Research | Penn State

VOLUME 35 | NUMBER 1 | SPRING 2015

TEAR DOWN That Wall

› ALSO IN THIS ISSUE

PENNSTATE 1855

Research | Penn State Volume 35 Number 1 Spring 2015

Worlds of **Discovery** ›

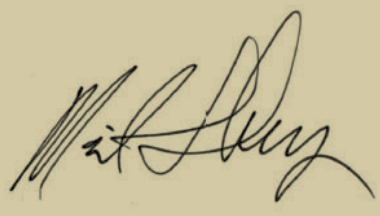
One of the most rewarding features of my position is that it gives me an up-close-and-personal look at a diverse array of fascinating topics through the eyes of some of the world's best researchers. The scope and quality of the work that's being done at this university never cease to amaze. This issue of *Research/Penn State* provides just a sampling of what I'm talking about.

Feature articles range from the weird new nanoscale world of 2D and layered materials to the long-term repercussions of child abuse, which can reach across generations. Our researchers are working on creative new ways to satisfy the planet's thirst for energy and attempting to understand and replicate, on silicon, the daunting complexities of human vision.

Nor does the expertise gathered at Penn State end with the STEM fields or the social sciences. It also includes impressive accomplishments in the arts and humanities, as exemplified here by a cultural critic who examines the role of satire in a healthy democracy and a historian who links malaria and the limits of empire.

The nation's major institutions of higher learning are under more pressure than ever before to provide innovative answers to real-world problems. Within these pages you'll find stories of discovery aimed at tangible solutions. Through these and many other endeavors, we at Penn State are doing our part to change the world for the better.

I hope you will find these stories as interesting as I do.



Neil A. Sharkey
Vice President for Research

ON THE COVER: Freshly-cut stalk of sugar cane from a Penn State greenhouse. Every plant cell is surrounded by a fibrous wall that provides strength while allowing the cell to continue growing. Penn State biologist Dan Cosgrove studies how these cell walls are made, information that could lead to better ways of harvesting the energy stored in their chemical bonds. See story on page 18. Photo by Patrick Mansell.

Research/Penn State is published by the Office of the Vice President for Research at The Pennsylvania State University. The magazine samples the diversity and drama of Penn State's $813-million-a-year research program as a public service to inform, entertain, and inspire the University community. Opinions expressed do not reflect the official views of the University. Use of trade names implies no endorsement by Penn State.

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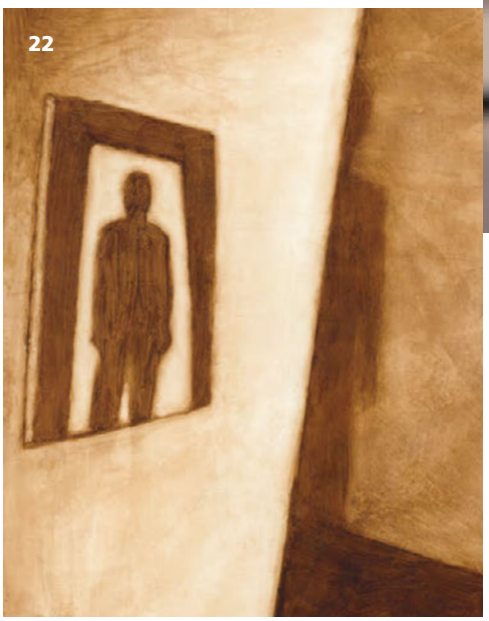

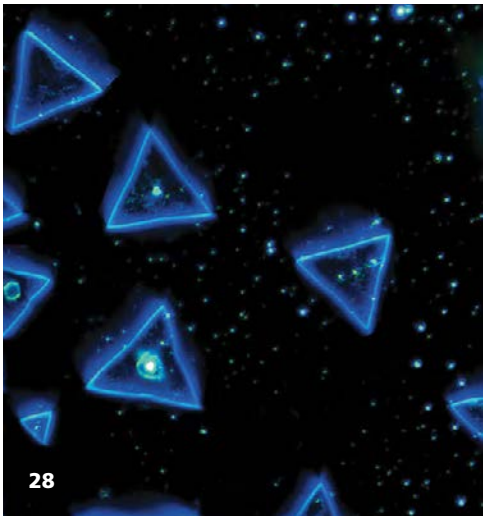

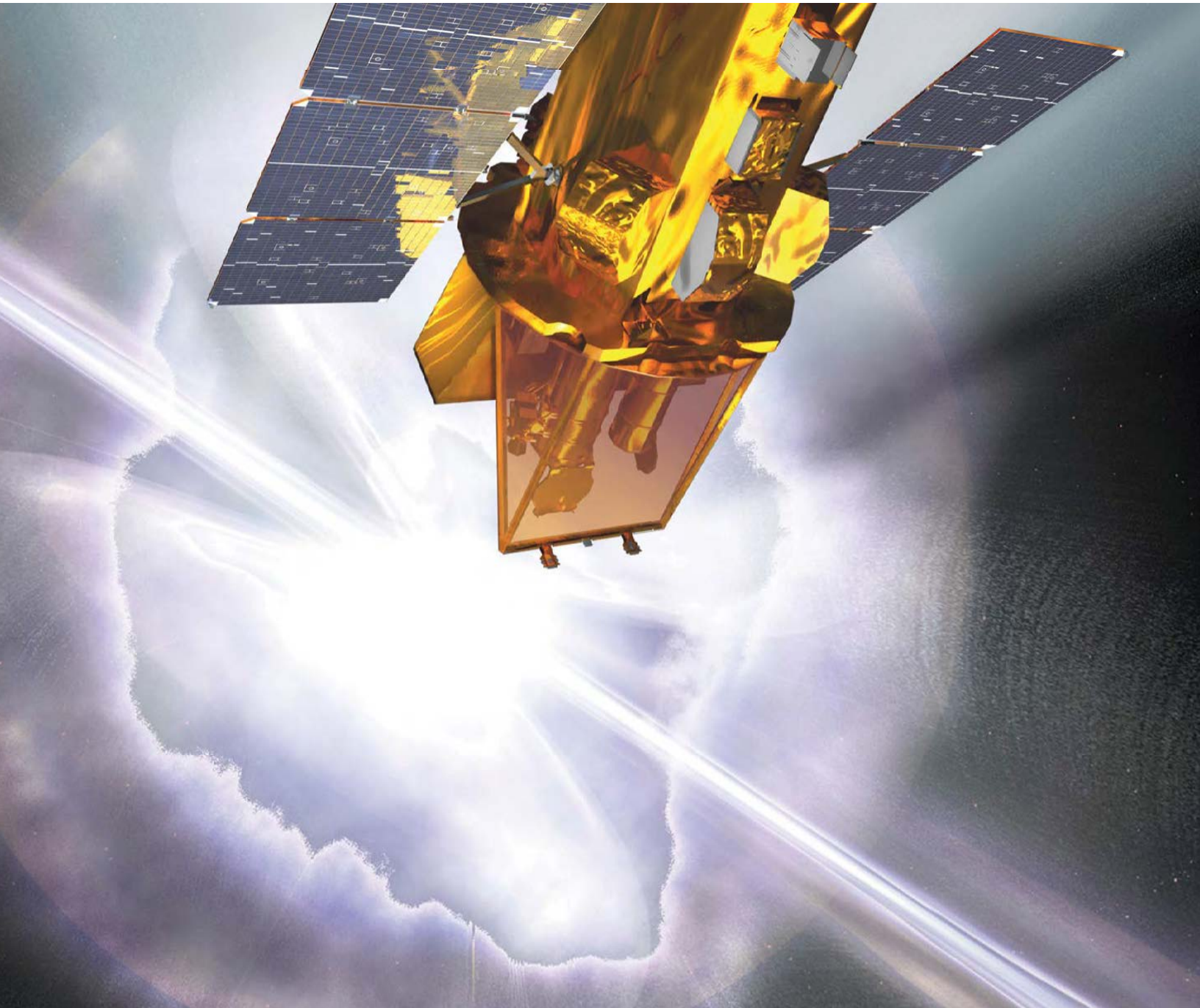

› A Swift Celebration

NASA's SWIFT GAMMA-RAY BURST EXPLORER, AN ORBITING SPACE observatory with major contributions from Penn State scientists, marked its tenth anniversary in November, 2014. It is the only satellite that can precisely locate and monitor gamma-ray bursts (GRBs), which are the most powerful explosions in the universe but which typically last less than one minute. In its 10 years of operation, Swift has made 315,000 observations of 26,000 different targets, supporting the work of more than 1,500 scientists around the world. It discovered the farthest-known GRB, whose light took more than 13 billion years to reach us; detected X-ray signals made by an exploding star; and mapped our nearest galaxies in ultraviolet wavelengths. **John Nousek**, professor of astronomy and astrophysics, directs mission operations from the University Park campus, and research with two of Swift's three telescopes is led by two other Penn State astronomers, **David Burrows** and **Michael Siegel**. Swift will continue its mission at least through 2016.

—BARBARA KENNEDY

Spectrum Astro and NASA E/PO

INSECTICIDES CREATE 'TOXIC' SLUGS, REDUCE CROP YIELDS

Insecticides aimed at controlling early-season crop pests, such as soil-dwelling grubs and maggots, can increase slug populations and end up reducing crop yields, according to researchers at Penn State and the University of South Florida.

"Neonicotinoids are the most widely used insecticides in the world," says **Margaret Douglas**, graduate student in entomology, Penn State. "Seed applications of neonicotinoids are often viewed as cheap insurance against pest problems, but our results suggest that they can sometimes worsen pest problems and should be used with care."

According to **John Tooker**, associate professor of entomology, Penn State, their study also confirms that predatory insects can provide significant control of slugs.

In lab experiments, the researchers exposed slugs to untreated soybeans, soybeans that had been treated with fungicide, or soybeans treated with fungicide and thiamethoxam, a commonly used neonicotinoid. The team then tracked slug weight and survival in each group. Next, the scientists presented slugs from the three treatments to a species of ground beetle that eats slugs. They then tracked slug mortality and symptoms of beetle poisoning.

"Slugs were unaffected by the fungicides and also unaffected by the neonicotinoid insecticides, likely because they are mollusks and not insects," says Tooker. "But the slugs did transmit the insecticide to the ground beetles, impairing or killing more than 60 percent of the beetles."

In a field experiment, the researchers planted quarter-acre plots with soybean seeds that were either untreated or treated with a neonicotinoid. The team monitored crop growth, slug and predator populations, and predation on slugs. They found that the neonicotinoid treatments depressed activity of insect predators, relaxing predation of slugs and reducing soybean densities by 19 percent and crop yield by 5 percent.

"Slugs are among the most challenging pests faced by Mid-Atlantic no-till growers," says Tooker. "Our research reveals that neonicotinoids can indirectly increase slug damage to crops by poisoning insects that eat slugs."

—SARA LAJEUNESSE

Margaret Douglas

Protein Changes Linked to Progression of ALS

Measuring changes in certain proteins called biomarkers in people with amyotrophic lateral sclerosis (ALS) may help doctors predict the progression of the disease, according to scientists at Penn State College of Medicine.

