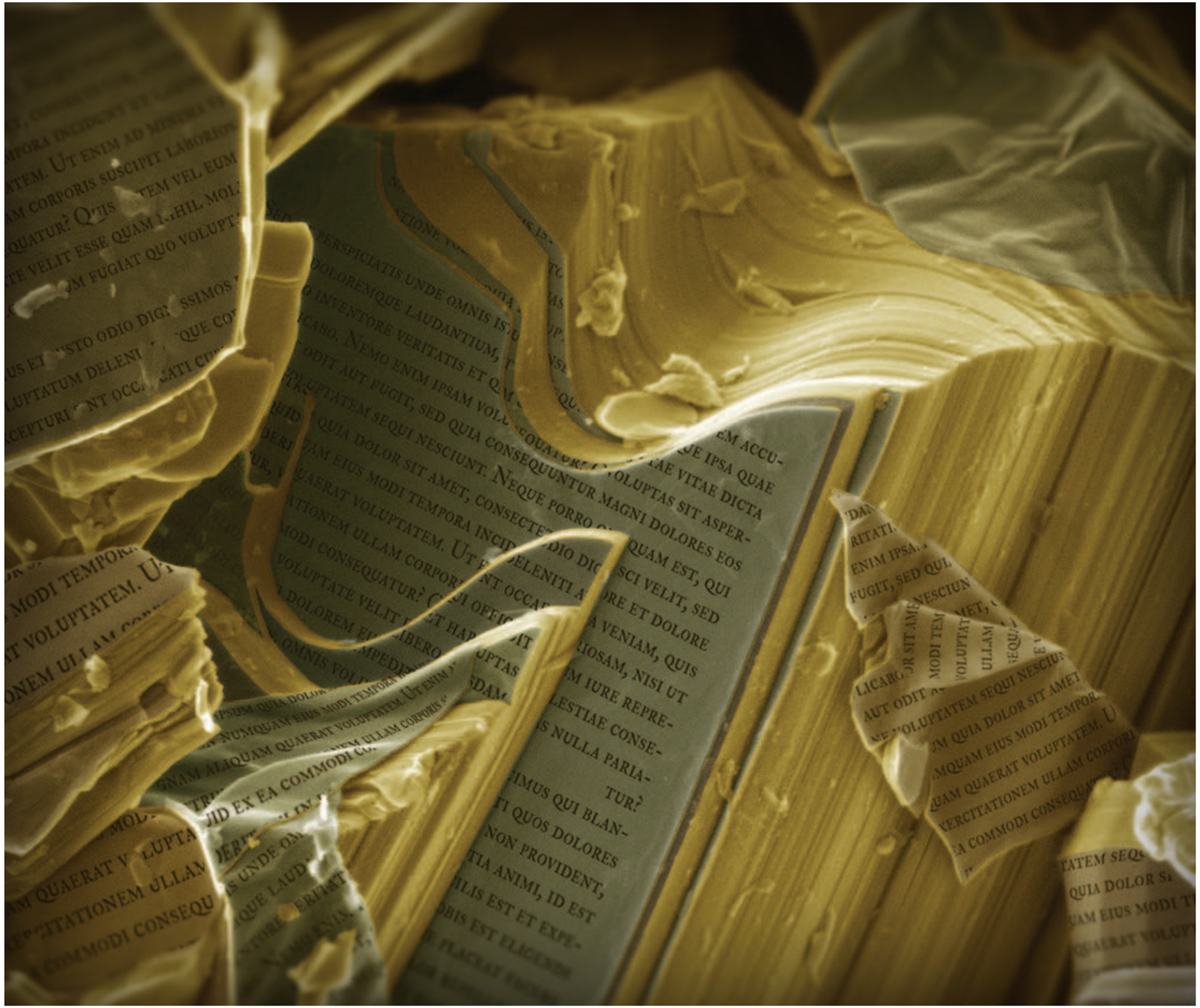


_"MXENE LIBRARY"
MXene Ti_3C_2 "clay" has a layered structure that can be easily sheared, creating fantastic forms on the microscale. This is a scanning electron microscope image of Ti_3C_2 stacks that have been partially sheared along their basal atomic planes and colorized to emphasize their likeness to books.

First Place Prize

MICHAEL GHIDIU
PhD materials science and engineering '18
Drexel University

_ATOMIC ART

The beauty of ***science at the nanoscale*** *is revealed by images from a new scientific images art contest established at Drexel.*

This image at left, nicknamed "MXene Library," is the inaugural top-winning photo of an international competition created by the A.J. Drexel Nanomaterials Institute to celebrate the surprising beauty within the microscopic details of everyday nanomaterials.

Babak Anasori, a research assistant professor in the institute and in the Materials Science and Engineering Department of the College of Engineeering, established the NanoArtography contest two years ago to help laypeople appreciate how scientists study the world at the atomic level and to bring attention to Drexel's groundbreaking materials science research.

The unusual images are scans of metals or nanoparticles taken by an electron microscope, then highly magnified (for perspective, a human hair would have to be sliced 100,000 times to reach the thickness equal to one nanometer) and often given an artistic touch with photo-editing software.

The judging panel, which includes Anasori and professors of both science and art, look for intriguing images that also have a story to tell, Anasori says.

"We ask, 'Can it convey a message about your research?'" he says. "By looking at natural things under a microscope we can see how nature uses nano features in its design. Seashells, for example, are made of nacre (mother of pearl) which is very strong, but on a nanoscale, shells are actually plates of hard material bonded to soft materials — that's what makes them resilient. To make something as strong as nacre, we have to be able to design from the nano level all the way to the macro level."

Drexel's Materials Science and Engineering Department is the birthplace of MXenes, a new family of atomic-thin, conductive materials that promises many potential uses, including high-capacity batteries, smaller and wearable electronics and even applications for the treatment of cancer.

While still a PhD student, Anasori created beautiful scans of MXenes that gained notoriety outside of science circles. One dramatic image of a titanium-based MXene by Anasori and fellow graduate researcher Michael Naguib won the People's Choice award in the National Science Foundation's International Science & Engineering Visualization Challenge, the most competitive contest of its kind. It later also appeared in *National Geographic* magazine and on MSNBC.

"These images are a way to communicate science to the public," Anasori says. "I think they brought more visibility than anything else to my research. Now I'm encouraging students and other researchers to do the same for their own good." — *Sonja Sherwood*

_"PIEZOELECTRIC NANOYARN GALAXY"

This is an electrospun PVDF-TrFe nanoyarn. PVDF-TrFe is a polymer capable of forming piezoelectric nanofibers without the need for additional poling. Nanoyarns are higher-order architectures of nanofibers and are fabricated by twisting bundles of aligned nanofibers together during the electrospinning process.

Second Place Prize

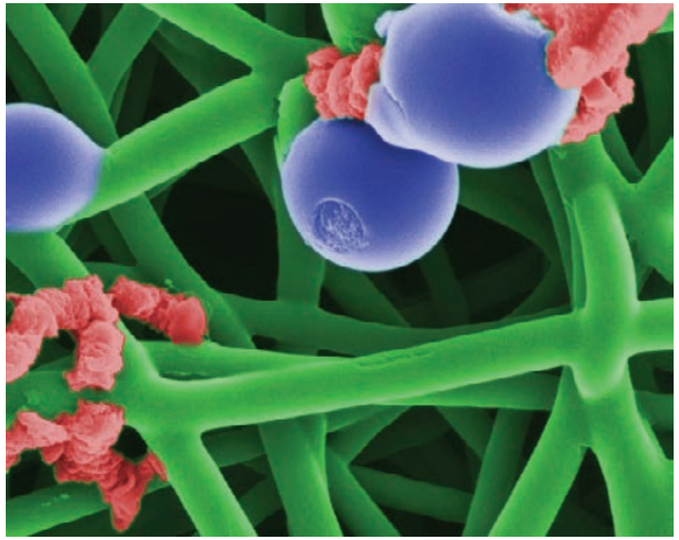
ARIANA LEVITT
PhD engineering candidate
Drexel University

_"GERBERA FLOWER"
This work reveals how common shapes and colors in nature can be visualized within microscopic images, making it possible to show that the nano world is similar to the macro world. The image was obtained through field emission gun–scanning electron microscope (FEG–SEM) using strontium tungstate.

Third Place Prize

RICHARDO TRANQUILIN
Federal University of Sao Carlos, Brazil

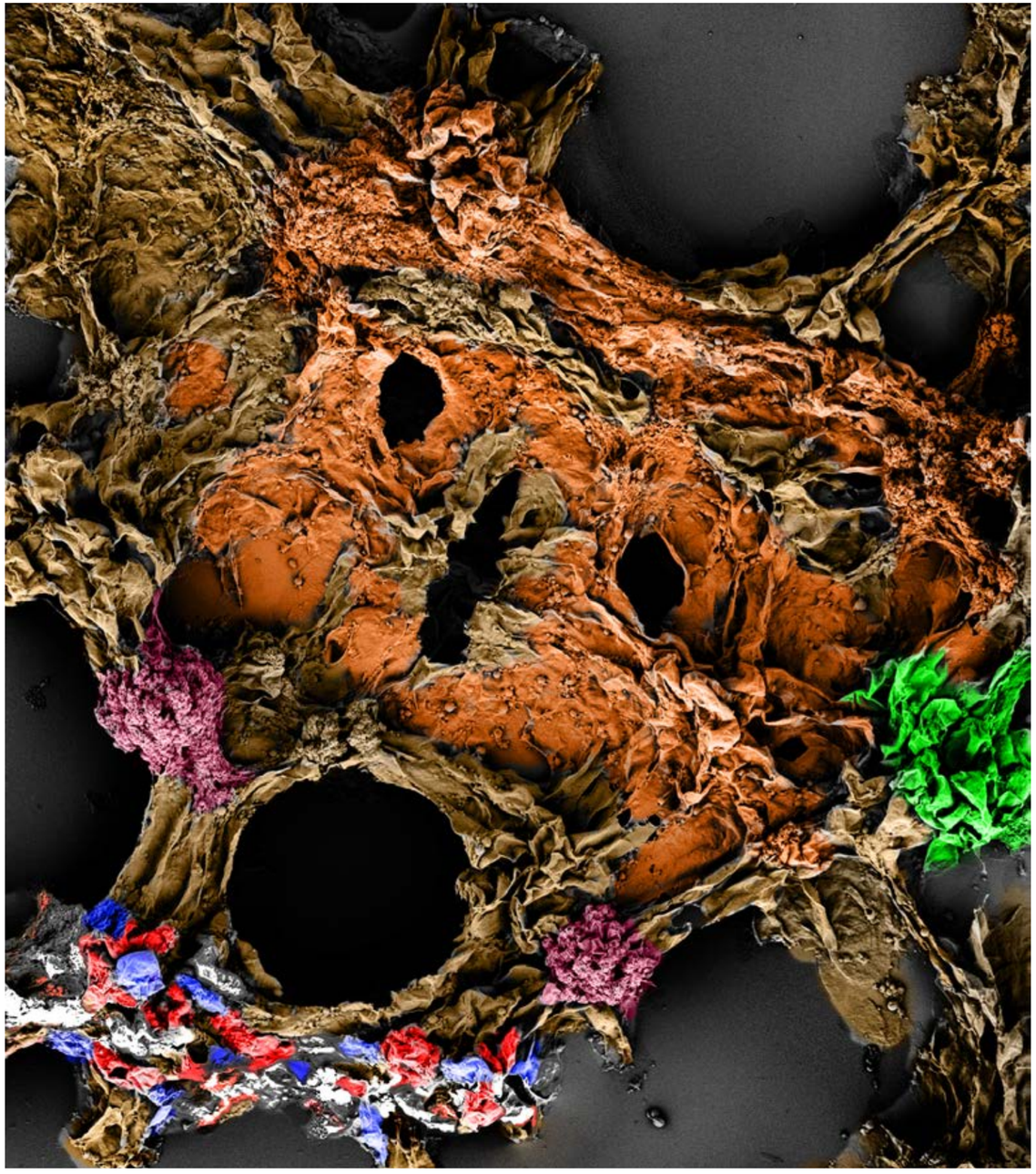
NANOMATERIALS



_"POLYANILINE BLUEBERRIES ON CARBON NANOFIBERS TWIGS"
Electrospun carbon nanofibers are coated with a 10-nanometers-thick polyaniline coating using oxidative chemical vapor deposition. During this specific reaction, spheres of polyaniline formed on the surface of the carbon nanofibers, along with some rough patches.

