



THE VIRUS
in the Cupboard

12 Hunting pathogens
close to home

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The Land Grant Promise

Penn State was among the nation's first Land Grant colleges established by the Morrill Act of 1862, to "teach such branches of learning as are related to agriculture and the mechanic arts . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." The ultimate aim of the act was to accelerate quality of life for local citizenry.

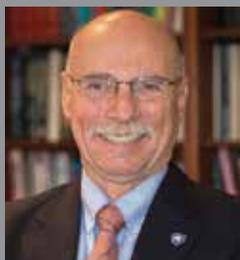
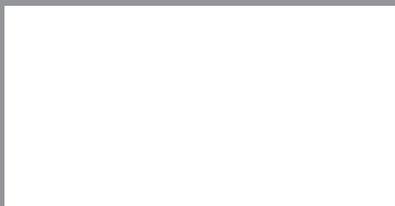
Reflecting this guiding vision, this issue of *Research/Penn State* features stories of direct relevance to Pennsylvanians and by extension to the rest of the world. In "The Virus in the Cupboard," biologists Peter Hudson and Kurt Vandegrift explore the viruses that are carried by the white-footed mouse, an all-too-familiar interloper in Pennsylvania's barns and sheds, and that have the potential to cause human disease. Pam Silver and her students at the Behrend campus are tracking the environmental consequences of rock salt, a winter constant on Pennsylvania's roads and walkways. With considerable implications for the advance of innovation around our state and beyond, Scarlett Miller's research reveals how and why many bright ideas never reach the marketplace.

Then there's the fascinating work of historian Ari Kelman, who accepted the challenge of an all-new approach to telling the familiar story of the American Civil War, an event in which our Commonwealth played a pivotal role.

Our "In Touch With" series asks geophysicist Andy Nyblade why we need earthquake monitoring in Pennsylvania. Finally, Josh Stapleton, manager of our Materials Characterization Lab, describes one of the many ways in which Penn State technology and shared expertise are helping to grow Pennsylvania businesses.

It's gratifying to know that we still take our land grant mission seriously.

NEIL A. SHARKEY
Vice President for Research



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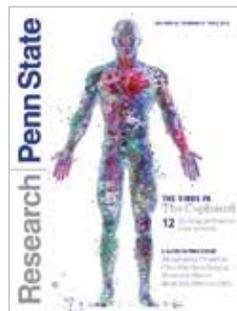
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ON THE COVER:
Viruses help make us who we are, but some can make us sick. The ones we need to worry about the most will probably come from animals that live nearby. See story, page 12. Illustration by Charis Tsevis.





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Giraffe necks, self-heating batteries, and other news highlights from Penn State researchers.



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A photo from the Great Barrier Reef captures its dazzling and vulnerable beauty.



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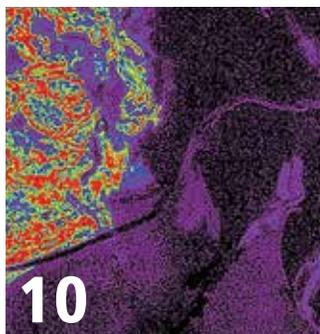
The rebel yell, Arctic exploration, pesticides, and more, in recent books by faculty authors.



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Geologist Andy Nyblade talks with us about seismic activity in Pennsylvania.



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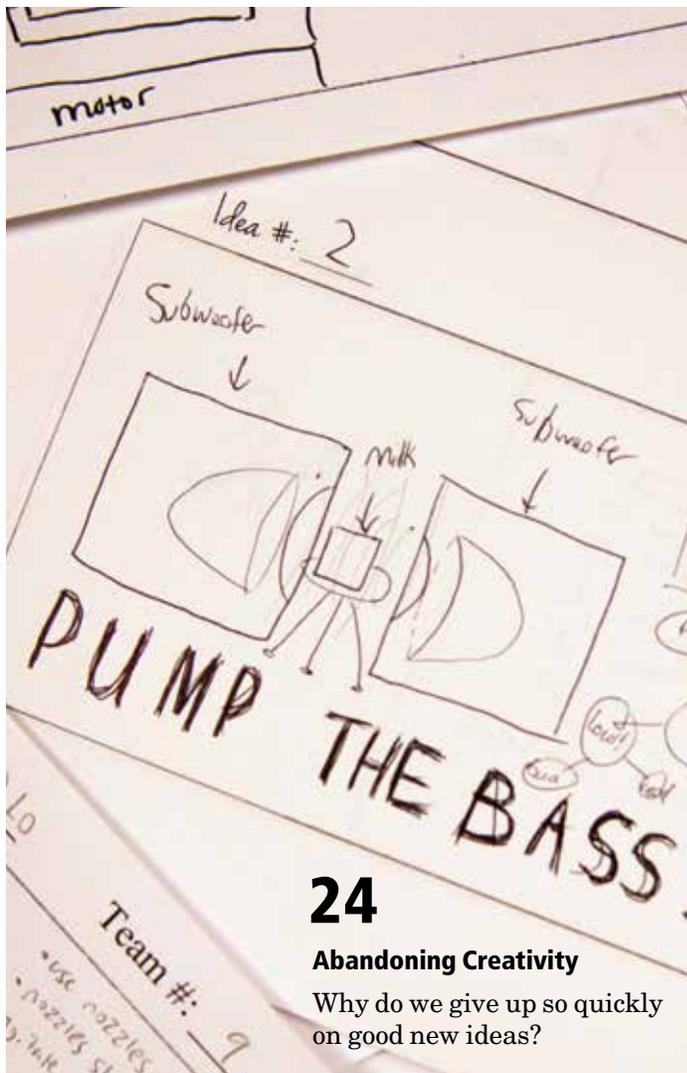
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Why do we give up so quickly on good new ideas?



Centers for Disease Control

» Bullseye: Malaria

RESearchers from Penn State are part of a team that has identified and characterized 42 proteins on the surface of the malaria parasite that are potential targets for new malaria vaccines.

“Current experimental malaria vaccines target single proteins and do not provide the level of protection necessary to prevent the spread of the disease,” says **Scott E. Lindner**, assistant professor of biochemistry and molecular biology at Penn State and a lead author of the study. “Our new list of potential vaccine targets will allow the development of more effective

vaccines that target several proteins on the surface of the parasite.”

The researchers collected malaria sporozoites—the stage in the parasite’s life cycle that is transmitted from mosquitoes to humans—from the salivary glands of infected mosquitoes. Once in a person’s bloodstream, sporozoites travel to the liver to undergo further development before spreading to the blood, where they infect red blood cells and cause symptoms. The researchers marked proteins on the surface of the sporozoite with a chemical label that could not cross through the outer membrane of the parasite.

They then isolated the labeled proteins and identified and characterized them using mass spectrometry.

“We focused on the transmission stage because at this point in an infection, the number of parasites is low, and if we can design effective vaccines for this stage, we can stop the progress of the disease before it causes symptoms,” says Lindner. “Once the parasites are in the liver they can hide from our immune system by residing inside of liver cells.”

—SAM SHOLTIS

Climate Change → Extreme Weather

While the evidence for human-caused alterations to the global climate is well-established, scientists have not been able to definitively link specific weather events to climate change. Now they can, thanks to recent scientific advances, according to a report by the National Academies of Science, Engineering, and Medicine.

“In the past, many scientists have been cautious of attributing specific extreme weather events to climate change,” says **David Titley**, Rear Admiral (Ret.), founding director of Penn State’s Center for Solutions to Weather and Climate Risk, who chaired the committee that wrote the report. “People frequently ask questions such as, ‘Did climate change cause Hurricane Sandy?’ Science can’t answer that because there are so many relevant factors for hurricanes. What this report is saying is that we can attribute an increased magnitude or frequency of some extreme weather events to climate change.”

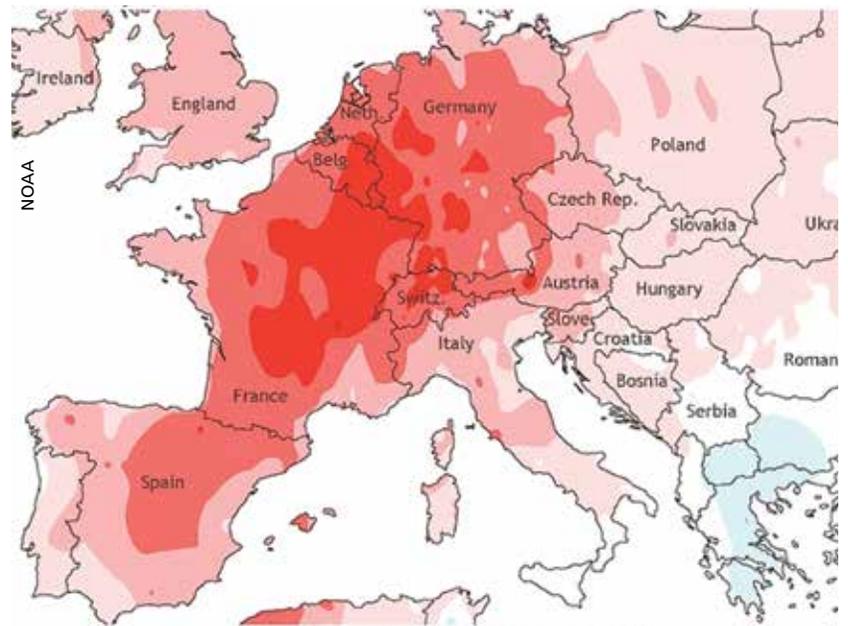
To confidently link specific weather events to climate change, says Titley, researchers need to understand the underlying physical causes of weather events, have enough observational data to place a specific event within a historical context, and be able to replicate an event with computer models. Those conditions are now met in many cases, allowing scientists to attribute some heat waves and cold events, and to a lesser degree droughts and extreme rainfall, to human-caused climate change.

The report, “Attribution of Extreme Weather Events in the Context of Climate Change,” was released in March.

—LIAM JACKSON



Europe suffered a heat wave in the summer of 2015 that set records across the continent. On this map, the colors indicate how much temperatures differed from average for the week of June 28–July 4 of that year. Temperatures are shown in degrees Fahrenheit.



WITH FRIENDS LIKE THESE... <<

PEOPLE ARE MUCH MORE CONCERNED ABOUT SHARING THEIR OWN PRIVATE INFORMATION with third-party app developers than they are about revealing their friends’ data, according to Penn State researchers. But as social media make data increasingly interconnected, preserving one’s own privacy while ignoring the privacy rights of others may make everybody’s data more vulnerable.

“The problem is becoming known as interdependent privacy,” says **Jens Grossklags**, Haile Family Early Career Assistant Professor of Information Sciences and Technology. “The privacy of individual consumers does not only depend on their own decisions, but is also affected by the actions of others.”

When the researchers asked participants to assign an economic value to their own and to others’ personal information, participants consistently valued the data in their own



social media profiles more highly than that of their friends.

Third-party developers, who create apps and games for social media platforms, typically require access to personal data from a user’s profile, and may require data about their friends as well, says doctoral candidate **Yu Pu**. “[They] may ask for innocuous data, such as name and birthdate, but they could also want access to very sensitive data.” The more sensitive data—for instance, photo files and videos—could hurt friends in a range of ways, according to the researchers.

“We are not proposing that third-party developers are by default unethical,” says Grossklags, “but there are questions of whether one engages in a fair deal here.”

—MATT SWAYNE

BATTERY, HEAT THYSELF <<

ALITHIUM-ION BATTERY THAT HEATS ITSELF if the temperature is below 32 degrees Fahrenheit may extend the winter range of electric cars, according to a team of researchers from Penn State and EC Power.

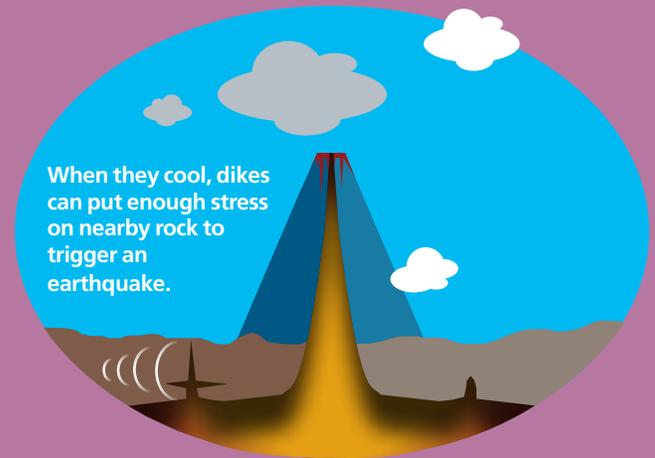
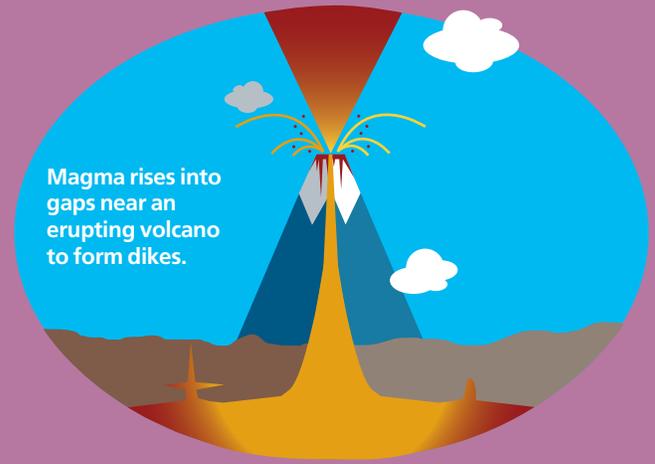
“It is a long-standing problem that batteries do not perform well at subzero temperatures,” says **Chao-Yang Wang**, William E. Diefenderfer Chair of mechanical engineering and director of the Electrochemical Engine Center. “This may not be an issue for phones and laptops, but is a huge barrier for electric vehicles, drones, outdoor robots, and space applications.”

Conventional electric batteries at sub-freezing temperatures suffer severe power loss, reducing vehicle cruise range by as much as 40 percent and requiring larger and more expensive battery packs to compensate for the loss.

The researchers developed an all-weather battery that uses very thin nickel foil with one end attached to the negative terminal and the other extending outside the cell to create a third terminal. In the cold, a temperature sensor triggers a switch that causes electrons to flow through the nickel foil to complete the circuit. This rapidly heats up the nickel foil and warms the inside of the battery. Once the battery reaches 32 degrees Fahrenheit, the switch turns off and current flows in the normal manner.

The new battery warms from -22 to 32 degrees Fahrenheit in 30 seconds, while consuming only 5.5 percent of the cell’s capacity. It weighs only 1.5 percent more and costs only 0.04 percent more than a standard lithium-ion battery.

