







_ INTO THE TREES

A few times a year, scientists from the Academy of Natural Sciences of Drexel University venture to remote regions of the planet on some of the most important field trips in the name of science: collecting expeditions. The material they bring back has the potential to open new lines of research and answer limitless questions about life on Earth.

NO INSTITUTION in the Americas has as rich a history of international field collecting in ornithology as the Academy of Natural Sciences of Drexel University. For over two centuries, the Academy has sent ornithologists to vanishing wild places to survey and sample local bird populations.

Recently, Academy scientists Jason Weckstein and Nate Rice, the assistant curator and collection manager of the Academy's Ornithology Collection, respectively, traveled to Parque Ejidal San Nicolás de Totolapan, a protected reserve about 20 miles southwest of Mexico City in Mexico. There were many reasons this location was selected for a collecting expedition, but one in particular demanded attention — it was time.

"Most of our collection from Mexico was collected around World War II or earlier," says Rice. "Our collection is really strong in New World holdings (North and South America), but in that, our weakest points are what we call Mesoamerica, which is Mexico and Central America. Mexico is a great place for us to add material that's new for the collection or add to series that haven't been added to in decades or even a century."

The pair worked with long-time collaborators from the National Autonomous University of Mexico (UNAM) for a 10-day trip along the thick forest terrain of the park. At roughly 3,000 meters above sea level, the air was thin, the nights cold and the mornings foggy, but it was all worth it for the "gold mine" of material brought home to the Academy.

The team has several projects in progress already with the Mexico specimens — Rice has been filling in gaps in the Academy's Ornithology Collection, which consists of study skins and tissue samples (and one of the world's best collections of avian parasites, since Weckstein's arrival in 2015). Weckstein plans to study the hippoboscids collected from bird specimens in the field to learn more about which birds the insects are feeding on. He is also conducting malarial screening on the tissue and blood samples from the trip.

And for the specimens that may not be of immediate scientific use, each day that passes makes them more historically valuable to the scientist who will surely come looking 100 years from now. — Katie Clark



The golden-crowned kinglet (*Regulus satrapa*) is a species that can be found outside the Academy's doors in Philadelphia. Although tiny, it can survive in cold, wintry environments, eating insects and insect eggs. Weckstein said he plans to compare this subspecies collected in Mexico with its counterparts from North America currently housed in the Academy's collection.

THE _ PROCESS

To "process a bird," ornithologists follow a certain order of steps. Here, Weckstein works with Erick Alejandro García Trejo, a professor in the department of evolutionary biology at the National Autonomous University of Mexico (UNAM), to prepare a bird for the collection. First, birds are captured in a mist net, which is a fine mesh suspended between two poles, like a volleyball net. The scientists then record the bird's weight, measurements and coloring; take a blood sample; make a blood film (a smear of blood on a slide, used later to look for blood parasites); euthanize the bird; "ruffle" the bird by placing it in a bag with a cotton ball of ethyl acetate to euthanize any parasites that may be living on its skin or in its feathers; ruffle the bird's feathers to shake out parasites and other debris; and skin the bird to prepare it for study.







Localidad _____

Coordenadas Geográficas: _____

No. Catálogo de campo _____

→ Fecha 10 - Julio -

Preparador DRP

Gónadas: _____

Muda: NO POCA R

Ubicación _____

Grasa: NO POCA R

Anillo ocular _____

Maxila _____

Tejidos _____

Observaciones: _____

No. Catálogo de campo _____

Fecha _____

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Tejidos _____

Observaciones: _____

Tissue _____

Species _____

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Locality _____

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Maxilla: _____

Mandible _____

Tarsus/toe _____

Body Weight _____

Blood

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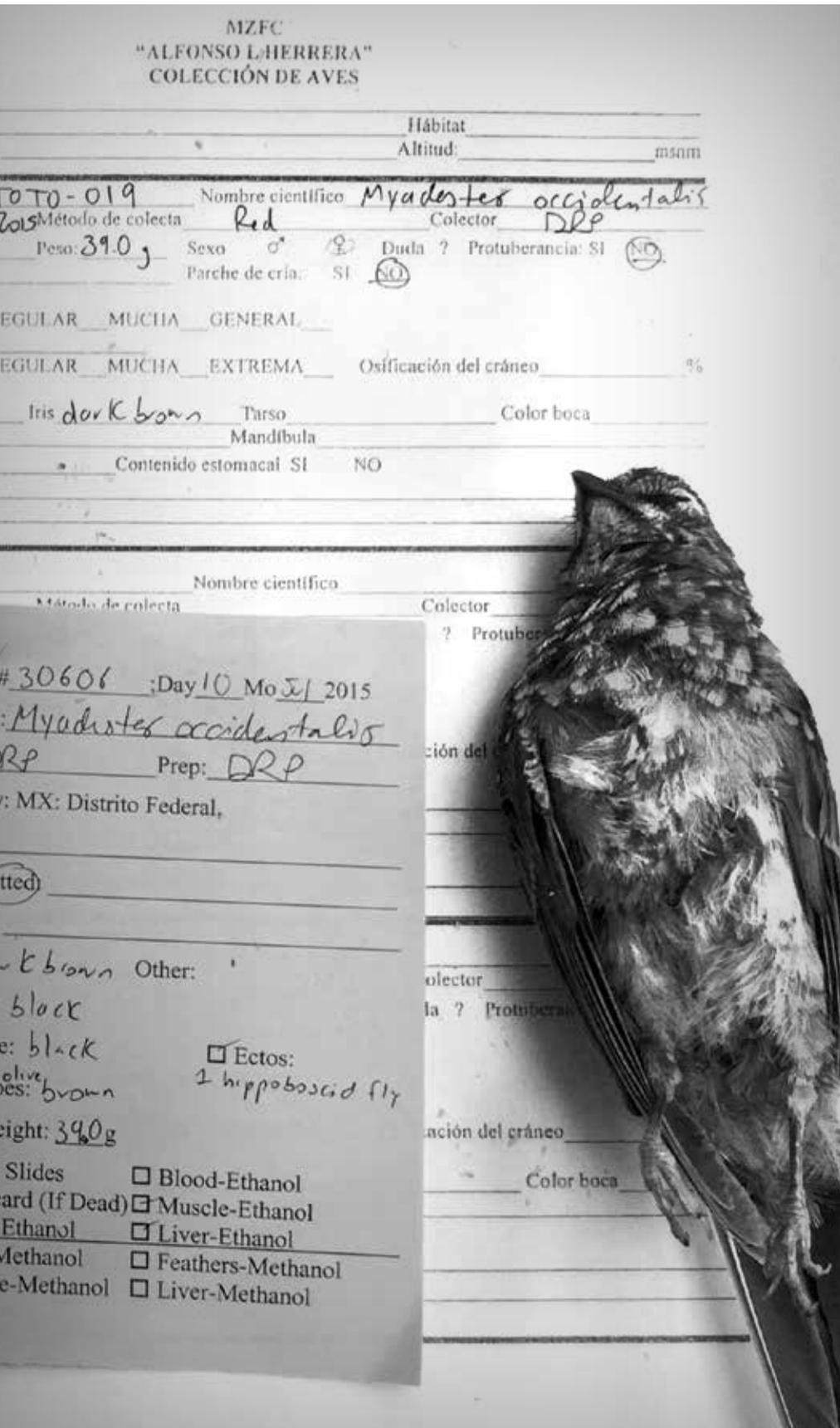
Heart-

Skin-M

Muscl

Stomach: _____

Participantes: _____



At the bottom of this vial is a hippoboscid fly collected from a bird. Hippoboscid flies are one of the groups of avian parasites that Weckstein's lab is studying. Weckstein will use the collected flies to determine their levels of host specificity — that is, how dependent the parasite is on a single host. The dogma in the science literature says that hippoboscid flies are generalists that feed on many hosts, yet this has never been rigorously tested. This is important data because these flies are vectors for *Haemoproteus*, a relative of malaria, and they also move lice and mites between avian hosts.

LET THE RECORD SHOW

This image highlights one of the most important steps in the collecting process: recording scientific data. The data sheets follow a specimen through the entire process from how it was caught, to its weight, to the coloring of its eyes, bills and legs, to what parasites were present on its body. The vials contain tissue samples and blood samples, both of which will be used for various projects. For example, Weckstein and his team will examine the blood for malarial parasites (*Plasmodium*, *Haemoproteus* and *Leucocytozoon*, for example). He'll screen individual birds for these infections and then sequence DNA from those pathogens infecting birds to characterize their diversity, host specificity, distribution and evolutionary history.



Weckstein and Rice brought back specimens of a russet nightingale-thrush (*Catharus occidentalis*), which will be used by environmental science doctoral student Matt Halley to study the genus *Catharus*. Halley is sequencing the DNA of the specimens using tissue samples, and then comparing these sequences to help determine how many species there actually are. He is also using DNA sequences to reconstruct the family trees of all species of *Catharus* thrush. It turns out, Halley says, there are some cryptic species that have long been overlooked — he’s gathering evidence to make the case (for or against) revising the taxonomy by adding or subtracting species.

UNDER THE SKIN

Nate Rice has been preparing, or “skinning,” birds for decades. He is an artisan of sorts, and takes pride in his craft. After a bird is euthanized and all of its data collected, the next step, Rice says, is to open the bird along the chest, pull the skin back and remove all muscles, bones and organs. The same goes for the head — the neck is turned inside out to remove most of the skull as well as the brain and eyes. Lastly, the skin is filled with cotton and stitched back up. The goal is to make the bird look as it did in life. Rice can make a robin-sized skin in 20–25 minutes; on the Mexico trip, he prepared about 10 specimens per day. Though they’ll never sing again, these birds will speak to scientists well into the future about the genetic, evolutionary and geographic changes influencing their species.

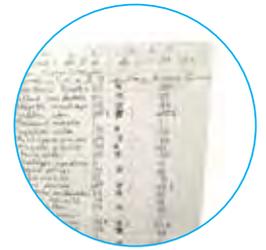






[_ONLINE](#)

Visit exelmagazine.org to view more images of the expedition and the wildlife the researchers observed.



Host countries set limits on how many birds of each species can be collected during field expeditions. On this particular trip, the team was allowed five per species. The one exception was the allowance of seven specimens of one particular species designated by the Academy for close study, the red warbler (*Cardellina ruber*).

THE FINAL HAUL

The researchers from the Academy and those from the National Autonomous University of Mexico each took an equal split of the specimens, taking into account whose research interests centered around which birds. In addition to what can be seen in the photo, each team also took blood and tissues samples back to their home institutions. "This material will absolutely benefit a whole slew of projects," says Weckstein.

_EXEL 2016



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A SOBER ANALYSIS

Should Pennsylvanians worry about the impact liquor privatization may have on public safety? For an answer, one researcher studied the data from Washington's privatization in 2012, and it isn't pretty: An increase in alcohol retailers is associated with more violence. *by Scott Pruden*

01

_EXAMINE

Field logs from a bird-collecting expedition in Mexico



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_VISIT EXEL ONLINE

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THE THINKER

Drexel's John Kounios and his collaborator were the first scientists to use brain scans to study how our minds make the leap from methodical thinking to sudden insight. In their new book, Kounios shares what they've learned about cultivating creativity. *by Lini S. Kadaba*



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VANISHING

In Ghana, over half of all forest understory birds have vanished in just 15 years as unchecked illegal logging, economic stress and demand for African timber take their toll on the nation's rainforests. *by Mike Unger*



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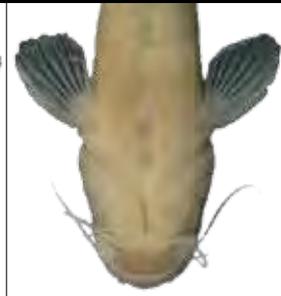
_PRESIDENT'S MESSAGE

Research that takes a fresh perspective

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_TECH/SCIENCE

Hypertloop pod, 3-D printed stem cells, crash lab, round crystals, atomic sandwiches, distracted driving, molecular materials, history's spear, carbon films, stem cell algorithms, algae filter



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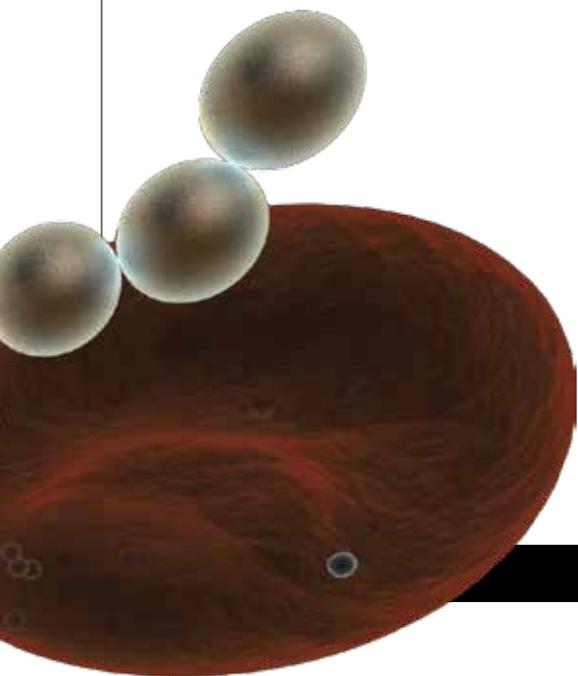
_NATURE/ENVIRONMENT

Black holes, **new species**, energy from tires, map of the world, *Dimetrodon* discovery, fate of the dinosaurs, Brook-trout Lake, Bioko bushmeat

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BOTS IN THE BLOODSTREAM

An international team of roboticists is collaborating on a groundbreaking treatment for blocked arteries that would put swarms of microscopic, magnetically controlled robotic beads directly inside blood vessels.
by Jen A. Miller



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THE INFECTION CONNECTION

Despite billions spent on Alzheimer's research to date, the precise cause of the disease remains a puzzle. Drexel microbiologist and genomics expert Garth Ehrlich is pursuing an intriguing new theory that suggests a microbial infection triggers the disease's devastating symptoms.
by Katie Clark

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CHILD'S PLAY

Most therapies for children with cerebral palsy focus merely on improving mobility, while overlooking the relationships that lead to a fulfilling life. A new approach by Drexel researchers puts the emotional and social needs of these children first.
by Lini S. Kadaba



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SECOND CHANCES

Strict "zero tolerance" policies in public schools trigger terrible collateral consequences for youth that diminish their life chances considerably. Psychology professor Naomi Goldstein is working with the City of Philadelphia on a program that permanently re-routes the "school-to-prison" pipeline.
by Tim Hyland

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_ BODY OF RESEARCH

The Academy of Natural Sciences of Drexel University's malacology collection contains more than two centuries of specimens



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_ PUBLIC HEALTH

E-cig marketing, fighting obesity, Ebola's lifecycle, asthma drugs and autism, behavioral health "home," pollution and health, secondhand smoke, depression and poor grades, rainfall collection



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_ MEDICINE

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Cameras for cops, disconnected youth, video games in the classroom, marketing fonts, CEOs and venture capitalists, sexual abuse and anonymity, appetite and romance, the study of takeover bids, **repurposing food waste**

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_RESEARCH, WITH FRESH EYES

A different approach to crucial questions



_ABOUT THE COVER
These photographs were taken by shooting downward into glasses filled with liquors and liqueurs. The resulting image is reminiscent of petri dishes and perfectly captures the topic and the approach of the cover story on liquor privatization.

WE OFTEN REFER TO “the Drexel difference,” because this isn’t a typical university. There is nothing ordinary about our signature model of experiential learning, our students, nor our outcomes.

Nowhere is this truer than in our research enterprise. Drexel owes its exceptional approach to inquiry to our belief that academics have a practical role to play in the world and that institutions of higher education should help to answer socially important questions.

I’m especially proud of the practical ingenuity on display in this edition of EXEL Magazine, our annual compendium of Drexel research. Whether wringing new insights from simple methodologies or boldly experimenting with new materials that seem straight out of science fiction, the researchers whose work is presented in these pages are gazing with open minds at problems that urgently demand a fresh perspective.

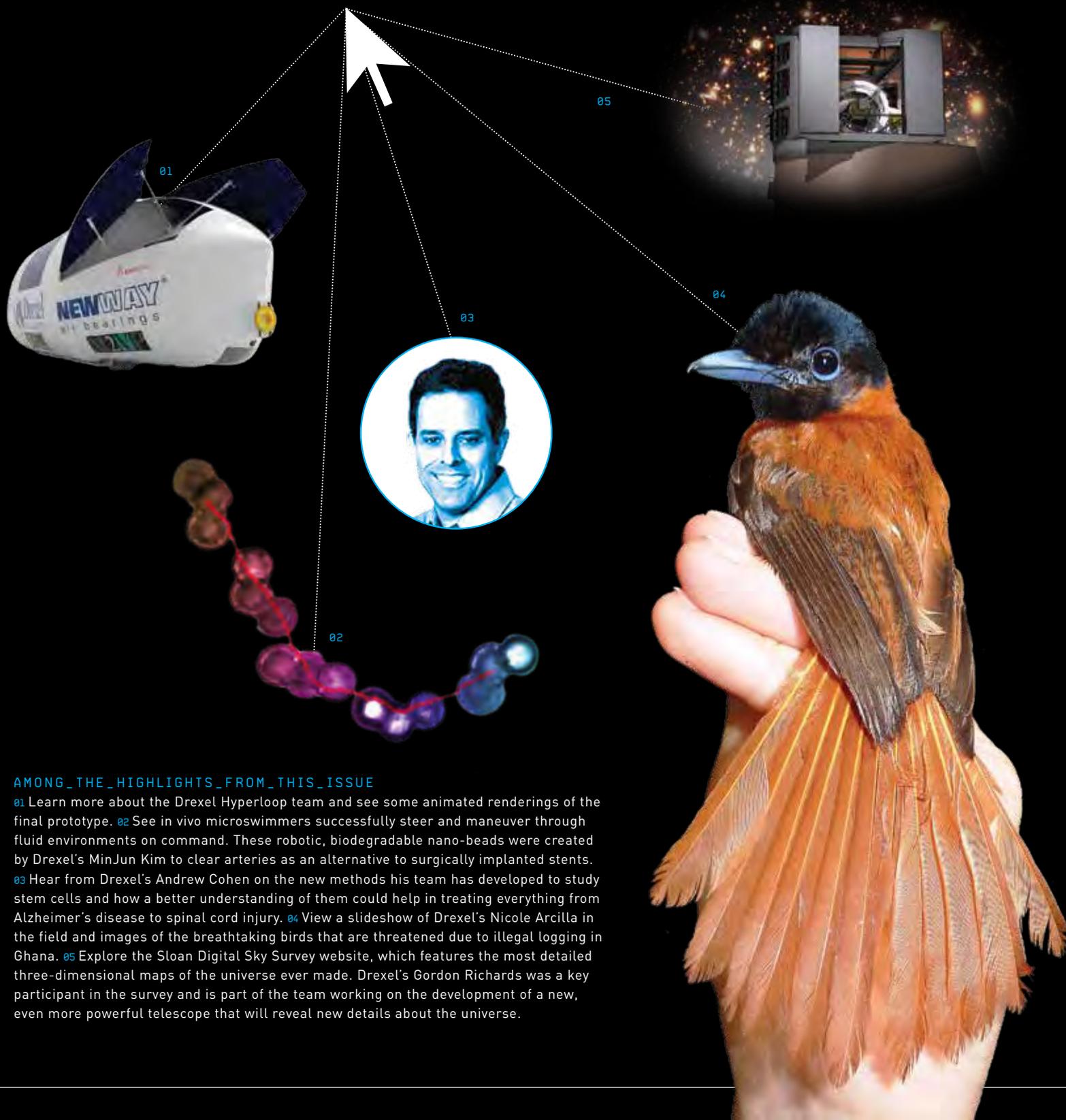
From the psychologist who combined simple brain scans in a new way to explain how creativity is sparked ... to the expert microbiologist pursuing a new infectious disease theory of Alzheimer’s ... to the engineer building microscopic “bots” to burrow through plaque inside blood vessels blocked by atherosclerosis — Drexel researchers veer from well-worn paths in pursuit of bold, impactful discoveries that can truly make a difference.

I hope you enjoy this edition of EXEL and find as much inspiration as I do in the unique contributions Drexel is making toward a healthier, safer and better world.

John A. Fry / President

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Connect with EXEL Magazine on the Web for online-only exclusive content, interviews with Drexel researchers, more in-depth coverage and videos about our work, updates from our growing research enterprise and more. Visit exelmagazine.org.



AMONG THE HIGHLIGHTS FROM THIS ISSUE

01 Learn more about the Drexel Hyperloop team and see some animated renderings of the final prototype. **02** See in vivo microswimmers successfully steer and maneuver through fluid environments on command. These robotic, biodegradable nano-beads were created by Drexel's MinJun Kim to clear arteries as an alternative to surgically implanted stents. **03** Hear from Drexel's Andrew Cohen on the new methods his team has developed to study stem cells and how a better understanding of them could help in treating everything from Alzheimer's disease to spinal cord injury. **04** View a slideshow of Drexel's Nicole Arcilla in the field and images of the breathtaking birds that are threatened due to illegal logging in Ghana. **05** Explore the Sloan Digital Sky Survey website, which features the most detailed three-dimensional maps of the universe ever made. Drexel's Gordon Richards was a key participant in the survey and is part of the team working on the development of a new, even more powerful telescope that will reveal new details about the universe.

_GREASED LIGHTNING

A group of Drexel undergraduate engineering students is among the last teams standing in the race to design a transportation pod for SpaceX's high-speed transit test track.

IMAGINE ZOOMING between cities in a high-speed transportation pod at 700-plus miles an hour, all the while levitated above a small pocket of air.

Now imagine designing, engineering, manufacturing and marketing a prototype of that very pod, all from scratch and while still an undergraduate student, with a chance to have your design incorporated into a new mode of super-fast transit envisioned by SpaceX founder and inventor Elon Musk.

For about 70 students at Drexel University, it's all real. They are one of 31 college teams, out of 1,200 original contestants from around the world, who have been chosen to advance in Musk's 2016 SpaceX Hyperloop Pod Competition after presenting their initial design to Musk, academics and other judges in January.

At press-time, the Drexel Hyperloop team is putting the finishing touches on its ambitious concept — a prototype of the bullet-like capsule that would hold passengers in Musk's visionary transit system.

"This is not just a project you do in school," says Om Mahida, 22, a junior computer engineering student who's involved in software development for the pod's control system. "You're basically running your own startup."

Most teams are focusing on a subsystem, but the Drexel Hyperloop team is among the few that decided to take on the whole she-

bang, down to a design for a pod transit station.

Those teams that have made the cut — meaning they secured tech company sponsors to build prototypes that can cost upwards of \$70,000 — will test their designs in Hawthorne, California, on a mile-long Hyperloop, which is the near-vacuum transportation tube that Musk proposed in 2013.

The concept works like a puck on an air-hockey table: Pods for either passengers or cargo float on a very thin air cushion to minimize the friction, the main culprit that limits speed, and as a result attain miles per hour, at least theoretically, close to Mach 1. A six-hour car ride between Los Angeles and San Francisco would be a mere 30 minutes on a Hyperloop.



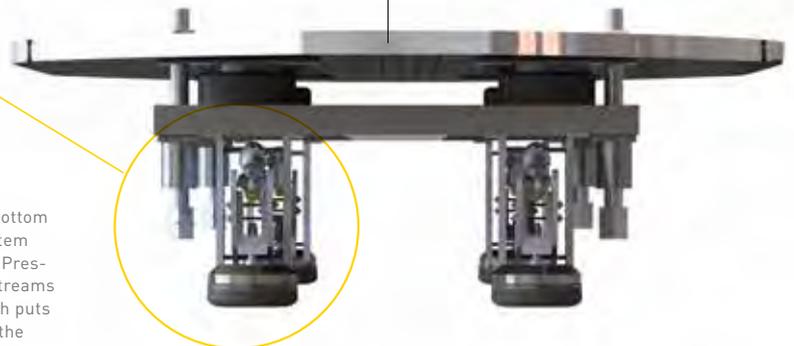
_GLIDING ON AIR

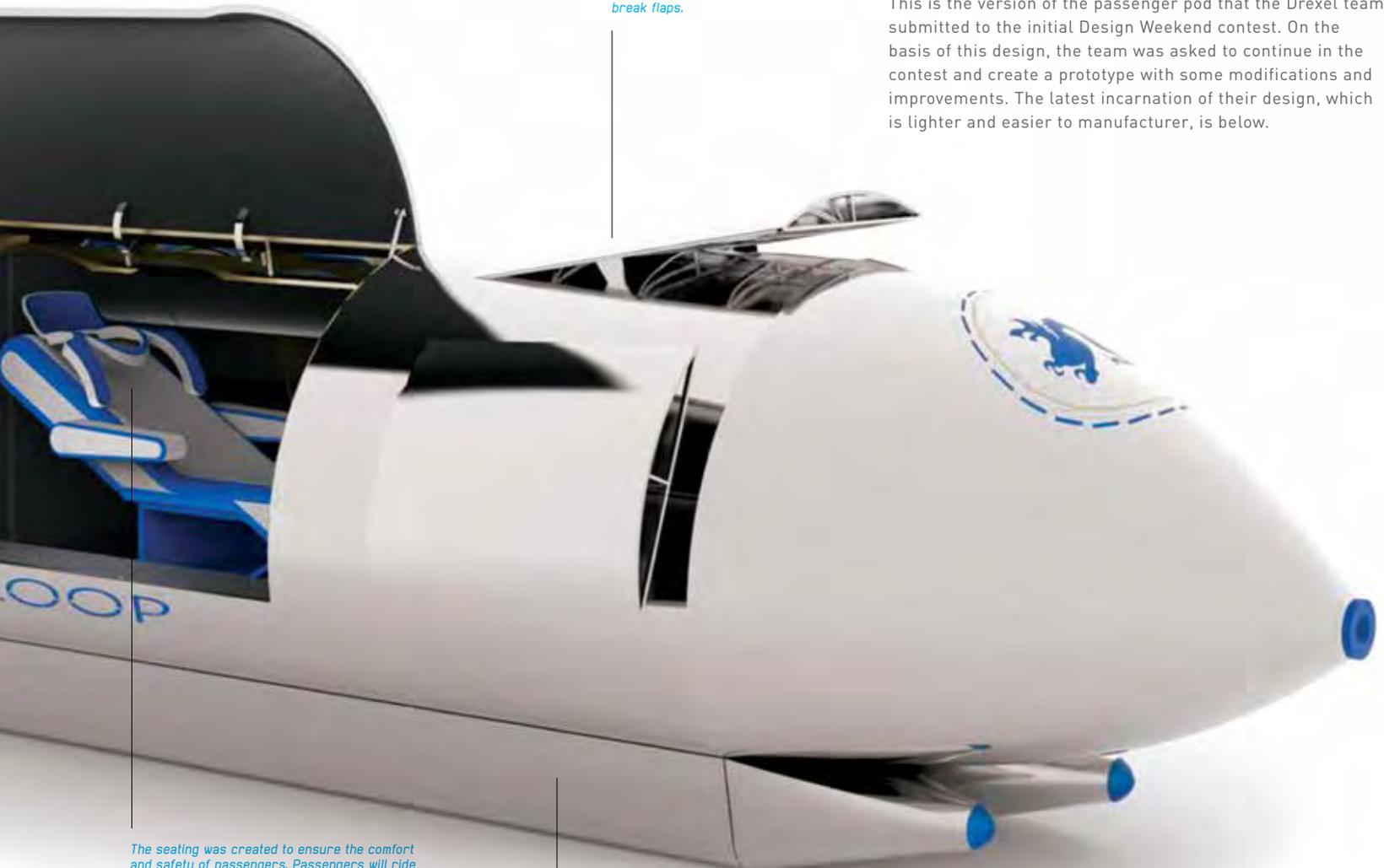
The round hockey-puck-like nodes at the bottom of the dynamic floor are an air bearing system that is unique to the Drexel team's design. Pressurized air tanks on board the pod direct streams of air downward from these bearings, which puts a small pocket of air between the pod and the track. The air bearings allow the pod to basically levitate over the track without friction. The concept is similar to hydroplaning, when a thin layer of water separates a vehicle's tires from direct contact with the surface of the road.

An aerodynamic flap creates air resistance for braking. When the flaps open, a pocket of air is created inside the tube through which the pod travels, which slows the pod down. The pod is also designed with two other backup breaking systems.



This, called the "dynamic floor," is the structure that will hold the pod and its suspension system together.





This is one of the pod's aerodynamic break flaps.

POD_1.0

This is the version of the passenger pod that the Drexel team submitted to the initial Design Weekend contest. On the basis of this design, the team was asked to continue in the contest and create a prototype with some modifications and improvements. The latest incarnation of their design, which is lighter and easier to manufacture, is below.

The seating was created to ensure the comfort and safety of passengers. Passengers will ride facing backwards, as is required by FAA standards for travel at high speed. Passengers won't be able to sense their direction because of the lack of acceleration or windows inside the tube, so to help orient them to their journey, the team has proposed displaying a digital "video" of realistic passing scenery on the interior walls.

The original design featured an aerodynamic undercarriage design that helps the pod maintain its fast speeds. In the newest prototype, the undercarriage mechanicals have been absorbed into a single molded chassis.

TECH_SUPPORT

The Drexel team has rallied companies to its cause. Among the sponsors are ide Group, a product design and development company with offices outside Philadelphia and in Sydney; Exelon Generation, a power generator serving the Midwest, Mid-Atlantic, Texas and California; and M2VP, a technology strategy consulting firm from West Chester, Pennsylvania. New Way Air Bearings, an air bearing manufacturer in nearby Chester, Pennsylvania, is working with the team to make the hover pads will that allow the pod to float along the rails at super-fast speeds.



_STEM CELL 'LEGOS'

Using a custom-designed 3-D printer, an engineer has devised a way to manufacture the building blocks of life.

INSIDE HIS Biofabrication Lab, engineering professor Wei Sun is making strides toward rapid prototyping the building blocks of life using an extrusion printer, designed by him, that squeezes out a mixture of hydrogel and stem cells.



_WEI SUN
Sun is the Albert Soffa chair professor in the Department of Mechanical Engineering and Mechanics in the College of Engineering and director of the Biofabrication Lab.

Sun's process, which was recently published in *Biofabrication*, gives scientists a head start at growing living three-dimensional tissues.

"We are able to apply a 3-D printing method to grow embryoid bodies (precursors of organs) in a controlled manner to produce highly uniform 'blocks' of embryonic stem cells," says Sun, who co-authored the research with colleagues from Tsinghua University in Beijing. "These 'blocks' are capable of differentiat-

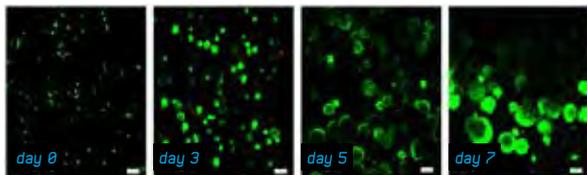
ing to other cell types and could be used as the 'lego bricks' to build tissue constructs, larger structures of tissues and potentially even micro-organs."

Sun's bio-printer, which was originally created with the goal of printing bone and tissue scaffolds, has also been modified to print living cancer tumors. It does so by extruding the cells in a temperature-controlled hydrogel mixture and depositing a three-dimensional grid-like structure, which not only keeps them viable, but helps them grow and multiply.

"There is still a long way to go from a varying sized embryoid body to a regenerated organ, but our work provides a promising tool to facilitate this development," says Sun.

The benefit of being able to carefully manipulate the environment that exists in a "block" of stem cells is that it gives researchers a controlled platform from which to study how and why the cells differentiate into precursors of organs.

Down the road, this could mean that scientists will be able to more efficiently grow organs in a lab by printing and growing the organ's corresponding embryoid body.



ORGANS_TO-BE

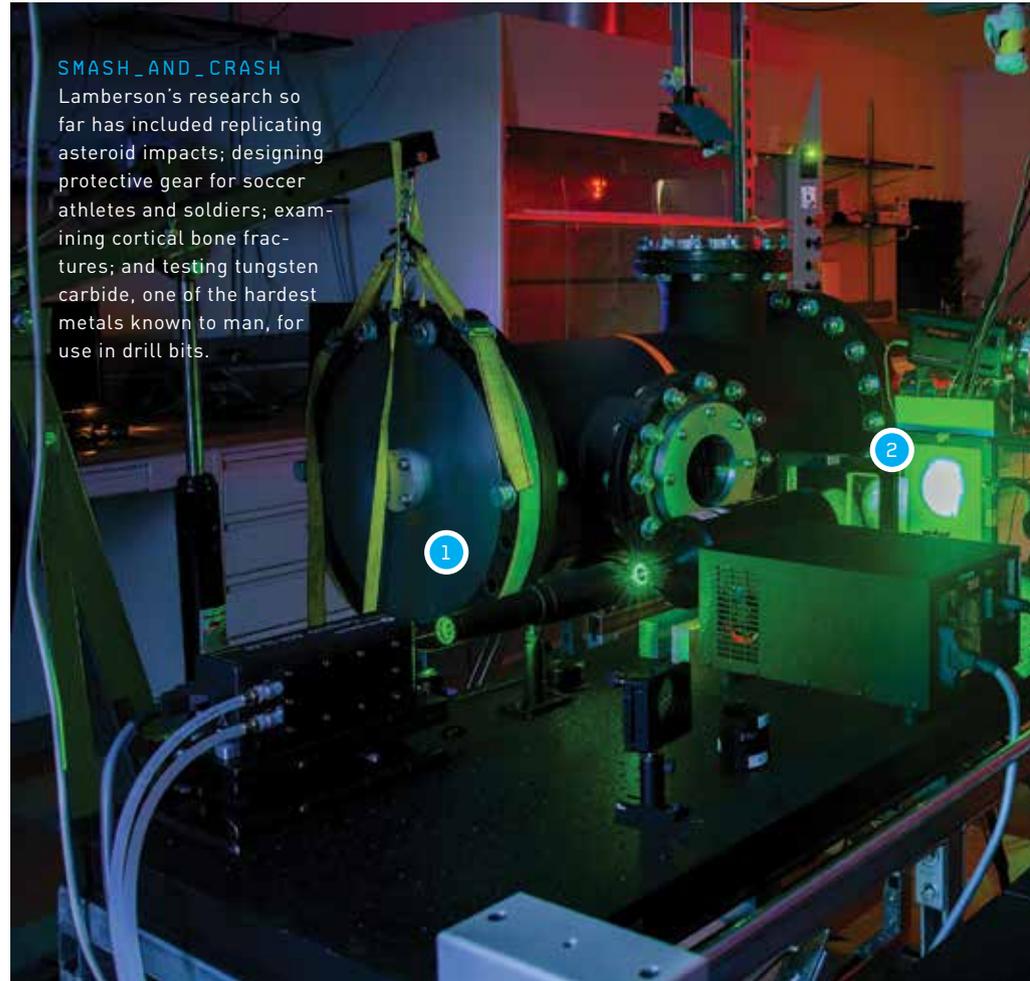
Three-dimensional stem cell clusters formed by Sun's bio-printer continue to grow and retain their ability to differentiate.

_THE BREAKING POINT

Inside her custom-designed lab, Leslie Lamberson smashes, cracks and pushes materials to better understand, and extend, their limits.

SMASH_AND_CRASH

Lamberson's research so far has included replicating asteroid impacts; designing protective gear for soccer athletes and soldiers; examining cortical bone fractures; and testing tungsten carbide, one of the hardest metals known to man, for use in drill bits.



IF YOU TRULY want to know what something is made of, you push it past its breaking point, or so the adage goes.

That's the idea behind Leslie Lamberson's Dynamic Multifunctional Materials Laboratory, a one-of-a-kind materials testing lab she built from scratch for the purpose of, basically, breaking things.

"We push materials to their extremes to get a better understanding of their behavior under complex, real-world loading conditions," says Lamberson, an

assistant professor in the College of Engineering. "If you know how something breaks, that knowledge informs design. You can tailor it to break in a certain way, or even not to break by understanding its dynamic properties."

To keep costs down and creativity and capability high, Lamberson designed and built — and even patented — most of the equipment in her lab using Drexel's Machine Shop and, in some cases, spare parts she acquired from eBay, Craigslist and even Ikea.

1 TARGET PRACTICE

This patented two-stage light-gas gun can propel a projectile into a target at hypervelocity speeds of over 7,000 mph. Lamberson personally designed the machine for around \$30,000, which is approximately how much it costs to run the NASA Ames Vertical Gun Range (a similar facility) for just one week. Lamberson uses the device to create micrometeoroid, orbital debris, and asteroid impacts within her lab. Plus, the first stage of the two-stage gun can be used individually as a blast tube to replicate the pressure profiles of an IED explosion on the battlefield — information that she's using to propose ways to improve the protective foams inside soldier's helmets with the Office for Naval Research.

MOLECULAR SCIENCE

_DIFFERENT KIND OF CRYSTAL BALL

A new method has been discovered for growing spherical crystals that could be used for drug delivery.