ALS, often referred to as Lou Gehrig's disease, is a neurological disease in which the brain loses its ability to control movement as motor neurons degenerate. The course of the disease varies, with survival ranging from months to decades.

"The cause of most cases of ALS remains unknown," says **James Connor**, Distinguished Professor of Neurosurgery, Neural and Behavioral Sciences and Pediatrics. "Although several genetic and environmental factors have been identified, each accounts for only a fraction of the total cases of ALS."

This clinical variation in patients presents challenges in terms of managing the disease and developing new treatments. Finding relevant biomarkers, objective measures that reflect changes in biological processes or reactions to treatments, may help address these challenges.

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The project was led by **Xiaowei Su**, an M.D./ Ph.D. student in Connor's laboratory, in collaboration with **Zachary Simmons**, director of the Penn State Hershey ALS Clinic and Research Center. Su studied plasma and cerebrospinal fluid samples previously collected from patients undergoing diagnostic evaluation, who were later identified as having ALS. Analysis shows that looking at multiple biomarkers to predict progression is not only mathematically possible, it improves upon methods using single biomarkers.

Perhaps most importantly, the results suggest that a combination of biomarkers from both plasma and cerebrospinal fluid better predicts disease progression than either used alone.

"The results argue for the usefulness of researching this approach for ALS both in terms of predicting disease progression and in terms of determining the impact of therapeutic strategies," Connor says. "The results present a compelling starting point for the use of this method in larger studies and provide insights for novel therapeutic targets."

—MATTHEW SOLOVEY

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(Dis)connected by Technoference. Huh?

Technology's interference in everyday life—"technoference"—appears to negatively influence relationship and personal well-being, according to researchers.

Brandon T. McDaniel, a doctoral candidate in human development and family studies at Penn State, coined the term "technoference" to describe the intrusions and interruptions in couple interactions that take place due to technology devices and their always-on and ever-present nature.

McDaniel and Brigham Young University's Sarah M. Coyne have examined the frequency of technoference in romantic relationships and whether these everyday interruptions relate to women's personal and relational well-being.

Participants were 143 married/cohabiting women who completed an online questionnaire. The majority perceived that technology devices such as computers, cell or smartphones, and television frequently interrupted leisure time, conversations, and mealtimes with their partners.

"Interruptions would likely be more frequent in a relationship where one or both partners have developed addiction-like tendencies for checking their devices or playing games, but even normal, everyday use of technology can potentially cause interruptions — many times completely unintentionally," says McDaniel.

Overall, participants who rated more technoference in their relationships also reported more conflict over technology use, lower relationship satisfaction, more depressive symptoms, and lower life satisfaction.

The researchers emphasize that they are examining complex relationships, and that factors beyond technology are likely to be involved.

Technology should not be viewed negatively in and of itself, McDaniel stresses, but due to its often always-on-in-the-background nature, boundaries on its use should be considered.

"We should all stop to think about whether our own daily technology use might be frustrating at times to our family members," he says. "Couples should talk about this and set some mutually agreed-upon rules. It may be helpful to block out times of the day when they will turn their devices off and just focus on one another." —MARJORIE S. MILLER

HIDING IN PLAIN SIGHT ‹‹

Developing a cloak of invisibility would be wonderful, but sometimes simply making an object appear to be something else will do the trick, according to Penn State electrical engineers.

"Previous attempts at cloaking using a single metasurface layer were restricted to very small-sized objects," says **Zhihao Jiang**, postdoctoral fellow in electrical engineering, Penn State. "Also, the act of cloaking would prevent an enclosed antenna or sensor from communicating with the outside world."

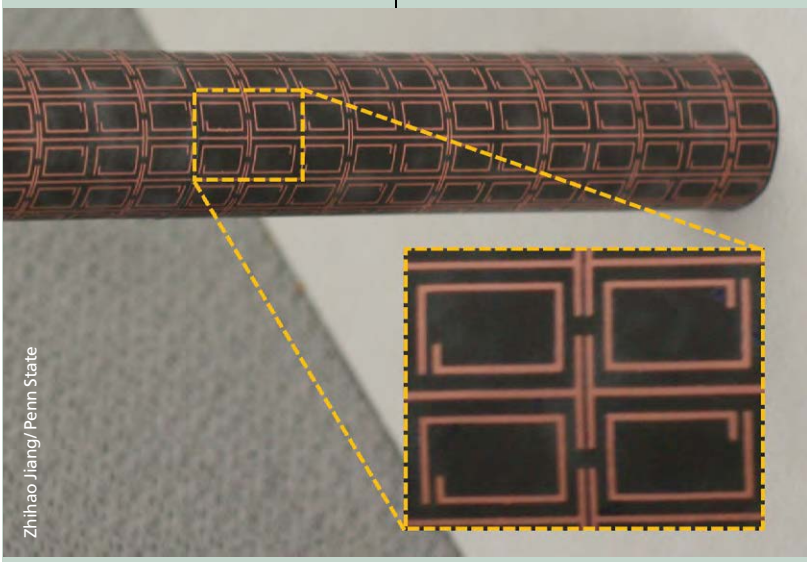
Jiang and **Douglas H. Werner**, John L. and Genevieve H. McCain Chair professor of electrical engineering, have developed a metamaterial coating that allows coated objects to function normally while appearing to be something other than what they really are.

The researchers employ "illusion coatings" made of a very thin, flexible substrate imprinted with copper patterns through the standard lithographic techniques that are used to create printed circuit boards. The pattern on each illusion coating is designed to cloak specific wavelengths of the electromagnetic spectrum, so the coated object is made invisible or deceptive to remote inspection.

The researchers coat a normal-sized metal antenna or sensor with the patterned film, and when the device is probed by a radio frequency source such as radar, the scattering signature of the coated object will appear to be that of something else, such as silicon or Teflon.

Currently, the illusion coatings only work in narrow bands of the electromagnetic spectrum, but Werner says they can probably be adapted to work with other wavelengths, including the visible spectrum.

—A'NDREA ELYSE MESSER



Zhihao Jiang/Penn State

Fossil of *Agathis* tree collected in South America

Peter Wilf

» Turn Back the Clock

Molecular clocks—dating tools based on changes in genetic material—indicate much younger ages for a wide variety of plants found as fossils in southern Argentina than do the geologic dates of those fossils, according to geoscientists who surveyed recent paleobotanical discoveries in Patagonia.

The finding suggests serious biases in molecular clocks, which are heavily used to date many kinds of living things. It also directly refutes a widely-held idea about how most Southern Hemisphere plant and animal groups attained their current distributions.

Geologists date fossils by radioisotopic analysis, which can produce absolute ages with uncertainties less than 0.05 percent. Molecular clocks apply rates of molecular change and fossil calibrations to the tree of life to construct a 'timetree' that estimates when evolutionary events occurred. Substitution rates come from DNA found in multiple genes, and radioisotope-dated fossils of known age provide the calibration anchor points.

"For years we have seen molecular dates, mostly for very deep evolutionary events, that are much older than the corresponding fossils," says **Peter Wilf**, a paleobotanist and professor of geoscience, Penn State. "This situation has been a frustrating catch-22 because if the clocks are wrong, no fossils exist that could demonstrate they are wrong."

Wilf and colleagues looked at 19 fossil lineages of ferns, cycads, conifers, and flowering plants from Patagonia, Argentina, and compared their ages to those from molecular clock studies that used other fossils as calibrations. They found that most of the fossil dates are significantly older than those determined by the molecular clock data. The work's further significance lies in the fact that all the fossils examined represent plants that lived on the supercontinent Gondwana, which once included most of the land that is now in the Southern Hemisphere, plus India.

At its last stage 45 million years ago, Gondwana still included Antarctica, South America, and Australia. The researchers' results show that living plant groups, whose ancestors are found as fossils across the Southern Hemisphere, evolved while there were still land connections or shallow water between these continents. In many cases, long-distance crossings of deep water were not necessary to achieve the distributions of the fossils' living relatives.

—A'NDREA ELYSE MESSER

Field of flax (purple flowers), a good source of omega-3 fatty acid

› Nothing Fishy About These Omega-3's

INCREASING THE AMOUNT of omega-3 fatty acids in your diet, whether from fish or flax, will likely decrease your risk of getting heart disease, according to Penn State nutritionists.

A substantial amount of evidence exists supporting the heart-health benefits of eicosapentaenoic acid and docosahexaenoic acid (EPA and DHA), marine-derived omega-3 fatty acids. However, much less evidence exists to demonstrate the positive effects of alpha-linolenic acid (ALA), a plant-based omega-3 fatty acid.

After reviewing the existing literature, the researchers conclude that ALA is likely just as effective in preventing cardiovascular disease as EPA and DHA have proven to be.

"Our understanding of the cardiovascular disease benefits of ALA has advanced markedly during the past decade," says **Penny Kris-Etherton**, distinguished professor of nutrition. "Based on the current evidence, ALA decreases CVD risk."

EPA and DHA can be found in seafood and fish oil, and are often consumed in the form of dietary supplements. ALA is found in flaxseed and its oil, vegetable oils, and some nuts, and is now also available in supplement form. Other sources of ALA, EPA, and DHA include fortified foods such as orange juice, eggs, peanut butter, margarine, and bread.

Omega-3 fatty acids are considered essential for human health, but the body does not produce them. Therefore, they must be consumed in order to maintain appropriate levels.

Kris-Etherton and **Jennifer Fleming**, clinical research coordinator in nutritional sciences, believe that dietary recommendations should be amended to increase the amount of ALA consumed, but note that randomized controlled clinical trials need to be conducted in order to determine the amount recommended.

"Heart disease is the leading cause of death in the country," Fleming says. "Learning what you can do to prevent heart disease is important and relevant for everybody."

The California Walnut Commission supported this research.

—VICTORIA M. INDIVERO

DELIVERING AIDS DRUG TO THE YOUNGEST PATIENTS

A NOVEL METHOD OF ATTACHING AN ANTIRETROVIRAL DRUG to a protein in milk promises to greatly improve treatment for infants and toddlers suffering from HIV/AIDS, according to a researcher in Penn State's College of Agricultural Sciences.

The World Health Organization estimates that 3.4 million children are living with HIV/AIDS. About 90 percent of them live in resource-limited countries in sub-Saharan Africa, where effective antiretroviral treatments are not widely available. International medical experts believe less than a third of affected children worldwide receive an antiretroviral drug.

Complicating treatment is that one of the most commonly prescribed antiretroviral drugs, Ritonavir, is difficult to administer and is not well tolerated by very young children.

To solve those problems, **Federico Harte**, associate professor of food science, is working with proteins in cow's milk called caseins. Caseins form spherical aggregates called micelles, which are natural delivery systems for amino acids and calcium from mother to young. Harte reasoned they might be able to deliver Ritonavir molecules as well.

Harte discovered that subjecting milk to ultra-high pressure homogenization—400 to 500 megapascals, compared to the 10 to 15 megapascals normally used—enhances the binding properties of the casein micelles, enabling them to carry small molecules such as Ritonavir.

"We believe a milk powder containing Ritonavir can be used as baby formula, providing a transport system for a drug that is not very soluble in water," says Harte. His lab is now testing the ability of such a formula to deliver a similar drug to piglets.

