

## Some Like It **COLD**

**14** What makes  
glaciers tick?

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Mega Data

Fixing Ribs

Patients on the Move

Life Under Enemy Rule

# The Power of Research

All around me and every day, I'm excited to see Penn State faculty and students harnessing the power of research. This issue of Research/Penn State magazine is filled with recent examples.

At our College of Medicine, a team of doctors and engineers have found a simpler, less invasive way to mend a broken rib, a painful and all-too-common injury. Meanwhile, biologists Nita Bharti and Matt Ferrari are using satellite imagery and cell-phone data to improve vaccination rates and minimize measles outbreaks in sub-Saharan Africa. In both cases, an innovative approach brings a creative solution to alleviate human suffering.

Our ice and climate group, led by Richard Alley, is one of the world's best. Its hardy members go literally to the ends of the Earth to understand how glaciers grow, flow, shrink, and retreat, and how their current and future melting will impact sea level rise. The complementary efforts of its observers and modelers demonstrate the power of teamwork to advance scientific understanding.

Research entails looking beyond the obvious to see what lies beneath. At the Center for Supply Chain Research™, that means recognizing that an entire ecosystem underlies the simplest product in a consumer economy. With the same goal, historian Sophie De Shaepdrijver digs deep in historical archives; her reward is the human stories that show war's lasting effects beyond the battlefield.

Finally, Penn State's new state-of-the-art data center exemplifies the high-performance computer power that is critical to solving complex problems in the era of big data.

These and other stories are unfolding all the time. Right outside my window and around the globe, Penn State faculty and students are harnessing the power of research to make the world a better place.



NEIL A. SHARKEY  
Vice President for Research



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**ON THE COVER:**  
*Rivers of ice: Two huge Antarctic glaciers meet as they flow toward the sea. Recent warming speeds the loss of ice and adds to sea-level rise. See story, page 14. Photo by Don Voigt.*



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## In Brief

Black holes, atomic stencils, and other news highlights from Penn State researchers.



## At Large

In Mongolia, horses provide a special harvest.



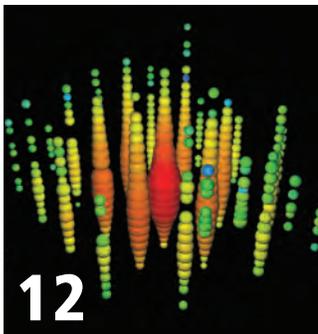
## Off the Shelf

Rock & roll, war poems, climate change, and more, in recent books by faculty authors.



## In Touch With

Supply-chain expert Steve Tracey on how things get made.



## Nuts & Bolts: Power Up!

New data center crunches big numbers, solves big problems.



## Moving Targets

Bringing vaccinations to people on the move.



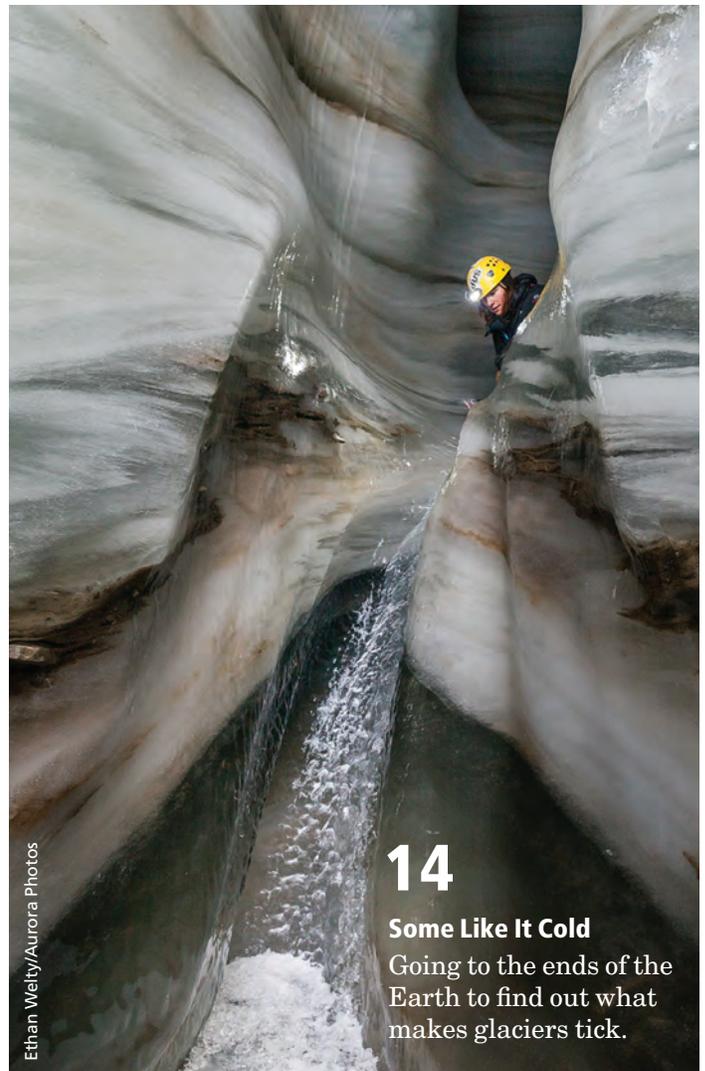
## Dancing With a Bully

When war isn't just at the front: life under enemy rule.



## Fixing Ribs

Penn State doctors invent a better way to help broken ribs heal.



Ethan Welty/Aurora Photos

## Some Like It Cold

Going to the ends of the Earth to find out what makes glaciers tick.

## » Women Rule

**D**iscovering who was a leader, or even if leaders existed, from the ruins of archaeological sites is difficult, but now a team of researchers using a powerful combination of radiocarbon dating and ancient DNA have shown that a matrilineal dynasty likely ruled Pueblo Bonito, in Chaco Canyon, New Mexico, for more than 300 years.

“We are not saying that this was a state-level society,” says Douglas J. Kennett, head and professor of anthropology. “But we don’t think it was egalitarian either.”

Typically, the only things found in prehistoric archaeological ruins to indicate elevated status are burial artifacts. Throughout the Southwest it is unusual to find formal burials within structures, but in excavations

carried out in the 1890s at Pueblo Bonito, archaeologists found a burial crypt within the 650-room pueblo that contained 14 burials.

“It has been clear for some time that these were venerated individuals,” says Adam Watson, a postdoctoral fellow at the American Museum of Natural History.

Radiocarbon dating showed that the indoor burials occurred over a 300-year period. The researchers then found that all the individuals shared the same mitochondrial genome sequence, indicating that not only were they all from the same family, but the inheritance was matrilineal — through the mother. Next, “Using DNA sequences from the nuclear genome combined with the radiocarbon dates, we identified a mother-daughter pair and a grandmother-grandson relation-

ship,” says Kennett.

According to collaborator Steve Plog of the University of Virginia, “This is the best evidence of a social hierarchy in the ancient Southwest.”

—A’NDREA ELYSE MESSER



Thinkstock



*Our brains process foreign-accented speech better if we recognize the accent we're hearing.*

- JANET VAN HELL

Psychology and Linguistics



*Dangerous ozone levels can now be predicted 48 hours in advance.*

- NIKOLAY BALASHOV

Meteorology



IStock Photo/Ociacia

## How Would You Like Your Robot?

In a study of robot use in a retirement home, senior citizens reacted differently to robots with different personalities depending on how they perceived the robot's role in their lives.

"We were actually surprised to find out that they wanted 'companion' robots to be serious and 'assistant' robots to be playful," says S. Shyam Sundar, Distinguished Professor of Communications, Penn State. "But it's pretty clear from our data that a serious demeanor adds credibility to a companion robot, whereas a playful demeanor softens the tension when interacting with an assistant robot."

Assistant robots are designed to help people with everyday tasks, such as dispensing medications, whereas companion robots are designed to support people emotionally, serving as friends or pets.

Knowing how people might react to a robot's demeanor and role could help designers make robots that people are more likely to accept and use, says Sundar. Both companion and assistant robots will likely find roles in hospitals and retirement homes to assist senior citizens with the physical, mental, and emotional challenges of growing old.

"In the future, we might see robots working in the healthcare system to provide senior citizens with physical assistance and emotional support in the comfort of their own homes," says Sundar. "Therefore, it's becoming more important to understand how we can promote healthy communications between senior citizens and robots."

—MATT SWAYNE

## MIND THE GAPS <<

**W**hole-exome DNA sequencing—a technology that saves time and money by sequencing only protein-coding regions and not the entire genome—may routinely miss detecting some genetic variations associated with disease, according to Penn State researchers who have developed new ways to identify such omissions.

Whole-exome sequencing has been used in many studies to identify genes associated with disease, and by clinical labs to diagnose patients with genetic disorders. However, the new research shows that these studies may miss mutations in a subset of disease-causing genes associated with leukemia, psoriasis, heart failure, and others, that occur in regions of the genome that are read less often by the cost-saving technology.

"Although it was known that coverage—the average number of times a given piece of DNA is read during sequencing—could be



Three methods commonly used to diagnose genetic disorders miss hundreds of mutations in disease-causing genes.

uneven in whole-exome sequencing, our new methods are the first to really quantify this," says Santhosh Girirajan, assistant professor of biochemistry and molecular biology and of anthropology.

The researchers have developed two different methods to identify low-coverage regions, and packaged both methods into an open-source software for other researchers to use.

"One solution to this problem is for researchers to use whole-genome sequencing, which examines all base pairs of DNA instead of just the regions that contain genes," says Girirajan. "However, the costs of whole-exome sequencing are still significantly lower than whole-genome sequencing. Until the cost of whole-genome sequencing is no longer a barrier, human genetics researchers should be aware of these limitations in whole-exome sequencing technologies."

—SAM SHOLTIS



Galvin Robertson, co-developer of a new drug to fight melanoma, examines a tissue sample with students.

## NANO NO-NO'S MELANOMA <<

The first of a new class of medication that delivers a combination of drugs via nanoparticles may keep melanoma from becoming resistant to treatment, according to Penn State College of Medicine researchers.

“Loading multiple drugs into nanoparticles is one innovative approach to deliver multiple cancer drugs to a particular site where they need to act,” says pharmacologist Raghavendra Gowda, lead author of the study. “Another advantage is that by combining the drugs, lower concentrations of each that are more effective and less toxic can be used.” Using two drugs also helps keep cancerous cells from developing resistance to a single drug.

The new medication, dubbed CelePlum-777, combines Celecoxib, an anti-inflammatory agent, and Plumbagin, a toxin, which work together to kill melanoma cells. Researchers

used microscopic nanoparticles to deliver the drugs in a specific ratio directly to cancer cells. Once inside a tumor, the nanoparticles release the drugs. The research showed that CelePlum-777 killed cancer cells both in culture dishes and in tumors in mice.

“This drug is the first of a new class, loaded with multiple agents to more effectively kill melanoma cells, that has potential to reduce the possibility of resistance development,” says Galvin Robertson, director of the Penn State Melanoma and Skin Cancer Center. “There is no drug like it in the clinic today and it is likely that the next breakthrough in melanoma treatment will come from a drug like this one.”

Penn State has patented this discovery and licensed it to Cipher Pharmaceuticals, which will perform the next series of FDA-required tests.

—MATTHEW SOLOVEY

## Going Deep Fast

Changes in climate can rapidly affect even the deepest freshwater aquifers, according to Penn State and Columbia University hydrologists.

The researchers found that responses to climate variations can be detected in deep groundwater aquifers faster than expected—in many cases within a year.

Because rainwater may take years to reach deep aquifers through natural infiltration, the findings suggest another factor is involved, such as pumping of aquifers done by agricultural industries.