Honorable Mention

YURIY SMOLIN
PhD chemical engineering '17
Drexel University



_"FALL IS HERE, BUT WINTER IS NEAR"
This image depicts colorized polyvinylidene fluoride (PVDF) crystallites viewed under a scanning electron microscope.

Honorable Mention

GABRIEL BURKS
PhD materials science and engineering '18
Drexel University

_"TI3CN ANTELOPE CANYON"
The curved structure presented in the picture is a porous Ti_3CN MXene. The width of the "cliff" on the right-hand side of the picture is approximately 20 microns. The author aims to relate the MXene micro-porous structure with the Antelope Canyon in Nevada, also made of soil.

People's Choice Award

KANIT HANTANASIRISAKUL
PhD engineering candidate
Drexel University

_EXEL 2018

E X E L
_DREXEL UNIVERSITY RESEARCH MAGAZINE 2018

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_LIFE-SAVING IDEAS

Research for the public good

_ABOUT THE COVER
Up close, the fabric worn by U.S. soldiers in the first Gulf War almost resembles the shape of cells. In Drexel's College of Medicine, researchers hope that the genetically modified cells of military veterans hold the key to treating the debilitating symptoms of Gulf War Illness.

With so many challenges facing society, it is reaffirming to see how research across Drexel University continues to benefit the public good.

This annual edition of *EXEL Magazine* details several promising research initiatives that share a common theme we all can appreciate: Saving lives.

For example, biomedical engineer Sriram Balasubramanian has created an innovative crash sled to test automotive vehicle restraints for children, an area in which few data currently exist. Balasubramanian's research will be used to build better, safer seatbelts and seats to protect children.

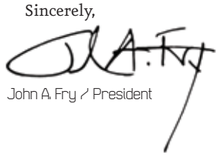
College of Medicine professors Olimpia Meucci and Alessandro Fatatis have developed a cancer drug that studies show not only blocks new tumors from forming, but also stops initial metastases from growing. This could be a breakthrough treatment for breast cancer, which often spreads to other parts of the body.

Thousands of U.S. soldiers returned from the 1991 Persian Gulf War with a mysterious, incurable illness. But a team of researchers at the College of Medicine are examining the neurological underpinnings of Gulf War Illness to develop treatments that would reverse it.

Drexel alumnus Mihir Shah developed a low-cost, portable breast cancer screening device based on technology pioneered by Drexel faculty. In his native India and throughout the developing world, breast cancer survival rates are low because poor access to screenings results in diagnoses that come too late. Last year, Shah's company partnered with GE Healthcare to distribute the iBreastExam to millions of women who wouldn't otherwise have access to early detection.

These stories and others in this edition of *EXEL* show how the hallmarks of Drexel University — research, innovation and entrepreneurship — are advancing society by literally saving lives. I am so proud of the work we do at Drexel and the critical role we play through our research, scholarship and education.

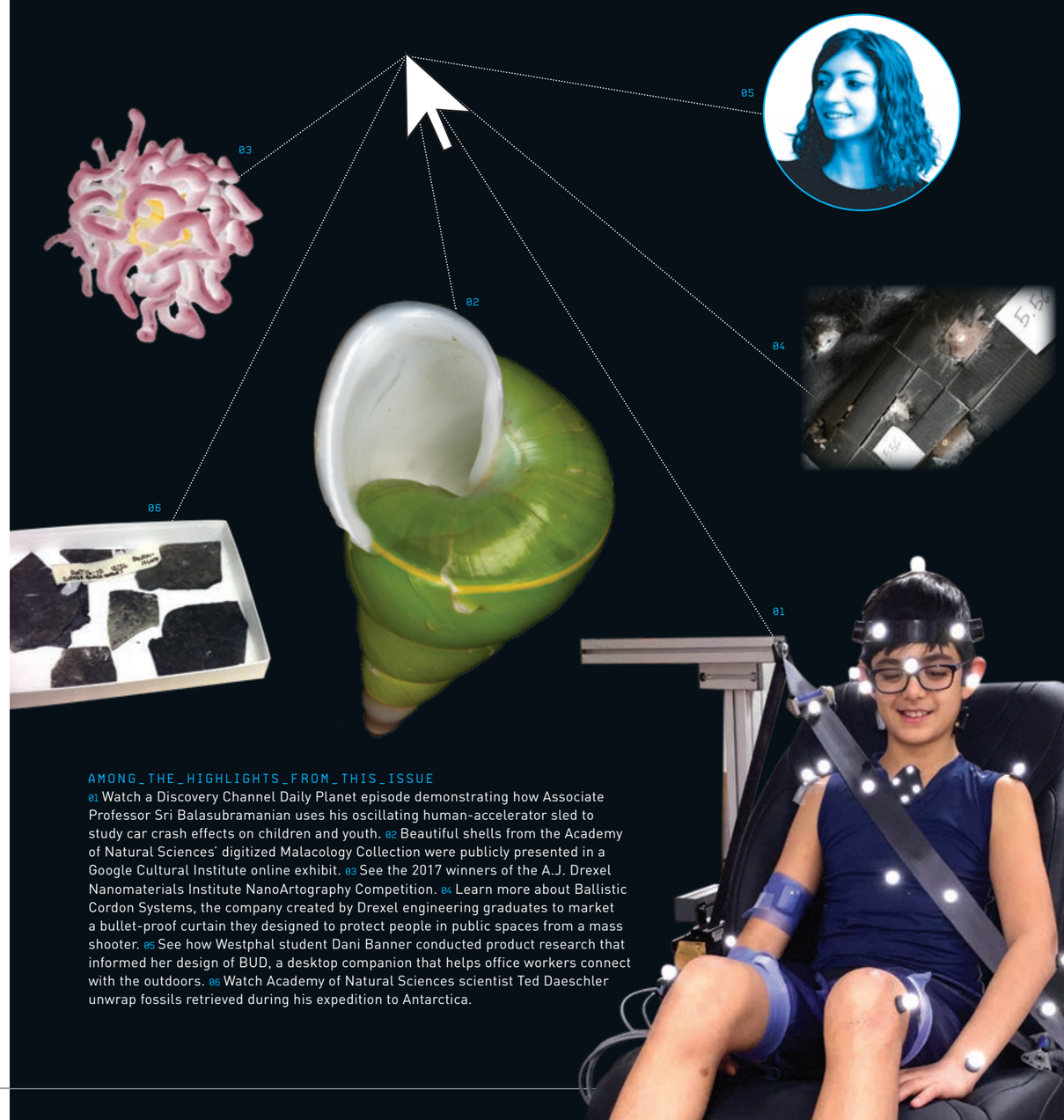
Sincerely,



John A. Fry / President

_EXPLORE *EXEL* ONLINE

Connect with EXEL Magazine at exelmagazine.org 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.



AMONG_THE_HIGHLIGHTS_FROM_THIS_ISSUE
01 Watch a Discovery Channel Daily Planet episode demonstrating how Associate Professor Sri Balasubramanian uses his oscillating human-accelerator sled to study car crash effects on children and youth. 02 Beautiful shells from the Academy of Natural Sciences' digitized Malacology Collection were publicly presented in a Google Cultural Institute online exhibit. 03 See the 2017 winners of the A.J. Drexel Nanomaterials Institute NanoArtography Competition. 04 Learn more about Ballistic Cordon Systems, the company created by Drexel engineering graduates to market a bullet-proof curtain they designed to protect people in public spaces from a mass shooter. 05 See how Westphal student Dani Banner conducted product research that informed her design of BUD, a desktop companion that helps office workers connect with the outdoors. 06 Watch Academy of Natural Sciences scientist Ted Daeschler unwrap fossils retrieved during his expedition to Antarctica.

_BULLET BLOCKER

*A group of Drexel engineering students invented a **bulletproof curtain** that can be instantly deployed to public spaces to protect people from a mass shooter.*

There were more than 300 mass shootings in America in 2017, according to nonprofit data-gathering organization Gun Violence Archive. And in 2016, and 2015 as well. While there is seemingly no public space that is safe from a shooting, some Drexel students have devised a way to make them less deadly.

James Ostman '17 and Daniel Navin '17, both Army veterans, designed a system of protective steel barriers that can be used to shield innocent bystanders and limit an attacker's ability to inflict damage. They call it the Ballistic Curtain Cordon System, and it has the potential to save lives.

"Taking something like an open space, it's easy for someone who wants to inflict harm to take advantage of that situation," Ostman says. "But when you start creating barriers, physical and visual, that's where you can really interrupt that intent."

Ostman and Navin, both of whom graduated from the College of Engineering in 2017 with mechanical engineering degrees, came up with the design by thinking back to their time on military bases in Iraq and Afghanistan, where large concrete walls functioned to halt the trajectory of any mortar or shrapnel that might come in. They teamed with classmates Peter Lewis (mechanical engineering '17), and Fen Tamulonis (electrical engineering '17) to create a prototype for a system of thin steel barriers that can be retrofitted into any ceiling and unfurled on command, creating a bulletproof set of obstacles.

Navin knew from his time as an Army sniper that AR500 steel can take hundreds of shots without showing any effects, so the engineers used it as the system's base material. Small plates of steel are placed between sheets of nylon and held in place with Velcro bonded to the steel with silicone-based adhesives. The curtains would be tucked away in a building's ceiling, ready to drop whenever needed.

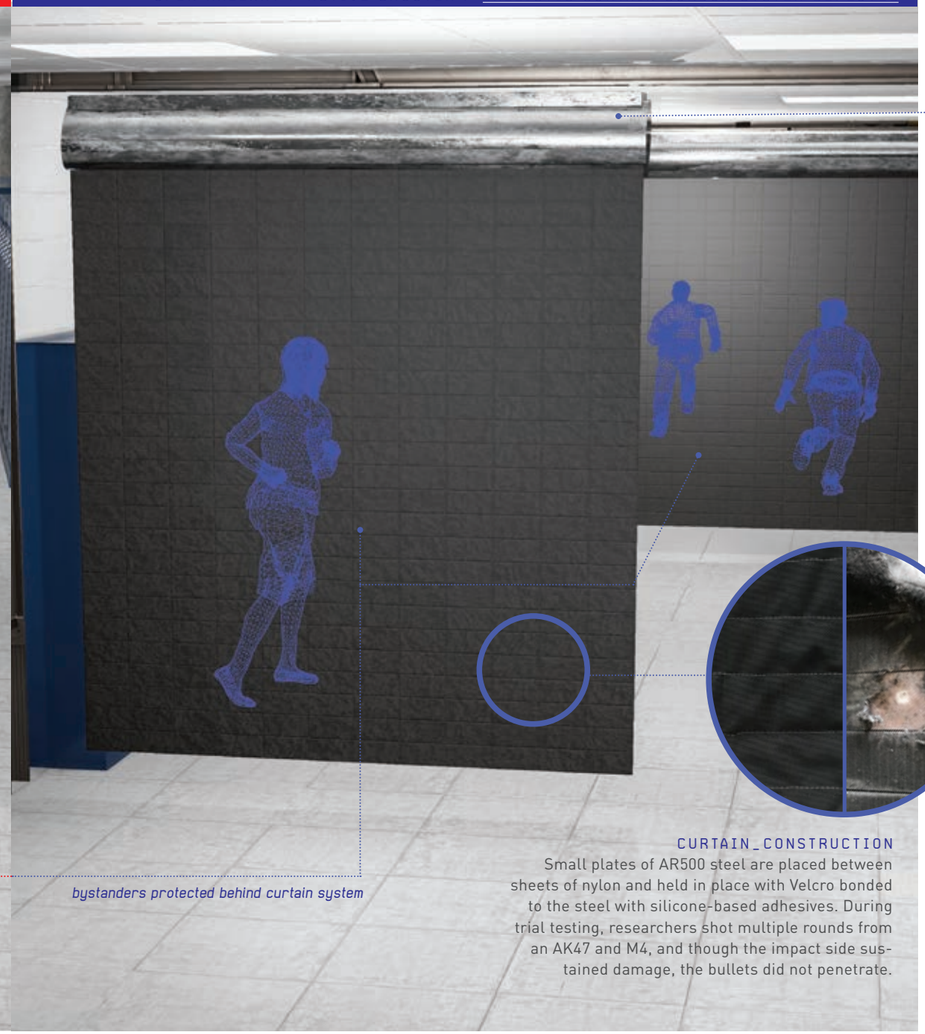
The design takes three to four seconds to unfurl, leaving a staggered series of six-foot-tall curtains in place to protect anyone from just above their feet to the top of their head. The cordon can be used repeatedly and even has an administrative override so police can electronically pull the curtains back into the ceiling when they need to clear a scene.

The team sees it as something that could be used in any school, office, night club or municipal building — a measure of insurance against the horror of a mass shooting.