—A’NDREA ELYSE MESSER



Kevin Carlini/Penn State

Volcanoes Can Trigger Strong Earthquakes

A geologic process associated with volcanoes can cause earthquakes with a magnitude between 6 and 7, according to research led by Penn State geoscientist **Christelle Wauthier**.

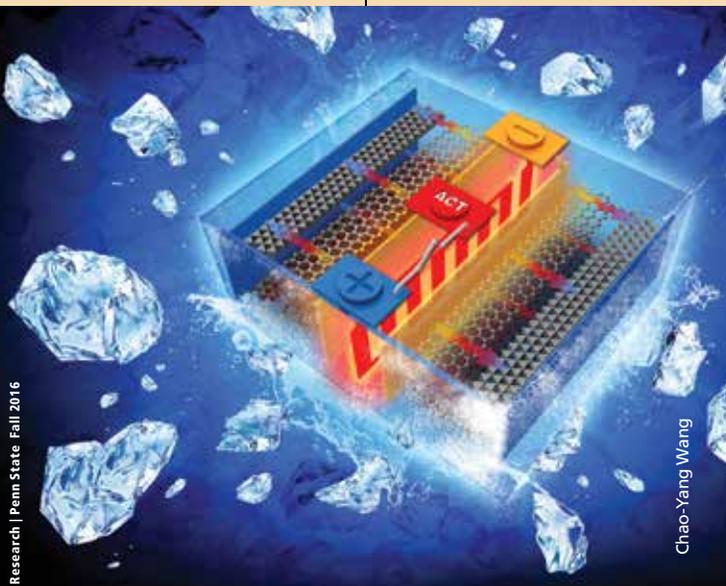
The process, called diking, most often occurs in areas where tectonic plates are moving apart. As plates separate, magma from beneath the surface rises into the gap, forming vertical intrusions known as dikes. The new study used remote-sensing technology and strain analysis to show that diking creates stress in the surrounding rocks, which can lead to seismic activity—earthquakes.

The researchers investigated possible ties between two natural disasters in the Democratic Republic of the Congo. On Jan. 17, 2002, the Nyiragongo volcano erupted, killing more than 100 people and leaving more than 100,000 homeless. Eight months later, a magnitude 6.2 earthquake struck the town of Kalehe just 12 miles from the volcano, inundating it with water from a nearby lake and killing several people.

Wauthier’s analysis found that the earthquake was caused by slippage of a fault on the border of the East African Rift System, and that a 12-mile-long dike produced during the eruption of Nyiragongo put enough stress on rocks in the area to bring the fault closer to failure.

“We’ve known that every time magma flows through the Earth’s crust, you create stress and generate seismicity,” says Wauthier. “But these are normally very low-magnitude earthquakes. This study suggests that a diking event has the potential to lead to a large earthquake.”

—LIAM JACKSON



Research | Penn State Fall 2016

Chao-Yang Wang

» Sea-level Rise

AN ICE-SHEET MODEL THAT INCLUDES PREVIOUSLY UNDERAPPRECIATED PROCESSES INDICATES THAT IF GREENHOUSE GAS EMISSIONS CONTINUE UNABATED, melting of the Antarctic ice sheet could cause sea level to rise up to 50 feet by 2500, according to researchers from Penn State and the University of Massachusetts, Amherst.

Antarctica was the primary contributor to sea-level rise in the past and may be the primary contributor in the future, because much of its ice sits on land. (Floating ice, like that of the Arctic Ocean, does not raise sea level if it melts.) According to

Penn State geoscientist **Dave Pollard**, if greenhouse gas emissions continue at their current rate, the new model suggests that Antarctic melting could contribute more than 3 feet to global sea levels by 2100, roughly doubling recent estimates by the Intergovernmental Panel on Climate Change of sea-level rise from all sources since preindustrial times. On the other hand, the model shows a much smaller Antarctic contribution if greenhouse gas emissions are drastically curtailed.

Pollard, working with UMass' Robert M. DeConto, incorporated two mechanisms

of ice loss that had not been applied before and were able to reproduce ice-sheet retreat consistent with geologic sea-level data for the warm Pliocene epoch, a past period of dramatic sea-level rise. They then applied their model to the future, incorporating various greenhouse gas emission scenarios.

“Although the future sea-level contribution in our model is greater than previously thought, it is based on credible mechanisms and is consistent with geologic evidence of past sea-level rise,” says Pollard. “We regard the results as worst-case envelopes of possible future behavior.”

—A'NDREA ELYSE MESSER

NASA

Chill Out

Firefighters entering burning buildings, athletes competing in the broiling sun, and workers in foundries may eventually be able to carry their own personal cooling units with them, thanks to a lightweight nanowire array, according to Penn State materials researchers.

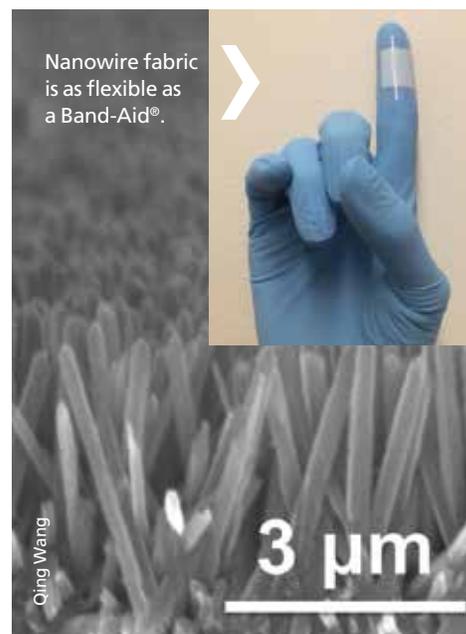
Electrocaloric materials are nanostructured materials that show a reversible temperature change under an applied electric field. Previously available electrocaloric materials are single crystals, bulk ceramics, or ceramic thin films. They can cool, but are limited because they are rigid, fragile, and require unsafe levels of electrical current.

Qing Wang, professor of materials science and engineering, and his team worked on creating a nanowire material that is flexible, easily manufactured, environmentally friendly, and that can cool with an electric field safe for human use.

At high magnification, their vertically-aligned ferroelectric barium strontium titanate nanowire array looks like a carpet or a close-mown lawn. The researchers can move the nanowire forest to any substrate they want—including clothing fabric—using a sticky tape.

This array can cool about 5.5 degrees Fahrenheit using 36 volts, a level safe for humans. A 500-gram battery pack about the size of an iPad could power it for about two hours.

“This low voltage is good enough for modest exercise, and the material is flexible,” says Wang. “Now we need to design a system that can cool a person and remove the heat generated in cooling from the immediate area.” —A'NDREA ELYSE MESSER



THE GENOME OF THE GIRAFFE HAS BEEN SEQUENCED, REVEALING CLUES ABOUT THE genetic changes that led to the evolution of the giraffe's long neck and legs and its ranking as the world's tallest land species.

Giraffes have the same number of neck vertebrae as other mammals (seven), which means their necks got longer not by adding bones but by making each bone bigger.

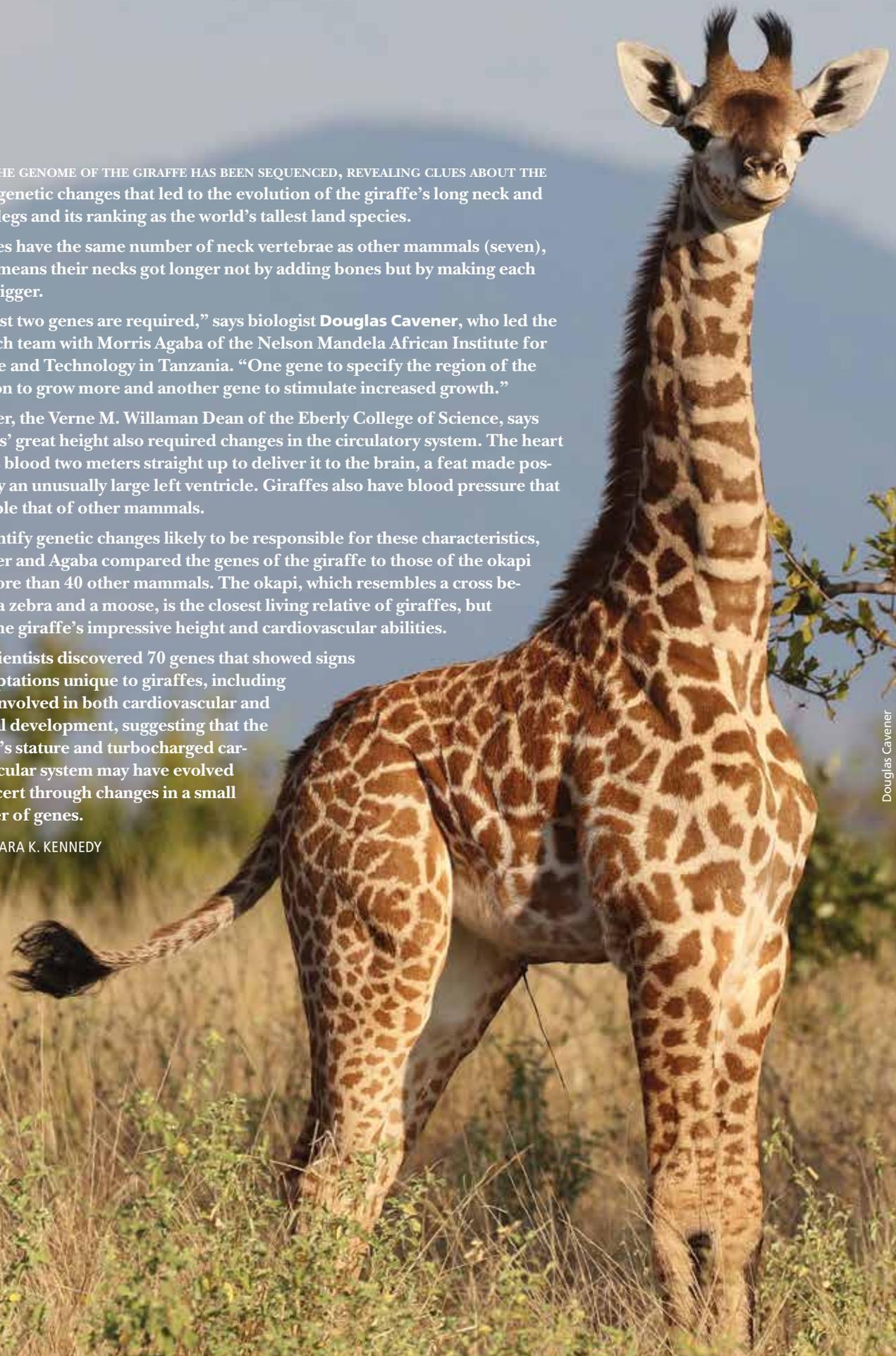
“At least two genes are required,” says biologist **Douglas Cavener**, who led the research team with **Morris Agaba** of the Nelson Mandela African Institute for Science and Technology in Tanzania. “One gene to specify the region of the skeleton to grow more and another gene to stimulate increased growth.”

Cavener, the Verne M. Willaman Dean of the Eberly College of Science, says giraffes' great height also required changes in the circulatory system. The heart pumps blood two meters straight up to deliver it to the brain, a feat made possible by an unusually large left ventricle. Giraffes also have blood pressure that is double that of other mammals.

To identify genetic changes likely to be responsible for these characteristics, Cavener and Agaba compared the genes of the giraffe to those of the okapi and more than 40 other mammals. The okapi, which resembles a cross between a zebra and a moose, is the closest living relative of giraffes, but lacks the giraffe's impressive height and cardiovascular abilities.

The scientists discovered 70 genes that showed signs of adaptations unique to giraffes, including some involved in both cardiovascular and skeletal development, suggesting that the giraffe's stature and turbocharged cardiovascular system may have evolved in concert through changes in a small number of genes.

—BARBARA K. KENNEDY



Douglas Cavener

OF FIRE AND FOREST <<

MOST FORESTS IN THE EASTERN UNITED STATES evolved with frequent fire, which promoted tree species and ecosystems that were both fire- and drought-resistant. In little more than a century, humans have upset that balance, suggest researchers, who blame the change in part on clear-cutting and the well-meaning efforts of Smokey Bear.

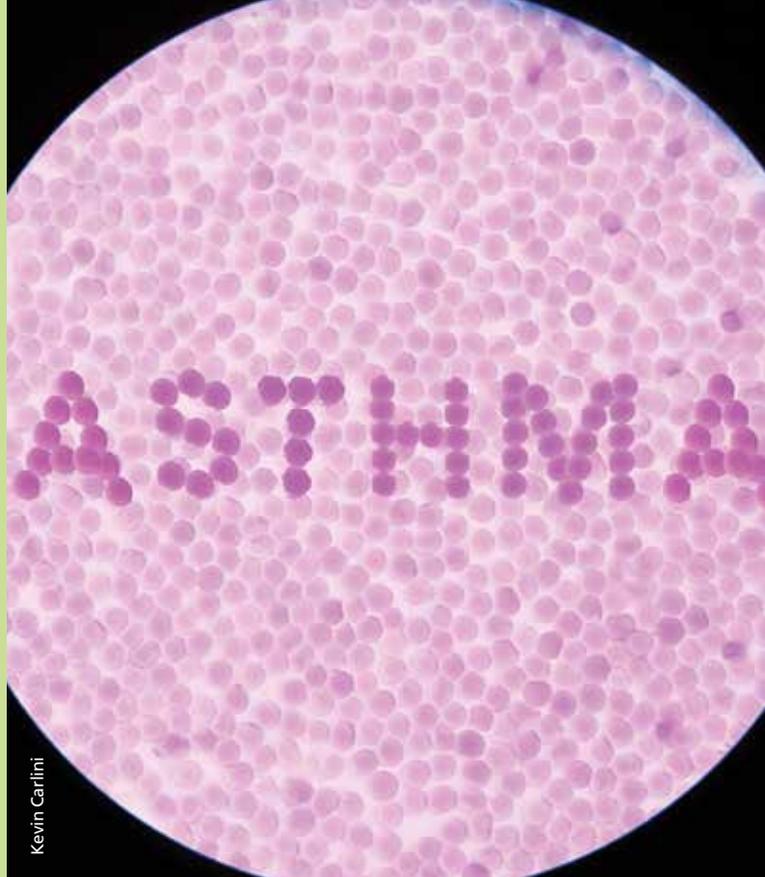
“Eastern forests are changing in a way that we haven’t seen for thousands of years, and this is basically because they have gone through major changes in disturbance regimes and land-use history,” according to **Marc Abrams**, professor of forest ecology and physiology.