—JEFF MULHOLLEM

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Of Mice and Men

A comprehensive comparison of the mouse and human genomes has revealed many similarities and some striking differences between them, in general validating the use of mice in studies of human biology and disease while clarifying the limitations of doing so.

Ross Hardison, the director of the Huck Institute for Comparative Genomics and Bioinformatics, Penn State, says the Mouse ENCODE (ENCyclopedia Of DNA Elements) project found that the systems used to control gene activity in mice and humans are very similar, but that the regulation of certain genes—when and how they are turned on and off—varies widely in the two species.

"We didn't know before these research results that there is a large number of genes with expression levels systematically different between mouse and human," says Hardison, who leads the Penn State portion of the international project. Other Penn State collaborators include **Yu Zhang**, associate professor of statistics, and **Feng Yue**, assistant professor of biochemistry and molecular biology at the College of Medicine.

The study showed that the mouse is an excellent model for some aspects of human biology, says Hardison, but for other aspects the differences in gene regulation make it more challenging to translate findings from mice into insights about human biology.

—BARBARA KENNEDY

HONEY BEE HEALTHY ‹‹

Honey bees crowd a comb at their hive on the University Park campus. Bees today face multiple threats including pesticides, loss of food sources, and disease. Research in the lab of **Christina Grozinger,** director of Penn State's Center for Pollinator Research, has shown that exposure to pesticides changes the activity of honey bee genes related to nutrition and immunity, and that bees fed natural pollen are more resistant to pesticides than bees fed an artificial diet.

"If we can figure out which diets and which flowering plants are nutritionally optimal for honey bees, we can help bees help themselves," says Grozinger. To learn more, visit ***ento.psu.edu/pollinators***.

—SARA LAJEUNESSE

THE MARK OF TIME

State-of-the-art carbon-14 dating facility will bring chronology into focus

BY A'NDREA ELYSE MESSER

PENN STATE WILL SOON BE HOME TO AN ACCELERATOR MASS SPECTROMETER (AMS) that will allow researchers all over the country to do high-precision carbon dating to address questions about Earth's past and present.

Carbon dating has been used since the 1940s to determine the ages of archaeological finds. Modern methods in mass spectrometry, far advanced since their development in the 1970s, now enable carbon dating to be applied to a wide range of new problems.

Katherine Freeman, distinguished professor of geosciences at Penn State, uses it to follow crude oil compounds released from the 2010 Deepwater Horizon oil spill that were taken up by microbes living in sediments of the Gulf of Mexico.

More traditional uses of carbon dating also benefit from an AMS, because it provides more precise measurements of carbon-14 than other methods, and it can do so with incredibly tiny samples—as small as 1 milligram. For scientists whose test material is rare, valuable, or extremely hard to collect, that's important. **Douglas Kennett,** professor of anthropology at Penn State, recently confirmed a correlation between the Maya Long Count calendar and the European calendar by AMS dating small slivers of wood from a carved Maya lintel.

Freeman and Kennett are co-directors of the new AMS Carbon-14 Laboratory, which is expected to be fully operational in early 2016. Archaeologists, environmental scientists, and other researchers produce thousands of potential AMS carbon-14 samples each year, but only two other high-precision AMS facilities exist in the United States, and access to them is limited. It can take up to six months to have a sample tested. The new Penn State lab, featuring a powerful Pelletron® accelerator built by the Wisconsin-based National Electrostatics Corporation, should ease that crunch considerably.

Douglas Kennett

Katherine Freeman

Patrick Mansell

"Even though there are carbon-14 facilities around the world, science is still underserved," says Freeman. "The new facility is an exciting addition both for Penn State and for the larger scientific community. It will enable precise dating of carbon-containing material with ages stretching back over the past 50,000 years."

"This new facility will improve our ability to study human-environmental interactions where chronology is key," adds Kennett. "It will be helpful in areas where we really need to know the order of events." For example, mammoths went extinct near the end of the last Ice Age, but whether the changing climate, disease, humans, or a comet impact did them in is a matter of debate that might be resolved with more precise dating techniques.

HOW IT WORKS

Carbon dating works because there are three naturally-occurring isotopes, or forms, of carbon, known as carbon-12, -13, and -14. Carbon-12, with six protons and six neutrons, makes up the vast majority of carbon on Earth, nearly 99 percent. Carbon-13, a stable, nonradioactive isotope with six protons and seven neutrons, makes up another one percent. The tiny amount left, only one carbon atom in a trillion, is carbon-14. This isotope has six protons and eight neutrons and, crucially, is radioactive; over time, it decays to nitrogen-14 (with seven protons and seven neutrons).

The half-life of carbon-14 is about 5,730 years, which means it takes that long for half the radioactive 14C atoms in a substance to decay. By measuring the ratio of carbon-14 to the other isotopes of carbon in a sample, researchers can determine that sample's age. The precision of Penn State's new instrument is impressive; it will be able to determine the age of samples from the past 10,000 years within 15 to 20 years.

PREPARATION COUNTS

To get an accurate date with an AMS, the sample must be completely pure. Since carbon exists all around us, opportunities for contamination are legion, and samples go through extensive processing to ensure their purity. After thorough cleaning, a small amount of the material is vacuum-sealed in a quartz tube, which is then heated to a high temperature to convert the material to carbon dioxide, water, and nitrous oxides.

Kennett currently directs the Human Paleoecology and Isotope Geochemistry Laboratory in the Department of Anthropology, where materials are prepared for carbon-14 analysis. Anything that contains carbon can be AMS-dated, including charcoal, hair, skin, carbonates, seashells, bone, wood, and teeth.

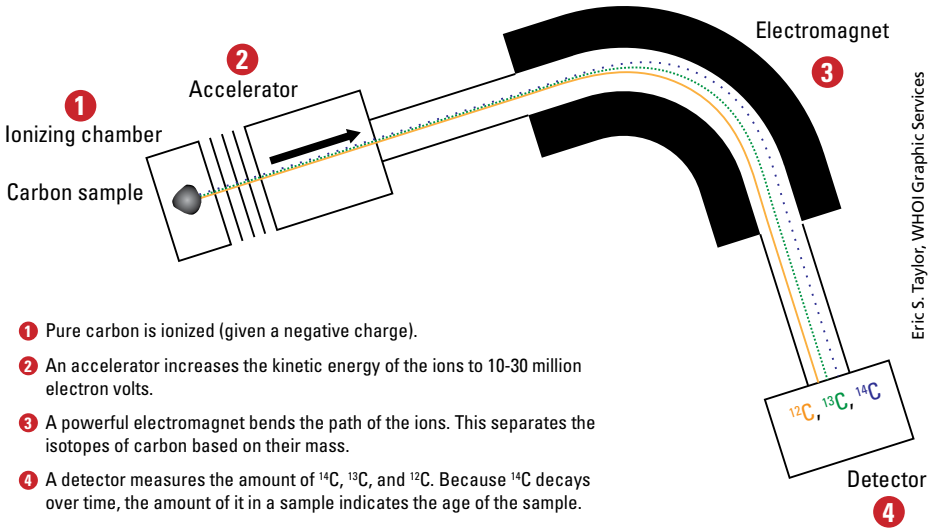
Currently, samples prepared here are sent to a high-precision AMS laboratory at the University of California, Irvine, for further preparation and testing. Soon, Penn State will complete the preparation process by converting the carbon dioxide to graphite targets that will be analyzed by the new AMS.

By the time the Penn State AMS facility is running at full tilt, it will be able to process and analyze up to 10,000 samples a year, from forensic cases, archaeological digs, and studies involving soil, sediment, water, and air. Once the initial equipment is in place and operating properly, refinements and additions will be made to broaden its potential applications.

"Eventually, we'd like to be able to look at individual molecules," says Freeman. "That would allow us to track the sources and fates of carbon at the molecular scale."

The Penn State Accelerator Mass Spectrometry Laboratory will be administered by Penn State's Institutes for Energy and the Environment. Penn State's Office of the Vice President for Research and the Provost's Office funded the AMS machine. The National Science Foundation is funding peripheral laboratories and equipment.

How an Accelerator Mass Spectrometer Works



Eric S. Taylor, WHOI Graphic Services

1. Pure carbon is ionized (given a negative charge).
2. An accelerator increases the kinetic energy of the ions to 10-30 million electron volts.
3. A powerful electromagnet bends the path of the ions. This separates the isotopes of carbon based on their mass.
4. A detector measures the amount of ^{14}C, ^{13}C, and ^{12}C. Because ^{14}C decays over time, the amount of it in a sample indicates the age of the sample.

MIND'S EYE

DESIGNERS OF A MACHINE VISION SYSTEM TACKLE A BIG QUESTION: **CAN WE MAKE IT SEE WHAT WE SEE?**

BY CHERIE WINNER

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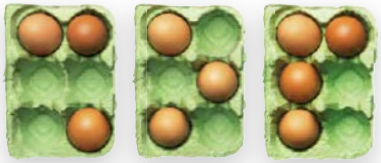

(Braille contraction for "shop")

You're in the mood for pasta, so on the way home from work you stop at the grocery store and pick up rotini, shaved Parmesan cheese, and the organic tomato sauce you favor. Into the store and back out, 15 minutes, tops. Simple, right?

For those of us who can see, it is. For those of us who are blind or have limited vision, a simple trip to the grocery store can be a major chore.

"You always have to find someone at the store to help you," says Michelle McManus, an IT consultant at Penn State and president of the Happy Valley chapter of the National Federation of the Blind. "Then you have to explain *exactly* what you want"—and hope the person helping you is diligent about getting it right.

Now researchers at Penn State are leading an effort to help visually-impaired people shop independently. They're creating machines that can interpret a complex visual scene much as the human brain does. They're making machines that can truly *see*.

AMBITIOUS VISION

This work is part of "Visual Cortex on Silicon," a massive endeavor that spans fields of inquiry ranging from materials design to brain circuitry and includes nearly 50 researchers, from grad students to senior scientists, at Penn State and seven other institutions. Research is under way on many fronts at the same time, with new findings from each field shedding light on the problems in other fields. What neuroscientists learn about the architecture of the mammalian visual cortex helps computer scientists design circuits that reflect the way the brain works.

In 2013 the project won a five-year, $10 million "Expeditions in Computing" award from the National Science Foundation. It is led by Penn State computer scientist **Vijay Narayanan**, who speaks in rapid-fire bursts and thrives on complex collaborative projects.

"I learn every day from people who work in other fields," says Narayanan. "That's what keeps me running!"

The project's formal name refers to the goal of creating a digital, silicon-based electronic system that performs like the human visual cortex, the part of our brain that processes and interprets visual information.

The project also has an informal name, "Third Eye," inspired by the Hindu god Shiva, whose third eye fills the universe with kindness and spews fire to dispel evil. The name suits both the metaphoric and practical aims of the project: If successful, the project will provide its human operators with additional, often enhanced, visual information that will make their lives easier and safer.