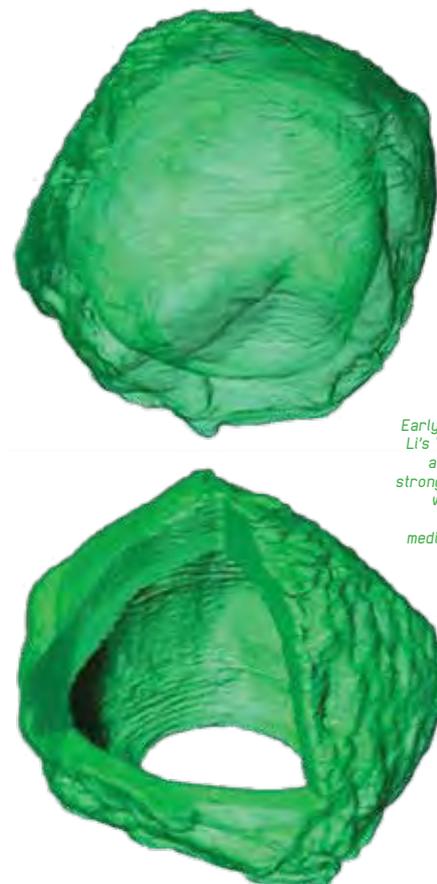
NO TWO SNOWFLAKES are alike, they say. And some are very different, indeed.

A Drexel materials scientist has discovered a way to grow a spherical, microscopic crystal — like a snowflake but in a 3-D orb — in a lab that could be used to encapsulate medication for more effective delivery inside the body.

The discovery was detailed by Professor Christopher Li and lead author Wenda Wang, a '15 Drexel graduate who is currently a post-doctoral researcher at Princeton University, along with other collaborators in a paper in *Nature Communications*.

Before now, crystals have grown in rigid, structured formations; think of how snowflake crystals are webs of straight lines connecting to form a grid.

Crystals form this way because their molecules are predisposed to align themselves in a way that links them via the strongest electrochemical bond available.



Early tests indicate that Li's "crystalsomes" are a few hundred times stronger than liposomes, which makes them a sturdier option for medicine encapsulation.



3

2 LASER FOCUS

The green laser light here is used as a lighting source while testing and photographing hypervelocity impacts, because regular white light does not have enough focused intensity to illuminate impact for the high-speed camera (to the right of the laser) to catch. The camera can take images up to 1 million frames per second, allowing it to capture all stages of damage evolution in order to understand how deformations, accelerations and fracture properties of growing cracks evolve under stress. "Using digital image correlation and other full-field optical diagnostics, we can get critical information on quantitative mechanical properties while the material is failing; and this information can be used to aid in the design of next-generation materials and structures," Lamberson says.

3 STRESS BEAM

This 20-foot Kolsky bar, also known as a split-Hopkinson pressure bar, is used to measure how materials respond to dynamic strain rates. A researcher would place a material to be tested between two long cylindrical bars, and then use a short projectile bar to strike the uprange end, to create a stress wave that propagates through the test material. Lamberson uses the device to study the effect of rate-dependent compression and confinement on materials, and also has the capability to electrically load and measure the stress and strain of a material under these extreme loading conditions. The equipment can be used with either two 9-foot steel bars to study hard materials like ceramics and rocks, or polycarbonate bars to examine soft materials like rubbers and foams.



_CHRISTOPHER LI
Li is a professor in the Department of Materials Science and Engineering in the College of Engineering and head of the Soft Materials Lab.

But crystal formation is strongly influenced by the environment in which a crystal forms. Li uses this molecular property

to engineer his hollow crystal spheres.

His "crystalsomes" are named for their similarity to liposomes — tiny bubbles with the same membrane as cells that are being explored for use as biological packages for delivering drug treatments.

Li made his crystalsomes spherical by containing them inside a droplet. A rough equivalent of this would be forcing a single snowflake to form inside a tiny snow globe, rather than in the open expanse of the atmosphere.

To do this, the research team employed a little trick that you might recognize

if you've ever tried to make vinaigrette. They created a tiny bubble of oil to encase water molecules. When the surfactant bubble was cooled to the appropriate temperature, the molecules inside began to crystallize. But rather than forming an angular web of connections, the molecules, instead, lined up along the interior of the oil bubble — crystallizing in a hollow, spherical shape.

With funding from the National Science Foundation, Li's team is now exploring ways to control the shape and strength of the spheres by making them out of different molecules.

_ATOMIC SANDWICHES

Drexel engineers' recipe for 'sandwiching' atomic layers expands the possibilities for making materials that store energy.

THE SCIENTISTS whose job it is to test the limits of what nature — specifically chemistry — will allow to exist just set up shop on some new real estate on the Periodic Table.

Using a method they invented for joining disparate elemental layers into a stable material with uniform, predictable properties, Drexel researchers are testing an array of new combinations that may vastly expand the options available to create faster, smaller, more efficient energy storage, advanced electronics and wear-resistant materials.

Led by A.J. Drexel Nanomaterials Institute Research Associate Babak Anasori, a team from the Department of Materials Science and Engineering created the material-making method that can sandwich two-dimensional sheets of elements that otherwise couldn't be combined in a stable way. And they proved its effectiveness by creating two entirely new, layered 2-D materials using molybdenum, titanium and carbon.

"By 'sandwiching' one or two atomic layers of a transition metal like

MIX_AND_MATCH

Drexel researchers have made several new layered materials and predict that they can make as many as 25 new combinations using their new method for atomic "sandwiching."



_BABAK ANASORI
Anasori is a research associate in the A.J. Drexel Nanomaterials Institute.

titanium between monatomic layers of another metal, such as molybdenum, with carbon atoms holding them together, we discovered that a stable material can be produced," Anasori explains. "It was impossible to produce a 2-D material having just three or four molybdenum layers in such structures, but because we added the extra layer of titanium as a connector, we were able to synthesize them."

The discovery was recently published in the journal *ACS Nano*. It's significant because it represents a new way of combining elemental materials to form the building blocks of energy storage technology — think batteries, capacitors and supercapacitors, as well as superstrong composites, like the ones used in phone cases and body armor. Each new combination presents new properties and researchers suspect that one, or more, of these new materials will exhibit energy storage and durability properties so disproportional to its size that it could revolutionize technology.

_DRIVEN TO DISTRACTION

Bodies release telltale signals when we're distracted, bored or stressed, and it may be possible to use that information to build adaptive technologies.

IT USED TO BE that you did one thing in your car: You drove. That's it.

Now, cars have become vehicles of infotainment complete with Bluetooth phones, GPS routing screens and even wi-fi.

In Drexel's Advanced Interaction Research Lab, Director Erin T. Solovey is studying how our brains and bodies handle distractions in real-time by measuring the physiological changes individuals undergo while multi-tasking.

One possible outcome of

"Right now, computers cannot pick up the signals we're giving off. If they could, it could really change our experience with technology,"

Erin T. Solovey, Director of Drexel's Advanced Interaction Research Lab

her research could be development of an automotive system that detects when a driver is multi-tasking and compensates to make driving safer or issues an alert the driver.

"Right now, computers cannot pick up the signals we're giving off," says Solovey, who is also an assistant professor of computer science in the College of Computing & Informatics. "If they could, it could really change our experience with technology."

Solovey uses portable, wearable technologies such

as functional near-infrared spectroscopy (fNIRS) to look at "people's brains in the real world while they're doing real things," not just while driving but in other scenarios, such as learning environments. She also uses non-invasive body sensors to pick up signals we naturally give off, such as changes in heart rate.

In one study, she and researchers at Massachusetts Institute of Technology asked 100 participants to drive on the highway while attached to sensors that measured heart rate and skin conductivity (as well as other things such as steering wheel position and velocity). The participants were asked to perform periodic cognitive tasks as they drove.

The researchers then mined the data to see if it was possible to identify when the participants were engaged in the other tasks.

"It was very clear in the data that we were able to detect distraction based on body signals," says Solovey.

If technology gets to a point where we wear brain sensors the same way that a lot of people wear a FitBit, this information could be incorporated into vehicle operating software.

"If a company is introducing a new in-vehicle interface, we can look at how that changes the workload in the car while driving," she says. "We could take this brain data and input it into the system that can then adapt and be more supportive of the user's changing state."

_TINY SWITCH

A BIT OF STRAY moisture during an experiment tipped off scientists about the strange behavior of a complex oxide material they were studying — shedding light on its potential for improving chemical sensors, computing and information storage.



_JONATHAN E. SPANIER
Spanier is a professor in the Department of Materials Science and Engineering and the Department of Physics.

In the presence of dissociated water molecules on its surface, the layered material emits ultraviolet light from its interior. The researchers — who hail from Drexel, the University of Pennsylvania, the University of California at Berkeley, and Temple University — discovered they could control UV light production via a chemical reaction that functions like flipping a light switch.

"This discovery is quite remarkable because we uncovered a chemical reaction at the surface that prompts the emission of light from the interface within," says Drexel's Jonathan Spanier, "and we are able to turn it off and on again. Amazingly, we can also make it stronger by increasing the distance between the molecules and surface and the buried interface, by using thicker films, for example."

Their findings appeared in the American Chemical Society journal *Nano Letters*.

DREDGING UP HISTORY

A Drexel lab is using digital technologies to replicate a long-hidden remnant of Philadelphia's revolutionary history.

THIS MASSIVE, iron-tipped spear was affixed to the bottom of the Delaware River during the Revolutionary War to thwart British ships intending to invade Philadelphia. More than two centuries later, the giant spike — which was pulled from the murky depths of the river about eight years ago — is being recreated in the Hybrid Making Lab in Drexel's Westphal College.

Using a 3-D scan of the cheval-de-frise made by digital media sophomore Mark Petrovich in 2007 and a tool that creates objects by rapidly carving a block of foam, Hybrid Making Lab Director Erik Sundquist and digital media junior Riley Stewart are producing a life-size replica of the weapon to serve as a stand-in as the Philadelphia's Independence Seaport Museum prepares the genuine artifact for public exhibition.

Weapons like this were originally developed in Europe as land obstacles to prevent cavalry charges. But during the American Revolutionary War colonial forces modified the design of the weapon for maritime defenses in the Delaware and Hudson rivers.

As part of Drexel's digital cultural heritage work, led by Associate Professor Glen Muschio, the cheval is being recreated to allow the Seaport Museum to build a brace for displaying the actual cheval.



STYRO_SPEAR
Students and faculty produced a life-size foam replica of the cheval using a Computer Numerical Control router tool.

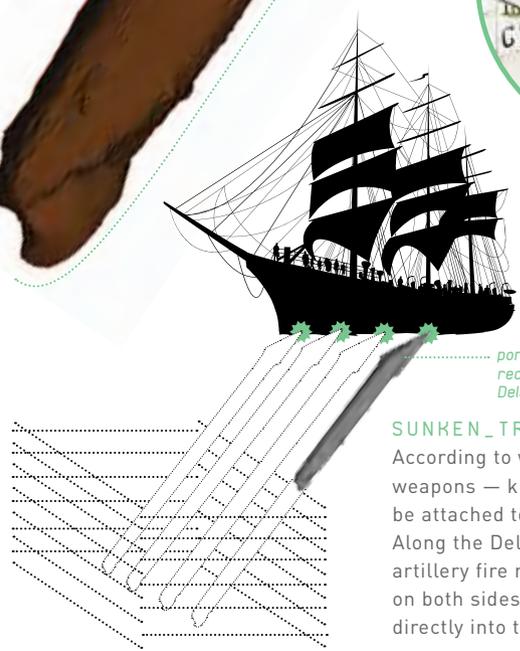


HULL_PIERCER
Measuring 11.5 feet and weighing approximately 250 pounds, the weapon has a width roughly equivalent to a telephone pole with a sharp metal tip capable of puncturing the hull of a boat.

138.2 inches x 18.1 inches



DELAWARE_DEFENSE
This Revolutionary-era map shows the positions of the chevaux de frise in the Delaware river near the New Jersey side. The spear-like weapons, combined with land-based artillery, were an effective deterrent for British ships.



portion of weapon recovered from the Delaware river

SUNKEN_TREACHERY

According to war historians, several of these weapons — known as chevaux de frise — would be attached to boxes affixed to the river bottom. Along the Delaware River near Philadelphia, artillery fire rained down on ships from forts on both sides of the river, forcing British boats directly into the path of the submerged spikes.

_CHIP COMBO



_YURY GOGOTSI
Gogotsi is a distinguished university and trustee chair professor in the Department of Materials Science and Engineering and director of the A.J. Drexel Nanomaterials Institute in the College of Engineering.

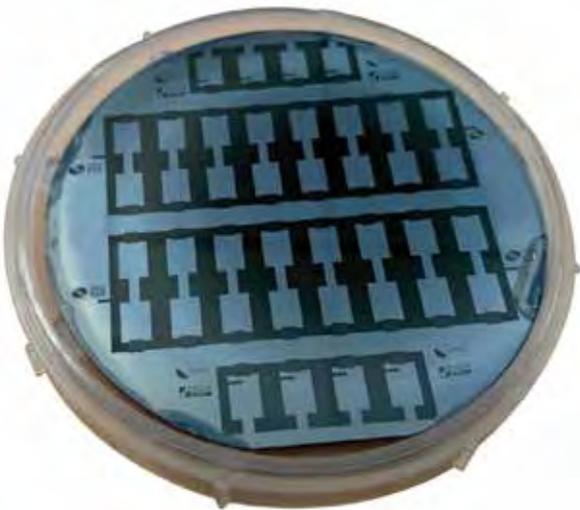
AFTER MORE THAN half a decade of speculation, fabrication, modeling and testing, an international team of researchers led by Drexel's Yury Gogotsi and Patrice Simon, of Paul Sabatier University in France, have confirmed that their process for making carbon films and micro-supercapacitors will make it possible to combine microchips and their power sources on the same silicon wafer.

"With this achievement, the future is now wide open for chip and personal electronics manufacturers," says Simon, who led the research.

The discovery, which was recently reported in the journal *Science*, is the culmination of years of collaborative research by the team. The same group of researchers had previously published a 2010 paper in *Science* announcing their creation of a carbide-derived carbon film material — made by etching supercapacitor electrodes into conductive titanium carbide substrates — that possessed a volumetric capacity exceeding that of existing micro- and macro-scale supercapacitors, by a factor of 2.

Their latest announcement confirms the team's long-standing belief that carbon films are versatile enough to be seamlessly integrated into the systems that power a multitude of modern personal electronics.

"The place where most people will eventually notice the impact of this development is in the size of their personal electronic devices, their smart phones, fitbits and watches," says Gogotsi.

**WAFER_THIN**

The team can deposit carbon films on silicon wafers in a variety of shapes and configurations to create dozens of supercapacitors on a single silicon wafer.

_STEM CELL ALGORITHM

Using image-tracking technology, Drexel scientists observe nature vs. nurture in neural stem cells — information that could lead to breakthroughs in regenerative medicine.

ONE OF THE longstanding debates in science that has permeated into the field of stem cell research is the question of nature versus nurture influencing development. Science on stem cells thus far has suggested that their fate is not predestined. But new research from the New York-based Neural Stem Cell Institute and Drexel's College of Engineering suggests otherwise.



_ANDREW COHEN
Cohen is an associate professor of electrical and computer engineering in the College of Engineering.

In a recent paper published in *Stem Cell Reports*, researchers present voluminous video evidence to support their discovery of distinct, intrinsic differences among stem cells found in the brains of mice. Through time-lapse imaging of cells cultured in identical in vitro environments, researchers were able to identify differences in growth, movement and differentiation that exist between stem cells found in two different areas of the brain.

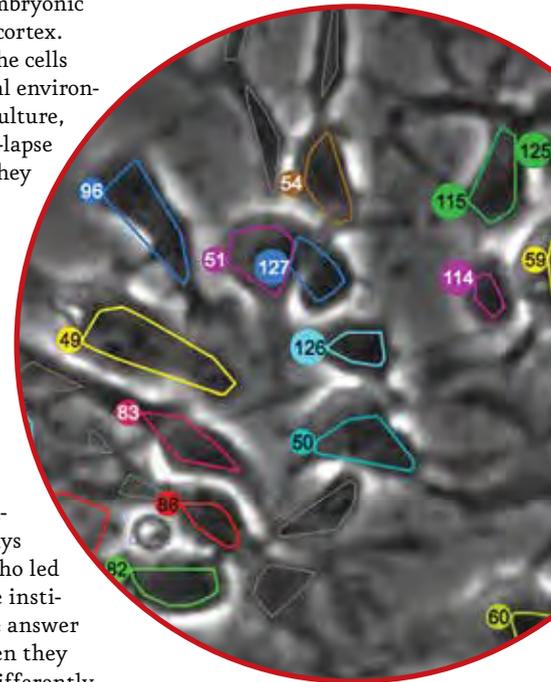
Neural stem cells are some of the most fascinating and unique cells in the body, but very little is known about their unusual behavior. A research group at the Neural Stem Cell Institute in New York studied single neural stem cells from the anterior

and posterior embryonic mouse cerebral cortex. They provided the cells with an identical environment in tissue culture, then made time-lapse movies of how they divided and differentiated into cortical cells.

"If the answer to the age-old question was, in fact, 'nurture' then these cells would behave the same, given the identical environments," says Sally Temple, who led the group at the institute. "But if the answer was 'nature' then they would behave differently. And this is actually what we found — anterior and posterior stem cells are intrinsically quite different from each other."

This discovery was made possible by a powerful set of biological tracking programs, developed in Drexel's Computational Image Sequence Analysis Lab led by Andrew Cohen, an associate professor in the College of Engineering. The programs, called LEVER and CloneView, automates the process of analyzing tens of thousands of time-lapse images. They can track the growth, movement and proliferation of cells and use this information to visually enhance the time-lapse movies and produce an entire family tree for each cell.

"Basically, the algorithms look for groups of pixels that have the right

**_FAMILY TREE**

Drexel's computational image analysis programs can generate a stem cell lineage tree from a series of time-lapse microscopic images.

appearance and that are in the right place to be the cells we're tracking," Cohen says. "From there we use other algorithms to cross-check the results multiple times, until we're almost 99 percent sure that the things LEVER has identified in all these pictures are, in fact, cells."

Displayed in CloneView, a time-lapse movie of a single stem cell is overlaid by a uniquely colored outline of its inner boundary. As it grows and eventually divides, new cells are delineated with a different color. Each of these colors

WATER FILTRATION

_NATURE'S FILTER

Algae scooped from an urban fish pond are the slimy secret ingredients in a bioreactor that Drexel environmental engineers say is more effective at treating wastewater than many processes employed in city treatment facilities today.



_CHRIS SALES
Sales is an assistant professor in the College of Engineering and a member of the research team at the A.J. Drexel Institute for Energy and the Environment.

ASSISTANT PROFESSOR Christopher Sales is using algae's symbiotic relationship with bacteria to remove excess nitrogen from water — a process that could aid municipal wastewater treatment plants.

In 2006, Sales and a colleague from the University of Pennsylvania first developed a high-density bioreactor to cultivate a dense mixture of microorganisms — called activated sludge — which is used to remove oxygen organic carbon compounds from wastewater.

Since then, Sales and his lab at Drexel have added algae to the mix to improve the reactor's nitrogen-removal capabilities.

This development is significant because today's predominant nitrogen-removal techniques are multi-step processes with long waiting periods.

By contrast, Sales's bioreactor works by continuously cycling water through an algae and bacteria-laden environment, almost like a biological filter, removing nitrogen by storing it in algae that can be easily separated from water in

their new reactor.

The system can remove up to 80 percent of nitrogen from a waste stream, according to data Sales reported in the *Journal of Visualized Experiments*.

The system does not require settling tanks because the flow of the reactor is designed to naturally promote settling of biomass. This separation, Sales speculates, could one day make the algae cultivated in these bioreactors an appealing source of biofuel feedstock by reducing the amount of energy required to dry the algae biomass.

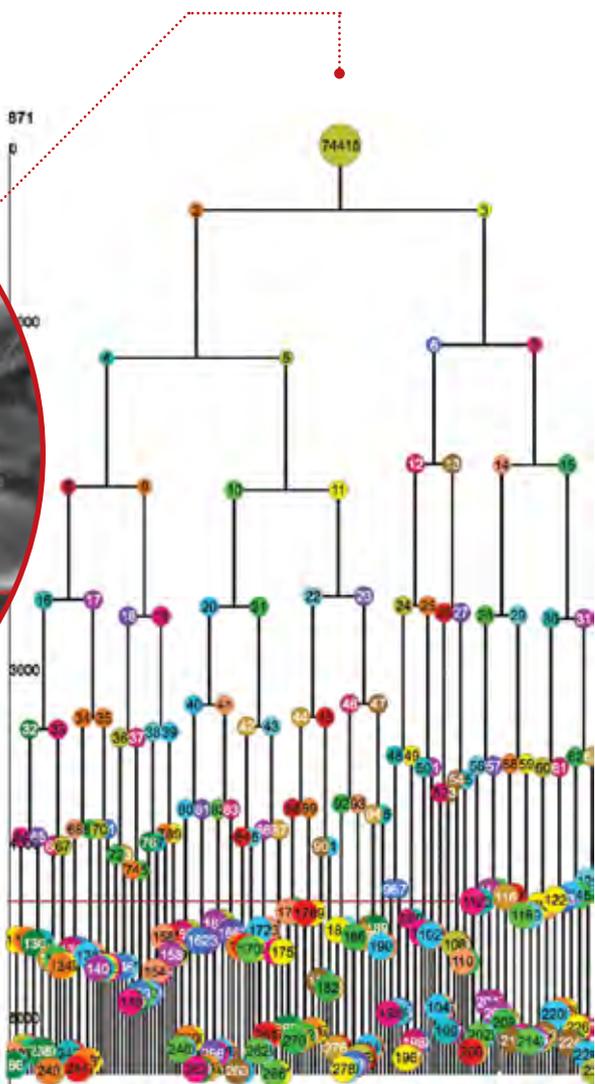
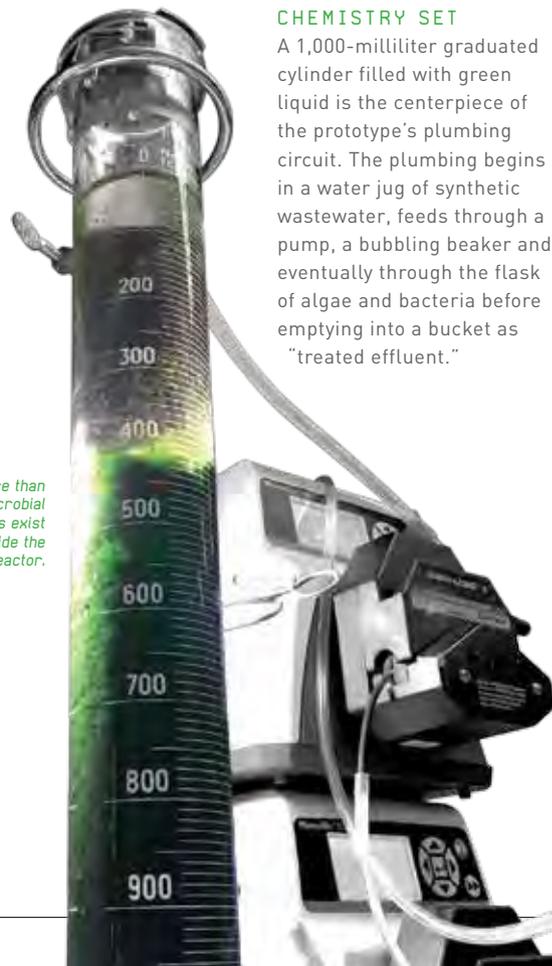
The lab-scale prototype resembles an elaborate chemistry experiment — which it is, essentially.

Wastewater enters the bioreactor with high concentrations of ammonia and nitrate. Inside, 350 different species of microbes either metabolize ammonia to nitrate or convert dead algal cells and algae byproducts into carbon dioxide. The algae use the carbon dioxide and a combination of ammonia and nitrate to grow and perform photosynthesis, which, in turn, produces oxygen that helps the bacteria thrive. Thus the cycle removes nitrogen from wastewater while also growing a healthy crop of algae and bacteria. The algal biomass can then be recovered as a product and used as a source of biofuel.

CHEMISTRY SET

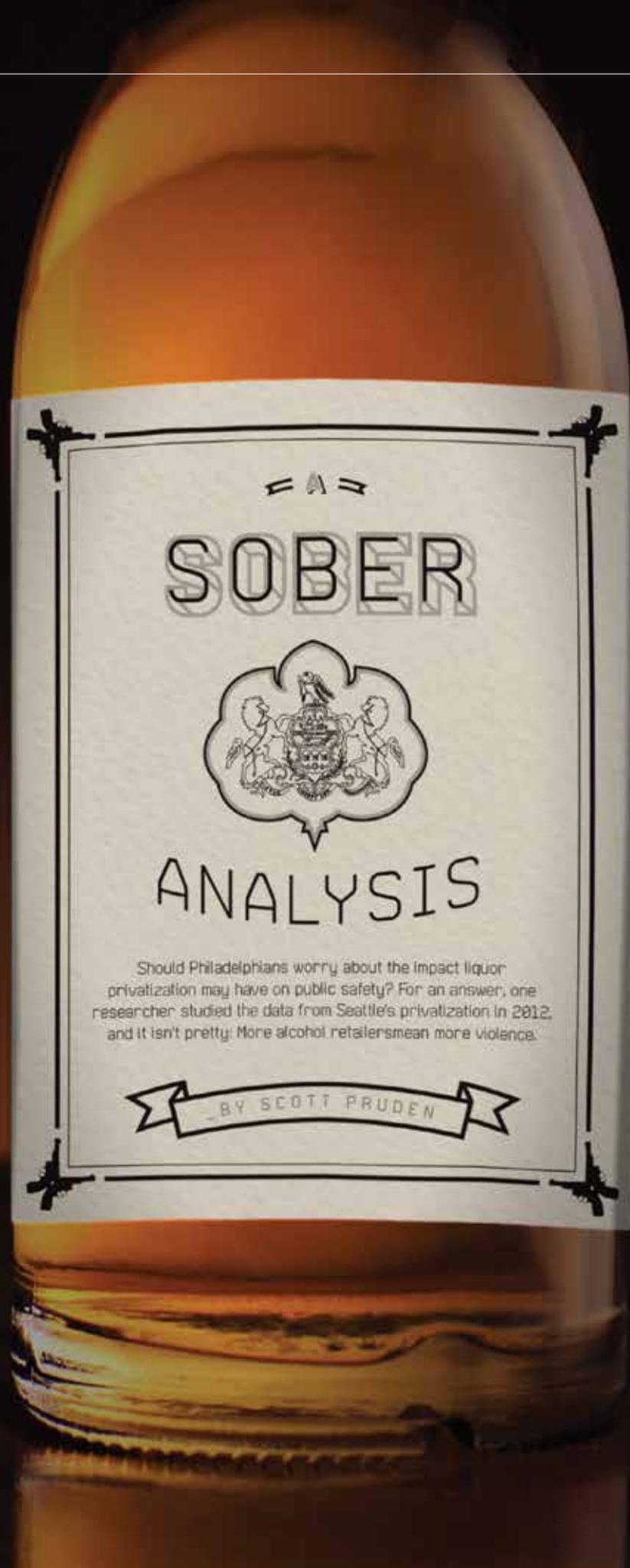
A 1,000-milliliter graduated cylinder filled with green liquid is the centerpiece of the prototype's plumbing circuit. The plumbing begins in a water jug of synthetic wastewater, feeds through a pump, a bubbling beaker and eventually through the flask of algae and bacteria before emptying into a bucket as "treated effluent."

More than 350 microbial species exist inside the bioreactor.



corresponds to the cell's node on the lineage tree, which is displayed in a separate frame next to the movie. This gives researchers a quick way to check the video to make sure LEVER correctly identified the cells and their progeny. Once checked by human eyes, the images are run through the program again for more precise delineation of the cells — this process is especially arduous when tracking stem cells because they often have long arm-like appendages

called processes that can look like a separate cell. "Human validation is a very important part of our process. We are still the most accurate judge of when cells have divided," Cohen said. "By running the time-lapse images through the program we get an output video that's easy to visually verify. As these corrections are made, the program can spot related errors and automatically fix those. The key is to minimize the amount of effort required from the humans."



SOBER



ANALYSIS

Should Philadelphians worry about the impact liquor privatization may have on public safety? For an answer, one researcher studied the data from Seattle's privatization in 2012, and it isn't pretty: More alcohol retailers mean more violence.

BY SCOTT PRUDEN



FOR DECADES, the debate raged.

“When,” legislators and citizens asked, “will our state government get out of the business of wholesale purchasing and retailing alcohol?”

Proponents of liquor privatization promised better selection, lower prices, opportunities for independent businesses and a windfall for state coffers. Opponents called the movement a corporate-backed cash grab that would put state employees out of work, with only short-lived benefits for taxpayers and potentially long-term public health consequences.

We’re talking about Washington, here; but it could easily be Pennsylvania.

Both states have long weighed the pros and cons of their state-run monopoly on alcohol sales amid organized efforts to privatize it.

So when Washington voters finally agreed to sell off state-owned liquor stores and convert to an open market in 2011 — becoming the first “control” state to do so since Prohibition — it behooved Pennsylvanians to pull up a chair, pour a stiff one and see how things turned out.

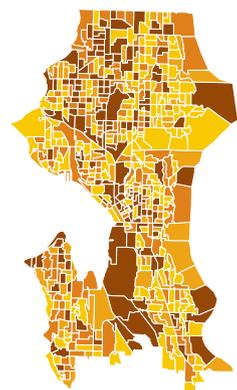
A few years in, there are signs that Washington’s Initiative 1183 has not gone down as smoothly as promised. A 2014 report in the *Seattle Times* noted that after liquor sales expanded from 328 state stores to more than 1,400 outlets, the average cost of a liter was 11 percent higher, due to fees the state added to make privatization revenue neutral. The paper also reported that half of the former state stores auctioned off to entrepreneurs closed within two years, crushed by new competition.

Of course, the devil is in the details, and Pennsylvania legislators and voters could structure privatization very differently to avoid Washington’s pitfalls.

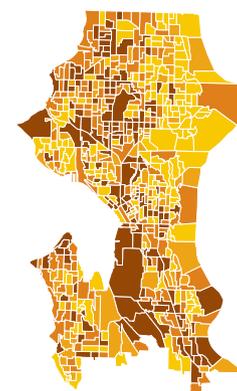
But either way, one outcome would likely be the same: a significant increase in urban violence.



LONI PHILIP TABB
Tabb is an assistant professor of biostatistics in the Dornsife School of Public Health within the Department of Epidemiology and Biostatistics. She studies how alcohol intersects with violence in urban settings.



non-aggravated assaults



aggravated assaults



UNINHIBITED

To track the impact of liquor privatization on violence in Seattle, Loni Philip Tabb examined crime data in the city, census block by census block. She compared the data from the two years prior to privatization with the two years afterward, and controlled for a host of variables that are also typically associated with crime. She found a statistically significant uptick in both aggravated and non-aggravated incidents for every additional retail outlet that opened in the city after 2012. In the maps above, anything above a “1” indicates an area where an excess risk of assault exists.

NATURAL EXPERIMENT

When Washington passed Initiative 183, Drexel researcher Loni Philip Tabb saw the perfect opportunity to put her interests in statistics and public policy to work studying the relationship between violent crime and increased alcohol availability.

Tabb is an assistant professor of biostatistics in the Dornsife School of Public Health with bachelor’s and master’s degrees in math from Drexel and a doctorate in biostatistics from Harvard University.

She specializes in spatial and spatio-temporal statistics, which means she observes not only how data changes within geographic locations, but also how the data may change over time.

“In order to address certain disparities, you need to know where these disparities exist and ultimately where to focus intervention and prevention resources to eliminate them,” she says.

Existing research already showed a correlation between the availability and consumption of alcohol and social and health problems. In her study, Tabb cites studies from as far back as 1983 to as recently as 2010 showing a connection.

Tabb herself has previously studied how liquor privatization could potentially affect Philadelphia, in a 2012 paper published with five co-authors in *BMC Public Health*. The team used geospatial analysis to map existing alcohol retail outlets throughout the city, including bars and restaurants where alcohol is sold for on-premise consumption, and retailers that sell alcohol to be consumed off-premise, such as state-owned wine and spirits stores and small groceries, pizza shops and bodegas that sell beer.

They noticed that crime rates tended to be higher around off-premise retailers where individuals may be purchasing alcohol to consume nearby, such as in a vacant lot or at home.

Then they asked what this might mean for Philadelphia if the city privatized alcohol sales. They found that Philadelphia’s zoning rules, which restrict alcohol retailers near schools, playgrounds and places of worship, could accommodate an additional 60 percent more outlets, or 1,115 more city-wide, bringing with them the “negative health, crime and quality of life outcomes that accompany such an increase.”

For her latest exploration of the subject, Tabb endeavored to avoid the cross-sectional approach of previous studies and instead do a longitudinal analysis, tracking a real-life situation over time — an approach that is more rigorous in pointing toward causation.

“We said, ‘Let’s try and find an area in the United States where they actually implemented some sort of policy that affects alcohol sales and see what happened,’” she explains.

Although a few states — Washington among them — have recently relaxed laws governing marijuana sales and consumption, “with alcohol, it’s not like you have states that go through this all the time, so Washington was perfect,” Tabb says.

SMOKING GUN

Tabb began the study with the hypothesis that increased availability of alcohol would result in more violence in the areas affected.

To test her hunch, she acquired data on aggravated and non-aggravated violent crimes from the Seattle Police Department, broken down by small census blocks, and compared it with liquor licensing records from the Washington State Liquor and Cannabis Board.

She also collected 2010 census data that she used to control for variables often correlated with local crime data, such as a neighborhood’s percentage of vacant housing units, families that were low-income and/or headed by a single female, residents age 15 to 29, density of bus stops and “risky” retail outlets, and broader indicators of racial and ethnic diversity.

“The nice thing about being in a big data environment is you’re able to access data through various settings,” she says.

With a wealth of information available, Tabb was able to compare the rates of violence in each census block group within Seattle for both the two years prior to privatization and the two years after it went into effect in 2012.

The data revealed an apparent “smoking gun.” Aggravated assaults, which are typically those involving a weapon with an intent to cause bodily harm, increased 8 percent for each additional off-premises outlet in a given neighborhood, and 5 percent for each additional on-premises outlet. The rate of non-aggravated assaults also increased, by 6 percent and 5 percent for each type of retailer respectively.

In Seattle overall, aggravated assaults increased 42 percent and non-aggravated assaults increased 74 percent between 2010 and 2013, the period overlapping the state’s transition to an open alcohol market.

South-central Seattle, the northwestern portion, and some blocks on the eastern border bore the brunt of the worsening violence.

Although the use of aggregate data, as Tabb used in her study, unintentionally lends itself to a research problem known as the ecological fallacy, which involves drawing conclusions about individuals based on analyses involving neighborhood-level data, her study sheds light on the various relationships that exist at the neighborhood level that can’t be ignored.

“The more alcohol available in a neighborhood, the tendency there is for more violence,” she says. “Since this policy allows for increases in sales and ultimately availability in these neighborhoods, we’ll likely see more violence in these neighborhoods as well.”

Washington attempted to head off this problem by requiring new off-premises outlets to be large retailers, such as supermarkets and warehouse stores. This was a direct attempt to avoid more liquor sales in corner stores and bodegas in already-disadvantaged neighborhoods. Such factors could be considered in Pennsylvania if the state were to approve privatization, for the very same reasons, Tabb says.

“Philly has a stronger relationship between alcohol and violence [than Seattle],” Tabb says. “Smaller stores are selling alcohol in neighborhoods that are even more disadvantaged than in Seattle.”

She theorizes that on-premises alcohol retailers such as the bars in Philadelphia’s Old City attract less violence crime because they self-police.

“They have a real vested interest in setting up a neighborhood where their customers are safe,” she says.

“I think if you’re going to have an additional [wine and liquor] outlet, I’d prefer that it be at a BJ’s rather than an [urban] mom-and-pop store that’s going to potentially attract other risky behavior often associated with alcohol and violence,” she says.

With Philadelphia capable of hosting as many as 1,115 additional alcohol outlets should privatization ever go through, Tabb says she hopes her study helps further inform the liquor privatization debate in Pennsylvania.

“I know for Philadelphia, there’s going to be a significant impact with respect to privatization,” she says. “There will be a substantial uptick in alcohol outlets, and we need to make sure there are policies in place that address the potential complications.”

“This kind of study is very useful for policy,” says Andrew Lawson, a distinguished professor at the Medical University of South Carolina who is also founding chief editor of *Spatial and Spatio-temporal Epidemiology*, the Elsevier journal where Tabb’s study is under review. “Public health departments need to make decisions all the time about whether there is risk in a certain geographic area, like in the case of environmental pollution from toxic waste dumps or incineration sites. These are known as ‘cluster alarms’ in the public health literature and health departments get them every day from people claiming that there is some adverse health risk in their neighborhood. The methods used by Dr. Tabb are used widely in those investigations.”

LAST CALL

Lore has it that Pennsylvania Gov. Gifford Pinchot created the Pennsylvania Liquor Control Board in 1933, just as Prohibition came to an end, expressly to “discourage the purchase of alcoholic beverages by making it as inconvenient and expensive as possible.”

That pretty much sums up the experience Pennsylvania drinkers have dealt with ever since.