"If we can put ourselves in position to positively impact one of these situations, that would be enough for me," says Ostman. "We would love to play a hand, because of this design, in actually mitigating one of these situations."

OPEN HALLWAY / ACTIVE SHOOTER

OPEN HALLWAY / ACTIVE SHOOTER / BALLISTIC CURTAIN CORDON SYSTEM DEPLOYED



The curtains are tucked away in a building's ceiling, and can be unfurled in three to four seconds. They can be activated manually or triggered automatically.

CURTAIN_CONSTRUCTION

Small plates of AR500 steel are placed between sheets of nylon and held in place with Velcro bonded to the steel with silicone-based adhesives. During trial testing, researchers shot multiple rounds from an AK47 and M4, and though the impact side sustained damage, the bullets did not penetrate.

_ONLINE

To learn more about the Ballistic Curtain Cordon System and to see the curtains in action, visit **EXELmagazine.org.**

_DUST MIGHT

_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.

You probably aren't aware of the invisible carpets of polymers that keep everyday items from collecting dust and dirt. But there these so-called "polymer nanobrushes" are, protecting your glasses from getting smudged or keeping the underbellies of ships from corroding.

Polymer nanobrushes ensure that artificial joints don't lock up and medical devices don't gather germs. And Drexel researchers have come up with a way to make them better.

LONGER_LIFE
Drexel researchers' new polymer nanobrushes, like those used to protect glasses from getting smudged, are more densely packed, and can help extend the life of various kinds of medical devices.

For years, the nanobrush production process has either involved "grafting-from" — similar to sprinkling seeds on soil and waiting for grass to grow — or "grafting-to" — more like transplanting individual blades of grass. The approach taken by Professor Christopher Li in the College of Engineering involves growing a functional, two-dimensional sheet of polymer crystals — something like a nanoscale piece of double-sided tape — and sticking it to an existing substrate, allowing the crystals to dissolve and the remaining polymer chains to spring up and form the brush's bristles.

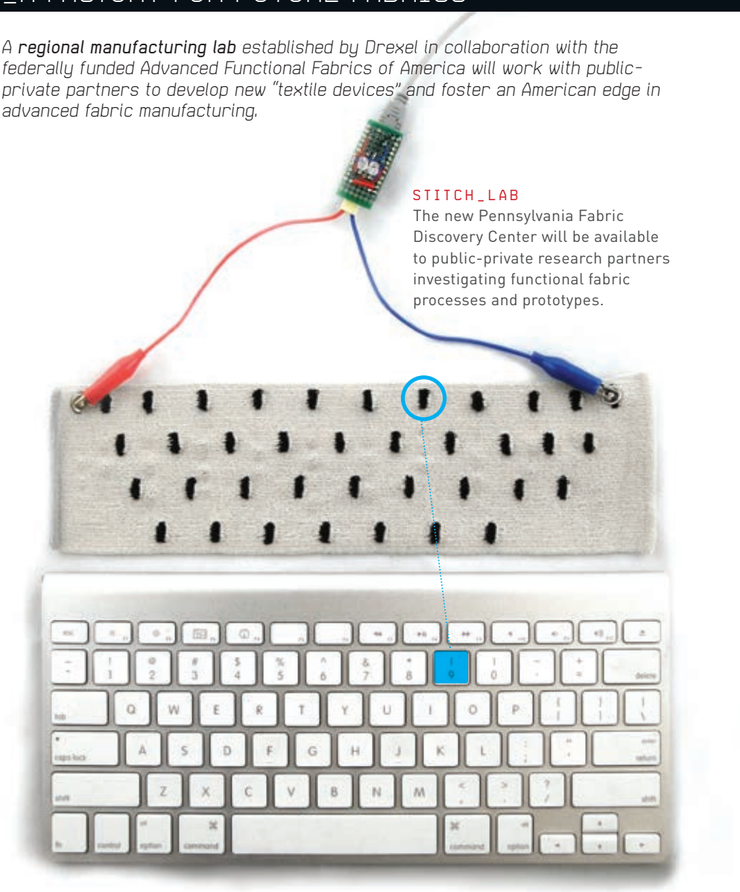
The relative amount of friction the brushes can eliminate by acting as a lubricant is determined by how long and rigid the polymers are and how far apart they're spaced. Li's method allows him to precisely tune those characteristics because he can control the formation of the two-dimensional crystal sheets, allowing for the creation of the most densely packed polymer brushes to date, with bristles less than a nanometer apart.

According to a paper in *Nature Communications*, Li's team is even able to create polymer crystals with anchor points on both ends so they form a loop, which is a much sturdier bristle formation than a single-anchored polymer.

"One day engineers will be able to tailor-make incredibly durable polymer brush coatings to extend the usage lives of all kinds of uniquely shaped joints and couplings," Li says.

_A FACTORY FOR FUTURE FABRICS

*A **regional manufacturing lab** established by Drexel in collaboration with the federally funded Advanced Functional Fabrics of America will work with public-private partners to develop new "textile devices" and foster an American edge in advanced fabric manufacturing.*



STITCH_LAB
The new Pennsylvania Fabric Discovery Center will be available to public-private research partners investigating functional fabric processes and prototypes.

Imagine a computer keyboard knit from yarn, embedded with touch sensors and bluetooth, so soft and flexible it could be crumpled into a pocket. Such a device would be cloth-like, yet highly technological and functional. Imagine how a class of textiles like that could transform everyday life and product design across multiple industries.

It sounds like science fiction, but interdisciplinary researchers working with Drexel's Center for Functional Fabrics, in partnership with a collaboration announced in 2016 with the Department of Defense-funded Advanced Functional Fabrics of America (AFFOA), are at the forefront of developing the models, standards, design and fabrication methods necessary to stimulate a domestic manufacturing industry around functional fibers.

_GENEVIEVE DION
Dion is an associate professor and design scientist in the Westphal College of Media Arts & Design and director of the Center for Functional Fabrics.

"Functional fibers," unlike traditional fabrics, integrate yarns and fibers engineered to see, hear, sense and communicate. Even before the AFFOA partnership was announced, teams of computer scientists, engineers, designers and experts in medicine and nanomaterials at Drexel were developing products such as a bellyband for respiration and uterine contraction monitoring, a fabric touchpad, a haptic glove for hand therapy and textile fibers that can store energy.

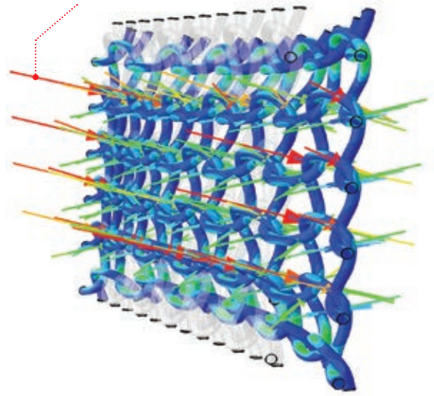
Through the partnership with AFFOA, Drexel helps universities in the mid-Atlantic region collaborate on the research and development of futuristic fibers with startups, venture capital groups, nonprofits and industry partners such as Nike, New Balance, VF Corp. and Steelcase.

In 2017, Drexel further announced that it is establishing a state-of-the-art, end-to-end advanced regional manufacturing facility capable of developing functional fabric prototypes for pilot-stage production.

It will be called the "Pennsylvania Fabric Discovery Center" and will be overseen by the Center for Functional Fabrics on behalf of mid-Atlantic members of the AFFOA manufacturing network. It is AFFOA's first national hub outside of Massachusetts; AFFOA's long-term strategy is to open similar centers across the country.

"The Fabric Discovery Center will build upon Pennsylvania's rich textile history and bring together academic and industrial expertise statewide to create an ecosystem that supports innovation, collaboration and education," says Genevieve Dion, associate professor in the Westphal College of Media Arts & Design and director of the Center for Functional Fabrics. "Our transdisciplinary approach at Drexel and the Center for Functional Fabrics will help resolve fundamental manufacturing problems, leading to the successful design and production of truly functional textiles. Ultimately, this will stimulate job creation activities and workforce development for an advanced functional fabrics industry."

"Functional fibers" integrate yarns and fibers engineered to see, hear, sense and communicate.



_JUST ADD SALT

*In the search for a **better recipe to produce thin sheets of metal oxide fit for energy storage**, a little salt can go a long way.*

Making energy-storage materials is a little like baking. It requires just the right mix of ingredients prepared in a specific way — at just the right temperature — to produce a thin, two-dimensional sheet of material with the perfect chemical consistency to be useful. And, researchers have found, it's best to add salt.

A team of scientists from Drexel (among them Yury Gogotsi, the Distinguished University and Charles T. and Ruth M. Bach Professor in the College of Engineering and director of the A.J. Drexel Nanomaterials Institute; and Xu Xiao, a postdoctoral researcher in the institute), Huazhong University of Science and Technology and Tsinghua University have discovered they can make the resulting materials bigger and better at soaking up energy by using salt crystals as a template to grow thin sheets of electrochemically active metal oxides. The team found that the salt helps create flakes of two-dimensional materials that are 50,000 times thinner than a human hair, but are large in lateral dimensions — and thus more suitable for gathering ions and storing energy.

In an energy-storage device energy is stored via adsorption or the chemical transfer of ions from an electrolyte solution to thin layers of conductive materials. As these devices evolve they're becoming smaller and can hold an electric charge for longer periods. The reason for their improvement is that researchers are fabricating materials that are better equipped, structurally and chemically, for faster transport of ions and electrons.

CRYSTAL_CLEAR
Table salt is a key ingredient in making better materials for energy storage.

In theory, the best materials should be thin sheets of metal oxides, because their chemical structure and high surface area make it easy for ions to attach — which is how energy storage occurs. But the metal oxide sheets that have been fabricated in labs thus far have fallen short.

Using salt crystals as a substrate lets the ingredients spread out and form a larger sheet of oxide material. Think of it like making a waffle by dripping batter into a pan versus pouring it into a big waffle iron; the key to getting a big, sturdy product is getting the solution — be it batter or a chemical compound — to spread evenly over the template and stabilize in a uniform thin sheet.

_CELL SKIN

For more than a decade, biomedical researchers have been looking for better ways to deliver cancer-killing medication directly to tumors. Tiny capsules called nanoparticles can transport chemotherapy medicine through the bloodstream, but the challenge is coming up with a delivery vehicle that is sturdy enough to survive the bumpy ride and also lithe enough to squeeze through a tumor's dense extracellular space — a matrix stuffed with sugars called hyaluronic acid.

In the journal *Nano Letters*, senior author Hao Cheng, an assistant professor with an appointment in the College of Engineering and affiliation with the School of Biomedical Engineering, Science and Health Systems, reported that his team, which includes Wilbur Bowne, a professor in the College of Medicine, had developed a method that involves the decoration of nanovehicles with enzymes known to break down the acid. There is also an extra layer of polyethylene glycol to partially cover the enzymes ensuring that particles have sufficient time to enter into tumors. The method is four times more effective at sending nanoparticles into a solid tumor than one of the best strategies in use, the group found.

The team tested their nanoparticle against competitors that lacked the additional layer of polyethylene glycol and ones that didn't have the enzymes. Their nanoparticle performed better in both penetrating tumors and in accumulating in the cancerous cells to get to work.

_MATERIAL WITNESSES

In the almost seven years since researchers in the Department of Materials Science and Engineering in the College of Engineering discovered MXene, a new two-dimensional material composed of titanium (or other metal) and carbon or nitrogen atoms, scientists around the world have taken up the task of seeing just how special it might be.

FLURRY_OF_EXPERIMENTS

Researchers in about 300 organizations in close to 40 countries have published research investigating ways to use the promising new material in a variety of applications. Drexel holds three issued patents related to MXene that cover broad composition of matter claims, with 10 more patents pending.

MXene was born from research inspired by the discovery of the amazing properties of two-dimensional graphite — called graphene. It builds on the idea that atom-thick materials could be the key to building smaller, faster electronics; improving energy-storage devices; adding impressive durability to products; and even repairing damaged neurons.

Researchers have already produced more than two dozen distinct MXenes with their own unique properties and identified more than 100 others that can be produced as stable materials.

Distinguished University and Charles T. and Ruth M. Bach Professor Yury Gogotsi, the principal investigator on the project that led to the material's discovery, says there is tremendous potential for MXene's use in energy-storage devices because it can hold and discharge electricity at exceptional rates without deteriorating. Its conductive properties can also be controlled and have even proven to be highly tunable.

Perhaps as important as any of the material's potential uses is the ability to produce it in large quantities. Gogotsi's lab can make as much as 100 grams of MXene at a time.