SEEING, SHOPPING, LEARNING

Visual Cortex on Silicon addresses three "domains" or end uses, each of which will augment human vision in particular ways. Third Eye-AR (Augmented Reality) and Third Eye-DA (Driver Assistance) will aid in the recognition of objects and people in a variety of settings, including busy streets and urban battlegrounds. Most of the team's effort in its first year has gone into the third domain, Third Eye-VI, where the aim is to develop a system coupled to a wearable device that will help visually-impaired people do their grocery shopping.

Narayanan, distinguished professor of computer science and engineering, says the "million-dollar question" in all three projects is whether the abilities of a cognitive system, be it electronic device or human brain, are due more to its hardware/structure or its software/algorithms. He and his colleagues are exploring multiple solutions to this question, ranging from new software that can run on existing processors to new hardware "fabrics" that have the potential to learn on their own.

He says his team's goal is to develop a system that will recognize that an object it sees is new to it, and store that object in memory. If it encounters the same or similar items enough times, that category will take on more importance. At some point, the system may prompt its human operator to give the item a name and tell the system where it fits in its collection of all known items.

PAY ATTENTION

A major challenge in all three domains is to create a system that will know what to pay attention to within a crowded visual field. The human visual cortex has two general modes of attention, says Narayanan. The "bottom-up" mode is akin to browsing, where we take in

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> "If it just says 'cereal' or 'dairy,' it's not going to help anyone."
> —VIJAY NARAYANAN

the scene without looking for a particular item—until something catches our eye because it stands out from its surroundings, like a face we recognize in a crowd or an orange sale sticker on a grocery shelf. In "top-down" mode, we're looking for a specific item and our eyes are drawn to things or qualities (size, color, shape) that we know resemble that item.

Third Eye scientists are trying to devise a machine vision system that can operate in either mode or combine the two, depending on the situation. Their major challenge is how to get the system to deal with a complex scene. For several years now, electronic image systems have been able to pinpoint faces and chunks of text in a scene—unless the scene is too cluttered. We need a system that can direct its attention to significant objects amid a hodgepodge of irrelevant items, as the human visual system does.

But how does the human brain control visual attention? This is where the neuroscientists in the project have provided essential insights.

"If you want to focus on something, you could amplify just the signal, or you can make everything else 'chatter' so the signal is the only voice you can listen to," says Narayanan. "The brain does it both ways. It amplifies this portion of focus and it also actively suppresses these other things that are not of relevance."

That understanding is a profound advance made possible by the collaboration among scientists from different fields, he says. The challenge now, for him and his colleagues, is to create a machine that can do both.

KNOWING WHAT IT SEES

Their system will have to be able to identify, in very specific terms, those objects it recognizes as being important. When the task at hand is grocery shopping, an obvious way to do that is to use barcodes. The technology for reading them is already well-established, and shopper-assistance devices using it are already being tried.

But that approach is far from perfect. Michelle McManus has little good to say about barcode-based recognition. The scanners work, she says, "but you have to find the barcode!" Every shopper, sighted or not, has probably had the experience of waiting while a cashier struggles to find the barcode on a package and get the scanner to read it. A visually-impaired shopper carrying a scanner would have to take an item from the shelf and keep turning it around until the scanner finds and reads the barcode.

"If the box you show it is not the right thing, you have to try another, and keep trying until you get the right one," says McManus. Multiply the frustration of that process by however many items you're shopping for, and a simple trip to the store becomes a maddening ordeal.

In her view, a better solution is what the Third Eye team is working on—a device that can actually read the labels using recognition skills such as reading and interpreting text and identifying logos and images.

Barcodes can, however, be useful in a supporting role. **Jake Weidman**, a graduate student in information systems and technology, says the team incorporated barcode recognition into its Third Eye prototype as an optional back-up to give shoppers a way to make sure they had the right item. In their first run-through with the system, he says, visually-impaired shoppers attempted to verify items via barcode about half the time.

Narayanan says that eventually, the Third Eye system will be so good at recognizing products that shoppers will be able to fine-tune the degree of match between an object it sees on the shelf and an object in the system's memory. With a low degree of match, Third Eye might consider Corn Flakes and Frosted Flakes similar enough to be the same; with greater stringency, the system would not judge them to match, or might offer them as a *potential* match the shopper might want to consider.

As of December 2014, the Third Eye: VI system could recognize 87 grocery products, and it recognizes them very precisely. Precision is necessary if the system is to be useful, says Narayanan; most shoppers have strong preferences as to brand and variety.

"If it just says 'cereal' or 'dairy,' it's not going to help anyone," he says. "If you want tomato sauce, we need to know if it's *Prego* tomato sauce. Is it *organic* Prego tomato sauce? That's the fine level of detail we need, and that's part of the challenge we face."

Graduate students Jake Weidman (foreground) and Josh Snyder (standing) demonstrate the "Wizard of Oz" setup they used to test what kind of verbal feedback was most helpful to visually-impaired shoppers. A small camera on Snyder's glove relays images of groceries to Weidman in a nearby control booth. Photo by Patrick Mansell.

FIRST, DO NO HARM

Devising a system that can recognize a useful number of objects within a cluttered visual field is only half the problem. The other half is making sure the system actually helps the people it is meant to help.

For **Jack Carroll**, distinguished professor of information systems and technology, that means asking prospective users about their experience of shopping, and taking their answers seriously.

"We're studying shopping with visually-impaired people: how they organize the task and how they think about it," he says. "What's difficult about it, what's rewarding about it, what's meaningful about it? Because what you *don't* want to do in supporting an activity technologically is make it less rewarding, less meaningful, or more challenging."

He and graduate students Weidman and **Sooyeon Lee** have been working with the Sight Loss Support Group of Central Pennsylvania, the local chapter of the National Federation of the Blind, and visually-impaired high-school students who came to campus last year for a three-week crash course in independent living. They were pleased to find out that grocery shopping was an excellent choice for the Third Eye's first application.

"It really is a key activity for visually-impaired people," says Carroll. "It's a kind of validation that they are like us, and that they can go into the stores, which are built for us, not for them, and they can cope." More than that, he says, they *enjoy* it. "Even the visually-impaired kids we talked to said shopping was right at the top of their list of things they like to do and value being able to do."

BROWSE, OR ZERO IN?

One thing the visually-impaired students helped them with was answering the basic question: What's the best way for the Third Eye system to guide a visually-impaired shopper toward items she might want?

To answer that question, Weidman and Carroll used a "Wizard of Oz" prototype. They had students wear a chest-mounted iPad that would see grocery items on the shelves and transmit the images to Weidman in a nearby control room. Based on what he saw through the iPad's camera, Weidman would give verbal instructions to the student.

> "What you *don't* want to do in supporting an activity technologically is make it less rewarding, less meaningful, or more challenging." —JACK CARROLL

"If you remember, in the movie there's a little guy behind a curtain who's creating the appearance of a wizard, but there isn't any wizard, there's just a guy behind the curtain," says Carroll. "In a Wizard of Oz prototype, there is no system. There's the appearance of a system"—in this case, Weidman giving the shopper verbal feedback as the Third Eye device might do. By following scripts that offered different kinds of information and different wording, the researchers were able to evaluate what kinds of guidance the students preferred.

"We looked at whether it's more desirable to give shoppers more directive feedback with respect to what the items were, where the items were, and where they should be directing their attention, or whether it would be good to give them more open-ended feedback," says Carroll. "There was a clear preference for the browsing dialog."

He says the Third Eye system could eventually do both, giving the shopper general information about what it sees while browsing and then, at the shopper's request, providing guidance to pick up a wanted item.

GUIDED BY TOUCH

Verbal feedback is a good way to go in browsing mode, but for selecting specific products it seems clunky—"Move your hand two inches to the right and six inches forward." So the Third Eye team developed a more subtle, elegant, and private form of direction: a haptic glove that guides the user's hand toward the chosen item by vibrating at different strengths and in different positions on the hand.

So far, people who have tried the glove have learned quickly—"within five minutes," said one—to respond smoothly and accurately to the vibrations.

The glove also gave the team a better place to put the system's camera. Instead of being strapped to the shopper's chest, the small webcam is attached to the glove at the base of the palm. When the hand reaches out, the "eye" sees what the hand is pointing toward and the system gets a continuous view of what's on the shelves near the shopper.

Carroll, his students, and the glove design team will soon launch a new trial with visually-impaired volunteers to further refine the system. For instance, what's the best way to guide shoppers looking for stacked items such as cans of soup? The shopper needs to pick up the can on top; if he grabs a can in the middle, the stack will come tumbling down.

LOOKING AHEAD

In related research, graduate student Sooyeon Lee is working with other volunteers to learn more about how visually-impaired people handle groceries at home: where they store and how they organize goods, how they know when supplies are running low, and how they maintain a list of items to buy on their next trip to the store.

Narayanan is already thinking about how the Third Eye-VI device could be made available to the people who could benefit from it. Businesses might buy one or two of the gloves for their visually-impaired customers to use, just as many stores now have motorized scooter-carts for their customers who have trouble walking. They could keep the devices updated with sale prices and locations of items. When a shopper scans in a list of items to be bought that day, the system might even suggest an alternative if a different brand of a list item is available for less money.

McManus says that from the point of view of the visually-impaired community, the research team is going about the project in exactly the right way.

"Part of the reason we like the Third Eye project is because they get in touch with blind and visually-impaired people before it's developed," she says, "instead of coming to us after it's developed, and then going, 'Oh, wait a minute, this may not work correctly.' "