The trend began about 140 years ago with the advent of clear-cutting to build and fuel a rapidly industrializing society. This was followed by catastrophic fires that burned most of the trees that remained on the region’s landscape. Forests

began to regrow as before, but in the 1940s the Smokey Bear fire suppression program began. With forest fire no longer a significant factor in the ecosystem, forest composition changed. Fire-adapted, drought-resistant species such as oak, hickory, and pine have declined and fire-susceptible, drought-sensitive species such as maple, birch, and hemlock have become much more abundant. These changes make the Eastern forests more vulnerable to drought.

“We had a lot of fire on the landscape during the time of Native American occupation and also during early European settlement and the associated clear-cut era,” says Abrams. “So we went from a moderate to large amount of fire to an era of overprotection. With Smokey Bear, we have lost fire, and we need to get it back.”

—JEFF MULHOLLEM



Kevin Carlini

Biomarkers Help Detect Asthma

People with asthma have telltale molecules circulating in their blood, say researchers at Penn State College of Medicine. The discovery could lead to the first diagnostic blood test for asthma, as well as more targeted treatments for the condition.

There are currently no definitive diagnostic tests for asthma, a chronic inflammatory lung disease that affects 25 million Americans.

“Right now, we diagnose asthma based on someone’s history and breathing tests—and both of those have limitations,” says **Faoud T. Ishmael**, associate professor of medicine. He and his team set their sights on microRNAs (miRNAs), molecules that help regulate gene expression. miRNAs were once considered “junk,” but over the past decade, scientists have come to realize that they play an important role in many human diseases.

The researchers looked at miRNAs in the blood of 79 people, including people with asthma, people with nasal allergies but no asthma, and people with no nasal allergies and no asthma. They found different miRNA production patterns among the three groups. Based on these patterns, they were able to predict with 91 percent accuracy whether or not a person had asthma.

“Our goal is to have a blood test for asthma developed in the next five years,” Ishmael says. “You might be able to take a drop of blood from a finger stick and analyze it in the clinic to determine whether someone has asthma at that visit. That would be the ultimate goal.”

—JENNIFER ABBASI



U.S. National Archives and Records Administration



Decades of clearcutting and fire suppression have made eastern forests more vulnerable to drought and wildfire. Photo from Minnesota, 1941.



CORAL COMFORT <<

DOZENS OF BLUE-GREEN DAMSELFISH (*Chromis viridis*) flit among the branches of a coral colony, which offer refuge from predation by larger fish. Postdoctoral scholar **Joe Pollock** shot this photo in 2015 at Lizard Island on Australia's Northern Great Barrier Reef. He and lab director **Mónica Medina** study the role of microbial symbionts in coral physiology and health, as part of the Global Coral Microbiome Project. Earlier this year, Lizard Island was hit by a mass bleaching event that damaged or killed about 90 percent of the branching corals in this part of the reef. Bleaching is a direct result of warming seas: An increase in water temperature of 1 degree C (1.8 degrees F) is enough to make some kinds of coral expel the single-celled algae living within them. Without their photosynthetic partners, the corals soon die.

Photo by: F. Joseph Pollock





STROLL THROUGH THE SERENE GARDEN AT THE ENTRANCE OF THE MILLENNIUM SCIENCE COMPLEX ON THE UNIVERSITY PARK CAMPUS, AND IT WILL GIVE WAY TO THE MATERIALS CHARACTERIZATION LAB (MCL) WHERE RESEARCHERS COLLABORATE TO SOLVE THE WIDE RANGE OF MATERIALS-RELATED PROBLEMS THAT COME THEIR WAY FROM ACROSS THE UNIVERSITY AND BEYOND.

“We’re a collection of instruments and people,” says **Josh Stapleton**, operations manager of the MCL, which is part of the Materials Research Institute. The lab’s array of instruments and capabilities, including electron microscopy, surface analysis, molecular spectroscopy, and x-ray scattering, allows users to evaluate aspects of materials such as composition, structure, and electrical conductivity. And the lab’s staff has the expertise to handle everything from basic hands-on training of students to real-world industry applications. In an average year, the lab sees more than 1,000 users from about 40 Penn State departments and 100 external organizations, including industry, academic institutions, and government.



Four samples analyzed with the instruments and expertise of the Materials Characterization Lab. Clockwise, from upper left: a hydrogel created for drug delivery applications; a biomedical implant surface; a composite containing microspheres; section from a honey bee brain showing distribution of lipids.



Patrick Mansell

Josh Stapleton places a sample on an X-ray photoelectron spectrometer.

WE'LL HELP YOU FIGURE IT OUT

The MCL operates as a shared user facility. “That means that—no matter what discipline you’re in—if you’re doing research and the instrument you need lives in our lab, you can come to us,” Stapleton says. “We’ll help you become a trained, proficient user of that instrument.” While many researchers approach the lab knowing exactly what instrument they need, others simply present their problem and MCL staff guide them to the technology that can solve it.

Most of the lab’s clients are in engineering, physics, and materials disciplines, but lab staff also work with researchers from many other fields. The MCL has helped archaeologists explore ancient environments and reconstruct prehistoric trade networks; entomologist Christina Grozinger and her colleagues are using Time of Flight Secondary Ion Mass Spectrometry to map brain tissue and measure molecules that regulate social and reproductive behavior of honey bees and bumble bees.

One recent industry success story involves the design and manufacture of a top-of-the-line snowboard. Gilson Snowboards, of East Berlin, Pennsylvania, came to the MCL with an adhesion problem: Two of the layers they use to build their signature snowboards weren’t holding together. “Snowboard manufacturers have to glue together multiple layers of dissimilar materials,” explains **Dave Fecko**, industry relations manager for the Materials Research Institute. “One of the layers Gilson uses in the laminate stack is a high molecular weight polyethylene, which really doesn’t like to stick to anything else. Traditional adhesive methods involve flame-treating the material’s surface with a torch. Using MCL’s expertise and analytical tools, we identified a process to optimize adhesion—and it brought the same result time and time again.”

Gilson’s collaboration with MCL made it possible for the company to build snowboards with “arguably the best adhesion in the world,” says CEO Nicholas Gil-

son. “And the response to our product—both from a performance perspective and construction perspective—has taken off. Since our collaboration we’ve watched our numbers double over and over again.”

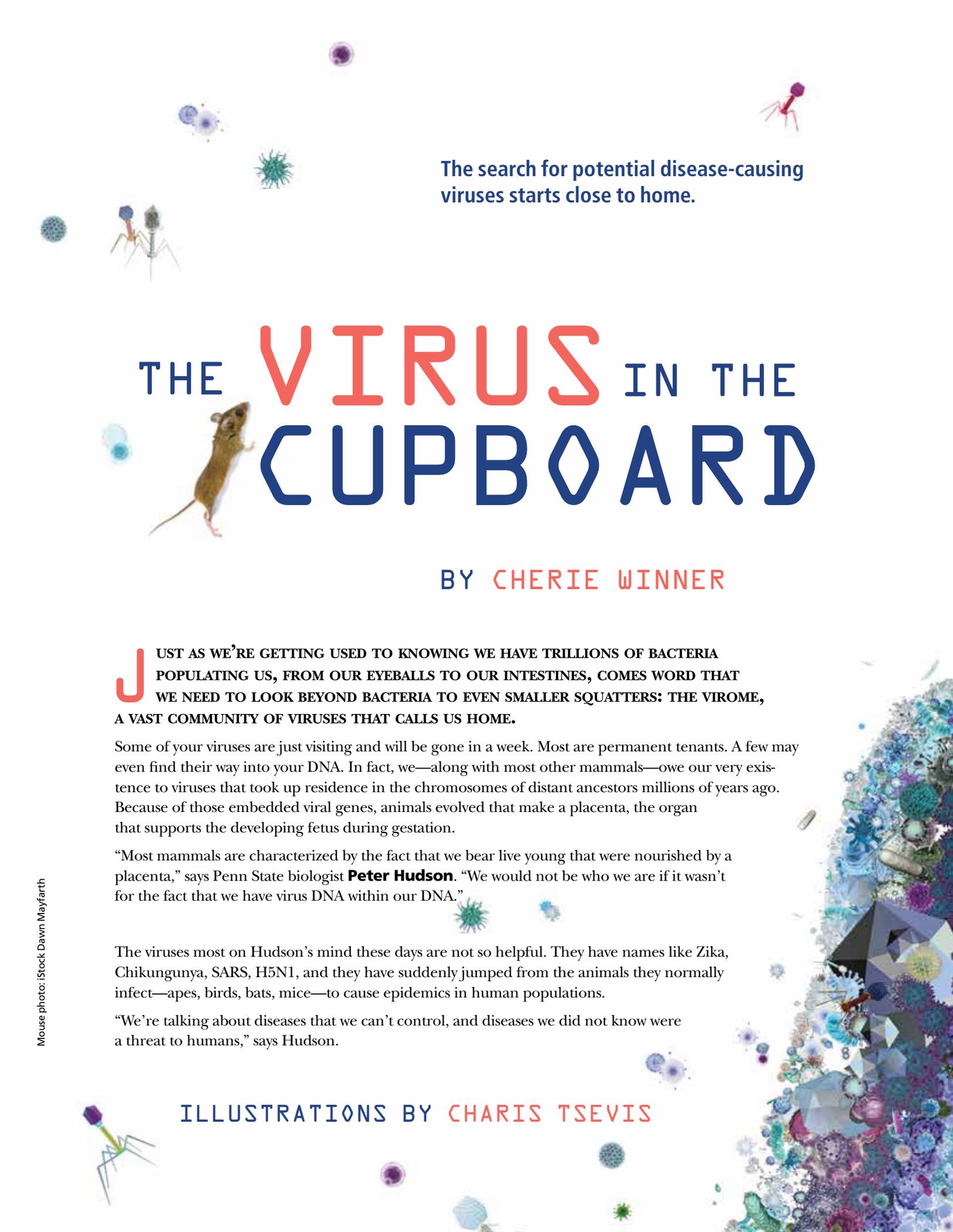
The lab also plays an important role in education, training undergraduate and graduate students how to use instrumentation independently. “Because of this facility, Penn State students have access to state-of-the-art analytical instruments, some of which are powerful enough to image individual atoms,” says Stapleton. “That’s pretty rare.”

QUIET PLEASE

A priority in the design process for the Millennium Science Complex was to build ultra-quiet lab space for highly specialized, multi-million-dollar instruments, particularly electron microscopes. That’s why the MCL is underground. “We need to be isolated,” Stapleton says. “We can’t have people walking around on a floor above us, creating vibrations. So right above our heads is the garden—our roof—which is supported by steel beams that keep it physically separated from the lab space beneath.”

Stapleton refers to each microscope lab as a building, rather than a room, because each space is actually a separate structure. In fact, the MCL’s atomic resolution microscope not only sits in its own building, it is operated from yet another building because of its sensitivity to the smallest of vibrations: It has a resolution of about 70 picometers, less than half the diameter of a carbon atom.

As scientific equipment becomes more and more sophisticated and costly, the shared user model becomes ever more important. “Rather than buying five expensive instruments and distributing them across campus, let’s just buy one and put it in a place where it can be used by everyone and staffed by experts,” Stapleton says. “That’s good stewardship.”



The search for potential disease-causing viruses starts close to home.

THE VIRUS IN THE CUPBOARD

BY **CHERIE WINNER**

JUST AS WE'RE GETTING USED TO KNOWING WE HAVE TRILLIONS OF BACTERIA POPULATING US, FROM OUR EYEBALLS TO OUR INTESTINES, COMES WORD THAT WE NEED TO LOOK BEYOND BACTERIA TO EVEN SMALLER SQUATTERS: THE VIROME, A VAST COMMUNITY OF VIRUSES THAT CALLS US HOME.

Some of your viruses are just visiting and will be gone in a week. Most are permanent tenants. A few may even find their way into your DNA. In fact, we—along with most other mammals—owe our very existence to viruses that took up residence in the chromosomes of distant ancestors millions of years ago. Because of those embedded viral genes, animals evolved that make a placenta, the organ that supports the developing fetus during gestation.

“Most mammals are characterized by the fact that we bear live young that were nourished by a placenta,” says Penn State biologist **Peter Hudson**. “We would not be who we are if it wasn't for the fact that we have virus DNA within our DNA.”

The viruses most on Hudson's mind these days are not so helpful. They have names like Zika, Chikungunya, SARS, H5N1, and they have suddenly jumped from the animals they normally infect—apes, birds, bats, mice—to cause epidemics in human populations.

“We're talking about diseases that we can't control, and diseases we did not know were a threat to humans,” says Hudson.

ILLUSTRATIONS BY **CHARIS TSEVIS**





This page: Deer ticks take a blood meal from the ear of a white-footed mouse. Because ticks also bite humans and can spread pathogens carried by mice, the interaction between mice and ticks can be very important for human health. Far right: A cave painting of antelope graces the office of Peter Hudson, whose lab works on infectious disease in wildlife worldwide, including wolves in Yellowstone, tortoises in the Mojave desert, mongooses in Botswana, and salmonid fish in Finland.



Courtesy of Jesse L. Brunner

“Most of the emerging infectious diseases that arise come from wildlife reservoir hosts,” says research associate Kurt Vandegrift, who did his doctoral work in Hudson’s lab and now runs a research program of his own. “When we find a new one, there’s always a scramble to find out where it came from. What species is the reservoir host? How did the virus get into humans? How does it spread? We never know this information, we don’t have a vaccine, we don’t have any of these things. We’re really behind the 8-ball.”

Hudson and Vandegrift aren’t virologists or medical doctors. They’re wildlife biologists in the classical mold, trained to observe animals in their natural habitat. They think one key to fighting emerging diseases is finding out before they get into humans which pathogens we’re mostly likely to encounter—the ones that are carried by the wild creatures we’re most likely to touch, share space with, or be bitten by. For people who live in the eastern U.S., the list of “peri-domestic” species includes deer, rabbits, chipmunks, and the white-footed mouse, as well as the ticks and mosquitoes that feed on both our furry neighbors and ourselves.

Aside from bug bites, we pick up viruses from these creatures through contact—removing a mouse from a trap, handling game during a hunting trip—or by inhaling their dust and dander in cupboards, sheds, and other confined places. As Vandegrift memorably puts it, “We breathe their fecal by-products.”

In 2012 Vandegrift and Hudson launched a study of the community ecology of the white-footed mouse: How many are there, what makes their numbers go up and down, what’s their social structure, what parasites do they have, and how do parasites spread through the population?