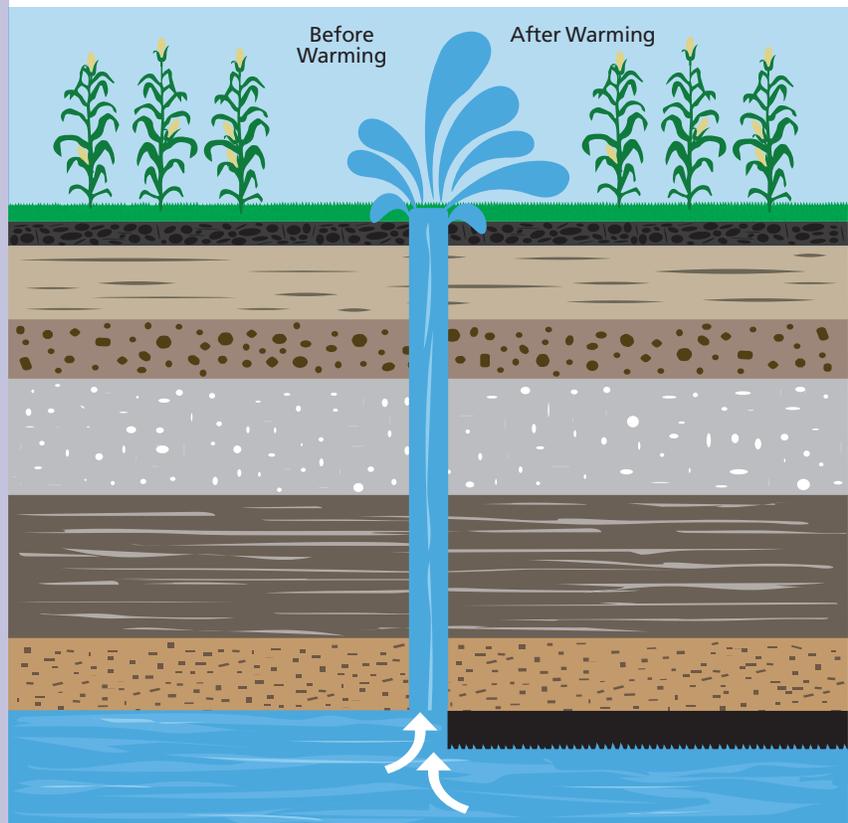
“We saw a rapid response in deep groundwater levels to both major climate cycles and local precipitation,” says Tess Russo, R.L. Slingerland Early Career Professor of Geosciences. “If it’s not natural recharge causing the response of groundwater to changes in precipitation, then it may be coming from pumping changes.”

The research sheds new light on groundwater budgets in the U.S. and better defines how water held in deep aquifers could change with the climate. Groundwater used by municipalities and industry is almost always drawn from deep wells, which provide a more reliable source of water than shallow aquifers, especially during times of drought.

Despite the importance of these deep aquifers, no one really knows how much water they contain or how they might react to climate change.

Russo and Upmanu Lall of Columbia University analyzed relationships between climate and groundwater data from across the United States, and used a small set of regional pumping data from wells in Kansas to demonstrate the potential connection.

—MATTHEW CARROLL



As average temperature rises, plants (including crops) need more water. In areas with irrigation, more water is pulled from deep underground, depleting the deep aquifers.



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## » Winter by a Nose

**B**ig, small, broad, narrow, long, short, turned up, pug, hooked, bulbous, or prominent, the shapes of our noses come from our parents, but ultimately, the shape of a person's nose evolved through a long process of adaptation to local climate, according to an international team of researchers.

"We are interested in recent human evolution and what explains the evident variation in things like skin color, hair color, and the face itself," says Mark D. Shriver, professor of anthropology. "We focused on nose traits that differ across populations and looked at geographical variation with respect

to temperature and humidity."

They considered a variety of nose measurements, made using 3D facial imaging, and found that measurements differed across populations more than could be accounted for by random genetic drift, indicating a role for natural selection in the evolution of nose shape. To show the contribution of climate, the researchers correlated the spatial distribution of these traits with local temperatures and humidity.

"The positive direction of the effects indicates that wider noses are more common in warm-humid climates, while narrower noses are more com-

mon in cold-dry climates," the researchers note.

One purpose of the nose is to condition inhaled air so that it is warm and moist. Narrower nostrils may accomplish this more efficiently, an important trait in cold and dry climates, says Shriver.

Sexual selection may also play a role. If an entire group thinks bigger is better, for example, then people with small noses will have more trouble finding mates and less success in reproducing.

—ANDREA ELYSE MESSER





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## » Consider the Cows

**T**he goal of eliminating malaria in countries like India could be more achievable if mosquito-control efforts take into account the relationship between mosquitoes and cattle, according to an international team of researchers.

“In many parts of the world, the mosquitoes responsible for transmitting malaria are specialist feeders on humans and often rest within human houses,” says Matthew Thomas, professor of entomology. “We found that in an area of India that has a high burden of malaria, most of the mosquitoes known to transmit malaria rest in cattle sheds and feed on both cows and humans.”

According to postdoctoral scholar Jessica Waite, cattle sheds are often next

to, and sometimes even connected by a shared wall to, human houses, yet current control efforts are restricted to domestic dwellings only.

The researchers determined the importance of cows in the malaria-control problem by capturing adult mosquitoes in different habitats within six villages in Odisha state. The team then used molecular techniques to determine which species they were and which hosts they had been feeding on.

Next, they used their field-collected data to build a computer model that simulated the life of an adult mosquito.

“Our model analysis suggests that conventional control tools, such as insecticide-treated bed nets and indoor insecticide sprays, are less effective

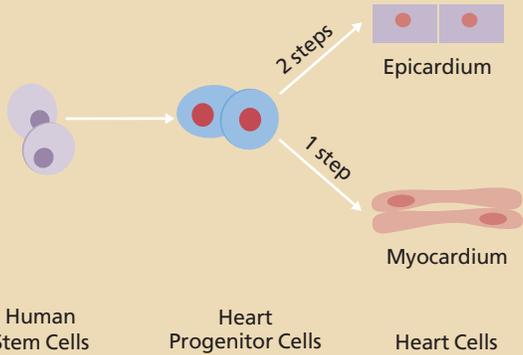


when mosquitoes exhibit ‘zoophilic’ behaviors (i.e., an attraction to nonhuman animals),” says Thomas. “However, extending controls to better target the zoophilic mosquitoes—for example, by broadening coverage of non-repellent insecticide sprays to include cattle sheds—could help reduce transmission dramatically.”

—SARA LAJEUNESSE

*Babies whose mothers are happy in their spousal relationship and have good social support are less likely to get colic.*

- CHANDRAN ALEXANDER  
Pediatrics  
&  
- KRISTEN KJERULFF  
Public Health Sciences



Kevin Carlini

Scientists can now produce two of the three main kinds of heart cells in the lab.

## A Little Piece of My Heart

Scientists at Penn State have devised a process to prompt human stem cells to develop into epicardial cells, which form the external layer of the heart.

This work extends the research team’s 2012 finding that treating stem cells with chemicals that activate and then inhibit a specific signaling pathway causes them to become myocardial cells. Myocardium, the middle of the heart’s three layers, is the thick, muscular part that contracts to drive blood through the body.

“We needed to provide the cardiac progenitor cells with additional information in order for them to generate into epicardium cells, but prior to this study, we didn’t know what that information was,” says biomedical engineer Xiaojun Lance Lian, who led the research team. The scientists found that activating the same pathway again stimulates the progenitor cells to become epicardium rather than myocardium.

Lian says the new method could benefit patients who suffer a heart attack.

“Heart attacks occur due to blockage of blood vessels,” he says. “This blockage stops nutrients and oxygen from reaching the heart muscle, and muscle cells die. These muscle cells cannot regenerate themselves, so there is permanent damage, which can cause additional problems. These epicardium cells could be transplanted to the patient and potentially repair the damaged region.”

The group’s results bring them one step closer to regenerating an entire heart wall. The last piece will be turning cardiac progenitor cells into endocardium cells, which form the heart’s inner layer.

—STEPHANIE TOMLINSON

## MEDICAID HELPS PARENTS OF KIDS WITH AUTISM KEEP WORKING <<

Medicaid waivers that improve access to home- and community-based services for children with autism also help their parents keep their jobs, according to research from Penn State College of Medicine and collaborators at the University of Pennsylvania and the RAND Corporation.

Previous research found that Medicaid waivers for children with autism spectrum disorder help their families obtain services they may not otherwise be able to afford. The new study shows another way that waivers benefit the parents of children with autism.

“When you’re spending all that time just trying to help your child, there’s less time for work,” says Douglas L. Leslie, professor of public health sciences and psychiatry, Penn State College of Medicine.

One parent often significantly reduces his or her work hours or stops working altogether, increasing financial stress on the family.

Leslie’s team used information from a national survey and Medicaid waiver data to determine how waivers affected parental employment from 2005-2006 and 2009-2010. They found that waivers allowed parents to remain in the work force and helped families at all economic levels.

Keeping these parents in the workforce goes beyond monetary considerations, says Leslie.

“Caring for a child with autism is difficult. Having an outlet through a job can be very beneficial to the parents’ mental well-being. It gets them out into the community.”

—ABBY SAJID



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*Broader updrafts in severe storms increase the chance of large, damaging hail.*

- MARK KUMJIAN  
Meteorology and Atmospheric Science



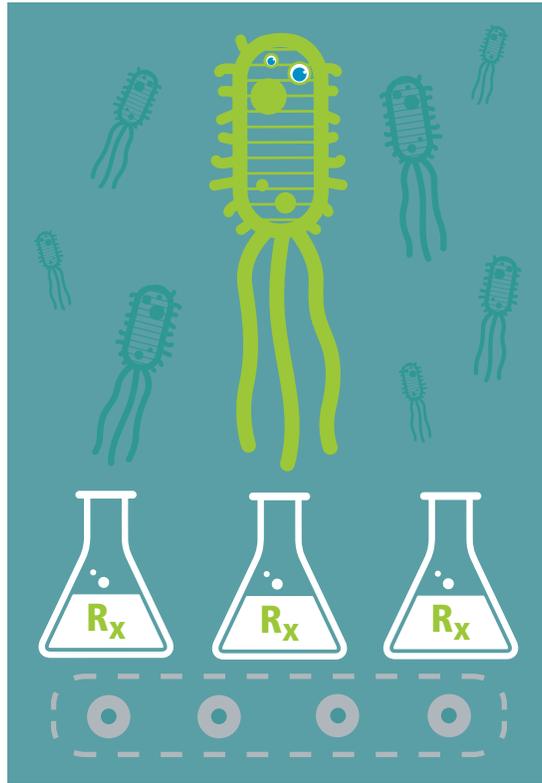
### Model Microbial Factories

The microbe *E. coli* gets a bad rap in the food industry, but in the chemical engineering field, it is one of the most important microorganisms for producing amino acids, bioethanol, vitamins, insulin, and more. Researchers in Penn State's Chemical and Biological Systems Optimization Lab have developed a kinetic model of *Escherichia coli*'s metabolic processes—a sort of blueprint showing the organism's chemical reactions, how they are controlled, and how they interact—which will allow scientists to better design microbial strains to make valuable products.

Costas D. Maranas, Donald B. Broughton Professor of Chemical Engineering, says recently-developed techniques for changing the native metabolism of microbes allow for the manipulation of several genes at the same time to turn the microbes into factories for the production of chemicals or biofuels. The key is to find the best candidates, out of hundreds of genes, to harness the organism's machinery. The new kinetic model provides this information about genetic and metabolic changes to *E. coli*. "This opens the door to testing in the computer many combinations and finding the best one before having to expend time and resources in the lab," Maranas says.

The model, called k-ecoli457, includes 457 chemical reactions, 337 metabolites, and 295 substrate-level regulatory interactions. It was developed with information on the metabolism of wild-type *E. coli* and 25 mutant strains, and is substantially more accurate than previous models.

—AMANDA JACOBSON SNYDER



Kevin Carlini

*Contrary to conventional wisdom, men and women are equally good at recognizing faces.*

- SUZY SCHERF

Psychology and Neuroscience



*Indigenous people living today in southern Alaska and the west coast of British Columbia are descendants of the first humans to live in the area, more than 10,000 years ago.*

- MICHAEL DeGIORGIO

Biology



## ATOMIC STENCILS <<

Penn State researchers have discovered a simple and effective way to "stencil" high-quality 2D materials in precise locations, overcoming a barrier to their use in next-generation electronics.

Two-dimensional materials—those a single atomic layer thick—possess properties not found in 3D materials and offer the possibility of ultra-fast electronics, computation, and other functions. Their promise has not yet been fulfilled, in part because it has not been possible to deposit them in precise locations, which is necessary to integrate them with silicon in transistors.

Materials scientist Joshua Robinson and his lab group devised a method for making precise patterns of 2D materials using common nanotechnology techniques. They start with a thin polymer over the substrate on which the 2D material will be deposited.

"We then expose it to ultraviolet light in the desired areas, and we develop it like a photograph," says Robinson. "Where the polymer was exposed to light, it washes away, and we then clean the surface further with standard plasma-etching processes. The 2D materials will only grow in the areas that have been cleaned."



