Research Penn State

VOLUME 34 | NUMBER 2 | FALL 2014

MANAGING Evolution

14 Can a smarter approach to drug treatment keep emerging pathogens at bay?

› ALSO IN THIS ISSUE

New Spin on Turbines

Challenged to Read

A Measure of Methane

PENNSTATE

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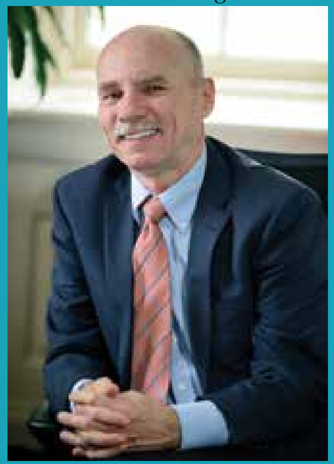
A long tradition of innovation



We live in an era of global mobility and rapid change. Communications and transportation technologies shrink our world at an accelerating pace, and offer us unprecedented opportunities.

Rapid change also brings new challenges. Easy movement between continents facilitates the spread of emerging diseases. Climate change drives the search for sustainable energy. A global economy rewrites the rules for regional economic development. Solving these and other challenges requires new and different ways of thinking.

As a land-grant institution, Penn State has always been in the vanguard of such innovation. From the early agricultural and engineering experiment stations built to serve a growing Commonwealth, the University's research enterprise now stands in the front rank of the nation's public universities. Our efforts are distinguished by the broad range of our expertise and a strong emphasis on interdisciplinary approaches—and as always, by a firm grounding in the practical needs of society.

This issue of *Research/Penn State* provides a small sampling of our remarkable reach. Penn State engineers are developing energy-efficient building systems in Philadelphia. Our atmospheric scientists are finding better ways to assess the impact of shale gas drilling across the state. A new jet-engine testing facility here in University Park is unique in the nation. And our biologists are on the front lines of a new approach to managing infectious disease around the world.

Yet another innovative undertaking, described beginning on page 20, helps kids with complex communication challenges—such as those with autism, Down syndrome, and cerebral palsy—to develop essential literacy skills. Shaped by ongoing research, this program also provides meaningful training opportunities for graduate students, teachers, and other professionals.

In combining these three elements—research, teaching, and public service—this project amply demonstrates the core commitments that have always formed the crux of Penn State's mission.

NEIL A. SHARKEY
Vice President for Research

ON THE COVER: Disease-carrying mosquitoes are responsible for transmitting malaria and many other diseases to humans. Penn State biologist Andrew Read is looking for solutions to the rising resistance in humans against antimalarial drugs—and to a similar resistance against insecticides in the mosquitoes that carry the disease. More broadly, Read is concerned with the rapid evolution of 21st-century pathogens, and with the overly aggressive use of drugs that he says drives this evolution. See story on page 14.

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The skull known as LB1 in three different views to illustrate facial asymmetry. A (left) is the actual specimen, B (center) is the right side doubled at the midline and mirrored, and C (right) is the left side doubled and mirrored. Differences in left and right side facial architectures are apparent, and illustrate growth abnormalities of LB1.

›› "Hobbit" had Down Syndrome

In October 2004, excavation of fragmentary skeletal remains from the island of Flores in Indonesia yielded what was called "the most important find in human evolution for 100 years." Its discoverers dubbed the find *Homo floresiensis*, a name suggesting a previously unknown species of human.

Now detailed restudy by an international team of researchers including **Robert B. Eckhardt**, professor of developmental genetics and evolution at Penn State, Maciej Henneberg, professor of anatomy and pathology at the University of Adelaide in Australia, and Kenneth Hsü, a Chinese geologist and paleoclimatologist, suggests that the single specimen on which the new designation depends, known as LB1, does not represent a new species. Instead, it is the skeleton of a developmentally abnormal human, and, according to the researchers, contains important features most consistent with a diagnosis of Down syndrome.

The first indicator is craniofacial asymmetry, a left-right mismatch of the skull that is characteristic of this and other disorders. Eckhardt and colleagues noted this asymmetry in LB1 as early as 2006, but it had not been reported by the excavating team and was later dismissed as a result of the skull's being long buried, he says.

A previously unpublished measurement of LB1's occipital-frontal circumference—the circumference of the skull taken roughly above the tops of the ears—allowed the researchers to compare LB1 to clinical data routinely collected on patients with developmental disorders. Here too, the brain size they estimate is within the range expected for an Australomelanesian human with Down syndrome.

LB1's short thigh bones not only match the height reduction seen in Down syndrome, Eckhardt says, but when corrected statistically for normal growth, they would yield a stature of about 1.26 meters, or just over four feet, a figure matched by some humans now living on Flores and in surrounding regions.

These and other Down-like characteristics, the researchers state, are present only in LB1, and not in the other skeletal remains found in Liang Bua cave, further evidence of LB1's abnormality.

—DAVID PACCHIOLI

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Popular Targets

Bullying affects more than just isolated and marginalized students. Researchers have found that relatively popular students are targeted, and may actually suffer more.

"We found, for most students, the likelihood of being targeted by aggressive acts increases as a student becomes more popular, with the exception of those at the very top," says **Diane Felmlee**, professor of sociology at Penn State.

In a study of students and their friendship networks in 19 North Carolina schools, Felmlee and her colleagues discovered that the risk of being bullied drops dramatically only for the adolescents in the top five percent of the school's social strata.

Bullying may be a tactical form of aggression, suggest the researchers, and young people who are attempting to climb in status may increase their risk of victimization.

"When youth are vying for status, they probably gain little from attacking students who are already marginalized—in fact, it might backfire," explains Felmlee. "But if adolescents put down someone who is trying to be a leader in their group, or who constitutes a threat to their status, then there is a lot more to be gained."

The researchers also found that girls are more likely to be victims of both male and female bullies. Girls who date are at increased risk of physical violence.

Bullying victims of both genders tend to suffer elevated levels of anxiety, depression and anger, and can develop negative feelings about their schools. These effects can be even more pronounced among relatively popular students, Felmlee notes. Higher-status students experienced significantly larger increases in depression, anxiety and anger than low-status students. —MATT SWAYNE

CASE BY CASE BASIS ‹‹

The public expects police to enforce laws uniformly in all cases, but in reality, officers use discretion in handling incidents, says **Joongyeup Lee**, assistant professor of criminal justice at Penn State Harrisburg School of Public Affairs.

Despite the presence of mandated rules and regulations governing police response, Lee says, "there are extra-legal factors, in addition to legal factors, that constitute the incident and ultimately matter to police officers."

Lee analyzed domestic violence cases handled by the Houston police department and found that officers were less likely to make an arrest in a neighborhood with a high-crime rate, compared to a more upscale neighborhood. Also, some of the situational contexts, such as age, gender and race of assailants, as well as time of day, day of the week, and location of the incident, were associated with the odds of making an arrest.

Lee suggests there is no single public agreement on applying the law, because as a case moves from one context to another, consensus on the topic changes as well.

He points out that police officers deal with an array of subcultures, each of which can place the same criminal act in a different context. For example, a police officer in a high-crime, urban neighborhood may decide not to arrest someone for smoking marijuana because the act is so socially negligible that making an arrest would not be appreciated by the residents. In contrast, the same officer may arrest someone for smoking marijuana in a suburban neighborhood, where marijuana smoking is rare and not tolerated by the residents.

"Police officers generally have a decent understanding of subcultural diversity in their jurisdiction," Lee says. "In this perspective, the police may actually be honoring social consensus under each subcultural context by using reasonable and rational discretion." —KALISHA DEVAN

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Lunar Mystery Solved

The "man in the moon" appeared when meteoroids struck the Earth-facing side of the moon, creating large flat seas of basalt that we see as dark areas called maria. But the moon's farside remained unseen from earth until 1959, when the Soviet spacecraft Luna 3 transmitted the first images.

Researchers noticed fewer dark areas; instead, they saw numerous mountains and craters. The cause of the difference has remained a mystery, described as the Lunar Farside Highlands Problem.

Jason Wright, assistant professor of astrophysics, **Steinn Sigurdsson**, professor of astrophysics, and **Arpita Roy**, graduate student in astronomy and astrophysics, think they have solved the problem.

The general consensus on the moon's origin is that it formed shortly after the Earth and was the result of a Mars-sized object hitting Earth with a glancing but devastating impact. The outer layers of the Earth and the object were flung into space and eventually formed the moon.

The moon and Earth were 10 to 20 times closer to each other than they are now. "They loomed large in each other's skies when they formed," says Roy, the study's lead author.

Later, when meteoroids struck the nearside of the moon and punched through the crust, they released vast lakes of basaltic lava that formed the nearside maria that make up the man in the moon. But when they struck the farside, in most cases the crust was too thick and no magmatic basalt welled up, creating a moonscape characterized by valleys, craters, and highlands, but almost no maria.

—A'NDREA ELYSE MESSER

TRACKING DEER DISEASE «

White-tailed deer suffering from chronic wasting disease tend to cluster in low-lying open and developed areas, suggesting that wildlife management agencies should concentrate surveillance efforts in such locations, according to researchers in the College of Agricultural Sciences.

The research team studied deer in Virginia, West Virginia, Maryland, and Pennsylvania in order to better understand how the disease, commonly called CWD, has progressed in the East, says **David Walter**, adjunct assistant professor of wildlife ecology. Subsequent modeling based on the research has revealed likely paths of future dispersal of the disease, which always is fatal to deer, elk, and moose.