"The fact that it can be produced in 100-gram quantities in the lab is a breakthrough that clearly shows that its practical applications are real," Gogotsi says.

Since 2011, Gogotsi's MXene research has received more than $2 million in funding from groups that include the U.S. Department of Energy, the Army Research Office, King Abdullah University of Science and Technology in Saudi Arabia, the Qatar Foundation and members of industry.

_THE BREAKING POINT

A new finding expands scientists' understanding of how ***layered materials handle pressure****.*

Bend, but don't break. It's an approach to life, and also the way materials in nature are inclined to function.

New findings from Drexel researchers indicate that contrary to common understanding of how layered materials — everything from sedimentary rocks to atomic layers of graphite — behave when compressed, they actually form a series of ripples as they deform.

"Dislocation theory — in which the operative deformation micromechanism is a defect known as a dislocation — is very well established and has been spectacularly successful in our understanding of the deformation of metals," says Garritt J. Tucker, who was an assistant professor in the College of Engineering's Department of Materials Science and Engineering when the study was published. "But it never really accurately accounted for the rippling and kink band formation observed in most layered solids."

A 2015 paper published by a group at the Massachusetts Institute of Technology suggested a new deformation micromechanism — best described as an atomic-scale ripple — that they dubbed a "ripplocation."

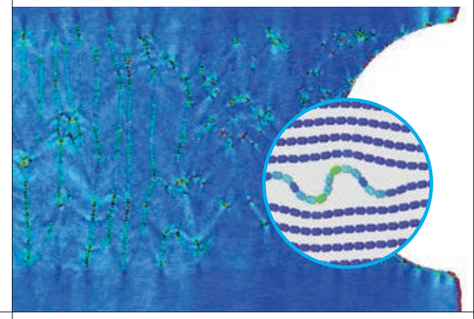
Inspired by the paper, Michel Barsoum, a distinguished professor in the Department of Materials Science and Engineering in the College of Engineering, and his team set about proving that ripplocation exists not only in near-surface layers of two-dimensional materials, as the MIT paper had suggested, but also throughout the internal layers of all layered materials. Through careful examination of computer models of compressed graphitic atomic layers, the researchers saw deformation consistent with ripplocation.

"We now have evidence for a new defect in solids; in other words, we basically doubled the deformation micromechanisms known," says Mitra Taheri, the Hoeganaes associate professor in the Department of Materials Science and Engineering.

The findings apply to most layered materials, including, quite possibly, geologic formations, says Barsoum.

RIPPLOCATION

Ripplocation, a rippling of internal atomic layers, is observed in a ceramic material when loaded parallel to the layers.



_AGING SECRET

A central riddle in the science of aging is that if the human body has evolved to protect itself, why can't cells cope with the challenges of getting old?

_ANDRES KRIETE

Kriete is associate dean for academic affairs and an associate teaching professor in the School of Biomedical Engineering, Science and Health Systems.

A study of quiescent (sleeping) human cells suggests that the body is hardwired to respond to aging with the same tactics it uses to fight off infections. Drexel researchers and colleagues at Thomas Jefferson University created an in vitro model to study quiescent cells — those that are not dividing and are most common in the body — and found that energetically stressed cells showed a signaling profile associated with cell survival inflammation. The results suggest that the body handles aging with a strategy similar to the way it fights off acute bacterial and viral infections. Findings were published in the journal *Frontiers in Genetics*.

The cellular instinct to survive acute challenges does not bode well for the ability to deal with long-term chronic stresses, according to the study's principal investigator.

"If cells are energetically stressed over longer periods of time, the survival response also impairs genome maintenance, which may explain why age is a risk factor for cancer," Professor Andres Kriete says.

_BUILDING A BETTER BORIDE

Oxidization can cripple even the most durable metals, but Drexel researchers have found a way to keep the elements from breaking down their borides.

COMBUSTION_ENGINES

Borides are used as coatings for surfaces that must survive the harshest environments, like the inside of combustion engines. Although some metal borides are among the hardest and most heat-resistant materials on the planet, they still oxidize at high temperatures.

Some metal borides are among the hardest and most heat-resistant materials on the planet, but like so many others they still oxidize at high temperatures. If not controlled, oxidation is often the death knell for the use of a material in high-temperature structural applications.

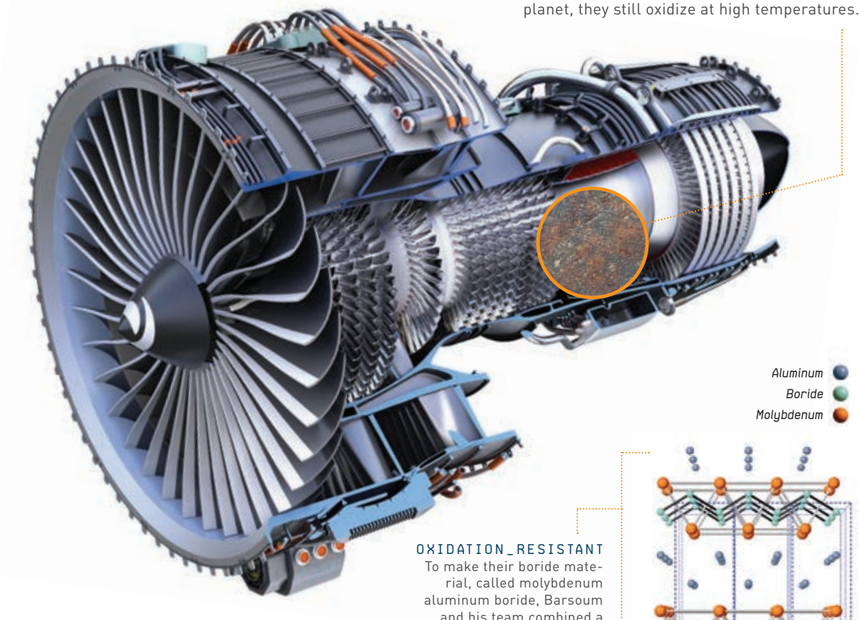
Researchers from Drexel, Linkoping University in Sweden and Imperial College London have produced an aluminum-layered boride that is uniquely resistant to oxidation at high temperatures, offering an upgrade to one of the most durable materials in production.

Borides are used as coatings for surfaces that must survive the harshest environments. But, according to Michel Barsoum, distinguished professor in the Department of Materials Science and Engineering and lead author of research published in *Scientific Reports*, we can make borides better.

"This discovery is quite significant because it is the first example ever of a transition metal boride that is quite oxidation-resistant," Barsoum says.

The findings have the team pointed in the right direction as they continue to search for game-changing materials, says Sankalp Kota, a doctoral student in Barsoum's research group and the paper's first author.

"Now we know we're looking in the right place to make materials with this impressive set of properties," Kota says.

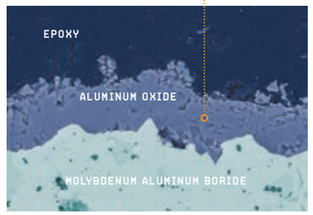


OXIDATION_RESISTANT

To make their boride material, called molybdenum aluminum boride, Barsoum and his team combined a molybdenum-boron lattice with a double layer of aluminum to produce a material durable enough to resist oxidation at extremely high temperatures. The key is the material's nanolaminated structure, in which layers of molybdenum boride and aluminum alternate.

HOW_IT_WORKS

When heated to high temperatures in air, the aluminum atoms selectively diffuse to the surface and react with oxygen — forming a SURFACE ALUMINUM OXIDE, or alumina, protective layer that slows down further oxidation considerably. In effect, the material forms its own protective coating.



+1400°C

Upon testing, the group also found the new material retains its high thermal conductivity at elevated temperatures. Its melting point hasn't yet been determined, but preliminary results show it to be greater than 1400 degrees Celsius.

ALESSANDRO FATATIS is a professor in the Department of Pharmacology and Physiology in the College of Medicine.

OLIMPIA MEUCCI is a professor and chair of the Department of Pharmacology and Physiology in the College of Medicine.

A CURE FOR CANCER'S SPREAD?

A drug compound in development at Drexel would give ***breast cancer patients the gift of precious time****, by keeping metastatic cells from seeding deadly new tumors. _by Lauren Ingeno _illustrations by Leandro Castelao _photo by Jeff Fusco*

IT WAS TOO LATE.

That's what doctors told then 41-year-old Tami Eagle Bowling, a former New York City advertising sales executive, on May 9, 2015.

Two weeks earlier, after a routine mammogram, she had gone from being a seemingly healthy mother of two toddlers to a breast cancer patient. Shocked and scared, she was also ready to fight. She prepared to have a double mastectomy.

But then she learned surgery wouldn't save her — the cancer had already spread to her liver. It was metastatic. And incurable.

While most breast cancer awareness campaigns are geared toward improving early detection and prevention, patients who succumb to the disease "almost never die from their primary tumor," explains Alessandro Fatatis, a cancer researcher and professor in the Department of Pharmacology and Physiology at Drexel's College of Medicine.

That's because most breast tumors can be successfully treated with surgery or radiotherapy. But in 30 percent of breast cancer patients, cancer cells have also spread silently — or metastasized — to the brain, bones, lungs or liver, only to be discovered months, or sometimes years, after a complete mastectomy or other therapies. In some cases, like Bowling's, a patient is diagnosed from the start with stage 4 breast cancer.

Scientists are struggling to understand why some patients have cancers that metastasize and others do not. Fortunately for Bowling, a new Pfizer drug called IBRANCE, which slows the progression of metastatic breast cancer, received accelerated approval by the Food and Drug Administration (FDA) just three months prior to her diagnosis. She now takes the drug in combination with hormone therapy, allowing her to avoid chemotherapy and remain largely asymptomatic.

Still, IBRANCE is not a cure. In clinical trials, the therapy was only effective for a little over two years. Bowling is learning to live in the present. But what she yearns for is more time.

"Every year in a child's life is so important," she says. "They have so many questions and so much to learn. One more year for my daughters to have me around will shape who they are as people forever."

KEEPING TUMORS AT BAY

In a corner of Fatatis' lab at Drexel, a graduate student is carefully removing metastatic tumors from a mouse that was treated with a drug candidate called FX-68.

The compound works by targeting circulating tumor cells that have leaked into the bloodstream. Rather than killing the cells directly, FX-68 blocks a particular pathway, which prevents the cells' ability to exit the blood, enter distant parts of the body and "seed" new tumors in surrounding organs.

It sounds counterintuitive — *killing* cancer is usually the goal, after all. But Fatatis is interested in finding a way to avoid "chasing the disease," or curing tumors as they arise. Every time you give cancer cells the chance to seed a new site and divide, he explains, the odds of cells accumulating genetic mutations and becoming resistant to drugs increases. His strategy, by contrast, is to prevent further seeding and extend the time doctors have to treat existing tumors.

By preventing new tumors from planting themselves in the body's organs, patients like Bowling could gain more time to live. Once the cancer cells are contained in the blood's circulation — rather than inside solid tumors, where they are often shielded from therapy — they become easier targets for more potent treatments, like immunotherapy.

"It's a more realistic, and also a more collaborative, approach," adds Olimpia Meucci, professor and chair of the Department of Pharmacology and Physiology in the College of Medicine. "Eventually, as more drugs come on the market, we can combine different approaches to treat the disease even better."

Meucci, who has an adjoining lab with Fatatis, has been collaborating with him on a series of research projects for more than 20 years. Over the past decade, this husband-wife team has been developing, testing and perfecting a series of compounds that they hope will one day treat patients with advanced breast and prostate cancers.

The pair met while in medical school in Naples, Italy, and spent summers together at the National Institutes of Health, where they were exposed to an environment that was "exhilarating in terms of the

resources and speed that you could complete experiments," Fatatis says. After earning medical and doctoral degrees in Europe, they began their careers as researchers at the University of Chicago. They joined Drexel's medical faculty in 2000, where they began searching for therapeutic targets to manage metastatic disease.

A decade later, thanks to funding from various sources, including the Coulter-Drexel Translational Research Partnership Program, Fatatis and Meucci were able to launch their cancer drug discovery program into Kerberos — a Philadelphia-based startup company.

The Coulter-Drexel program helps researchers commercialize inventions that improve human health, and since its inception 11 years ago, it has awarded nearly $8 million in proof-of-concept funds to 50 projects. To receive a grant, faculty members submit proposals to an oversight committee of the University and advance to a series of other rounds, where they are grilled with questions ranging from regulatory requirements to reimbursement strategies. Along the way, the researchers receive critical guidance on market analysis, company formation, intellectual property and regulatory pathways.