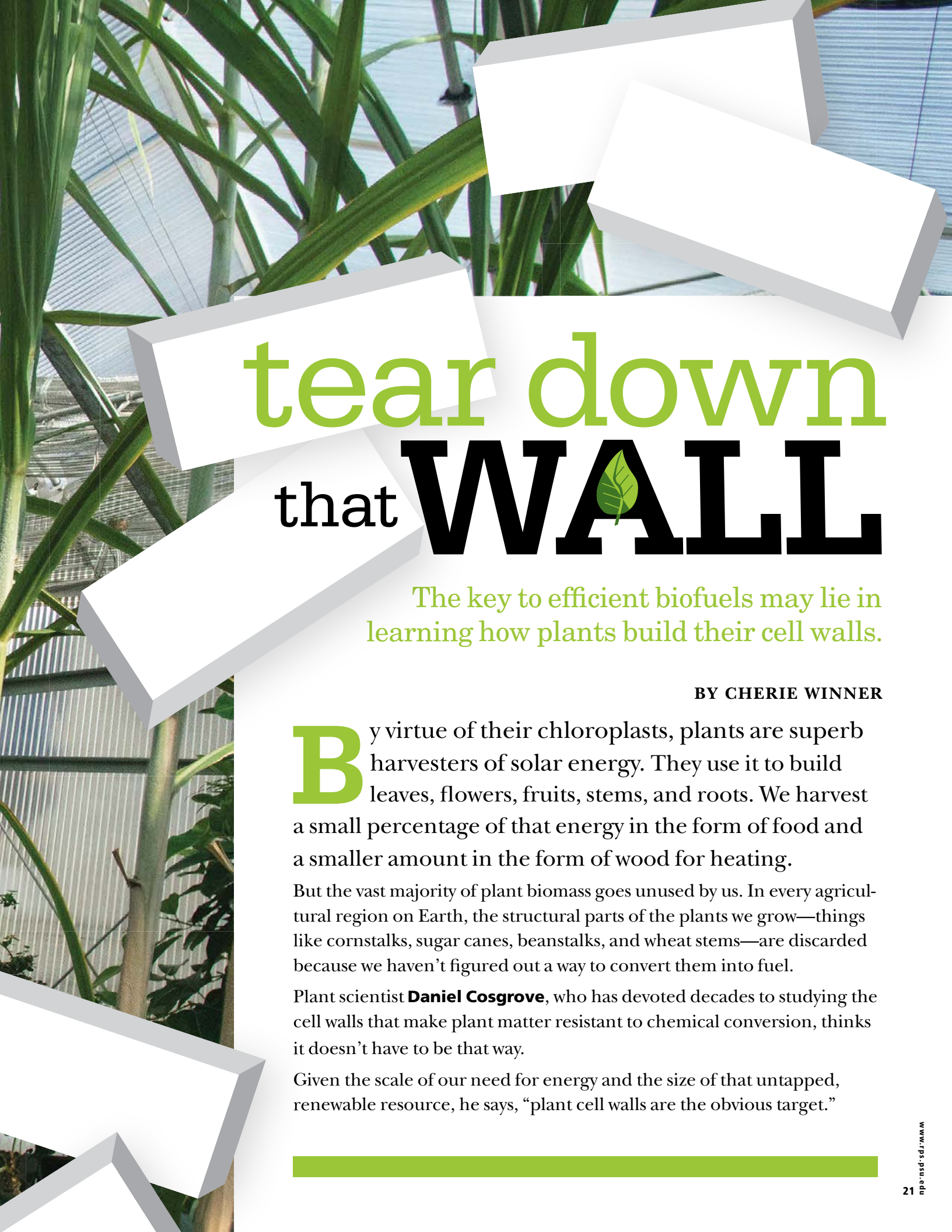
Narayanan agrees that listening to the potential users of their device has been a crucial aspect of the program, both to set goals and to keep the project in perspective.

"I do not want to over-promise," he says. "There are certain things that they are extremely good at managing themselves. We do not need to assist them in certain environments. We are just trying to make sure we are sensitive to their needs."

Other Penn State faculty involved in this project are Chita Das, Suman Datta, Lee Giles, Dan Kifer, and Mary Beth Rosson. To learn more about the Summer Academy for Students who are Blind or Visually Impaired, go to ***bit.ly/1COWoDC***

(Top) Graduate student Siddharth Advani displays the webcam-equipped haptic glove he helped design as part of the Third Eye: Visually Impaired project. (Bottom right) Former Penn State research associate Kevin Irick, another member of the design team, uses the glove to scan groceries. (Bottom left) When the Third Eye's vision system recognizes an item the shopper wants, it makes different areas of the glove vibrate to direct the shopper's hand toward that item. Photos by Patrick Mansell.

Sugar cane towers over Penn State biologist Dan Cosgrove in the gree house at Buckhout Lab. Photo by Patrick Mansell.



tear down that WALL

The key to efficient biofuels may lie in learning how plants build their cell walls.

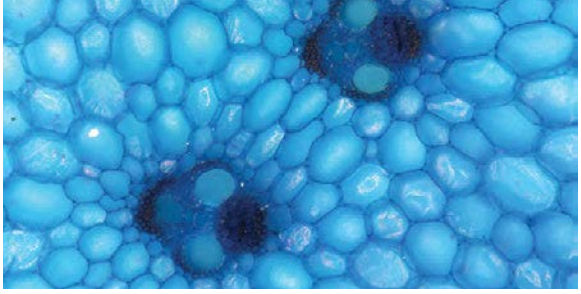
BY CHERIE WINNER

By virtue of their chloroplasts, plants are superb harvesters of solar energy. They use it to build leaves, flowers, fruits, stems, and roots. We harvest a small percentage of that energy in the form of food and a smaller amount in the form of wood for heating.

But the vast majority of plant biomass goes unused by us. In every agricultural region on Earth, the structural parts of the plants we grow—things like cornstalks, sugar canes, beanstalks, and wheat stems—are discarded because we haven't figured out a way to convert them into fuel.

Plant scientist **Daniel Cosgrove**, who has devoted decades to studying the cell walls that make plant matter resistant to chemical conversion, thinks it doesn't have to be that way.

Given the scale of our need for energy and the size of that untapped, renewable resource, he says, "plant cell walls are the obvious target."



Freshly-cut piece of sugar cane, stained with toluidine blue to make the cells easier to see. Each cell is surrounded by a thin, fibrous cell wall. The two large, dark areas are vascular bundles that transport water and sugars. Photo by Edward Wagner.

UNLOCKING PLANT ENERGY

We are expert at using the structural parts of plants to make things—wood for buildings and furniture, flax and cotton for clothing—but when it comes to using them for energy, we haven't progressed much beyond the Neanderthal stage: We burn them.

"I have a wood pellet stove at home, and with the cold spell we've got right now, we're cranking through a lot of those wood pellets to keep warm," says Cosgrove, holder of the Eberly Chair in biology. "The problem is, unless you want to go to an old steam engine or something of that fashion, it's hard to harvest the energy in wood pellets to power an automobile."

What we need, he says, is a liquid fuel, preferably one that's carbon-neutral. The closest we've come is ethanol, made mainly through fermentation of corn, which we then mix with petroleum gasoline. But corn ethanol is not a long-term solution. It diverts prime agricultural land away from food production, decreases ecosystem diversity, and, when production and transportation are considered, it is not carbon-neutral.

It also misses the point. We make ethanol from the starch inside corn kernels. The millions of tons of corn stalks are wasted. So is all the energy stored in chemical bonds in their cell walls, because we don't know how to break down the walls and release it. Biofuel crops such as poplar and switchgrass are problematic for the same reason.

"The problem is, we don't understand cell wall structure well enough to approach its conversion scientifically," says Cosgrove.

The U.S. Department of Energy (DOE) agrees with him. In 2009, the agency funded three Energy Frontier Research Centers geared toward finding a good way to turn wood and fibrous plant material into liquid fuel. Two of the programs focus on trying to break down cell walls. The third, the Center for Lignocellulose Structure and Function headquartered at Penn State, looks at the problem from the opposite perspective: how cell walls are made in the first place. The idea is that understanding how cell walls are made will make it easier for us to take them apart.

"We have a unique angle and a unique group of investigators, mostly from Penn State but also from five other institutions," says Cosgrove, the Center's director. "We're doing a variety of trans-disciplinary work that involves physicists and computational modelers and biologists and geneticists. We're interested in the fundamental problems of how cell walls are put together, because it's not just biochemistry that determines cell wall properties."

HOW YOUR GARDEN GROWS

The mystery of plant structure starts with how plants grow. In specific zones at the tips of the stems, shoots, and buds, new cells are added through proliferation: The cells take in nutrients, approximately double in size, and then divide to form two daughter cells, which themselves grow and divide. When the structure or organism reaches full size, both cell expansion and cell division stop. That kind of growth is much like what happens in animals.

But other parts of a plant grow, sometimes massively, without cell division. The stem gets longer and thicker because the cells in it elongate and expand. This kind of growth occurs in all plants, from petunias to redwoods—and it is essential for them to attain large size. If plant cells didn't get larger, if they stayed the same size they were in the seedling, the landscape would look much different.

"Someone has calculated that if the tallest tree in the world, a redwood tree, grew the way your liver cells grow, it would be about hip-high, waist-high. About three feet high," says Cosgrove.

LET IT FLOW

The puzzling thing is how, exactly, plant cells expand so much. Each cell is enclosed by a flexible cell membrane and, just outside that, by a cell wall, a box-like structure that is as strong and tough as it sounds.

Most major constituents of the cell wall have been known for almost 200 years. Perhaps the most familiar is cellulose, the indigestible-but-good-for-colon-health polymer we know as "dietary fiber." In its most basic form, cellulose is a long chain of glucose (sugar) molecules. Cell walls contain dense layers of cellulose microfibrils made of two dozen of these chains adhering to each other.

But our understanding of how all the parts are made and how they interact with each other is still developing. During the past four years, Center scientists have learned a lot about the Cellulose Synthesis Complex, or CSC, that produces cellulose chains and microfibrils. Hundreds of CSCs are embedded in the cell membrane that surrounds each growing cell.

This "nanomachine," as Cosgrove calls the CSC, is a big, donut-shaped structure comprising at least 18 enzymes, each of which builds cellulose chains. The newly-made chains pass through the "donut hole" in the middle of the CSC to the outside of the cell. There, they line up parallel with other new chains to form a microfibril. Then the microfibrils become embedded in and cross-linked to a matrix of other molecules.

After one entire sheath around the cell is completed, a new one begins to form just inside the first. Over time, many layers develop, the innermost one always being the newest. In woody plants, there's a second phase of development in which the walls lignify, or become woody. At that point, the cells don't get any bigger, but their walls get thicker and harder.

In the 1990s, Cosgrove's lab discovered a class of proteins that somehow loosen the bonds that hold the wall components together just enough to let the cell wall grow, creating a bigger space inside for the cell's gel-like innards to fill. He called the proteins expansins.

"To this day, the mechanism of action of expansins is mysterious," says Cosgrove. "They work in a way that seems contradictory to our notions of how the cell wall is structured—they turn the cell wall from something that behaves like a solid to one that behaves like a liquid and starts to flow. Then the walls can extend and the cells grow."

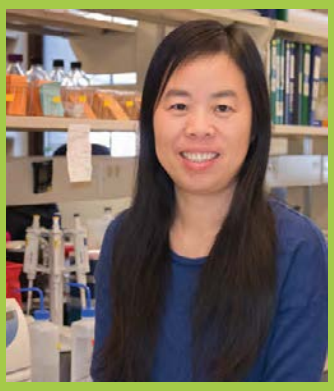
And yet, even while growing, the walls remain strong. Their constituents remain linked together in a way we don't yet understand—and those are the bonds that need to be broken to release the energy stored within.

SEEING IS BELIEVING

To learn more about how cell walls are made, **Charles Anderson**, assistant professor of biology, and **Ying Gu**, assistant professor of biochemistry and molecular biology, use techniques that allow them to actually see many of the building blocks of cell walls and the cellular machinery that puts them together.

"I like to see things," says Gu. "Seeing is believing!"

Her lab is studying how the orientation of cellulose microfibrils is controlled. When cellulose chains first emerge from the cell, they lie crosswise, perpendicular to the long axis of the cell. They later rotate and end up arranged lengthwise.



Patrick Mansell

Ying Gu

In an experiment with seedlings of a small flowering plant, Gu's research associate **Shundai Li** and graduate student **Lei Lei** showed that the Cellulose Synthesizing Complex is linked to supportive structures inside the cell, and that the linkage helps control how the cellulose fibers are oriented outside the cell.

They marked specific proteins with compounds that fluoresce when exposed to a laser. They then photographed individual cells of the seedling—which was still alive and growing—through a laser confocal microscope.

Under one wavelength of light, a red glow revealed the location within the cell of the supportive struts. Under a different wavelength of light, a green glow showed the location of a protein, CSI1, that Gu had previously found is attached to the cellulose-making machinery. Time-lapse recordings of the living cell under both wavelengths showed CSI1 shuttling back and forth along the struts.