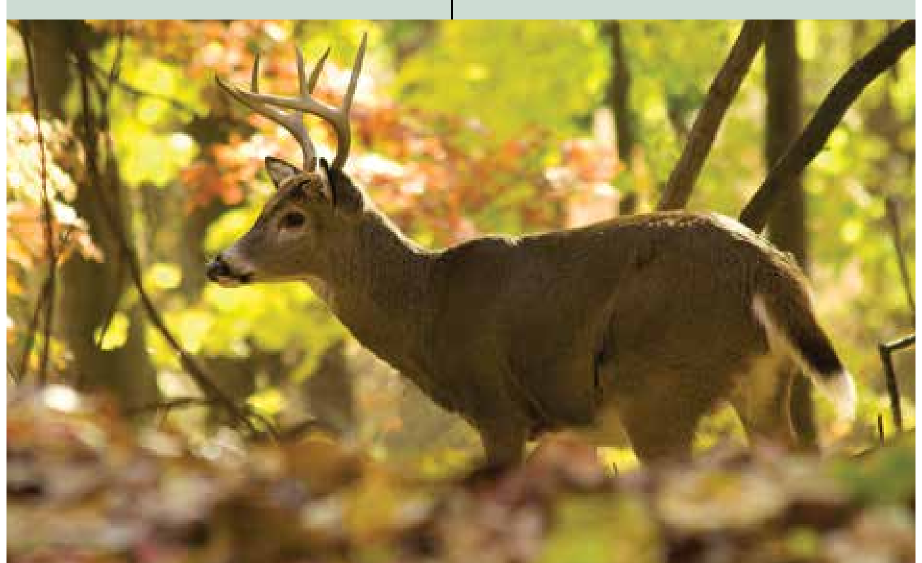
"We obtained the geographic coordinates of hunter-killed deer that tested positive for CWD and overlaid them on a map showing a variety of habitat and landscape features," explains Walter, who also is an assistant leader of the Pennsylvania Cooperative Fish and Wildlife Research Unit at Penn State.

"The analysis showed a high prevalence of CWD in deer sampled from low-lying open and developed landscapes."

This data were generated by thesis work performed by graduate student **Tyler Evans**, who is advised by Walter. Given CWD's prevalence in low-lying areas, Evans has modeled how it is likely to spread in free-ranging deer, in valleys parallel to mountains and along river bottoms, most likely through developed and agricultural terrain. This information should help agencies, such as the Pennsylvania Game Commission, know where to sample for CWD-infected deer.

Chronic wasting disease infects the brain and nervous system. Scientists believe that it may be transmitted through animal-to-animal contact and indirectly via soil or other surfaces—most likely through the saliva and feces of infected animals or decomposing carcasses. The disease was first documented in Eastern states in 2005.

—JEFF MULHOLLEM



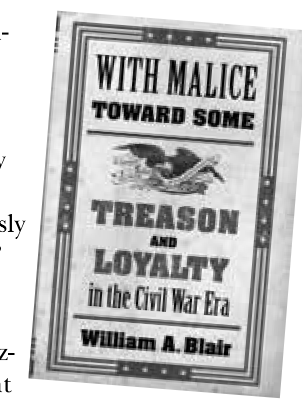
» Civil War Treason

The U.S. Constitution defines treason as levying war against the government and aiding and abetting its enemies. By that definition, every Confederate soldier in the Civil War and every political leader was a traitor, according to **William A. Blair**, Liberal Arts Research Professor of History. Yet no one was executed for treason, and Confederate President Jefferson Davis did not even go to trial.

In *With Malice Toward Some: Treason and Loyalty in the Civil War Era* (University of North Carolina Press, 2014), Blair examines how Northern states reconciled a heartfelt hatred of the rebels with a demonstrable record of leniency toward them.

"The literature of the Civil War era is massive, but a study of how Northerners conceived of, and acted upon, treason was missing," Blair says, noting that treason occurred as a topic in public discourse as often as commentary on the progress of the war and the concern for soldiers.

There was no federal agency to identify treasonous or disloyal acts, nor was it clear what level of government could make an arrest, or who should decide what acts were disloyal.



"Spying, running guns, committing sabotage, and similarly blatant acts were obviously treasonous," Blair says. "But what about criticizing President Lincoln? What about selling food to people in one of the states in rebellion? Was that giving aid and comfort to the enemy?"

Civilian and military authorities sometimes took egregious actions against those deemed traitors. Yet in the end, passion failed to overcome leniency. Confederate soldiers of all ranks were generally paroled and faced no formal charges of treason.

Northerners took a pragmatic approach to the war's end, Blair emphasizes. They realized the impracticality of trying thousands of Southerners for disloyalty in states where juries were unlikely to deliver guilty verdicts, and that continued cries of treason would interfere with the more important task of nation-building.

—MICHAEL BEZILLA

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Keeping Kids Safe Online

In a study on parenting strategies and online adolescent safety, Penn State researchers have found evidence suggesting that parents should try to establish a middle ground between keeping their teens completely away from the internet and not monitoring their online activities at all.

Pamela Wisniewski, a postdoctoral scholar in information sciences and technology, describes the issue as a "Goldilocks problem."

"Overly restrictive parents limit the positive online experiences a teen can have," she says, "but overly permissive parents aren't putting the right types of demands on their children to make good choices."

Active mediation and monitoring online behavior, not blanket rules, may be a better strategy.

"Parents should have some level of monitoring their teens' online usage, but not necessarily in a covert way because that may create trust problems," says Wisniewski.

Ideally, parents would start to work with their teens to guide their moral development in making decisions about online behavior when their children are young. The earlier the better. "By the time they are age 16 or 17, it's probably too late to jump in and start to intervene," Wisniewski cautions.

Parents who learn more about technology can better guide their children, according to the researchers. Those who knew more about technology tended to be more actively engaged in their teens' online behaviors while those who were less technically inclined tended to be more in favor of restricting online activity. —MATT SWAYNE

Penn State Hershey

A researcher at Penn State Hershey Medical Center purifies leelamine.

» Pine Bark for Melanoma

A SUBSTANCE DERIVED FROM pine bark is a potential source for a new treatment of melanoma, according to the director of the Penn State Hershey Melanoma Center.

Gavin Robertson, professor of pharmacology, pathology, dermatology, and surgery, explains that current melanoma drugs targeting single proteins can initially be effective, but resistance develops quickly and the disease recurs—usually when the cancer cell's circuitry bypasses the protein that the drug acts on, or when the cell uses other pathways to avoid the point on which the drug acts.

"To a cancer cell, resistance is like a traffic problem in its circuitry," he says. "Cancer cells see treatment with a single drug as a road closure and use a detour or other roads to bypass the closure."

Gavin and a team of researchers may have solved this problem by identifying a drug that simultaneously creates many road closures.

The researchers screened 480 natural compounds and identified leelamine, derived from the bark of pine trees, as a drug that can cause this traffic jam in the cancer cell's circuitry.

"Natural products can be a source of effective cancer drugs, and several are being used for treating a variety of cancers," says Robertson. "Over 60 percent of anti-cancer agents are derived from plants, animals, marine sources or microorganisms. However, leelamine is unique in the way that it acts."

Researchers discovered that leelamine shuts down multiple protein pathways at the same time in melanoma cells, pathways that are involved in the development of up to 70 percent of melanomas. Pathways like these help cancer cells multiply and spread.

Leelamine works by shutting down cholesterol transport and its movement around the cancer cell. As a result, the exceptionally active survival communication that cancer cells require is shut down. The end result is death of the cancer cell. Since normal cells are not addicted to the same high levels of activity in these pathways, the drug has a negligible effect on them.

In laboratory experiments, the drug inhibited tumor development in mice with no detectable side effects.

Penn State has a patent for this discovery and has licensed it to Melanovus Oncology for the next series of experiments that must be completed before leelamine can be tested in humans. Melanovus Oncology is partly owned by Penn State and Robertson.

—MATTHEW SOLOVEY

ATTITUDE AFFECTS WEIGHT GAIN DURING PREGNANCY ‹‹

TOO MUCH WEIGHT gain during pregnancy can lead to postpartum and long-term weight gain and obesity, and cause premature birth. To head off these negative outcomes, **Cynthia Chuang**, associate professor of medicine and public health sciences, and her colleagues studied habits of women who gained appropriate weight and those who exceeded guidelines.

They found that overweight or obese women who express an attitude that they are "eating for two" are more likely to experience excessive weight gain while pregnant.

The Institute of Medicine recommends that women of normal weight gain 25 to 35 pounds during pregnancy. Overweight women should gain 15 to 25 pounds, and obese women, 11 to 20 pounds.

The researchers studied post-partum women who were overweight or obese before pregnancy. Some met the appropriate guidelines, and some exceeded the recommended weight gain.

Those who gained the appropriate amount of weight stuck to a meal plan and chose foods carefully. They also had little or no increase in the amount of calories they consumed during pregnancy and exercised as much or more than they had before the pregnancy.

"Overall, the women were more goal-oriented in regulating weight during pregnancy," Chuang says.

Women who gained excessive weight had fewer goals and exercised less than usual during their pregnancy. They also made less healthy food choices and ate more as a result of cravings. The American College of Obstetricians and Gynecologists recommends only 300 extra calories per day for normal weight pregnant women, and less for those who are overweight or obese.