Fatatis and Meucci say the funding and direction they received through Coulter were "invaluable" in allowing them to launch their startup. "Drexel is exceptional in this regard, because this university environment really supports entrepreneurship," Meucci says.

As Kerberos seeks funding to test its compound in clinical trials, Fatatis and Meucci are prepared to face resistance from pharmaceutical industry investors, who historically are less than enthusiastic to tackle metastatic disease. But with a unique approach and promising pre-clinical results, the Drexel research team is optimistic that it can turn a pipe dream into a life-saving drug.

REDIRECTING SEEDS FROM SOIL

For many years, the oncology research community hypothesized that each metastasis in a cancer patient originates from *one* single tumor. Cancer cells from a breast tumor for instance, leave the original site, travel into a patient's blood, and then seed into bone, or liver, or brain. Once there, the cancer could lay silently dormant for months or years before growing into a new lesion.

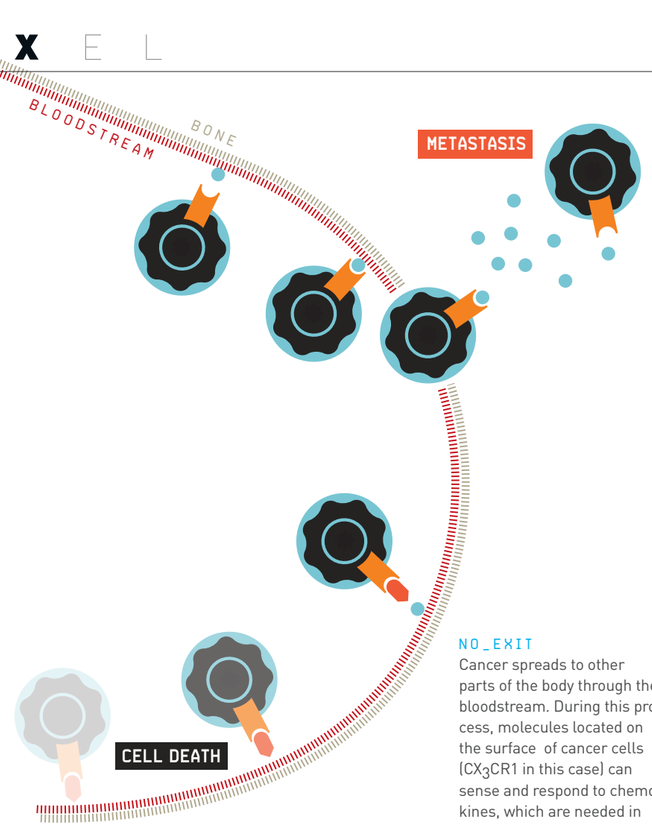
"The thought was that there was nothing you could do to stop new metastases from seeding, because the horse already left the barn," Fatatis explains. "Whatever tumor develops between now and the next 10 years, was planted long ago."

But more recently, new studies emerged that supported an entirely different school of thought: That in fact, in addition to the previous scenario, metastases themselves can actually seed *new* tumors or existing ones, even *after* the primary tumor is removed.

This evidence, supported by two separate 2015 studies, "completely changed the game," Fatatis says, and identified a new route for researchers to stop cancer from spreading. If existing metastases were able to mobilize cancer cells back into the blood, then, Fatatis thought, he would just need to find a way to keep them there. In the blood, cancer cells are vulnerable to spontaneous death. "A cytotoxic effect achieved without using a cytotoxic drug," Fatatis explains.

Coincidentally, Meucci is an expert in the pathology of chemokines — a large family of signaling proteins, which serve as the mediators of intercellular communications. Or more simply, "it's one of the key ways cells talk to each other," she explains. While the function of chemokines in the immune system has been well-documented, Meucci was exploring their lesser-known role in the central nervous system around the same time that her husband was studying metastases.

> BY PREVENTING NEW TUMORS FROM PLANTING THEMSELVES IN THE BODY'S ORGANS, PATIENTS GAIN MORE TIME TO LIVE. ONCE THE CANCER CELLS ARE CONTAINED IN THE BLOOD'S CIRCULATION... THEY BECOME EASIER TARGETS FOR MORE POTENT TREATMENTS, LIKE IMMUNOTHERAPY.



NO_EXIT

Cancer spreads to other parts of the body through the bloodstream. During this process, molecules located on the surface of cancer cells (CX_3CR1 in this case) can sense and respond to chemokines, which are needed in order for the cancer cells to cross from the bloodstream to the skeleton and other organs. Cancer cells can only survive in the bloodstream for a few hours, so migrating toward chemokines is essential for the cancer not only to spread but also to avoid death. Researchers are developing drugs that stop chemokines from engaging CX_3CR1, thus stranding cancer cells in the bloodstream, where they die.

CANCER CELL
CX_3CR1 PROTEIN
ANTAGONIST
CHEMOKINE

It turned out that a chemokine receptor could be the perfect target for stopping the spread of secondary tumors, because chemokine receptors, at least in part, are responsible for directing particular cancer cells to specific locations.

"Cancer cells use signals to disseminate to different sites in the body," says Fatatis. "They tend to go everywhere, but they *thrive* only on some specific organs. You don't hear about a brain tumor in a prostate cancer patient, but you often hear about a brain mass in a breast cancer patient."

What if, the researchers thought, they could simply cut off communication between cancer cells and the organs they metastasize? Unable to reach their final destination, the cells would be rerouted back to the blood, where they could do no harm, and eventually die off or be eliminated by other drugs.

Then in 2008, a breakthrough: Fatatis and Meucci identified that the chemokine-receptor pair CX_3CR1 was overexpressed in both primary prostate tumors and metastatic lesions in patients. This observation was extended to breast cancer patients in 2010. Further, studies from other groups showed that this particular receptor did more than control cell migration — it also seemed to promote the growth and survival of cancer cells. By targeting CX_3CR1 then, the research team could potentially stop secondary tumors from seeding new, multiple organs, while also shrinking the growth of existing lesions.

While a major development, the discovery still only solved one part of the equation. To block the cancer cells, they still needed a drug.

THE RIGHT PLACE AT THE RIGHT TIME

Enter Joseph Salvino.

Salvino, a medicinal chemist with over 20 years of industry experience and now a professor at the Wistar Institute, was an adjunct at Drexel in 2010 and was particularly interested in meeting the Italian scientists who had recently identified a new target to stop the spread of breast and prostate cancers.

Fatatis recalls that when Salvino approached him to ask if he could help with the project, "I told him I needed to block this chemokine receptor and had no way to do so."

Salvino's response? "Give me two weeks."

Salvino, impressed by Fatatis' initial results, was exhilarated by the meeting. "I liked the initial data, and I liked the target, because this class of receptors is very druggable," Salvino says now. "Also, [Alessandro's] a very interesting guy. He challenged me. I took the challenge."

Ten days later, Salvino handed Fatatis a vial and the collaborators got to work. Fours years later, the researchers had perfected the compound, which granted them entry into the National Cancer Institute's highly competitive anti-cancer drug development program, the Experimental Therapeutics Program (NExT).

When the group tested their lead compound — FX-68 — on pre-clinical animal models, they saw something remarkable: Not only did the drug candidate block breast cancer cells from seeding into the skeleton and soft-tissue organs, it also prevented the growth of already existing metastases. Their results were published in 2016 in *Molecular Cancer Research*.

Their next steps will be isolating the best drug candidate (they have 50 in the pipeline), and then securing investor funding to test the safety and efficacy of the drug in clinical trials. The team is optimistic, but cautious, about what lies ahead. Salvino offers this staggering statistic: Drugs in the pre-clinical trial phase have around a 90 percent failure rate.

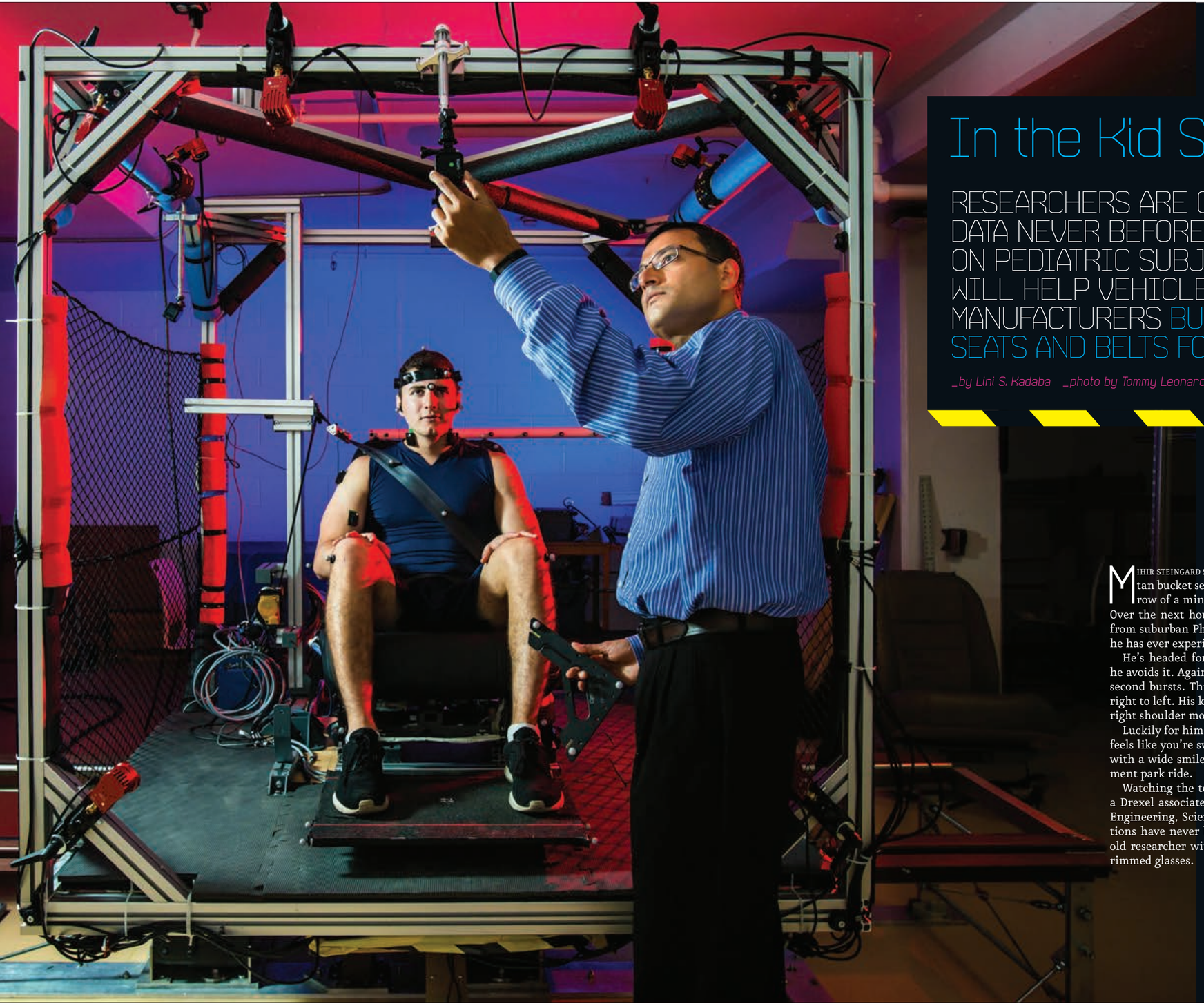
Still, the researchers have good reason to be confident. Their target, Salvino points out, is very selective, rather than "promiscuous," and their compound is a small molecule, which means the drug could be taken orally. Even more promising, the team's animal studies offer strong data that the drug can be effective for an extended period of time.

"Many times, with other cancers, a drug may work for a time, but then the tumor becomes resistant and comes back with a vengeance," he explains. "We haven't seen that so far."

Their studies also indicate that their leading compound is not toxic. "Unlike chemotherapy drugs, when we treated cancer cells in a dish with our compound, the cells did not die," Fatatis says.

All that's to say that the research team may one day soon be enrolling patients like Tami Eagle Bowling into a clinical trial.

"I think a new drug to give me more time is much more likely than finding a cure during my lifetime," Bowling says. "I'm hoping to live long enough for the next scientific breakthrough."



In the Kid Seat

RESEARCHERS ARE GATHERING DATA NEVER BEFORE AVAILABLE ON PEDIATRIC SUBJECTS THAT WILL HELP VEHICLE RESTRAINT MANUFACTURERS BUILD SAFER SEATS AND BELTS FOR CHILDREN.