The PLCB’s rules and stores have become more consumer-friendly in recent years and, at press time, Pennsylvania passed a new law that will soon allow gas stations, grocers and hotels to sell take-out wine and beer (the law is being regarded as a stalking horse for eventual full privatization). But up until this recent law change, the system has restricted liquor and wine sales to state-owned stores and beer sales to distributors and to bars or grocery stores with special licenses. For a long time, evening and Sunday retail hours at state-owned stores were restricted, and bars weren’t allowed to offer happy-hour specials for more than two hours per day.

Pennsylvania also adds a hefty tax to every bottle, courtesy of a supposedly temporary 10 percent tax instated in 1936 to help rebuild Johnstown after one of its many floods. The mining town was eventually rebuilt, but the tax was never repealed. Instead, Pennsylvania increased it — to 18 percent, where it generates \$334 million for the state treasury but also contributes to high prices and a perennial chorus of voices demanding change.

Among the policymakers and influencers who have staked out positions in the liquor privatization debate, the lines are drawn almost indelibly.



LIQUOR LIMITS

Seventeen states, plus small jurisdictions within Alaska, Maryland, Minnesota and South Dakota, control alcohol sales or wholesaling in some form. They control the sale of distilled spirits and, in some cases, wine through government agencies at the wholesale level. Thirteen of those jurisdictions also exercise control over retail sales for off-premises consumption; either through government-operated package stores or designated agents.

Against privatization are the unions and their members — particularly the approximately 4,500 state workers who staff the state-owned wine and spirits stores — as well as the Democratic lawmakers who depend on their support.

“The people who champion the privatization of liquor stores promise better prices and no change in the current rates of crime or alcoholism, but their argument is a Trojan horse,” says State Sen. Anthony Hardy Williams, a Democrat whose district includes Philadelphia and Delaware counties. “The Washington state study proves there are increases in both when there is greater access to alcohol. That greatly concerns me, and it should greatly concern most people who value community and a good quality of life.”

And even though beer distributors are private enterprises licensed by the state, privatization would likely also negatively impact their business, just as Washington liquor retailers discovered when they suddenly got more competition from other outlets than many could handle.

“Eighty to 90 percent of our income comes from beer sales,” Mark Tanczos, president of the Malt Beverage Distributors Association of Pennsylvania, told the *Harrisburg Patriot-News*. “How are we going to be making a living if everyone has it?”

Those in favor of privatization are represented by an almost exclusively Republican coalition that promises that a state-licensed private enterprise system would provide convenience and choice at lower prices, plus more tax revenue from additional stores.

“Other states do this and the world has not fallen apart there, unless you’re assuming that Pennsylvanians and Washingtonians are unique in some way,” says State Rep. Kate Harper, who supports privatization.

The Montgomery County Republican says she sees the results of Tabb’s study as being potentially helpful in setting zoning limits for new retailers under liquor privatization.

However, she’s troubled by the notion that disadvantaged neighborhoods might receive limited access to alcohol because of the potential for violence.

“To pick out people in a neighborhood and say, ‘Sorry, Prohibition still applies to you,’ I don’t think that’s fair,” she says. “I think it’s completely inappropriate for government to set socioeconomic limits on the consumption of alcohol.”

That said, with Gov. Tom Wolf’s veto of the latest privatization bill in July of last year, Harper expects other, more urgent state issues to take precedence, such as the state’s budget.

“I’ve voted for [privatization] twice now,” she says. “It’s not the biggest issue for my constituents or on my agenda.”

For Tabb’s part, she wants to make sure those who are in positions to decide the matter have all of the facts at their disposal.

“Being here and knowing that it’s something that is probably going to be implemented in my lifetime, I thought it was necessary to continue to build the evidence,” she says. “I like to think that policymakers try to find the information that’s out there with respect to how neighborhoods function. My role is to conduct sound research that allows for an evaluation and assessment of these complex relationships.” ✕



THE THINKER

Drexel's **John Kounios** and his collaborator were the first scientists to use brain scans to study how our minds make the leap from methodical thinking to sudden insight. In their new book, Kounios shares what they've learned about cultivating creativity. *— by Lini S. Kadaba*

How does a brain scientist known for discovering the neural pathway of sudden, creative insight achieve his own flashes of inspiration? It's all about getting into the right headspace.

When Drexel Professor of Psychology John Kounios has a problem to solve, he takes a ride in the quiet car on the regional rail line. He leans back in his seat for the 45-minute commute between his home in West Chester and Drexel's University City Campus. He dons special noise-cancelling headphones, slaps on his sunglasses and closes his eyes. No cellphone ringtones. No chatter of voices. No distractions, not even the rumble of the train nor the scenery streaking past the window.

Then, Kounios lets his thoughts wander.

In this relaxed state where the mind is most open, the affable, 58-year-old with a shock of gray hair meditates and allows associations to flow as he turns thoughts over in his mind.

Often enough, he has what's called a *eureka!* or *aha!* moment, that sudden awareness of a new idea, new perspective or solution.

"I really think the modern lifestyle is not as conducive to this deep creativity that produces really powerful insights," says Kounios, who also directs the doctoral program in Applied Cognitive and Brain Sciences at Drexel. "We're too busy, too distracted, too stressed out. We don't get enough sleep. We're too tired. It's hard to get into this creative state."

Insight is a unique phenomenon within the brain that can be encouraged by creating the right conditions, argues Kounios. In a new book, "The Eureka Factor: Aha Moments, Creative Insight, and the Brain" (Random House, 2015), he unpacks his groundbreaking insight research conducted with co-author Mark Beeman, a professor of psychology and neurosciences at Northwestern University.

A decade ago, the scientists identified the "neural signature" of insight through cutting-edge brain-imaging studies, and ever since, the work has generated buzz. Most recently, Kounios was interviewed on WHY?Y's "Radio Times" and appeared in the *Philadelphia Inquirer*.

Daniel Schacter, a professor of psychology at Harvard University and author of the book "The Seven Sins of Memory," calls the scientists pioneers.

"They've shown insight is not just an ephemeral thing that happens once in a while," he says. "It is something you can study. You just need the right paradigm."

The researchers, he quips, have "obviously had some insights into insight."

FLASH IN THE PAN

In his third-floor lab in Stratton Hall on Drexel's University City Campus, Kounios and his graduate students explore the complex workings of the creative mind with the simplest of tools: EEGs and word puzzles.

The modest room houses computer terminals, a couple of chairs and two Styrofoam head models — nicknamed Aristoteles and Bartholomew — used to store the lab's two elastic EEG caps equipped with red, yellow and green electrodes that connect to a Kleenex-sized box that amplifies electronic signals.

On a recent summer day, doctoral student Monica True-love-Hill, 28, has volunteered to demonstrate a typical insight study. The electrode-laden cap is positioned on her cranium. Next, each electrode, including reference nodes behind her ears, is painstakingly filled with a conducting gel that ferries a small voltage from the scalp to the electrode.



— JOHN KOUNIOS
Kounios is a professor of psychology in the College of Arts and Sciences and director of the PhD program in Applied Cognitive and Brain Sciences.

TRAIN OF THOUGHT

When John Kounios started out, there was no name for the field of science he has helped shape and define. Few people believed that insight was even a topic worthy of study.

As an undergraduate at Haverford College, this son of a banker and schoolteacher knew he wanted to double major in psychology and music theory and composition.

Kounios delighted in playing the piano, which he occasionally still does, but psychology seemed a more practical career. In graduate school at the University of Michigan in Ann Arbor, he studied semantic memory, earning his doctorate in 1985. He also joined a Greek Orthodox church choir and met a fellow Greek American, Constantine Papadakis, who would go on to become president of Drexel and prove pivotal in Kounios' career.

The field he ultimately pursued — cognitive neuroscience — did not even exist. It wasn't until the development of neuroimaging in the mid- to late-1980s that scientists began looking at the functional aspects of the brain.

After a post-doc at Princeton University, where he explored the origins of memory, Kounios joined Tufts University in 1987 as an assistant professor. Eventually, he made his way to the University of Pennsylvania in 1996 and soon became director of the Cognitive Electrophysiology Lab at the school's Institute for Research in Cognitive Science.

There, Kounios had his own *Eureka!* Insight, he realized, would be an ideal new field to explore. While creativity, including insight, had been studied for decades, nothing had been done on the neural basis of the process.

By 2003, Kounios was recruited to Drexel, by none other than his grad-school friend Papadakis. Within a year, he and Beeman had published their discovery.

Then, Truelove-Hill is shown a series of anagrams. For example, she sees the letters *free*, and comes up with *reef*. Or she sees *endo*, and finds *done*. After each try, she notes whether she arrived at the solution through insightful thought — that is, a sudden, unexpected answer — or through analytical thought, which requires methodically trying different options. *Reef*, she says, required analysis, but *done* just came to her.

All the while, her brain waves rise and fall like peaks and valleys on a mountain range on a nearby computer screen. Later, the researchers scan the waves for signals that stand out from the general noise of the working brain.

"It's like panning for gold," Kounios says. "You get rid of the junk and then you find that nugget."

By now, most cognitive psychologists agree that insight is distinct from analytical thought, but when Kounios and Beeman met as researchers at the University of Pennsylvania in late 2000, skeptics in cognitive science were arguing that *aha!* moments were nothing more than emotional reactions to otherwise deliberate, analytical thoughts. Kounios and Beeman believed something else was going on. Insight, accompanied by a rush of excitement, even joy, just felt different.

In what might now be regarded as an inspired choice, they decided to use then-new technologies — brain scans — to study a topic long explored only with behavioral experiments.

Each scientist brought his expertise to the lab. Kounios' work on the neural basis of semantic memory (how people acquire, use and sometimes forget knowledge) involved EEG scans; Beeman was versed in functional MRI (fMRI, a method of measuring brain activity through changes in blood flow) through his study of language comprehension and the brain's right hemisphere, which is used to draw together distantly related information.

The EEG can spot when things happen in the brain within milliseconds. But it's not so great with where. fMRI, however, can produce "exquisitely detailed" maps of where things are happening. Its limitation was in pinpointing when.

Put the two together, the researchers figured, and they might see what happens in the brain at the precise moment of an insight.

The next challenge was to design an experiment to illuminate the instant when a person solved a problem with a sudden idea. After all, Kounios and Beeman couldn't follow around subjects 24/7 hoping for epiphanies.

That's where word puzzles came in. Consider *pine*, *crab* and *sauce*. Then figure out a common word that makes a familiar compound or phrase with each. (Spoiler alert: *apple*.) These puzzles can be solved either with solutions that pop into the mind suddenly or through a process of elimination.

Each did the experiment in his own lab with a set of subjects and analyzed the data. Then the scientists traded brain scans. When the images were overlaid, what they saw was astounding in many ways.

"You couldn't find a more perfect match," Beeman says.

Here's what the researchers uncovered: At the moment of insight, high-frequency EEG activity known as *gamma* waves occurred above the right ear. (*Gamma* waves represent cognitive processes that link together different pieces of information.) The fMRI showed a corresponding increase in blood flow in part of the brain's right temporal lobe involved in making connections between ideas (think jokes or metaphors), as Beeman suspected.

The kicker: This activity was not present in analytical solutions to the word problems.

The two had discovered the pathway in the brain triggered during an *aha!* moment: the right temporal lobe, located just above the right ear, lights up when a flash of knowledge occurs.

"By showing that insights have a different neural correlate from analytical thought ... we could show that insight is really different," Kounios explains. "This sudden neural event occurs right about the time an idea pops into awareness."

Their 2004 article in the journal *PLoS Biology* fired the public's imagination. *The Times* of London proclaimed the discovery of the brain's E-spot, E standing for *Eureka!*

"John is one of the leading EEG researchers in the world," says James D. Herbert, inaugural dean of Drexel's Graduate College and former head of the psychology department. He points out that EEG has often been the stepchild of fMRI, even though it is considerably cheaper to use. "What he is brilliant at is using EEG to address questions that everyone else is using much more expensive technology to address," says Herbert.

In fact, Kounios is finding more ways to translate his work into inexpensive, real-world applications. He's investigating how to use EEGs as an early screening test for conditions as diverse as Alzheimer's disease and obesity. Another project underway applies EEG to the emerging field of neuro-marketing to better predict consumer interest in products.

"It's in keeping with the Drexel way: Doing things in the most efficient way possible," says Herbert.

BEYOND THE 'E-SPOT'

Kounios has taught introductory and graduate level courses, but his first love is research, and he and Beeman, who moved to Northwestern in 2002, have continued to collaborate, with some interesting results.

One study showed that a couple of seconds *before* a puzzle is presented to a subject, the brain engages in different activity depending upon whether that individual ultimately solves the problem insightfully or analytically. Another documented that even during a resting brain state, distinct areas light up, pushing subjects toward one type of thought or other.

"We're getting very consistent results," Kounios says. "When an idea pops into awareness, it seems to come from nowhere. But it's not coming from nowhere. There are events in the brain that lead up to that *aha!* moment."

Going forward, the scientists want to explore the influence of genetics on creativity and what other factors, besides mood and anxiety, might play a role.

Currently, Kounios has a proposal out that will look at whether people who have a track record of creative accomplishment tend to move back and forth between insight and analysis more often than the average person.

Most people have a predilection, says Kounios. Kounios says he favors insight, and he recently co-authored a paper in *Thinking & Reasoning* that he says shows that solutions to problems that were derived by insight are more accurate than analytically derived solutions. The reason for that, he says, is that analytic thinking is fragile and error-prone because it can be rushed or sloppy. In contrast, insights are the product of unconscious processes that can't be rushed and that come to a conclusion only in their own time. A person may fail to have an "aha moment" and thereby draw a blank, but if they do have one, chances are that it is a correct solution.

True success demands measures of both. Every great idea needs an analytical workhorse to make it happen. And the most methodical person will never achieve significant progress without a dose of spur-of-the-moment creativity.

The *Eureka Factor* is replete with interesting examples. Did you know that Paul McCartney keeps a piano bedside to try out ideas that come to him in the middle of the night? Judah Folkman, a cancer surgeon and researcher, created the new field of angiogenesis around his insight that cancer tumors need a substantial blood supply to grow. "The West Wing" creator Aaron Sorkin says he overcomes writer's block by taking six or more showers a day, as a way to cut off distractions.

For the rest of us, Kounios suggests three strategies to stimulate creativity:

1. STAY POSITIVE. A good mood has a powerful effect on creativity, he says.

2. FOCUS INWARD. Take time outs to recharge, even if only for a split second. In fact, an early study by Kounios and Beeman produced a surprise. A second before the *gamma* wave activity, a burst of *alpha* waves appeared on the right side of the brain at the back of the head. It's called a "brain blink" because it restricts visual input.

Visual information can "hijack thought," says Kounios. "By looking at a blank wall, or closing your eyes, or looking down, you cut off that distraction and that boosts the signal-to-noise ratio of that weakly activated, unconscious idea," he says.

3. CATCH SOME ZZZS. Naps work. Besides improving mood, sleep consolidates memories. "It brings out the non-obvious connections and associations in the details of a memory," Kounios says.

Kounios saw the virtue of a nap play out while struggling to come up with a title for his book. One late night his wife, Yvette, fell asleep on the couch. An idea jolted her awake and she immediately woke her husband.

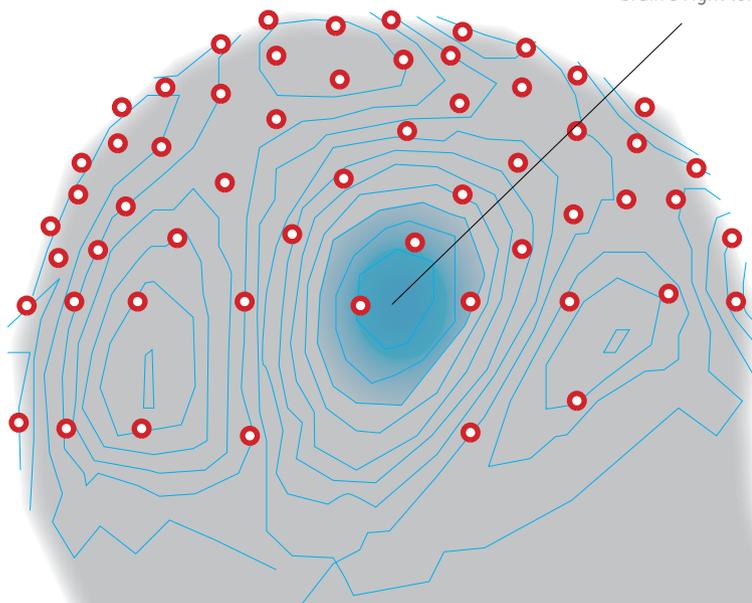
"I have the title for the book," she told John.

Her idea was *The Eureka Factor*.

It stuck. ✕

THE_AHA!_MOMENT

At the moment of insight, high-frequency EEG activity known as *gamma* waves occur above the right ear. At the same time, there is a corresponding increase in blood flow in the brain's right temporal lobe.



_ SHINING A LIGHT ON BLACK HOLES

Astrophysicist Gordon Richards has discovered more black holes than anyone else in the universe. With assistance from a powerful new telescope being built in Chile, he plans to beat his own record.

BLACK HOLES are typically known for the absence of light, so it's ironic that astrophysicist Gordon Richards has discovered more black holes than anyone else in the universe by finding the light, so to speak.

"It's an oxymoron: There's this black hole that isn't emitting any light, but when nearby gas and dust from star explosions spiral into the black hole, they heat up and become very bright," says Richards, who published two papers this year in *The Astrophysical*

"There's this black hole that isn't emitting any light, but when nearby gas and dust from star explosions spiral into the black hole, they heat up and become very bright."

Journal. "These black holes that are outshining the rest of their galaxy are called quasars, and they're actually some of the brightest things in the universe."

How many black holes has Richards spotted, exactly? Well, first he was part of a team who counted 10,000 black holes, back in the '90s. After integrating technological advances and statistical algorithms into his detection research in the early '00s, he was able to detect 100,000. Now, he says, he's closer to about a



_ GORDON RICHARDS Richards is a professor of physics in the College of Arts and Sciences.

million black holes.

When quasars were first discovered in the '60s, maps of the universe were only available on huge glass plates. If you wanted to look closely at a certain part of the sky, you'd have to find an institution that stored these glass plates.

In the 1990s, the process became easier through the Sloan Digital Sky Survey (SDSS), which used a telescope at Apache Point Observatory in New Mexico to digitally map the sky. Between 1998 and 2009, researchers were able to map a quarter of the sky.

When Richards started working with the SDSS as a graduate student, the common practice was to filter the light from stars and galaxies through a sort of prism, breaking the light into different color components revealing the

composition and distance of those objects. But he and his colleagues realized they could apply modern data mining techniques to identify quasars, using the type of Big Data algorithms common today but rare back in the early '00s.

"In the same data that we had found 10,000 quasars through this prism technique, we found 100,000 through modern statistical techniques," he says. "Once we had a bigger area, we basically ratcheted that up. We don't know if each one is a quasar, but we can put a statistical probability to it."

This technique was later adapted by others in the field, but Richards was one of the first to embrace it.

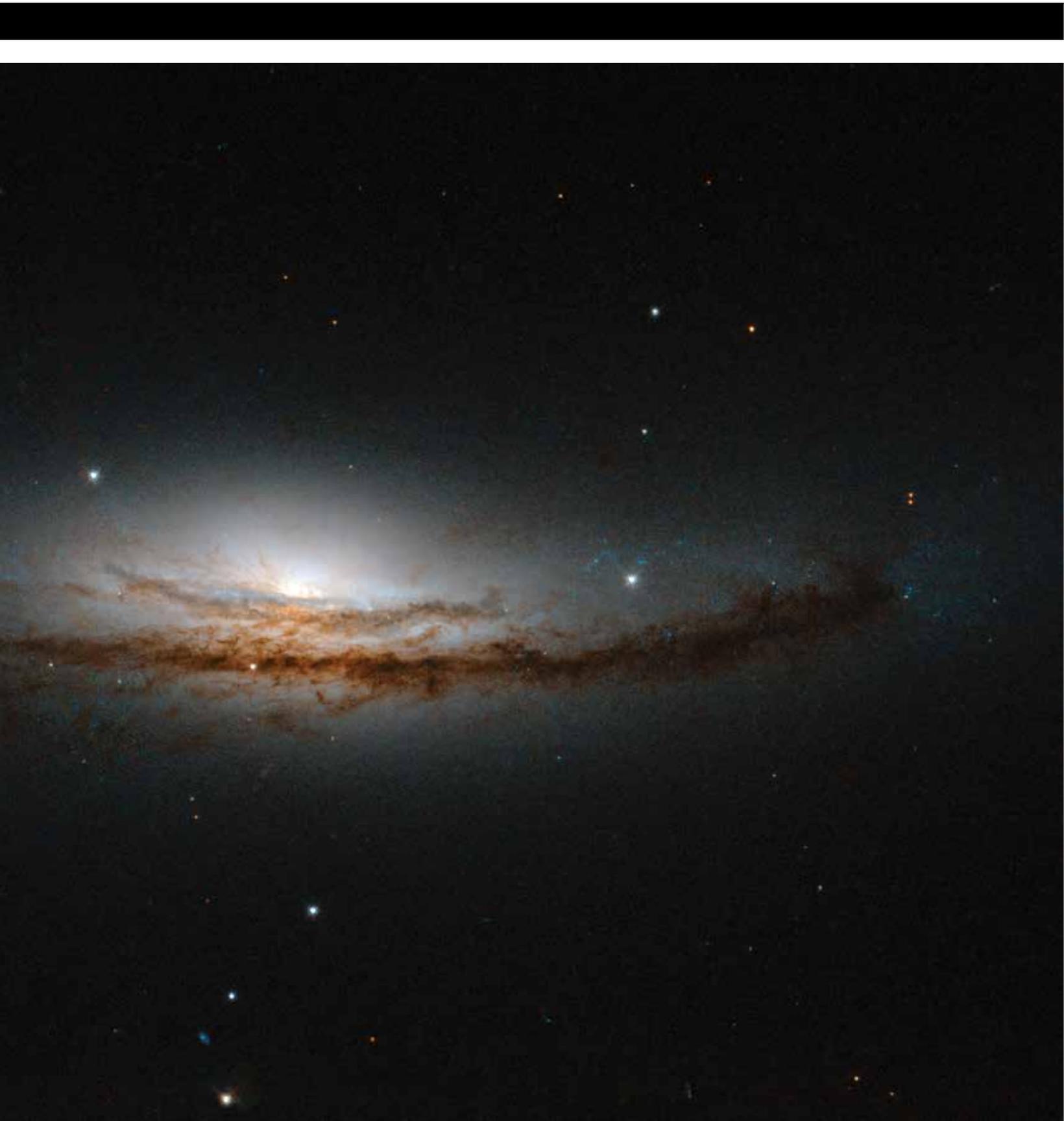
He expects to discover even more quasars in the near future through his involvement with the Large Synoptic Survey Telescope (LSST) project, which aims to build a far more powerful telescope in Chile by 2022. The LSST will take a full survey of the entire night sky every three days — completing what the SDSS project accomplished in eight years.

"SDSS is like making a map of the sky; LSST will make a movie," he says.

SUPER_LENS

This image, from the Hubble Space Telescope's Hubble Ultra-Deep Field, is sharp and magnificently detailed because the Hubble telescope is in outer space, outside of the distorting effects of the Earth's atmosphere. However, its limitation is that it is focused on only a tiny portion of the universe. While no land-based telescope can match the clarity of Hubble's images, the new LSST telescope being built in Chile will be capable of discovering galaxies just as distant, numbering in the billions, and will be able to scan half of the night sky every three days.





NATURAL-BORN MYSTERIES

SCIENTISTS FROM Drexel and the Academy of Natural Sciences of Drexel University regularly discover, describe and pen new species into the catalog of life on Earth, often investigating specimens that have eluded classification for a long time. Here are some that have made their way into the scientific record this year.

Average length of new species: 2". Average length of a common game catfish in the US: 12-24"



A LOCAL SECRET

More than 3,700 recognized catfish species exist worldwide, but in one area of Sumatra in Indonesia, locals have known about a previously unidentified species for years.

This year, that catfish got a name, *Sundolyra latebrosa*, after the Academy was contacted by a colleague in Singapore asking for help gathering information about the bony skeleton.

Despite the specimen's poor state of preservation, this international team of scientists was able to determine that the fish, known to reach only about 2 inches in length, was different from other catfishes in the family Bagridae, in that it had an eel-like body, no spine on the leading fin on its back and less bone projecting from the back of its skull. The species most closely resembles *Olyra longicaudatus*, but *Sundolyra latebrosa* has a dorsal fin farther forward on its body that also features a long spine instead of a flexible ray, the spines of side fins are smooth without serrations, and the tail fin has more fin rays, among other distinct features.

WEST COAST DIATOMS

Diatoms are a group of unicellular algae that exist all over the Earth. This year, the Academy received samples of two new species that were discovered in the Cascade Mountains in western Oregon.

Diatom expert Marina Potapova, assistant curator of diatoms at the Academy, was able to determine that the diatoms' skeleton structure — made from silicon dioxide, or glass — were unique enough to be named as two new species: *Navicula volcanica* and *Navicula subwalkereri*. Although both species likely interact in the environment, *Navicula subwalkereri* can be found in more places than *Navicula volcanica*. Additionally, *Navicula subwalkereri* have wider valves, among other features.

"The new species are clearly endemic of the Cascade Mountains," Potapova says. "This finding contributes to our understanding of the biogeography of microbes and helps us to better use diatoms as environmental indicators."

Navicula volcanica
Clearwater River,
Oregon



Sarcobolus cambogensis,
Cambodia

THE RHEOPHYTE PUZZLE

Until recently, the flora of the interior of Cambodia's Cardamom region has remained largely uncatalogued. But as Cambodian and international survey teams collaborate, more and more species are coming to light.

Such was the case for *Sarcobolus cambogensis*, a rheophytic shrub discovered in the Tatai River in the Koh Kong province.

Academy scientists used specimens and images provided by several collectors to determine that the plant was a unique *Sarcobolus* species similar to but distinct from two other species, *Sarcobolus luzonesis* and *Sarcobolus borneensis*, from the Philippines and Borneo, respectively.

Sarcobolus cambogensis differs from the latter two species in its broader leaves, prominent coronas on the stamens and a differently shaped pollen transport apparatus.

"This is the third species of rheophyte described from *Sarcobolus*," says Tatyana Livshultz, assistant curator of botany at the Academy. "The three species are geographically isolated from each other. Did the rheophytic habit evolve independently in each place or are these species all descended from a single most-recent common ancestor exclusive to them?"



WHEN RUBBER HITS THE ROAD

Old tires could find new life as energy-storing materials thanks to a process developed in part at Drexel.

RESEARCHERS HAVE figured out a way to turn the rubber from old tires into material that can store energy — a discovery that could aid in recycling some of the nearly 300 million tires that are discarded annually in the United States.



YURY GOGOTSI
Gogotsi is a distinguished university and trustee chair professor in the Department of Materials Science and Engineering and director of the A.J. Drexel Nanomaterials Institute in the College of Engineering.

The research, which was co-developed by scientists from Oak Ridge National Laboratory and Drexel University's College of Engineering, appeared in the journal *ChemSusChem*. It suggests that about 50 percent of the mass of a tire could be converted to carbon powder that can

300 MILLION

Number of tires discarded annually in the United States.

1.5 MILLION TONS

Amount of carbon powder that could be produced if all discarded tires were recycled for this purpose.

be used in batteries and supercapacitors.

"If we were to recycle all of the scrap tires, that would translate into 1.5 million tons of carbon, which is half of the annual global production of graphite," says Drexel researcher Yury Gogotsi.

The process entails pretreating the tires and heating them in a special tube-shaped furnace, and then depositing the resultant carbon on a thin film.

In addition to Gogotsi, co-authors of the paper include Muhammad Boota, a doctoral candidate in Gogotsi's lab; and Oak Ridge's Amit Naskar, Yunchao Li, Koukoubi Akato and Parans Paranthaman.

GEOLOGY

_SCIENCE UNDERFOOT

The Academy of Natural Sciences of Drexel University celebrated the 200th anniversary of the geological map that laid the foundation for earth science with a rare public viewing this year.



TED DAESCHLER Daeschler is an associate professor in the College of Arts and Sciences and associate curator of vertebrate zoology and vice president for systematic biology and the library at the Academy of Natural Sciences.

AMONG THE artifacts housed within the collections of the Academy of Natural Sciences are many remarkable items that never see the light of day.

At least, until one celebrates an anniversary.

A massive map of Great Britain created by geologist William Smith in 1815 was brought out this year in honor of its 200th birthday. It was the world's first nationwide geological map, and it helped develop stratigraphy and biostratigraphy as we know it.

When Smith created his map, scientists were still debating the origin and structure of the earth. Smith's brilliance came with a deeper understanding of the continuity of strata (stratigraphy) and the use of fossils within those layers to help with correlation (biostratigraphy). Both of these are foundational ideas in unraveling the history of the planet.

The map shows England, Wales and part of Scotland and it measures about five feet wide and nearly 10 feet



"This was the first detailed geological map, and maps like these are the foundation for doing earth science. To be able to express on a map the geology underfoot in a sensible and usable way was a huge step."

Ted Daeschler, Academy of Natural Sciences

high, a necessary size to meet Smith's specification of five miles to the inch.

Smith's expertise came from years as a land surveyor and canal builder, mapping coal formations and assessing values for landowners.

"Smith began to put evidence together about the geological formations that were encountered in coal mines and as they surveyed or dug canals," says Daeschler. "He began to realize that geology was predictable; that you can map it and understand that a sequence in one area is often repeated in another area. That was all somewhat revolutionary."

PALEONTOLOGY

_DIMETRODON DISCOVERY

A prehistoric fossil is "discovered" in the University's collections and finally classified with its close relatives, 160 years after being dug out of the ground.

SINCE 1845, a segment of an upper jawbone with serrated, inches-long teeth has resided on a shelf at the Academy of Natural Sciences of Drexel University under the name *Bathygnathus borealis*.

But like many of the millions of specimens at the Academy, this 270-million-year-old fossil still had a story to tell.

Researchers from the University of Toronto Mississauga, Carleton University and the Royal Ontario Museum, led by Kirstin Brink, used the Academy's fossil specimen to determine that *Bathygnathus borealis* was not actually a unique kind of animal.

By scanning and studying the eight preserved teeth in the jaw, the researchers found the evidence they needed to change the classification of the fossil to *Dimetrodon*, a "mammal-like reptile" that lived 40 million years before the first dinosaurs.

GOT BACK

Featured in the 1959 movie "Journey to the Center of the Earth" and many children's toys, *Dimetrodon* was a four-legged animal with a spiny, sail-like back ridge.

"They were able to zero in on unique features of this specimen that we've suspected for a long time," says Ted Daeschler, the Academy's vice president for systemic biology and the library. "The images they were able to develop allowed them to say 'This is a pelycosaur, specifically *Dimetrodon*.'"

Dimetrodon is believed to be the first land-based animal to sport "ziphodont" teeth meant for ripping flesh.

The jaw was initially discovered in Canada on Prince Edward Island in 1845. A farmer was digging a new well when the fossil was discovered nine feet down nestled in red sandstone.

With no natural history museum in Canada at the time, the specimen was sold to Joseph Leidy, a prominent paleontologist and curator of the Academy.

Leidy presented and named it at an Academy scientific meeting in 1845.

"He called it *Bathygnathus borealis*, which means 'deep jaw from the north,' basically," says Daeschler. "That's how it was back then. They just stood up at those meetings and presented."



_WHAT REALLY KILLED THEM?

A new theory suggests that the dinosaurs' fate was sealed by not just one, but two separate disasters around 66 million years ago.

WHEN AN ENORMOUS asteroid struck the planet 66 million years ago, a worldwide quake shook the magma plumbing of a massive, active volcano — radically changing its style of eruption and hastening the end of the age of dinosaurs.

This sequence of events is supported by a new study published last year in the *Geological Society of America Bulletin* by a team of scientists, including Drexel University volcanologist Loÿc Vanderkluyesen, and led by geologists at UC Berkeley.

Evidence for this colossal, catastrophic chain reaction came from geological features of a massive lava flow field in central-southern India known as the Deccan Traps. Lava erupted in this region for half a million years or more. The event occurred very close, in geologic time, to the major asteroid strike off the coast of Mexico 66 million years ago. In fact, for a time, it was believed that the asteroid strike had triggered the eruption.

It has since been established that the eruption was already underway before the asteroid hit, but evidence

LAVA_OCEAN

This mountainous region is part of a massive lava flow field in central-southern India known as the Deccan Traps. The lava that flowed there millions of years ago was so abundant that an area the size of Texas would have been submerged a mile deep.



_LOÿC VANDERKLUYSEN
Vanderkluyesen is an assistant professor in the Department of Biodiversity, Earth & Environmental Science in the College of Arts and Sciences.

presented in the new paper suggests that the impact coincided with a major shift in the volcano's activity.

"Suddenly, the flows are much larger, the morphology is different and the chemical composition is different," Vanderkluyesen explains.

"This was an existing massive volcanic system that had been there probably several million years, and the impact gave this thing a shake and it mobilized a huge amount of magma over a short amount of time," says team leader Mark Richards in UC Berkeley's press release. "The beauty of this theory is that it is very testable, because it predicts that you should have the impact and the beginning of the extinction, and within 100,000 years or so you should have these massive eruptions coming out, which is about how long it might take for the magma to reach the surface."

_BREATHING LIFE BACK INTO BROOKTROUT LAKE

A group of ecologists prove that recovery is possible for lake ecosystems devastated by acid rain — and that clean air regulations do work.

BROOKTROUT LAKE WAS once teeming with the speckled fish after which it is named, but by the 1980s, it had become one of hundreds of lakes and ponds in the Adirondacks of upstate New York that were devoid of fish. The culprit: acid rain from the burning of fossil fuels.

The bodies of water in this region are among the most impacted by acid deposition in the United States.

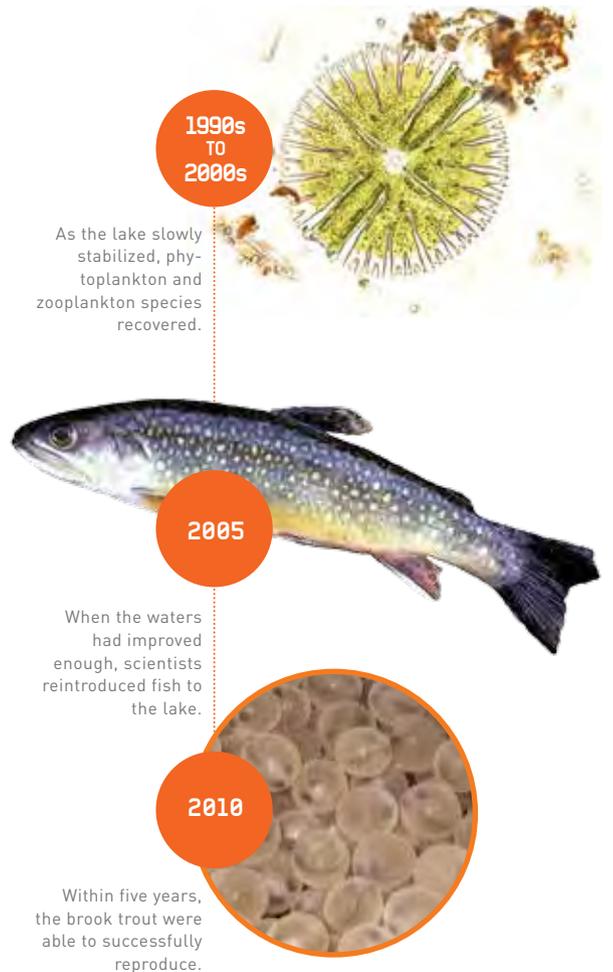
But reductions in sulfur dioxide emissions over the past three decades, fostered by federal environmental regulations, have allowed the pH of the Adirondack lakes to stabilize over time — giving scientists a unique opportunity to attempt to reintroduce fish to the lake.

Two researchers from the Academy of Natural Sciences of Drexel University — Donald Charles and Frank Acker — were part of a nine-institution group that has spent two decades documenting changes in the lake and their effects on species such as bacteria and fish.

Their research, which was published in 2015 in the journal *Environmental Science and Technology*, marks the most comprehensive long-term study of how acidification affects lake ecosystems to date.

The researchers documented the water quality and aquatic plant and animal life recovery throughout the 1990s and 2000s.

They discovered that, as lakes recover, more species of phytoplankton and zooplankton were found, thus beginning to rebuild the food chain.



By 2005, the waters had improved enough that scientists decided to re-introduce fish to the lake.

In the paper, the researchers describe the complex process by which they reconstructed historical conditions, re-introduced tagged fish to the lake and then meticulously monitored changes in the lake's species and water chemistry over time.

Finally, in 2010, the researchers discovered that the brook trout could not only survive but also reproduce.

This achievement was the first demonstration of food chain recovery through re-introduction and re-establishment of fish in a region that had been heavily affected by acid deposition.

Most significantly, the study underscores the success of national and international environmental regulations that limit pollutants, enabling nature to begin its healing process.

"Although it took a long time, the recovery of fish in Brooktrout Lake shows that the reduction in emissions did pay off," says Charles.