Women should be advised and receive feedback on weight gain goals by prenatal care providers before pregnancy or early into it, Chuang says, noting that "women who closely monitor their weight gain during pregnancy can prevent future complications." —MATTHEW SOLOVEY

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Powered by Spit

"There's a lot of organic stuff in saliva," says **Bruce Logan**, Evan Pugh Professor and Kappe Professor of Environmental Engineering—enough, in fact, to power micro-sized microbial fuel cells that can produce enough energy to run on-chip applications.

Logan and an international team of engineers are researching the idea, which he credits to fellow researcher **Justine Mink**. "The idea was Justine's because she was thinking about sensors for such things as glucose monitoring for diabetics and she wondered if a mini microbial fuel cell could be used," Logan says.

Microbial fuel cells create energy when bacteria break down organic material, producing a charge that is transferred to the anode. By producing nearly one microwatt in power, this saliva-powered, microbial fuel cell generates enough power to be used as an energy harvester in microelectronic applications.

These cells could enable development of ultra-low-power chip-level biomedical electronics. One possible application would be a tiny ovulation predictor based on the conductivity of a woman's saliva, which changes five days before ovulation. The device would measure the conductivity of the saliva and then use the saliva for power to send the reading to a nearby cell phone.

Previously the smallest fuel cells have been two-chambered. This micro version uses a single chamber with a graphene- rather than platinum-coated carbon cloth anode and an air cathode. Air cathodes have not been used before because if oxygen can get to the bacteria, they can breathe oxygen and do not produce electricity.

"We have previously avoided using air cathodes in these systems to avoid oxygen contamination with closely spaced electrodes," Logan explains. "However, these micro cells operate at micron distances between the electrodes. We don't fully understand why, but bottom line, they worked." —A'NDREA ELYSE MESSER

This photo of icebergs calved from the Jakobshavn Glacier at the UNESCO Ilulissat Icefjord World Heritage Site, near Ilulissat, Greenland, was taken by **Don Voigt**, a member of The Polar Center at Penn State. Voigt, a senior research associate in geosciences, has worked seven seasons on the Greenland ice, and has been deployed to Antarctica 19 times in 17 seasons, starting in 1996.

The Polar Center provides a cross-disciplinary platform for Penn State faculty in life, physical, and social sciences to address the ecological, economic, environmental, and cultural complexities of the Arctic and Antarctic regions, and thereby lead the development of the next generation of polar science and education. To learn more, visit ***polar.psu.edu***.

ROAD TEST *for* Methane

MOBILE MEASUREMENT SHOULD GIVE A BETTER HANDLE ON EMISSIONS FROM GAS DEVELOPMENT.

BY ANNE DANAHY

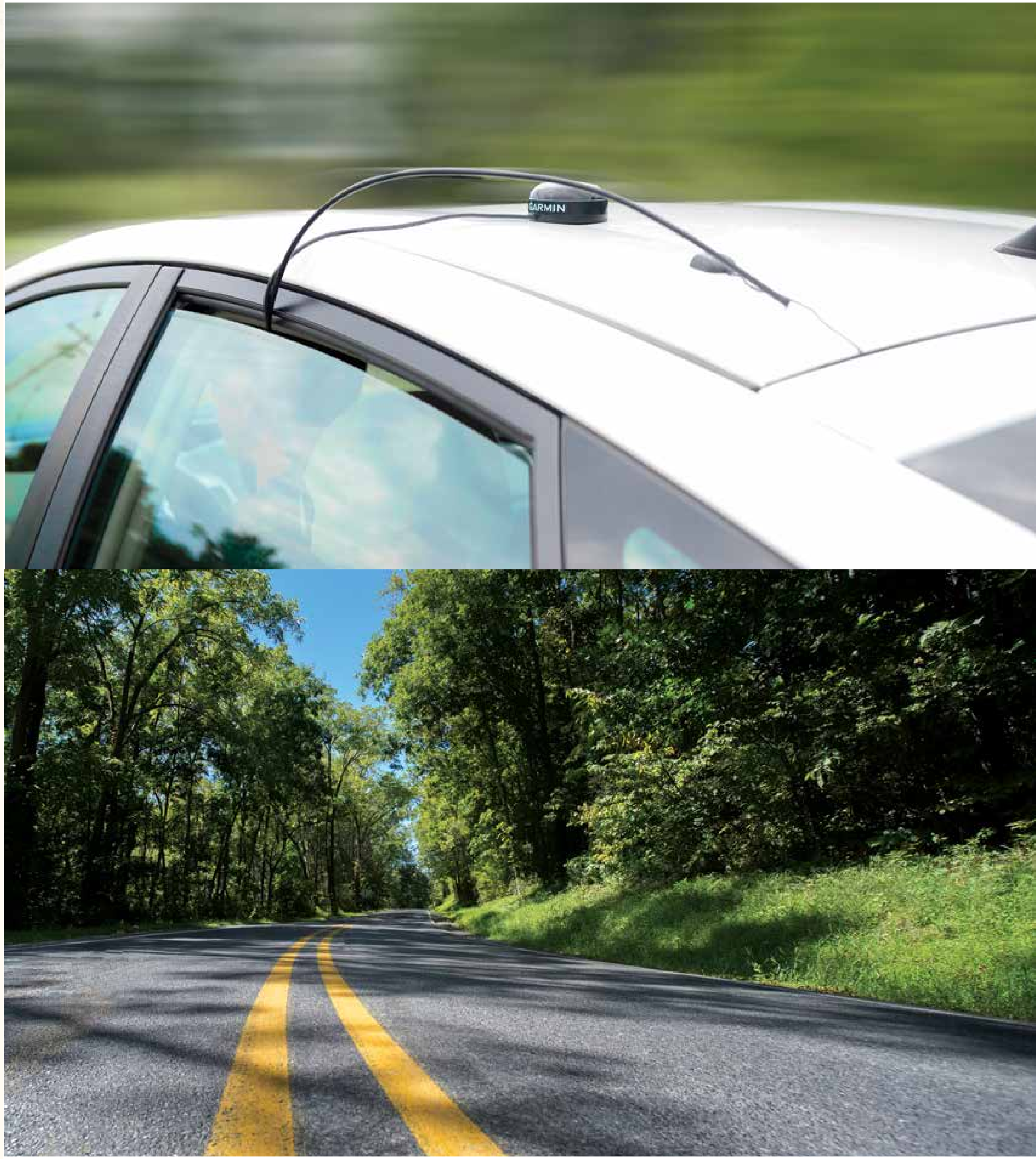
McHenry Township, Lycoming County. Equipped with a gray box, a map and an SUV, **Thomas Lauvaux** and a team from Penn State's Department of Meteorology has been at it for hours, taking measurements and racking up the miles.

It's one in a series of road trips across northcentral and northeastern Pennsylvania, and neighboring southern New York, aimed at figuring out how much methane is in the air and how much of it is coming from the booming natural gas industry.

"Isotopes of methane will tell us how much comes from natural gas and how much comes from other methane sources, such as cows, landfills, wetlands and natural seeps," Lauvaux explains.

The mobile measurements are one of the first steps in a three-year $1.8 million study funded by the U.S. Department of Energy, a project mentioned in the March 2014 *White House Climate Action Plan Strategy to Reduce Methane Emissions.*

While burning natural gas to generate power produces about half the carbon dioxide of burning coal, the gas extraction process comes with its own challenges, including emitting methane—a potent greenhouse gas. "Measuring emissions of methane from a large area for a long time, and determining the source of those emissions is difficult," says **Ken Davis**, professor of meteorology. "But that's what we hope to accomplish with this project." (CONTINUED ON PAGE 20.)



A roof-mounted sensor (top) captures raw data and feeds it to a chemical analyzer in the vehicle's back seat, providing a real-time read of fluctuating carbon dioxide and methane levels along a rural Pennsylvania road (bottom). Photos by Patrick Mansell.




A large area, in this case, means three counties in northern Pennsylvania; a long time means two years. **Zach Barkley**, who worked on the project as a research assistant during the summer and is continuing as a doctoral student in meteorology this fall, says measuring atmospheric methane concentrations on the fly will help the team decide where to place tower sensors that will eventually provide emissions data over time.

The chance to work on the project was of particular interest to Barkley—giving him an opportunity to apply what he learned as an undergraduate at Penn State to an issue that literally hits home.

"I'm from Tunkhannock, a small town in northeastern Pennsylvania," he says. "Over the last few years, it's been very, very close to the center of the drilling. I've seen the town transformed from this tiny little place. I've seen all these changes happen first-hand."

FROM THIN AIR

The team captured its initial measurements while driving past farms and forests, down winding country roads and over mountains. They measured during the day when the sun was high, and late at night after the winds had died down. They took to the road in the dead of winter and again in the summer months when the bogs and marshes had heated up and the cows were out to pasture.The SUV they drive is equipped with a gray box about the size of a small microwave. A thin plastic tube runs from the box through the cracked window to a sensor poking off the roof. The sensor captures raw data, which is fed back to the box, providing a real-time read on fluctuating levels of carbon dioxide and methane.

The study will sample those levels in Pennsylvania and beyond at a time when hydraulic fracturing, which allows companies to tap into reserves thousands of feet below the surface, continues to grow in the Marcellus Shale region that stretches from New York to West Virginia. Including measurements from New York, where a moratorium on horizontal drilling and hydraulic fracturing is in place, will allow researchers to compare methane levels in areas where drilling is going on to those where it isn't.