_by Lini S. Kadaba _photo by Tommy Leonardi

Mihir Steingard settles into a contraption that includes a tan bucket seat, the type usually found in the second row of a minivan, and clicks the seatbelt into place. Over the next hour at Drexel University, the 11-year-old from suburban Philadelphia takes a ride like none other he has ever experienced before.

He's headed for a car crash, but at the last moment, he avoids it. Again and again, 10 times in a row, in eight-second bursts. This time, his slender torso slaloms from right to left. His knees lurch one way, then the other. His right shoulder moves in and out of the seatbelt.

Luckily for him, this is a simulation of a near crash. "It feels like you're swerving in a car," Mihir says afterward with a wide smile, likening the experience to an amusement park ride.

Watching the test unfold is Sriram Balasubramanian, a Drexel associate professor in the School of Biomedical Engineering, Science and Health Systems. "These conditions have never been studied before," says the 39-year-old researcher with a boyish face and rectangular wire-rimmed glasses.

In fact, all of this herky-jerky recreates what happens in the microseconds before a car crash. Imagine Mihir's mother, Nimisha Ladva, driving on a highway at a nice clip with Mihir buckled into his seat. A car cuts in front of her. She veers back and forth in the hope of avoiding a collision. In that moment, their bodies move wildly side to side. Mother and son are sharply thrown in and out of the ideal position for their seatbelts to best protect them.

Would they survive without injury?

Chances are, the adult will be much better protected than the child. That's because an abundance of data exists on how vehicle restraint systems work with adult test subjects. But studies involving child subjects are more rare.

The wild ride that Balasubramanian simulated in the lab may provide the crucial answer, particularly in the case of young passengers — and in the process, save lives of children and prevent injuries.

"We want to understand what happens during this crash-avoidance phase," he says. "Even with the best restraint system, if you're sub-optimally positioned, it may not provide the best protection."

This crash safety study, and two others over the past dozen years led by Children's Hospital of Philadelphia (CHOP) that also involved Balasubramanian, are the first ever to evaluate actual, living children — not just pediatric crash-test dummies or cadavers.

Currently, boys as young as 9 years old are being tested in a device Balasubramanian calls an oscillating human-accelerator sled. The box-like structure with an automobile seat that slides right to left along an 8-foot track exerts a maximum acceleration of about 0.75g, what Balasubramanian describes as "a good poke." The clues found here are expected to inform the design of crash-test dummies and automobile restraint systems in years to come.

Balasubramanian is one of those keen on leading the charge.

The team's initial step, completed in 2016, was to design the world's first and only oscillating sled. The apparatus mimics the emergency swerving maneuvers of a typical driver by way of low-acceleration time extended (LATE) events, slowing down what actually happens in a blink of an eye.

Crash avoidance tactics are an area within the field of impact bio-mechanics that are of increasing interest to vehicle manufacturers. In the real world, 60 percent of crashes involve some type of avoidance maneuver — usually either hard braking or, as in this study, swerving — according to the Institute for Traffic Accident Research and Data Analysis in Japan.

Balasubramanian first explored child-injury prevention research in 2006, when he joined CHOP as a senior research engineer. Since moving to Drexel in 2010, he has continued this line of work in collaboration with CHOP colleagues.

The LATE sled came together over the span of a year. Together, CHOP and Drexel colleagues worked with a California engineer responsible for various innovative designs in automotive testing. Then the team assembled the occupant compartment from scratch. The imposing structure sits in a basement lab inside of One Drexel Plaza at 31st and Market streets.

Given that crashes are the leading cause of death and acquired disability for children, the stakes are high, says Kristy Arbogast, co-director of CHOP's Center for Injury Research and Prevention and principal investigator of the LATE study. Balasubramanian is a co-investigator. Since 2003, Takata Corp., the Japanese company known for manufacturing a large share of seatbelts and airbags, has awarded $5.4 million in grants for the studies, including $2.5 million for the current, five-year project.

According to the National Highway Traffic Safety Administration's most recent data, every day on average in 2016, three children under the age of 15 were killed in U.S. traffic crashes, and in 2015, nearly 500 injured. That adds up to 1,233 deaths — about 3 percent of all fatalities in 2016 — and 178,000 injured.

Historically, motor vehicle crash death and injury rates have plummeted with the advent of better restraint systems and other safety measures to protect vehicle occupants. The safety administration's statistics on children represent a 27 percent drop in the number killed compared to 2007 and a 14 percent decline in those injured compared to 2006.

Of course, a death of even one child is one too many. "This type of work is necessary to chip away at these numbers," Arbogast says, "until we have zero."

Arguably, the easier fixes have been done. What's left is more complex and goes beyond the dynamics during a crash.

3

Number of children under the age of 15 killed in U.S. traffic crashes every day on average in 2016.

27%

Drop in the number of children under the age of 15 killed in 2016 compared to 2007.

In 2006, Balasubramanian spent the first day of his new job at CHOP at New Jersey's Six Flags amusement park — all in the name of serious science, of course.

Balasubramanian was rigging bumper cars with accelerometers to measure speeds as the cars banged about. His project was to create a safe human accelerator, safe enough to study children using low-speed impacts.

The bumper car data was the ideal foundation for the first frontal-impact sled suitable for testing pediatric volunteers in non-injurious, but dynamic, conditions. The research conducted from 2006 to 2009 became known informally as the "Bumper Car Study," Balasubramanian says.

Looking at subjects age 6 to 40 years, it found that during frontal collisions, children move more than adults because of the inherent flexibility of pediatric spines. This is significant. Pediatric crash-test dummies are scaled-down versions of adult models, which are mainly designed based on cadaver testing. In other words, the child dummy did not account for important physiological differences between children and adults. Or how bracing — that is, muscle tensing — can play a role.

"The dummy is only as good as the data that went into validating it," Balasubramanian says.

That's why sled tests on child volunteers are so important.

"The crash-test dummy has gotten us really far," Arbogast says. "But to take that next level and improve on protection, we have to use other tools."

Published in 2009 in the well-regarded *Stapp Car Crash Journal*, the work was recognized with a best paper award at the 2010 Stapp Car Crash Conference.

A subsequent study, "Bumper Car Study No. 2," used the sled to understand oblique and lateral impacts. It began in 2010, the year that Balasubramanian, by then co-director of CHOP's Center for Child Injury Prevention Studies, joined Drexel. Similarly, it showed that the increased mobility of children results in inaccurate estimates of occupant motion during tests. It also evaluated the countermeasure of motorized seatbelts, which alert to an impending crash (using radar and other vehicle sensors) by tightening any belt slack. The study demonstrated the upper torso of an occupant is better kept in place during evasive maneuvers when the seat belt is motorized.

Over the years, Balasubramanian and Arbogast have worked closely with Takata engineers looking to offer protection beyond current requirements, according to Mike Scavnicky, who was until recently the vice president of core engineering for Takata North America. Last summer, Takata declared bankruptcy after faulty inflators on its airbags were linked to at least 14 deaths and the largest worldwide automotive safety recall in history; most of its assets were acquired by Key Safety Systems in November.

Despite the change in Takata's fortunes, the research will continue under a new company named Joyson Safety Systems, says Scavnicky, who is staying on in a similar role. Joyson will continue to support the project and use the results to improve restraint designs. "We design to the current industry standards," he says. "But we also want to make sure our restraint systems perform well in the real world across all the occupants of the vehicle."

Current standards assume the occupant is centered on the seat in a neutral, upright posture at the time of the crash. Of course, that is not reality — certainly not when it comes to children.

"Seatbelts might be perfectly positioned before a crash, and then, when the swerving starts, you come out of the seatbelt or move into the seatbelt," says Balasubramanian, who drives a 2006 Honda Odyssey that he jokes barely runs. "If you are completely out of the seatbelt and then go hit a pole, well, good luck."

That's why automotive crash safety has moved away from crash-injury prevention to actual crash avoidance, he says.

Many cars already carry sensing technology to detect impending crashes and can respond by autonomously applying brakes or swerving out of the way. The LATE research also is proving relevant as the automobile industry shifts toward self-driving vehicles.

The LATE study of 40 boys and men in four age groups ranging from 9 to 40 years old examines two different types of seats and five different conditions to document the amount of movement that occurs during emergency maneuvers and the effectiveness of countermeasures.

Occupants are tested in both relaxed and braced positions with a regular seatbelt. In another run, subjects are put through paces in a relaxed position but with a motorized seatbelt. Finally, a seat with a back bolster is evaluated with inflation that holds the passenger in place and then with a motorized seatbelt but no inflation. Researchers at the University of Virginia will conduct further studies at higher speeds on cadavers.

"Through these five different tests, we want to understand the effects of age, size, bracing, the restraint type and the resulting forces," Balasubramanian says.

Before Mihir entered the sled, various measurements were taken, including his torso width, seated height and distance between core to knees. Dressed in a tank top and athletic shorts, the sixth grader's body and face were prepped with surface EMG electrodes to measure muscle activity and photo-reflective markers to capture motion. The occupant compartment has eight motion-capture cameras and three GoPro cameras located in the front, sides and overhead.

For 30 minutes before the simulation, Mihir did a variety of exercises (curling his bicep, flexing his quad, pulling on a bar to engage his trapezii) that measured maximum voluntary isometric contractions and helped establish a baseline for comparisons with the test data, explains Christine M. Holt, a 28-year-old Drexel doctoral student in biomedical science who Balasubramanian and Arbogast co-advise.

More than most, Holt has a vested interest in this research and the tests she helps run and analyze. When Balasubramanian invited her to join the LATE study in 2014, she had just lost a friend to car crash two days earlier.

"I felt it was the way the universe was telling me that this is something I should get involved with,"she recalls.

Holt, who was a key member of the team that built the occupant compartment on the oscillator sled, describes the research as "amazing. … This project provides the missing puzzle piece to crash safety." Its translational nature has convinced her to pursue industry work after her expected graduation in 2019, she says.

The baseline tests completed, Mihir climbed two steps and entered the sled. He faced a white wall with large traffic decals and street signs. Dashed lane markings wound across the floor.

_ONLINE
The oscillating sled was shown in an episode of the Discovery Channel's Daily Planet last year and can be viewed at **EXELmagazine.org.**

The decorations make the space more child friendly but also serve another role: They reduce motion sickness. So far, Holt says, no one has thrown up.

Mihir was urged to sit back and relax. Then, showtime!

He was warned the sled would move anytime within a 10-second countdown. When it did, he was unexpectedly jolted side to side in 6-foot spurts. He kept a smile plastered to his face throughout.

Afterward, the youngster allows "that was pretty fun. I liked it." He also observed that the seat with the inflated bolster held him more securely. "I didn't flop over," he says. The motorized seatbelt, he adds, "was not as comfortable as the bolster, but it worked way better."

His mother says the research reassures her. "It's good to see," Ladva says, "there is the possibility of safer and safer cars."

> *"Through these five different tests, we want to understand the effects of age, size, bracing, the restraint type and the resulting forces.*

In a corner of his office, Balasubramanian keeps a model of a pediatric spine. His bookshelves are replete with anatomy, orthopedic and mechanical engineering texts. The white board is crowded with mathematical equations and graphs.

He didn't plan to research child crash safety. After a bachelor's in mechanical engineering from Regional Engineering College in Jalandhar, India, Balasubramanian pursued graduate studies in the United States. At Kettering University in Flint, Michigan, he traveled with his professor to Wayne State University in Detroit to perform cadaver experiments. The lifelong vegetarian says he was not fazed:

"You have this human cadaver and you have to instrument it … and essentially make it a crash-test dummy. It was very interesting for me to see how these studies are going to inform what will be. Sometimes we take for granted that a seatbelt does this, an airbag does this. Somebody designed it and tested it through these rigorous means."

Based on his research, he secured a biomedical engineering doctoral spot at Wayne State to test knee-injury tolerance in humans through study of human cadaver knees. According to Balasubramanian, the results inform standards in Europe and Japan for the knee slider, a type of sensor used in their crash-test dummies to determine vehicle star ratings.

"My study might have dinged many stars for many cars," he says with a wide smile. "But it's a good thing. You go back and redesign whatever structure and get a better star rating."

Since joining Drexel's faculty, he has expanded his research focus to also include the development of computational models to explore surgical interventions for scoliosis.

From the get-go, Balasubramanian has been attracted to translational work. "Usually, academic research sits on a shelf for a few years, often never seeing the light of day," he says. "This is very applied research."

When it comes to car safety, this project's sled tests will ultimately lead to better-designed restraints.

"It is directly going to go into an automobile environment," he says, "and it's going to save somebody's life."