_LAW OF THE JUNGLE, IGNORED

On Equatorial Guinea's island of Bioko, rising prosperity and lax conservation enforcement have devastated the population of primates and other animals prized by consumers as "bushmeat" delicacies.

THIRTEEN YEARS of data collected by a team of researchers on the island of Bioko show how ineffective the country's lax environmental conservation laws were in stemming the growth of illegal hunting.

The team's full dataset from their long-running study was published for the first time last year in the journal *PLOS One*.

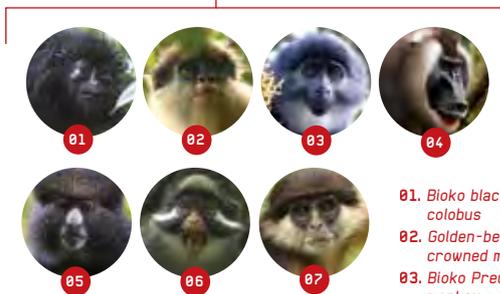
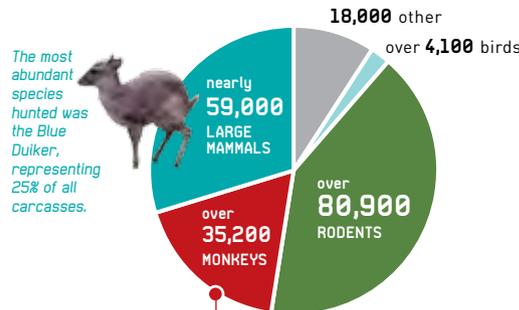
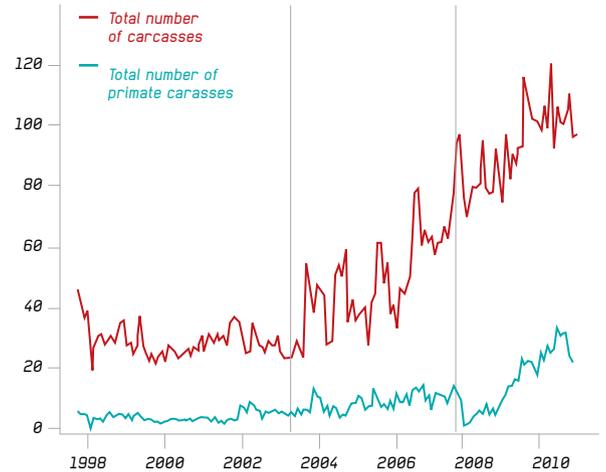
Researchers tallied the types and amounts of bushmeat sold at market in the capital city of Malabo between 1997 and 2010 and measured the increases in relation to the country's prosperity and other political and legal conditions. With the discovery of offshore oil, the island's prosperity has increased, and so has demand for the meat.

The legal protections Equatorial Guinea enacted in 2007 to limit hunting and sales of primates were not upheld — and even backfired to the point where bushmeat hunting actually increased.

The study was conducted as part of the Bioko Biodiversity Protection Program, a joint venture of Drexel University and the National University of Equatorial Guinea. The program was established in 1998 by Gail Hearn, now a Drexel emeritus professor. After her retirement in 2014, it was taken over by Associate Professor Mary Katherine Gonder. Drew Cronin, PhD environmental science '14, was the study's lead author.

197,000

Number of carcasses recorded for sale during the 13-year study. At the peak of recorded activity in 2010, on any given day, more than 30 freshly killed primates, such as Bioko red-eared monkeys and drills, were brought to market.



ENDEMIC_PRIMATES

A later study by the team found that all of the island's monkeys were vulnerable to heavy hunting except *Cercopithecus erythrotis* (6), *Cercopithecus nictitans* (5) and *Cercopithecus preussi* (3), with the *Procolobus pennantii* (7) being especially vulnerable.

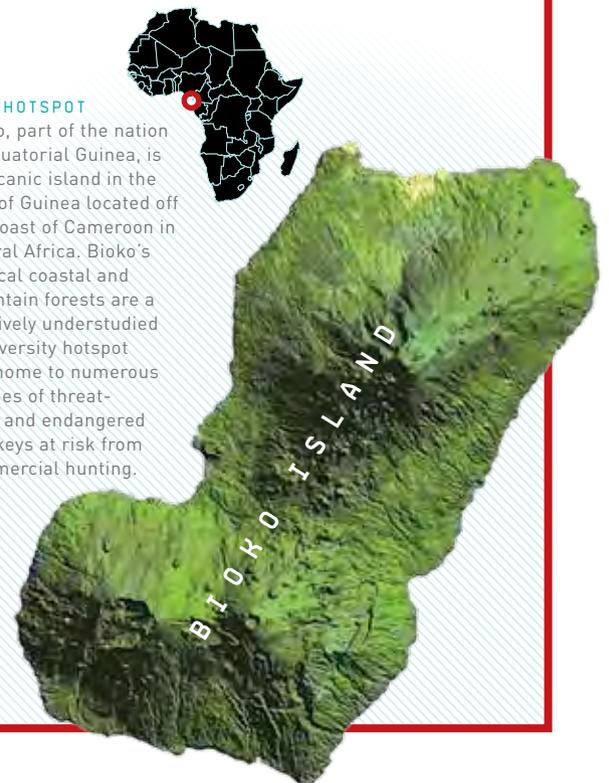
- 01. Bioko black colobus
- 02. Golden-bellied crowned monkey
- 03. Bioko Preuss's monkey
- 04. Bioko drill monkey
- 05. Bioko Stampfl's putty-nosed monkey
- 06. Bioko red-eared monkey
- 07. Pennant's red colobus

BUSHMEAT_BULL_MARKET

Shown are the total number of animals and primates captured on Bioko overall for bushmeat between 1997 and 2010. Market growth was consistent over time for overall carcasses, as the mean number of carcasses per market day increased progressively over three periods: 1997–2003, 2003–2008 and 2008–2012. In the later years of the study, endangered monkeys became more frequently hunted.

BIO_HOTSPOT

Bioko, part of the nation of Equatorial Guinea, is a volcanic island in the Gulf of Guinea located off the coast of Cameroon in central Africa. Bioko's tropical coastal and mountain forests are a relatively understudied biodiversity hotspot and home to numerous species of threatened and endangered monkeys at risk from commercial hunting.





VANISHING



*In Ghana, **over half of all forest understory birds have vanished in just 15 years as unchecked illegal logging, economic stress and demand for African timber take their toll on the nation's rainforests.***

_by Mike Unger



One calm, moonless night in the Ghanaian rainforest, Nicole Arcilla heard the rumble of an approaching truck. ¶ Arcilla was camping in the forest with special permission from the Ghana government to conduct research on the impact of logging on local wildlife populations. During the two-year project, she often slept outdoors so that she could start work before dawn, when the forest's array of beautiful birds chirp to life, greeting the sun. ¶ No one else was supposed to be there at night. ¶ "Our truck was parked in the middle of the road, and we had to move it so they could pass," she recalls. "I thought, 'Wait a second. The only reason they're here is to do something illegal.'"



—NICOLE ARCILLA
Arcilla is a post-doctoral research associate in the Biodiversity, Earth & Environmental Science Department in the College of Arts and Sciences.

Arcilla, a postdoctoral research associate in the Biodiversity, Earth & Environmental Sciences Department in Drexel's College of Arts and Sciences, reported the illegal loggers to the authorities, but she had little hope that anything would come of it. Hardly a day passed in the forest without her or someone on her team seeing evidence of illegal activities.

Although the West African nation is a peaceful, vibrant democracy, enforcement of its forestry and wildlife laws is extremely weak, a fact Arcilla and her co-researchers uncovered in a study that sheds light on the serious effects both legal and illegal logging are having on the country's understory bird populations.

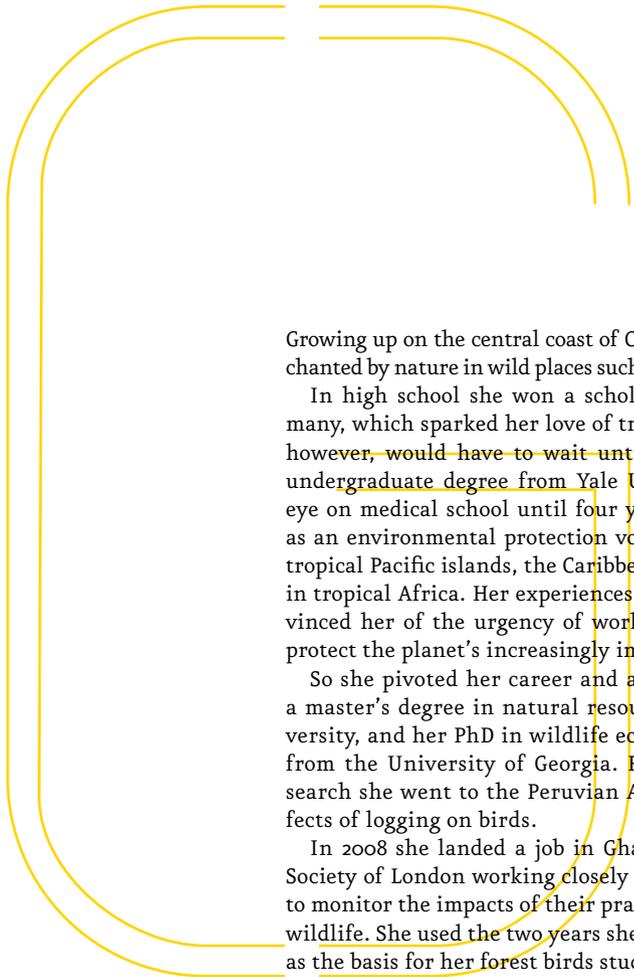
the long-term effects of logging activities on forest birds, and the results were alarming.

Between 1995 and 2010, the level of legal and illegal logging in Ghana's forests shot up more than 600 percent, and over half of Ghana's birds disappeared.

Environmentalists everywhere have taken note. An online petition asking the president of Ghana to crack down on illegal logging has garnered more than 40,000 signatures, and the results of the study have been published by media around the globe.

"To our knowledge, this is the first peer-reviewed scientific study that links illegal logging to declines in forest wildlife," Arcilla says. "Illegal logging is a major problem in many countries with tropical forests, which sustain most of the world's terrestrial biodiversity. If the world doesn't take this issue seriously, I think we're going to be losing a lot more global biodiversity — birds, other wildlife, and a lot more of our forests — in our lifetimes."

The study, published last year in *Biological Conservation*, compared data collected by Arcilla between 2008 and 2010 to a previous study of the forest's birds 15 years earlier, from 1993 to 1995. Comparing her findings to the earlier data gave Arcilla a rare chance to measure



Growing up on the central coast of California, Arcilla was enchanted by nature in wild places such as Big Sur and Yosemite.

In high school she won a scholarship to study in Germany, which sparked her love of travel. Marrying the two, however, would have to wait until after she earned her undergraduate degree from Yale University. She had her eye on medical school until four years in the Peace Corps as an environmental protection volunteer took her to the tropical Pacific islands, the Caribbean, and Gabon and Togo in tropical Africa. Her experiences during those years convinced her of the urgency of working to understand and protect the planet's increasingly imperiled wild nature.

So she pivoted her career and academic goals, earning a master's degree in natural resources from Cornell University, and her PhD in wildlife ecology and management from the University of Georgia. For her dissertation research she went to the Peruvian Amazon to study the effects of logging on birds.

In 2008 she landed a job in Ghana with the Zoological Society of London working closely with logging companies to monitor the impacts of their practices on the forests and wildlife. She used the two years she spent in the field there as the basis for her forest birds study.

It's important to note that controlled, minimal and carefully managed logging, while possibly disruptive to an ecosystem, can be sustainable, says Nat Annorbah, a Ghanaian who helped Arcilla set up her research project. He is the author of a new study, related to Arcilla's, which shows that African Grey Parrots have nearly been wiped out in Ghana due to habitat loss and the pet trade.

"However, the rampant and indiscriminate excessive logging currently practiced in Ghana inevitably alters both the macro- and micro-environments for many species, resulting in unsuitable habitats which means that many species fail to flourish," says Annorbah, now a teaching doctoral candidate at England's Manchester Metropolitan University. "This situation ultimately results in species population declines and the eventual loss of biodiversity."

Mammals and amphibians also are suffering. Arcilla's team found mammal abundance five times lower in logged forest compared with unlogged forest, and she's not the only researcher to document problems in Ghana's forests.

Sylvain Gatti, a French primatologist who conducted transect surveys for mammals as part of Arcilla's team,

found 13 times more evidence of poachers (gun cartridges, snare traps, hunting camps, etc.) than evidence of mammals (tracks and feces) in logging concessions.

Previous research by British primatologist John Oates and colleagues documented the global extinction of an endemic West African monkey from Ghana and neighboring Côte d'Ivoire due to the combined effects of uncontrolled hunting and habitat loss; many other forest primates, including Western chimpanzees, teeter on the brink of extinction in Ghana.

Gilbert Adum, a Ghanaian graduate student who conducted amphibian research alongside Arcilla's team, found that the habitat loss and damage in Ghana's forests was threatening native forest amphibians and drawing invasive amphibian species into their domain — another clear indication that Ghana's forest reserves are in danger, Arcilla says. Adum is now executive director of Save the Frogs! Ghana, an organization working to advance conservation in Ghana's forests.

Arcilla had originally planned to study just the effects of legal logging on the understory bird populations, but she quickly saw that illegal logging was a major problem, making up as much as 80 percent of Ghana's logging activity.

"It turned out to be everywhere," she says.

One day, when her team was in the forest doing bird surveys, a truck with a sticker on the windshield that said "CASH" rambled past with a cargo of boards covered by a tarp. The boards were clearly cut into lumber.

"In Ghana, that means it's not a logging company," says Arcilla. "Companies take out the whole tree and then take it to a mill, so when you see boards being taken directly out of the forest, you know it's illegal."

The more that she learned to recognize the signs, the more she saw: "We'd arrive at a protected forest that was supposed to be recovering from a legal logging operation years ago, and instead we'd find that illegal loggers had punched big holes in the forest by cutting many huge trees, the sawdust still fresh."

Logging — both legal and illegal — has other unintended consequences for Ghana's forests. Roads built to give trucks access to the timber make it easier for poachers to enter the forest.

"Snare traps are against the law, but we saw them everywhere," Arcilla says. "In some cases a single trapper can set hundreds of snares that kill indiscriminately and often go unchecked. Shotgun hunting is only legally allowed during certain times of the year for certain species, but we found poachers using guns throughout the year, and many told us they felt compelled to kill any animal that could be eaten or sold. We also repeatedly observed evidence of poachers using dogs, traps and setting fires to smoke out animals, all practices that are illegal, but common."


80%

Arcilla had originally planned to study just the effects of legal logging on the understory bird populations, but she quickly saw that illegal logging was a major problem, making up as much as 80 percent of Ghana's logging activity.

"This is the first study to our knowledge that links illegal logging to declines in forest birds. The crux of our study was that over a 15-year period for which we have empirical data, we've shown that over half of Ghana's forest understory birds have disappeared. If the world doesn't take this issue seriously, I think we're going to be losing a lot of biodiversity – birds, other animals, and a lot of our forests."



“These are forest birds. Like other forest species, they may persist in logged forests that are protected from excessive damage, but they cannot survive in farmland or urban areas.”

“In general, the illegal logging and poaching are so normal and accepted in Ghana that people don’t even really think about it — it’s all out in the open,” says Arcilla. “Many people prefer to eat ‘bushmeat’ — or wildlife — rather than meat from readily available domestic animals like chicken or goat, or fish. Even many poor people pay more to eat wildlife because it is considered a delicacy.”

When it comes to wildlife protection, incidences of law enforcement are few and far between. Almost all of Ghana’s legally logged timber is exported to wealthier nations in Europe, North America and Asia, where it fetches a much higher price than it would at home. Ghana’s policy of exporting almost all of its legal timber leaves the country’s own burgeoning population — it has increased fivefold in the past 60 years — struggling to find the materials it needs to build. In fact, Arcilla says, there is little legal timber for sale on Ghana’s domestic market — the vast majority of it is illegal, and much of this illegal timber is sold in neighboring African countries.

Independent studies by multiple researchers, both Ghanaian and foreign, estimate that logging in Ghana is proceeding at four times the sustainable rate.

“This is effectively deforestation,” Arcilla says. “If the current trajectory is not altered, Ghana could lose much of its remaining forest in the next 25 years.”

Which leaves the forest birds of Ghana with no place to go. One might ask why they can’t simply fly away and relocate elsewhere, to which the answer is “what elsewhere?” Ghana has already lost 80 percent of its precolonial forest, says Arcilla.

“Take away the forests, and the forest wildlife goes with them,” she says.

To measure the impacts on birdlife, Arcilla spent 80 days at 27 sites in 15 forests counting birds. She and her team set up 10 fine mesh nets that immobilize birds without harming them and counted the birds they caught every 20 to 25 minutes before releasing them back into the forest.

Among the species they found was the Red-fronted Antpecker, a songbird the size of a sparrow that is considered threatened with extinction in the near future by the IUCN, or International Union for the Conservation of Nature.

“We caught only two pairs of them in a single location in a single forest. This bird has a very limited range, and this finding shows you how vulnerable they are; if a logging operation is done in that area, and the birds are already on the brink, that could contribute to wiping out a species,” Arcilla says. “These are forest birds. Like other forest species, they may persist in logged forests that are protected from excessive damage, but they cannot survive in farmland or urban areas.”



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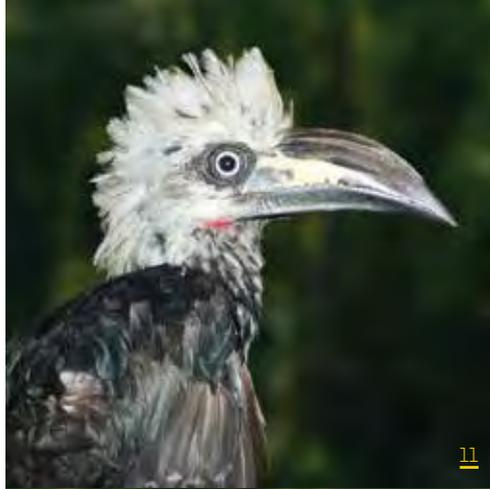
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BIRD IN HAND
 During the two years that Nicole Arcilla spent netting and counting Ghana's birds, she collected 20,000 photos, mostly of birds and other wildlife. Many of the species native to Ghana's forests could not survive outside the forest's canopy.

- 01. Red-fronted Antpecker
- 02. Fraser's Sunbird
- 03. African Goshawk
- 04. Blue-billed Malimbe
- 05. Forest Robin
- 06. Finsch's Flycatcher Thrush
- 07. Red-chested Owlet
- 08. Blue-headed Crested Flycatcher
- 09. African Dwarf Kingfisher
- 10. Bristle-nosed Barbet
- 11. Western Long-tailed Hornbill
- 12. Finsch's Flycatcher Thrush
- 13. Blue-headed Wood Dove
- 14. Latham's Forest Francolin
- 15. Green Hylia
- 16. Rufous-sided Broadbill
- 17. Black-headed Paradise Flycatcher
- 18. Western Bluebill
- 19. Grey-headed Bristlebill
- 20. Red-thighed Sparrowhawk

Illegal logging was far less prevalent 15 years ago, when Arcilla's co-author Lars Holbech conducted his earlier study of Ghana's birds in many of the same forests. Holbech, who is on the faculty in the Department of Animal Biology and Conservation Science at the University of Ghana, says that the severe impact on the area's biodiversity appears relatively irreversible.

"Compared to two decades ago, the problem has more than doubled, literally," Holbech says. "Heavily logged areas will require 50 to 100 years to recover, but some rare species may be in danger of local extinction."

The White-necked Picathartes is a sort-of white whale for bird watchers. Thought to have gone extinct from Ghana, it was rediscovered in 2003 by American museum collectors — sparking efforts by the Ghana Wildlife Society to protect the species in the forests where it has survived.

To Arcilla, at least, the bird provides a symbol of hope for all of Ghana's wildlife.

"I do see solutions," she says, "but for these to succeed, serious conservation steps need to be taken, and there is no time to lose."

First, she says, until the government of Ghana effectively tackles its illegal logging problem, it should put a moratorium on exporting timber. "There is simply not enough timber left in Ghana's forests to supply the world market and its own growing population," she says. "Right now they are trying to have their cake and eat it, too: Exporting large volumes of timber for foreign consumption and allowing a high level of illegal logging to feed domestic demand."

"It's basically a free-for-all," she says. "Imagine if we had no traffic police on our streets. People would be speeding and running stoplights."

Limiting the timber trade is easier said than done, of course. Ghana's economy, like many in Africa, is dependent on its natural resources. Ghana is Africa's second-biggest producer of gold after South Africa, and it's also rich in diamonds, bauxite and oil. But the government was forced to seek a loan from the International Monetary Fund last year and the recent plunge in oil prices has worsened the country's economic options.

On the other hand, tourism has been growing in Ghana and is an increasing source of revenue, Arcilla notes.

Back to the White-necked Picathartes: It's a very charismatic bird and very rare — only about 10,000 exist. "People will pay thousands of dollars to join birding tours to come see them and other African wildlife," Arcilla says.

But ecotourism alone can't replace logging revenues, Arcilla acknowledges, and investments are needed to motivate governments to keep forests standing.

A big step in this direction was recently taken by the neighboring West African country of Liberia, which made

a deal with Norway to accept payments to shift from logging its forests to protecting them, while including forest communities as beneficiaries.

"This partnership shows tremendous foresight and leadership," Arcilla says. "I hope it will inspire other such partnerships, where wealthy countries step in to assist developing countries to save their forests before it's too late."

Liberia's partnership with Norway is an example of an approach called "direct payments for biodiversity conservation," which has been used in other places where poverty is an obstacle to conservation.

In Cambodia, for example, local farmers and hunters were rewarded for safeguarding the nesting sites of nine bird species threatened by the collection of eggs and chicks. Since the program's inception in 2003, it has protected more than 2,700 nests over more than 1,200 miles of habitat. Local people were directly paid about \$65 to \$120 per nest and the overall program cost \$30,000 a year to operate, making it relatively affordable.

The protected nests produced far more fledglings than control nests, and the population of three of the species increased during the program, though results weren't uniform. The program did nothing to influence other threats to species, such as clear-cutting for development, and at least one species declined regardless of the effort. A tentatively optimistic evaluation of the program published in 2012 in *Biological Conservation* concluded, "Direct payments can be a highly effective conservation tool in those cases where payments correctly target the cause of biodiversity loss."

In Ghana, one idea that might work would be to pay residents to patrol the forests or to gate and maintain road closures after logging company trucks depart, so the roads can't be used by illegal loggers.

"Direct payments for conservation has great potential," says Arcilla. "If local people can financially benefit from conservation I think they will rally to the cause."

The problem is not going to go away by itself, says Arcilla. But if urgent, effective action is taken, she says, and those working for forest conservation in Ghana receive the help and support they need, Ghana's remaining rainforests can be saved.

"What gives me hope is knowing some wonderful people in Ghana who are fighting to protect their forests and wildlife," she says. "But they can't do it alone. Like anything, it's going to take a political shift, and conservation-minded partners to help them in this fight. Ultimately, it's not up to anybody except the people of Ghana. It's in their hands; it's their country." ✕

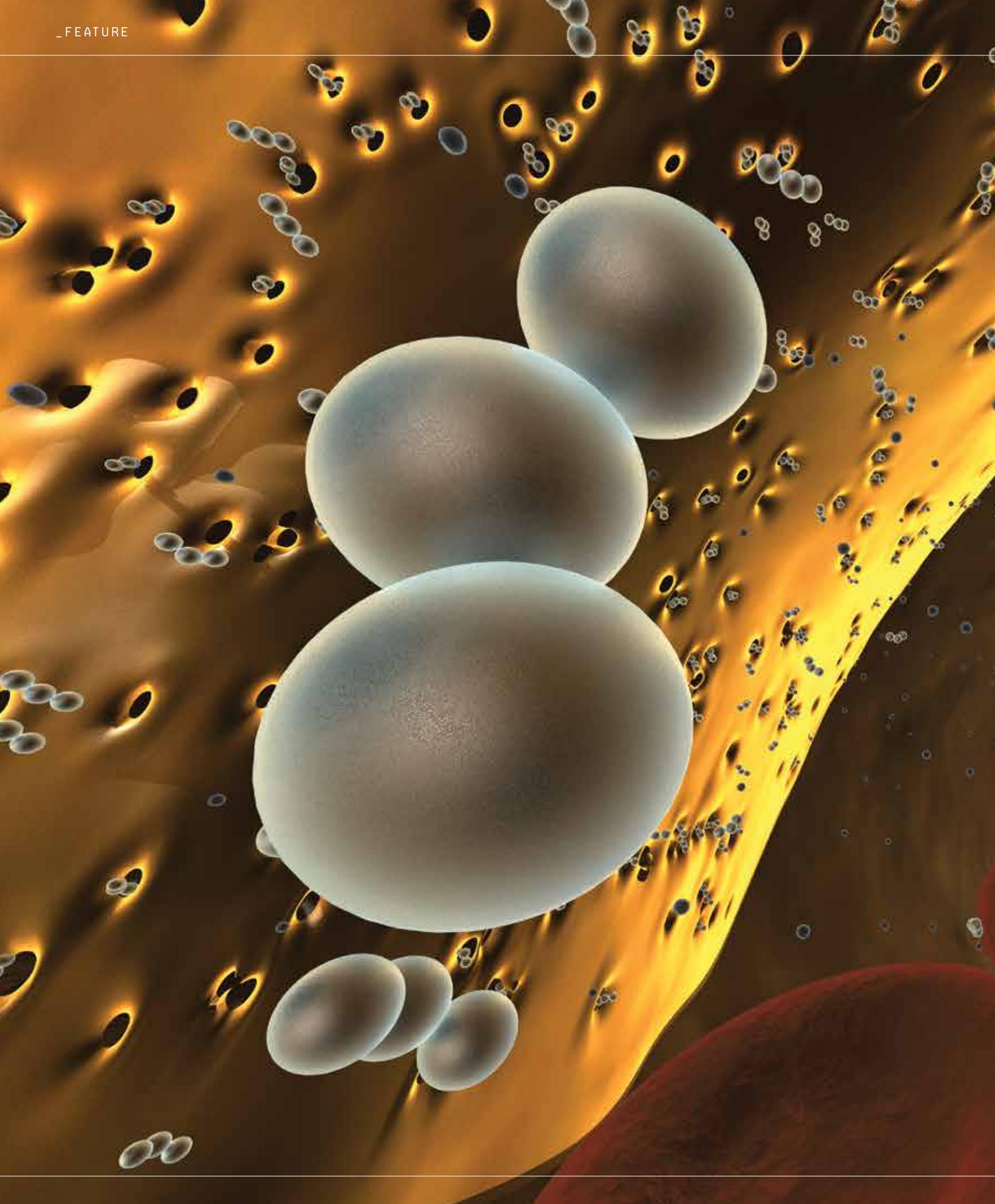


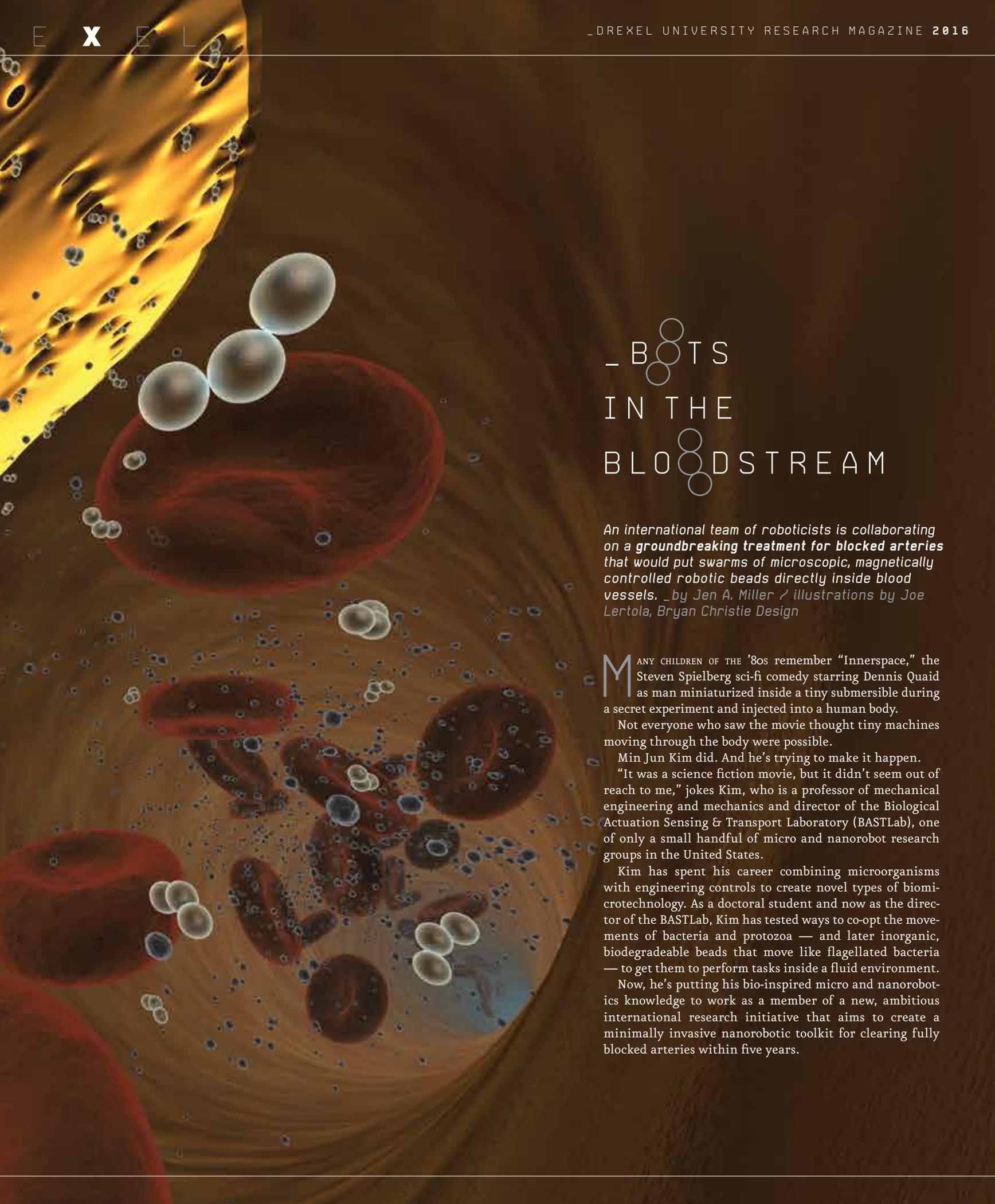
50
TO
100
YEARS

Heavily logged areas will require 50 to 100 years to recover, but some rare species could face local extinction in that time.

"Direct payments for conservation has great potential. If local people can financially benefit from conservation I think they will rally to the cause."







_ BOTS IN THE BLOODSTREAM

*An international team of roboticists is collaborating on a **groundbreaking treatment for blocked arteries** that would put swarms of microscopic, magnetically controlled robotic beads directly inside blood vessels. _by Jen A. Miller / illustrations by Joe Lertola, Bryan Christie Design*

MANY CHILDREN OF THE '80s remember "Innerspace," the Steven Spielberg sci-fi comedy starring Dennis Quaid as man miniaturized inside a tiny submersible during a secret experiment and injected into a human body.

Not everyone who saw the movie thought tiny machines moving through the body were possible.

Min Jun Kim did. And he's trying to make it happen.

"It was a science fiction movie, but it didn't seem out of reach to me," jokes Kim, who is a professor of mechanical engineering and mechanics and director of the Biological Actuation Sensing & Transport Laboratory (BASTLab), one of only a small handful of micro and nanorobot research groups in the United States.

Kim has spent his career combining microorganisms with engineering controls to create novel types of biomi-crotechnology. As a doctoral student and now as the director of the BASTLab, Kim has tested ways to co-opt the movements of bacteria and protozoa — and later inorganic, biodegradable beads that move like flagellated bacteria — to get them to perform tasks inside a fluid environment.

Now, he's putting his bio-inspired micro and nanorobotic knowledge to work as a member of a new, ambitious international research initiative that aims to create a minimally invasive nanorobotic toolkit for clearing fully blocked arteries within five years.

The \$18 million project combines 11 institutions that are home to some of the top roboticians and engineers in the world, including ETH Zürich, Seoul National University, Hanyang University and Samsung Medical Center, among others. The project is backed by the Korea Evaluation Institute of Industrial Technologies and organized by the Daegu Gyeongbuk Institute of Sciences and Technology, a government-funded research entity in South Korea.

Kim's team, which includes Drexel post-doctoral researcher U Kei Cheang, is the only member of the group from the United States. Kim is already well on his way to having a working model and will test the technology in animal models as early as this summer.

"Microbotics is still a rather nascent field of study, and very much in its infancy when it comes to medical applications," Kim says. "Microbots are scalable, easily manipulated and non-disruptive to the human body; they can do many things, such as deliver medication to tumors or unclog arteries, without using open surgery. A project like this, because it is supported by leading institutions and has such a challenging goal, is an opportunity to push medicine and microbotics into a new and exciting place."

BEADS AND MAGNETS

This is only the first year of a five-year partnership, but Kim has been refining the science of his design for a long time already.

Kim's microbots, which he calls "microswimmers," are chains of three or more flexible iron-oxide particles, rigidly linked together through chemical bonds and magnetic force.

In a series of papers published in *Physical Review*, *Applied Physics Letters* and the *Journal of Nanoparticle Research* in 2014 and 2015, Kim and his research team chronicle their progress in achieving control over the beads. In lab tests, using an external electromagnetic field to actuate and control the microswimmers, they've been able to combine beads into chains and disperse them at will. They've also propelled two different microswimmers in opposite directions simultaneously in the same fluid environment. And they've moved the pair at the same and at different speeds, too.

"We can control speed, direction, orientation, docking and undocking," Kim says. "It was truly a challenge to develop a 2D/3D magnetic field control system with micro and nanoscale precision as well as control theories and algorithms for in vivo environments."

The beads are so small — 4.40 micrometers in diameter, about half the size of a red blood cell and a third of the size of a white blood cell — that they can glide easily through the bloodstream.

The beads are put in motion by an external magnetic field that causes each bead to rotate. Because they are linked together, their individual rotations propel them forward in a twisting corkscrew pattern, ideal for burrowing through arterial plaque to loosen blockages in the bloodstream.

The team's plan is to use the microswimmers in concert with a probe that resembles a tiny drill, which is being designed by another member of the team, Professor of Robotics and Intelligent Systems Bradley Nelson at ETH Zürich. A catheter will be used to deliver the microswimmers and the drill directly to the blocked artery. From there, the swimmers would push their way into the blockage, after which the drill would clear it completely.

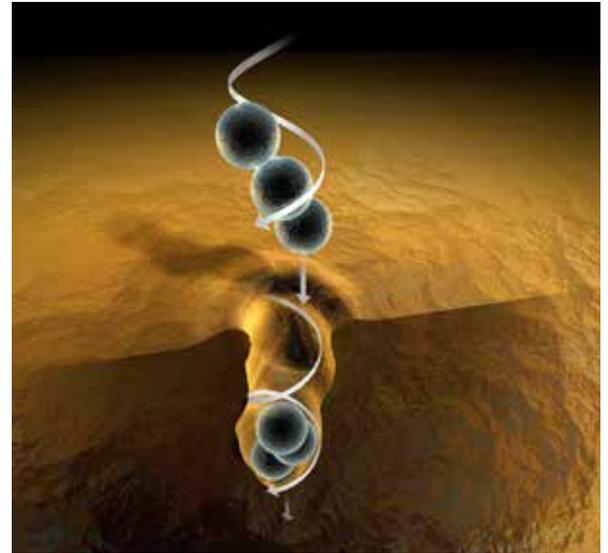
The Daegu Gyeongbuk Institute asked Kim to be involved in the project because the organizers believed he might be able to help them achieve better control over the drill robot, Kim says.

"But they would also like to see if our beads can do the drilling," he says. "Our tool is easier to fabricate; theirs requires at least a week to manufacture."

As Kim and the team envision it, a trained surgeon will control the microswimmers' speed and direction inside a patient by manipulating an external magnetic device made up of electromagnetic coils, similar to a mini-MRI.

Kim has engineered a couple of these devices, each about the size of a tissue box, to steer and manipulate micro and nanorobot prototypes in his lab. During the next couple of years, other researchers in the partnership will develop a sophisticated version of the device that doctors can use to direct surgeries. The partnership anticipates testing the technology in lab and clinical settings within in the next four years.

"Microbots are scalable, easily manipulated and non-disruptive to the human body; they can do many things, such as deliver medication to tumors or unclog arteries, without using open surgery."



Each microswimmer consists of three beads made of magnetic iron-oxide. To bind the beads strongly to each other, some are coated with the small molecule biotin and others with the bacterial protein streptavidin. The biotin-streptavidin bond is one of the strongest noncovalent interactions in nature.

Kim modeled the corkscrew movements of his microswimmers after a bacterium that wreaks havoc in the body by burrowing through healthy tissue. *Borrelia burgdorferi*, the bacteria that causes Lyme disease, is classified by its spiral shape, which enables its movement. Kim hopes to harness the malicious structure and motion that makes Lyme so destructive to improve lives instead.