The researchers also discovered a simple way to separate a 2D layer of molybdenum disulfide from its sapphire substrate, just far enough to allow the 2D material to display its own properties and not be affected by the sapphire.

"We simply tried dunking the as-grown material into liquid nitrogen and pulling it out into air to 'crack' the interface," says Robinson. That weakened the bonds connecting the 2D material to the substrate without completely setting it free.

—WALT MILLS



The research group created this approximation of the Penn State logo with their new stenciling technique. The image was just one atom thick and about 20 microns across—about one-fifth the diameter of a human hair.



Thinkstock



Artist's conception of a black hole

## » Early Black Holes

**A**n unparalleled image from NASA's Chandra X-ray Observatory is giving an international team of astronomers the best look yet at the growth of black holes over billions of years beginning soon after the Big Bang. This is the deepest X-ray image ever obtained, collected with about 7 million seconds, or 11 and a half weeks, of Chandra observing time.

The image comes from what is known as the Chandra Deep Field-South. The central region of the image contains the highest concentration of supermassive black holes ever seen.

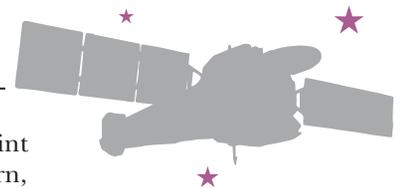
"With this one amazing picture, we can explore the earliest days of black holes in the universe and see how they change over billions of years," says Niel Brandt, Verne M. Willaman Professor of Astronomy and Astrophysics, who led a team of astronomers studying the deep image.

About 70 percent of the objects in the new image are supermassive black holes, which may range in mass from about 100,000 to 10 billion times the mass of the Sun. Gas falling toward these black holes becomes much hotter as it approaches the event hori-

zon, or point of no return, producing bright X-ray emissions.

The new ultra-deep X-ray image allows scientists to explore ideas about how supermassive black holes grew one to two billion years after the Big Bang. Using these data, the researchers showed that these black holes in the early Universe grew mostly in bursts, rather than via the slow accumulation of matter.

—CHANDRA OBSERVATORY







## SPIRITED AWAY <<

**A** Mongolian horseman gathers his mares prior to milking. Every year, from late August through late October, he and his family milk their mares four times a day to collect the raw material they ferment to make airag, a mild alcoholic beverage. Kirk French, a senior lecturer in anthropology, took this photo in September 2016, as part of his research on the social and economic impacts of small-scale alcohol production in cultures around the world. His work has taken him to sites in Mexico where locals ferment agave sap and distill whole cane sugar; Scotland, where whiskey production is a fine art; and North Carolina to interview “moonshiners.” Later this year he’ll visit Denmark to look at the role of akvavit and gløgg consumption during the winter holidays.

Photo© Kirk French



# POWER UP!

BY KRISTA WEIDNER

TOO MUCH OF A GOOD THING. THAT'S THE SITUATION MANY SCIENTISTS FACE IN THIS AGE OF BIG DATA. With sophisticated sensors and surveys gathering information all the time, everywhere, the pile of data available to researchers is growing at a dizzying pace—so fast, that in many cases it has outstripped our ability to make sense of it.

Thanks to a new data center at Penn State, researchers can now analyze huge amounts of information and complex models that were grindingly slow or impossible to handle before. The 49,500-square-foot facility hosts 23,500 computer cores. A typical desktop computer has two cores.

“The data center enables us to provide world-class computation in an energy-efficient and economical way,” says meteorologist Jenni Evans, director of the Institute for CyberScience (ICS), which is responsible for the center’s research computing component. “Instead of having computer clusters all over campus, we put it all in this secure facility where researchers can share resources.”

## PLANETS AND PARTICLES

One research group is gearing up to employ a computer cluster called the Cyber-Laboratory for Astronomy, Materials, and Physics (CyberLAMP). Led by astrophysicist Yuexing Li and funded by a \$1 million grant from the National Science Foundation, the team “includes astronomers, physicists, materials scientists, and computer scientists, working on an incredible range of scales—from nanomaterials to planets in other galaxies,” says Evans.

The computing power of the data center will help astronomer Eric Ford better understand planet masses and orbits and predict where to look for planets that might be habitable.

“Lab experiments only go so far,” Ford says. “They let us measure the temperatures at which gas condenses into ice and determine which combinations of grains, pebbles, and rock fragments collide to merge into a larger body, as opposed to bouncing off each other or shattering into smaller particles. But we can’t create a solar system in a lab.”

What he and his team *can* do, with help from the data center, is integrate what they know about basic physics into computer models that simulate planetary system formation.



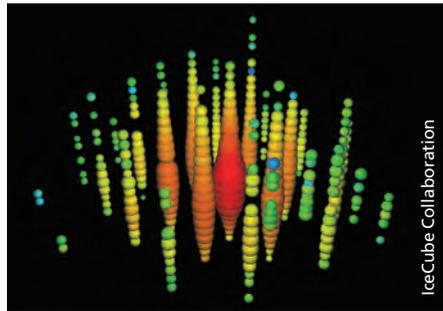
Evidence of a neutrino: Data from the IceCube project that detects neutrinos as they collide with matter on their way through Earth.

“We can compute predictions of different models for planet formation and compare those to observations to test hypotheses for how planets are formed,” Ford says. “The CyberLAMP cluster will let us create much more sophisticated simulations with much greater realism.”

At the other end of the scale, fellow astronomer Doug Cowen will soon start using CyberLAMP to study neutrinos, the smallest sub-atomic particles known. Sometimes called “ghost particles,” neutrinos are everywhere in the universe, and understanding them can help scientists answer fundamental questions in physics. Cowen is a member of the international IceCube project that uses neutrino detectors embedded up to 2 kilometers deep in Antarctic ice.

“Cosmic rays crash into our atmosphere, and in those cosmic ray showers you have neutrinos,” he says. “Most of them keep going straight through the Earth, but rarely, some interact with matter in our detector and produce tiny amounts of light.”

The South Pole ice cap—where the crystal-clear ice allows even the tiniest flashes of light to be detected—serves as an ideal spot to record these rare interactions. The data center’s 100 graphic processing units (GPUs) will allow Cowen and his colleagues to rapidly analyze more neutrinos, in much finer detail, than has been possible before. “Right now, if we want to reconstruct one year’s worth of data, it takes a couple of months,” he says. “It will be an enormous benefit to shrink that down to a few days.”



IceCube Collaboration



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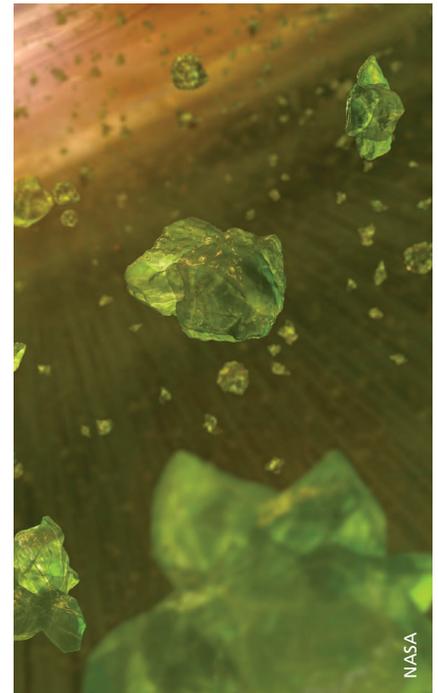


Penn State’s new data center is helping us understand how changes in a natural system such as rainfall affect human systems such as agriculture and energy.

### MELDING MODELS

The data center’s ability to integrate data and models from many sources is essential to a multi-institution project headed by Penn State and Stanford University. Funded by a \$20 million U.S. Department of Energy grant, the Program on Coupled Human and Earth Systems aims to develop tools to assess how stresses in a natural system—such as a major hurricane or drought—or a human system—such as dramatic population growth—affect other systems, such as energy infrastructure, water supply, and food production.

“Current models for understanding the impacts of climate-related variability or other natural disasters deal with their effects on one or a few parts of other systems,” says economist Karen Fisher-Vanden, Penn State’s lead investigator on the project. “Our project



NASA



Artist’s conception of crystals of the mineral olivine near a brown dwarf star. Such crystals are thought to help seed the formation of planets.

emphasizes the interconnectedness of all the systems, and how stresses on one can reverberate through all the others. To do that by combining our standalone models from different fields would be a computational nightmare. Our goal is to create a state-of-the-art framework of computational tools that allows us to model the interconnected ‘system of systems,’ so sharing data across all those fields will be seamless.”

ICS director Evans expects the data center to play an ever-expanding role for Penn State researchers in coming years. “Sciences such as astronomy and meteorology have a history of using Big Data,” she says. “Now, new instrumentation and data availability are bringing new research areas, such as biology and political science, into the Big Data venue. The data center will continue to be integral as it provides an incredible leveraging of shared computing facilities.”



Kiya Riverman looks down into a glacier before rappelling in to study how meltwater carves canyons in the ice. See photo on page 1 for a look inside such a canyon. © Alexis Fagnoni

Penn State glaciologists are at home on the ice

# SOME LIKE IT COLD



As graduate student Kiya Riverman plants her crampons into solid ice, she inspects the surrounding walls. No cracks, so she knows she is safe here. She unhooks her carabiner from the rope used to rappel fifty feet down into the ice cave where she now stands, inside a glacier on the Norwegian archipelago of Svalbard. She pulls out a scratch pad and pen and begins sketching the shape of the tunnels before her, tunnels carved by water melting at the glacier's surface and cutting its way down, forming deep canyons whose walls later closed in above them.

Nearly 4,000 miles away, senior scientist David Pollard sits at his desk on the University Park campus, next to whimsical pictures drawn by his children, and types numbers into his computer. He hits Enter to start a simulation which, after it finishes running in several days, will yield the most accurate prediction yet of what Antarctica's ice sheets will look like in 500 years. Pollard's model shows how the warming from increasing greenhouse gases will melt large portions of the ice sheet that now caps the pole, and how that meltwater, dispersed into the ocean, will contribute to a rise in global sea level.

The explorer and the modeler. They work in very different modes, yet Riverman and Pollard share a passion for understanding what makes glaciers and ice sheets move, shrink, and grow, and their efforts are closely linked. Both are members of a cadre of scientists known as Penn State Ice and Climate Exploration, or PSICE.

Riverman's goal in exploring ice caves is to track the path of glacier meltwater as it descends from surface to bedrock. Once it meets bedrock, this water can provide lubrication that speeds the glacier's slide toward the sea. The data Riverman collects are an invaluable commodity for computer modelers like Pollard. His work, in turn, can determine what Riverman or another explorer will look for next.

This close collaboration between modelers, observational scientists, and others focused on the ice has allowed PSICE to make a number of significant advances in glaciology since its formation in the early 1990s.

## BRIDGING BOUNDARIES

The PSICE group originated when Charles Hosler, then dean of Earth and Mineral Sciences, created the College's Earth System Science Center. Hosler and his successor, John Dutton, helped lay the groundwork for researchers to pursue a broad, holistic approach to understanding how Earth's systems—air, ocean, water, ice, and more—function naturally, and how human activity might be affecting those systems. They hired climate scientist Eric Barron, now Penn State's President, as the center's first director. One of Barron's first hires, in turn, was a young glaciologist named Richard Alley.

"He was working to assemble a broad-based, comprehensive group of Earth system researchers, and wanted coverage of ice," says Alley, now Evan Pugh University Professor of Geosciences. "I was hired to provide that."

by Liam Jackson



Alley had cut his teeth, glaciologically speaking, on Greenland ice cores, tubes of ice the diameter of a two-liter soda bottle that totaled two miles in length and had been painstakingly drilled from the Greenland ice sheet beginning in 1989. These cores, composed of layers of snow accumulated and buried over thousands of years that gradually densified into ice, provide a unique window into the history of Earth's climate.

As a graduate student, Alley had gone to Greenland to help learn where to drill, and soon after arriving at Penn State he was part of the team that extracted the cores. He and several collaborators then developed a more accurate method for dating the cores, vital to establishing a record of changes in snowfall, temperature, and other parts of the climate over more than 100,000 years.

One of the major revelations to come out of the ice core data was that Earth's climate can change drastically in a relative heartbeat. "We've seen changes from a climate like that of northern Alabama to conditions similar to southern Maine that occurred over a period of about ten years," Alley says.