_ONLINE
To see more of the fossil samples from the expedition, visit **EXELmagazine.org.**

PALEONTOLOGY

_FISHING FOR FOSSILS IN ANTARCTICA

An expedition to one of the most inhospitable climates on the planet brought home a treasure trove of ***390-million-year-old fossils*** *for researchers at the Academy of Natural Sciences of Drexel University.*

One of the over 630 cataloged specimens the research team shipped back from Antarctica. The samples shipped back weighed 500 pounds.

_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 of Drexel University.

TED DAESCHLER

NO_MAN'S_LAND
"This is the closest thing to being on Mars here on Earth. There are no living things like birds or plants. There's lichen and microbes. That's it."
— Ted Daeschler

Last winter, an international research team including Ted Daeschler from the Academy of Natural Sciences of Drexel University went prospecting for fossils in Antarctica, and they found what they were after.

They went in search of evidence of the evolution of fishes during a critical interval in Earth's history that saw the rise of the first limbed animals, and came back with an array of 390-million-year-old fossils so large it qualifies the Academy as a center of research on Devonian-age Antarctic fossils. The samples shipped back weighed 500 pounds and included 630 cataloged specimens.

The Devonian fauna included certain species of fish that evolved muscular "lobed" fins that enabled them in some cases to move on land for short stretches. Their descendants gave rise to all limbed animals on Earth.

Daeschler and a team of researchers from four universities traveled to the Transantarctic Range, a portion of the 2 percent of the southernmost continent that is not covered in ice year-round, in December 2016 and January 2017.

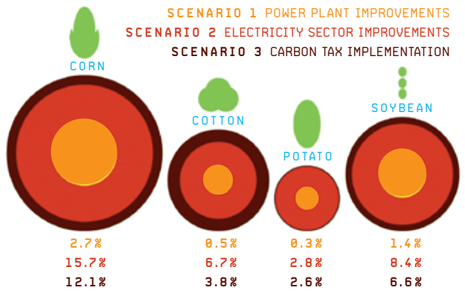
"We're looking at the diversity and distribution of vertebrates there and trying to find centers of evolutionary change," Daeschler says shortly before the journey, which required two days of travel to New Zealand followed by an eight-hour leg on a military cargo plane. "Hopefully we'll also find species new to science."

The team explored deposits of sandstone and siltstone in a portion of Antarctica that was much warmer and wetter 390 million years ago than it is now. They found bony plates from long-ago armored fish, primitive shark teeth, and the remains of early ray-finned and lobe-finned fish.

The trip was part of a three-year research grant funded by the National Science Foundation. A second expedition is slated for winter 2018–19.

_PLANT POWER

The clean power Plan as finalized by the Environmental Protection Agency in 2015 wouldn't just be good for human health. Regulation of carbon dioxide emissions in the energy sector could also enhance yields of food plants and trees, likely saving farmers millions of dollars, according to research published by a Drexel researcher and her colleagues at Syracuse University, Boston University and Harvard University.



Researchers estimated productivity reductions of indicator crops and tree species resulting from three sets of carbon emission reductions policy options.

According to the study, reduction in carbon, nitrogen and sulfur emissions from coal power plants would lead to a decrease in ground-level ozone — a known inhibitor of plant growth. By modeling the EPA's reductions for the year 2020, the researchers found that they would provide a significant boost to the productivity of key indicator crops, such as corn, cotton, soybean and potato, as well as several tree species.

"Our findings suggest that crops like corn, soybeans and cotton could benefit from substantial productivity gains under moderate carbon standards for power plants," says Shannon Capps, an assistant professor in Drexel's College of Engineering and lead author of the study. "With policies similar to those in the Clean Power Plan, we're projecting more than a 15 percent reduction in corn productivity losses due to ozone exposure, compared to business as usual, and about half of that for cotton and soybeans. Depending on market value fluctuations of these crops over the next few years, that could mean gains of tens of millions of dollars for farmers."

The study was the first to model the ecosystem impact of policy options for reducing carbon dioxide emissions.

The team used three policy scenarios and they compared each policy scenario with a "business-as-usual" reference case that represents current clean air policies as well as energy demand and market projections.

"The option most similar to the Clean Power Plan has the greatest estimated productivity gains for the crops and trees that we studied," Capps says.

_AN UNEXPECTED GUEST

Researchers at the Academy of Natural Sciences of Drexel University found a ***foot-tall, dinosaur-era alga*** *that had never previously been discovered in North America.*

Imagine you're at work and a cheetah pokes its head through your window.

That's roughly what Richard McCourt and his colleagues experienced when they came across *Lychnothamnus barbatus*, a large green alga that was thought to have died out in the Western Hemisphere long before the last of the cheetahs roamed here.

"This means mainly that we don't know as much about what's out there as we could," says McCourt. "*Lychnothamnus barbatus*' survival isn't, per se, ecologically earth-shaking, but it changes our view of what the algal flora of North America is composed of and inspires us to keep hunting for more new finds."

A paper on the find, featuring mapping and analysis by Academy researcher John D. Hall and lead-authored by Kenneth Karol of the New York Botanical Garden, was published in the *American Journal of Botany*.

The team took algae samples from 14 lakes in Wisconsin and two in Minnesota between 2012 and 2016 and found the surprising results. The only record of the alga on the western side of the Atlantic Ocean was in Argentinian Cretaceous-era fossils from the same time period as *Tyrannosaurus rex*, and it had never been seen in North America.

"Almost right away we knew we might be dealing with something previously thought to be extinct because it was clearly different from any other species seen in North America," McCourt says. "But we had to look at it closely to confirm the identity and also extract the DNA to confirm."

_RICHARD MCCOURT
_JOHN D. HALL
McCourt is a professor in the College of Arts and Sciences and director of the Center for Systematic Biology and Evolution at the Academy of Natural Sciences of Drexel University; Hall is an Academy researcher.

ALGA: PAUL SKAWINSKI, UNIVERSITY OF WISCONSIN EXTENSION

Much like cheetahs, *Lychnothamnus barbatus* is relatively rare in the areas it is currently found. A "stonewort" type of alga, it is known to inhabit areas of Europe and Australasia (the area of Australia, New Zealand and Papua New Guinea).

But this species actually grows relatively tall and has a pretty distinct shape to it, raising the question of how it was missed.

"We might not have been missing it — it might be a new invader," McCourt says.

_MOSS AND HIDDEN POLLUTION

A sampling of ***naturally growing*** Orthotrichum lyelli *moss from Portland, Oregon, exposed previously undetected sources of industrial pollution.*

Moss, that ubiquitous tree hugger of the Pacific Northwest, can be an inexpensive, effective tool for identifying pollutants in cities where it commonly grows, according to a Drexel study.

The study of naturally growing tree moss at more than 300 sites across Portland, Oregon, was a joint project between the U.S. Department of Agriculture's Forest Service and researchers from Drexel's Dornsife School of Public Health.

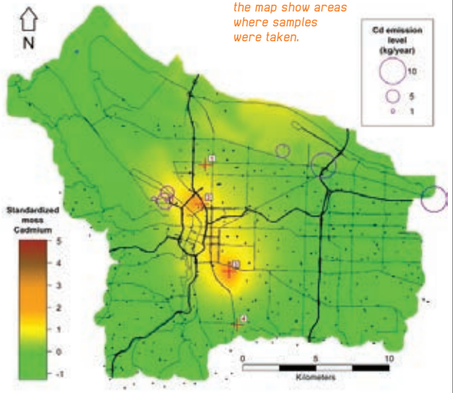
Moss has been established as a bio-indicator for chemicals in the air for some time, but this study used the moss in a new way.

"What's unique about this study is that we used moss to track down previously unknown pollution sources in a complex urban environment with many possible sources," says Sarah Jovan, a research lichenologist with the Forest Service.

Jovan was joined by Geoffrey Donovan, Demetrios Gatziolis, Michael Amacher and Vicente Monleon from the Forest Service, and Igor Burstyn and Yvonne Michael, both associate professors in the Dornsife School of Public Health, as co-authors for the study, which was published in *Science of the Total Environment*.

The research team collected *Orthotrichum lyelli* moss in late 2013 using a modified, randomized, grid-based sampling strategy.

When tested, the samples indicated two distinct hotspots for cadmium. These fell outside of the area where cadmium was expected to be higher, where companies with permits for cadmium emission were located. Within each hotspot, there was a stained glass manufacturer that used cadmium (sometimes used in pigments) in production. Neither company was required to have cadmium emissions permits and both voluntarily stopped using cadmium after the monitoring results were made public.



Moss samples indicated two previously unknown hot spots (in red) for high cadmium levels. The black dots on the map show areas where samples were taken.

MAP: SARAH JOVAN, U.S. FOREST SERVICE

_YOUNG URBAN SCIENTISTS

Four hundred fourth-, fifth- and sixth-grade students in the federally designated "Promise Zone" of West Philadelphia will have the opportunity to study local ecology with resources made possible through a three-year, $1.17 million grant from the National Science Foundation.

The project is called "Philly Scientists: Mapping Biodiversity of the Philadelphia Promise Zone." The goal is to foster immersive science learning experiences for students who live or attend school in the Promise Zone, a federal designation given to a handful of socioeconomically disadvantaged urban communities earmarked for preferential economic development treatment. Drexel's School of Education researchers are partnering with Philadelphia teachers and out-of-school providers to provide local students with science, technology, engineering and math (STEM) learning opportunities.

The initiative builds upon previous NSF-developed mobile apps and curricular activities to design and study an immersive, mentor-guided biodiversity field experience and career awareness program.

Students are learning to identify all species of animals, birds and insects over a two-square-mile region located in Mantua, Powelton and West Philadelphia through the NSF Innovative Technology Experiences for Students and Teachers (ITEST) project. Scientists from the Academy of Natural Sciences of Drexel University will guide students in the study of biodiversity and the generation of solutions to increase urban biodiversity for their schoolyard and neighborhood. The project began in September 2016 and will run through August 2019.

_NANCY SONGER
Songer is dean of the School of Education.

"This is a wonderful opportunity to have Philadelphia youth partner with professional scientists to gain an understanding of local science and apply their knowledge in important ways, including making sound recommendations to improve our neighborhood."
– Nancy Songer

"This is a wonderful opportunity to have Philadelphia youth partner with professional scientists to gain an understanding of local science and apply their knowledge in important ways, including making sound recommendations to improve our neighborhood," says Nancy Songer, dean of the School of Education. "We saw firsthand the positive impact a project like this had on children in Detroit, and we are thrilled to bring a similar opportunity to children just beyond Drexel's campus."

Researchers have adapted an existing mobile app to fit Philadelphia's unique environment and the age range of participating students. This May, three teachers and 75 students served as "Urban Animal Trackers" to gather and analyze data for their solutions.

ICHTHYOLOGY

_COMMON CORE

An excavated Belgian quarry provides some of the earliest evidence of ***schools of different fish species using a common nursery*** *to raise their young.*

A team of scientists uncovered a rare fossil site believed to be among the earliest evidence of different fish species using the same nursery.

A quarry in Strud, Belgium, excavated between 2004 and 2015 by French and Belgian scientists, was home to multiple species of placoderms, which are extinct, armored fish that represent some of the earliest jawed vertebrates on Earth. The site yielded smaller-sized fossils showing that immature placoderms occupied the area in the Devonian period, an era predating the dinosaurs by hundreds of millions of years. No mature fish were found, indicating that the fossils were part of a nursery, according to a study published in *PLOS One*.

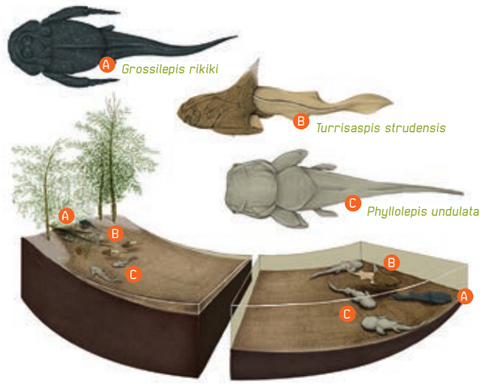
The abundance of juveniles from three different types of placoderm fossils — *Grossilepis rikiki*, *Turrisaspis strudensis* and *Phyllolepis undulata* — opens questions for scientists like Ted Daeschler, an associate professor in the College of Arts and Sciences and associate curator of vertebrate zoology at the Academy of Natural Sciences of Drexel University. Daeschler co-authored the paper with Sébastien Olive, then a post-doctoral fellow at the Academy.

"This is the first time that it can be demonstrated that several species seem to have used a common nursery," Daeschler says. "It makes us wonder: Has that been a common reproductive strategy through time?"

Ultimately, Olive and Daeschler hope the Strud site provides a lens through which scientists can study current conditions.