Because the struts are oriented crosswise in the cell and CSI1 is connected to both them and the cellulose machinery, that motion would result in new cellulose chains being oriented crosswise to the cells.

Now colleagues in the Center can use other techniques to study how the microfibrils rotate and how that movement is related to the cell's ability to grow.

"We have good collaborations across the Center," says Gu, "so we can do our thing, which we are good at, and then send our samples to other people to analyze, to measure the physical properties and see how they relate to cell structure."

THE PAYOFF

Solving the mystery of cell walls could do more than provide an alternative fuel source, says Cosgrove. Farmers could sell the crop residue they currently discard, gaining extra income with little or no additional investment. In some areas, getting rid of the leftover plant matter may be even more important than gaining income.

"Down in Brazil they grow sugar cane," says Cosgrove. "They chop up the stalks, they extract the sugars, but then they're left with a huge residue of cell wall material. It's very much like cornstalks, just bulkier. They used to burn it but it created air pollution problems, so they banned burning it. So they're left with this problem, what do you do with all this stuff?"

Raising crops specifically for fuel production, already under way on an experimental basis, could become efficient enough to be profitable.

The research could even translate into a wide range of other products. "Cell walls go into all kinds of things," he says. "It's cotton, it's wood, it's fibers, and it's used in a lot of industrial processes. Knowledge lets you improve all of that. You never know where this will be picked up by engineers who say, OK, we now see a way that we can tweak this to make a product better, different, cheaper."

Last year, the DOE renewed the Center's funding for another four years. Cosgrove says he'll be happy to let others develop specific applications from cell wall research. He just wants to learn how walls are made and how they work.

"We knew a whole lot more about cell walls 20 years ago!" he laughs. "We were totally misinformed. We thought we knew, and we didn't. We keep coming upon surprises, all the time, as we learn more. The wall is a much more sophisticated structure than anyone had believed."

Long-term studies reveal that the health consequences of child sexual abuse linger into adulthood.

LASTING DAMAGE

BY SARA LAJEUNESSE

CLICK.

That simple sound is enough to send some women into a panic as memories of their abuser unlocking the front door surface in their minds. For these women, such a noise can transport them back to their childhoods—to the many nights they lay awake in terror, waiting for their perpetrator to act, not knowing when it would happen, how long it would last, or how much it would hurt.

According to **Jennie Noll**, professor of human development and family studies and director of research and education for the Network on Child Protection and Well-Being, some 70,000 to 100,000 girls are sexually abused in the United States each year, and those are just the cases that are reported. Noll believes these egregious sexual violations can have long-term effects on health and development that are different from the effects of other kinds of childhood abuse.

ILLUSTRATIONS BY NATHAN WAGONER

> "It is the kind of stress that never goes away, even when the danger subsides." —JENNIE NOLL

"The kind of stress caused by sexual abuse is unpredictable, yet constant and extreme," says Noll. "It starts early in life when physiological systems are developing and their future organization and function are being established. It is the kind of stress that never quite goes away, even when the danger subsides. As a result, it has significant wear and tear on the body, including on the brain and on multiple endocrine and neurobiological systems."

To investigate the unique effects of childhood sexual abuse, Noll conducts longitudinal—or long-term—studies of girls who have been sexually abused and compares them to girls who have similar backgrounds, including family makeup and neighborhood origin. Such a "prospective" study design enables Noll to observe outcomes as they happen rather than "retrospectively" looking into the past to see what may have caused a particular outcome, an approach that often is criticized for being biased and leading to inaccurate results.

"People at the legislative level sometimes argue that we don't know if it's abuse or poverty or the family situation that causes health problems, so why would we put our money into dealing with something that we can't make strong inferences about?" says Noll. "The kind of prospective research that we do is the best kind of research we can offer to demonstrate that childhood sexual abuse causes certain public health problems."

LONG-TERM HEALTH CONSEQUENCES

Depression. Substance abuse. Liver disease. HIV. Katie [not her real name] is suffering from a multitude of health problems, perhaps directly attributable to the sexual abuse she endured as a child.

"Beginning at age 10, Katie's stepfather engaged her in a non-violent sexual relationship under the auspices of love," says Noll. "When her mother was not at home—which was a lot because her mother worked nights—he would ask for sex and they would have intercourse. He did it by convincing her that it was part of being loved, that he loved her so much that having sex with her was one way that she could know that she was loved. This can be very confusing for a young girl who may feel as though she participated in the sexual relationship in a way or somehow gave consent. But as we know, no child can give consent for sex."

According to Noll, this abuse set Katie—a participant in one of Noll's studies—on a trajectory that led to several incidences of revictimization and numerous health problems. After graduating from high school, she enlisted in the military, where she was raped several times. Her resulting post-traumatic stress disorder symptoms eventually interfered with her ability to do her job, and she ended up being discharged from the service before her tour was over.

When she returned to the United States, Katie began to drink heavily and to use methamphetamines. She was involved in a number of additional sexual assault situations and had some trouble with the law. Now in her late 30s, she is struggling to hold down a job and does not have a stable relationship. Her health is starting to fail.

"When I asked her what has been the biggest barrier in her life, what has gotten in the way of her being able to function and be happy, she said it was the sexual abuse that she suffered as a child, because it set her on a course of victimization and misery and psychological problems that she's never fully recovered from," says Noll.

Katie's HIV, liver disease, substance abuse, and depression are just a few of the negative health outcomes that often are associated with childhood sexual abuse, according to Noll. "Obesity, diabetes, cancer, and cardiovascular disease also appear to be related to abuse," she says.

Jennie Noll

Patrick Mansell

In one study, Noll has been following a group of 90 sexually abused females, as well as 90 matched comparison females, all of whom were recruited by scientists at the National Institutes of Health in the late 1980s, when the participants were around 10 years old (Noll joined the project in 1995). The women now are entering their late 30s and early 40s. Among many other health measures, Noll has been tracking the participants' cognitive abilities by conducting memory, reasoning, and vocabulary assessments over the years.

"We are beginning to see premature cognitive aging and early signs of cognitive decline, although none of these women have even reached the age of 45," she says. "These findings are consistent with what we believe to be the later-life manifestations of early brain maldevelopment and evidence for the neurobiological consequence of early and chronic stress."

Noll also has been measuring the women's body mass and has found that 42 percent of the abused females were obese by late adolescence, while only 28 percent (the national average) of the comparison group were obese. Noll suspects that, perhaps as a result of the high rates of obesity, the abused women may also exhibit higher rates of diabetes, high blood pressure, heart problems, and cancer. She is currently investigating those possible health outcomes.

In addition, Noll's work has shown that sexual abuse victims are more likely to suffer from depression and substance abuse problems, to be raped in late adolescence and early adulthood, and to experience domestic violence.

"The abused girls are two to three times more likely to be revictimized than the comparison girls," says Noll.

CROSSING GENERATIONS

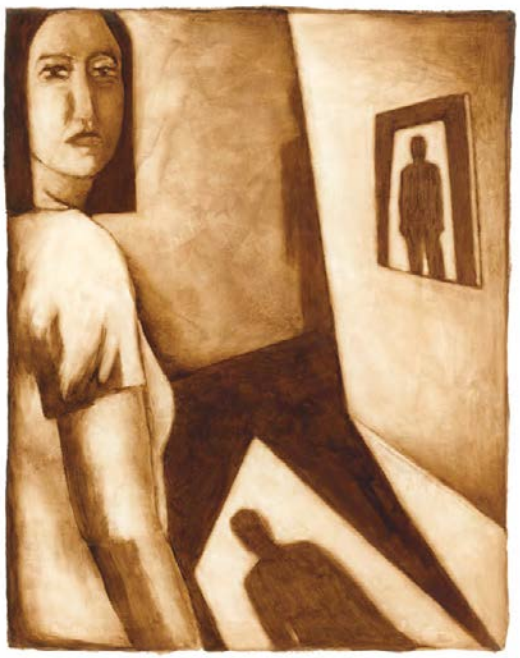
Perhaps even more disturbing than the pain these women continue to experience is the suffering that is passed on to their offspring. According to Noll, 20 percent—twice the national average—of the abused women in her sample gave birth to premature babies. Noll's data suggest that the premature status of these babies is due to the abused mothers' high cortisol levels as a result of stress and/or alcohol abuse during pregnancy.

In addition, as the children of abused mothers age, they are more likely to enter child protective services, to score significantly lower on cognitive

> "We need to equip our kids to monitor their *own* online behavior, especially those who are the most vulnerable." —JENNIE NOLL

ability tests than children of comparison mothers, and to suffer from sexual or physical abuse.

"Typically, it isn't the mom who goes on to abuse the kids," says Noll. "That's the myth that I've been able to dispel with this study. More often, there's an environment that's recreated wherein kids are put at risk for being exploited by other people who have been brought into that family system, or the mother is neglectful. Because we've followed this sample for so long, we have some of the only data on how the abuse experience of the mother confers risk to her offspring."



Noll's data show definitively that childhood sexual abuse has long-term health and wellness impacts, but do the frequency, severity, or age at onset of abuse also have effects?

"It's very difficult for us to put a judgment on how people interpret their traumatic experiences," says Noll. "One traumatic experience may be pretty severe for one person, while another person may have had really severe and repeated trauma that does not impact them much. It's very individual. The outcome often has to do with how resilient the victims are. Anecdotally, those who were able to remove themselves from the situation, who were able to find solace in a strong female role model or in religion, or who just had the kind of personality that allows them to say, 'This abuse is not going to define me or stop me,' tend to do better. One definitive thing our data show is that the girls who did not experience physical threats, but instead had a lot of confusion about what their role was in the relationship, do the worst long-term."

ONLINE VICTIMIZATION

An image of a pair of breasts, a name scribbled across the flesh. This is the publicly available Facebook profile picture of a 15-year-old girl—with 1,500 Facebook friends—who is part of Noll's latest study on the effects of childhood sexual abuse on Internet and social media behaviors.

To conduct the study, Noll recruited 450 girls, ages 12 to 17, 150 of whom were victims of sexual abuse that was reported and substantiated in a court of law within the year prior to their involvement in the study. The remaining 300 girls were either matched comparison girls or census-matched girls. Noll gave each of the girls a laptop computer and told them they could do whatever they wanted with it. She is currently tracking and recording every URL visited, search term entered, and social media post made, among other things.

"So far, I have noticed something very peculiar about the publicly available profile pages of the girls from the sexually abused group," said Noll. "They are much more provocative in their self-presentations and revealing in terms of personal identifying information than the comparison girls. Their pages are suggestive of an individual who might be willing to entertain sexual advances online."

Noll says that "creepers" choose vulnerable adolescents to lure offline and may even find them by looking for provocative profile pictures. She has found that about 30 percent of the adolescents in all groups in her studies have gone to meet someone offline whom they first met online. She also has found that only 2 percent of parents in both the

abused and comparison groups implemented a parental control device on their daughter's computer, even when Noll and her team gave them explicit instructions on how to do so.