"With natural gas extraction, there is a certain amount of leakage that takes place, but it isn't well quantified," Davis says. "If leakage rates are large enough, then natural gas may be a poor energy choice for climate change. If leakage rates are small, then natural gas has lower greenhouse gas emissions than coal.

"Both coal and natural gas are fossil fuels. Burning either emits greenhouse gases. But we need to minimize our climate impact, and reducing methane emissions from natural gas extraction would be progress. Measuring the emissions accurately is an important step."

PLAYING IT BACK

On a cold February afternoon, Lauvaux and fellow research associates Natasha Miles and Scott Richardson drove from just north of Lock Haven to the border of New York and back again, capturing data. The live feed showed when methane levels were low and when they spiked—hitting 3,000 parts per billion near one gas well. Background atmospheric levels are typically about 1,800 PPB, rising higher near sources.

"We don't really know what the main sources of methane in the area are," Lauvaux says. "It could be specific wells in the area. It could be specific facilities. So we want to have a picture of all of that."

Lauvaux, a research associate who joined Davis's research group as a postdoctoral fellow in 2009, developed the data analysis system that will be used to estimate regional methane emissions and served initially as the project's principal investigator. He has since joined NASA's Jet Propulsion Laboratory in California, but is still participating in the project.

That night, after touring farm lands and woods, the team went back out again.

This time, they brought a 1,500-foot-long tube coiled like a snake, with them. The black rubber tube—thin enough that it could be stacked neatly in the back of the SUV—captured the air samples, which were then fed to a methane isotope analyzer back at the research station, around a rented house near Tiadaghton State Forest.

This method, more sophisticated than the real-time readings, not only provides concentration levels, but characterizes the isotopes it captures. According to the researchers, the long tube full of air acts like a tape recorder, storing the atmospheric information as they're driving. "Playing it back" via the analyzer, they can tell for the miles they drove whether upswings in methane measurements were mostly from cows or from oil and gas. That's because the methane from a cow burp has a different isotopic composition than that emitted by oil and gas deposits.

After the drive-arounds, the data on atmospheric conditions will be coupled with maps of gas wells, compressor stations and pipelines, in addition to data that shows where other contributors to methane levels — wetlands, landfills and farms — are located.

The combined information will help the team decide where to station the continuously-operating, tower-based sensors that will enable the researchers to determine natural gas methane emissions over the entire three-county region. The tower sensors will provide a flow of data on methane levels over time — in cold months when wetlands are dormant and cows are in barns and in warm months when biological sources are emitting more methane. The seasonal changes help the researchers isolate how much is coming from natural gas.

Changes in wind direction will also help. "We won't need to move the instruments because the wind is changing every day," says Lauvaux. "When the wind is from the north, we can see everything coming from the north of the tower. Every day you have a different wind direction, so you can scan the area without moving."

CONTINUOUS MONITORS

The tower observations will continue over at least two years. Once the team has assembled all that data, Davis's group will input the measurements into Lauvaux's analysis system to quantify how much methane has been leaking into the atmosphere.

The method being used is similar to one that Davis and the Penn State team employed as part of a multi-institution, long-term study of carbon dioxide fluxes over the corn fields of the upper Midwest, and that they're currently using to document greenhouse gas emission rates in the city of Indianapolis. In each case, they depend on a thorough understanding of winds and atmospheric mixing, combined with the sensor network, to compute regional emissions.

"We have done this with other greenhouse gas emissions, so the methodology has been tested. But we haven't applied that methodology to this problem," says Davis, who is also a faculty member in the Earth and Environmental Systems Institute.

They picked northeastern Pennsylvania for the study because, while southwestern Pennsylvania is also seeing a natural gas boom, that region also has oil and coal beds.

"This area only has dry gas," Lauvaux says. "So we know the natural gas emissions are coming from the gas."

While there have been other studies of methane emissions from natural gas extraction, Davis says, the conclusions drawn from that work have been inconsistent and are limited by relying on localized methods that collect data for only hours or days. The Penn State study represents important progress towards establishing continuous monitoring of the greenhouse-gas impact of this emerging industry.

Ken Davis is professor of meteorology and a member of the Earth and Environmental Systems Institute. Zach Barkley is a graduate student in meteorology. Thomas Lauvaux, formerly a research associate at Penn State, is now a researcher at NASA's Jet Propulsion Laboratory.

The project reported above started with a pilot study funded by the Earth and Environmental Systems Institute in the College of Earth and Mineral Sciences, which led to a successful proposal to the Department of Energy's National Energy Technology Laboratory. The Penn State team will include participants from the College of Earth and Mineral Sciences, the College of Agriculture, and the Marcellus Center for Outreach and Research. Participants outside of Penn State include the University of Colorado and National Oceanic and Atmospheric Administration's Earth Systems Research Laboratory.

Above, from left: Ken Davis; Natasha Miles monitors readings; tube threaded through vehicle window; Zach Barkley mounts GPS. Photos by Patrick Mansell.

OVERCOMING *R*esistance

ANDREW READ argues for a new approach to the evolution of pathogens.

BY DAVID PACCHIOLI

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EVOLUTION KILLS PEOPLE. Andrew Read has been saying so for years. But he never actually saw it firsthand until he worked this summer in a hospital in Ann Arbor, Michigan.

That's when Read, who is Evan Pugh Professor of Biology at Penn State, stepped away from his busy University Park lab to study the problem of drug resistance up close, sifting through massive clinical databases and consulting with infectious-disease specialists struggling with difficult cases in real time. He well remembers the first patient he saw die.

"She had a chronic bacterial infection which was unable to be cleared out," he says. "She had been in and out of the hospital for months. The docs who were treating her used one drug after another. When resistance arose, they tried another. Finally, they just ran out of drugs."

Read works in the relatively new field of evolutionary medicine, specializing in infectious diseases. He is best known for his work on malaria, looking for solutions to the rising resistance in humans against antimalarial drugs—and to a similar resistance against insecticides in the mosquitoes that carry the disease.

"Malaria parasites," Read says, "do evolution on steroids. The only way we can stop them evolving in my lab is by freezing them solid." His basic premise is that an overly aggressive, unscientific use of drugs is driving this evolution, and the evolution of many other pathogens.

"We attack these things that harm us—the bugs or the mosquitoes or the viruses or the cancers," he says, "and they evolve back."

Call it adaptation writ large. To a biologist like Read, what's happening is rapid evolution in response to selection pressure—the same force that shaped the bills of Darwin's finches on Galapagos. In this case, he argues, the pressure is being applied by modern medicine.

"That woman in Michigan died of what I think of as uncontrolled evolution," he says. "We don't know how to slow that evolution down."

ADAPT OR DIE

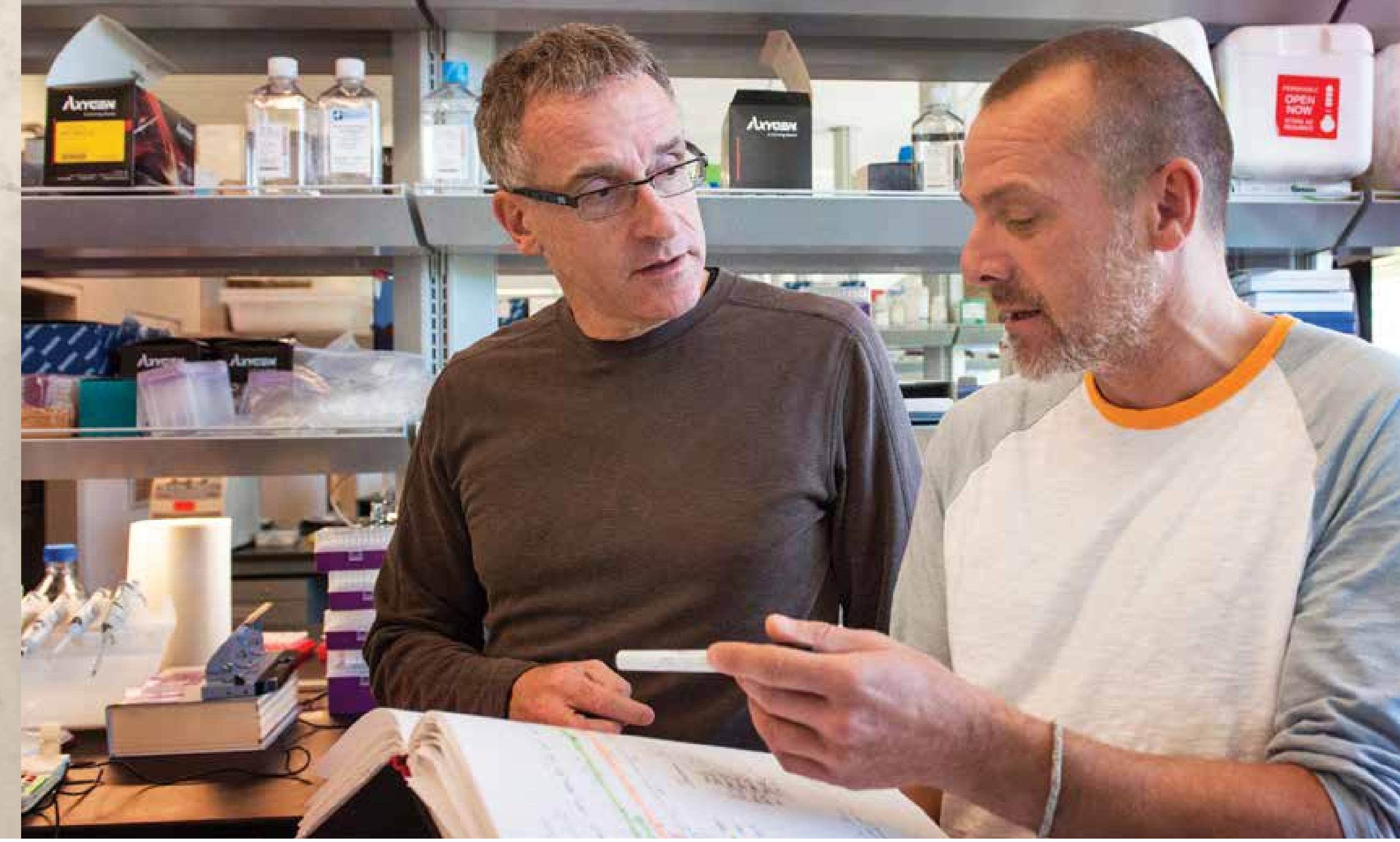
The development of antibiotics in the middle of the last century stands among the greatest triumphs of medical science. "In the case of infections," Read says, "these drugs worked just stormingly well. We went from situations where you would die from a prick in the finger to where—surgery, immuno-suppression, everything is possible."