When he started in the field, atmospheric carbon dioxide levels were not considered a matter of pressing urgency. Today, as the Earth's warming intensifies due to carbon dioxide and other greenhouse gas emissions, it's becoming imperative for glaciologists to understand what that warming means for the future of ice sheets, glaciers, and the world's oceans.

### ALL IN THE FAMILY

In 1992, the PSICE group doubled when Sridhar Anandakrishnan joined as a research scientist working with Alley. Now a professor of geosciences, Anandakrishnan uses his background in electrical engineering to develop devices that can monitor subtle changes in the ice sheets using a combination of seismic and radar waves, GPS coordinates, and other data. His networks of devices have provided researchers a way to see through glaciers without cutting into them. The two have continued to build the group in the years since, adding a half dozen research-

ers with complementary skill sets. "PSICE studies how ice interacts with the land, how ice interacts with erosion, the properties of ice as a material, and ice as a historical archive," says Alley. "But our main focus recently has been to understand how ice is a driver of sea-level rise."

It takes a special brand of hardiness to sign on for a three-month season in Antarctica or Greenland, to live in a tent and work on the ice, long grueling days at the mercy of sun and wind and cold.

"When the wind blows it is unrelenting; there's nothing to stop it," writes Don Voigt, a senior research associate and veteran of 18 seasons on the ice. "It's a rare opportunity to have sunburn, windburn, and frostbite all at the same time."

Not surprisingly, then, the team's members share a special bond. Their energy and camaraderie, Riverman says, is what drew her to Penn State in the first place. "It's a dynamic group of people who are excited about figuring out how this part of the world works," she says. "We meet every week for pizza, spit-balling ideas. It's science at its finest. I came to one of those meetings and I knew I wanted to come study here."

Alumni from the group, now scattered around the world, continue to collaborate with Alley, Anandakrishnan, and other PSICE researchers. Riverman, who received her Ph.D. in May 2017, plans to do the same.

"Richard and Sridhar have built a glaciology family that keeps on growing," she says.

### HISTORY ON ICE

As Anandakrishnan sees it, a glacier is like a diary.

"It writes down in its body all the dirt and dust that fall on it. All the gases that it's 'breathing,' if you will, and

all the temperatures it's experiencing," he says. "We can go back and read that diary, page by page, and we can say 'here's when it was dirtier,' or 'this ice over here is radioactive, so it could have been from years right after World War II.'"



(Top) Sridhar Anandakrishnan. (Bottom) Research associate Leo Peters lays down seismic sensors on Greenland's Jakobshavn Glacier.

Fresh ice near the surface traps bubbles of gas, which provide even more insight into Earth's past.

"You can pull the bubbles out and put them into a gas analyzer as you would with air today, and that's a powerful tool that's unique to glaciers," Anandakrishnan explains. "With most Earth systems, animals breathe gases, or use oxygen and interact, so you don't have a pristine view of what the air looked like. But there are no animals on ice sheets. Once snow and air and dirt are captured in ice, they're there forever." Senior scientist Todd Sowers, another PSICE member, analyzes the gas from frozen bubbles to build long and exquisitely accurate histories of the composition of past atmospheres.

The bubbles can be used in other ways as well, as Alley realized when working with Matthew Spencer, a graduate student during the early 2000s. The density of bubbles in an ice core, for example, provides a gauge of temperature and other factors.

Alley and Spencer developed a method for gathering information from air bubbles without destroying them in the process. Other innovations the team has developed build on existing data-gathering techniques, such as GPS, radar, and satellite imagery. Recently, geosciences grad student Nicholas Holschuh worked with PSICE members to devise a better way to use radar data to map the interiors of ice sheets. "The way a radar wave refracts tells us something about the nature of the ice through which it's traveling," Alley says.

As new approaches help to fine-tune our understanding of how glaciers change and move over different time scales, the PSICE team is finding, to its surprise, that the path to understanding the future of Earth's glaciers lies in combining understanding of short-term changes with the earlier work on long-term factors such as ice ages.



Courtesy of Richard Alley

Richard Alley

Flags mark spots on the Jakobshaven Glacier where a PSICE team later set off explosive charges to fire sound waves down through the ice. Reflections of the sound gave researchers information about thickness of the ice and stickiness or fluidity of the bed below it. Photo by Don Voigt.

**"It's a rare opportunity to have sunburn, windburn, and frostbite all at the same time."**





**A glacier is like a diary. "It writes down in its body all the dirt and dust that fall on it."**

Don Voigt examines melt layers in a shallow core from the West Antarctic Ice Sheet Divide, where he was Chief Scientist overseeing the operation. Courtesy of Gifford Wong.

## ON THE MOVE

As snow accumulates on a glacier, the glacier is pushed by its own weight outward or downward, toward the sea. The conventional wisdom is that this movement takes place over extended time periods—"at a glacial pace," as it were. But the phrase is a misnomer.

"There are two ideas that come out of that phrase—that glaciers' movement is slow, which is not true, and steady, which is also not true," says Anandakrishnan. "In some places their movement is steady and slow, but what we've found is that as the glacier approaches the edges of the continent it sits on, it starts to flow faster."

Anandakrishnan was one of the first glaciologists to confirm that glaciers undergo change over periods of hours as well as centuries. He and his team had set up a network of GPS monitors in West Antarctica to track the movement of glaciers. West Antarctica is a rapidly changing area of the continent covered with an ice sheet so vast that, if it one day collapses into the ocean as some scientists predict, it could raise global sea level by as much as 13 feet.

He and his colleagues noticed that Bindschadler Ice Stream, a fast-flowing river of ice in the area, would move and then suddenly stop at regular intervals. As they began to pore through their data, the team noticed an odd correlation—the changes in speed were linked to the tides. Specifically, when the tide comes in it pushes on a glacier, sometimes enough to stop its movement entirely.

"It's a relatively small force," says Anandakrishnan, "but we found that it was enough to change the speed of these glaciers quite a bit, not just at the coast but also far inland."

Not all glaciers stop dead in their tracks in response to the tides, however. Some are barely affected at all.

The difference has to do with how "slippery" glaciers are, Anandakrishnan says. The giant masses sit on a material that isn't just solid rock. As a glacier moves, it breaks off pieces of the bedrock, which gets turned into a muddy mix with help from subsurface heat and friction and meltwater from above.

"If the bedrock is very bumpy, the force is dissipated due to frictional influences," Anandakrishnan says. "It's like pushing a person in sneakers compared to someone on roller skates."

The PSICE group has also made headway in understanding the effect of meltwater lakes, pools that form when the sun melts the surface layer of ice and snow. This meltwater then drains through the ice sheet to the bed. Its path down through the ice can have varying effects on the speed and "slipperiness" of a glacier.

"We came up with a theory on how surface meltwater can drill its way through a thick, cold ice sheet and then did some modeling to see what type of impact this process of lubrication could have on the long-term evolution of the Greenland Ice Sheet," says Byron Parizek, associate professor of mathematics and geosciences at Penn State DuBois and part of the PSICE team.

"We predicted relatively minor changes unless the meltwater accessed the bed in regions where the ice was frozen to the bed." Subsequent observations by other scientists have thus far confirmed that the impact of surface meltwater on ice flow speeds in Greenland is not as straightforward as the old adage "just add water."



To test the meltwater penetration-mechanism hypothesis, Sarah Das, a former PSICE grad student, traveled to Greenland to witness a drainage event. The amount of water she saw draining was staggering—“twice the volume of Niagara Falls in less than one hour,” says Alley—and the team was able to confirm its hypothesis.

## AN UNCERTAIN FUTURE

What ice sheets will look like 10, 50, or 100 years from now—and whether they will disappear into the sea as Earth continues to warm—is a question at the forefront of climate science. To try to answer it, glaciologists rely on computer models that simulate future climate—models informed by observations from the field.

For years, David Pollard had been working on a model that simulates both Antarctica’s past and its future. Replicating past conditions on Earth, which scientists can confirm from ice cores and other evidence, is critical for ensuring that a model is accurate.

Pollard was struggling to get his model to conform with some aspects of the historical record, when he heard Alley describe for the first time the huge ice cliffs that would arise if the margins of the West Antarctic Ice Sheet continued to retreat deep into the interior, where the bed is far below sea level but thick ice towers far above. “This led us to add large ice cliffs that can fail structurally into our model,” Pollard says.

These failure events result when the ice can’t support its own weight. A giant chunk falls off into the ocean, exposing a new cliff face. When Pollard and his collaborator, Robert DeConto of the University of Massachusetts, incorporated cliff failure and hydrofracturing, the effects of water wedging open cracks the way Sarah Das’s lake did in Greenland, into their model, they were able to simulate documented levels of past sea level rise. Theirs was the first model to do so.

That same model drew a lot of attention last year when Pollard and DeConto applied it to the future and published

results of a simulation suggesting that, given a continuation of current trends, global sea level could rise by up to 50 feet by the year 2500, with ice crumbling from the larger East Antarctic ice sheet as well as West Antarctica.

Such a change, though catastrophic, would not be unprecedented. “In past ice ages, global sea level has dropped and then risen about 100 meters with the growth and then shrinkage of huge ice sheets over North America, Europe, and Asia,” says Pollard. “The question is, how much will the remaining ice sheets melt and raise sea level over the next thousand years?”

It’s a complex question, one whose answer will require both ingenuity and a mix of minds. Parizek says that the PSICE group’s accomplishments over the years are an ongoing example of that.

“Every time someone comes back from the field with a new data set, we look at and interpret it to see if we have accounted for the physical processes in our models that likely led to the unexpected behaviors in nature,” he says. An updated model, in turn, can suggest a new direction for experiments in the field.

This accumulation of small, complementary steps and varying perspectives adds up to a growing understanding of how ice sheets and glaciers change over a day, a year, and a century. And an understanding that stretches across these multiple timescales, PSICE scientists believe, will be key to predicting how much and how quickly the ice sheets will contribute to sea-level rise.

“Right now we’re trying to reduce the uncertainties by learning more about the flow of the ice in Antarctica,” Alley says. “Then we can get together and make informed decisions about the best solution.”

“It’s a zero-sum game between oceans and glaciers,” adds Anandakrishnan. “Every time you change the size of a glacier, it will immediately affect sea level. There’s nowhere else where this water can go.”



Patrick Mansell



Patrick Mansell



Don Voigt



Byron Parizek (top) and Dave Pollard (center) use field data to refine their models. Parizek’s addresses how lubrication from meltwater affects glacier flow. Pollard’s predicts how much sea level is likely to rise as great ice sheets melt into the ocean.

remote  
technologies  
help biologists  
predict disease  
outbreaks

# moving targets

BY JOHN TIBBETTS

**e**ach autumn in the Sahel, a vast band of grasslands just south of the Sahara desert, seasonal farmers and their families move from their farms when the long dry season begins. Many travel long distances to large towns and cities where they squeeze into already crowded districts, finding spaces in extended family compounds or temporary sites on the city's edges.

In places like Niamey, capital of the West African nation of Niger, the dry season also brings measles. Every autumn, a fresh outbreak. When the rains come in spring and the people return to their farms, measles cases drop off abruptly.

Was the virus itself affected by weather? Or, as researchers suspected, were the outbreaks related to the influx of seasonal migrants? Measles, after all, is highly infectious; it flourishes under crowded conditions. But with no good way to track the changing population in a densely populated place like Niamey, they had little chance to test their hypothesis.

Nita Bharti, now an assistant professor of biology at Penn State, began working on this problem as a postdoc at Princeton. "We knew these places had very important and predictable fluxes in population," she says, "but no one had ever found a way to measure those changes."

Bharti first looked at infectious disease as an anthropologist, with a focus on the role of behavior on epidemiology. When she began her Ph.D. research in biology at Penn State, she found that human behavior, especially long-distance movements, had been somewhat neglected as an important driver of infectious diseases.

She and geographer Andrew Tatem, who was then at the University of Florida, devised a novel method to measure fluctuating populations. They used satellite images of nighttime lights, a data source that had been previously used to create composite images over large periods of time in order to study urbanization and economic development, but had never been analyzed across shorter time scales or applied to predicting disease outbreaks.

When large numbers of migrants moved into Niamey, they reasoned, the nighttime city would appear both brighter and larger in satellite imagery, reflecting the increased number of cooking fires and electric lights associated with a swollen population. When seasonal migrants left the city to return to agricultural areas, the nighttime images of the city would dim to reflect a reduced population

size. By comparing satellite images over time, they were able to estimate population changes, and then correlate those changes with public-health records of measles outbreaks. This provided a more precise understanding of the links between human movement and disease, and could in turn help them to more accurately predict future outbreaks.