"Parental control is the primary means of prevention for keeping kids out of pornography and other dangerous online behaviors, and that's not happening," says Noll. "We need to equip our kids to monitor their *own* behavior, especially those who are the most vulnerable, like abused kids who are often not fully aware that they have the power to protect themselves from perpetrators who seek victims online."

INFLUENCING POLICY

Noll often has to intervene when she sees problems occurring among her study participants. "We are mandated to report to authorities if we see a child whom we suspect is being abused or a woman who is depressed, suicidal, has psychiatric conditions, or is abusing her own kids," says Noll.

But Noll's hopes extend beyond just helping her own study participants. She wants to make a difference for sexual abuse victims throughout the nation. To do so, she works with policy makers, such as those in the Pennsylvania General Assembly, to help them better understand the impacts of sexual abuse and to write legislation that protects victims and may even prevent abuse from happening in the first place. She also works with the National Institutes of Health to help establish funding priorities so as to bring about systemic change in the area of childhood sexual abuse.

"People really won't pay attention unless we have rigorous scientific evidence," says Noll. "We need to use this evidence as the basis for policy changes. We especially want Pennsylvania to be a major player in research that can change the lives of these victims."

To see a video conversation with Jennie Noll, visit ***bit.ly/1GVtvXC***

"Our darkest days."
The cover of the January/February 2012 issue of the University's alumni magazine, the *Penn Stater*, aptly described the mood on campus following the news of child sex abuse by former football coach Jerry Sandusky. The letters of the *Penn Stater* banner, which normally sit prominently at the top of the magazine's cover, lay in a heap at the bottom of the blackened page. University affiliates at all levels—faculty, staff, students, and alumni—were shocked by the heinous crimes, and their hearts went out to the victims.

Determined to make a positive difference in the lives of at-risk children, members of the University community began to take steps toward combatting child maltreatment. Then-President Rodney Erickson established a task force to explore how Penn State, through its mission to advance research, education, and service, could best address what has been described as an "invisible" problem—but one researchers have shown can affect the life-long health and well-being of victims.

Craig Hillemeier, senior vice president for health affairs and dean of the College of Medicine, and **Susan McHale**, director of the Penn State Social Science Research Institute and professor of human development and family studies, co-chaired the task force. Its first step was to propose a University-wide Network on Child Protection and Well-Being.

"Child abuse is difficult to study and hard to treat," says McHale. "The Network on Child Protection and Well-Being is approaching the serious and widespread problem of child maltreatment from a wide variety of angles and involving individuals from many disciplines and professions with a goal of making a real difference."

As part of this effort, Penn State is hiring at least 12 new faculty members with expertise in child maltreatment issues. Several of these faculty members already have been hired.

"If we can bring the best and brightest minds to do relevant work, then Pennsylvania can really be a place where we lead the charge in terms of translating research in a way that moves policy and practice," says Jennie Noll, the network's director of research and education and the first new faculty member to be hired.

Another goal of the network is to create an undergraduate minor in child advocacy and maltreatment studies for students who plan to work in professions involving at-risk children.

The network also sponsors an annual conference on child protection and well-being. This year's conference, slated for September 30 and October 1, 2015, will focus on new frontiers in the biology of stress and maltreatment trauma.

protectchildren.psu.edu

STRANGE NEW WORLD

IN THE REALM OF 2D MATERIALS, WEIRDNESS WORKS

BY MICHAEL HART

Thinkstock

Materials scientist Joshua Robinson looks inside a chemical vapor deposition furnace, which is used to make two-dimensional materials. Photo by Patrick Mansell.

JOSHUA ROBINSON RECALLS THE DAY IN 2006 WHEN HE LEARNED OF A MATERIAL THAT IS, FOR ALL PRACTICAL PURPOSES, TWO-DIMENSIONAL.

At the time, he was a post-doctoral researcher at the Naval Research Laboratory in Washington, D.C. His advisor, Eric Snow, was raving about graphene, a newly isolated form of carbon. A cousin of the widely known buckminsterfullerene (or "buckyballs") and carbon nanotubes, graphene was a flat sheet only one carbon atom thick. The atoms were linked together in a six-sided, chicken-wire pattern, forming a lattice with astonishing properties. It was flexible, transparent, and stronger than steel. It conducted electricity better than copper and heat better than anything. In short, carbon in this form didn't behave like carbon anymore.
It acted like an entirely new material.

Small monolayers of tungsten disulfide as seen under a blue filter. These samples range from 5 to 20 microns on a side. Photo by the Terrones group.

(Left) Inside the deposition furnace, a quartz tube provides a controlled environment for the formation of 2D materials from vaporized organo-metallic compounds. (Right) A silicon wafer placed into the tube serves as a substrate on which the new materials can grow. Photos by Patrick Mansell.

Graphene became known as the first two-dimensional, or monolayer, material. Indeed, at one-third of a billionth of a meter thick, it's as close to two-dimensional as a tangible object can get. Graphene is 300,000 times thinner than common printer paper. If the paper were as thick as a six-story building is high, graphene would be the thickness of the original paper.

Robinson was in an ideal position to recognize the importance of two-dimensional (2D) materials. He was working with carbon nanotubes, adapting them to detect minute amounts of airborne substances such as those given off by chemical weapons and explosive devices.

"Graphene was simply an unzipped nanotube," says Robinson, who is now an assistant professor and Corning Faculty Fellow in the Department of Materials Science and Engineering, Penn State. "Eric was so damn excited that I couldn't help but start reading about graphene, and instantly became hooked—this 'new material' seemed too good to be true."

STUMBLING BLOCKS

Scientists, engineers, and investors around the world also became excited by graphene, especially its potential to revolutionize electronics. The term "post-silicon" was coined to describe this new frontier, and in 2010 the discovery and initial characterization of graphene won the Nobel Prize in Physics.

But the transition from discovery to practical application has turned out to be not so easy. Although materials scientists could create a variety of new 2D materials using other elements and compounds, they could not always predict what properties those materials would have. The tiny or even microscopic bits of monolayer were hard to manipulate and analyze—despite their strength, they were easily torn—and difficult or impossible to make on an industrial scale.

What the field needed was a deeper understanding of 2D materials and their weird properties. To take on this challenge, in 2013 Penn State's Materials Research Institute started the Center for 2-Dimensional and Layered Materials (2DLM). The center brings together about 50 faculty, postdoctoral researchers, and students from Penn State and other institutions around the country. It is the first research center to focus not just on graphene but "beyond graphene," according to Robinson, the center's associate director. "It has really helped attract some of the best new faculty in the nation, as well as many high-performing students."

BUILDING BLOCKS

Work at the center addresses several broad themes, such as finding new ways to make 2D materials and combine monolayers made of different compounds, developing techniques to analyze new materials and their properties, understanding how the architecture of a layered material affects its properties, and tech transfer—seeking patents and pursuing commercially viable products.

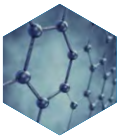
Scientists here have made new monolayer materials by combining a variety of elements, such as tungsten or molybdenum with sulfur, gallium or silicon with selenium, and boron with nitrogen.

Improved techniques for studying 2D materials have made it easier to predict which compounds will form monolayers and how they might behave in that form. Like graphene, these materials exhibit properties not seen in their three-dimensional forms. Several of them—such as molybdenum disulfide, tungsten disulfide, and a form of boron nitride—are semiconductors that offer the promise of ultra-small electronics. Some are photoluminescent, absorbing light of one wavelength and sending the energy back out at another wavelength. They may become the basis for a new generation of devices that detect or emit light.

Some monolayer-based products are now working their way toward commercial applications.

"I have seen and touched and used flat panel displays using graphene as a conducting, transparent electrode," says **Mauricio Terrones**, professor of physics, chemistry, and materials science and engineering, and director of the 2DLM. "This could be the first product in the market. The advantage of graphene is making flexible flat panels, something it is not possible to do with the current technology."

Major projects aimed at turning such futuristic technologies into realities are under way at Penn State. The National Science Foundation (NSF) recently offered support to three of the center's projects with more than $4 million in research grants. Robinson's group is developing a new type of post-silicon transistor, opening



"2D IS LIKE THE WILD WEST RIGHT NOW." —JOSHUA ROBINSON

the way for ever-smaller electronics. **Joan Redwing**, professor of materials science and engineering, and her team are working on ways to create two-dimensional materials at low temperatures, to make production more feasible for industry and to allow the materials to form on glass and plastic. **Zhiwen Liu**, professor of electrical engineering, and **Ana Laura Elias Arriaga**, research associate in physics, are working with colleagues at Rensselaer Polytechnic Institute to develop layered materials for use in light-based technologies.

STACKING MONOLAYERS

Terrones and Robinson believe that the key to success in their field will be to combine different types of monolayers. Robinson's group has worked with other Penn State faculty and researchers at the University of Texas at Dallas to induce different two-dimensional materials to form directly on top of one another.

"By doing this, we have been able to achieve really clean interfaces between the layers," Robinson says. "This is a key for novel nanoelectronic circuits."

As with layered materials made of a single compound, these "hybrid" materials often display unexpected—and potentially useful—behaviors. Two such materials were made in the lab of Pulickel Ajayan, a 2DLM member at Rice University, and then sent to Terrones for analysis.

In an attempt to make the materials at lower temperatures than ever before, an advance that would ease mass production, Ajayan's team had inadvertently caused two familiar materials to settle into new relationships with each other.

At one temperature, tungsten disulfide formed a layer on top of a layer of molybdenum disulfide. In this configuration, the combined materials work like a transistor. At another temperature, the two materials formed layers side by side in the same plane.

"It is like having two different fabrics joined together, but at the joint the two fabrics are like one," says Terrones. In the edge-to-edge configuration, the junction between the two fabrics is a meeting place where electrons and photons pass energy back and forth.

"We are now finding these materials might have important uses as very fast and sensitive photo-sensors or even light-emitting devices," Terrones says.

THE 'WILD WEST'

With similar discoveries occurring on almost a weekly basis, predictions of amazing new products to come have returned. This time, the excitement has a sound foundation of basic science—and this time, the scientists and engineers are looking beyond the initial goal of turning graphene into a new type of semiconductor material.

"It is likely that graphene and other 2D materials will be important components of wearable electronic devices," says Terrones. "I also foresee that we will see these materials in 'smart' coatings that change properties upon an external stimulus." 2D coatings could fight rust and bacteria. They could serve as sensitive detectors of air quality. They could even discourage barnacles from fouling boat hulls. The possibilities seem limitless.

Robinson agrees.

"Two-dimensional materials are much more than a replacement for silicon," he says. "The key thing about 2D is that it's like the Wild West right now. There is nearly an unimaginable number of potential applications out there. But first we need to understand their basic properties to be able to best identify which applications are going to benefit from these novel materials."

(Top) Under some conditions, tungsten disulfide monolayers emit red light. Photo by the Terrones group. (Bottom) A "glove box" allows materials scientist Mauricio Terrones to handle chemicals in an ultra-clean and air-tight environment. Photo by Patrick Mansell.

Patrick Mansell

In 2014, Sophia McClennen, professor of comparative literature, and media studies major Remy Maisel published a book about the role of satire in American politics. *"Is Satire Saving Our Nation? Mockery and American Politics"* is the first book co-authored by a Penn State faculty member and an undergraduate student.