"This international collaboration is a way to grab onto the opportunity to introduce our robots to the world," says Kim. "If our microbots can drill through clogged arteries, it would help many people who suffer from atherosclerosis."

THE HEART OF THE PROBLEM

Heart disease is the world's largest public health problem, responsible for killing more than 375,000 Americans each year — more than any other cause of death. Medical research has raced to keep up with treatments as the number of cardiovascular operations and procedures has grown by nearly a third to 7.6 million between 2000 and 2010, according to statistics compiled by the American Heart Association.

The most common type of heart disease, atherosclerosis of the coronary arteries, happens when the vessels that supply blood to the heart become narrowed by a buildup of cholesterol and plaque on their inner walls.

If those arteries become blocked suddenly, a heart attack results. But for about 10 percent of patients, blockage builds up slowly, and an individual may walk around for several months or more with a fully blocked artery, experiencing fatigue and chest pain as his heart slowly starves for oxygen.

This slow-motion heart attack is known as chronic total occlusion, and it's the condition that most interests the researchers assembled by the Daegu Gyeongbuk Institute.

It used to be that the only treatment for a totally blocked artery was open-heart bypass surgery. In the past few years, cardiologists have had increasing success using angioplasty and stents to treat total occlusions. Angioplasty pushes out the blockage by expanding the artery with a balloon-like probe, while stents are mesh-like structures placed inside blood vessels to create a channel for blood to flow through.

But overall success rates for treating total blockages using stents and angioplasty can vary, depending on the condition of the patient and the skill of the surgeon, from 60 percent to 85 percent — far below the 98 percent success rate that can be achieved in patients with partial blockages. And blockages are known to recur inside stents 10 to 20 percent of the time, with many patients needing another procedure within a year of insertion.

That's too many failed procedures, especially for an organ as important and delicate as the heart.

This is where micro and nanorobotics comes in.

The tools being developed by the Daegu Gyeongbuk team promise to be less invasive than a stent placement, and could also cut down on the risk of post-surgery complications. Many stents are made of metal that become part of the permanent wall of the blood vessel and sometimes trigger the development of scars or clots at the stent site. The beads that Kim has developed are made of materials that won't trigger an immune response and that will degrade in the body without leaving a trace or damaging the integrity of the artery wall.

MILE MARKER ONE

The crucial test for the Daegu Gyeongbuk team will be to successfully translate lab results to human studies. Kim's microswimmers will be first tested in mice in 2016 and then in increasingly complex mammals over the next few years.

Kim has already shown that the technology works "in the glass" — that is, in a controlled liquid environment. In videos produced in his lab, microswimmers are filmed conducting small orchestrated tasks like moving toward targets and mimicking pre-set patterns and shapes, such as the outlines of the letters D and U (a microscale nod to Drexel University).

Inside the surging arteries of a human body, however, fluid dynamics are relatively chaotic. "We have a lot of trial and error to do, but I'm excited," says Kim.

It's a goal with a huge payoff. Nanobots have potential beyond just treating blocked arteries. If they can be successfully steered inside the body, they could bring unprecedented precision to many medical treatments.

Kim is studying ways to make microswimmer beads move in swarms and work together toward a common goal, such as delivering doses of drugs in effective quantities to a target site in the body. For instance, after they've helped to clear an artery, his microswimmers could disperse and deliver anti-coagulant medication directly to the affected area to prevent clotting.

Another possibility is that medicated beads could be injected close to a disease site in the body and moved to the precise target.

"For cancers that have antigens, microrobots could deliver the antibodies right to the tumor site," Kim says. "Or the structure and movement of the microrobots could allow them to penetrate through the cancer membrane, vastly increasing drug effectiveness."

Kim is able to move a microswimmer with a margin of error of less than 2 microns — which would be valuable in surgeries where precision and nimbleness are essential, such as brain operations.

"Given what we've shown so far, nanorobots could be deployed and not damage a single neuron," Kim says.

Kim hasn't stopped seeing his dream up on screen in the years since Dennis Quaid landed a tiny craft on Martin Short's optic nerve in "Innerspace." Shows like "Arrow," "Futurama" and movies like "GI Joe" have taken the mental leap that Kim hopes to make a reality.

"'Fantastic Voyage' came out 50 years ago," Kim says, referring to the 1966 movie about a submarine shrunk small enough for its crew to repair brain damage — a poster of which he keeps on his computer for inspiration. "And to realize this science fiction dream in real life is what we're working for." ✕



MEDICINE INSPIRED BY PATHOGENS

Bacteria — their movements, their shapes — have been at the root of Kim's robotics since he was a doctoral student at Brown University.

At Brown, Kim experimented with a strain of *E. coli* bacteria that had been genetically modified by Howard Berg, a Harvard University physics professor (Kim would later become a postdoctoral fellow at the Rowland Institute at Harvard) to have a varying number of flagella. Flagella are lash-like appendages that propel certain microorganisms; by altering their number, the organism's rotation speed can be controlled by external factors, such as chemicals, specific wavelengths of light and electric fields.

Kim's idea was to harness *E. coli*'s motility as a sort of motor to power other things, and in 2006, he attached the bacteria to the bottom of a micro-fabricated structure to create a bacteria-powered microrobot. He successfully showed that the hybrid could be used for micro-manipulation and obstacle avoidance.

That same year, Kim came to Drexel, where his interests shifted toward applications that could improve human health, one of the main tenets of Drexel's translational research mission. And while his experiments had shown promise of having some practical applications, *E. coli* is still *E. coli*. Even modified to reduce its innate toxicity, *E. coli* has the potential to startle the immune system and throw the body into chaos. "People don't want bacteria inside them," Kim says simply.

Kim continued to dabble in experiments involving artificially magnetotactic (prone to self-align with the Earth's magnetic field) protozoa until 2011, but by then his team had largely switched their focus to man-made biodegradable particles, such as the microswimmers he is currently studying as a treatment for blocked arteries.

Not only do non-cell-based materials eliminate the risk of an immune system response, but magnets promised to be a more accurate and safer way to direct their creations around the body — with no need to convince a skeptical public that their tool isn't a dangerous pathogen.

_ TWO CENTURIES OF SHELLS

Scientists and naturalists have spent more than 200 years building the Malacology Collection at the Academy of Natural Sciences, making it one of the richest and largest collections in the country, and even the world. It's no wonder, then, that researchers from across the globe are regularly knocking on the Academy's door, asking for access to it.

THE MALACOLOGY Collection at the Academy of Natural Sciences of Drexel University is the oldest of its kind in North America, and the third largest in the world. Collection Manager Paul Callomon is its gatekeeper. Only he doesn't keep anything from anyone. The collection is meant to be explored, it's meant to be used. It's a record of the natural world with the potential to answer limitless questions.

Researchers from around the world come to the Academy to tap into its riches. Many come from countries like Brazil and Singapore, countries that perhaps never had museums or biological collections as old as the Academy's, to learn more about the biological history of their own country, Callomon says.

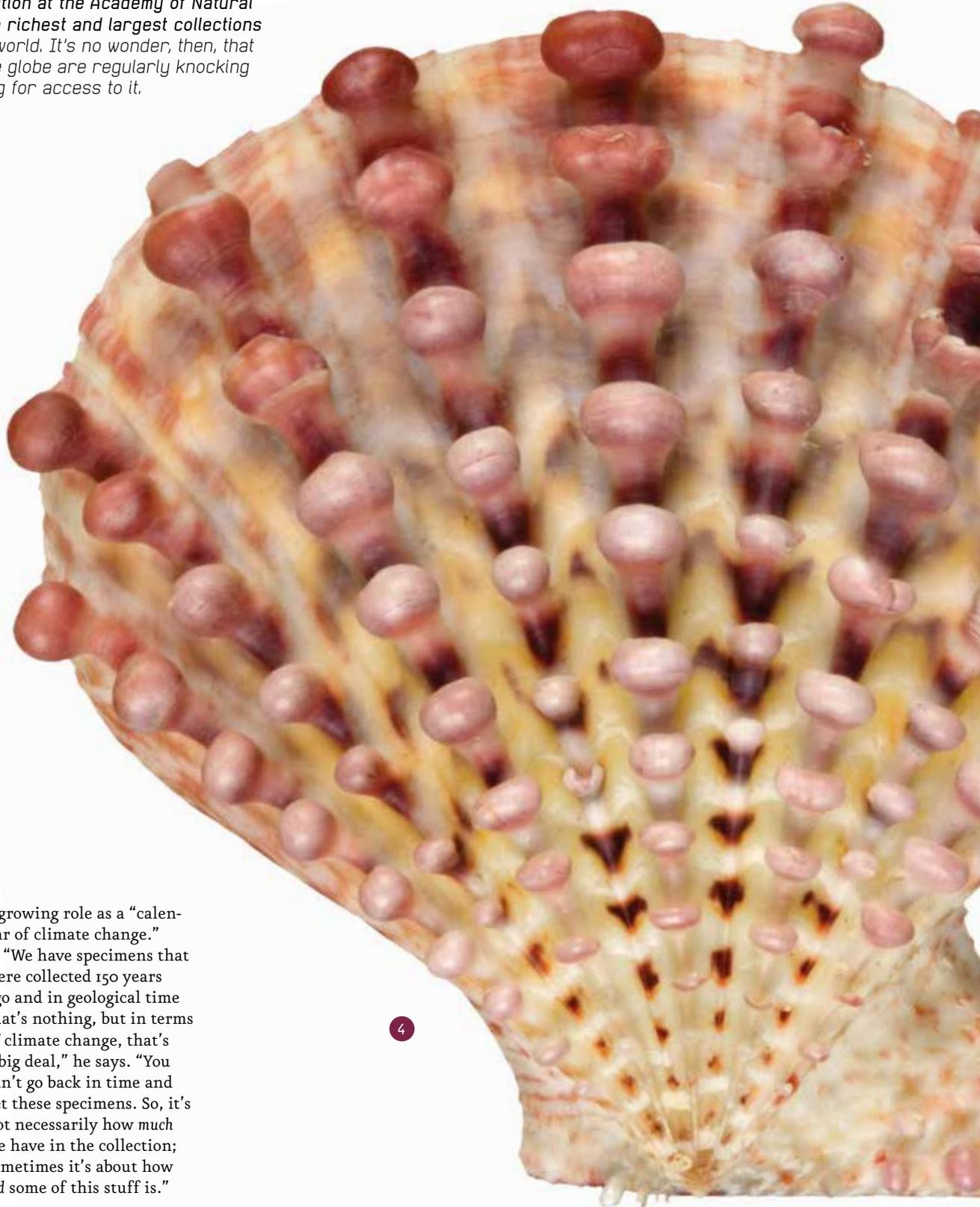
Within the museum, Academy scientists often discover new species while organizing and cataloging the collection, a seemingly never-ending task when you have more than 8 million specimens collected over two centuries. Recently, Callomon reclassified a specimen — the spindle shell (*Fusinus*) — that was new to science but which had previously grouped in with existing names.

"We are discovering new stuff in our cabinets all the time," he says.

While the collection is primarily used for systematic work like identifying species or describing new ones, Callomon says, it has

a growing role as a "calendar of climate change."

"We have specimens that were collected 150 years ago and in geological time that's nothing, but in terms of climate change, that's a big deal," he says. "You can't go back in time and get these specimens. So, it's not necessarily how much we have in the collection; sometimes it's about how old some of this stuff is."





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- 1 *ARGOPECTEN LINEOLARIS*
Lamarck, 1819
Caribbean Sea, Gulf of Venezuela, taken by local fishermen at 30 fathoms. 1980s.
- 2 *BRACTECHLAMYS CORALLINOIDES*
d'Orbigny, 1840
Eastern Atlantic Ocean off Punta Teno, Tenerife, Canary Islands; taken by free diver at 22 meters. 2012.
- 3 *FLEXOPECTEN GLABER*
Linnaeus, 1758
Ionian Sea off Taranto, Italy; netted by local fishermen. 2010.
- 4 *CARIBACHLAMYS PELLUCENS*
Linnaeus, 1758
Western Atlantic Ocean off Palm Beach, Florida, in rubble at 65 feet. 1980s.

MALACOLOGY



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- 1 **_SCAEOCHLAMYS SQUAMATA** Gmelin, 1791
Sulu Sea off Zamboanga City, Philippines, at 100 meters deep, in a tangle of nets set for shell fishing. 1986.
- 2 **_COMPLICACHLAMYS WARDIANA** Iredale 1939
Indian Ocean at Broome, Western Australia; under rocks on a reef. 1985.
- 3 **_ARGOPECTEN GIBBUS** Linnaeus, 1758
Caribbean Sea, in seagrass beds on north side of Isla de Coche, Nueva Esparta State, Venezuela; taken by SCUBA diver at night at 45 feet. 1993.
- 4 **_DECATOPECTEN PLICA** Linnaeus, 1758
Mindanao Sea off Surigao City, Surigao del Norte Province, Philippines, taken by local fishermen. 2013.
- 5 **_EUVOLA ZIGZAC** Linnaeus, 1758
Caribbean Sea off La Isleta, Islas Margarita, Nueva Esparta State, Venezuela; dredged in 11–14 meters. 1990s.
- 6 **_MIMACHLAMYS VARIA** Linnaeus, 1758
Mediterranean coast of Morocco, by local fishermen. 1980s.
- 7 **_MIRAPECTEN RASTELLUM** Lamarck, 1819
Camotes Sea off Nocnocan Island, Bohol Province, Philippines, by local fishermen. 2012.



These were the attributes that caught the attention of David P. Gillikin, associate professor of geology at Union College in New York, who was searching for freshwater mussels from Africa. The Academy's database of freshwater mussels happens to be one the collection's strongest assets.

Gillikin and his team are in the middle of a four-year Belgian Flemish Science Foundation-funded project to reconstruct the paleohydrology and hydroclimate of Africa, using freshwater mussels to study ancient rainfall patterns by comparing shell chemistry and water chemistry over time. They've collected modern specimens — anything collected in the past 10 years — in the field but when it came time to examine centuries-old specimens, the Academy's collection was the clear choice.

Gillikin accesses the shells' chemistry through destructive sampling, which usually means drilling a small hole in the shell and placing the powder in an isotope ratio mass spectrometer. This practice is allowed, Callomon says, when the Academy has multiple examples of a particular species.

"Having curators and collection managers who are open to this is really useful for this type of work," says Gillikin. "And luckily, since we're working with bivalves, we only sample from one of the two shells each animal produces."

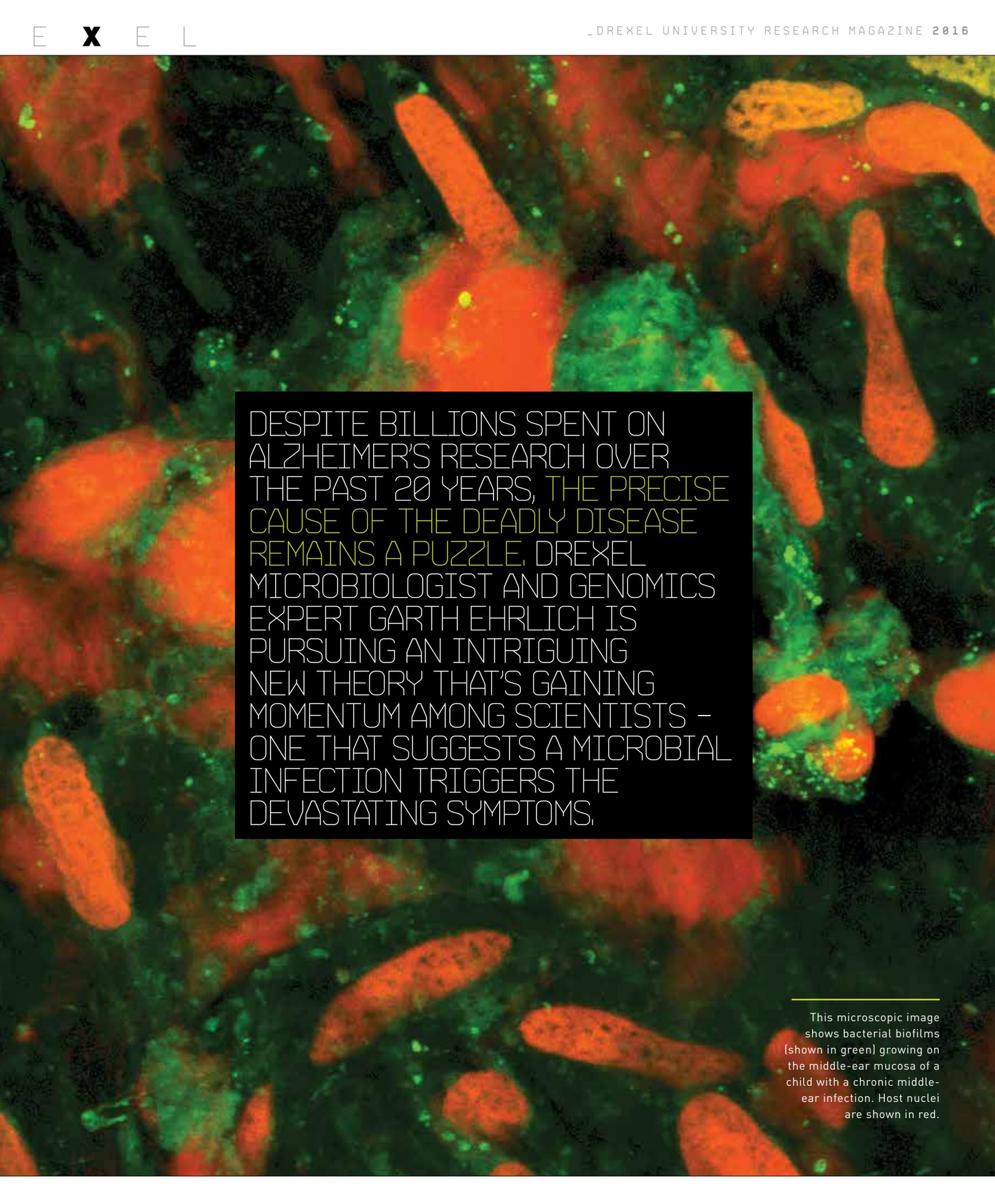
His work would not be possible without the Academy's specimens, he says. "Without the shells from the Academy and the blessing to do destructive sampling, we would have a huge hole in our dataset of African shells."

_THE

I N F E C T I O N

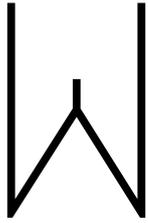
C O N N E C T I O N

_by Katie Clark

A microscopic image showing bacterial biofilms (green) growing on the middle-ear mucosa of a child with a chronic middle-ear infection. Host nuclei are shown in red. The image is a composite of several panels, each showing a different view of the biofilm and host cells. The biofilms are irregular, elongated structures with a textured, porous appearance. The host nuclei are smaller, more rounded structures with a smoother surface. The background is dark, making the green and red structures stand out.

DESPITE BILLIONS SPENT ON ALZHEIMER'S RESEARCH OVER THE PAST 20 YEARS, THE PRECISE CAUSE OF THE DEADLY DISEASE REMAINS A PUZZLE. DREXEL MICROBIOLOGIST AND GENOMICS EXPERT GARTH EHRLICH IS PURSUING AN INTRIGUING NEW THEORY THAT'S GAINING MOMENTUM AMONG SCIENTISTS – ONE THAT SUGGESTS A MICROBIAL INFECTION TRIGGERS THE DEVASTATING SYMPTOMS.

This microscopic image shows bacterial biofilms (shown in green) growing on the middle-ear mucosa of a child with a chronic middle-ear infection. Host nuclei are shown in red.



WHEN IT COMES TO Alzheimer's disease, there is no denying the staggering numbers: It affects 5.4 million Americans and claims the No. 6 spot among the leading causes of death in the United States. It is the only one of the nation's Top 10 killers that cannot be prevented, cured or slowed.

For those lucky enough to reach the age of 85, roughly half will develop the disease and likely die from its complications.

"If you live long enough, this is almost an inevitability," says Aleister Saunders, Drexel's senior vice provost for research, who has been studying Alzheimer's disease since the '90s.

Serious dollars have been spent in the hunt to better understand the disease — in 2015, Alzheimer's and other dementias cost the nation \$236 billion. By 2050, these costs could rise to \$1.1 trillion, according to the Alzheimer's Association. And these figures do not include the loss of wages for family caregivers, which typically equal or even exceed the cost of the health care.

Still, the disease's etiology remains unknown. And the research dollars, which are only a fraction of that spent on diseases like HIV and cancer, are not enough, not by far.

Most research grants go toward studies based on the widely accepted hypothesis that the disease is caused by either intracellular neurofibrillary tangles or extracellular buildups of sticky beta-amyloid plaques in the brain, both of which are thought to interfere with communication between neurons and lead to inflammation, memory loss, cognitive decline and eventually death. It remains unknown, however, whether these processes cause the disease, or are merely symptoms.

Garth Ehrlich, an internationally recognized professor of microbiology and genomics in Drexel's College of Medicine, is one of an increasingly vocal number of scientists who think Alzheimer's research is headed in the wrong direction.

"Despite the billions that have been spent, we have no effective drugs, we have done nothing to change the natural history of the disease," says Ehrlich. "This stands in stark contrast with the other chronic conditions that we deal with like cancer, stroke and heart disease. For Alzheimer's we have nothing. The approach people are taking is not right."

Some scientists now believe that chronic microbial infection of the brain is the culprit in Alzheimer's disease.

Chronic infectious disease happens to be Ehrlich's wheelhouse. He and his team have spent years perfecting tools for studying how bacteria form multicellular and polymicrobial communities that can persist for years as deeply entrenched infections protected by extracellular matrices in the body.

Now they're ready to test the Alzheimer's chronic-infection hypothesis.

With brain samples supplied by the University of Arkansas, Ehrlich has designed a blinded study of post-mortem samples that uses a commercial pan-domain diagnostics assay and a second, more powerful, pan-domain assay newly developed in his lab, both of which can identify essentially all species of bacteria present within human tissue.

If the team confirms bacterial infections in the brains of the patients who died of Alzheimer's, the findings could shift the research paradigm toward the development of tests for bacterial detection in the central nervous system and new treatments for combating chronic infections and inflammation.

It's a theory that "deserves to be rigorously tested," Ehrlich says.

All that's needed is funding.

'A MOVING TARGET'

Ehrlich has been studying the infectious causes of disease for three decades. He's an expert on bacteria and how they communicate with one another, how they grow and spread, how they function; he's spent his career marveling at how they've evolved over the last four billion years, including their adaptation to survive modern medical attempts to fight them.

One of the ways he believes bacteria cause the long-term ravages of Alzheimer's is through their ability to form biofilms, which are slimy matrixes of living and dead bacteria cells bonded together by DNA, proteins and complex sugars that provide adherence to each other and to surfaces in the body. Biofilms congregate on mucosal surfaces; within spaces in the body like the sinuses and the cavities of the middle ear; and around foreign objects such as artificial joints and pacemakers. Think of the way plaque forms on teeth and harbors cavity-causing bacteria — the plaque is a biofilm.

Biofilm formation starts when a single cell attaches to a surface. It waits. Finds friends that have attached nearby. They link up, they form colonies, then form slime. Within the layers of slime, the innermost cells are able to ramp down into a metabolically dormant state that shields them from antibiotics.

They're also able to swap genes amongst themselves to create new strains, "like sex for bacteria," Ehrlich explains, only half jokingly. It's a virulence phenomenon Ehrlich himself first postulated, known as the distributed genome hypothesis.

In one study of long-term infection conducted by Ehrlich in the early 2000s, his colleagues collected throat swabs from a child with chronic ear infections, so-named "Patient 19," for seven months — and he found that one strain appeared over and over, but kept changing. "This one strain underwent 24 transformation events, replacing 8 percent of its genome with pieces of its buddies," Ehrlich notes.

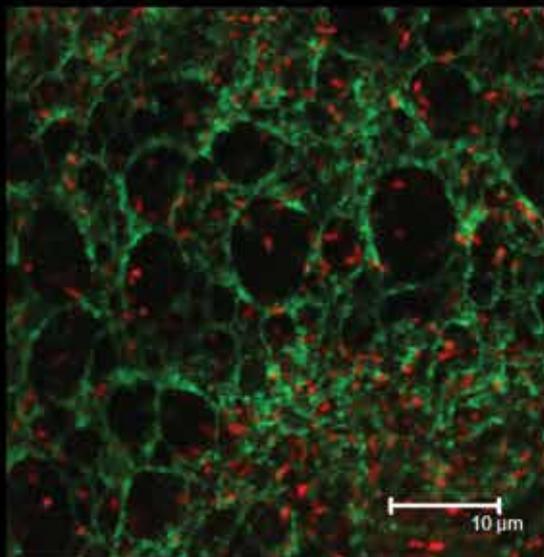
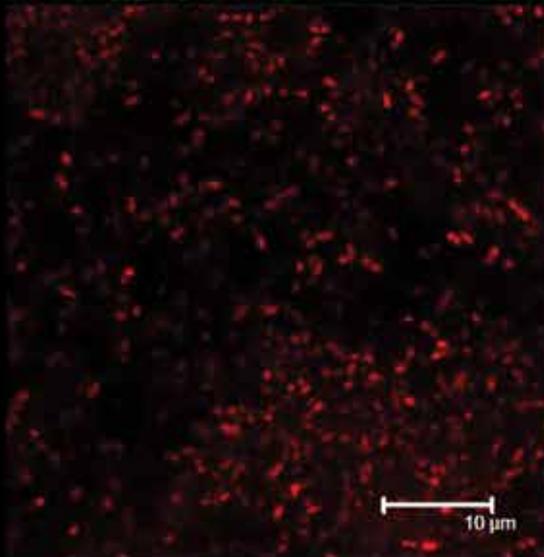
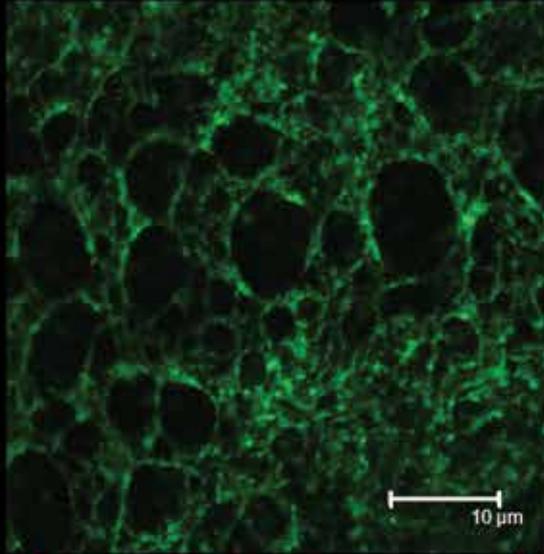
The ability to go dormant and to share genes, some of them progressively more resistant to antibiotics, makes bacteria living in biofilms very, very difficult to identify through cell cultures or to eradicate.

"Because the cells in a biofilm are transforming and exchanging genes and creating new strains, the body's immune system is always chasing a moving target," Ehrlich explains. "How do you combat something that is always changing?"

Ehrlich began studying the way bacteria communicate, collaborate and colonize into biofilms in 1996, when he befriended microbial ecologist Bill Costerton, known in the field as "the father of biofilms." At the time, Costerton was director of the NSF-funded Center for Biofilm Engineering at Montana State University,



_ GARTH EHRLICH
Ehrlich is a professor in the departments of Microbiology & Immunology and Otolaryngology-Head and Neck Surgery in the College of Medicine. He is also executive director of the Center for Advanced Microbial Processing and the Center for Genomic Sciences, both in the Institute of Molecular Medicine and Infectious Disease. And he serves as executive director of the Genomics Core Facility, which is part of Drexel's Clinical and Translational Research Institute.



NOT-SO-SIMPLE CELLS
Bacteria may be single-celled organisms, but they shouldn't be underestimated. In addition to forming biofilms for self protection and reproduction, they're capable of combining into multiple large-ordered structures, analogous to the tissues of highly differentiated animals such as ourselves.

HIGHLY ORGANIZED EXTRACELLULAR STRUCTURES BUILT BY THE COMMON OPPORTUNISTIC PATHOGEN BACTERIUM, PSEUDOMONAS AERUGINOSA.

top regular hexagonal extracellular matrix that the bacteria form.

middle actual bacteria (each point of red is a bacterium).

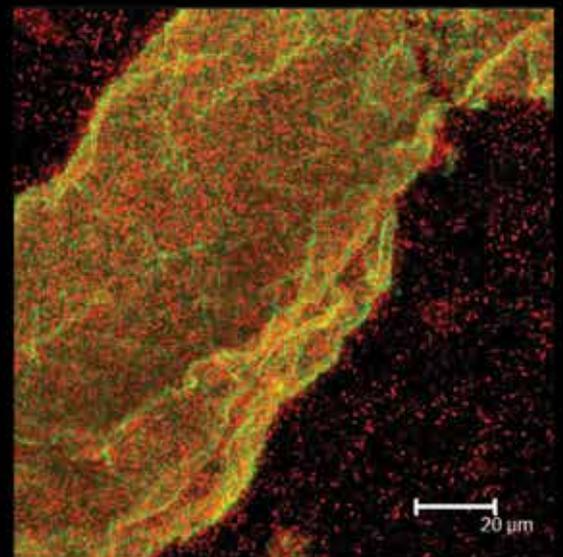
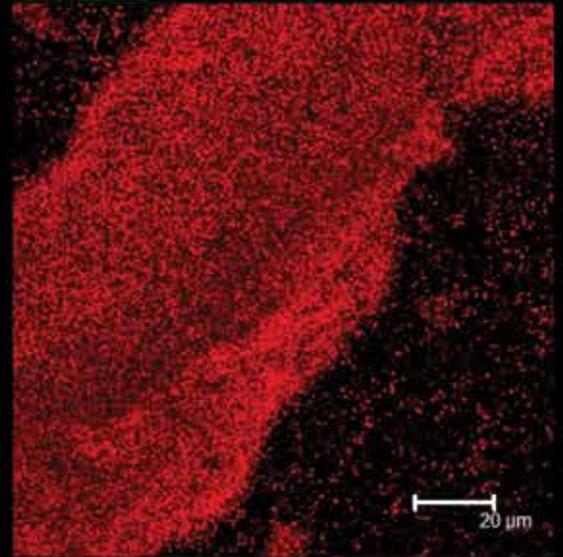
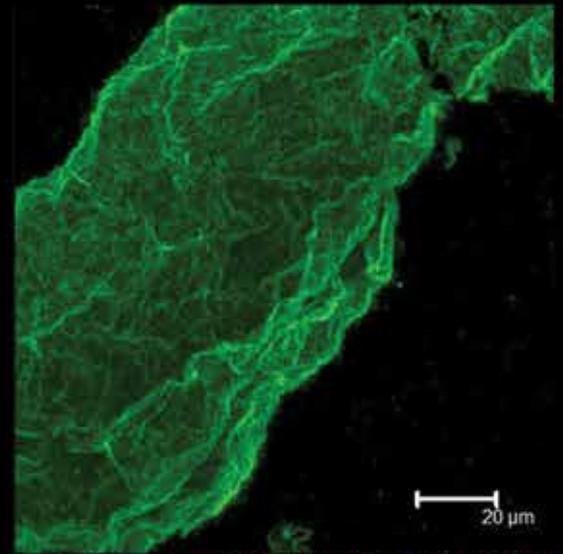
bottom superposition of the top two images which shows the bacteria embedded in the organized matrix that they have produced.

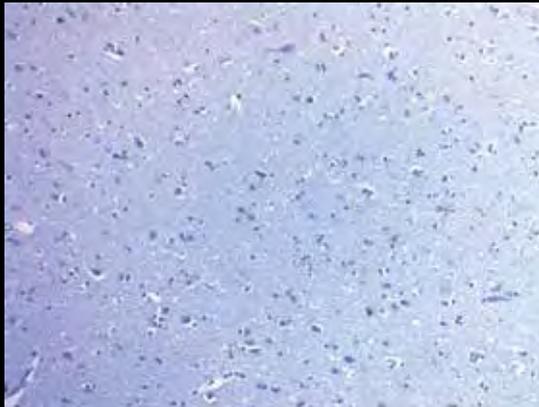
BACTERIALLY PRODUCED FILAMENTS

top matrix only

middle bacteria

bottom bacteria embedded in the matrix they have extruded.





BIOFILM ON THE BRAIN

Drexel dermatologist Herbert Allen has experience studying how biofilms interact with immune cells in the skin and shares Ehrlich's interest in the biofilm-Alzheimer's hypothesis.

Allen, who is chairman of Drexel's Department of Dermatology in the College of Medicine, showed that eczema may be caused by biofilms in a 2014 study. The study proposed that staphylococcal bacteria that live on the skin produce a biofilm that blocks sweat ducts, activating the immune system, which causes itching and irritation.

More recently, Allen published a small study in *Neuroinfectious Diseases* that investigates whether spirochetes in the brain could be operating in the same way to cause Alzheimer's.

Allen and a team of collaborators examined seven post-mortem brains of Alzheimer's disease patients, comparing them to 10 control samples from people who had died from other causes.

In each of the Alzheimer's brains, the researchers saw what they believe to be biofilms. The researchers also identified a protein called TLR 2, which plays a key role in activating the body's immune system.

Allen is a member of the camp that hypothesizes that the spirochetes enter the brain during a dental procedure or after a person contracts Lyme disease, and then spin out a protective biofilm. The body's first responders try to clear the infection, but immune cells cannot penetrate the biofilm matrix that encases the organisms. Instead, the immune system destroys the surrounding tissue.

"So it's neither the infection, nor the biofilm, nor the beta-amyloid that causes the disease, but the body's own immune system," Allen argues. — *Lauren Ingenu*

which soon became the leading biofilm research center in North America. Late one night, Ehrlich was reading an article in *Science* magazine authored by Costerton that included the sentence, "Bacteria in biofilms can be very difficult to culture and are resistant to up to one thousand times the concentrations of antibiotics that can kill their free-swimming counterparts."

A light blub went off, Ehrlich says.

He immediately recognized that Costerton's biofilm paradigm would explain the contradictory results he had been seeing in chronic middle-ear infections in children. He and his colleague, an ear-nose-and-throat surgeon named Chris Post affiliated at the time with the University of Pittsburgh and the Children's Hospital of Pittsburgh, had found evidence of live, metabolically active bacteria in the middle ear canals of children with chronic effusions. Puzzlingly, the bacteria could not be cultured, yet survived repeated courses of antibiotics.

Ehrlich contacted Costerton, and together they forged a fruitful collaboration resulting in a series of papers demonstrating that all of the common bacteria associated with sore throats and other childhood maladies could form biofilms in the middle ears of both chinchillas and children. Through subsequent research, they were eventually able to generalize these findings to all chronic mucosal infections and eventually to all chronic bacterial infections.

Ehrlich went on to devote years to studying biofilm science and perfecting DNA tests to prove the presence of hard-to-culture bacteria. He has published more than 100 papers and two textbooks proving that many chronic inflammatory conditions are actually biofilm infections.

About six years ago, he began to consider the possibility that the inflammation associated with Alzheimer's might also be a symptom of an established infection that had traveled from the sinuses to the brain.

Biofilms that form in middle-ear mucosa and on implanted devices like pacemakers and artificial joints can be removed surgically, but what about biofilms in the brain, he wondered?

One theory he's exploring for removing biofilms involves "debulking" the biofilm slime that shelters bacteria. Since bacterial cells inside biofilms are most impervious to antibiotics when they're metabolically dormant, or "starving," he's looking at ways to "feed" the cells pharmacologically to make them active again. "If you increase the metabolic rate, they become more susceptible to treatment with antibiotics," Ehrlich says, quoting a paper he published more than a decade ago. "You could get rid of a lot of the cells and, if you get the infection small enough, the host's immune system might even be able to clear it."

A TRAIL OF CLUES

The idea that Alzheimer's may be caused by an infection has been catching. In the early '90s, pathologist and Lyme disease expert Alan MacDonald, currently a research associate at the University of New Haven in Connecticut, originated the theory that Alzheimer's disease may have a bacterial component. Later, Judith Miklosy, who is director of the International Alzheimer Research Center at the Prevention Alzheimer International Foundation in Switzerland, made a profound observation when she showed that neurosyphilis (a bacterial disease of the brain) and Alzheimer's were essentially identical on a tissue-level basis.

In a subsequent small study, Miklosy and her colleagues found multiple types of cork-screw-shaped bacteria called spirochetes, which are relatives of the syphilis-causing bacterium, in the brains of more than 90 percent of Alzheimer's disease patients.

One of the bacteria was *Borrelia burgdorferi*, which causes Lyme disease. Others were periodontal pathogens closely related to syphilis, which is known to cause amyloid deposition, inflammation and, eventually, dementia similar to Alzheimer's. Studies by other researchers have made similar connections between bacterial or viral infection and dementia.

The unique pattern of the disease's progression also hints at an infectious origin. Ehrlich points out that when the brains of people afflicted with Alzheimer's are autopsied, it's possible to see damage to the brain spreading out radially in many directions from the hippocampus, where the nerve cells from the olfactory system terminate. Ehrlich believes

“THERE IS ONE PLACE
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USE THIS ROUTE.”

that this is because infections are crossing into the brain from the olfactory epithelia.

