. Fischer graduated from Rensselaer Polytechnic Institute in Troy, NY, with a Ph.D. in Nuclear Science and Engineering. He took a postdoctoral year (1966-67) in Paris at l'École Normale Supérieure and, after doing research for a number of years at Michelson Laboratory in China Lake, CA, joined the faculty at Penn in 1973, first in Electrical Engineering and later (1984) in Materials Science and Engineering.

Dr. Fischer is survived by his wife Linda (née Mammano); sons John, Jr. and Jason; daughter Ruth; grandsons Quinlan and Garrick Schultz; and sister June Roos.

**Jack Keil Wolf (EE ’56).** 76, a pioneer in information theory and its applications, died on May 12, 2011, following a battle with cancer.

Considered one of the most influential scientists of the digital age, Dr. Wolf’s groundbreaking research (known as the Slepian-Wolf Theorem) proved fundamental regarding the efficient compression of correlated streams of data, which is a cornerstone of today’s state-of-the-art video transmission and sensor network design. He received numerous awards for his research, theory, and distinguished teaching, including induction into the National Academy of Engineering in 1993, one of the highest professional honors accorded an engineer. In 2010 he was elected to the National Academy of Sciences.

Dr. Wolf was a dedicated mentor and teaching was a special joy. "My dad loved teaching and he is remembered fondly by many students around the world," says Sarah Keil Wolf (EE ’86, W ’86). "I once asked him why he didn’t go into business, and he just said that his love was teaching."

"Jack was a staunch supporter of the School, respected by all and a friend to many," says Dean Eduardo D. Glandt. "Part of his legacy are the many exceptional engineers that, because of his teaching and mentorship, continue in his footsteps today."

Dr. Wolf studied Electrical Engineering at Penn and graduated in 1956. He completed his studies at Princeton University where he earned an M.S.E. (1957), M.A. (1958), and Ph.D. (1960). He served in the Air Force and taught at New York University, the Polytechnic Institute of Brooklyn, and the University of Massachusetts at Amherst before moving to San Diego in 1984, where he was professor of Electrical and Computer Engineering and a member of the Center for Magnetic Recording Research at the University of California, San Diego. He also held a part-time appointment at Qualcomm, Inc., San Diego.

Dr. Wolf is survived by his wife Toby; his children, Joe, Jay, Jill, Sarah and her husband Charles; and his grandchildren, Rachel, David, Becca, AJ and Julia.
Thomas Stump

Tom Stump, Deputy Dean for Budget and Administration, has been a diligent steward of the School since 1982. He oversees financial operations, facilities and technology, while enhancing and strengthening Penn Engineering’s core mission.

What is your role as Deputy Dean for Budget and Administration? I have to be certain that the School has the resources and support necessary to accomplish its mission of teaching and research. We balance the budget, meet all commitments to faculty hiring and new construction, properly account for all research dollars, and ensure that all monies, especially from the endowment, are spent in accordance with University policy. My group also oversees facilities, human resources and administrative and research computing support.

How has Budget and Administration changed over time? Computing was in its infancy when I arrived at Penn Engineering. We had one PC in the entire complex—a Radio Shack Tandy TRS-80 with 125K of memory. The School’s budget was entered into accounting ledger books by hand and those books were carried home each evening for security. As you know, technology has changed the way we do almost everything.

Tell us about your career prior to joining the staff at Penn. I actually had two careers before coming to Penn. I was a pilot in the Air Force for five years and then worked as a mechanical engineer for a multinational manufacturing company for eight years. Both positions provided me with very challenging assignments, great opportunities for travel and even an occasional adventure. However, the finance field always interested me. With Wharton nearby, I decided to go back to school and prepare myself for what turned out to be my third and most rewarding career.

What is the most satisfying contribution you’ve made to the School? I could mention a number of “most satisfying” moments but if I had to name one it would have to be our success in constructing three new buildings that have done so much to attract outstanding faculty and students. Given our faculty size and a financial system that puts the onus on the School for meeting the costs of new construction, this has been the greatest challenge and the most interesting and rewarding experience for me at Penn.