“We need to understand the dynamics of the mouse population,” says Hudson. “As they increase, so the risk of infection to us increases—there’s more mice, there’s more ticks, there’s more disease transmission taking place.”

The implications of the study reach beyond mice and the diseases they carry, says Vandegrift. “We’re using a wildlife system to learn how we can monitor and manipulate things, to then inform public health practices in humans. Or at least give us an idea about what we should look for.”

TO CATCH A MOUSE

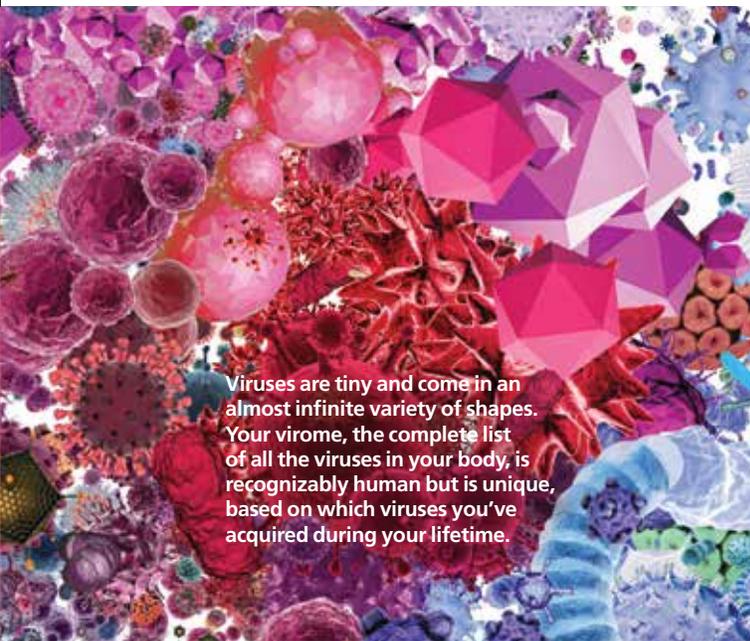
Their target animal was easy to find. The white-footed mouse, *Peromyscus leucopus* (PAIR-oh-MIS-kus loo-KOH-pus), ranges throughout most of the eastern two-thirds of the U.S. and is abundant in and around Penn State’s University Park campus.

“They’re everywhere,” says Vandegrift. “They’re so adaptable.” They live in houses, barns, and sheds, under tent platforms and in woodpiles, in long-parked cars and lawnmowers. They also carry several pathogens that can infect humans, such as *Borrelia*, the bacterium that causes Lyme disease, and the hantavirus, which kills nearly 40 percent of the people it infects. “I don’t touch any of these critters without wearing gloves,” says Vandegrift. “The hantavirus seriously freaks me out. It’s only in extreme cases that people get it—but we are an extreme case, seeking out these animals and spending eight hours a day around them.”

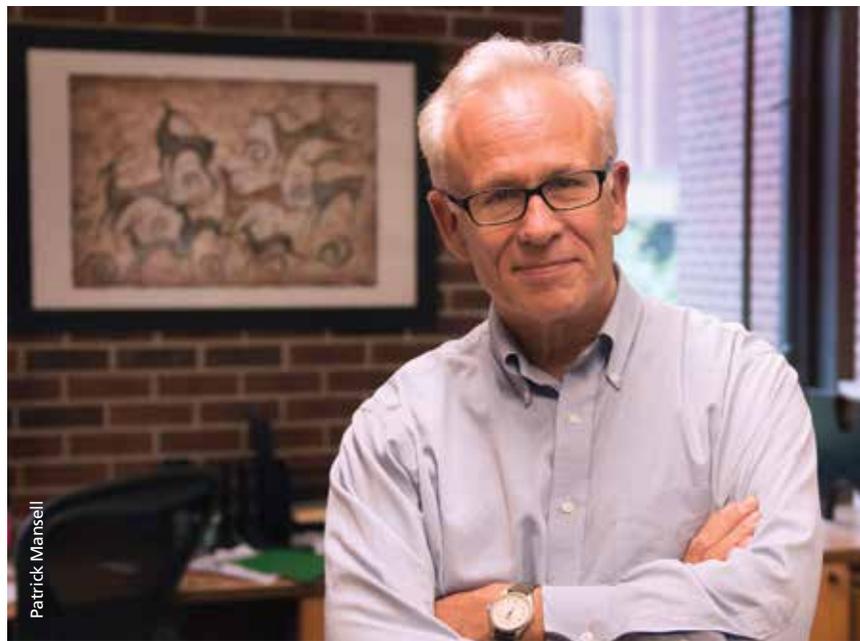
Three times a week, he and his team of graduate and undergraduate students set out live traps baited with oats in two dozen 100-meter-square grids on a wooded hillside southwest of town. Each caught mouse gets the equivalent of a thorough medical exam: The researchers weigh and measure it, estimate its age, check its overall condition, whether it has bred recently, and how many fleas and ticks it carries, and gather blood and fecal samples for analysis in the lab. It also gets a tiny Passive Induced Transponder (PIT) tag inserted into the scruff to trace its movements and range. Like a pet’s microchip, the tag provides a unique ID number that can be read by an electronic scanner. If a trapped mouse already has a tag, the team scans it and records the information from it before releasing the mouse to carry on with its life.

“We can actually follow individuals through time,” says Vandegrift. “We know who lives where and whose home ranges overlap or touch. We can check whether they have been exposed to a certain pathogen, and we can know when they got infected. Ideally, we should be able to watch parasites flow through the populations.”

"WE WOULD NOT BE WHO WE ARE IF IT WASN'T FOR THE FACT THAT WE HAVE VIRUS DNA IN OUR DNA." —PETER HUDSON



Viruses are tiny and come in an almost infinite variety of shapes. Your virome, the complete list of all the viruses in your body, is recognizably human but is unique, based on which viruses you've acquired during your lifetime.



Patrick Mansell

AN UNUSUAL CORPORATE PARTNERSHIP

Vandegrift found that *Peromyscus* numbers in his study area vary widely; sometimes a sampling grid yields one mouse per day, other times it catches 100. But he learned from colleagues doing similar trapping studies that the population highs and lows near State College do not match the highs and lows elsewhere in the region over the same period. That lack of synchrony makes it much harder to correlate population levels with disease transmission.

Figuring out the population cycles of a wild species by doing a trapping study is incredibly laborious in one small location. To do it over the entire country, or even just the Northeast, is simply not feasible.

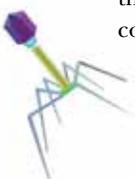
Trying to come up with a way of estimating mouse population cycles, Vandegrift recalled the classic example of Canada lynx and snowshoe hares, a roughly 10-year wax-wane cycle between predator and prey. To discover that cycle experimentally would have meant catching and counting lynx and hares, year-round, for decades.

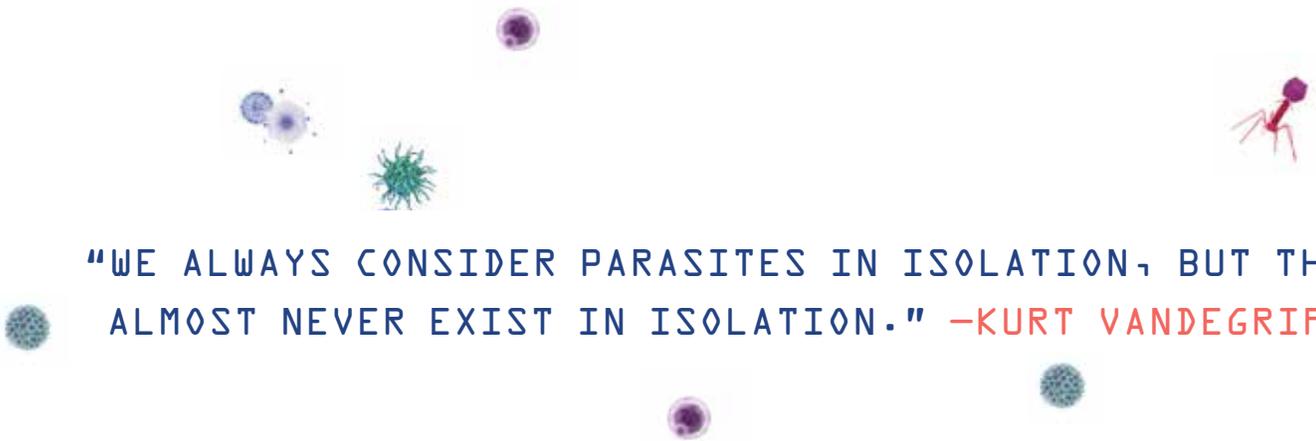
As it happens, the lynx-hare cycle was not found by doing field work. It was discovered by studying the fur-trapping records of the Hudson's Bay Company from the 1820s into the early 1900s. Trappers turned in more hare and lynx pelts in years of abundance of each species, and fewer in years of scarcity. In that nearly century-long record, the 10-year cycles were clear.

Vandegrift wondered whether comparable records were available that would be relevant to *Peromyscus* numbers.

"We thought and we thought," says Vandegrift. "And we thought, maybe it's mousetrap sales, because people don't buy mousetraps unless they see a mouse in the house, and that happens primarily when the populations are elevated."

He contacted Woodstream, Inc., the company that makes Victor mousetraps, and asked if they would share their sales figures with him. The Woodstream people sent records for the past 10 years broken down by postal code, by week, for all of the U.S., Puerto Rico, and Canada. "It's a huge file—a HUGE file—more data than I've ever dealt with," says Vandegrift.





"WE ALWAYS CONSIDER PARASITES IN ISOLATION, BUT THEY ALMOST NEVER EXIST IN ISOLATION." —KURT VANDEGRIFT



His lab is now comparing that data with results of other trapping studies done in the same time frame across the U.S., to see if mousetrap sales are indeed a reliable indicator of mouse population numbers. If they are, Vandegrift can use the sales figures to construct long-term *Peromyscus* population maps for any area of concern. So far, it's looking good.

GOING VIRAL

Seed money from Hudson's Willaman Chair endowment enabled Vandegrift to start the field studies, but at the time, tests to identify viruses were prohibitively expensive. Without the means to catalog the entire community of viruses the mice carry, he checked the blood samples for a few viral infections for which tests were available. He also checked for gut worms, parasites large enough to be identified with a relatively low-cost, low-power microscope. He encountered one kind of worm he had to send to an expert for identification. It turned out to be a new species, which has since been named after him—*Heligmosomoides*

vandegrifti. "I told my mother that now I don't have to have children, because I've preserved the family name forever," he says.

Then, as word of his fieldwork got around, a group of Columbia University scientists led by Amit Kapoor, now at Nationwide Children's Hospital in Columbus, Ohio, got in touch with Vandegrift to ask if they could have blood samples from his mice. They wanted to test for a virus similar to Hepatitis C, in hopes that *Peromyscus* could serve as a model system for studying the disease.

According to the Centers for Disease Control, close to 200 million people worldwide carry Hep C as a chronic infection, and about 20,000 Americans die from it each year. The Hep C virus has been notoriously hard to study because other than humans, it was known to infect only chimps and horses, neither of which anyone wanted to experiment on. Finding a version of Hep C in *Peromyscus*, which is easy to handle in a laboratory, could greatly improve the odds of developing treatments or possibly even a vaccine for the disease.





Vandegrift agreed to his colleagues' request, and added one of his own. "Could you identify *all* the viruses in the samples? Because we have this data set on the population biology that nobody else has, and we could really make use of those," he recalls. "And they said OK."

With powerful and less costly new "454" DNA-sequencing technology, the Columbia team compared all the potential viral DNA in the mouse samples with the DNA sequences in GenBank, a massive library compiled from thousands of species. The result was the first comprehensive study of the *Peromyscus* virome.

The *Peromyscus* samples do not have any of the viruses typically seen in lab mice—"They're a different species, so you shouldn't really expect that," he says—but they do have at least eight that had never been identified before, including a form of Hepatitis C. Vandegrift and his lab are now studying the course of the disease in *Peromyscus*. Humans don't catch the mouse version of the virus, but if the illness it causes in *Peromyscus* is similar to what happens in people, the adaptable little mouse could become a great boon to those researching the human form of the disease.

KEEPING IT REAL

The *Peromyscus* virome project was so successful that Vandegrift, Hudson, Kapoor and other colleagues have gone on to survey the virome of the deer tick (*Ixodes scapularis*, also known as the black-legged tick). The project has the potential to spot viruses that don't currently pose a threat to humans but that could jump to us if they undergo a small genetic change that allows them to infect people or makes them more virulent. Like finding the relative of Hep C in mice, such a discovery would let us study how the virus works and how it is transmitted. "We could even create a vaccine for it pre-emptively, so if it does spill over into humans, we're finally not behind the 8-ball," says Vandegrift.

The research team recently won a \$2.35 million grant from the National Science Foundation to study the complex interactions between *Peromyscus* and its viruses, including how they relate to each other during an infection

This page: White-footed mice are abundant in north-eastern woodlands. Facing page: The tiny nymph stage of the deer tick, seen here on a human fingertip, is the most dangerous for transmitting disease to people. Kurt Vandegrift and colleagues take a "pro-active, targeted approach" to emerging infectious diseases by studying the viruses carried by ticks, mice, and other species that live in close proximity to large numbers of humans.

and over time. This goes far beyond an inventory of the viruses the mice carry. It's more like a detailed community history, and it could help solve one of the persistent mysteries of medicine: Why do some people get much sicker than others with the same illness?

Genetics has something to do with it, but Hudson and Vandegrift think it has more to do with the fact that we are rarely, if ever, infected by just one germ at a time—and since pathogens change your immune system, how sick you get from a new pathogen doesn't depend only on the ones you're infected with now; it's a reflection of all the infectious diseases you've ever had, and even in what order you had them.

"Your ability to be invaded depends on what's happened in your life," Hudson says. "It's going to be different for everybody, because everybody's life is different."

He offers himself—a native of Great Britain who has worked with wildlife in Africa, Australia, and the Americas—as an example. "I have had tuberculosis, I've had sleeping sickness. I was also infected with measles, chicken pox, rubella, German measles, all of those childhood diseases. Given that, what is my susceptibility to new infections? Am I less likely or more likely to get malaria or to get Chikungunya or to get Zika virus?"

The new project, again working with the wild mice of central Pennsylvania, will help them understand those kinds of interactions in a way no lab study ever could.

"We always consider parasites in isolation, but they almost never exist in isolation," says Vandegrift. "The dynamics of that pathogen may be totally different if the host has another infection. Studying it in a wild population gives us all of these biological realities that you don't have in a lab.