In fact, one of the first signs that a person will develop dementia is the loss of their sense of smell, he says.

“Our brains are protected by a unique capillary architecture called the blood-brain barrier — but there is one place where the brain is not protected by that barrier and that’s the olfactory epithelium,” he explains. “We know that’s the path herpes simplex virus has used to get to the brain, and we suspect that the pathogens causing Alzheimer’s also use this route.”

Other scientists have also found tantalizing clues suggesting an infection connection. Recently an international group of more than 30 senior scientists and clinicians, including specialists from Oxford, Cambridge, Edinburgh and Manchester universities, authored an editorial in the respected *Journal of Alzheimer’s Disease* calling upon the scientific community to give the hypothesis credence.

They point out that viruses and other microbes are present in the brains of most elderly people. Although usually dormant, reactivation can occur after stress or a treatment from antibiotics. The writers also note that Alzheimer’s has long been known to have a prominent inflammatory component characteristic of infection and, even more interesting, the writers point out that features of Alzheimer’s pathology are transmissible by inoculation of an Alzheimer’s-affected brain to primates and mice.

The authors name the herpes simplex virus — the type that causes cold sores — and *Chlamydia pneumoniae* as possible culprits. They cite growing evidence in the literature, including more than 100 studies related to the herpes virus alone, that suggest a possible link.

“We propose that further research on the role of infectious agents in [Alzheimer’s disease] causation, including prospective trials of antimicrobial therapy, is now justified,” they wrote.

There was even a documented instance, published in the journal *Nature*, in which Alzheimer’s-like amyloids were discovered in the autopsied brains of eight adults in the United Kingdom who had died from Creutzfeldt-Jakob Disease. The seeds of Alzheimer’s were believed to have been transmitted through a contaminated medical procedure that all eight patients had received, contradicting the mainstream belief that Alzheimer’s is primarily genetic.

Proving the infection theory — or even disproving it — both carry equal weight, says Drexel’s Saunders. “Following this line of research is so crucial because even if it shows that infection isn’t causative, that’s just as important,” he says. “In our discipline, data talks and what Ehrlich is proposing involves studying thousands of [brain] samples. That will be definitive and help sway what the scientific community thinks.”

FIERCE FIGHT FOR DOLLARS

As for why funding agencies and other scientists have been largely unreceptive to the “microbial” Alzheimer’s hypothesis, Ehrlich defers to a quote from German physicist Max Planck: “Science advances one funeral at a time.”

“Scientists are supposed to be the most open-minded people in the world, but many of them are not,” Ehrlich says. He says that many experts in the field conduct a kind of turf war and will actively work to suppress other ideas. “But my question is, if they are such experts, why haven’t they figured out the disease?” he asks.

The Alzheimer’s Association, the largest nonprofit funder of Alzheimer’s research, has said that it is very interested in funding “out-of-the-box” ideas.

“I like to use the hockey analogy — you never know when you’re going to score, so you need as many shots on goal as you can get,” says Keith Fargo, the association’s director of scientific programs and outreach. “We have to have new avenues of research, with people taking a look at this disease from as many different angles as possible.”

But, competition for federal dollars is fierce, Fargo notes.

He says that there was some light at the end of the tunnel in 2011, when President Barack Obama signed into law the National Alzheimer’s Project Act requiring the establishment of a national plan to accelerate the development of treatments for the disease through coordinated research, federal services and funding.

But though the act resulted in a decent bump in research dollars, it still wasn’t quite enough, Fargo says. Currently, the government allocates about \$991 million annually for Alzheimer’s and other dementia research, which is a fraction of what is needed to fulfill the national plan’s \$2 billion per year goal.

“What that means is that there is very high competition for those research dollars, so difficult decisions have to be made,” says Fargo. “Some avenues that are promising may get overlooked in favor of other avenues that are more developed.”

And while Alzheimer’s disease research is indeed expensive, it’s also quite tricky. The brain is a complex organ made up of billions of cells — “the best estimate is about 80 billion cells with literally trillions of connections — and different cell types,” says Fargo. “It’s a really tough nut to crack.”

“In HIV and cancer drug development, there have been some sterling successes,” Drexel’s Saunders says. “Something that was once a death sentence, now isn’t. If cancer shows up in a patient, you can biopsy it and then tailor treatments, but we can’t do that in Alzheimer’s disease, because it’s in your brain. And this is something that probably starts developing in your 40s and manifests when you’re around 75 or 80 — that’s not something we’re used to.”

Ultimately, the scientific community is going to have to marshal a consensus, says Fargo.

“The onus is really on the people who believe in the infection hypothesis to prove it, for lack of a better word,” Fargo says. “Yes, there is a suggestive link, but research has to be done to establish that link.” ✕

_RETURN OF #MARLBOROMAN

Researchers measuring the reach of e-cigarette marketing on social media find that pro-smoking messages travel easily and widely, with potential to reach many underage audiences.

WHILE PLENTY of legislation exists to shield minors from cigarette marketing, e-cigarettes are less regulated than their paper-and-tar progenitors, and when it comes to social media, marketing messages are about as containable as secondhand smoke, a study reports.

The study, conducted by researchers at Drexel and the University of Southern California and published in the journal *PLOS ONE*, is one of the first to track how far e-cigarette marketing spreads on Twitter beyond its original target audience.

The researchers looked at three months of data from Twitter users that originated with tweets from @blucigs, the Twitter handle used by Blu, the largest e-cigarette brand on

"The retweet network in our data demonstrated how rapidly and widely messages diffused — reaching an exponential number of users."

Christopher Yang, College of Computing & Informatics

the market. They tracked the growth of the audience pool from followers of @bluecigs to the followers of those who retweeted @blucigs to the followers of those who retweeted the retweets.



_CHRISTOPHER YANG
Yang is a computer science professor in the College of Computing & Informatics.

The data yielded an eye-opening data visualization map (at right).

"The retweet network in our data demonstrated how rapidly and widely messages diffused — reaching an exponential number of users," says co-author Christopher Yang. "By the second level of followers, there was a large change in the types of users who were seeing the messages, exposing those who might not explicitly support e-cigarettes, or potentially vulnerable populations such as youth."

By the end of the three months, a single tweet that originally reached 214 @blucigs followers eventually made its way to more than 2,600 unique users.

"The diffusion of tobacco-related marketing messages through social media suggests a need for real-time surveillance of brand marketing messages through internet channels that do not require age-verification," Yang adds. "As consensus on the public health impact of e-cigarettes grows, restrictions may need to be placed on how companies market their products via social media."





BLOWING_SMOKE

These data visualization maps show the number of Twitter followers of e-cigarette company Blu who retweeted the company's marketing messages (A) and the total number of Twitter users who eventually saw that tweet in their feed (B). COURTESY OF PLOS ONE

_THE \$150 BILLION PROBLEM

A multidisciplinary team is developing ways to battle the obesity epidemic by helping people lose weight and keep it off.

A STAGGERING 34.9 percent of the U.S. population is obese, and its resulting effects — heart disease, stroke, Type 2 diabetes and cancer — are all on the rise. This ever-worsening endemic costs the nation nearly \$150 billion each year.

Associate Research Professor Meghan Butryn is developing ways to help people not only lose weight, but keep it off. It's that second part of the equation — keeping the weight off — that has most flummoxed dieters and health professionals.



_ MEGHAN BUTRYN
Butryn is an associate research professor in the Department of Psychology in the College of Arts and Sciences.

College of Nursing and Health Professions, and Eugene Hong from the College of Medicine are working with 300 participants to determine whether exercise or diet is more important for keeping weight off after initial weight loss. All participants will receive 18 months of group-based behavior modification, and will be followed for another 18 months afterward.

Butryn, Forman and Michael Lowe, who is also from the Department of Psychology, also have a \$2 million grant from the National Institutes of Health. That project, which also enrolled 300 participants and is currently in the follow-up phase, used a similar approach to study how the “food environment” and specialized behavioral skills influence participants’ ability to keep weight off.

78.6
MILLION
[OR]
34.9
%

Total number / percentage of Americans who are obese.

With a recently awarded \$2.5 million grant, Butryn and Drexel co-researchers Evan Forman from the Department of Psychology, Stella Volpe from the

The goal is to help people develop the lifestyle habits and mental framework that will allow them to live the lives they’ve dreamed of — free of the extra weight, and free, too, of the many health problems that weight can bring.

_THE SECRET LIFE OF EBOLA

The discovery that the Ebola virus can survive longer in wastewater than was previously known has implications for how governments respond to outbreaks.



THE DEADLY OUTBREAK OF Ebola virus disease in West Africa that began in March 2014 raised new questions about the resilience of the virus and tested scientists’ understanding of how to contain it.

The latest discovery by a group of researchers, including Drexel’s Charles Haas, the LD Betz Professor of Environmental Engineering in the College of Engineering, suggests that the procedures for disposal of Ebola-contaminated liquid

waste might underestimate the virus’ ability to survive in wastewater.

Current official epidemic response procedures advise that after a period of days, Ebola-contaminated liquid can be disposed of directly into a sewage system without additional treatment.

However, new data from researchers at Drexel, the University of Pittsburgh and the National Institutes of Health indicate that Ebola can survive in detectable concentrations

in wastewater for at least a week or longer.

The researchers gathered their data by observing the change in viral particle concentration in two samples, spiked with different concentrations of the virus, over an eight-day period, all in a secured lab at NIH. While the researchers observed a 99 percent decrease in concentration after the first day, the remaining viral particles were detectable for the duration of the experiment.

AUTISM

AUTISM

_ASTHMA-AUTISM LINK

Prenatal exposure to anti-asthma drugs is associated with increased risk for autism.

CHILDREN OF mothers who took certain asthma medication during pregnancy were 30 percent more likely to be diagnosed with autism spectrum disorder, Drexel researchers have found.

After studying a decade of birth records from Denmark, the team concluded that children whose mothers took (B2AR) agonist drugs such as Advair, Symbicort or Dulera during pregnancy were at greater risk. These drugs can cross the placenta and reach the fetus, potentially affecting its developing neurons.

“Since the teratogenic potential of most drugs... is generally understudied, I would hope my research would encourage more researchers to explore prescription drug use as a potential autism spectrum disorder risk factor,” says Nicole Gidaya, a doctoral alumna of the Dornsife School of Public Health and the lead author of the study, which was recently published in *Pediatrics*.

Additional co-authors were Associate Professors Brian Lee, Igor Burstyn and Yvonne Michael and Craig Newschaffer, director of the A.J. Drexel Autism Institute.

Gidaya and the research team drew their sample from 57,200 children born in Denmark between 1996 and 2006 with a biological mother who’d been living in Denmark for at least a year.

The study found that 3.7 percent of children diagnosed with autism spectrum disorder had mothers who took the B2AR agonist drugs during pregnancy.

Of children not diagnosed with autism spectrum disorder, 2.9 percent were born to mothers who took the drugs.

“A challenge here is that the effects of the underlying health conditions, themselves, can also influence developmental outcomes,” says Newschaffer. “Newly pregnant women taking medication for asthma need to work with their health care provider to weigh the benefits of continuing medication use against risks.”



AUTISM_AND_ASTHMA

Children whose mothers took agonist drugs such as Advair, Symbicort or Dulera during pregnancy were at greater risk.

_A HOME BASE

A virtual “home” for the behavioral health needs of children and young adults on the autism spectrum aims to provide better outcomes at a lower cost.



JAMES E. CONNELL JR. Connell is a professor in the School of Education and clinical director of the A.J. Drexel Autism Institute.

TREATING CHILDREN with many different health needs can be a tricky and expensive business. If the right specialist isn’t found, a child can be put on an unnecessary drug, which can lead to more wrong drugs, when what the child really needs is a behavioral intervention.

That’s what the Behavioral Home Model, developed by Professor James E. Connell Jr. and set to be implemented in 2016, aims to address. Its purpose is to keep children healthier with fewer pharmaceuticals while also cutting unnecessary costs from their treatment. Right now, Connell says, high-risk, high-need users can cost up to \$300,000 a year to treat.

The “home” isn’t a physical building but instead a database and electronic health record system that brings the right players to the table when treating a child. For example, Connell says, some children with autism have food selectivity issues, but a pediatrician may misinterpret these symptoms as GI specialist, who could

prescribe a drug treatment, which then requires more drugs to treat the side effects of the original drug — and still not treat the real issue.

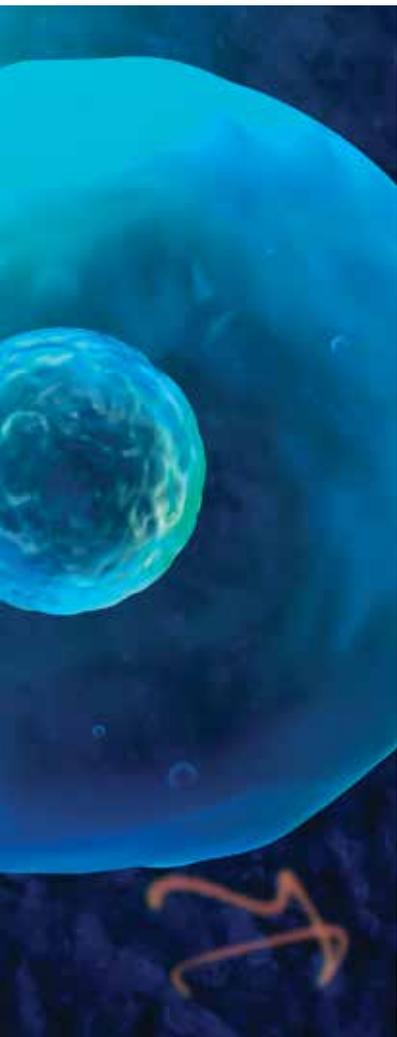
A better approach is to screen the child first to determine if their issue is physical or behavioral, followed by a behavioral specialist recommendation for behavioral concerns.

Connell is now working with Jordan Weisman of

“The Behavioral Home works in conjunction with physicians’ offices to help identify behavioral health needs, then get the right specialists to work on that concern in an integrated, interdisciplinary system.”

James E. Connell Jr., School of Education and the A.J. Drexel Autism Institute

the Philadelphia Mental Health Center, with whom Connell proposed the behavioral home model to Community Behavioral Health, a division of Philadelphia’s Department of Behavioral Health and Intellectual Disability Services that handles mental health and substance abuse services for the city’s Medicaid recipients, including autistic children and young adults.



Historically, it was believed that the virus could only be transmitted through direct contact with bodily fluids, but there have been cases where people contracted the disease without apparently coming in contact with infected fluids.

This, the study suggests, could be an indication that large liquid droplets might be a vector for the virus — which means greater care should be taken when handling contaminated liquid waste.

_FUMES AND PLUMES **_NO BUTTS** **_PARENTAL BLUES & POOR GRADES**

Drexel researchers found a significant link between elevated air pollution and the occurrence of several chronic health conditions.

CITIES WITH HEAVY pollution are slowly harming their residents, according to a review of data by a Drexel team of public health epidemiologists, environmental health and environmental engineering experts.

The team, led by Associate Professor Longjian Liu, found that heart disease, stroke, diabetes and hypertension, along with all-cause mortality, were found in a greater percentage of people living in cities and counties with a higher concentration of air pollution indicators — which were primarily in the northeastern and southern parts of the country.

“If we are able to identify and control the risk factors, then we should be able to prevent or significantly reduce the occurrence of these diseases, which are the leading

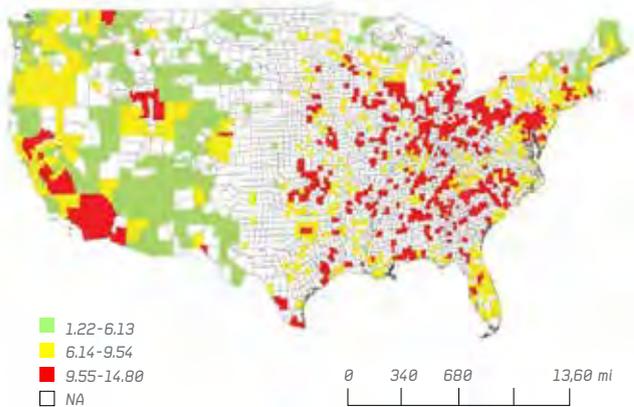


_LONGJIAN LIU
Liu is an associate professor of epidemiology and biostatistics in the Dornsife School of Public Health

causes of death in the country,” says Liu.

Liu and his team will continue to analyze data — looking at pollution levels during different times of year and different neighborhoods within and between cities and compared to other countries — to measure the impact of climate change and air pollution on environmental health disparity and public health in urban populations.

FINE PARTICLE CONCENTRATION



BAD_AIR

Researchers compared daily air pollution data from the Environmental Protection Agency and health outcomes data from the Centers for Disease Control and Prevention and found the greatest correlations in the northeastern and southern parts of the country.

Research conducted by the Dornsife School of Public Health was an important part of the Philadelphia Housing Authority’s decision to enact a smoke-free policy in all public housing.

LAST SUMMER, Philadelphia’s public housing went smoke-free in one of the largest public health changes of its kind in the country. The new policy was informed by a solid base of scientific evidence — some of which was generated through evaluation research conducted by city agencies and Drexel’s Dornsife School of Public Health.

Ann Klassen, a professor in the School of Public Health, has worked with the Philadelphia Housing Authority and Philadelphia Department of Public Health since 2011 on the evaluation of the impact of smoking in public housing. The monitoring data from this evaluation was an important element of the evidence used in support of the new policy.

Through her research, Klassen found that 70 to 85 percent of common areas and over 20 percent of non-smoker apartments had detectable nicotine levels.

“That provides important evidence that previous policies were not effective in protecting residents, and that it is not possible to avoid harmful levels of secondhand smoke without community-wide smoke-free policies,” Klassen says. “When tobacco is used anywhere in a multi-unit building, there’s really no part of the building that won’t have air exchange and won’t be exposed to that secondhand smoke.”

There’s a connection between depression in parents and poor academic performance by their children.

IN A MASSIVE study of more than 1 million children, researchers found that parental depression at home coincides with lower grades in class, which can have lasting repercussions as children mature.

The Drexel-led team found that children whose mothers had been diagnosed with depression are likely to achieve grades that are 4.5 percentage points lower than peers whose mothers had not been diagnosed with depression. For children whose fathers were diagnosed with depression, the difference is 4 percentage points lower.

Put into other terms, when compared with a student who achieved a 90 percent, a student whose mother or father had been diagnosed with depression would be more likely to achieve a score in the 85–86 percent range.

How well a student does in school has a large bearing on future job and income opportunities, which has heavy public health implications, says Félice Lê-Scherban, assistant professor in the Dornsife School of



FÉLICE LÊ-SCHERBAN AND BRIAN LEE
Lê-Scherban is an assistant professor and Lee an associate professor in the Dornsife School of Public Health.

Public Health. On average in the United States, she says, an adult without a high school degree earns half as much as one of their peers

↓ 4.5%

Children whose mothers had been diagnosed with depression are likely to achieve grades that are 4.5 percentage points lower than peers whose mothers had not been diagnosed with depression.

with a college degree and also has a life expectancy that is about 10 years lower.

The research team, which included faculty from the Karolinska Institutet in Stockholm, Sweden, and the University of Bristol in England, conducted a cohort study of more than 1 million children born from 1984 until 1994 in Sweden. Using computerized data registers, the scientists linked parents’ depression diagnoses with their children’s final grades at age 16, when compulsory schooling ends in Sweden.

“Anything that creates an uneven playing field for children in terms of their education can potentially have strong implications for health inequities down the road.”

Félice Lê-Scherban, Dornsife School of Public Health

_DOWN THE DRAIN

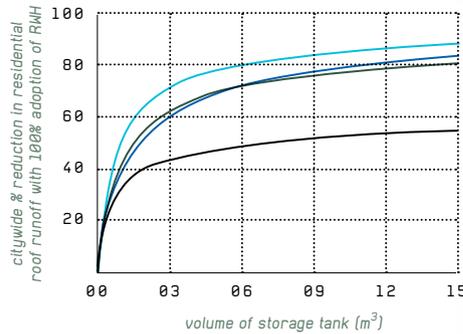
A new study suggests that city residents could be letting the benefits of an ubiquitous natural resource go to waste, when it could be used to reduce their water bills.

GOOD NEWS for residents of Philadelphia, New York, Seattle and Chicago: It rains so much in these cities that if residents collected and stored the rain falling on their roofs, they could significantly reduce their water consumption, according to research by a team of Drexel environmental engineers.

Toilet flushing is the biggest use of water in households in the United States. But there is no reason that clean, treated, municipal water needs to be used to flush a toilet when rainwater is plentiful.

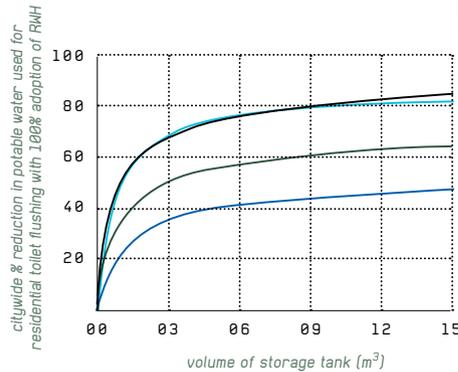
“People have been catching and using rainwater for ages, but it’s only been in the last 20 to 30 years that we have realized that this is something that could be done systematically in certain urban areas to ease all different kinds of stresses on watersheds; potable water treatment and distribution systems; and urban drainage infrastructure,” says team leader Franco Montalto, who is an associate professor in the College of Engineering and director of the college’s Sustainable Water Resources Engineering Lab.

The study was recently published in the journal *Resources, Conservation and Recycling*, and is one of the first to show how feasible, and beneficial, rainwater catchment would be.



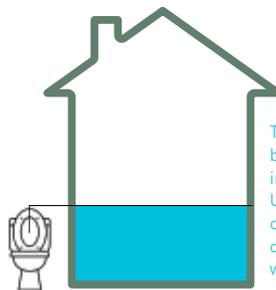
_LESS RUNOFF

This chart shows what impact 100 percent adoption of rainwater harvesting systems could have on citywide reductions in roof runoff from residential buildings.

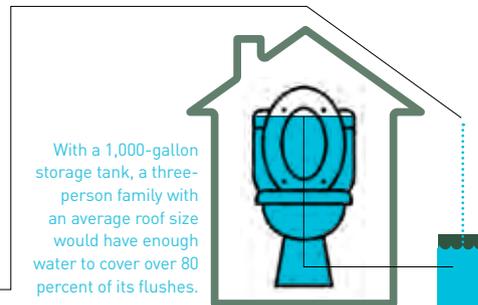


_LOWER WATER BILLS

Significant reductions in potable water used to flush toilets in residential buildings in four major cities could be achieved if rainwater harvesting systems were adopted in 100 percent of the cities’ residential buildings.



Toilet flushing is the biggest use of water in households in the United States, accounting for nearly one-third of potable water use.



With a 1,000-gallon storage tank, a three-person family with an average roof size would have enough water to cover over 80 percent of its flushes.



25%
By installing a standard 1,000 gallon home storage tank, researchers found that a three-person family could reduce their overall household potable water demand enough to slash the municipal water bill for an average-sized home by as much as one-fourth.

RAIN_FOR_GAIN

An average residence with a 1,000-gallon rainwater harvesting system could reduce runoff by over 40 percent, according to the study.



Child's Play

MOST THERAPIES FOR CHILDREN WITH CEREBRAL PALSY FOCUS MERELY ON IMPROVING MOBILITY, WHILE OVERLOOKING THE RELATIONSHIPS THAT LEAD TO A FULFILLING LIFE. RESEARCHERS AT DREXEL HAVE SPENT A DECADE DEVELOPING AN APPROACH THAT PUTS THE EMOTIONAL AND SOCIAL NEEDS OF THESE CHILDREN FIRST.

_by Lini S. Kadaba

_photographs by Jeff Fusco



_LISA CHIARELLO & BOB PALISANO
Chiarello is a professor and Palisano is a distinguished professor in the College of Nursing and Health Professions' Department of Physical Therapy and Rehabilitation Sciences.

NO ONE, IN ALL the years of therapy for his cerebral palsy, had ever asked 12-year-old Jonathan Bamberger this one, simple question:

What do you like to do?

No therapist had asked his mother, Terry, about her son's interests, either.

That changed in 2009, when a physical therapist working with a Drexel researcher named Tracy Stoner '08 did just that as part of a Drexel-led case study on a novel,

five-step model of intervention for children affected by the neurological brain disorder or injury. Called participation-based therapy, the model is designed to help children with cerebral palsy engage more in their community life.

According to Bamberger, those six words — integral to participation-based therapy — created “a life-altering experience” for her and her son.

“That was very powerful,” says Lisa Chiarello, a professor of physical therapy and rehabilitation sciences at Drexel who is a lead researcher in formulating the new model. “It’s not the therapist’s goal. It’s the child’s goal.”

The model significantly shifts the paradigm of physical therapy’s role — from improving impairments to fostering participation and relationships.

“I’ve always been interested in children’s social interactions with peers, which is unique for a physical therapist,” says Chiarello, who has been a key investigator over the last decade in three major studies (see sidebar, “A Decade of Data”) of children with cerebral palsy that focus on the child’s participation in activities that build social relationships. “Physical therapy is about physical functioning.

But you often are using physical functioning in these social interactions to have relationships with others.”

Going forward, Chiarello, along with Drexel co-investigator Bob Palisano and other researchers, seeks to further refine and test how well the model supports a child’s interaction with parents, siblings and friends.

“To me, this level is the ultimate goal,” Chiarello says, “because participating in life really gives their life meaning.”

They hope that the data they accumulate can one day be used to create first-of-their-kind longitudinal developmental curves and therapy recommendations for the 1 in 323 children in the United States living with the disorder, similar to a pediatrician’s growth chart or a *What to Expect* resource.

Such a tool is long overdue in the field of pediatrics. While parents of developmentally typical children have access to charts and data alerting them to typical milestones — is your child smiling by 6 weeks? is she walking at 12 months? — no such benchmarks exist for children with cerebral palsy to help caregivers gauge how they are progressing, particularly recreationally and socially.

“Resources exist for gross motor skills, but life is so much more than gross motor skills,” says Stoner, who is a Philadelphia regional coordinator for a current study with Chiarello. “As clinicians, we have never had anything like this.”

MEET AND GREET

It has long been known — and Chiarello’s research confirms — that children with cerebral palsy participate less and in fewer activities than other children. Participation-focused therapy uses a five-step process to address that challenge.

Participation-based therapists begin by establishing rapport directly with the family and the child, usually in the family’s home or community setting. Together, they come up with goals that are important to the child and family; for example, a child may want to go to the playground. They then develop real-life strategies to accomplish the goal. That might mean that a therapist accompanies a child to the playground to see firsthand her obstacles, so the two can brainstorm and implement solutions. The therapist then evaluates outcomes with the family.

“We need to support the child’s adaptive behavior,” Chiarello says, “and we also need to support the family in expecting from the child the best [he or she] can do. ... Participation is multi-dimensional, the physical doing, the social belonging, and the being, which is the fulfillment, learning and enjoyment a person gets from participating. A therapist needs to scaffold all of that as they’re trying to foster a child’s participation.”

Chiarello and her team are leaders in this field of physical therapy, says Joe Schreiber, president of the pediatrics section of the American Physical Therapy Association and a professor of physical therapy at Chatham University in Pittsburgh.

“She’s been an incredible advocate,” says Schreiber.

New participation measurement tools that came out of the team’s studies have proven useful to clinicians, he notes, and therapy focused on participation has made the profession more effective.

“It’s a really important mental switch for the profession,” Schreiber says.

Two of the team’s studies, *Move and PLAY* and *On Track*, also broke ground by involving parents as research collaborators, who offer lived-experience perspectives and play significant roles in the study.

“It’s not the norm,” Chiarello says. “We envision it becoming much more so. People affected by research should be involved in research, and not just as participants.”

In the *Move and PLAY* study, two parents started as consultants, offering feedback on study recruitment literature and such, but over time moved into larger roles that continue with *On Track*. An additional five parents joined the team, and Palisano runs monthly teleconference meetings between them and investigators.

“Increasingly, our voices were more and more valued,” says Tina Hjørngaard of Toronto, whose 17-year-old daughter has cerebral palsy. The parents have helped design materials and translate results into formats useful to families. They’ve also presented at conferences alongside academics, and written articles for lay publications.

Hjørngaard says her only regret is that participation-based therapy was not common when her daughter was younger. “She felt really isolated,” Hjørngaard says.

Barbara Sieck Taylor, a parent collaborator from Pittsburgh whose 24-year-old son has cerebral palsy, says the relationship works in large part because Chiarello is the “queen of listening.”

“Parents can help by reminding people who are deeply embedded in data and models that those abstractions represent individuals,” says Taylor.

Chiarello’s research thus far provides the foundation for a new, as-yet-unfunded pilot study to test participation-based therapy.

Such studies are often considered “messier,” because of the focus on lived experiences and numerous variables that can affect outcomes. “But in the end, you have much richer and much more data,” says Annette Majnemer, director and associate dean of the School of Physical and Occupational Therapy at McGill University in Montreal.

Majnemer, who co-edits the journal *Physical and Occupational Therapy in Pediatrics* and is familiar with Chiarello’s work, says that the real strength of her studies is the use of very large samples, which allow the researchers to draw statistically significant conclusions.

“Sometimes we really get caught up in these randomized control trials,” says Audrey Wood ’95, who serves as coordinator of the *Move and PLAY* study for Greater Philadelphia and is a physical therapist at Children’s Hospital of Philadelphia. “These qualitative studies are important, too. They really speak to everyday life.”

HAPPY TOGETHER

For Jonathan Bamberger, participation-based therapy was like nothing he’d ever experienced before.

When the Maryland pre-teen joined the study, he needed help with transfers from his motorized wheelchair, getting around and self-care. At times, his speech was hard to understand, and he had a visual impairment.

THE FIVE STEPS OF PARTICIPATION-FOCUSED THERAPY

- 1 Develop a collaborative relationship with the family and child.
- 2 Establish mutually agreed-upon goals for participation in home and community activities.
- 3 Assess the child’s and family’s strengths in the context of the specific goals. This includes the family ecology, meaning its connections to the community and access to resources — factors that affect participation.
- 4 Implement strategies that work in real life. That might mean a therapist accompanies a child to her evening activity to see firsthand the child’s frustrations and how possible solutions actually work.
- 5 Finally, the outcomes are evaluated with the child and family.

Previously, his physical therapy had always focused simply on stretches and transfers. It did nothing to give him the sense of belonging that comes through joining after-school activities alongside his peers.

Once he joined the case study, he met with Stoner, who talked with him and his mother about his interests. She probed his likes and dislikes, his routines and abilities. She took notes about his goals and his family's goals.

At first, his mother kept saying: "We want him to transfer better. We want him to sit better."

Stoner was persistent. "I kept asking, 'Why do you want to transfer better? Why do you want to sit better?'"

Stoner and the Bambergers brainstormed four real-life experiences that Jonathan could join: Boy Scouts, a baseball challenger league, chorus and a church youth group. The trio decided to pursue the youth group, where Jonathan hoped to meet girls and make friends.

"I thought it was a godsend," Bamberger says. "Those are the things that are important to parents and the kids."

Stoner, in her role as assessor for this case study, suggested therapy that worked toward specific, youth-group-related outcomes. She knew Jonathan would need to learn to speak louder, to express his needs, to explain to others how to provide physical assistance and to practice social interactions.

"Those were really useful life skills he wanted to learn," says Stoner.

Bamberger recalls her initial reaction was surprise. "Wow, this is what you guys consider therapy?" she asked.

To develop strategies and implement them, Stoner actually accompanied Jonathan to several of the 7 p.m. youth group meetings, smoothing the way for him. She worked with the group director on how to include Jonathan in activities and how to help with transfers, with eating the customary pizza dinner and with emergencies, such as choking.

At the first meeting, Jonathan was bombarded with questions from the group in their zeal to include him. Stoner says she taught the kids that Jonathan needs a little extra time to process and answer a question.

"You need to see it in action to say this is not working," she says. "It was being able to step out of that clinic environment ... and work with the people interacting with him."

Soon, Jonathan was initiating conversations with the adults and other kids. As the weeks unfolded, he joined the singing, played a part in a skit and talked with three girls. By the end of the therapy, Jonathan was thrilled with the experience, Bamberger says, and she rated her overall satisfaction with her son's participation a top score of 10.

"It gave me a lot of hope that there are ways to include children with disabilities," she says. Her son, now 18, still maintains friendships he began in youth group.

For Stoner, the participation-based therapy was eye opening. "I saw the progress in a way I never did in clinic," she says. "It makes physical therapists think outside the box. In the end, it's how happy they are in life. What does it matter if I teach them to sit better if they can't go to the mall and hang out with their friends?"

Exactly, says Chiarello. ✕

A DECADE OF DATA

Over the course of three groundbreaking, multi-site and multi-year studies of children with cerebral palsy, Lisa Chiarello and Bob Palisano have amassed an extensive body of research detailing the challenges and importance of participation-based therapy.

CAPS

The Children's Activity and Participation Study interviewed 600 children ages 3 to 21 between 2006 and 2008. The children were asked about their involvement in 55 activities, such as playing with puzzles, doing team sports, or going to concerts; how often they partook; and how much they enjoyed the activities.

CAPS produced more than a dozen publications and concluded that a child's adaptive behavior — that is, his or her motivation, perseverance and ability to interact with the demands of a particular situation — was a crucial factor for participation.

The study was funded with \$850,000 from Shriners Clinical Outcomes Program.

MOVE AND PLAY

The Movement and Participation in Life Activities for Young Children with Cerebral Palsy study followed 430 preschoolers ages 18–60 months over a year, collecting data at three points on the factors that support motor function, self-care, play and participation in daily activities. According to Chiarello, the 2006–09 study developed several important measurement tools, including child engagement in daily life and ease of caregiving for children.

One finding was that a child's ability to adapt to a situation has the biggest influence on participation and playfulness. This suggests that rehab services should be conducted in the context of real-world experiences, such as going to the playground or visiting a library for story time, Chiarello says.

Move and PLAY was funded with \$450,000 from the National Institute of Disability and Rehabilitation Research and \$925,000 from the Canadian Institutes of Health Research (CIHR).

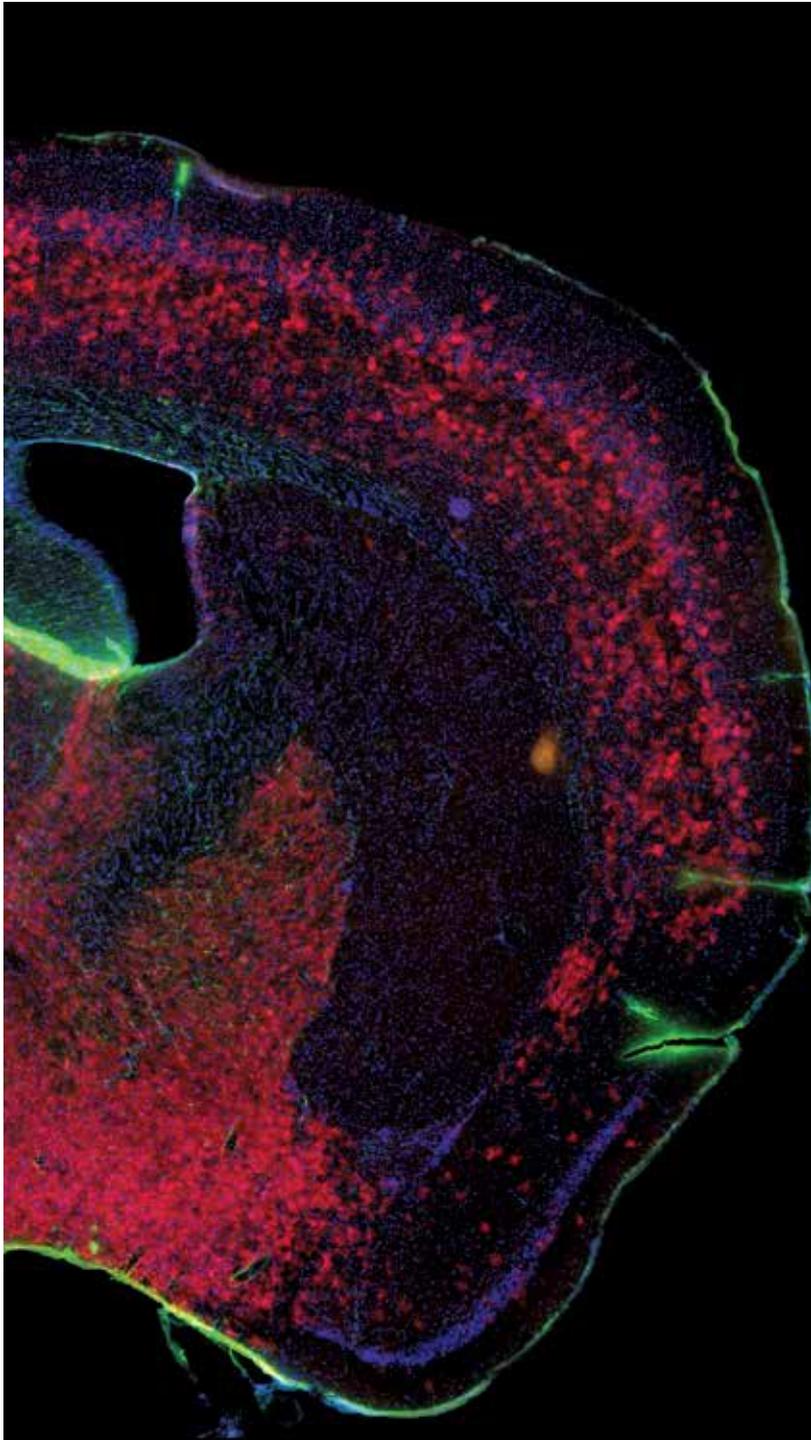
ON TRACK

The team's latest study, which began in 2012 and continues into 2017, is monitoring about 720 children with cerebral palsy ages 18 months to 11 years over five check-ins. It's a longitudinal, labor-intensive undertaking that is expected to yield insight into developmental changes over time.