As a graduate student, Bharti had begun collaborating with fellow biologist Matthew Ferrari, who was then a post doc and is now an associate professor at Penn State. Ferrari, a specialist in quantitative epidemiology, developed a way to estimate transmission rates of measles at different times, including during the spikes in urban populations which Bharti could now measure.

"I count things—that's what I do," says Ferrari. "I count people because we need to know where populations are, how large those populations are, how often they move, and where they are going. When are places experiencing high population density, at which times? These factors not only influence the incidence of infectious disease but also the effective functioning of the health system."

## POPULATIONS AT RISK

"Because measles is so infectious and potentially deadly, it's an important disease for aid and development organizations to study," he adds. "Measles is relatively easy to diagnose, and easy to see in health surveillance data. Because it's so transmissible and visible, it is a bit of a 'canary in the coal mine'—if you see a place that is having measles outbreaks, then you know their immunization system is not working."

Migrant families frequently live beyond the reach of conventional health care; the Sahel is no exception. Many children are malnourished, unvaccinated, and suffering from weakened immune systems. When these families move into the cities, public health authorities often don't know how many have come and which urban districts they are staying in.



**“These are the kinds of places where vaccine-preventable diseases persist. They are also places where well-timed interventions may do the most good.”**



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Migrant families are also often overlooked by population censuses, health surveys, and vaccination campaigns. The small villages where they spend the growing season can be difficult to reach and sparsely populated, making them strategically low risk or low priority. However, these families may, for at least part of the year, constitute a significant portion of the population in nearby cities. “These are the kinds of places where vaccine-preventable diseases such as measles persist. They are also places where well-timed interventions may do the most good,” says Bharti.

In a 2016 study, Bharti, with Ferrari and other colleagues, developed a model that combined the population estimates they derived from satellite imagery with health care data—such as the timing of measles cases, deaths, and vaccinations—from three municipal districts of Niamey in the winter of 2003-2004. During that outbreak the city experienced 10,880 measles cases and 397 deaths from the disease.

Bharti’s previous work using satellite imagery had conclusively shown that measles outbreaks in Niger’s big cities were not driven by some characteristic of the measles virus itself or some other physical or biological cause. Instead, outbreaks spread rapidly because of those predictable seasonal spikes in population.

In the 2003-04 event, Niamey’s public health authorities had undertaken a vaccine campaign during the dry season, when measles cases typically take off. But the campaign did not work as effectively as expected. Public health officials had calculated that the vaccination effort, together with existing measles immunity, would reach 57 percent of the combined seasonal and resident population of children under five, a high enough coverage to halt the outbreak. But they had underestimated the total size of the target population.

Reviewing the satellite data, the research team found that there were 11,000 to 17,000 more young children present in the city during the outbreak than had originally been estimated—a result of the influx of migrant families. That meant only 50 percent coverage—too few children vaccinated to effectively slow the spread of disease. The team’s retrospective

estimates matched actual measurements of campaign coverage made following the outbreak.

Now that they’ve proven their method works, they are eager to use it to better target public health interventions for other highly communicable diseases where fluctuating populations play a role. Rather than seeing times of high population density only as a time of high risk, Bharti suggests, public health officials could take advantage of them.

“We could use migrants’ time in the city as an opportunity,” she says. “That’s when immunization and health care are most accessible to them and easier for governments to provide.”

### **A PHONE CALL AWAY?**

Satellites are an established technology, and satellite images are especially good at offering insights from the past to predict large-scale population movements. Bharti and other researchers are also exploring a much newer technology—mobile phones—to track finer-scale movements of small groups of people across remote regions in order to be able to reach them with vaccines and other health care interventions.

In sub-Saharan Africa, many people carry cell phones. Each time an individual places a call or text, that usage, along with the location of the routing tower, is recorded by network operators for billing purposes. Researchers can analyze sequences of calls or texts and their locations for large numbers of individuals with their identities concealed.

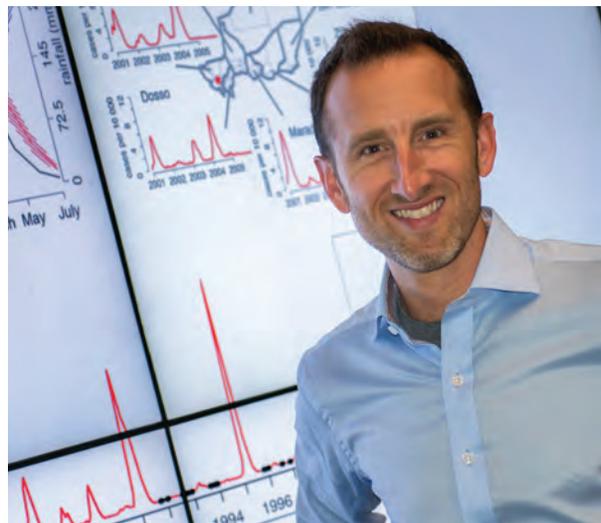
Phone data are great for big cities, Bharti says. But will they work in underserved, under-resourced areas where data and health care are scarce? That’s why she is studying pastoral villages in the desert of Namibia, whose inhabitants migrate with their herds of livestock in pursuit of suitable grazing land. These pastoralists live and roam across vast desert areas beyond the reach of government health services.

Mobile call traces could be useful to track this population, but phone data have inherent biases, Bharti says, and these must be factored in.



Nita Bharti

Bharti wrote a program to convert the brightness of nighttime lights, as recorded by satellite, into population density, shown here as spikes above cities and towns in Niger. The tallest spike is over the capital, Niamey. Ferrari's interest in immunization began in grad school, when the aid organization Doctors Without Borders asked him to work on a measles project. "Once I got into it, I was hooked," he says. Photos by Patrick Mansell.



Matthew Ferrari

"We've found that less than one third of the adult population in these villages has ever used a phone, and far fewer own a phone. Additionally, very few locations in the large desert have network coverage," she says. Moreover, "Men are far more likely to own and use phones, and they are more likely to be the herders. Women are more likely to work near their homes."

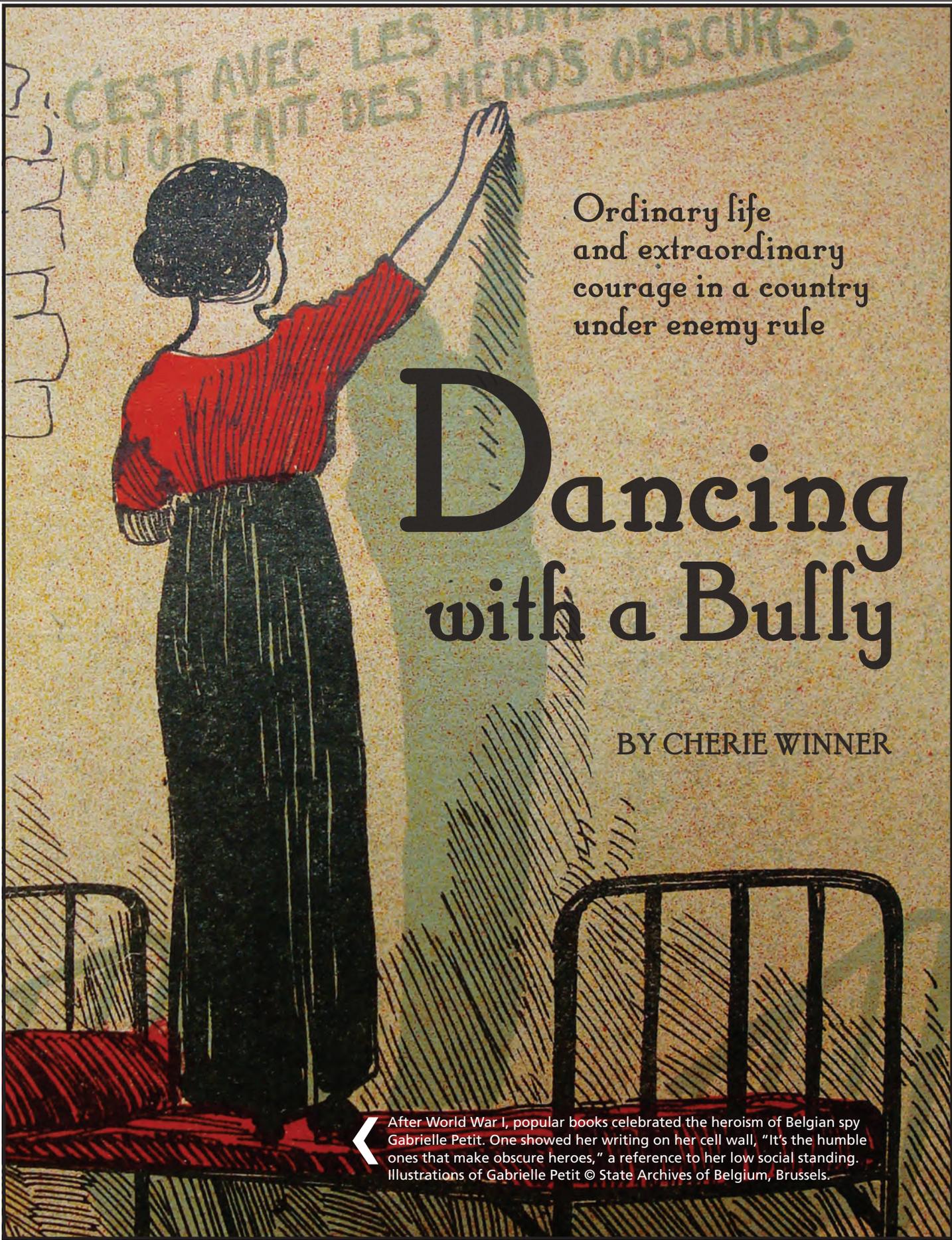
In other words, "Mobile phone usage data do not provide an accurate picture of this population, so we can't use them assuming that they're representative. But they're a great resource and we don't want to throw out a data source that we could use if we could simply interpret it better."

Bharti is currently using video footage shot by drone and household survey data she has collected to compare against phone records, in order to account for the biases in the phone data and interpret it accurately.

As researchers like Bharti and Ferrari work towards the global elimination of measles and other scourges, they rely on remote technologies to pinpoint the last stubborn reservoirs of disease, the areas that are the most difficult and expensive to reach. These reservoirs, says Bharti, "persist in populations that we're not measuring accurately, or where we're using remote technologies without understanding their biases."

"We need to develop better tools and better understanding of these cultures to learn what we're missing."





Ordinary life  
and extraordinary  
courage in a country  
under enemy rule

# Dancing with a Bully

BY CHERIE WINNER

◀ After World War I, popular books celebrated the heroism of Belgian spy Gabrielle Petit. One showed her writing on her cell wall, "It's the humble ones that make obscure heroes," a reference to her low social standing. Illustrations of Gabrielle Petit © State Archives of Belgium, Brussels.

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**I**n Europe in the summer of 1914, war loomed. What started as a sabre-rattling between Austria-Hungary and Serbia quickly escalated into a continent-wide war. Belgium, however, remained neutral; its independence guaranteed by an international agreement, the small country tucked between France and Germany had no quarrel with either side.

That changed when Germany tried to use the low-lying Belgian farmlands as a quick route to Paris before Allied forces could fully mobilize. “Then, of course, Belgium *became* a belligerent,” says Penn State historian Sophie De Schaepdrijver. “The Belgian army fought to defend the country.” In early August, in the first battle of the First World War, Belgium’s army fended off the Germans at the southeastern city of Liège long enough to delay the quick-strike strategy.

Belgium’s defiance helped Paris, but it also consigned Belgian civilians to years of occupation by German soldiers. Every invader from the Romans through Napoleon had set up an administration in its conquered territories, but this occupation was different: The occupier had not yet won. The armies became mired along a front across northern Belgium and France that stayed much the same for the duration of the war. Fighting raged just a few dozen miles from Belgian cities, and the Germans were understandably jumpy and mistrustful. There was still a chance they could lose.

So civilian life went on, but under the control of a foreign power “within the soundscape of the guns,” as De Schaepdrijver puts it. “The question is, to what extent *does* life go on? It’s not all repression and it’s not all coercion. In some cases, if you know how to deal with the occupying army, you can still maintain some kind of routine. So it’s actually a kind of dance—but it’s a dance with a bully.” She pauses, considers.