"It's real science. Real complicated, though."

Peter Hudson and Kurt Vandegrift are members of Penn State's Center for Infectious Disease Dynamics. Hudson is Willaman Professor of Biology in the Eberly College of Science and director of The Huck Institutes of the Life Sciences.

**STIRRING BOOK SHOWS US THE CIVIL WAR
THROUGH THE STORIES OF COMMON PEOPLE**



HISTORY MADE GRAPHIC

BY MATT SWAYNE

Illustrations by Jonathan Fetter-Vorm
Courtesy of Hill & Wang

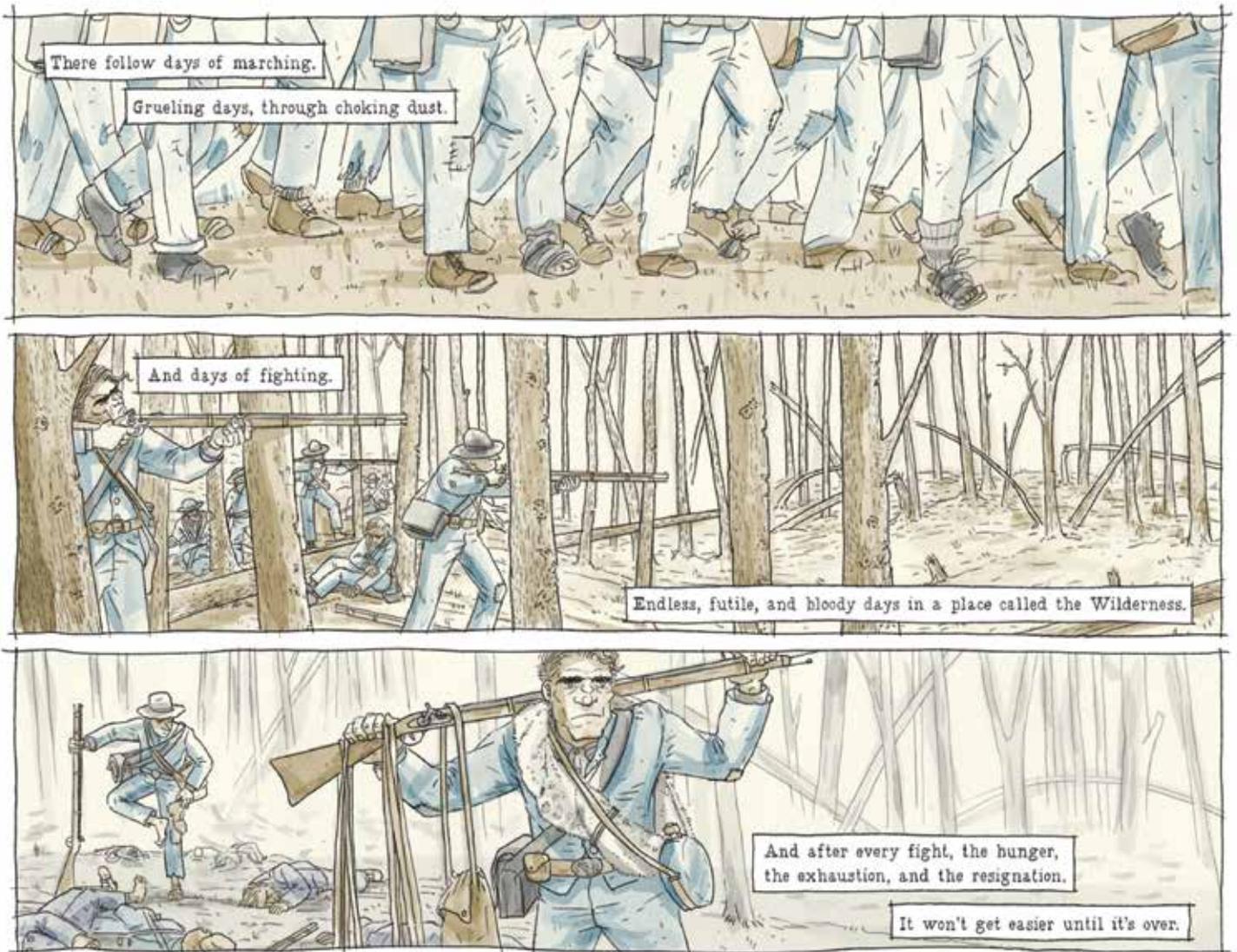


Patrick Mansell

Ari Kelman

IN *A MISPLACED MASSACRE*, HIS AWARD-WINNING 2013 BOOK ABOUT THE SAND CREEK MASSACRE, ARI KELMAN HELPED EXPOSE ONE OF THE DARKEST, MESSEIEST EVENTS IN AMERICAN HISTORY BY UNTANGLING GENERATIONS OF CONFLICTING MEMORIES—WHITE AND NATIVE AMERICAN.

No sooner was that book published than Kelman, the McCabe Greer Professor of History at Penn State, began to contemplate another complex research challenge: Could he tell the story of the American Civil War, one of the country’s most exhaustively documented events, in a brief, fresh, and accessible way? The answer would lead him to one of the least likely and most innovative publishing vehicles for a university researcher. He agreed to work on a graphic novel—a narrative in comic strip format—to help tell the story of the conflict in an immersive, yet economical, way.



Facing page: The Battle of First Manassas is depicted through the eyes of civilian spectators who thought the war would end quickly. Above: At the Battle of Spotsylvania Court House three long years later, soldiers gathered what supplies they could from the dead.



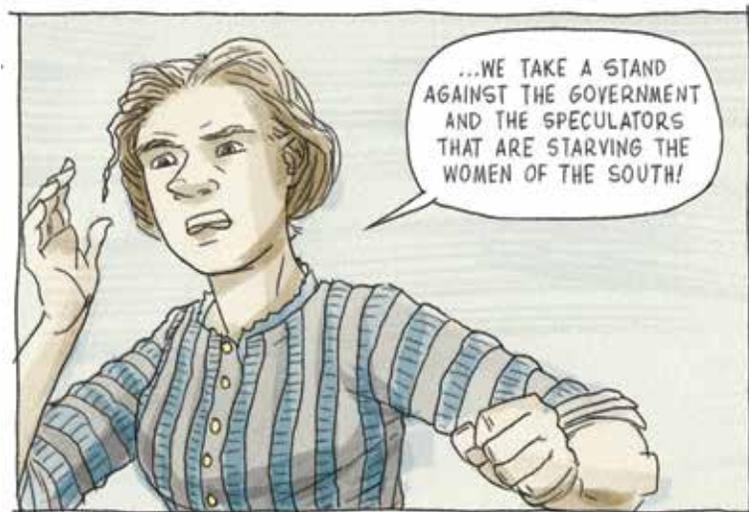
Above: Advances in weaponry combined with outmoded stand-and-shoot tactics filled the field hospitals of both sides. Facing page: Shortages of food, other supplies, and reliable currency made life on the Confederate homefront difficult.



“I didn’t read comic books as a kid and, before we published this book, I didn’t read graphic novels as an adult, so I’m not really an enthusiast,” says Kelman. “For me, this was a storytelling challenge, and the graphic novel was a solution.”

The result, *Battle Lines: A Graphic History of the Civil War* (Hill & Wang, 2015), tells the story of the conflict using different voices and augmenting those stories with artwork from author and illustrator Jonathan Fetter-Vorm, whom the publisher selected to work on the project.

“The real strength of the graphic approach to history is that it creates a sense of resonance,” says Fetter-Vorm, who had previously worked on a graphic novel about the history of the atom bomb. “With images, you can suggest things and create a way of telling history that leaves a lot of room for the reader to investigate even further.”



TEACHER BECOMES THE STUDENT

Kelman says Fetter-Vorm helped him navigate the new territory, which he found intimidating at first.

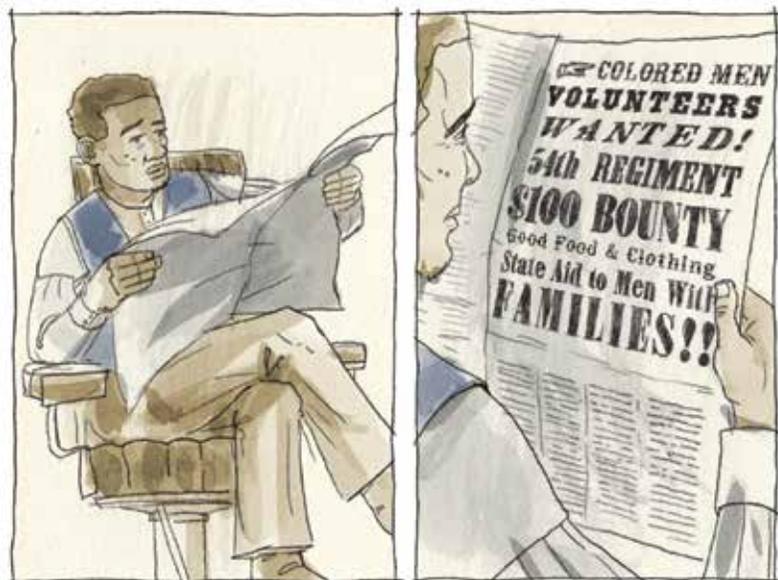
“Jonathan took me to school on how to write this, which is more like how a television show or a movie script is written,” he says. “It wasn’t until the fourth or fifth chapter working with Jonathan that I really got it.”

For one thing, he says, in a graphic novel, subtle aesthetic changes can profoundly alter the story.

“There’s a particular way that images carry meaning, and that meaning can often be compromised or enhanced when the images change. For example, moving the image from portrait to a landscape orientation can affect what you are trying to say,” says Kelman. “I just don’t think in those terms. As a writer, if I want to change the story, I just throw more words at it.”



This page: In 1863 the Union Army recruited free black men for a new regiment. The 54th Massachusetts led the assault on Fort Wagner, South Carolina. Facing page: Both sides benefitted and suffered from improvements in war technology, such as rifles with grooved barrels and the minié ball bullets they hurled toward the enemy.



The book is divided into 15 chapters, with each chapter using an ordinary object, such as a flag, a photograph, or opera glasses, as a focal point to tell personal narratives about the Civil War from different perspectives.

Kelman says that rather than focusing on generals and political leaders, as is done in most books about the Civil War, he and Fetter-Vorm chose to profile common people—soldiers, civilians, and people of color—caught up in the conflict.

“Lee, the other generals, and political leaders may be there on the periphery, but most people already know *their* stories,” he adds.

KEEPING HISTORY CIVIL

Kelman says the graphic novel format, along with a narrative approach that focuses on common people and ordinary objects, helps explain the war from a fresh perspective.

“There are more than 65,000 books written about the Civil War,” he says. “If you published one book about the Civil War every day since the war ended, you would still have 1,000 books left over.”

The authors hoped the new format would introduce Civil War history to a new audience. But they were also aware that Civil War buffs, and military historians in general, can be exacting critics. A writer of a standard book doesn’t have to get all the visual details right. But a story told in pictures has to show a lot more—and make sure it’s all accurate.

“That was actually one of my top concerns,” says Fetter-Vorm. “How do you tell the story that everybody knows about, a story that everyone has strong opinions about, and, on top of that, you have a contingent of people who know specifically what kinds of buttons are on the uniforms at a certain period in the war and all of the intricacies of the weaponry?”

Before the book was published, the authors submitted it to a group of military historians to make sure the details were as historically accurate as possible.

“We sent the book out for a scholarly and artistic peer review,” says Kelman. “Jonathan sent it to contacts in the comic community, as well as his writing group, and I sent it to scholars around the United States. We got feedback from around 20 people—really useful feedback, ranging from details we got wrong to some extraordinarily helpful feedback from military historians.”

Kelman and Fetter-Vorm are already looking forward to their next graphic novel project.

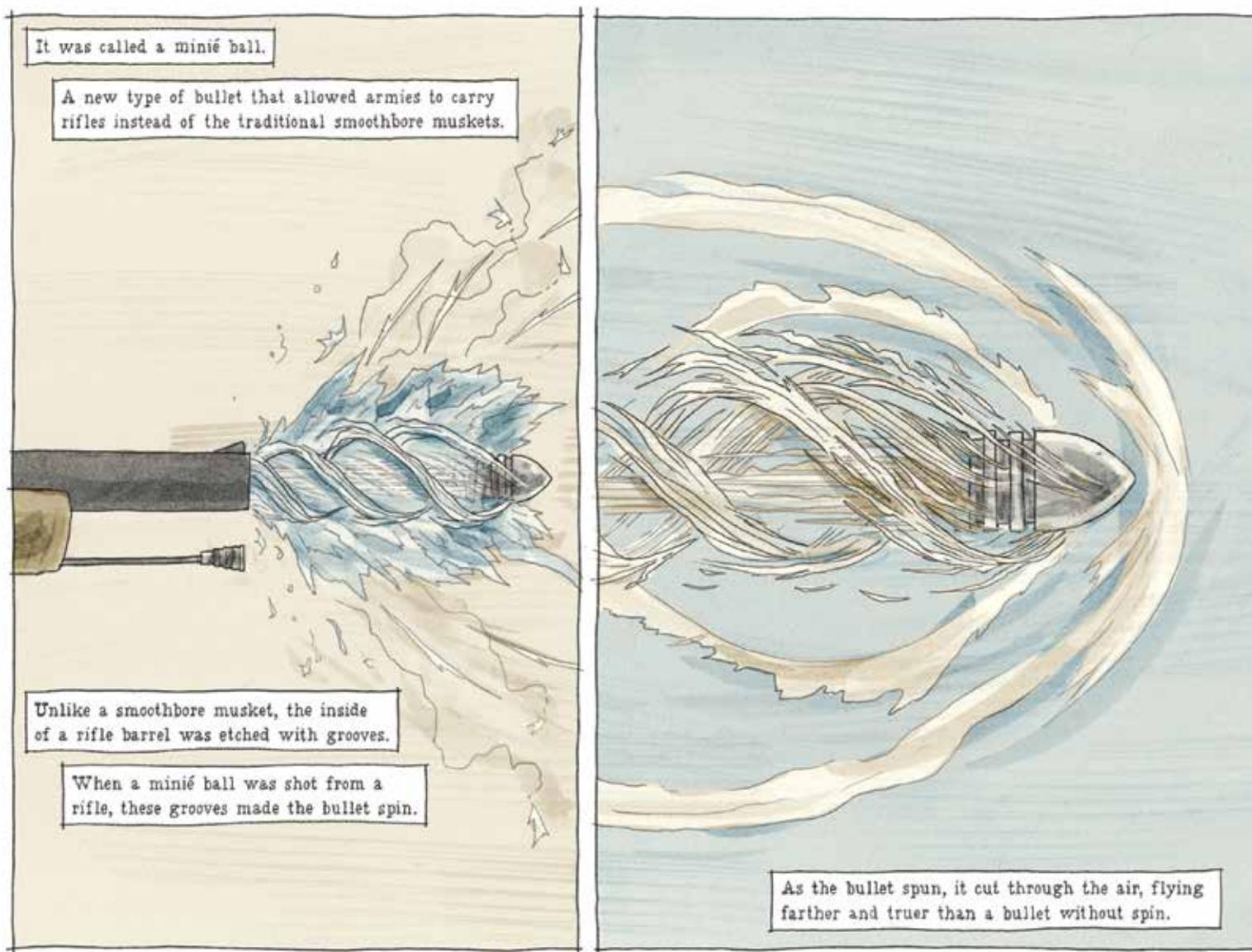
“We definitely want to do another one, this one on the road to and from the Little Bighorn,” says Kelman. “Jonathan is from Montana and I write about Western U.S. history and about the American empire. The Little Bighorn is also another one of those stories that is a quintessential American epic.”