A key objective of the current study is to produce baseline charts of participation levels at different ages and at different degrees of motor impairment.

On Track is funded with \$1.9 million from the Patient-Centered Outcomes Research Institute in Washington, D.C., and \$1 million from CIHR.

_ONE CELL, MANY ROLES

**ASTROCYTES**

Transgenic mouse brain showing astrocytes in red. Garcia's lab utilizes conventional and advanced microscopy of fixed and living tissues to study how astrocytes respond to injury.

Specialized cells called astrocytes were once thought to be bit players in the central nervous system, but closer inspection suggests they have complex roles.

A PATIENT REGAINS consciousness after a devastating accident to learn that his spinal cord has been crushed and he may not walk again. A soldier suffers from memory loss after being struck with shrapnel that enters his brain. An elderly patient succumbs to the confusion and jumbled speech of early Alzheimer's.

While the precipitating neurological damage in each of these examples is distinct, in each case, the central nervous system unleashes a chain of biochemical and cellular responses that irreversibly destroys the brain's neurons.

Why can't the nervous system heal itself the way other parts of the body do? To answer that question,

"Evolution has selected for this for a reason. There's a tradeoff: You lose some function but perhaps you get more tissue spared. Long term, someone can take this knowledge and develop therapies that promote the cells' positive functions, while attenuating the negative."



A. DENISE GARCIA
Garcia is an assistant professor in the Department of Biology in the College of Arts and Sciences. She specializes in cellular and molecular neurobiology.

researchers are studying how central nervous system cells respond to injury.

Drexel neurobiologist Denise Garcia has focused on relatively under-studied cells called astrocytes. Astrocytes are a type of glia cell, so named because they were once regarded as mere "glue" that provides structural support to neurons. Historically, they've been overlooked by neuroscientists, but that's starting to change.

Garcia believes they are more than just support staff.

For one thing, higher species have a higher ratio of glial cells to neurons. Leeches have one astrocyte for every 30 glial cells. Rodents have one for every three. Humans are believed to have a ratio of one to one. It has been estimated that astrocytes are the most numerous cell type in the central nervous system, and some neuroscientists believe that the ratio has increased across evolution to facilitate increasingly complex cognitive tasks. Indeed, astrocytes are now

known to be an important component of synaptic formation and communication between neurons.

When it comes to injury, astrocytes wear both white and black hats, and their role isn't trivial.

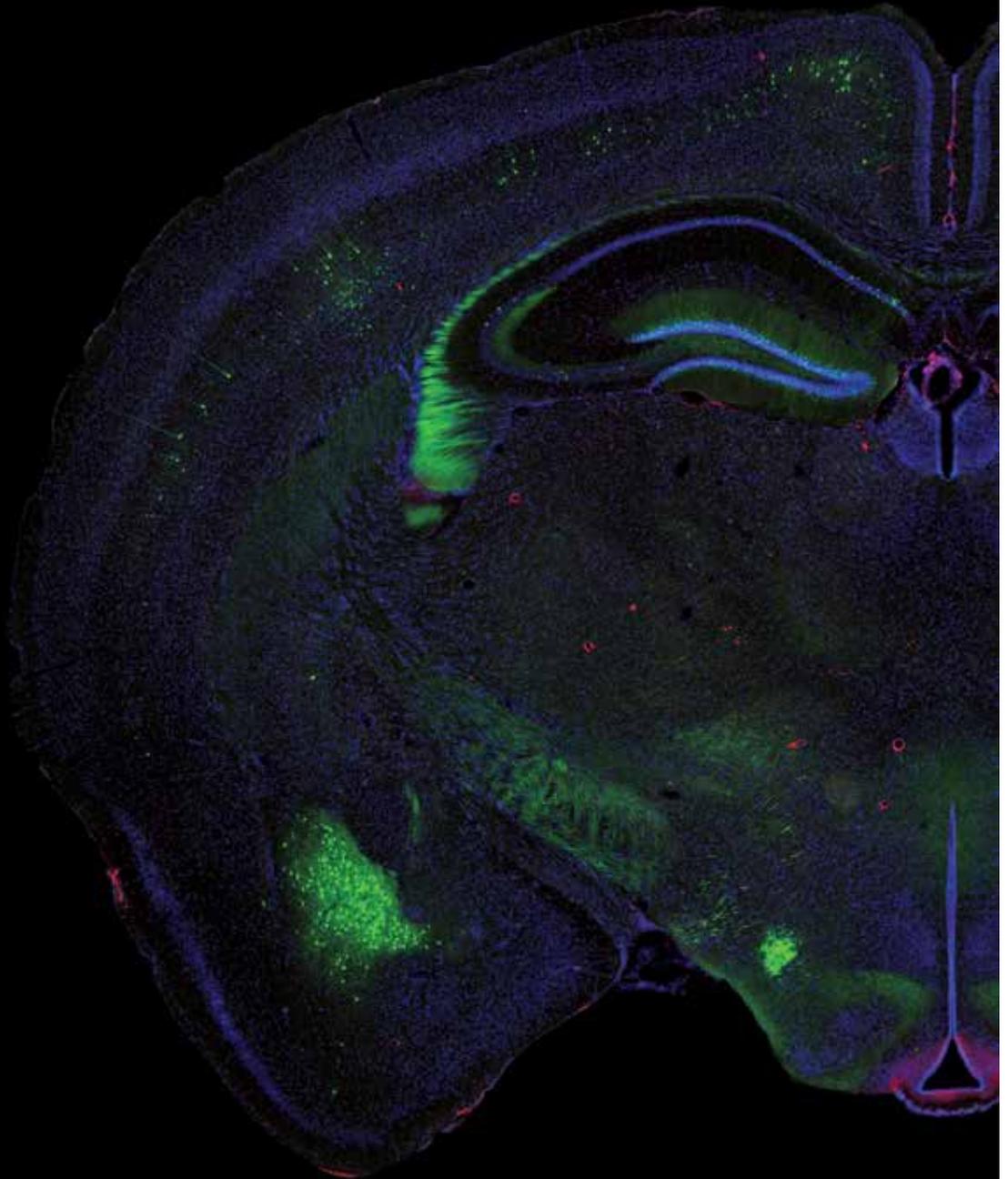
"They are principal players," Garcia says. "Some are hostile to neuron survival, and some are conducive to repair and help to spare the central nervous system from further damage."

When the central nervous system suffers trauma, astrocytes are known to release inflammatory molecules that can interfere with healing. In severe cases, they proliferate and form a "glial scar," like an internal scab, that neurons can't bridge, which in the case of spinal cord injury results in permanent paralysis. However, they also serve a helpful role by forming web-like enclosures around macrophages that would otherwise infiltrate an injured area and destroy neurons.

How does this one cell type do these disparate things?

It's a question Garcia has been pursuing in her lab at Drexel.

"Evolution has selected for this for a reason," says Garcia. "There's a tradeoff: You lose some function but perhaps you get more tissue spared. Long term, someone can take this knowledge and develop therapies that promote the cells' positive functions, while attenuating the negative."



NEURONS

Transgenic mouse brain in which a subset of neurons are selectively expressing green fluorescent protein. The Garcia lab studies how astrocytes regulate the organization and function of neuronal synapses.

_ VARSITY BLUES

A large study of college athletes found that contrary to popular belief, jocks are just as likely to have down spells as the general population.

PARTICIPATION in college athletics typically isn't regarded as a risk factor for depression — in fact, quite the opposite is true. Because sports involve regular exercise and a support group of peers, they would seem to be positive for mental health.

But a new study by researchers at Drexel University and Kean University found that college athletes aren't any more immune to mental illness than other students.

The researchers examined data collected over three consecutive years from 465 undergraduate athletes who attended a NCAA Division I private university. They found that nearly a quarter of Division I college athletes reported depressive symptoms, with women almost twice as likely to experience symptoms than male peers.

The multi-year sample, published in the *British Journal of Sports Medicine*, is one of the largest to date to

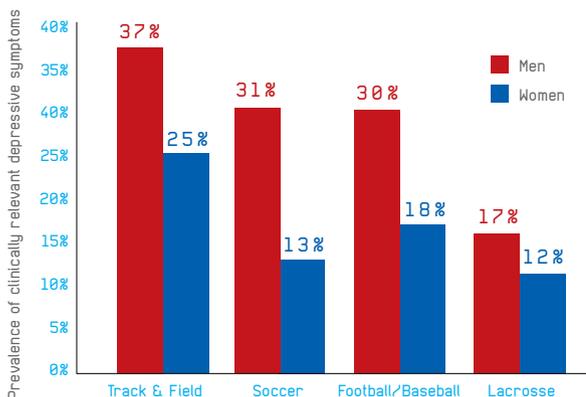
look at depression in college athletes.

"[This study] highlights the need for increased mental health screening for athletes as part of standard sports medicine care," says Eugene Hong, an associate dean for primary care and community health at the College of Medicine and the study's principal investigator.

Student-athletes may experience stressors unique to the athletic experience, including high-pressure expectations and injuries, said study co-author Andrew Wolanin, director of the Department of Advanced Studies in Psychology at Kean.

"There is lot of opportunity for failure, which can be a key component of depression," he said.

Nearly 24 percent of the 465 athletes in the study reported a "clinically relevant" level of depressive symptoms, and 6 percent reported moderate to severe symptoms.



DISPIRIT_DE_CORPS

While past research has tended to focus only on specific sports or genders, this study examined whether the prevalence of symptoms varied between gender and across a variety of sports.

_ CLUES TO A DOWN-ALZHEIMER'S CONNECTION

Children with Down Syndrome have distinctive differences in the structure of their cerebral cortex that could help to explain the link between Down and Alzheimer's.

THE THICKNESS of the brain's cerebral cortex could be a key to unlocking answers about intellectual development in youth with Down Syndrome. It could also provide new insights to why individuals with this genetic neurodevelopmental disorder are more susceptible to early-onset Alzheimer's disease than the general population.

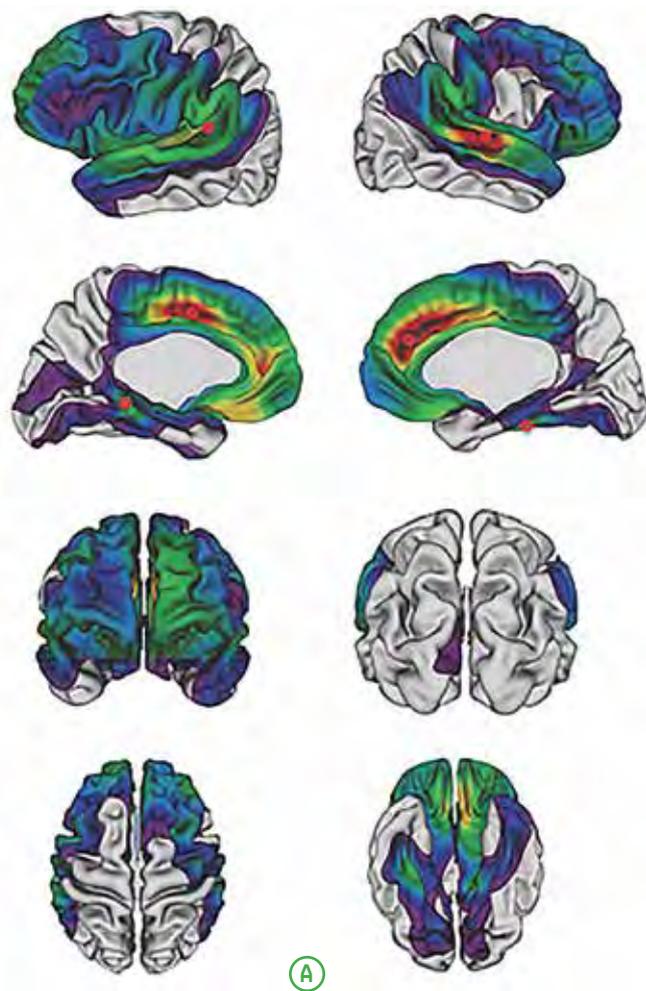


_NANCY RAITANO LEE Lee is an assistant professor in the Department of Psychology in the College of Arts and Sciences and a child clinical psychologist specializing in developmental neuropsychology.

Brain-imaging research published in the journal *Cerebral Cortex* and led by Drexel psychologist Nancy Raitano Lee shows that the cortex is thicker on average in youth with Down Syndrome than in typically developing youth, even though the overall volume of the cortex is lower in those with Down Syndrome.

The cerebral cortex is the outer layer of brain tissue, a folded region about 2–4 millimeters thick, that is involved in many important aspects of brain function including sensory and cognitive processes.

Lee conducted the research with colleagues at the National Institute



CEREBRAL SIGNS

These scans show reductions in cortical surface area and increases in cortical thickness in brains of youth with Down Syndrome relative to typical controls. Panel (A) displays surface area findings; panel (B) displays cortical thickness findings. The peak regions in which cortical surface area and thickness were most different from control are marked with small red circles.

of Mental Health who perform structural magnetic resonance imaging (MRI) of the brains of children and youth to better understand aspects of brain development. They compared MRI measurements from 31 youth with Down

Syndrome and 45 typically developing peers.

The cause of the increased cortical thickness in Down Syndrome is still uncertain, but one possibility is that the brain in Down Syndrome doesn't prune excess neural con-

_IMPROVING THE PICTURE

The same nanocrystals used to produce sharp images in liquid crystal display (LCD) televisions can be engineered to glow red when bonded to cancer cells – giving surgeons a rapid way to verify that they've removed all of a tumor.

WHEN CANCER surgeons remove tumors from the body, the difference between success and failure can come down to just a single errant cell. If the surgeon fails to encapsulate all of the cancerous cells within a solid buffer of healthy cells, any malignant material left behind could lead to a recurrence of the cancer.

Wan Shih, as associate professor in the School of Biomedical Engineering, Science and Health Systems; and Wei-Heng, a professor in the Materials Science and Engineering Department in the College of Engineering, are developing a special molecular dye made of fluorescent nanocrystals, called quantum dots, that clings to cancer cells and glows under infrared light. The luminescent dye lets

surgeons rapidly verify the presence of unexcised cancer cells.

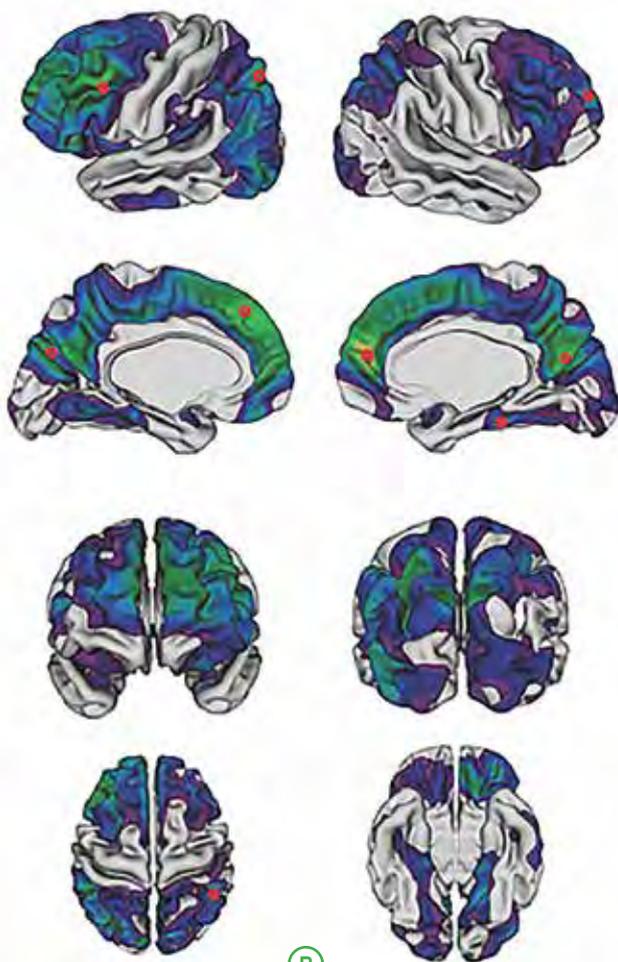
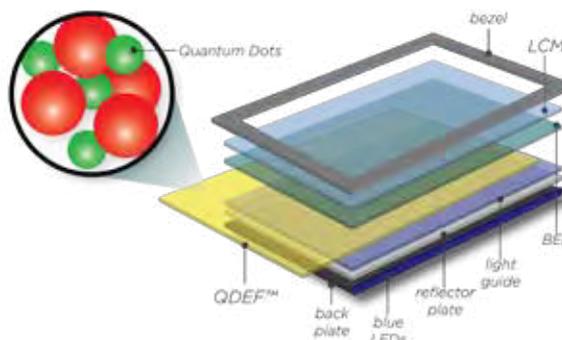
The Shihs' dots are both safer and cheaper than dots commercially synthesized for research purposes, but their most valuable feature is that they're built for speed.

The method the Shihs developed, with guidance from Drs. Vanlila Swami and Ari Brooks, who were both professors in the Drexel College of Medicine, generates a fast and accurate result. Once the tumor is removed, it is submerged in a solution of quantum dots for about 10 to 15 minutes, then rinsed with water. Next, an infrared camera captures a series of images, which are immediately viewed on a computer screen or with special goggles.

This procedure has been tested in 10 clinical excised tissues with good preliminary results. The procedure and applications on animal models have been reported in the *International Journal of Surgical Oncology*.

HIGH-REZ SURGERY

Fluorescent nanocrystals, called quantum dots, are part of the technology used to produce the sharp images of LCD televisions.



(B)

nections as effectively as in typical development, a process believed to occur during childhood and young adulthood as part of reaching cognitive maturity.

Some of the brain regions with increased cortical thickness were nodes in the Default Mode Network (DMN), the part of the brain that is active when a person is at rest. Because deterioration in the DMN has been associated with Alzheimer's disease, Lee

said the difference found between Down Syndrome and typical development in youth could turn out to be an early indicator of susceptibility to Alzheimer's later in life.

Lee hopes that her finding will spur further research on animal models to more clearly draw the connection of how genetic abnormalities cause brain abnormalities — knowledge that could inform potential biomedical treatment approaches for intellectual disability.

_PLAQUE BUST

Drexel is leading a landmark investigation of a new drug that may prevent the plaque buildup thought to cause Alzheimer's dementia.

BRAIN SCANS show that protein plaques associated with Alzheimer's disease accumulate for years or even decades before people begin to experience cognitive decline. Once the process takes hold, there is little doctors can do to reverse it.

Researchers believe the best hope is to stop the progression of plaque buildup before symptoms begin.

A new landmark study will evaluate a new drug, called solanezumab, that may reduce plaque formation.

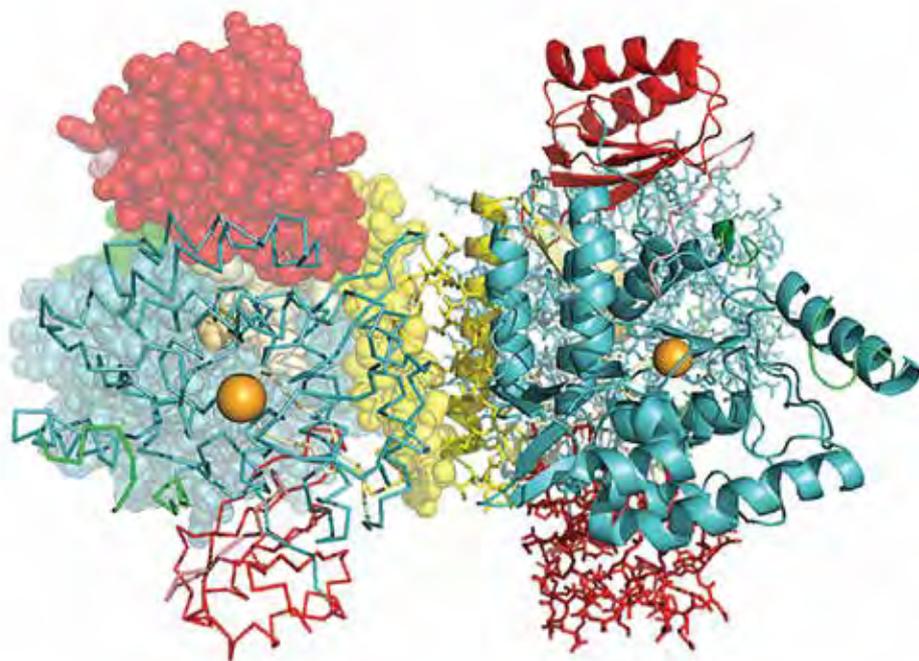
The study, called A4 for Anti-Amyloid in Asymptomatic Alzheimer's Disease Study, will examine healthy people whose brain scans show the build up of the protein associated with the disease — but who do not yet have any memory loss or other symptoms. The study will determine if solanezumab can clear the built-up plaque of the protein, called amyloid, before brain cells are impaired.

The principal investigator is Carol F. Lippa, director of the Cognitive Neurology and Alzheimer's program at Drexel Neurosciences Institute, which is one of 60 study sites around the world. G. Peter Gliebus, assistant professor of neurology in the institute, is also part of the research team.

"Clearing out the amyloid is like clearing out the kindling before the fire starts," Lippa says. "We are hopeful we can prevent Alzheimer's."

_A STEP TOWARD SOLVING PKU

For the first time, scientists have a model of the enzyme that is defective in patients with the metabolic disorder PKU – opening the door to new drug discovery.



CRYSTAL CONUNDRUM

The PAH enzyme eluded crystal-structure determination for years, until researchers discovered that the enzyme is represented by two distinct structures rather than one. Once they could separate the two, they were able to grow crystals from which they could determine one of the two structures.

FOR THE ONE IN 20,000 people born in the United States each year with the rare metabolic disease phenylketonuria, every meal is an exercise in abnegation.

In phenylketonuria, or PKU, the enzyme that breaks down the amino acid phenylalanine is either missing or defective. Those afflicted must adhere to a protein-restricted diet throughout their lives to prevent mental and behavioral abnormalities.

That means eating only carefully measured amounts of fruits, vegetables and low-protein breads and pastas, supplemented with a special phenylalanine-free medical formula.

Dairy products, meat, fish, chicken, eggs, beans and nuts are off limits.

Because maintaining this strict diet can be a challenge, researchers are always looking for new, non-dietary treatments to combat PKU symptoms.

Recently, Drexel researchers and an international group of scientists made a critical step toward understanding the disorder by successfully solving the first X-ray crystal structure of phenylalanine hydroxylase (PAH), the enzyme that is defective in patients with the disorder.

For decades, researchers have tried to determine the structure of the PAH enzyme without success.

The team's breakthrough came from discovering that the enzyme is represented by two distinct structures rather than one.

"Knowing the structure at this high resolution is expected to speed up any current drug discovery pursuits," says Emilia Arturo, a Drexel graduate student in the College of Medicine and study co-author.

Results were published in the *Proceedings of the National Academy of Sciences*.

Using what they have learned from this study, the team is now working on solving the structure of activated PAH, which functions to prevent blood phenylalanine from rising to neurotoxic levels.

_BODY, HEAL THYSELF

A biomedical engineer is investigating how to use the body's own immune cells to grow blood vessels necessary to wound healing.



KARA SPILLER
Spiller is an assistant professor in the School of Biomedical Engineering, Science and Health Systems.

SCIENTISTS ARE getting closer to mending damaged tissue and even creating whole organs, thanks to advancements in regenerative medicine. But a significant roadblock exists: the absence of blood vessels inside damaged tissues.

Spiller has been studying ways to naturally spawn blood vessels to feed new tissue growth by taking advantage of the body's response to injury and disease. She believes that vital immune system cells, called macrophages, are key to that process.

The National Institutes of Health has awarded her with a five-year, \$1.9 million grant to study the cells.

Macrophages roam throughout tissues in the body and engulf any pathogens in their path. Though these immune cells destroy foreign invaders, they have earned a bad reputation, Spiller says, because they also contribute to inflammation, causing bruises, ulcers and sometimes, degenerative diseases.

However, more recent studies have shown that macrophages, and inflammation more generally, can play an important role in tissue repair and regenera-

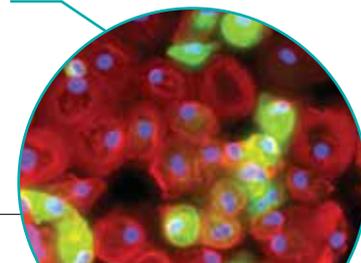
tion, due to the cells' ability to change their form and function — each orchestrating events specific to different stages of repair. Though this process has been identified, it is not well understood.

Once macrophages are better understood, Spiller and her research team hope to develop a biomaterial platform and strategy for delivering drugs to control macrophages and encourage vascularization by the body's own cells.

"Damaged tissue – due to cancer, a bone fracture or a disease like diabetes – happens because insufficient blood vessel growth has cut off oxygen. If we cannot engineer blood vessel networks, then we cannot repair any tissue."

"The idea is that if you can manipulate the macrophages via just a single drug, then the macrophages will be able to control the blood vessels," Spiller says.

A microscopic view of macrophages, immune system cells that may be key to blood vessel growth.



_CRYSTAL CLEAR

X-ray crystallography is used to create three-dimensional models of molecules that help researchers understand how the molecules function within the body – knowledge that can be used to develop new antibiotics.

A COUPLE OF years ago, Patrick Loll and his students solved a nearly 70-year-old mystery. Using crystallography, they became the first researchers to understand precisely how bacitracin, a household antibiotic derived from the bacterium *Bacillus subtilis* var *Tracy* and first approved in 1948, combats infection in the body.

Crystallography — the study of how atoms in a material are arranged — involves the creation of three-dimensional models of molecules. The models allow scientists to see how the molecules are structured, in order to better understand how they function. In the case of antibiotics such as bacitracin, the structural models reveal how these molecules latch onto and interact with their bacterial cell targets.

By elucidating the structure of bacitracin, Loll, his student Nicoleta Economou, and their Drexel collaborator Simon Cocklin were able to determine that the antibiotic works by targeting a lipid that harmful bacteria use to shuttle essential building blocks to their cell walls. Bacitracin is able to grab onto the lipid in a way no one had predicted; this interaction prevents the lipid from delivering materials that the cell needs, thereby killing the bacteria.

Their finding was published in the *Proceedings of the National Academy of Sciences of the United States of America*.

MODELS_FOR_MEDS

Loll estimates that he has grown thousands of crystals, including those displayed at right.

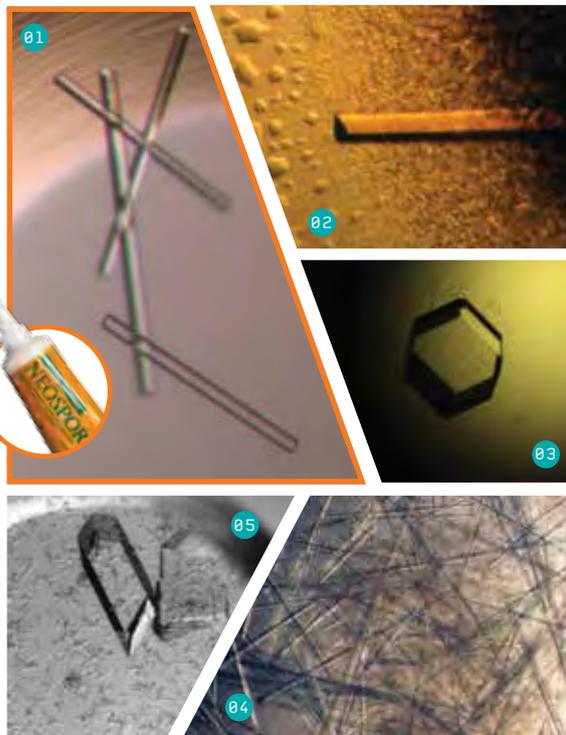
01. Bacitracin is a natural-product antibiotic best known as a component of "triple antibiotic" ointments.

02. This is a crystal of the COX1 enzyme, which is the target of aspirin, ibuprofen, naproxen and other NSAIDs.

03. Ramoplanin is a new investigational antibiotic that is being tested as a treatment for *C. difficile* infections.

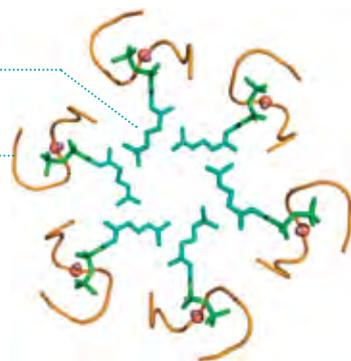
04. Porin is a protein from the outer membrane of the bacterium *E. coli*, where it mediates the uptake of various nutrients and drugs.

05. PfeA is a protein from the outer membrane of *Pseudomonas aeruginosa*, an opportunistic pathogen.



geranyl tail of lipid

bacitracin backbone



_CRYSTALS OF VANCOMYCIN

The rise of bacterial resistance to vancomycin (often considered the antibiotic of last resort) has motivated researchers to find alternatives. Through crystallography, Drexel researchers seek to understand how vancomycin recognizes its target, with the goal of exploiting this information to design new, more effective variants.



A_HOW-TO

The process of growing crystals is laborious and famously prone to failure.

01 Researchers first must generate large quantities of the molecule of interest. This step can require many months of trial and error, and in some cases it simply fails outright.

02 Researchers then purify away other kinds of molecules, so that only the desired molecule remains in the test tube.

03 In the crystallization step, researchers experiment with different reagents in hopes of finding an additive that coaxes the delicate molecules into assembling into a nicely ordered 3-D lattice. The crystallization step is very sensitive to outside variables. Many projects fail at this stage, and even the ones that work usually require thousands of experiments to hone in on the right set of conditions for good crystallization.

04 Researchers then shoot a beam of X-rays at the crystal, which scatters the X-rays in different directions. High-tech detectors capture the scattered radiation and this information is fed into a series of calculations that ultimately yields an image of the molecule.

_ CREDIBILITY, ON CAMERA

A Drexel professor will evaluate a new body camera initiative launched by Philadelphia's transit agency meant to reduce crime and improve officer-citizen relationships.



JORDAN HYATT
Hyatt is an assistant professor in the College of Arts and Sciences' Department of Criminology and Justice Studies.

DOMINATING THE headlines over the past several years has been an increased demand for police accountability, the need for autonomy in law enforcement and the public's desire for transparency.

In response, the Southeastern Pennsylvania Transportation Authority (SEPTA) serving Philadelphia launched an initiative this year to equip all of its transit police officers with body cameras. This policy will seek to reduce crime, strengthen relationships with the public and provide valuable evidence for investigations.

Drexel criminology professor Jordan Hyatt has been tapped to evaluate the program's success. The team will examine the impact of the camera program on some key measures, including crime in the system, complaints against officers and use of force. They also will study officer attitudes toward use of the body cameras and public perceptions. The first results will be presented in the fall.

"Body-worn cameras are being used, with increasing frequency, by law enforcement agencies across the

county," Hyatt says. "The development of solid, empirical research has not kept pace. Working with the SEPTA police department, an agency committed to evidence-based policies, presents an opportunity to rigorously examine the effects of body-worn cameras on a number of important dimensions, including crime within the transit system and the nature of officer-citizen interactions."

"We believe it gives the SEPTA Transit Police Department more credibility with the community," says SEPTA Police Chief Thomas Nestel III. "These cameras will also greatly aid with our investigative efforts."

This initiative enhances SEPTA's overall video coverage of the transit system, which currently includes over 18,000 surveillance cameras at stations and on trains, buses and trolleys.



EYES_ON_OFFICERS

Philadelphia's transit police are required to activate the cameras when they are interacting with the public and responding to calls from police radio. When recording is in progress, officers are expected to notify the individuals with whom they are speaking.



_ THE GREAT DISCONNECT

Too many Philadelphia youth are *disconnected* from school and work at a crucial juncture in their lives, a Drexel study found.

ONE IN FOUR people in Philadelphia between the ages of 18 and 24 are “disconnected” from the labor market — neither employed nor in school — according to a recent study from Drexel’s Center for Labor Markets and Policy. Nationally, the rate of disconnected youth was just 17.7 percent.

“These numbers are extraordinarily high,” says Paul Harrington, who is director of Drexel’s Center for Labor Markets and Policy in the School of Education and co-author of the report with Neeta Fog, a labor economist in the center. “Disconnected youth are disengaged from school and work, both of which are considered ‘human capital’ building activities that add to the long-term productive abilities of individuals.”

The study used the most recent three years (2011–2013) of American Community Survey data to measure

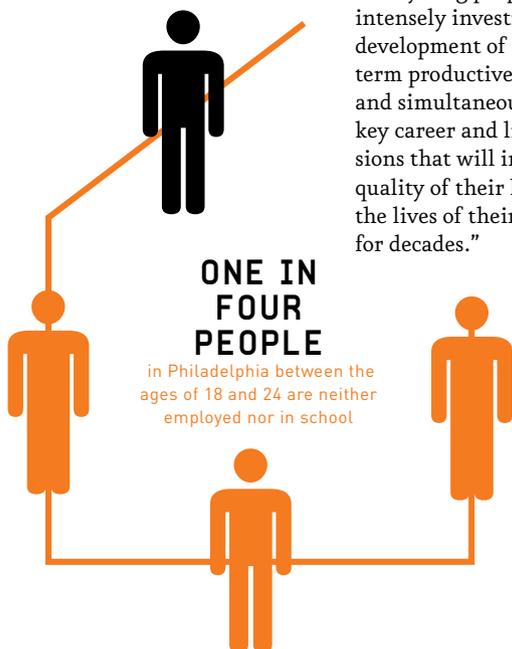
the size of the disconnected 18- to 24-year-old population in the city and the surrounding suburbs. The researchers compared basic measures of the development of human capital traits for disconnected young adults and their connected counterparts including education, labor force attachment and prior work experience.

Within the city, disconnection rates were as high as 38 percent in East Philadelphia and 29 percent in North Philadelphia. The Center City area was the exception with a disconnection rate of just 10 percent.

Males were more likely than females to be unemployed and out of school at 28.5 percent versus 22.7 percent.

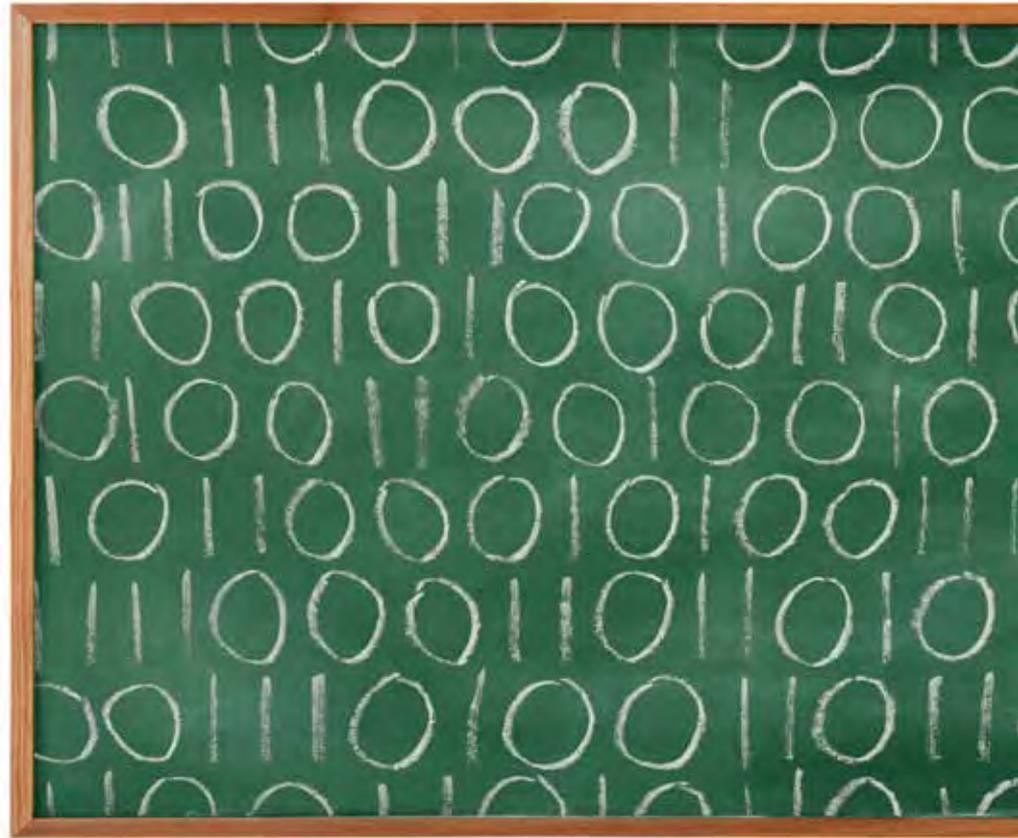
So, if these young people aren’t in school or at work, where are they?