“And you dance with a bully at your peril.”

### TALES TO TELL

As a native of Belgium herself, De Schaepdrijver (pronounced “sharp-driver”) would seem like a natural to explore the country’s role in World War I. But the Great War wasn’t talked about when she was growing up. Her paternal grandfather, who fought in the war, and her father, who might have been a conduit for his stories, died when she was very young. School was silent on the subject. “I never heard a word about the First World War, not in school, not at university, even though I was a history major,” she says. “It was a war that at that time, very few people were interested in.”

For one thing, she says, Belgians’ sense of their history had become increasingly segregated between French- and Dutch-speaking populations. Today, says De Schaepdrijver, “You basically have two political universes, and the dogma is that there is nothing in Belgian history that pertains to both linguistic groups.”



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Gabrielle Petit, photographed not long before her arrest for espionage.  
© Royal Museum of the Armed Forces and Military History, Brussels, Belgium.



In addition, the academic study of history in Belgium had long avoided a narrative approach in favor of “serious” sources and quantitative analysis. “The notion was that you can’t use literary sources such as diaries,” she says. “You can only use what you can measure.” She wrote a numbers-heavy Ph.D. thesis on city growth and migration in the mid-1800s. After defending her thesis at the University of Amsterdam and publishing her first book in 1990, she thought of taking her interest in the history of cities into the 1700s. But a publisher friend suggested she move in the opposite direction.

“He said, ‘There is no book on Belgium in the First World War, although Belgium is so crucial to the war and the war is so crucial to Belgium.’ It took a Dutch publisher to point this out to me. I’m still grateful to him for that.”

Her 1998 book on Belgium in the First World War (published in Dutch and later in French) examined the war’s impact on an entire society. Marking De Schaepdrijver’s shift to a cultural approach that favored “unimportant” sources such as ordinary people’s diaries, it became a best-seller and has gone through 35 printings so far. “There was clearly a yawning demand for that kind of thing,” she says.

Her 2014 book, *Bastion: Occupied Bruges in the First World War*, illuminated the role of that Belgian city as a base for German submarine warfare, and what that meant for its inhabitants. She also got involved with “public history” projects such as writing and presenting a prize-winning television documentary and curating historical exhibits. Over the years, she came across intriguing hints about other stories just waiting to be told. One of those involved Gabrielle Petit, a young woman who spied for the Allies and became a folk hero after the war, a symbol of Belgian resistance to tyranny. While visiting a monument to Petit in Brussels, De Schaepdrijver says, “Suddenly it came to me, this is the first time that a working-class girl is commemorated like this. It’s the first monument in European history to a contemporary woman of no social status.”

Although Petit no longer seemed part of the national identity, De Schaepdrijver sensed that her story would be a rich one. “I still have the Post-it® where I wrote to myself, ‘Must write her book!’ And so I did.”

## BORN TO SPY

Gabrielle Petit doesn’t seem to have been tempted to dance with the German bully or any other. Whatever degree of defiance she had by nature, her upbringing accentuated. She was born into a middle-class family, but her mother’s early death left her in the care of her ne’er-do-well father, who soon placed Gaby and her sister into orphanages. After that he offered little financial support and nothing in the emotional realm.

In her 2015 book, *Gabrielle Petit: The Death and Life of a Female Spy in the First World War*, De Schaepdrijver drew on the meager evidence available to sketch Petit’s early life and her development into an effective spy.

“A lot of words have been attributed to her, but there was very little in her own hand, just a few scraps,” she recalls—and most of the accounts published soon after the war were shaped by the need for a hero and a heroic view of the nation. “You have to check, ‘can we trust this, can we trust that?’ I made the search for evidence a part of the story.”

At her orphanage school, Petit was a bright student with a troublesome reputation for resisting authority and rules she thought were unfair. She aspired to become a governess, a position that would require further schooling and impeccable recommendations, but at age 14 she took a stand that got her expelled from school and placed that option forever out of reach: She refused to snitch on a classmate she felt had been unjustly accused of a minor infraction.

“I found her profoundly engaging, sometimes infuriating—this high school dropout who could be a total drama queen but at the same time a great stoic, and who could be pretty silly and extraordinarily intelligent, and who was all of those things at once,” says De Schaepdrijver.

For the next few years Petit marked time in jobs that offered little opportunity for improving her situation. The German invasion galvanized her. She ran errands for the nascent underground, and in 1915 she was recruited by British intelligence operators. Her audacity and keen sense of justice, which had led to nothing but trouble for her in the confines of life as a discarded child, became valuable assets. She went to London for two weeks of training, and immediately upon her return started reporting on the movement of troops and matériel through train stations in western Belgium and northern France.



Petit faces the firing squad, as depicted in a postwar booklet. In reality, she wore the long coat shown on previous page and no flower in her hair.



◀ Governess Mary Thorp with the three sons of the Wittouck family. Courtesy Oxford University Press.

▼ An entry in Mary Thorp's diary describes a friend's visit to a German prisoner-of-war camp: "When the Van den Brandens and Carola go to see their sons, prisoners at Liège, only one person is allowed in, & only for 5 minutes. The other day they saw a woman have her baby of 3 months old, thrown on a table while she "ein person" was allowed in alone to see her husband." © In Flanders Field Museum, Ypres, Belgium.

*When the Van den Brandens & Carola go to see their sons, prisoners at Liège, only one person is allowed in, & only for 5 minutes. The other day they saw a woman have her baby of 3 months old, thrown on a table while she "ein person" was allowed in alone to see her husband.*

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By all accounts, she was a very good spy—accurate, detailed, tireless. But the Germans were cracking down on the resistance and infiltrating the spy networks. Petit was arrested on February 2, 1916. She was tried on March 2 and sentenced to death. Throughout her trial and imprisonment she refused to name her contacts. She also refused to ask for leniency. "I want to show them that I don't give a damn," she wrote on the walls of her cell, a German witness would later recall. After the war, those promoting her as a heroine would leave these un-ladylike words out of Petit's story.

Execution was usually carried out shortly after sentencing, so as her stay in prison lengthened, Petit began to think she would be spared. But the delay was merely procedural. Six months earlier, occupation officials in Brussels had executed English nurse Edith Cavell for helping Allied soldiers escape Belgium. International condemnation had been fierce. "After that it was determined that if another woman was ever on death row, Berlin would have to decide," says De Schaepdrijver.

Not just some official in Berlin, but Kaiser Wilhelm II himself. De Schaepdrijver recalls the moment when, looking through a box of documents in a German archive, she struck gold.

"Sometimes you have these discoveries, like, 'No, I can't believe it!'" she says. "I found the actual telegram from the Emperor saying 'You can proceed with the execution.'" It was dated March 27. Petit was killed by firing squad on April 1.

## **BUTTER AND SOAP**

Several months after Petit was shot, another woman in Brussels began keeping a diary. All five volumes of it, from autumn 1916 through the end of the war, had been in an archive in Belgium since the 1980s. De Schaepdrijver had known of the journal for some time, "but nobody knew who had written it or recognized its value as a record of life under occupation," she says.





Belgian refugees arrive in Paris soon after German troops invaded their homeland. "In 1914, one in seven Belgians was on the road, was a refugee," says De Schaepdrijver. "You see the exact same stories we see today—people packing their few belongings, losing their children on the roads, people dining on roots." © Bain News Service.



German troops drove toward France through the Belgian lowlands, hoping to capture Paris quickly. But Allied and Belgian forces stopped them at what became the Western Front, which ran close to the French-Belgian border. Belgian civilians were trapped on the German side of the front for the duration of the war.

Thinkstock

Finally, in 2015 the temptation became too much. With colleague Tammy Proctor of Utah State University, De Schaepdrijver decided to publish the diary. Armed with only an address in Brussels associated with the document, she set out to track down the writer, combing through century-old paper records because none of the information had been digitized.

"My one clue was that the author knew English," she says—and in fact, appeared to be a native English speaker. De Schaepdrijver searched the census records looking for potential candidates. "That's when I saw there's an English governess at that address," which turned out to be the home of a prominent Brussels family, the Wittoucks.

With the name of the governess in hand, De Schaepdrijver went to the foreigners' registers—ledgers listing all foreigners living in Brussels. "Sadly, there was no picture," she recalls, "but there was her signature. I compared that to the handwriting in the diary—and concluded it had to be her."

The writer was Mary Thorp, who had been born in England to English parents but had lived in Belgium since childhood and had friends from the U.S., Russia, Austria, and France, which gave her a keen international perspective. In her journal she noted her efforts to get letters to friends nearer the front or in other countries, and the ever-more-challenging task of obtaining food, blankets, soap, and shoes.



Sophie De Schaepdrijver

She recorded the forced deportation of Belgian men to work in German factories, and, almost every day, the blasts of artillery shells at the nearby front.

Rarely mentioning her own discomfort, she went out of her way to help others who were suffering more. Whenever she obtained butter or good soap, rare treats during those years, she parceled them out to acquaintances who were worse off than she and the Wittoucks.

“It was part of her sense of self,” says De Schaepdrijver. “It was simply what you did. She also was able to acknowledge that other people had it way harder than she did. She would say that over and over again: ‘Well, it’s tough, but oh my goodness I am so privileged compared to others.’”

“*An English Governess in the Great War: The Secret Brussels Diary of Mary Thorp*,” edited with commentary by De Schaepdrijver and Proctor, came out in early 2017. Despite its detailed and moving depiction of life under enemy rule, De Schaepdrijver thinks Thorp was not intentionally bearing witness and never meant for her diary to be made public.

“She is like many people who, because of living under occupation, started writing a diary because time seems to be losing its form. It just flows with nothing to show for it,” she says. “Keeping a diary was a form of daily discipline, the notion being that if you record your thoughts and actions every day, then the time that goes by is not completely lost.”

Thorp kept a diary until a few months after the Armistice and then, apparently, never did so again.

## THE LONG ARC OF MEMORY

Gabrielle Petit became a public figure after the war, when the story of her spying, arrest, and death came out. But commemoration changes over time, as the world around us changes, or how we wish to be viewed changes. Petit’s prominence as a Belgian hero dimmed during a period of anti-war sentiment in the late 1920s, recovered a decade later when Nazi Germany began to flex its muscles, and declined again in the 1960s, when the linguistic division in Belgium deepened and opposition to the Vietnam War took hold. “For western Europe, that was the moment when the whole idea of dying for ‘the fatherland’ takes a nosedive,” says De Schaepdrijver.

That was the end of “the long arc of her memory” as a public figure, as De Schaepdrijver calls it. Now, two generations later, appreciation for Petit has returned, due largely to a flowering of interest in the cultural history of the war—“culture” in the wider sense of how people lived and how they sought to understand what was happening to them..

In honor of her work, in 2017 the King of Belgium named De Schaepdrijver Baroness (comparable to being made a “Dame” in the U.K.). She has just returned from a year as a Leverhulme Visiting Professor at the University of Kent, in England. While there she started working on a book about occupations throughout Europe during the First World War.

“We tend to associate military occupation with World War II, but we forget that close to 40 million people in Europe, from France to Ukraine, lived under occupation regimes in the First World War,” she says. Bringing out the stories of individuals who struggled as unwilling partners in their nation’s forced dance then may help us see that none of us are immune to violence and oppression today. “Calamities can happen. They can all of a sudden break into your very ordered life, and you might find yourself as helpless as those people, through no fault of your own.”

*Sophie De Schaepdrijver is professor of history at Penn State. In 2017 she was awarded the university’s Faculty Scholar Medal for Outstanding Achievement in the Humanities.*

New procedure promises faster healing,  
less pain for patients with chest injuries

# FIXING RIBS

BY CHERIE WINNER

**“THERE’S GOTTA BE A BETTER WAY.”**

Dr. Peter Dillon, chief of surgery at Penn State Health Milton S. Hershey Medical Center, likes to drop in on his doctors at work, and on that day in early 2010 he was watching as staff surgeon Dr. Don Mackay affixed thin metal plates to the broken ribs of an elderly patient. Mackay had modified the standard way of fixing ribs, making it less traumatic for patients, but the procedure was still long, laborious, and somewhat bloody.

“I just said, there’s gotta be a better way,” recalls Dillon. “Why can’t you do that minimally invasively?”