Such success has its costs. "People have this expectation that these wonder drugs are going to keep working like that," he continues, "or that there'll be new ones coming along. But new drugs are not coming along at the rate they once did."

One hundred thousand Americans die of infections each year, according to the Centers for Disease Control—at least a quarter of them from drug-resistant infections that were easily cured 20 years ago. And evolution is speeding up: Read says pathogens are now evolving resistance to existing drugs faster than new drugs can make it through the regulatory process.

It's not just antibiotic resistance, either. "The exact same problem applies in cancer," he says. In the United States, where well over half a million people die annually of the disease, "almost all of those are cases where the cancer has evolved resistance to the chemotherapy."

One reason, he says, is the systematic overuse of these drugs, an orthodoxy well-entrenched since Alexander Fleming's discovery of penicillin. The flamethrower approach, Read calls it: full-frontal attack. The clinical object is to wipe out every last trace of infection. The problem, says Read, is that



"in evolutionary terms, that very, very strong attack means that the pathogens are under equally strong natural-selection pressure to respond."

In other words, if you kill all the weak, drug-sensitive bugs, you leave the field wide open for the strong, drug-resistant ones. The least harmful result of this kind of survival-of-the-fittest, Read says, is that our drugs grow less and less effective, and eventually fail. The worst case is the development of brand new superbugs, pathogenic strains of extraordinary—and terrifying—virulence.

An emerging perspective in evolutionary medicine, he says, suggests that a different approach may be warranted. "There's an idea that, in cancer treatment for example, maybe you shouldn't be going at it quite as aggressively. You could step back a bit.

"In some mouse experiments," he explains, "better outcomes have been generated by treating a tumor with chemo when it's growing and leaving it alone when it's not growing. A rule like that keeps the tumor there, but also keeps it drug-sensitive. Instead of trying to eradicate the tumor, you go for control."

Read himself has seen similar results—in mice—with malaria parasites. "We set up infections with resistant parasites and sensitive parasites, and we ask, 'What's the best way to treat an infection like that?'" he explains. "Our object is to make the host as healthy as possible as fast as possible. How do you best do that while controlling the resistant strains? And in our hands, with our mice and our strains of parasites, the current guidelines of the World Health Organization—take a full drug course for many days past the time you feel better—is the worst thing you can do. Everything else we've tried works better than that."

Not surprisingly, Read's ideas have caused considerable controversy, especially in medical circles. But after ten years, he says, they are now at least firmly on the scientific agenda. And indeed, he isn't pushing them for clinical use. Not yet. The whole point is that the best course isn't clear.

"Kill every last bug is probably good advice in particular circumstances," he says. "What we don't know is what those circumstances are."

FROM BIRDS TO BUGS

As a boy in his native New Zealand, Read dreamed of saving that country's exotic endangered birds. The dream eventually carried him to Oxford University in England, where as a graduate student he began a study of avian blood parasites.

"Toward the end of my Ph.D.," he says, "it dawned on me that nobody was paying much attention to these parasites, even though they are very closely related to malaria parasites which kill people, and they evolve in real time. The field was wide open." The exact same science that had unlocked the secrets of adaptation in Darwin's finches, he realized, could be applied to infectious disease.

There's no one-size-fits-all, he quickly understood. Instead, "We've got to figure out what are the fundamentally important issues, and then ask in any particular disease context, how those fundamental issues apply."

As Read explains, there are two vital components in the evolution of a pathogen: the genetic mutation that is the origin of resistance, and the natural selection that spreads it. "You need both," he says. But depending on the disease, one component can be more important than the other.

In something like HIV, he explains, new mutants are constantly arising, so that resistance pops up all the time. In something like malaria, by contrast, resistance arises extremely rarely—the spread is the issue.

If there is a general rule, it may be this: Treating aggressively is a double-edged sword. It kills bugs so they can't mutate to resistance, but at the same time it amplifies any resistance that might already be present. "These two opposing evolutionary forces will always play out," Read says. "The question is, in each particular case, which will win?"

VACCINES THAT LEAK

The same pressures that drive the evolution of drug resistance, Read says, can also play out with vaccines. Think about extremely deadly pathogens—"by which I mean ones that kill everybody all the time," he says.

"There are only a few of these in humans, and they are typically spillover things," he says. So something like the Ebola virus, while it might spill over occasionally to humans from bats or other animal hosts,

Opposite page: In the insectary where Andrew Read and colleagues study mosquitoes that carry malaria, postdoctoral researcher Eleanore Sternberg uses a bottle of warm water to draw female mosquitoes to the wall of a mesh box for separation. Above: Read, left, reviews Marek's virus data with senior research associate Andy Bell. Photos by Patrick Mansell.

“We need a science that will allow us to make the best and longest use of the drugs we have.” —ANDREW READ

doesn’t circulate widely. The reason is that it kills the host before it spreads, and therefore kills itself. “If you’re a bug, you’ve got to keep the host alive in order to transmit.”

With the use of vaccines, however, strains that previously would’ve been sufficiently nasty to obliterate themselves find themselves in a host who is protected. And if that vaccine is “leaky,” i.e., not good enough to prevent transmission, the pathogen can spread to other hosts. “The result is you keep alive in a vaccinated population something that’s nastier than what you would’ve had in the population before.” When that strain enters an unvaccinated individual, the results are devastating.

Read believes this is what happened in the case of Marek’s disease, a scourge of the modern poultry industry. Sixty years ago, Marek’s symptoms in barnyard fowl were mild but in the 1960s the virus became troubling enough in industrial operations to spark development of a vaccine. It became routinely administered to commercially raised chickens. In the decades since, two versions of the vaccine have grown ineffective, with a third showing signs of weakening. Meanwhile, Marek’s expression has become lethal. “The strains that are now circulating are so nasty they kill 100 percent of unvaccinated birds within 10 days,” Read says.

There could be many contributing factors, he allows, including a half-century’s worth of changes in the poultry industry. But “our theoretical work suggests that vaccination alone is sufficient to maintain these hyperpathogenic strains.” He is currently conducting experiments to test the theory.

Read emphasizes that Marek’s is a leaky vaccine, unlike those that have proved so successful in the eradication of human diseases like measles, mumps, rubella, and polio. But there are several human diseases, he says, including Pertussis, typhus, and human papillomavirus, which may be susceptible to the same possibility.

“One of the concerns I have,” he adds, “is that if this theory is correct, then with something like avian flu, where we vaccinate birds to keep them alive, we could be allowing very virulent strains to circulate. To the extent that avian flu is a risk factor for humans, that’s a problem.”

SUSTAINABLE USE

When Read speaks about managing the evolution of pathogens, his goals sound deceptively modest. “We might not be able to make things better,” he says, “but we should try to avoid making them worse.”

That means no more “wasting good drugs” the way we did in the last century. “We need to use them more scientifically,” he says. Instead of relying on a constant stream of drug development—engaging in an arms race with nature that we’re bound to lose—we need to practice stewardship, finding ways to keep our current drugs effective for as long as possible.

Using drugs thus sustainably, Read acknowledges, “means there’s often going to be a trade-off between what we do now for patient health and what might make things safer for the future.”

It will also mean trying new things. In the case of HIV, he notes, medical researchers scrambling for a cure figured out that the best approach is combination therapy. “This is an example of where evolution has been tamed,” Read says. “And they did it empirically, just by fiddling around with combinations of drugs. My contention is that we can have that sort of success faster if we understand the underlying science.”

In the world of agriculture, an evolution-based approach to protecting livestock, he suggests, might include counterintuitive measures like breeding for disease susceptibility instead of resistance—so that infected individuals die off before pathogens are transmitted. “Keeping every chicken alive might be bad,” he says.

For slowing the evolution of malaria, conversely, it might be best to let some mosquitoes live. Read and Penn State colleague Matthew Thomas made headlines a few years ago when they developed a fungal insecticide that kills only older mosquitoes. Since only older mosquitoes can transmit the parasite, the theory runs, this is enough to stop the disease from spreading. At the same time, leaving younger mosquitoes alive to breed greatly lessens selection pressure—the reproductive advantage that comes with evolving resistance to the insecticide. With the pressure removed, evolution slows, and the insecticide remains potent much longer.