Ari Kelman is McCabe Greer Professor of History. Jonathan Fetter-Vorm is a freelance author and illustrator.



Courtesy of Jonathan Fetter-Vorm

Illustrator Jonathan Fetter-Vorm



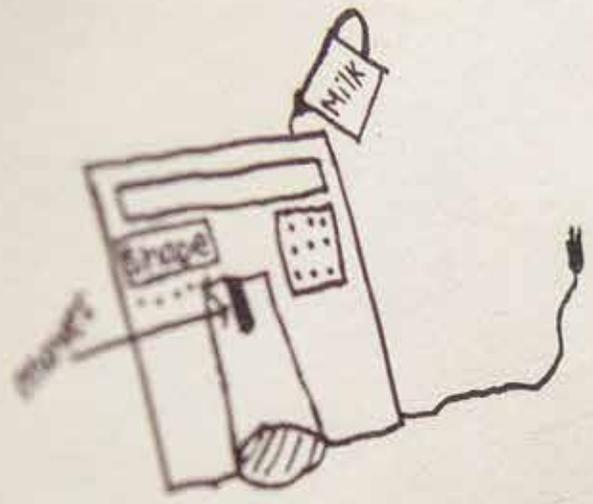
Participant Code: EQME

Team: SAR

Idea

Two characters of first name 2 digits of day of birth last 2 characters of

There's no shortage of good new ideas, says engineering design expert Scarlett Miller. We walk away from them every day.



ABANDONING CREATIVITY

BY CHERIE WINNER



WHEN SCARLETT MILLER STARTED TEACHING A FIRST-YEAR CLASS IN ENGINEERING DESIGN AT PENN STATE A FEW YEARS AGO, SHE NOTICED SOMETHING ODD.

“I would see the students come up with really cool ideas for new inventions, and then we’d get to the final prototype of the semester, and somewhere along the line something had happened,” she says. The students had left their most original ideas behind.

Miller, an assistant professor of engineering design and industrial engineering, had studied creativity in her graduate work—specifically, how to teach and encourage others to come up with promising new ideas. That students who already *had* good new ideas would quickly abandon them came as a big surprise.

So she began investigating how her novice designers decided which ideas to pursue. At the start of each semester, she surveyed the students to assess various personality traits, then had them form groups of four and gave them their assignment: Design and build a new device to froth milk for use in cappuccino. Emphasis was on the *new*—the students were told they would be graded on the novelty of their device, as well as on its function.

Each student sketched several ideas, then privately rated the creativity of each design generated by everyone in the group and indicated which one he or she thought the team should build. That allowed Miller to see which ideas each student favored before hearing—and possibly being swayed by—their teammates’ opinions. Then each group discussed its ideas and chose one to develop into a prototype. Miller recorded and analyzed their deliberations, hoping to learn where in the process the best new ideas got left behind—and why.

“If we can understand why the design decisions are being made, then we can start developing tools to help creative ideas to be more thoughtfully considered and not just quickly discarded,” she says.

How much are businesses, and society as a whole, losing by leaving so many creative ideas behind?

RISKY BUSINESS

The pre-project surveys revealed that many personal traits correlate with which ideas a person will favor. Extroverted students push harder for their ideas to be chosen than do more introverted students, for instance, but that sense of confidence in their own ideas varies by gender.

“We found that women are more likely to support or select their team members’ ideas, even if their own idea is good,” says Miller—and they choose those other ideas even in the initial, private assessment. “Men are more likely to select their own ideas, regardless of whether they’re good or not.”

Overall, the most significant factor influencing the students’ choices involved the *newness* of the ideas—and not in the way Miller had hoped. Despite knowing they would be graded on the novelty of their device, the students overwhelmingly chose to pursue designs that were close enough to existing products that they were almost guaranteed to work.

“Yes, it needs to work,” says Miller, a note of exasperation in her voice. “But it also needs to be a new way of solving the problem. If you’re working for a company, they’ll want to patent the idea—and if you can’t prove that it’s a new way of solving the problem, then you can’t have a patent in that space.”

The students’ overriding concern about whether their device would work got Miller thinking about their comfort with risk. She and graduate student Christine Toh began surveying students at the beginning of the semester to evaluate their risk-taking behavior in situations involving small sums of money. They found that students who were relatively tolerant of risk and uncertainty in that realm were more likely to select creative ideas during the design process—and that those students were very much in the minority. Most of their colleagues were much more averse to risk and uncertainty and much more likely to opt for a conservative design choice.

Miller thinks this tendency toward caution is not unique to students. In preliminary surveys of professional designers, she heard of a similar reluctance to invest in new ideas in the business world.

“There is kind of a disconnect between what the explicit goals are of the company and how that translates into the acceptance or support of creative ideas,” she says. In such

an organization, no one wants to be associated with a new product that fails, so everyone steers toward safer, more conservative choices. Bringing company practice into line with the goal of creativity would require everyone, from design interns to the CEO, to tolerate more uncertainty—and to not punish employees for trying something truly new.

Companies that excel at innovation have plenty of misses to go along with their greatest hits—and, crucially, they can’t tell ahead of time which will make it big and which will fail. In 2007, industry analysts predicted that a radical new device combining mobile phone, camera, music library, and email access would be a disaster for Apple, which had previously struck out with the Newton, the “hockey-puck mouse,” and several other highly novel offerings. But the company persisted, and the iPhone became one of the best-selling products ever made.

“Not every innovative product is going to be a huge success on the market,” says Miller. “The company has to have a culture that allows and can rebound from that.”

REDEFINING CREATIVITY?

From the beginning, Miller has shared the results of her surveys with her students so they could see how their habitual mindset might affect their design decisions. She and graduate students Christopher Gosnell and Elizabeth Starkey took that a step further with their invention of the Tool for Assessing Semantic Creativity (TASC), an online survey that uses students’ own descriptions of their designs to identify the most novel, yet workable, ideas.

“This tool doesn’t make the decision for you,” says Miller. “It informs your decision-making.”

Miller hoped it would help students become more aware of their own tendencies to dismiss radically new ideas too quickly. It seems to be working. In classroom experiments, groups that use TASC to assess their ideas do choose more creative options than groups that don’t use it.

After analyzing the results from several of their studies, Miller and Toh realized something totally unexpected: The most “creative” students, in terms of being able to come up with highly novel ideas, tend to be really bad at recognizing and pursuing novel ideas. When the time comes to decide which design to develop into a product, they actually choose more conservative options.

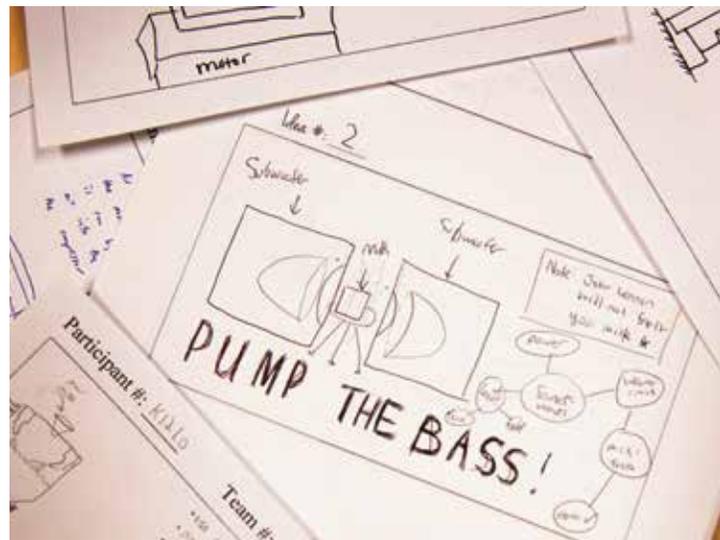


“There is NO correlation between someone who’s able to generate really good ideas and one who prefers them during the concept selection process,” says Miller—and that has big implications for business leaders. Stacking a new product development team with employees who are good at coming up with highly innovative ideas is probably not going to lead to the most innovative result.

Throughout these studies, Miller keeps thinking about her graduate work on how to stimulate creative thinking. She is now convinced that we already have effective techniques to help people think more novel thoughts. What’s needed now is for designers and the people who manage them to learn how to identify and encourage a whole different set of creative skills. How do we decide what to do with the results of our brainstorming sessions? And how much are businesses—and society as a whole—losing by leaving so many creative ideas behind?

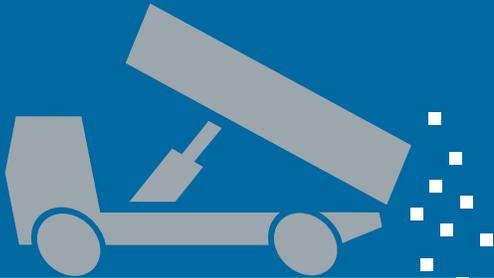
“You can train someone to be good at coming up with ideas,” says Miller. “That’s pretty easy. But the question has always been and will continue to be, what happens to those ideas?”

This work is supported by a grant from the National Science Foundation. Scarlett Miller is an assistant professor of engineering design and industrial engineering.



(Top) Doctoral candidate Christine Toh sorts through students’ sketches of new devices to froth milk. (Middle) One student proposed using sound waves to agitate the milk. (Bottom) Lab director Scarlett Miller explores why students are reluctant to pursue their most creative designs. Photos by Patrick Mansell.

When ice and snow melt away into streams and groundwater, road salt goes with it.



Salt on the

Earth

BY ROBB FREDERICK

AT THE EDGE OF BEHREND FIELDS, WHERE A FOOTPATH LEADS BACK TO A ONE-ACRE PARKING LOT, PAM SILVER BENDS DOWN AND SCOOPS A HANDFUL OF SNOW INTO A SMALL PLASTIC CUP.

It's February. Silver, Distinguished Professor of Biology at Penn State Erie, The Behrend College, hands the cup to Mali Lubic, one of a dozen biology and environmental science students who have volunteered to collect snow from 110 locations on campus. Lubic fits it into a tote with a four-acre grid mapped on the lid. Fresh snow blows around her as she seals it.

"I could do without that wind," Lubic says.

They've been out here for an hour, cupping snow from the banks of Trout Run, and from the woods above it, and from a spot just beyond the track-and-field team's shot-put pad. They have samples from the bike trail, the third- and first-base edges of the softball field, and from the base of the directional sign that guides traffic off the four-lane, \$180 million Bayfront Connector that runs along the north edge of campus.

Silver, an aquatic ecologist, is collecting the snow to get at the rock salt that has been mixed into it. She wants to know where the salt that is washed, plowed, and blown off campus paths and roads goes after the snow melts. In the lab, she, Lubic and other students will melt the samples and measure their electrical conductivity, an indication of how much salt is in each. That data will refine a map that shows elevated concentrations of salt not only on the college's parking lots and walkways, but also along Trout Run, which flows into Fourmile Creek, which empties into Lake Erie, the primary source of drinking water for the 280,000 residents of Erie County.

When it snows again, and the bank teller or the postal clerk or the cart boy at the supermarket, stomping through the winter slop, jokes that Erie's winters never really end, Silver will have data that proves it.

Four months later, on an 88-degree day, she will check the salinity in Fourmile Creek, a three-skip stone's throw from her office in the Benson Building. It will be nine times higher than it should be.

BENEFITS AND COSTS

Silver accepts that some level of salt is necessary. The 4,300 students and 700 employees who live, study, and work at Penn State Behrend do so through the winter season, which in Erie typically produces more than 100 inches of snow.

"In the short term, the primary concern is safety," Silver explains. "We don't want people to be falling as they walk to class."



The campus Maintenance and Operations staff, which has provided data and logistical support for her study, applies more than 500 tons of rock salt to the college's walkways and parking lots each year. They mix it with stone grit, which adds friction. The grit also reduces the cost of the salt, which is purchased in bulk from Morton Salt, which extracts more than 1.3 million tons of rock salt every year from a vast deposit 2,000 feet beneath Lake Erie. Even then, the cost is significant: The college will spend more than \$39,000 on rock salt this year.

Parking lot curbs keep some of the salt on the pavement, reducing salt levels in adjacent areas. Culverts draw more of it into storm sewers, which eventually empty into the lake. An elaborate drainage system beneath the Bayfront Connector directs runoff into a constructed wetland and away from nearby homes. A second wetland absorbs salt overspray from the road.



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Robb Frederick



Collecting snow to be tested for the presence of road salt, aquatic ecologist Pamela Silver (left) and undergraduate Mali Lubik brave Erie's frigid February wind.



“To fix a problem, you have to first see it.” —Michael Naber

The Pennsylvania Department of Transportation is mindful of its salt use: It applies nearly 27,500 tons of salt every year to 779 miles of Erie County roads, including highways. In 2003, when the Connector was completed, the department asked Silver to study the new road’s impact on nearby animals.

“We had these brand-new, virgin wetlands that had never had water in them,” she says. “It was a perfect starting point for a research study.”

Data loggers purchased by the Pennsylvania Department of Transportation measured the level of salt in and near one of those wetlands for three years. Silver analyzed the data, and sediment from the bottom of the wetlands, to assess the impact on non-biting midges, which live in marshy conditions.

“Midges are a good indicator species,” Silver explains. “They’re easy to cultivate, their biology is well understood, and they live in the mud. If salt is going to accumulate, it will be there, in the sediment. We can see how it affects them.”

Two years after the road opened, there were significantly fewer midges in the wetland designed to receive the runoff than in other constructed wetlands that were kept free of salt.