The treatment of rib fractures has long been ripe for an overhaul. A typical scene of the conventional method, which attaches a plate to the outer surface of a broken rib, has the patient on his side, a slab of flesh from waist to armpit folded back to reveal the pale ribs and the red intercostal muscles. “Skeletonizing” is how one of Dillon’s colleagues describes the operation, “like something out of *Game of Thrones*.”

The surgery is so hard on patients that it is used only in cases with multiple breaks, especially of ad-

acent ribs. Such a cluster of broken ribs causes “flail chest,” a condition where that section of the ribcage moves opposite the way it’s supposed to move, interfering with the ability to breathe. The broken ribs have to be stabilized, or the person runs a high risk of dying due to pneumonia or other infections.



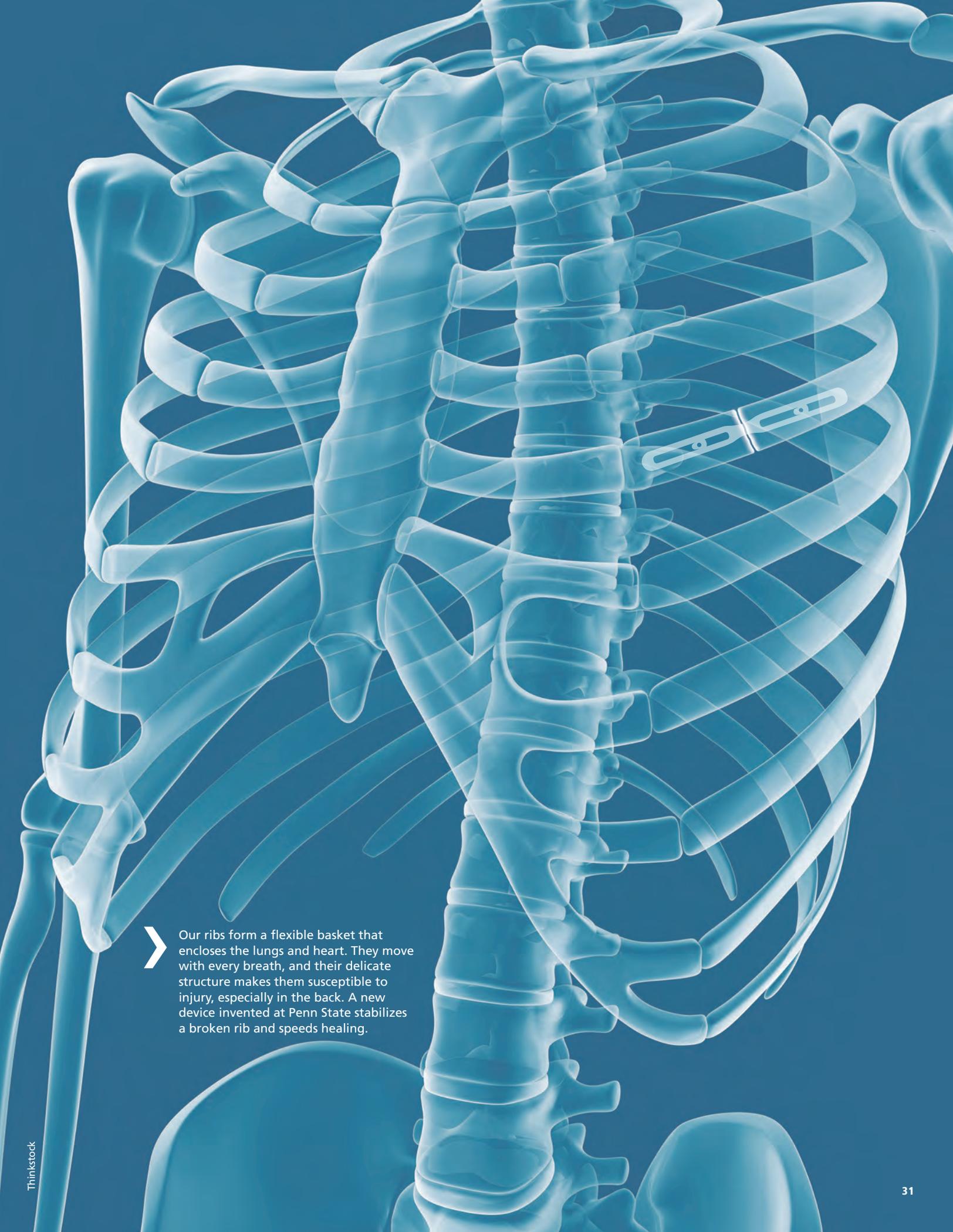
Penn State Health

Dr. Peter Dillon, professor of surgery at Penn State College of Medicine

For patients who break just one rib, or who don’t have flail chest, the surgery usually isn’t worth the trauma; standard treatment is to leave the rib alone. “You take aspirin, go home, and suffer,” says Mackay. “For weeks.” He knows from personal experience: A few years ago he broke several ribs in a car accident. The native of South Africa with strong Scottish roots managed to play the bagpipes at his nephew’s wedding four weeks later, but it was excruciating.

A broken rib hurts like hell every time the broken ends move, which is every time you breathe. That can lead to more serious problems, especially for older patients and others whose lung capacity is limited.

To minimize the pain, you breathe as shallowly as possible, which leads to fluid build-up in the lungs, which leads to infections, which puts you on a ventilator—or in the morgue. Because of how much they compromise the ability to breathe normally, broken ribs are the second leading cause of trauma deaths.

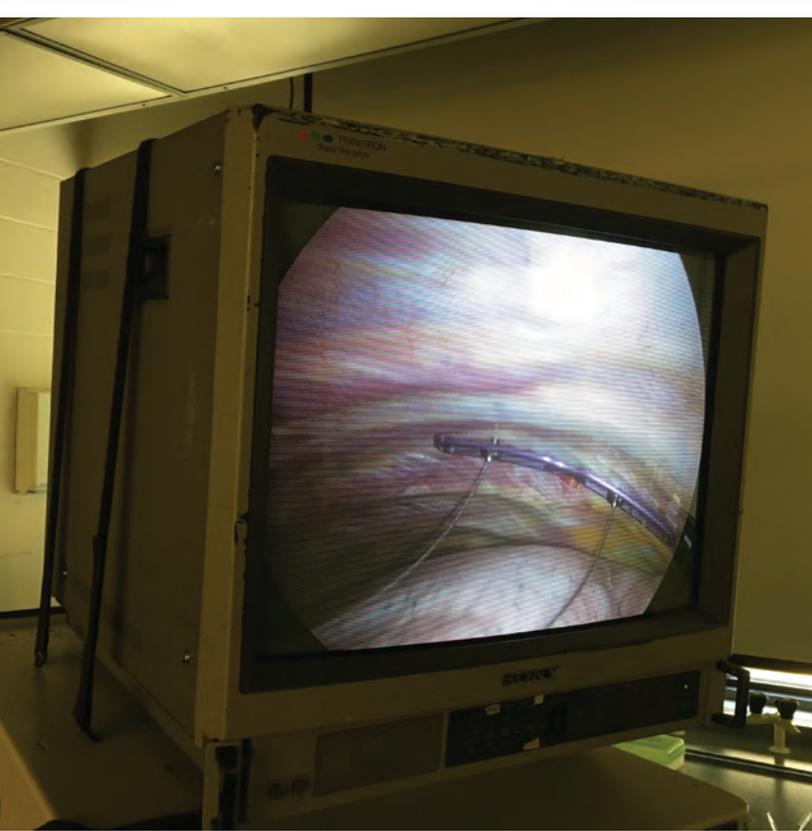


Our ribs form a flexible basket that encloses the lungs and heart. They move with every breath, and their delicate structure makes them susceptible to injury, especially in the back. A new device invented at Penn State stabilizes a broken rib and speeds healing.



New rib-fixing hardware developed at Penn State Health. The splint (purple) is attached to the inner surface of a rib (right) with screws that pass through the rib and lock into posts inserted from the rib's outer surface (left). Photos by Penn State Health.

Dr. Randy Haluck (top), engineer Barry Fell (lower left), and Dr. Don Mackay (lower right) were part of the team that invented a new way to treat broken ribs. Their system gives surgeons a clear view inside the chest (center) with just three short incisions. Photos by Penn State Health.



## FINDING A BETTER WAY

To devise a better way to ‘fix,’ or stabilize, broken ribs, Mackay and Dillon enlisted the help of Dr. Randy Haluck, chief of minimally invasive surgery at the Medical Center, and Barry Fell, a biomedical engineer whose company, TPC Design, specializes in orthopedic devices such as artificial hips and knees. Like Mackay, Fell has gone through the pain of broken ribs—in his case, many times, most due to his lifelong enthusiasm for playing ice hockey.

The Penn State group thought attaching the plate to the *inner* surface of the broken rib, the side facing the lungs, would be less traumatic than the standard procedure, because it would leave the overlying tissue largely undisturbed. A device already existed for doing some types of minimally invasive surgery in the chest: the thoracoscope, which carries a fiber-optic cable through a short slit in the chest wall and transmits live images to a video monitor. The view from a thoracoscope inserted low in the ribcage looks like a room in a cave, the smooth arched walls glistening pink and white. From this vantage point, most of the ribs are visible and can be fixed without repositioning the scope. The surgeon can see exactly where the break is—something not always possible from the outside or even with an x-ray. “Once you are oriented to where things are, you have a wonderful, magnified, high-definition view,” says Haluck.

While the surgeons considered how to use a thoracoscope to fix ribs, Fell did what comes naturally to an engineer: He tinkered.

“He ended up going to Giant and getting a side of ribs from the meat department,” says Dillon. “He called me up one day and said, ‘Hey, come on over. I put some plates and screws into some ribs; what do you think?’ ”

Fell’s plates looked good: solid, secure. Splinting ribs from the inside would work from a mechanical perspective. But was it do-able in real life? The thoracoscope would let them see into the chest; next they had to figure out how to get the hardware in and attach it to the broken ribs, without making a big incision.





“You need to hold the screw; you need to get the screw and the plate to the right angle and location,” says Haluck. “And how do you then introduce a screwdriver that goes in, down, and up? Consider all the angles that you have in here, and where the breaks might be.”

“It’s like building a ship in a bottle, with two or three parts simultaneously.”

Over the next several months, the group designed new hardware and a system that lets them bring a plate and screws into the chest cavity through two short incisions above the broken rib, while the thoracoscope provides a view of the injury from a slit lower down.

Their procedure is much quicker than the conventional method—less than an hour, compared to several hours—which greatly reduces the cost of the operation. Most importantly, the group says, by being so much less traumatic than the conventional surgery, it should speed recovery, keep patients off a ventilator, and get them back to their normal activities sooner.

### PUTTING IT INTO PRACTICE

In 2013 the group filed patent applications for the new system and licensed it to Synthes, the market leader in conventional rib repair hardware. Because it uses materials and methods—stainless steel, titanium, thoracoscopy—already approved for use in patients, it did not have to go through lengthy clinical trials. Instead, it quickly won a “510k clearance” from the FDA.

But it nearly died before it could be brought to market, when mega-corporation Johnson & Johnson bought Synthes and decided not to market the new system. And then, surprising everyone, J & J allowed Synthes to return the license to the group at Hershey.

“We were a little taken aback by that,” says Fell, “but we said ‘Thank you very much!’ Because it was already FDA-cleared, it had everything that’s required to market the product 90 percent completed.”

To take it the last ten percent, the team sought advice from Kevin Harter, director of Penn State’s brand-new Center for Medical Innovation. He first verified that there is a market for the procedure. Nationwide, around 100,000 people per year are seen at trauma centers, suffering from multiple broken ribs—a huge potential market for the new technique. And that doesn’t count the hundreds of thousands more with just one broken rib, especially seniors, for whom repair might be an excellent option now that there’s a minimally-invasive way to do it.

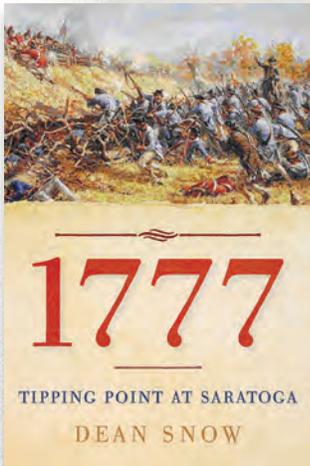
Fell started a business, SIG Medical, to produce and sell the system, now named AdvantageRib, in conjunction with the Medical Center. Ethics rules prevent the surgeons from taking a director’s or management role in the business, but they have invested in it, as have Ben Franklin Technology Partners and several private investors. SIG Medical also won the \$75,000 top prize at Penn State’s Venture and Intellectual Property Fair last fall.