Mathematical models and laboratory experiments with mosquitoes bear this out, Read says, “but we have had almost no luck getting money to move that project forward.

“It’s a big jump from where we are now,” he acknowledges, “killing every last mosquito with DDT. I think we might get some traction as resistance to conventional insecticides continues to spread.”

In the case of hospital infections, the traction is already there. “All of the physicians I work with are up for anything I’ve got to say if I’ve got data to back it up,” Read says. “They’ve got problems, and they want solutions. But they’re not going to be persuaded by mouse experiments.”

The Michigan patient he saw die, he continues, “had a big effect on me. The doc I was working with said he thought it was a failure of the science. We had uncontrolled evolution and we did not know how to get it under control.

“That’s going to be a major challenge in the current century. We need a science that will allow us to make the best and longest use of the drugs we have.”

Andrew Read is Evan Pugh Professor of Biology, afr3@psu.edu.


Penn State

THE EVAN PUGH PROFESSORSHIPS

In May 2014 **Andrew Read** was named an Evan Pugh Professor, the highest distinction Penn State bestows on its faculty. He is one of only 65 men and women to have received that distinction since the professorships were created in 1960.

The Evan Pugh Professorships honor the University’s founding president, a renowned nineteenth-century chemist and scholar. They are awarded to faculty members who are nationally or internationally acknowledged leaders in their fields of research or creative activity; have shown outstanding leadership in raising the standards of teaching, research or creativity, and service; and demonstrate superior teaching skills with undergraduate and graduate students who have subsequently achieved distinction in their fields.

Read, a native of New Zealand, earned a doctorate in evolutionary biology from the University of Oxford in 1989 and has been a member of the Penn State faculty since 2007.

Thoughts | INTO | WORDS

A research-based literacy program teaches children with communication challenges to read, write, and communicate. BY SARA LAJEUNESSE

The boy is delighted. You can see it in his eyes—his enthusiasm for the task, his pride in his ability. Indeed, Max has good reason to be proud: At age three, he is reading. And at this precise moment, he is reading a story about the Disney character Elsa with his speech-language pathologist, Jessica Caron, a Penn State graduate student in communication sciences and disorders.

As I sit watching the scene from the other side of the one-way mirror, my heart wells with affection for this petite, brown-headed boy who is so eager to learn. But another part of me is confused. I can't reconcile Max's sweet-natured and agreeable behavior with my own biased and inexperienced ideas of how a child with autism should act.

It isn't until his mother, Gina, joins me in the observation room that I learn of the difficulties she faces on a daily basis. Gina, who also has two daughters, says that Max often has tantrums; becomes obsessed with things like numbers, which he'll repeat over and over; and has difficulty expressing himself verbally, only recently being able to ask for something as simple as a drink of water.

But the hardest part about being a parent to Max, Gina says, is anticipating all the challenges he will face in his life.

"It's my job to prepare him for school, for life," says Gina. "They say early intervention is the best. That's why we're here."

OVERCOMING CHALLENGES

Max is a participant in the Literacy Program (Maximizing Outcomes for Individuals with Autism, Cerebral Palsy, Down Syndrome, and Other Disabilities) at Penn State. Directed by **Janice Light**, the Hintz Family Chair in Children's Communicative Competence, the program helps kids with complex communication challenges—such as those with autism, Down syndrome, and cerebral palsy—develop literacy skills including reading, writing, typing, and speaking.

Three-year-old Max works with speech-language pathologist Jessica Caron in the Penn State Speech, Language and Hearing Clinic. Photo by Patrick Mansell.

"Literacy skills are critical to all of our lives," says Light. "They are fundamental to education, employment, social networking, access to technology, and the activities of daily living."

The purpose of the literacy program is threefold. First, as a research initiative, it enables Light to gather the data she uses to develop, implement, and evaluate the effectiveness of such tailored interventions. The program also provides a public service through the Penn State Speech, Language, and Hearing Clinic, and offers training and research opportunities to graduate students and other professionals.

For kids who have limited or no speech, the program makes use of augmentative and alternative communication (AAC) techniques—forms of communication other than oral speech—to help them begin to express their thoughts, needs, and desires. "Most kids are not able to speak when they first come to us," Light explains. "So they are very limited in terms of their communication with other people."

As she begins to describe the mobile devices and other technologies they use to help kids with complex communication needs, it becomes immediately apparent that she has spent many years—decades even—working with people who have trouble communicating. Her own speech is slow and deliberate. As she speaks, she looks me straight in the eye and refers to me frequently by name: a model communicator.

Light created the literacy component of her program—the one in which Max is participating—in collaboration with David McNaughton, professor of special education, based on the National Reading Panel standards aimed at at-risk children. The team adapted the program for learners with limited or no speech.

"Most literacy intervention programs require participants to use spoken responses," says McNaughton. "They are not appropriate for individuals with complex communication needs who are not able to rely on speech to communicate."

TEACHING KIDS TO READ

A, B, C. Say those letters out loud and you'll hear a long A, the word for a buzzing insect, and a synonym for vision. But the sounds the letters actually make within words can be very different. As children, we were all taught to recite the letters first, but this tactic can confuse early readers—even those who are typically developing—and slow them down, Light says.

In her literacy program, she teaches children the sounds letters make instead of their names. She teaches lower-case

Patrick Mansell

Janice Light

letters before capitals, because the former are what kids see most when they read. She teaches the most common letter sounds first, instead of going in alphabetical order. "We want to get the kids up and reading as quickly as possible," she says.

Another skill Light teaches is phonological awareness, the relationship between individual sounds and whole words. "If I hear someone going 'mmm…aahh…mmm,' can I blend that together and know it's 'mom?' Kids have to be able to make the sounds of the letters and then blend them together into words. We also teach phoneme segmentation, which is the opposite; it is taking a word and breaking it into sounds, which is needed when you write or type."

From there, the program moves into reading, starting with sentences in which the child is responsible for reading certain words and the teacher helps to fill in the gaps. Each child receives one-on-one instruction once or twice a week for 30 to 45 minutes. According to Light, it can take as little as 10 hours of intervention for a child to begin reading.

To date, Light has evaluated the literacy intervention with a wide range of individuals, including preschoolers, school-aged children, and adolescents. So far, all of the participants successfully acquired basic literacy skills and learned to apply them during meaningful reading activities. The Penn State program, Light notes, is the biggest and highest-ranked program of its type in the United States.

"We have had a 100 percent success rate; all of our kids have transitioned from being non-literate to being readers," she says. The research is still in progress, but several publications are currently in preparation to share the outcomes.

"Ultimately, our goal is to have the children start kindergarten as readers and writers because it provides evidence that these kids are learners, which can make a tremendous difference for their educational process," she says. "They end up being included in regular education programs rather than shuffled aside into special education classrooms."

The next step, she says, is to help kids use their reading and writing to support more effective communication skills that they will need in school and work. According to Light, spoken language is difficult for many children with autism because it is transient—there one moment and gone the next. "For many, that type of auditory processing is really challenging," she says. "For these kids, visual support really helps."

One of her grants, from the National Institute on Disability and Rehabilitation Research, is enabling her to develop new software for mobile platforms—Android, iPad, and others—that will allow kids who are using picture-based communication, such as communication boards and speech-generating assistive technologies, to seamlessly transition into using typing and words.

TRAINING PROFESSIONALS

In addition to research and public service, Light also focuses on teaching both graduate students at Penn State and teachers and speech-language pathologists in schools.

Jessica Caron, the graduate student who is Max's designated speech-language pathologist, worries particularly about the teenagers who may have been passed over. "People often think if you can't talk, how are you going to be able to sound out a word, so parents and teachers often don't work on literacy skills with their children with communication disabilities," she says. "There are often low or inappropriate expectations of these kids, and that isn't fair because it doesn't give the kids full access to the world."

This fall, Caron will begin a project with teens aimed at achieving some of the same great advances the younger children in the program have made.

"It's such a text-based world," she says. "Teens are texting and on Facebook and that requires knowledge of text and reading. It's a huge part of their lives. If you can't read you get left out."

With grants from the U.S. Department of Education, Light is training 21 master's students and 12 doctoral students. She also provides training to schoolteachers and speech-language pathologists via both direct instruction and a comprehensive website (***http://aacliteracy.psu.edu***) that is accessible to all.