Silver would like to know the impact elevated salt concentrations have on other strands of the food web, including algae, salamanders, frogs, and fish. “Salinization of fresh water can cause immense ecological harm,” she says. “All of the natural services that fresh water provides, including photosynthesis and the processing of leaf material—the processes that are not on our radar, but that keep us alive—are directly affected by it.”

There is an economic cost as well. Recreational fishing is a \$1.3 billion business in Pennsylvania, according to the state’s Fish and Boat Commission. That disappears if the habitat can no longer sustain fish.

For now, however, Silver is focused on the salt runoff across Penn State Behrend’s 854-acre campus. “If we can put the pieces together here,” she says, “we will

have a far more complete picture of the impact this salt is having on our environment, including our drinking water. If we can develop new methods for containing it, or for using it more efficiently, and we can point to that success, other, larger entities, including municipalities, might follow suit.”

SEEING THE PROBLEM

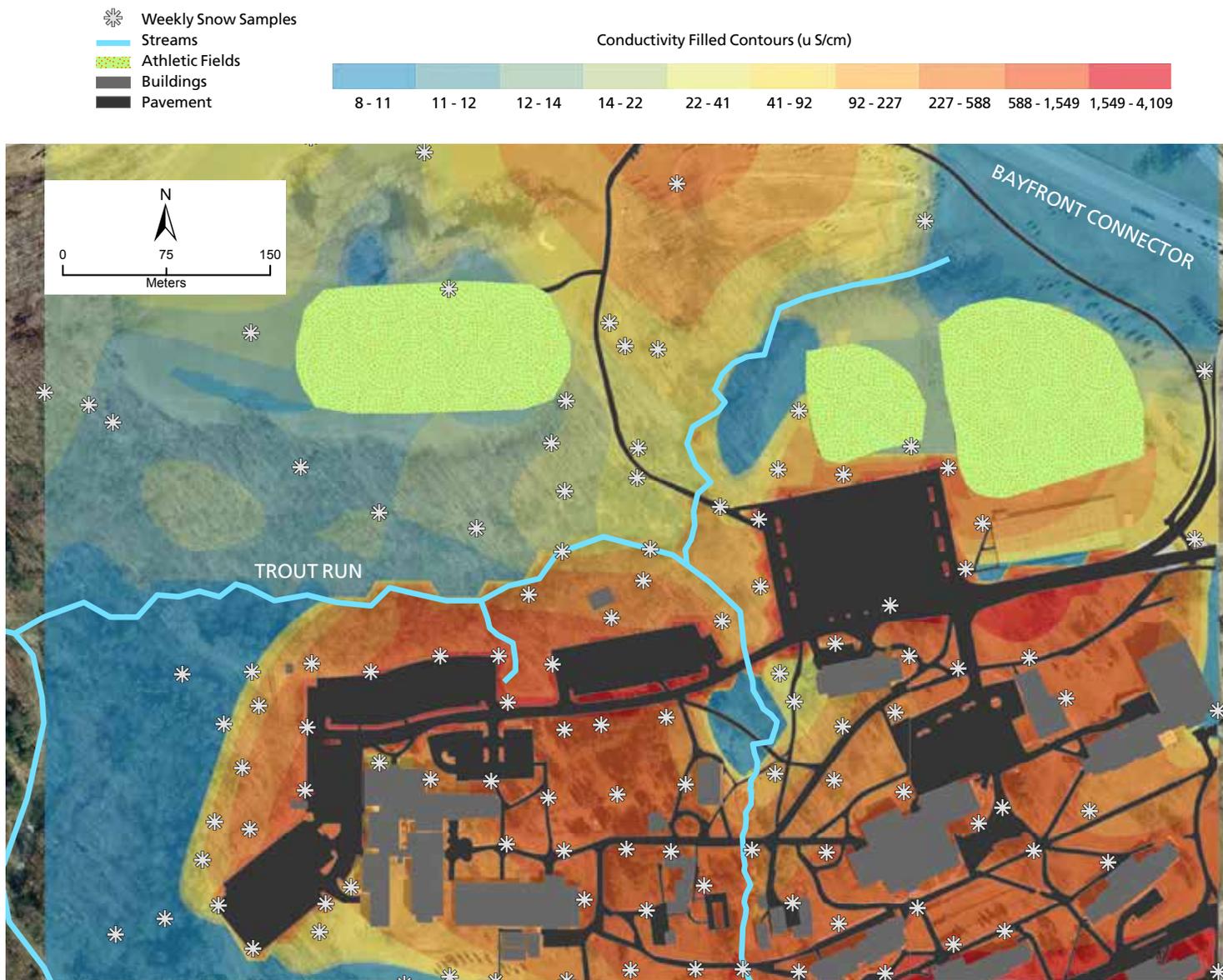
“To fix a problem, you have to first see it,” says Michael Naber, a lecturer in geoscience. With help from Devin Beggs, a science major, Naber mapped the conductivity levels that Silver and her students recorded over a six-week period last winter. That data, drawn from the 110 sampling sites, allowed him to predict the presence of salt elsewhere on campus.

“People know this stuff’s out there,” he says. “They see it on their cars and their boots and on the carpets when they enter a building. What’s eye-opening is how concentrated it is in some areas.”

On his map, the small parking lot near Glenhill Farmhouse is alarm-button red. Some snow samples collected there had conductivity rates of more than 44,000 microsiemens/cm, which is 40 times the safe level for drinking water. At that concentration, the salt kills grass, algae, midges, and fish.

Over the next year, Naber will work with Michael Rutter, associate professor of statistics, to refine the salt-distribution projections on the map. They will use additional data, including samples from the southern edge of campus, where construction of a 250-bed residence hall is expected to begin in late 2017, altering the route of runoff to lower elevations.

In November, Silver will collect a trove of new information from three data loggers she placed in streams on campus last fall. The loggers measure the water’s conductivity every 15 minutes. By matching that data to weather reports, Silver should be able to determine how quickly conductivity spikes during storms and warming periods—and how long the salt concentrations remain elevated.



 A map based on average conductivity of snow collected over six weeks in early 2016, and on drainage patterns, predicts conductivity (salt levels) across the Penn State Behrend campus during the sampling period. Map by Devin Beggs and Michael Naber; data from Pennsylvania Spatial Data Access and Pam Silver.

Additional samplers will be secured to the grates on 15 campus storm drains. That effort is being coordinated by Tony Foyle, associate professor of geology, whose students will measure the conductivity of water that enters the drains during peak flow events, including storms. A spike in those readings would be particularly troubling: Medallions on the tops of the grates explain that the pipes beneath them drain into Trout Run.

INFORMED CHOICES

The third phase of the project will involve faculty members with expertise beyond the biology and geology departments. Silver has a particular skill for opening her work to additional collaborators, including undergraduates.

“I talk a lot about this project,” she says. “I keep putting it out there, saying, basically, ‘This is what we’re doing. Do you want to play?’ People pick up the pieces of it that interest them.”

High-school students from Northwest Pennsylvania Collegiate Academy are helping Luciana Aronne, a lecturer in chemistry, test Silver’s snow samples for chloride.

Deborah Aruguete, assistant professor of environmental science, will provide additional analysis. She studies the impact on soils when toxic metals are released in automobile emissions. Those metals do even more damage when they are mixed with salt.



Clockwise, from above left: A data logger anchored to the bed of Glenhill Stream on the Behrend campus records conductivity and temperature of the water every 15 minutes; because she downloads data from the logger just once a year, Silver takes readings monthly with a hand-held unit; road runoff reaches the stream via surface flow and culverts.





“Environmental problems don’t begin with science. They result from people needing or wanting something else.” —Pamela Silver

Silver has met with Joshua Shaw, associate professor of philosophy, to discuss the ethical ramifications of salt use. She also sees opportunities to work with colleagues in the college’s communication and political science departments.

“Environmental problems don’t begin with science,” she explains. “They result from people needing or wanting something else. They are political, social, and economic problems, and to address them you really do need to get buy-in from the wider community. If we can put all these pieces together and present a clear picture of the impact this salt is having on our environment, people will say, ‘Wow, I had no idea.’ And then, maybe, they’ll change their habits.”

Silver and her students have talked through a long list of potential fixes, including higher curb heights and the use of salt brines—liquid salt mixtures—to treat roadways before snow falls. It takes four times more salt to remove ice after it forms than to prevent it before or during a snow event, a 2014 study by the New York State Department of Transportation found.

Other options include canopies, solar panels, and enclosed paths to connect some buildings on campus. The Otto Behrend and Hammermill science buildings were connected in 2015, allowing students to move through the six-building School of Science complex without having to go outside.

That’s an expensive fix. Silver’s own approach—to blaze her own path, whenever possible, avoiding surfaces that have frozen or crusted over—is no more realistic: Most people prefer to take the clearest, most convenient route.

There she goes, though, with her tote full of samples, stepping off the cleared path and into deep snow. It grips her, like movie quicksand, clamping onto the full length of her legs. She trudges forward, Lubic a few steps behind, stirring up fine clouds of light, white snow. The path, and the salt that cleared it, is just one piece of a much larger puzzle, a reminder that every convenience comes with some consequence.

Pamela Silver is Distinguished Professor and Department Chair of Biology and Michael Naber is lecturer in geoscience at Penn State Behrend.



BOOKS



ON OBAMA

by Paul Taylor, associate professor of philosophy and African-American studies

Has Barack Obama's presidency ushered in a "post-racial" age in America? In the international arena, has his emphasis on problem-solving rather than ideological warfare (a very different approach from that of his predecessor) produced a long-term shift in the way the nation conducts foreign affairs? Does it suggest he is a pragmatist in the philosophical sense?

In *On Obama*, philosopher Paul C. Taylor considers these and other questions raised by Obama's image and history-making career. Applying philosophical analysis to matters of cultural and political import, Taylor explores the significance of this deeply thoughtful, reflective leader and how his presidency has affected our views of race, power, and pragmatism. He also examines the common assumption that Obama's rise has ushered in a post-historical age, and Obama's own views on that idea.

Taylor's previous books include *The Philosophy of Race* and *Black is Beautiful: A Philosophy of Black Aesthetics*.

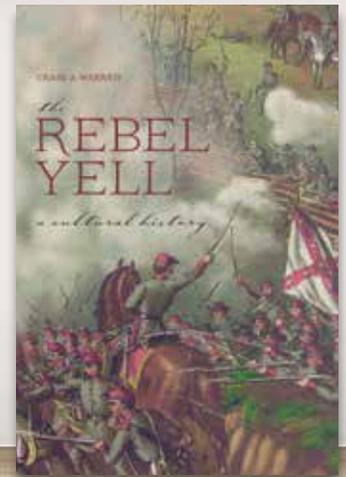
THE REBEL YELL: A Cultural History

by Craig Warren, associate professor of English, Penn State Behrend

As a Confederate battle cry, the Rebel yell—a yowling holler, equal parts hog call and Indian war whoop—was exaggerated by the smoke on Civil War battlefields. It unnerved Union soldiers, who heard the threat before they could pinpoint its direction.

Craig Warren's latest book, *The Rebel Yell: A Cultural History*, is the fullest picture yet of the Confederate rally cry. It traces the Rebels' use of the yell—"the ugliest sound that any mortal ever heard," according to the writer Ambrose Bierce—through key battles at Manassas, Sharpsburg, and Honey Hill.

Warren uses diary entries from both sides of the conflict to depict the yell's effectiveness in battle. His account continues into Reconstruction and on to the civil rights era, where the yell had divisive, and often racist, intent, and then watches as the tradition is co-opted and rebranded in the spirit of individual defiance in order to sell bourbon, records, and roller-coaster rides.



PESTICIDES, A LOVE STORY: America's Enduring Embrace of Dangerous Chemicals

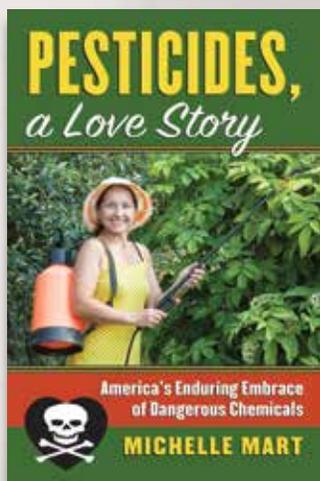
by Michelle Mart, associate professor of history, Penn State Berks

We just can't seem to quit bug-killing chemicals.

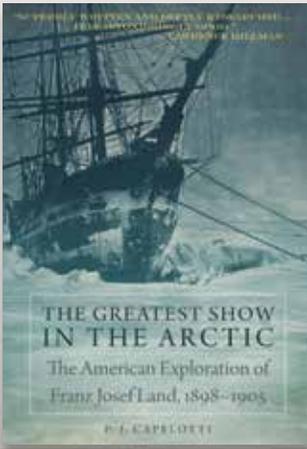
That's the finding of historian Michelle Mart, whose book, *Pesticides, A Love Story: America's Enduring Embrace of Dangerous Chemicals*, investigates why Americans cling to their love of pesticides despite warnings, rising costs, and declining effectiveness.

According to Mart, America's love affair with synthetic pesticides started with the use of DDT during World War II to kill the organisms that carry typhus and malaria, and continued with heavy residential and agricultural use after the war. Concern over the ecological effects of pesticides, particularly DDT, eventually led to federal restrictions on their use. Despite that, we remain quick to seek chemical solutions to pest problems, due to deep cultural beliefs about our ability to manipulate the environment and the primacy of short-term over long-term interests.

Mart's book grew out of a research fellowship she received from the Rachel Carson Center for Environment and Society in Munich, Germany.



BY PENN STATE FACULTY



THE GREATEST SHOW IN THE ARCTIC: The American Exploration of Franz Josef Land by P.J. Capelotti, professor of anthropology, Penn State Abington

In Gilded Age America, Arctic explorers were fabulous celebrities, assured of riches and near-immortality if they reached the North Pole first. Of the many attempts to meet that goal, three American expeditions, launched from the Russian archipelago of Franz Josef Land, ended in abject failure. In *The Greatest Show in the Arctic*, the first book to chronicle all three expeditions, P. J. Capelotti explores what went right and what, in the end, went tragically wrong.

The cast of colorful characters included a Chicago journalist and bon vivant running from debts, his mistress, and an illegitimate daughter; a deranged meteorologist with a fetish for balloons and a passion for Swedish conserves; and a pious photographer in search of God in the Arctic.

Through close study of the expeditions' journals, Capelotti reveals that the endeavors foundered chiefly because of poor leadership and internal friction, not for lack of funding, as historians previously suspected. Presenting tales of noble intentions, novel inventions, and epic miscalculations, his book brings fresh life to a unique and underappreciated story of American exploration.