They are “essentially idle,” the report states, “at a time in their lives when most young people are intensely investing in the development of their long-term productive abilities and simultaneously making key career and life decisions that will impact the quality of their lives and the lives of their children for decades.”



_ BINARY BLACKBOARDS

Video games aren’t just for recreation; when brought into the classroom they can help students discover their destiny.



HOW DO KIDS learn about what they might want to be? About what they might expect to do? How do they put on different hats and try out different roles to see possibilities of a future self without worrying that they’re going to fail?

Through something they’ve been doing outside the classroom for centuries: gaming.

School of Education Associate Professor Aroutis Foster wants to bring games into the classroom, and show teachers how to make them work systematically.

“Teachers are able to use those same things kids are already interested in and capture their interest



_ AROUTIS N. FOSTER
Foster is an associate professor in the School of Education.

in things they wouldn’t otherwise think about,” he says. This can be especially powerful in introducing students to careers in STEM, he adds, especially for students who don’t have role models showing them otherwise.

In a study recently published in the *Journal of Technology and Teacher*

Education, Foster, along with then-graduate student Mamta Shah ’15, assessed teacher knowledge on using game-based technology in the classroom, and found it’s not a style regularly taught in education courses. “In a classroom,” Foster explains, “teachers can’t afford the luxury of trial and error when their jobs are at stake.”

He saw the need to give teachers preparation with systematic ways to teach with games and other immersive digital environments.

Foster developed a model by working with in-service teachers and students — over the course of a year at a high school and during

MARKETING

MANAGEMENT

_GAME OF FONTS

A study of consumer behavior has found that shoppers are more drawn to sales prices when they are displayed in a hard-to-read font.

BIG NAME companies like Target, Mattel, Staples and The North Face are keeping things nice and easy — at least, when it comes to the font they use to convey their brand to consumers. They all use Helvetica — an easy-to-read, so-called “fluent” font.

One might assume that fluent fonts are the best way to communicate with consumers.

But LeBow College of Business Professor Rajneesh Suri has found that disfluent, or more ornate fonts such as Bradley, buck that trend, at least when it comes to showing prices, and that they turn browsers into buyers more often.

“Marketers have a tendency to go to the easy-to-read font,” he says. “But when it comes to actual purchase behavior, we found that, when we used the more ornate font, sales were significantly higher.”

In a study published in the *Journal of the Academy of Marketing Science*, Suri and a team of researchers went into a supermarket for a month and analyzed how bags of Doritos chips sold when promotional sale prices were listed in the fluent Helvetica font compared with how they sold when promotional sale prices were listed in the disfluent Bradley font.

They found that 23 percent more bags of Doritos sold when the prices were displayed in the Bradley font.

They also asked people to look at two fictional ads for cell phones, and found that



_RAJNEESH SURI
Suri is an expert in consumer behavior and a marketing professor in the LeBow College of Business.

participants found fluent prices easier to grasp, but that sales promoted using a disfluent font inspired more purchases.

Suri doesn’t think that marketers should go and switch all of their sale price displays to the Bradley font, but it is worth considering — and more research.

“These fonts make them more interesting to the participant,” says Suri. “Consumers are more engaged when the fonts look good.”

SHOPPERS’_SCRIPT

Twenty-three percent more bags of Doritos sold when the prices were displayed in the “disfluent” Bradley font, compared with Helvetica.



_THE VC-CEO DYNAMIC

Startups should be aware that *the more power they assign to their CEO, the more risk the chief could be willing to take on, especially in the beginning.*

VENTURE CAPITALISTS (VCs) tend to encourage their investees to pursue risky and novel innovations in the early stage of a new venture, but discourage them from doing so late in the game — where they may be sitting on a profit they don’t want to risk losing, according to a new paper recently published in the journal *Organization Science* co-authored by two LeBow College of Business management professors.

H. Dennis Park and Daniel Tzabbar found that pressure to pursue riskier and more novel innovations can be tied to a specific type of CEO — those who hold a higher degree of structural or expert power.

“These companies with very powerful CEOs — the ones that hold a bunch of titles such as CEO, chairman, etc. — tend to push their agenda more as compared with CEOs with fewer titles and less power,” Park and Tzabbar explain. “And when they have more structure of power, they tend to push for greater risk taking.”

They argue that this explains why we are most likely to see the greatest innovation novelty early in the investment process, when a VC partners with a structurally powerful CEO. However, they note that in the late stage of the venture, such CEOs

attenuate the negative effect of VC funding on innovation novelty. On the other hand, CEOs with a lot of technological

“We’re not saying one type of CEO is better or worse — we’re hoping our findings will be helpful to boards, VCs and CEOs as they consider risk-tolerance orientation.”

*-H. Dennis Park,
LeBow College of Business
management professor*

expertise tend to balance the innovation-oriented agenda throughout different stages of the ventures.

Park says the findings of this study could help startups to choose the best CEO depending on their objective — and provide insight into how much power to assign to the CEO.

“We’re not saying one type of CEO is better or worse — we’re hoping our findings will be helpful to boards, VCs and CEOs as they consider risk-tolerance orientation,” says Park.

The researchers based their findings on an analysis of 482 U.S. biotech companies.

They assessed whether the companies received VC funding or not and how the VC-CEO relationship changed through the life-cycle of the startup.



another six months at a middle school — to study teaching game analysis, game integration and ecological conditions impacting game use in schools. He also tested the model with 14 pre-service teachers at Drexel. The resulting model supports a systematic process for designing games and teaching with games.

His research has shown that using games in the classroom can trigger identity exploration and self-relevance in a safe environment.

“Kids have a sense of learning in schools that failure means ‘I’m in big trouble.’ Games provide a safe space where you can fail and try again,” he says.

_ HIDDEN IN PLAIN SITE

The anonymity of online forums may be a unique source of support, guidance and healing for survivors of sexual abuse.

THE PRIVATE AND personal nature of sexual assault means that more than half of survivors don't report the abuse or seek outside help, even when talking about their experiences with others could help them cope.

A new study finds that anonymous online forums may fulfill that unmet need.

In a study of how sexual abuse survivors interact online when they are able to mask their identity, a multi-institutional team led by Drexel doctoral candidate Nazanin Andalibi and advised by the College of Computing & Informatics' Assistant Professor Andrea Forte found that people are willing to ask for help — both emotional support and information — sometimes for the very first time.

Additionally, men are more likely to disclose that they've been victims of sexual abuse if they can post about it without identifying themselves.

"We found that people sometimes referred to unmet disclosure-related needs when posting



_ NAZANIN ANDALIBI
Andalibi is a doctoral candidate in information studies in the College of Computing & Informatics.

online," Andalibi says. "Sometimes people have never shared these experiences with anyone before online or off and they feel they need to."

The team looked at publicly available posts on the social networking/news website Reddit in three abuse-related forums, called subreddits. The messages were posted over the course of 10 months in 2014.

"This suggests the potential of designing new kinds of provisions that subreddit moderators could use to identify potential support-seeking and sensitive disclosures by throwaway accounts, so they can direct timely help and support," the authors wrote.

The paper was published in the *Proceedings of the 33rd Annual Association for Computing Machinery's Conference on Human Factors in Computing Systems*.

PRIVATE_FORUM

People are more comfortable disclosing sexual abuse and seeking help anonymously online.

_ GUT REACTION

The way to a woman's heart is through her stomach, a new study shows.

HOW CAN YOU get a woman to become more receptive to romance? Feed her!

Michael Lowe, a psychology professor in the College of Arts and Sciences, and alumna Alice Ely '14 collaborated on research that shows women's brains respond more to romantic cues on a full stomach than on an empty one.

The study, published online in the journal *Appetite*, found results that are contrary to previous studies that showed people typically demonstrate greater sensitivity to rewarding stimuli like food, money and drugs when they are hungry, says Ely.

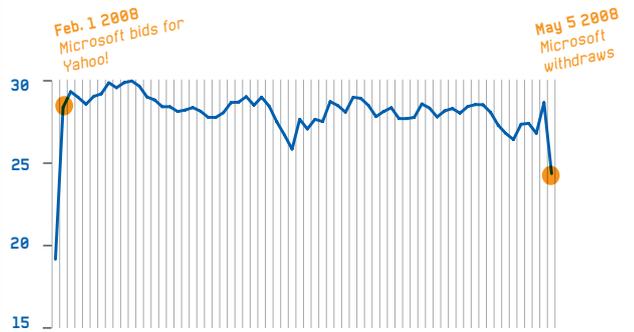
"We found that young women both with and without a history of dieting had greater brain activation in response to romantic pictures in reward-related neural regions after having eaten than when hungry," says Ely. "This data suggests that eating may prime or sensitize young women to rewards beyond food. It also supports a shared neurocircuitry for food and sex."

The latest finding, based on a small pilot study, grew from earlier work looking at whether the brain response to food differed significantly in women who were historical dieters versus those who had never dieted.

That study, published in *Obesity* in 2014, found that the brains of women with a history of dieting responded more dramatically to highly palatable food cues when fed as compared to women who had never dieted or who were currently dieting.

_ THE ART OF THE TAKEOVER

Public companies that refuse generous takeover bids face punishing consequences in the stock market.



ROLLER_COASTER

When Microsoft gave up its generous bid for Yahoo! Inc. in May 2008, four months after making an offer in February, the company's market value slid 15 percent.

AFTER REVIEWING thousands of recent corporate takeover bids that didn't go through to assess how the stock market reacted, researchers found that there is intelligence in the machine.

Companies that resist a "bad" takeover offer generally were not punished in the market, while the obverse is true when firms turn down "good" bids, according to a recent paper co-authored in the *Journal of Financial and Quantitative Analysis* by LeBow College of Business finance professor David Becher.

"Sometimes, an offer is rejected because it's a bad deal," Becher explains. "But sometimes, companies turn down a good deal — probably because the target is entrenched."

Becher and his co-author defined a "good offer" as one where the premium offered was higher than what the market was expecting, with the average premium in deals being around 40 percent.

Then they looked at firms that turned down offers for mergers — broken down by

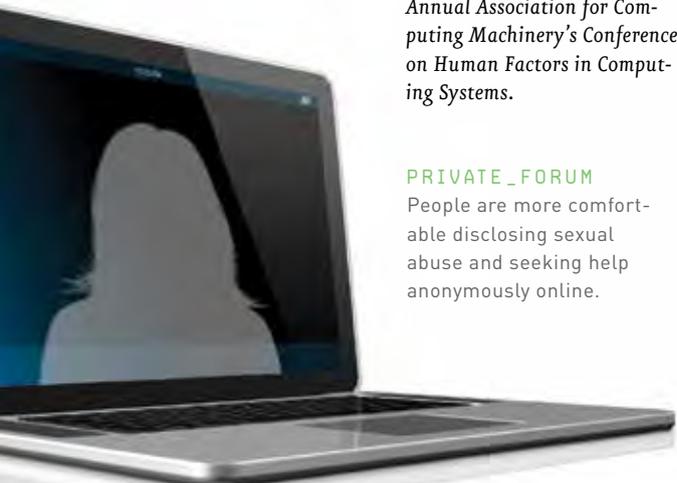
offers that were more, or less, than expected — and what happened next.

"Firms that turn down good offers tend to be punished," he concludes. "They are more likely to eventually go out of business or be delisted from the stock exchange. The CEO is more likely to be pushed out, and they tend to do worse, fiscally."

A classic example of that is Yahoo!, says Becher. In 2008, the struggling search engine company received a public bid from Microsoft valued at approximately \$47 billion, representing more than a 60 percent premium over Yahoo's pre-bid stock price.

Yahoo executives rebuffed the offer, which Microsoft then increased by 14 percent. That bid was also rejected, and Microsoft withdrew.

The bid's withdrawal coincided with a 15 percent reduction in Yahoo's market value — drawing the ire of shareholders. Pointed criticism was directed at the negotiating skills of then Yahoo! CEO Jerry Yang, who was eventually replaced.



NEW LIFE FOR LEFTOVERS

With roughly 40 percent of food in the United States going to waste, food researchers are exploring ways to repurpose groceries destined for the dumpster.

Nowhere is the problem of food waste more obvious than at supermarkets, where fresh produce is routinely tossed out for cosmetic reasons.

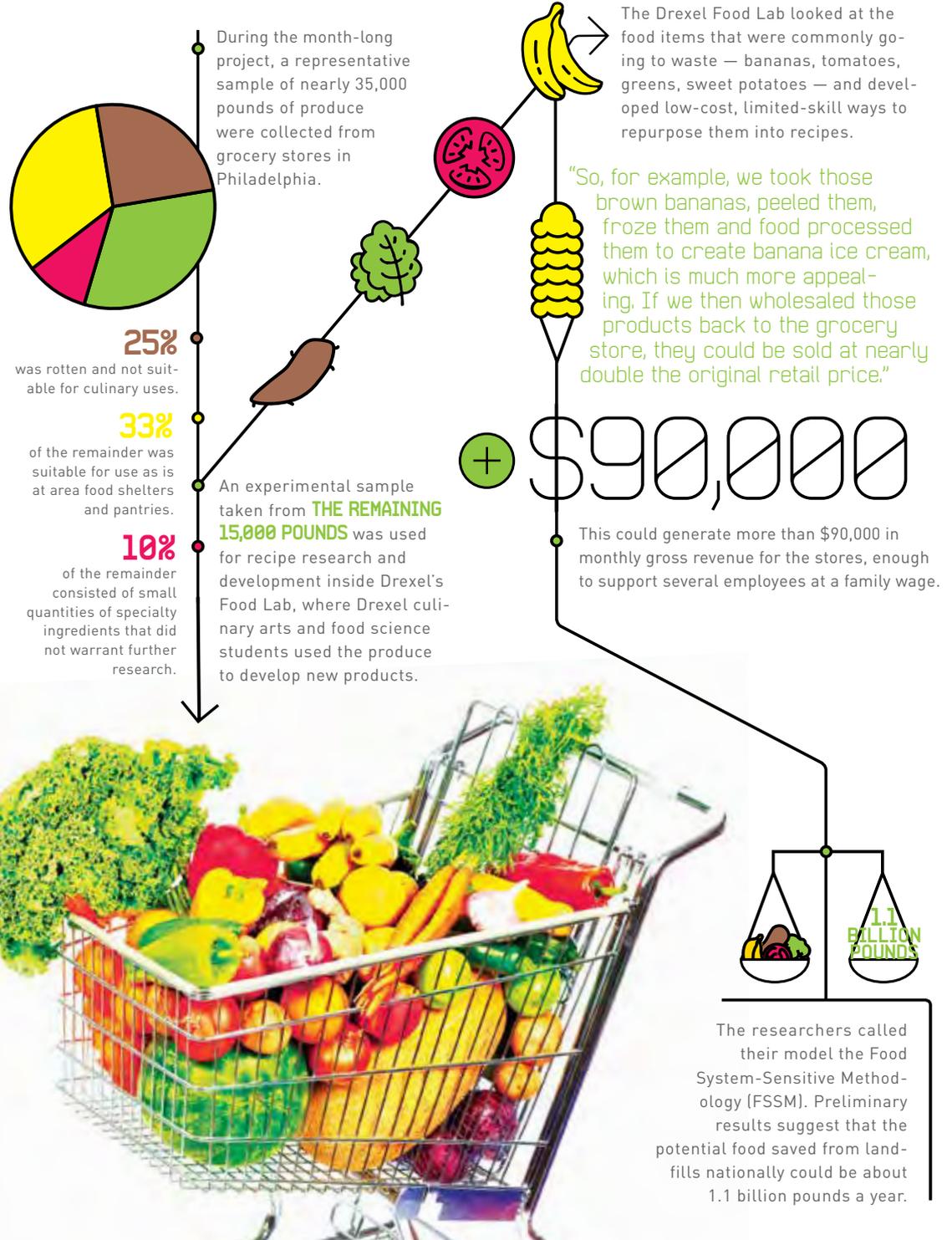
“If I offered you a bruised banana, you probably wouldn’t be interested,” says Professor Jonathan Deutsch. “But what if I offered you some banana ice cream on a hot summer day? I bet you’d find that a lot more appealing.”

It was this simple observation that inspired researchers to explore ways to recover supermarket surplus food and repurpose it to feed hungry people, generate revenue and even create jobs.

Deutsch, along with researchers from the University of Pennsylvania, Cabrini College and the Environmental Protection Agency, piloted a surplus food management model in West Philadelphia in 2015 that diverted fresh-but-unsold fruit and vegetable groceries from landfills and processed the food for donation or for new businesses.

If diverted to new foods, each of the country’s 46.1 million SNAP recipients could figuratively receive an equivalent of 24 pounds of food a year.

“An important way to address global food security is to make better use of the food already produced,” the researchers wrote. “[The model] could help relieve chronic hunger and address the cost barriers that prevent these important sources of healthy dietary nutrients from reaching lower-income Americans.”





CHANCES

_SECOND

for First-Time Offenders

Strict “zero tolerance” policies have led to a **disturbing number of in-school arrests - about 1,600 in the School District of Philadelphia annually**. Once in the justice system, youths’ life chances are diminished considerably. Psychology Professor Naomi Goldstein is working with community partners to divert students from the damaging “school-to-prison pipeline,” improving outcomes for youth and making Philadelphia a national leader in the process.

_by Tim Hyland / Illustrations by Brian Stauffer

After spending nearly two decades working to transform juvenile justice in America, Naomi Goldstein understands that changing people’s minds about crime and punishment — especially crime and punishment for at-risk youth — is no easy task.

But Goldstein, an associate professor of psychology in Drexel’s College of Arts and Sciences, also knows that change is possible, and sometimes, she says, a simple shift in mindset can make all the difference.

“In all of my work, it’s about transforming this idea that there’s no hope for these youth,” Goldstein says. “It’s about recognizing that, if we use empirical data, if we enact the right changes in philosophy and if we change the structure of the system, these young people can lead positive lives. And that’s not only better for them; it’s better for their communities, for their states and for the country.”

Goldstein has emerged as one of the nation’s leading thinkers in the area of juvenile justice reform.

Her unique research interests — which range from anger management to trial competence and from interventions with girls in juvenile justice facilities to Miranda rights comprehension among youth suspects — have uncovered serious structural problems within the nation’s juvenile justice systems.

Perhaps most importantly, her work has delivered real solutions to some of the trickiest problems facing those systems today, and has offered greater hope to an untold number of at-risk youth in Philadelphia and beyond.



_NAOMI GOLDSTEIN
Goldstein is an associate professor of psychology in the College of Arts and Sciences, director of Drexel’s Juvenile Justice Research and Reform Lab, and a Stoneleigh Foundation Fellow.

ONE SIZE DOES NOT FIT ALL

At the core of Goldstein’s work is the very simple, very problematic and, to Goldstein’s mind, entirely undeniable fact that the American juvenile justice system was adapted from the adult system and, therefore, designed for mini-adults, not kids.

“We know that adolescents don’t make decisions the same way that adults do, particularly in high-pressure situations,” she says.

One couldn’t find a situation more “high-pressure” than that of a police interrogation room. It was in that context that Goldstein, as a graduate student at the University of Massachusetts in Amherst and on clinical internship at the University of Massachusetts Medical School, first became curious about the workings of the juvenile justice system.

More specifically, she developed an interest in how well — or how poorly — adolescents would perform in the context of interrogation.

It didn’t take her long to discern that many young people don’t have the capacity to make informed decisions such as whether to waive their Miranda rights or to provide confessions to police.

“These kids are brought in for questioning, and it’s a very intense situation,” Goldstein says. “The police are allowed to deceive suspects — even juvenile suspects — in order to get a confession, and many youth simply have fundamental misunderstandings about what their [Miranda rights] mean.”

During a typical interrogation, there is no sympathetic adult in the room advising the young person.

“Even when there is, the adult may be pressuring the kid to respond to the police — to cooperate with them and take responsibility for what they may have done,” she says. “The adult is not encouraging the child to assert their rights to silence and legal counsel, which would be in the child’s best legal interest.”

Goldstein's work on Miranda rights eventually led her to question juvenile justice more broadly. She began to think about how the legal system treats youth as opposed to adults and about how the unique psychological characteristics that may increase youths' risks for entering the system undermine their abilities once they enter the system.

In short, she has developed a broad-based interest in not just identifying the problems within our nation's juvenile justice system, but also in developing and implementing solutions.

In Philadelphia, Goldstein's work on two related projects has already gone a long way toward improving outcomes for at-risk youth.

With the support of a fellowship from the Stoneleigh Foundation, a Philadelphia-based foundation focusing on juvenile justice and child welfare reform, Goldstein has been partnering with Philadelphia's Juvenile Probation Department and juvenile justice leaders to reform the city's juvenile probation system.

By making the system more responsive to the ways adolescents make decisions about their behaviors, Goldstein believes these youth can be better positioned to successfully complete the terms of probation.

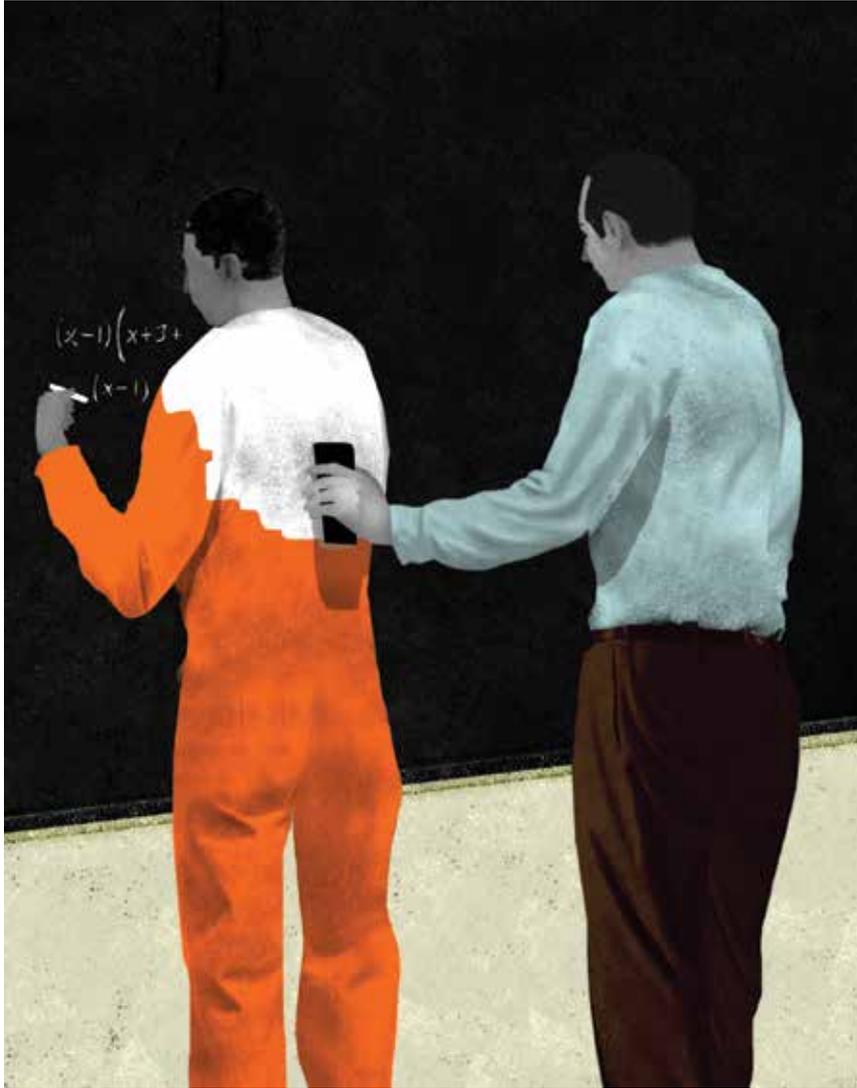
At the same time, she is evaluating a citywide program established two years ago that aims to give students who misbehave at school a second chance to stay out of the justice system.

The Philadelphia Police School Diversion Program was established and implemented in all Philadelphia schools in May 2014.

Under the program, a student who commits a lower-level offense on school property, and who has no history of a delinquency finding in juvenile court, is not arrested. Instead, with this one-time opportunity, he or she is diverted to community-based prevention programming to address the underlying challenges in the lives of the student and family.

The program — a collaborative effort between the Philadelphia Police Department, the Philadelphia Department of Human Services and the School District of Philadelphia — is intended to address the underlying reasons for misbehavior rather than subjecting the youth to the immediate and collateral consequences of an arrest record. Goldstein is evaluating the program with support from a grant from the U.S. Office of Juvenile Justice and Delinquency Prevention.

This innovative approach is built on a rather simple premise: Once a young person is arrested and placed in some kind of correctional facility, his or her chances of ever leading a normal, productive life are slashed considerably.



About 90 percent of youth in juvenile justice facilities report histories of traumatic events, and the seclusion, loss of privacy and perceived lack of safety in these residential facilities can exacerbate mental health problems.

Once released from juvenile justice facilities, youth can experience a cascade of negative consequences. More than

half will drop out of school upon release, Goldstein says. A history of arrest and conviction can trigger the family's eviction from public housing and the youth's disqualification from many colleges and jobs. Those with a criminal record may be ineligible for military service — no small issue for the many young people who may see that as their path out of a disadvantaged upbringing.

So, Goldstein says, it only makes sense to keep the youth who present little risk to the community out of those facilities and out of the juvenile justice system whenever possible.

"The simple fact of the matter is that residential juvenile justice facilities have incredibly negative impacts on young people," she says.

And since not all arrests can or should be avoided, Goldstein focuses on preventing arrest when appropriate and also on reforming probation systems for youth who have entered the system.

"What we hope to do with the probation reform work is to reduce the number of kids in detention, and reduce the number of kids in longer-term residential placements," she explains. "If kids are low-risk offenders, then we want to keep them out of placement."

THE POWER OF POSITIVE REINFORCEMENT

It's completely normal for kids to break the rules, says Goldstein. For some, that means breaking the rules of the house. For others, it's getting into trouble in school. And for some others still, that rule-breaking can cross into criminal activity.

But even the latter situation should not necessarily portend a bleak future.

"The vast majority of kids who do these things go on to become completely well-adapted individuals who don't commit crimes," Goldstein says.

Unfortunately, even for kids who do manage to stay out of legal trouble after their first offense, the justice system can be stacked against them. And the problems caused by that structural flaw are far-reaching.

Sixty percent of delinquent youth receive probation as their primary legal disposition. That at least keeps them out of detention and residential placement. Unfortunately, half of those youth will eventually end up in a juvenile justice facility anyway, not because they committed a second crime, but because the strict terms of probation are easy to violate. Violation can be as simple as missing a mandatory meeting with a probation officer or skipping school.

Complicating matters further is the fact that many “first offenses” may be very minor or even sometimes accidental, says Goldstein. Imagine this scenario: A student who works an afternoon job at a warehouse accidentally brings his box cutter to school with him — careless mistake or not, that offense often sends an otherwise innocent student into the system.

When Goldstein argues against automatically arresting youth or putting probation violators in detention or residential placements, she has biology and psychology on her side.

The undeveloped adolescent brain is wired differently than an adult brain. Chemically and physiologically, teenage minds are prone to impulsiveness and risk taking and are geared toward emphasizing short-term rewards over long-term negative consequences.

This can create problems for youth on probation. The immediate fun of partying with friends on a Saturday night is a more powerful motivator than the risk of probation revocation at next month’s court hearing because of a curfew violation and failed drug screen.

“Historically, if you fail one of your, often, very numerous probation requirements, the thinking has been, ‘Well, OK, you’ve violated your probation and so our only option is to lock you up.’ What I’m doing is applying empirical data to the juvenile justice system — data that suggest that the use of behavioral-shaping principles will work to improve youth probationers’ behavior.”

Establishing a juvenile probation system that reinforces positive behaviors while providing proportional consequences for negative behaviors can help shape youths’ decision making, and, as a result, help them successfully complete probation.

“We’re trying to move away from this ‘all or nothing’ mentality when it comes to probation,” Goldstein explains.

For instance, one common requirement of probation is daily school attendance. But imagine the student, raised by a single mother working irregular jobs or suffering from an illness, who skips school to take care of younger siblings.

“[This kid] hasn’t been to school in two months and is now attending a couple days a week,” says Goldstein. “You can either tell this kid that he has failed to fulfill his probation requirement or you can recognize that going from no school to two days per week is a big improvement — and that he actually deserves credit for that behavior.”

“If these young people on probation learn that there is something for them to work toward and to achieve, it can promote positive behavior in the long run,” she says. “That’s a big part of this work.”

ONE-TIME GET OUT OF JAIL CARD

In Philadelphia, Goldstein’s somewhat radical ideas are being put to the test in the form of the city’s Philadelphia Police School Diversion Program, a city-wide program initiated by the Philadelphia Police Department.

So far, the approach is passing with flying colors.

The diversion program was initially rolled out in all Philadelphia schools in May 2014. Though the program launched during the tail end of the 2013–14 school year, it immediately showed great promise.

Under the rules of the program, a first-time offender who commits low-level delinquent acts on or around school premises is not arrested — which is to say, he or she never formally “enters the system.”

Instead of being handcuffed, removed from school, taken by police car to the police station, held for up to six hours for processing and finger printed, the student meets with

a Philadelphia Department of Human Services social worker and is referred for intensive prevention services after school. Therapy and other support is available not only to the youth, but to parents and families as well.

Imagine a 12-year-old boy carries a knife to school because he feels unsafe in his neighborhood. In previous years, this student would likely have been arrested. Now, school police and staff address how to improve his commute to school and the student is provided with the support services he may need.

“It’s a one-time deal, yes, but at least with that first incident, they are staying out of the system,” says Goldstein.

The Philadelphia Police School Diversion Program showed its full potential during its first full year of operation, in the 2014–15 school year.

According to Goldstein, total school-based arrests dropped 54 percent from the previous year — falling from 1,582 to just 724. Arrests related to the possession of weapons were down 87 percent, and those tied to the possession of marijuana fell 85 percent.

The results from the 2015–16 school year are on track to be even better, with a further decline in the number of school-based arrest across the city.

In fact, as of December 2015, more than 800 students had been diverted through the program, and of those, only 36 — 4.5 percent of the total — were later arrested for new offenses in school or in the community. This is particularly notable, Goldstein says, because national data suggests that between 37 percent and 67 percent of young people who end up in custody will be re-arrested.

In truth, the program is succeeding far beyond what even she had expected. “You don’t see results like this very often,” she says. “It’s pretty amazing.”

Some of the biggest fans of the program are the arresting police officers, many of whom had been dissatisfied with the old policies. “The vast majority felt it was not only helpful to the youth directly involved, but it was actually increasing the overall safety of the schools,” Goldstein says.

The more successful Philadelphia’s programs become, Goldstein says, the more hope there will be for at-risk youth nationwide.

“There’s a lot of attention on this topic now, but that certainly wasn’t the case a decade ago,” Goldstein says. “Philadelphia really took the lead on reform efforts in this area. ...My hope is that a lot of these projects will be successful not only in Philadelphia, but in other cities around the country as well.” ✕

“If these young people on probation learn that there is something for them to work toward and to achieve, it can promote positive behavior in the long run. That’s a big part of this work.”

This is an updated version of a story that previously appeared in Ask Magazine.



_ABOUT DREXEL



_SCHUYLKILL YARDS
In March, Drexel and Brandywine Realty Trust announced the planned development of Schuylkill Yards, a 14-acre, \$3.5 billion “innovation neighborhood” built on long-underutilized Drexel-owned land adjacent to Amtrak’s 30th Street Station in West Philadelphia.

FOUNDED IN 1891 in Philadelphia, Drexel is a comprehensive urban university of more than 25,500 students, consistently ranked in America’s Top 100 by *U.S. News & World Report*.

Drexel is a leader in experiential, technology-infused education, enriched by the nation’s premier cooperative-education program. The University’s recognized excellence in translational research is supported by the Coulter Foundation through the Coulter-Drexel Translational Research Partnership and by \$101 million in sponsored research awards.

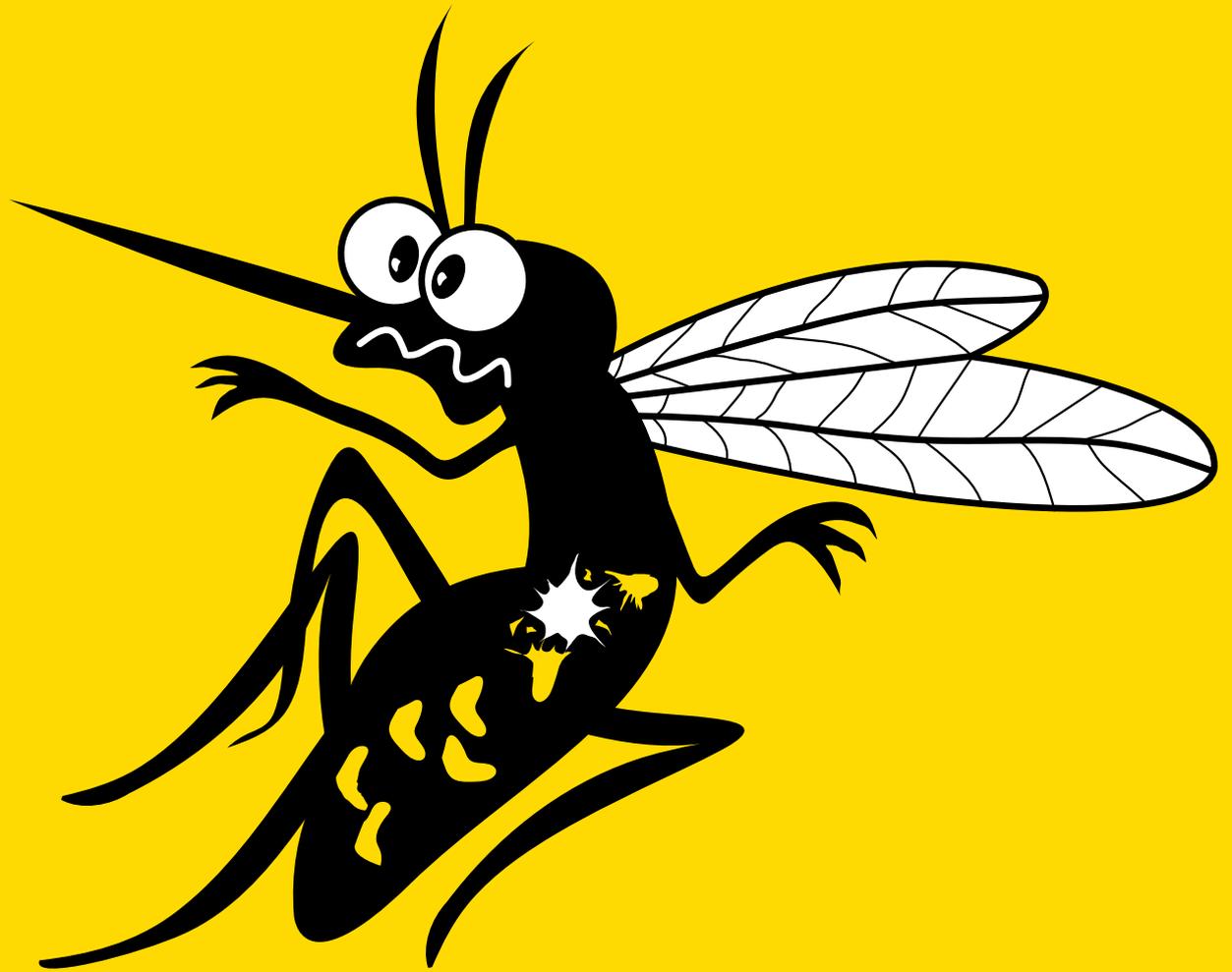
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Drexel operates out of its 123-acre University City Campus in West Philadelphia and at four additional locations: the Center City Campus for the College of Nursing and Health Professions and the Academy of Natural Sciences; the Queen Lane Campus in East Falls for the College of Medicine; and through its online platform, Drexel Online.

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This Disease Will Self Destruct in 5... 4... 3... 2...

Exploding Parasites Spell Progress in the Battle Against Drug-Resistant Malaria

The mosquito-borne malaria parasite kills nearly 500,000 children every year. As the parasite continues to spread and evolve, the best drugs that we have to fight it are losing potency. If humanity is to gain the upper-hand in the battle against this global menace, we need new weapons, fast.

A team of Drexel University College of Medicine researchers, led by Dr. Akhil Vaidya, has discovered a new class of chemicals to combat malaria. These compounds — pyrzaoleamides — block the parasite's ability to maintain normal sodium levels in its cells, causing the organism to swell and burst. Their work is a continuation of more than 50 years of malaria research at Drexel, all aimed at better understanding and combating this deadly disease.

When tiny bugs pose huge threats to public health, Drexel researchers race to even the odds in humanity's favor.



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A SOBER ANALYSIS

When Washington became the first state to privatize liquor sales since Prohibition, it provided a rare chance to observe the impact of alcohol availability on public safety.