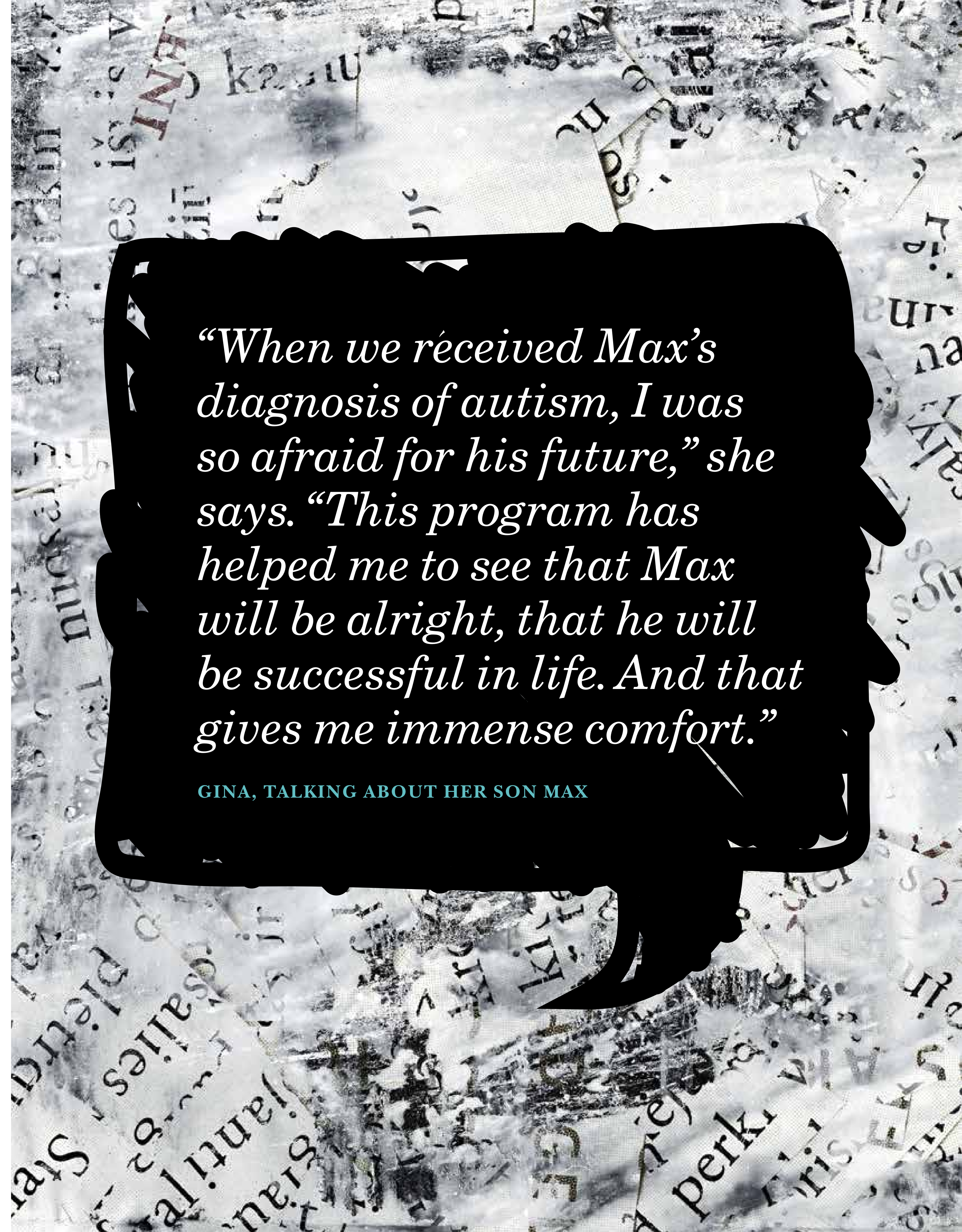
"It is amazing to see the huge impact our work has on kids' lives," she says. "And it is rewarding to be able to help parents to see what their kids are capable of doing."

For Gina, seeing her son Max succeed as a reader and learner has helped her to feel at peace.

"When we received Max's diagnosis of autism, I was so afraid for his future," she says. "This program has helped me see that Max will be alright, that he will be successful in life. And that gives me immense comfort."

Janice C. Light is Hintz Family Chair in Children's Communicative Competence and Distinguished Professor of Communication Sciences and Disorders, jcl4@psu.edu. Jessica Caron is a graduate student in Communication Sciences and Disorders.

At press time, the National Institute on Disability and Rehabilitation Research awarded a $5 million grant to Penn State's Department of Communication Sciences and Disorders and partners for a Rehabilitation Engineering Research Center on Augmentative and Alternative Communication. Light is principal investigator on the project.



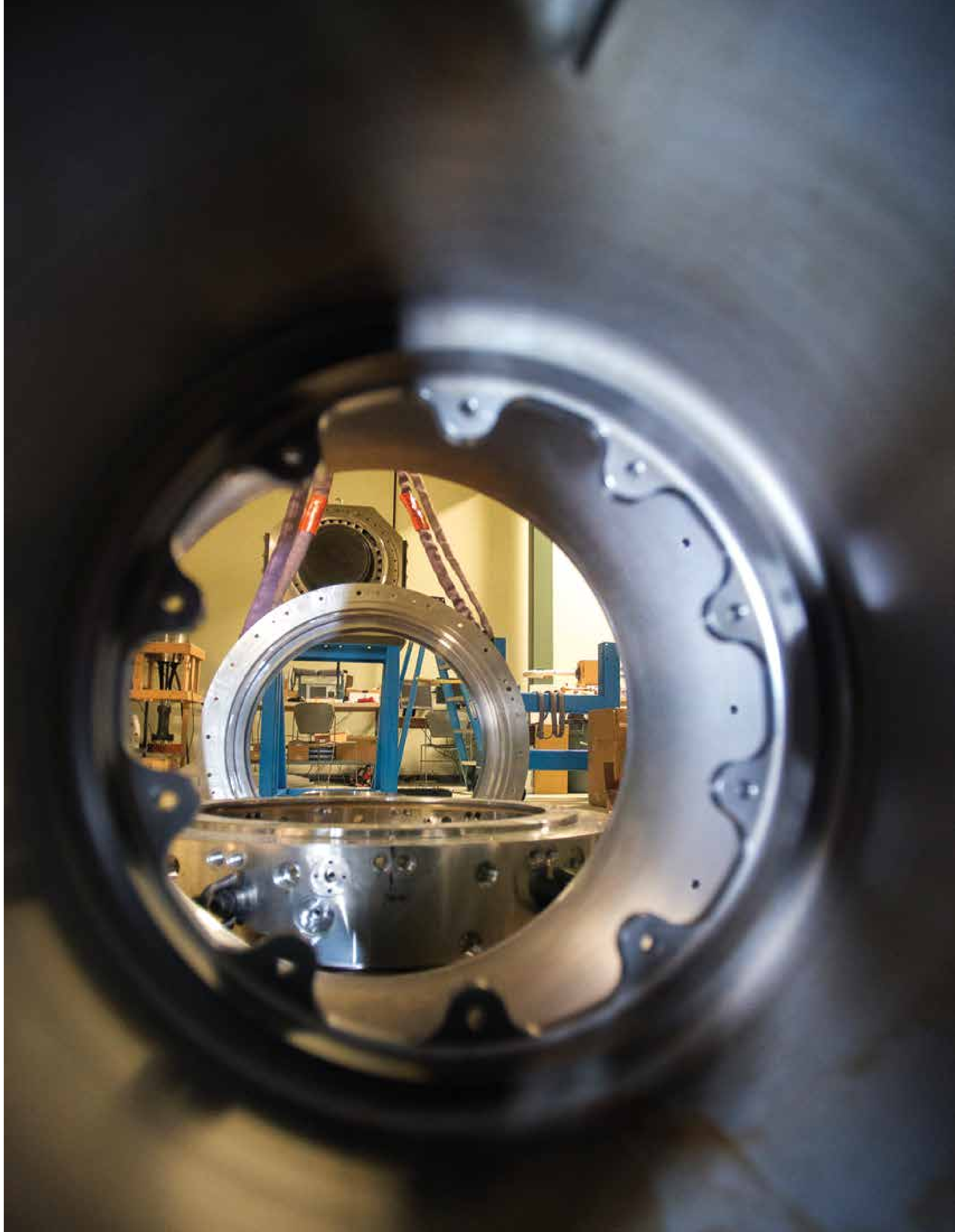
START YOUR ENGINES

Full-scale facility provides a new spin on gas turbines

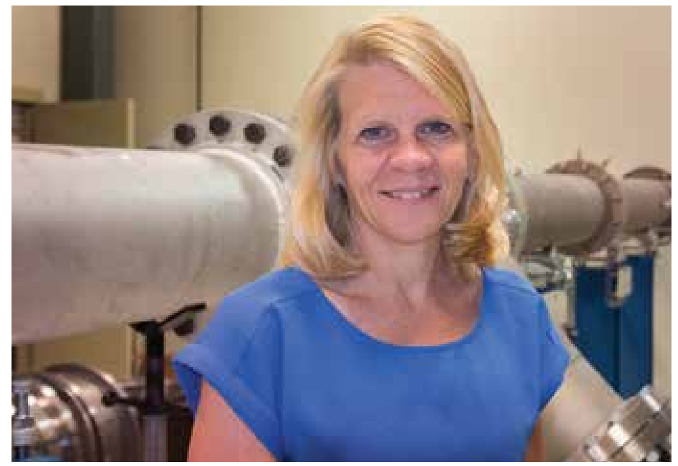
BY KRISTA WEIDNER

THEY SAY A LITTLE KNOWLEDGE IS A DANGEROUS THING. But a little knowledge can also be comforting. For anyone who has sat on a jet airplane at takeoff, tense and sweaty-palmed, wondering how in the world this gigantic assemblage will manage to climb into the sky and stay up, here is a little knowledge: That plane is propelled by a gas turbine engine, which is ideal for jet aircraft because of its excellent power-to-weight ratio—it's a relatively small turbine engine that produces a lot of power for its light weight.