Although clinical trials aren’t required, the group wants to demonstrate that their system offers an improvement over current methods of rib fixation before taking it to market. This spring and summer, other surgeons at the Medical Center started trying it with live patients. Their first case was a tough challenge: a young girl with flail chest due to 13 fractures of eight ribs on the left side of her chest, caused by a car accident. The surgery restored the normal shape of her chest, allowed good lung ventilation, and reduced her need for pain medications.

If AdvantageRib continues to prove itself, the team’s next step is to ask leading surgeons around the country to try it. Harter calls this a “seed strategy” that relies on opinion leaders spreading the word, rather than on a sales force and advertising. Initially, at least, all prospective users will come to Hershey for training.

“You always hear about doctors going to Cleveland Clinic or Johns Hopkins to learn new techniques,” says Harter. “This is a Penn State technology. The first surgeries will happen here. The experts will be here.”

# BOOKS



## 1777: TIPPING POINT AT SARATOGA

by Dean Snow, professor emeritus of anthropology

In the autumn of 1777, near Saratoga, New York, an inexperienced and improvised American army led by General Horatio Gates faced off against the highly trained British and German forces led by General John Burgoyne. The British strategy was to separate rebellious New England from the other colonies. Despite inferior organization and training, the Americans ultimately handed the British a stunning defeat, and, for the first time in the war, confirmed that independence from Great Britain was all but inevitable.

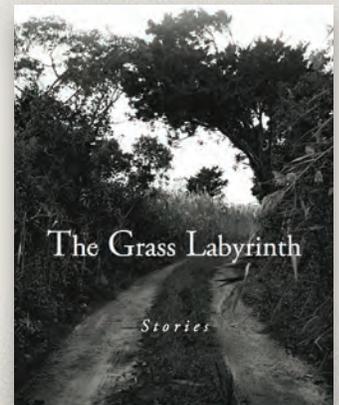
Assimilating the archaeological remains from the battlefield along with the many letters, journals, and memoirs of the men and women in both camps, Dean Snow's *1777* provides a richly detailed narrative of the two battles fought at Saratoga over the course of thirty-three tense and bloody days, an intimate retelling of the campaign that tipped the balance in the American War of Independence.

## THE GRASS LABYRINTH

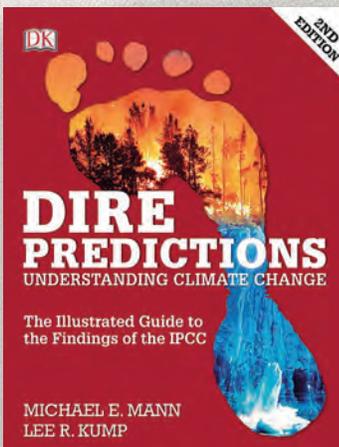
by Charlotte Holmes, associate professor of creative writing and women's studies

A successful artist is expected to give his or her all for "the work." The linked stories in *The Grass Labyrinth* challenge the reader to determine if the artist's work is worth the pain often visited on those who share an artist's life.

Whether in a college town in Pennsylvania, a loft in Brooklyn, or a ramshackle cottage on the Carolina coast, these stories explore, over a thirty-year span, how the choices made by these characters—a family of visual artists and poets—end up shaping those they love in ways they never anticipate, down through the generations. By turns ironic, hopeful, and wry, Charlotte Holmes paints a surprising portrait of one family's intimate struggle to find the paths that will carry them to the work they want to do, the lives they want to lead, and the people they can't help but love.



Charlotte Holmes



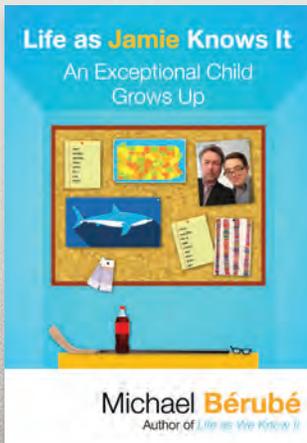
## DIRE PREDICTIONS: Understanding Climate Change

by Michael Mann, Distinguished Professor of Atmospheric Science, and Lee Kump, Dean of the College of Earth and Mineral Sciences

In this second edition of their important book, Michael Mann and Lee Kump address important questions about global warming and climate change, diving into the information documented by the Intergovernmental Panel on Climate Change (IPCC) and breaking it down into clear graphics that explain complex climate questions in simple illustrations that present the truth of the global warming problem clearly.

These experts take scientific findings about climate change and use analogies, striking images, and understandable graphics. *Dire Predictions* shows the evidence and the causes that respected scientists have documented in IPCC findings and climate change studies. This powerful book is updated with the latest IPCC information and is a must-read for anyone interested in understanding climate change and in joining the debate over the best way to combat it.

## BY PENN STATE FACULTY



### **LIFE AS JAMIE KNOWS IT: An Exceptional Child Grows Up**

by Michael Bérubé, Edwin Erle Sparks Professor of Literature

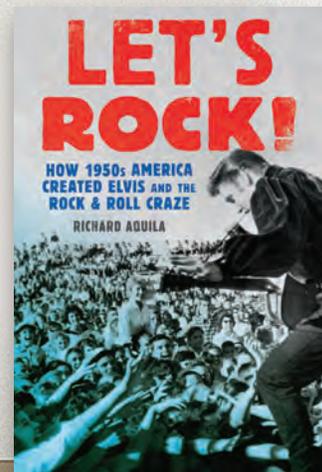
Published in 1996, *Life as We Know It* introduced Jamie Bérubé to the world as a sweet, bright, gregarious little boy who loves the Beatles, pizza, and making lists. At four, he is like many kids his age, but his Down syndrome prevents most people from seeing him as anything but disabled.

Twenty years later, in *Life as Jamie Knows It*, Michael Bérubé chronicles his son's journey to adulthood and his growing curiosity and engagement with the world. With a combination of stirring memoir and sharp intellectual inquiry, Bérubé tangles with bioethicists, politicians, philosophers, and anyone else who sees disability as an impediment to a life worth living. Far more than the story of an exceptional child growing up, *Life as Jamie Knows It* challenges us to rethink how we approach disability and is a passionate call for moving toward a more just, more inclusive society.

### **LET'S ROCK! How 1950s America Created Elvis and the Rock & Roll Craze**

by Richard Aquila, professor emeritus of history, Penn State Behrend

Rock & roll was one of the most important cultural developments in post-World War II America, intertwined with the rise of a youth culture, the emergence of African-Americans in society, the growth of consumer culture, technological change, the expansion of mass media, and the rise of a Cold War culture. Richard Aquila's book demonstrates that early rock & roll was not as rebellious as common wisdom has it. The new sound reflected the conservatism and conformity of the 1950s as much as it did the era's conflict. Rock & roll supported centrist politics, traditional values, and mainstream attitudes toward race, gender, class, and ethnicity. The musical evidence proves that most teenagers of the 1950s were not that different from their parents and grandparents when it came to basic beliefs, interests, and pastimes. Young and old alike were preoccupied by the same concerns, tensions, and insecurities.



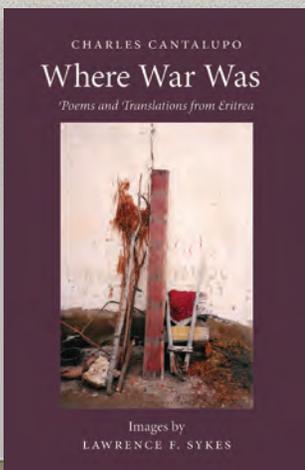
### **WHERE WAR WAS: Poems and Translations from Eritrea**

by Charles Cantalupo, Distinguished Professor of English, Comparative Literature, and African Studies, Penn State Schuylkill

Located in the Horn of Africa, on the Red Sea, and roughly half Christian and half Muslim, Eritrea is a new nation but an ancient country with a tradition of writing going back at least 4,000 years. A former Italian colony, Eritrea has nine major ethnic groups, each with its own language.

Charles Cantalupo has been visiting and writing about this place since 1995. His latest book crosses genres: *Where War Was* is part translation, part reflection, and part epic, and is illustrated with starkly beautiful photographic images by Lawrence Sykes. The book includes Cantalupo's own poetry as well as his translations of poems by Eritrean writers.

Cantalupo's previous translations of Eritrean poetry include *We Have Our Voice*, *We Invented the Wheel*, and *Who Needs a Story*, and he has written *War and Peace in Contemporary Eritrean Poetry*. He is also the author of a memoir, *Joining Africa: From Anthills to Asmara*.



In touch with ›



Almost any item we buy or sell today was made with contributions from many companies and individuals in many places. The Center for Supply Chain Research™ in Penn State's Smeal College of Business is dedicated to understanding the logistics of supply, transport, and distribution at local and global scales. Steve Tracey, executive director of the center, talked with us about the challenges of doing business in our highly interconnected world.

#### WHAT'S A "SUPPLY CHAIN?"

It's a whole ecosystem of organizations that starts with a company's suppliers' suppliers and ends with the customers' customers. Think about how a pencil is made—the yellow pencils that we've all used since we were little kids. What's in a pencil? There's wood, there's paint, there's the lead inside, the metal that holds the eraser on, and the eraser itself. All of which originate in different places, from different firms. On the other end, a company that makes the pencils might sell them to office supply companies, but they're not the ultimate purchasers. Consumers are, or businesses or school districts.

#### DOES THE CONCEPT OF A SUPPLY CHAIN APPLY TO SMALL BUSINESSES?

It exists no matter what size the firm is. Even if you're a one-person operation, you still have the same challenges. Let's say you own a little shop that sells ornaments for the holidays. None of that comes from here. It's being manufactured overseas somewhere. A lot of these firms use services to run their supply chain, handle all the paperwork that's necessary with U.S. Customs, pay the duties and the brokers' fees and all that. And that store owner may have no interest in how they do it. All the owner is interested in is, 'I give them the order, and the product shows up at my door.'

#### DEALING WITH INTERNATIONAL TRADE SOUNDS ESPECIALLY COMPLICATED.

It's as complex as you can possibly imagine. Everything is an export or an import somewhere. I was in the textile business. We had manufacturing facilities in 14 countries, and we sold in 92 countries, and we sourced in others. So probably 20 countries of origin and 92 countries of delivery. And that's just the movement of goods; that's not making anything.

#### WHAT KINDS OF RESEARCH DOES THE CENTER DO?

Our highest level marries industry and academia to do research that's applicable to the business but also fundamental to the supply-chain area. In 2015 one of our faculty members won an award for research he did with Dow AgroSciences. He created a solution for a complex problem they had, published it in an academic journal, and won an award for it. We also do 'practitioner research,' like a project on maintenance and repair in highly automated businesses—how do they keep track of all their spare parts? And our students do about 40 projects a year that companies come to us with. It's really good for the students—they learn how to do research in a supervised way, and they get a lot of contact with the companies.

#### ARE BUSINESSES LOOKING FOR PEOPLE WITH TRAINING SPECIFICALLY IN SUPPLY CHAIN?

Yes! Most of the people who are in these roles today don't have professional training in it. They tend to be later-stage professionals with broad expertise. I would be a classic example of that. I was a finance guy by training. I ended up in supply chain sort of by accident, five or six years into my career. It was called "operations" back then. Companies now recognize that their supply chain is this big ecosystem that has to be managed in a thoughtful, organized way, but there's a big talent gap in the profession. That's wonderful for our students—they get plenty of job offers!

#### WHAT QUALITIES ARE NEEDED TO DEAL WITH SUPPLY CHAINS?

You have to be good with numbers, you have to be able to think on your feet, and you have to be able to find creative solutions to problems. Students often ask, 'How do I do this?' and I always say, 'There's a hundred ways to do it—and the hundred-and-first way might be the best way.' You have to be a little bit of a scientist, because people are constantly experimenting with new ways to do things.

*The Center for Supply Chain Research™ is supported by contributions from corporate sponsors. With its emphasis on research, its educational programs for business executives, and more than 1,000 undergraduates majoring in supply chain and information systems, Penn State is a world leader in supply chain research and education.*



Steve Tracey

Michelle Bixby

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## Moving Targets

Satellite images of nighttime lights help scientists track seasonal movement of people into cities, aiding efforts to deliver vaccinations and prevent deadly disease outbreaks.

**SEE PAGE 20**