THE RISE OF WOMEN FARMERS AND SUSTAINABLE AGRICULTURE

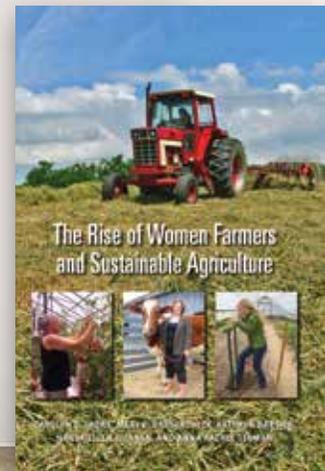
by Carolyn Sachs, professor of rural sociology and women's studies, and others

Researchers from Penn State and Ohio University have written a new book that examines a recent cultural shift in agriculture, marked by an unprecedented number of women who have entered into farming.

The Rise of Women Farmers and Sustainable Agriculture explores the societal changes that have empowered women to claim the farmer identity, describes barriers often encountered by women farmers, and posits that their innovative responses to these barriers are helping to redefine agriculture.

Lead author Carolyn Sachs and her co-authors collected hundreds of anecdotes to lend context to the book's themes, beginning with a discussion of barriers women farmers have experienced, from resistance to the very idea that they are farmers to more tangible difficulties accessing land, labor, and financing.

Mary Barbercheck, professor of entomology, Kathryn Brasier, associate professor of rural sociology, and Nancy Ellen Kiernan, professor emerita, all of Penn State, and Anna Rachel Terman, assistant professor of sociology, Ohio University, co-authored the book.



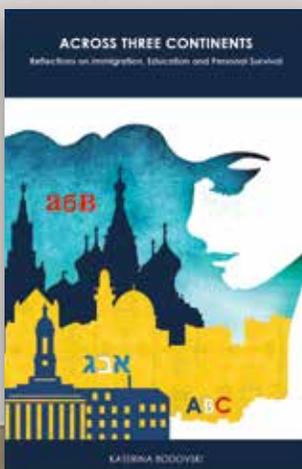
ACROSS THREE CONTINENTS: Reflections on Immigration, Education and Personal Survival

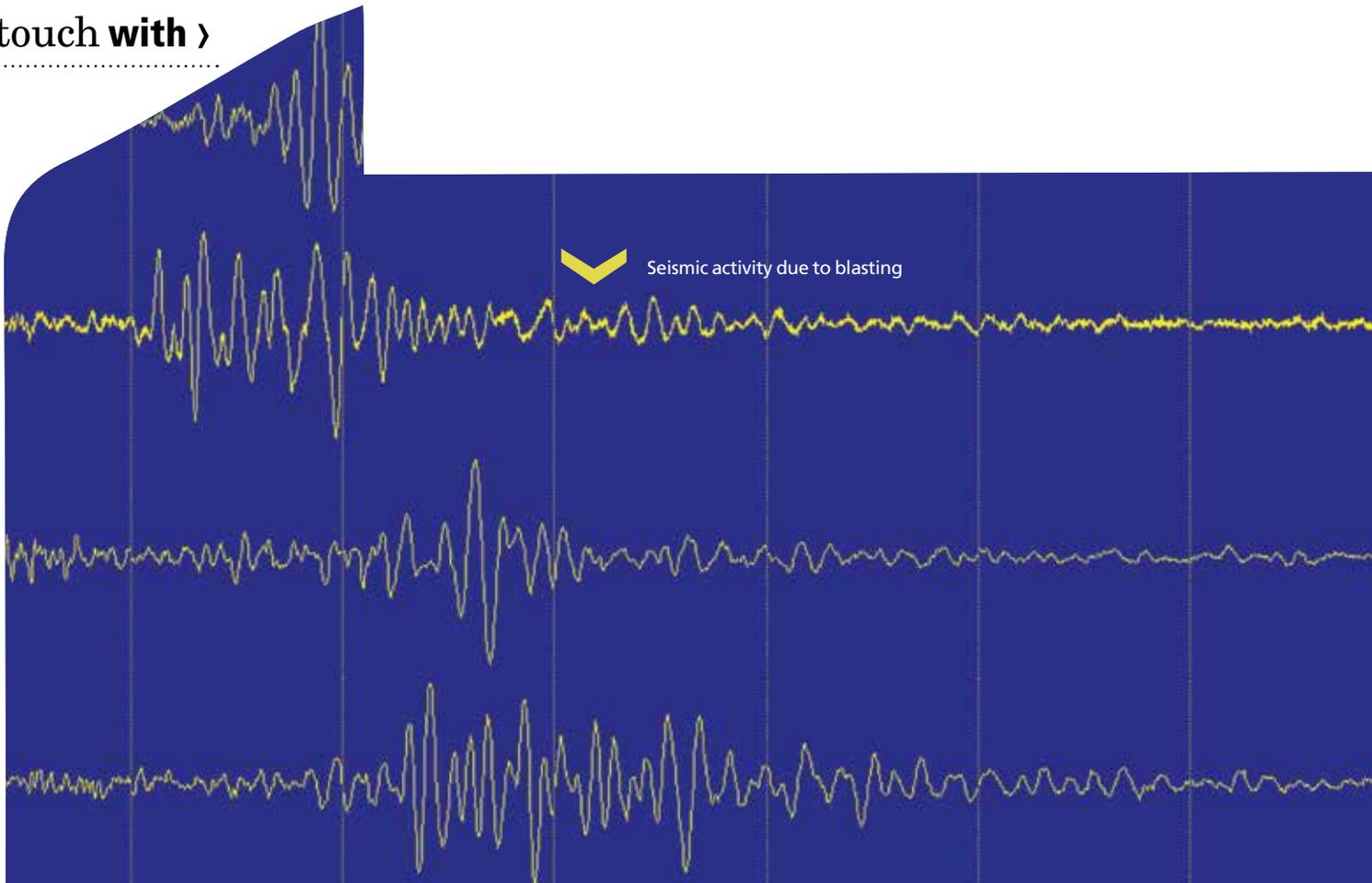
by Katerina Bodovski, associate professor of educational theory and policy

Few experts on immigration can speak from personal experience, and few people who have lived in more than one country can speak about their experiences from the standpoint of a professional sociologist.

Katerina Bodovski does both in *Across Three Continents: Reflections on Immigration, Education and Personal Survival*. Part autobiography and part sociological analysis, the book connects the dots between Bodovski's personal experiences and the research she has conducted for more than 15 years.

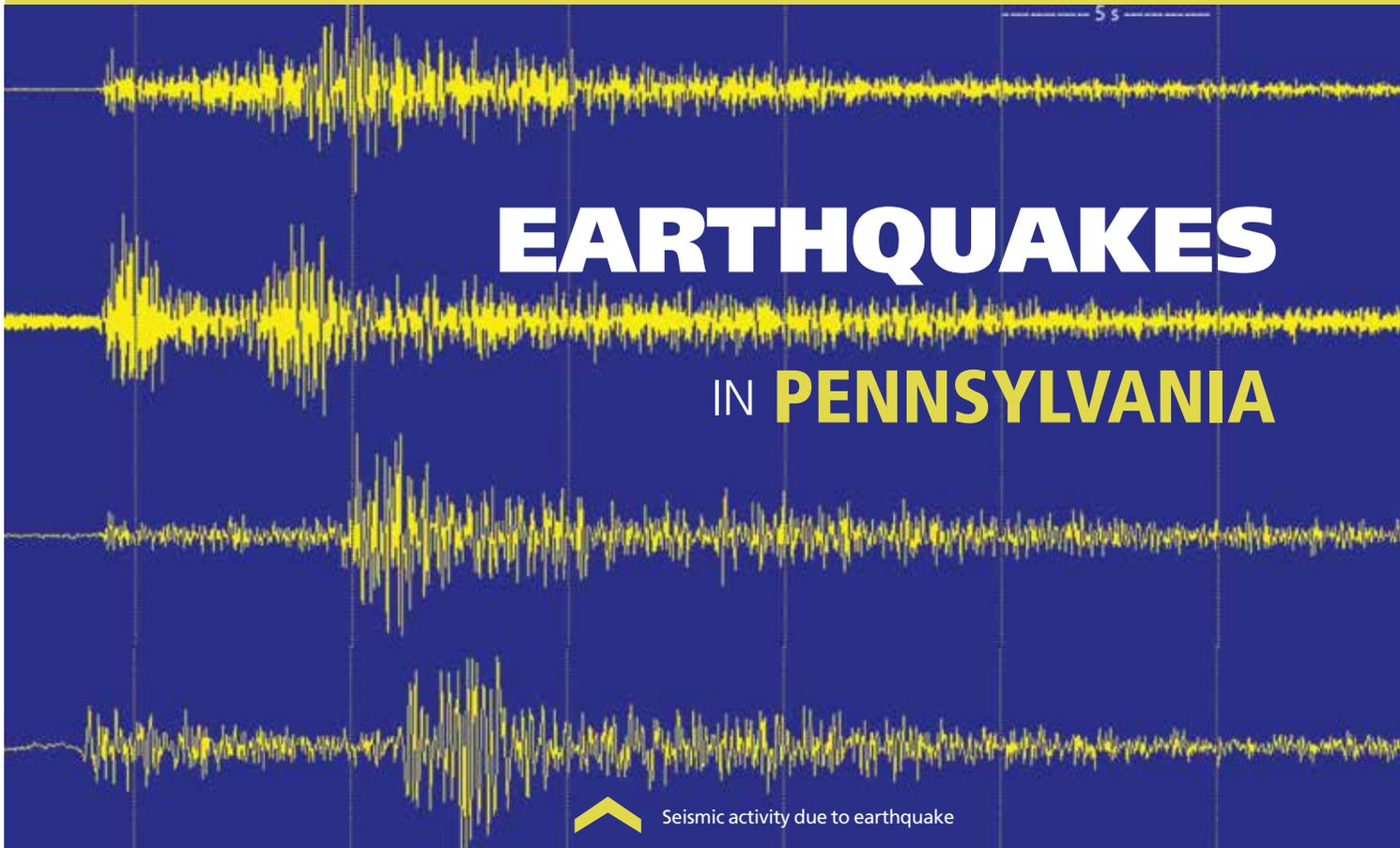
She has lived through key events in the breakup of the Soviet Union, where she grew up; the assassination of Prime Minister Yitzhak Rabin and subsequent collapse of peace talks in Israel, where she earned her bachelor's and master's degrees; and, while pursuing a Ph.D. in sociology at Penn State, the Sept. 11 terrorist attacks in the United States. A combination of personal experience and sociological training allows her to explore how cultural, historical, and economic circumstances shaped what occurred in classrooms and homes of the three countries.





Seismic activity due to blasting

ANDREW NYBLADE ON



EARTHQUAKES

IN **PENNSYLVANIA**

Seismic activity due to earthquake

This summer, with funding from the state Department of Conservation and Natural Resources, a Penn State team led by geophysicist Andrew Nyblade completed a major expansion of the Pennsylvania Seismic Monitoring Network, creating a system of 30 seismic stations spread across the Commonwealth. Located at Penn State campuses and state parks, the stations contain state-of-the-art ground motion sensors and GPS clocks. The added coverage provides for much more uniform seismic monitoring than was possible before. Nyblade spoke to David Pacchioli about the reasons behind the build-out, and the history of earthquake activity in Pennsylvania.

WHY DO WE NEED AN EXPANDED SEISMIC MONITORING NETWORK IN PENNSYLVANIA?

There are three reasons. One is that there are areas of natural seismicity in Pennsylvania—one in the Lancaster-Reading area, where there have been magnitude 4 earthquakes, and the other just south of Lake Erie on the Pennsylvania-Ohio border. The largest earthquake yet recorded in Pennsylvania was the Pymatuning earthquake of 1998, just south of Erie. That was a 5.2 magnitude event. When you get to magnitude 4 and 5 events, they can be felt, and they have potential to cause damage to structures, so we need to better understand those zones of seismicity.

Then there are the reasons related to oil and gas activities—induced seismicity, possibly by fracking and more probably by wastewater disposal.

HOW MUCH SEISMIC MONITORING HAS BEEN DONE HERE BEFORE, AND WHAT DID IT FIND?

In 2013-14 we were able to take advantage of a temporary array of seismic stations, part of the NSF EarthScope project, to get a good baseline read on seismicity within the state. What we found was that over 99 percent of the seismic activity in the state actually comes from blasting. There is blasting in coal mines and quarries going on all the time, and some of those blasts are equivalent to magnitude 2, 2.5 earthquakes. So there's all this background seismic activity, and we need to be able to detect and locate those events so that we can discriminate between them and anything else that might be happening.

ARE FRACKING-RELATED EARTHQUAKES A REAL POSSIBILITY IN PENNSYLVANIA?

We don't yet know for sure, but Pennsylvania may have had its first fracking-induced seismicity already. In late April, we

had a series of seismic events in Lawrence County, near the Ohio border, that have been correlated with a well that was being fracked there.

The bigger concern, though, is with seismicity that's induced from wastewater disposal. The flowback waters from fracked wells, and also the wastewater that comes from conventional oil and gas wells, has to be disposed of, and a common practice is to pump it back into the ground. There's been a huge ramp-up of seismicity in places in Oklahoma, Kansas, Texas, and some places in Canada, and most of that is related to wastewater disposal, not to fracking itself.

WOULD IT BE POSSIBLE THAT ANY INDUCED ACTIVITY WOULD BE ON A PAR WITH NATURAL EARTHQUAKES THAT HAVE BEEN RECORDED IN THE STATE?

Yes. In Oklahoma there have been events induced by wastewater injection that were 5.7, 5.8 magnitude. Magnitude 4s have been recorded in Arkansas and Texas related to wastewater injection. The largest fracking-related events reported

so far are magnitude 4s, and those have been in Canada. So there is potential for magnitude 4s and 5s—potentially damaging earthquakes—that could be induced by either fracking or wastewater disposal.

IS THERE SOMETHING WE CAN DO TO MITIGATE THE CONCERN?

Absolutely. As we monitor seismicity across the state, we can detect small events when they happen and determine if they are related to fracking or to wastewater disposal, and if so notify the Department of Environmental Protection, who can then ask the well operator to shut down or take other steps. That's one of the main purposes of the network, to be able to detect events before they get too large, so that the state authorities can take remedial action.

Andy Nyblade is co-director of the Marcellus Center for Outreach and Research.



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Salt on the Earth

Where does road salt go after the ice melts? Behrend biologist Pam Silver finds it in streams and wetlands—even in the middle of summer.

SEE STORY, PAGE 28