Gas turbine engines, lesser known than their steam, water, and wind counterparts, are found primarily in jet aircraft and in electric power plants. They are well suited for these uses because they operate best under a long-term, consistent load, rather than a fluctuating load, like that experienced by an automobile engine. Because gas turbines spin at high speeds and at temperatures well over 2,000 degrees Fahrenheit, they generate large amounts of power. In fact, gas turbines produce 15 percent of all energy used in the U.S. for air transportation and electricity generation. (CONTINUED ON PAGE 26.)



Turbine test room at the Steady Thermal Aero Research Turbine (START) lab in Penn State's Department of Mechanical and Nuclear Engineering. Photo by Patrick Mansell.



Clockwise, from left: Turbine components lined up in the START lab prior to assembly; A deswirl vein being installed in a turbine assembly; Lab director Karen Thole. Photos by Patrick Mansell (4).

Research associate Michael Barringer sets air pressure and checks parameters to supply appropriate compressed energy flow to turbines undergoing testing.

That process requires burning up a lot of jet fuel. To find ways to increase gas turbine engine efficiency and thus reduce fuel burn, researchers in Penn State's College of Engineering have teamed with aerospace manufacturer Pratt & Whitney and the Department of Energy's National Energy Technology Laboratory, performing experiments on a full-scale test turbine at the Steady Thermal Aero Research Turbine (START) facility near University Park. "The United States uses 1.4 million barrels of jet fuel each day, and our goal is to reduce that number by 5 percent," says **Karen Thole**, professor and head of Penn State's Department of Mechanical and Nuclear Engineering.

One important step toward greater engine efficiency is improved air system seals. Gas turbines have both rotating and stationary components—blades and vanes, respectively—that contain gaps at their interfaces, creating airflow leakages, Thole explains. She and her research team will experiment with various types of seals to see which ones best reduce leakage, and the data they generate will help Pratt & Whitney improve its engine design tools.

After completing the experiments on turbine seals, the team will shift its focus to cooling technologies—how to better cool the vanes and blades that drive a gas turbine. A gas turbine engine consists of a compressor that takes in and pressurizes air; a combustor that burns fuel (propane, natural gas, kerosene, or jet fuel) and produces high-pressure, high-velocity gas; and a turbine that extracts energy from the gas.

"The hot combustion gas is on the order of 2,000 to 3,000 degrees Fahrenheit," Thole says. "So the turbine's vanes and blades need to withstand extremely high temperatures, and the better we can cool them, the more durable and long-lasting the airfoils will be."

The Department of Energy (DOE), a partner in the gas turbine research, has a particular interest in advanced cooling designs. "We're interested in applying improved cooling technology to the larger, stationary gas turbines in power plants," says Richard Dennis, turbine technology manager of DOE's Office of Fossil Energy. "Our goal in this project is greater energy efficiency, and cooling is a key component. The better cooling we can do, the higher temperatures we can use, the more efficient the machines. That greater efficiency means less fuel needed, less air pollution, and lower electricity costs."

ONE OF A KIND

The START facility boasts two qualities that make it unique in the nation. First, it operates under full-scale engine conditions. That's important for accurate research results. "Because this gas turbine will run at realistic engine scales and speeds, it will give us relevant data that we need to make military and commercial jet engines more fuel efficient," says John Weidemer, chief engineer for Pratt & Whitney's hot section.

The second standout feature of the START lab is that it's a steady-state, long-duration facility, meaning that it can run continuously. "Other gas turbine labs are blowdown facilities," explains research associate **Mike Barringer**. "That means they'll blow air for a second or even a few milliseconds, and that short-term flow doesn't have the chance to establish itself as it would in an operating engine. Here, we can keep the air blowing—several hours of testing will be no problem. And that will let us generate more realistic, fully developed flow conditions."

As well as the research on sealing and cooling, experiments with additive manufacturing (3D printing) are advancing gas turbine design and development at the START facility. In current industrial practice, Thole explains, gas turbine vanes are first cast and then shipped to a turbine manufacturer, where engineers use lasers to drill cooling holes into them.

"But the engineers are limited in where they can drill the holes because they need a line of sight for the laser," she says. "We thought, what if you could skip those processes and instead grow the vane using additive manufacturing? So we start with a very thin layer of powdered metal, melt it with a laser, and grow the part, one layer at a time. This technique allows us to incorporate the cooling holes in the initial design, eliminating the need for drilling. And this is an important role for our facility—we're becoming a test bed for a variety of research projects. This lab has many uses."

Yet another test-bed role for the START lab is to facilitate research on sensors. Thole's team recently won a $500,000 Defense University Research Instrumentation Program (DURIP) award through the Office of Naval Research to incorporate sensor instrumentation into the gas turbine.

"All turbines need sensors that monitor temperature and pressure," she says. "Often, a professor will develop a sensor in a nice, clean lab, take it to a gas turbine company, and say, 'I've created this new sensor. Why don't you put it on your engine?' But the reality is that a simple lab test won't translate into a real-world situation. Our lab is the intermediate step that will allow instrumentation such as sensors to be developed and tested in a realistic engine environment."

Karen Thole is professor and head of Penn State's Department of Mechanical and Nuclear Engineering, kat18@psu.edu. The START research team consists of Thole, research associates Mike Barringer and Andrew Coward, and doctoral student Ken Clark. The team also collaborates with research engineers, designers, and technicians from Penn State's Applied Research Lab.

Artist's rendering of the new Center for Building Energy Education & Innovation at the Navy Yard in Philadelphia (left). In the background is the Center for Building Energy Science & Engineering, future headquarters of the Consortium for building Energy Innovation. Credit: Courtesy Kieran Timberlake.

MARTHA KREBS

In December 2013, Martha Krebs was named senior scientist in Penn State's College of Engineering and principal investigator and director of the Consortium for Building Energy Innovation at The Navy Yard in Philadelphia. The Consortium is supported by the U.S. Department of Energy and aims to reduce energy use in commercial buildings. Activity areas include development and deployment of energy-efficient building systems and control technologies, building-energy modeling and simulation, and economic and business analytics. We asked Krebs to assess the state of the Consortium.

WHAT MADE YOU SAY "YES" WHEN YOU HAD THE OPPORTUNITY TO DIRECT THE CONSORTIUM?

I thought it was a great experiment that then-Secretary of Energy (Steven) Chu was proposing. And that's what attracted me. The whole idea of how energy hubs and consortia work and how science and technology fit in was interesting and exciting. Also, I had served as an assistant secretary of energy, so I deeply care about the Department of Energy and I cared about the idea of making existing commercial buildings more energy efficient.

WHAT ASPECTS OF THE JOB HAVE YOU FOUND MOST REWARDING, OR PERSONALLY SATISFYING?

First, it's an incredible opportunity to work at such an interesting place. But I'm really pleased and honored to be with a team of people that is affiliated with the consortium and the institutions. We have 14 really important Pennsylvania and greater Philadelphia area institutions as partners, and important industrial partners, like Bayer and United Technologies. They have all been committed to the consortium and the work we're doing.

WHAT, SO FAR, WOULD YOU SAY ARE THE GREATEST CHALLENGES?

Well, I arrived on January 6, and within a few days we found that Congress had reduced our budget from $24 million to $10 million. We had to reduce our partnership from 25 organizations to 14, to reconfigure what kinds of research we were going to do and to convince a whole new set of Department of Energy staff from the Building Technology Office that this was valuable for us to be doing. So this was the main challenge: building a new and reduced program, but still producing a real contribution to the Buildings Technology Office.

WHAT IS PENN STATE'S ROLE IN THE CONSORTIUM? WHAT DOES THE UNIVERSITY BRING TO THE TABLE?

First of all, Penn State provides overall management support for the Consortium. It also provides the engineers who run the program, as well as computer scientists and other researchers who lend their expertise to the program and who do, for example, demonstrations in the Philadelphia area. A lot of this support comes from Penn State's College of Engineering. Without the commitment of that college, the project would not be what it is. Also, researchers from Penn State's Department of Architectural Engineering and their students have played an important role in the research agenda of the Consortium. Beyond that, there are a lot of opportunities for faculty in the Smeal College of Business and for Penn State economists, to name just a couple of examples.

HOW WILL THE CONSORTIUM BE CONTRIBUTING TO ECONOMIC GROWTH, IN TERMS OF JOB CREATION, BUSINESS EXPANSION AND THINGS OF THAT NATURE?

We're learning about what types of job skills, what types of engineers, what kinds of installers and service providers are going to be needed to make sure we can support deep energy savings for small and medium-sized business owners. That's why the Department of Energy is investing in this project. Philadelphia is a classic old east coast city that presents interesting challenges that are similar to other cities and communities. This project is meant to be a model to export to different parts of the country, so I think we'll have an impact in the Philadelphia area, the state, and across the country.

This summer **Hester Blum** went to sea on the world's last surviving nineteenth-century wooden whaleship, the *Charles W. Morgan*. Built in 1841, the *Morgan* had not sailed from its museum berth at Mystic Seaport, CT in nearly 100 years. Blum, an associate professor of English at Penn State, was one of a select group of public historians for the ship's "38th Voyage," producing a creative project sponsored by the National Endowment for the Humanities. Blum studies sailors' unexpected participation in literary culture as producers and consumers of books. As a 38th Voyager, she occupied—however fleetingly—the very space of that oceanic literary community. Photos courtesy Hester Blum.

Research/Penn State
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Start Your Engines

Full-scale turbine test facility helps improve jet-engine efficiency.

SEE STORY, PAGE 24