Staff writer Matt Swayne spoke with McClennen about the history and role of political satire in America.

SATIRE IS OFTEN CONSIDERED FUN AND FRIVOLOUS, BUT, AS THE ATTACK ON THE FRENCH SATIRICAL MAGAZINE *CHARLIE HEBDO* SHOWS, IT IS A POWERFUL FORM OF EXPRESSION. WHY IS SATIRE SO POLITICALLY POWERFUL?

Satire tends to poke at figures of authority and powerful institutions. It attempts to use humor and irony to suggest to audiences that their assumptions about those in power should be altered. And that is why it is often the subject of censorship, oppression, and threats. Those who feel ridiculed by satire often respond with frustration, anger, or, in extreme cases as we recently saw in Paris, violence.

WHY DID YOU START LOOKING INTO THE ROLE OF SATIRE IN AMERICAN POLITICAL DISCUSSION?

There are a few ways to answer that. First, when I was an undergraduate, I was on the staff of *The Harvard Lampoon* and I fell in love with satire. This was my way to get back to that.

But the real answer to the question is that not long after Steven Colbert emerged on the scene in character, he hosted the White House Correspondents' Dinner. Someone told me to watch his appearance and when I saw him roast President Bush to his face, I knew I had to write about the experience. That turned into my book, *Colbert's America*. After that I realized there was a lot more going on. It wasn't just limited to Stephen Colbert, so that led to the second book project.

DO YOU THINK POLITICAL SATIRE IN THE UNITED STATES HAS CHANGED IN RECENT YEARS? IS IT DIFFERENT FROM WHAT IT WAS IN THE LATE-1800s, MID-1900s, AND WHAT HAS BEEN ITS EFFECT ON OUR CIVIC LIFE?

That's what our book's about!

Satire has always existed to comment on politics and the media. What's different now is that satire is actually a source of news. It's not just the second thing people go to for information, sometimes it's the *first* thing, and that's really significant because it means the mainstream media are being cut out of the process.

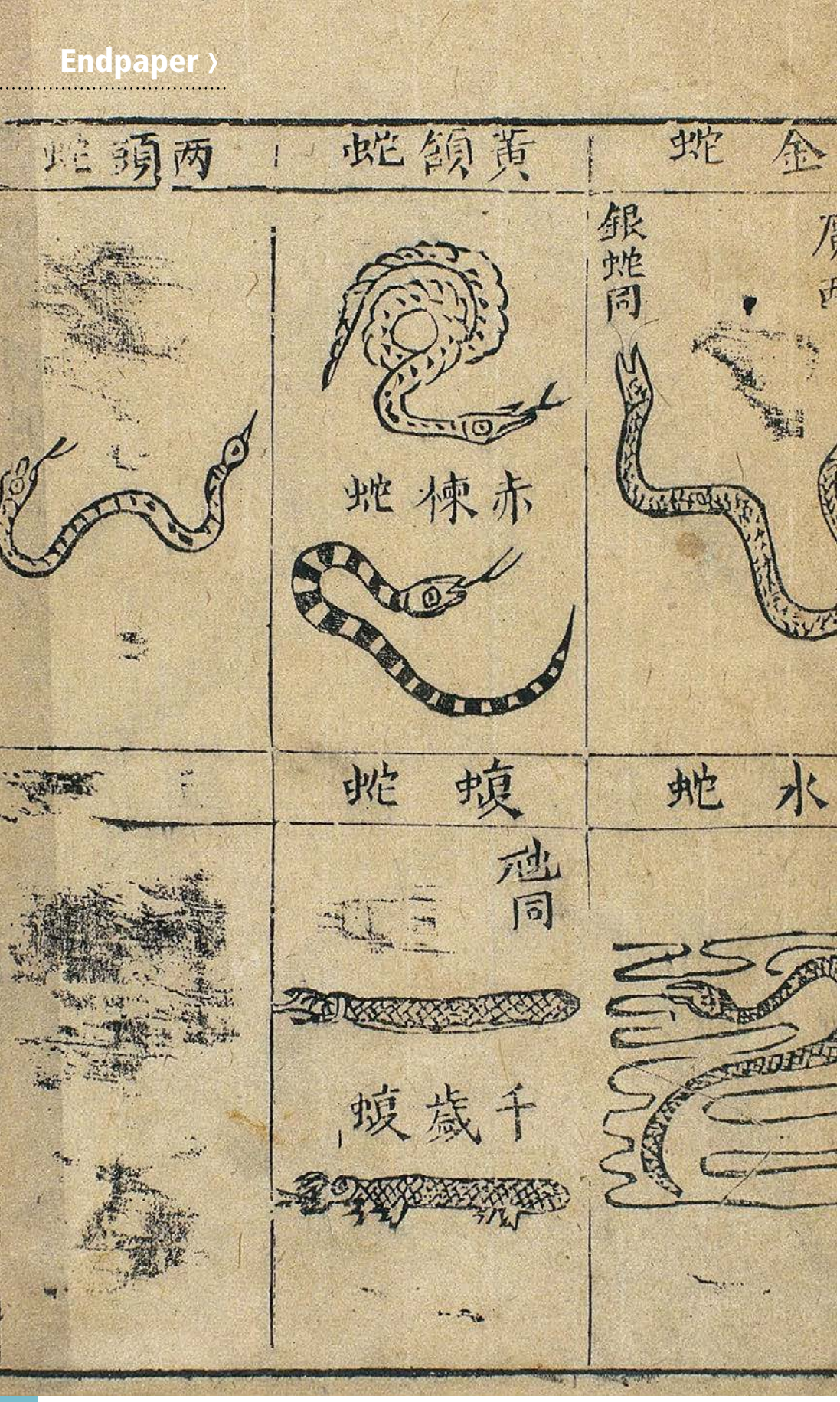
The second change is the creation of what Remy and I are calling citizen satire. We now have satire being produced by many more people other than the professionals. Satire is being created a lot more by millennials and by average people who have Twitter feeds with 200,000 people following them.

HOW DO YOU THINK THE SATIRICAL LANDSCAPE WILL CHANGE NOW THAT COLBERT IS MOVING TO *THE LATE SHOW*?

Remy and I have different answers to that!

I am sad. I think it's a huge loss because we are losing the character, so even though Steven Colbert is going to go on to have what everyone expects to be a productive and important impact on the late-night format, what we are going to have is the loss of the character that Colbert created. That character has done a lot of significant things in the satire world. Most people expect that in the new show, he won't be able to use the same amount of satire because the late-night show is not a format that uses a lot of satirical content.

Remy is more optimistic that Colbert can hold onto



Woodcut illustrations from *Bencao Gangmu,* or *Systematic Materia Medica*, a Ming-era pharmaceutical encyclopedia published in China in 1596. The book describes the source, preparation, and uses of nearly 2,000 medicinal substances. Penn State historian **Kathlene Baldanza** used this text in her study of how the natural barrier created by malaria and other mosquito-borne diseases helped protect the country now known as Vietnam from invasion by Chinese forces. The diseases also prompted efforts by medical practitioners to develop treatments using local plants and animals. Woodcut photos courtesy of the Wellcome Library, London. Kathlene Baldanza photo by Patrick Mansell.

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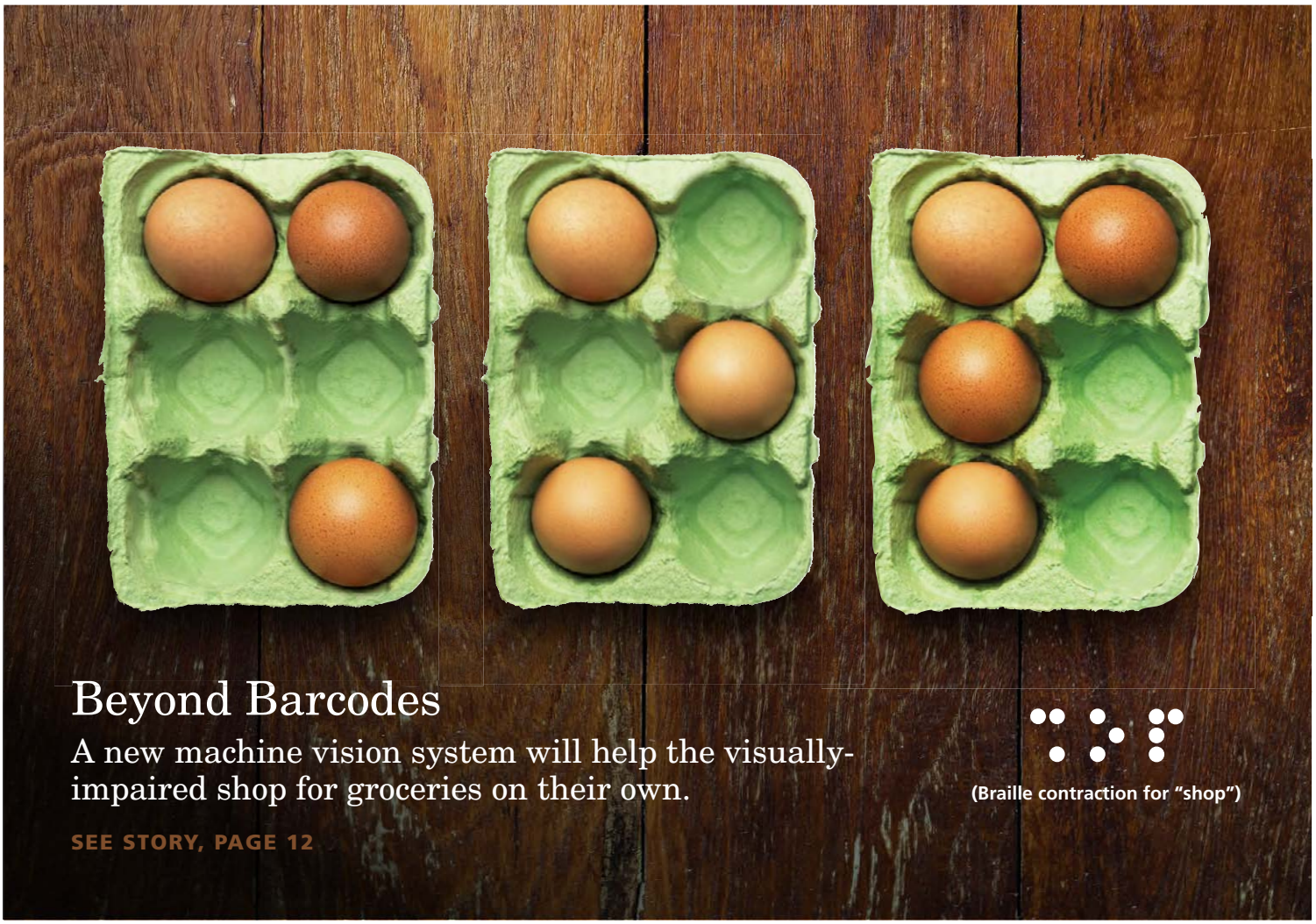

Beyond Barcodes

A new machine vision system will help the visually-impaired shop for groceries on their own.

SEE STORY, PAGE 12

(Braille contraction for "shop")