"Geologists say that the present is the key to understanding the past. But we can also say that the past is the key to understanding the future," Olive says.

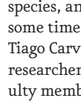
FISHING_HOLE
An artist's depiction of how fish used the Strud nursery ecosystem, including the three different placoderm species discovered at the site.



ICHTHYOLOGY

_TINY CATFISH

It took nearly four decades, but an elusive eyeless catfish measuring less than an inch has finally been given a name and a detailed description by researchers from the Academy of Natural Science of Drexel University.



SMALL_FRY
Shown here at full-size, one of two *Micromyzon orinoco* specimen caught in the Orinoco River were finally placed in the taxonomy nearly 40 years after being found. The species pair provide an example of the evolutionary and biotic link between fishes in the Orinoco.

Two specimens of the catfish, now named *Micromyzon orinoco*, were caught in the Orinoco River near Ciudad Guyana in Venezuela in an expedition from 1978–79. But taxonomy isn't so simple as picking out a name, says John Lundberg, emeritus professor in the College of Arts and Sciences and emeritus curator of the Academy, who was the chief scientist on the expedition.

"We knew what these fish were upon capture," Lundberg says. "But the devil is in the details."

Careful examination and comparison of existing species must be done to properly identify a new animal species, and that can take some time. Lundberg and Tiago Carvalho, an Academy researcher who is also a faculty member at the Federal University of Rio Grande do Sul, were able to co-author the description of the species with ichthyological collaborators based in California, Alabama and Brazil.

ECOLOGY

_SOMETHING'S IN THE WATER

Researchers have developed a ***new way to measure freshwater quality*** *using microscopic algae called diatoms.*

The key to measuring dangerous levels of nutrients in freshwater streams might lie in the microscopic organisms swimming through them.

A team largely of researchers from the Academy of Natural Sciences (namely research scientist and professor in the College of Arts and Sciences Don Charles, researcher Thomas Belton, and former rsearch scientist Sonja Hausmann) analyzed data from 1,400 freshwater Mid-Atlantic streams to see whether a group of tiny algae called diatoms might be efficient indicators of overly high nutrient levels, termed "eutrophication."

Eutrophication — caused by runoff of agricultural fertilizer, sewage and other forms of pollution — feeds algae and plants in water to the point of overgrowth. The algal blooms can cause low dissolved oxygen and fish kills.

The team found a new way to use diatoms' particular sensitivity to nutrients as a measuring stick.

They call it the Diatom Biological Condition Gradient, or BCG. "The BCG has an advantage over other nutrient indicator metrics because it can be used to identify boundaries along the nutrient concentration gradient that separate unimpaired from impaired sites," says Charles.

The Academy-based team's research found that the composition of diatom species correlated with New Jersey water quality. Diatom species in waters considered unimpaired were largely made up of surface-attached species; diatoms in water considered impaired were motile — having the ability to move. The changeover occurred primarily at the split between level three and level four on the biological condition gradient.

Biological condition gradients methods were created by the U.S. Environmental Protection Agency to provide objective standards for assessing the health of freshwater systems. The scale ranges from level one, a pristine waterway, to level six, which stands for the most ecologically stressed habitats.

Without a uniform scale, states are left to their own devices to grade their water.

A colorized scanning electron microscope image of a diatom.

STRUD: JUSTINE JACQUOT-HAMEON/PLOS ONE; DIATOM: DIANE WINTER

_MUSEUMS? THERE'S AN APP FOR THAT

A new project offers patrons a chance to discover museums in their area and museum leaders a chance to better understand their communities – all in the form of a website and mobile app.

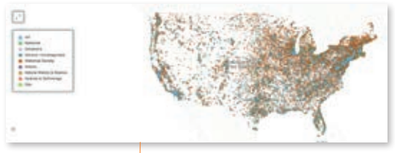
There are more than 30,000 museums spread across the United States, and a new online resource can tell you about every one of them.

MuseumStat is the first comprehensive documentation of museums across the country. It was developed by Drexel researchers in the Westphal College of Media Arts & Design to help museum leaders better understand museums and their role in our communities, and its associated iOS app, MuseumFinder, can reveal museums just around the corner through its location-based GPS search.

"This project is a direct result of how we can leverage the power of data and technology to help the nation's museums and the communities they serve," says Neville Vakharia, an associate professor and research director, as well as program director of arts administration in Westphal. "In an increasingly digital and knowledge-driven world, MuseumStat can serve as the means by which museums can better tell their stories, reach new audiences and demonstrate their impact."

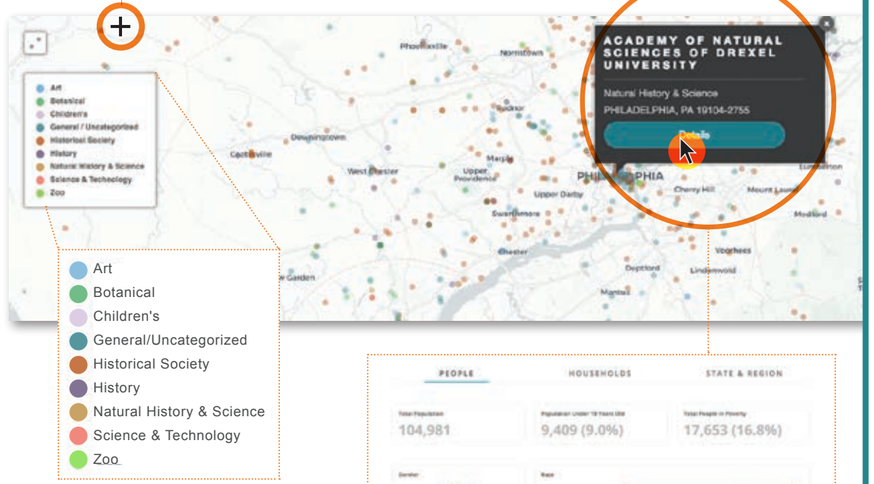
The project developed thanks to a cooperative research grant from the Institute for Museum and Library Services.

Vakharia worked with students from Westphal and the College of Computing & Informatics to gather and decipher data and plan and code the components.



30,000

Approximate number of organizations in the Institute of Museum and Library Services' Museum Universe Data File whose information is included in the MuseumStat system.



FOUND_ART
MuseumStat is a crucial tool for museum leaders, researchers, advocates and policy makers working to understand museums' scope and seeking to create exhibits and programs tied to their surrounding communities, says Vakharia.

Information helps to plan programming and outreach, improve casemaking to grant-makers, and generate analyses to enhance community impact.

Indicates community health and well-being, accessible through maps, charts and graphs. A wide range of museums are identified as community assets and potential partners.

Data help researchers to understand the potential reach of museums in communities. Data are provided for download to allow for wide use and analyses.

Selecting a specific museum from the search bar will display a page for the museum and show its location on a map with surrounding museums within a one-mile default radius.

Below the map are data on individuals and households in the area along with regional and statewide comparisons of museums.

BODY BY DESIGN

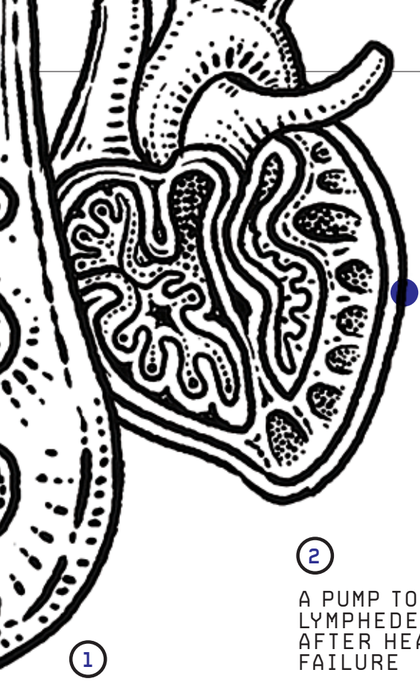
- HEART
- TISSUE
- BONES
- BRAIN
- PROCEDURAL
- MISC
- MUSCLES

A DREXEL EDUCATION HAS always been about solutions. Every day inside classrooms and labs, students and faculty work alongside each other in search of a better procedure, a stronger material, a smarter gadget — a continual collaboration in innovation. Perhaps no school within the University epitomizes this more than the School of Biomedical Engineering, Science and Health Systems (BioMED).

In the spring of 2017, in a quiet room filled with posters presented by BioMED seniors, the next generation of solutions was on display. Over the course of two days, students unveiled their final projects, each one answering a specific question that has troubled the medical community: How can clinicians in the field better identify when a traumatic brain injury has occurred? How can doctors apply epidural steroid injections without risking nerve damage? Is there a way to deliver melatonin in tune with nature's rhythms so patients can sleep through the night and limit the effects of dementia? And so on.

Most of the projects detailed in the following pages are only exciting preliminary concepts — for now. But each is a blueprint for a plausible product or process that addresses some of the trickiest problems in medicine.

_by Ben Seal / _illustrations by Katie Scott



1 CHANNELING BLOOD FOR PEDIATRIC HEART PATIENTS

_PROBLEM
There are 400 pediatric heart transplant surgeries each year, and 10,000 to 20,000 pediatric patients each year would benefit from a long-term blood pump, but there are no total artificial hearts approved for pediatric clinical use.

_SOLUTION
An optimized channel for the blood being moved by a pediatric cardiac pump, allowing the flow from a patient's pulmonary vein to be distributed uniformly to both the left and right ventricle. A flat profile would allow the pump to fit into a child's chest, with shunts to redistribute flow to all sides of the pump and peaked edges to help guide the flow.

2 A PUMP TO LIMIT LYMPHEDEMA AFTER HEART FAILURE

_PROBLEM
In patients with congestive heart failure (expected to be a population of roughly 3 million by 2020), inadequate blood flow can lead to lymphedema, in which excess fluid in the veins causes swelling in the legs. There is no currently available, minimally invasive treatment device.

_SOLUTION
A roller pump the size of a pacemaker that can be implanted in a patient to overcome pressure in the venous system and return lymphatic fluid into circulation. The acrylic and aluminum roller pump prototype the team designed could advance the development of an implantable device that would be able to alleviate lymphatic congestion and mitigate the potential byproducts of heart failure.

TISSUE

3 BUILDING BETTER IMITATIONS OF BIOLOGICAL TISSUE

_PROBLEM
Electrospinning, a common technique used in tissue engineering studies, fabricates nanofiber matrices with exceptional mechanical strength made from biocompatible polymers. But current spinning devices can only enable in-plane control of the fibers' alignment. A tool is needed that can better mimic the 3D architecture of biological tissues.

_SOLUTION
A new spinning device that allows for continuous through-plane control by integrating a rotating collection plate to collect an aligned nanofiber layer and rotate it, allowing another layer to collect on top and enabling through-plane control. The team's testing revealed continuous control of the collection plate angle, which would allow the device to produce scaffolds more closely aligned with native biological tissue.

4 A SMARTER WAY TO GRIP TISSUE WITHOUT DAMAGE

_PROBLEM
Laparoscopic graspers are surgical tools used in minimally invasive procedures to safely manipulate tissue. No method currently exists to modulate the force applied by surgeons, which often leads to tearing and bruising of tissue, resulting in greater patient pain and longer recovery times.

_SOLUTION
By placing sensors at either end of the grasper, along with a braking mechanism and an electromagnet in the middle of it all, the team designed a tool that can apply just the right amount of pressure to grip difficult parts of the body while not crossing the damage threshold. The device could reduce the risk of tissue injury and improve the surgical training process.

5 A DEEP DIVE TO DIAGNOSE TISSUE INJURIES

_PROBLEM
Deep tissue injuries — pressure ulcers that spread outward to a patient's skin and affect 250,000 patients annually — aren't typically detected until they've progressed to the skin's surface, at which point surgical intervention is required. There are no ideal methods for measuring the stiffness of different tissue samples in order to identify pressure ulcers.

_SOLUTION
A 3D-printed, handheld design that houses a piezoelectric finger that can measure the elasticity of materials in the human body at the depths where deep tissue injuries typically originate. The device offers precise measurements that could improve the quality of life for at-risk patients and open doors for further diagnostic applications.

6 A STAGE TO STUDY TISSUE SAMPLES

_PROBLEM
There is currently no way to measure the nanoscale properties of a tissue sample under strain in a simulated physiological environment. This limits the capacity for research into materials such as prosthetics, synthetic tissue grafts and athletic clothing.

_SOLUTION
The team designed a device with a stage to hold a tensile specimen and a surrounding fluid chamber to provide support. Grips secure the ends of the tissue and strain is applied, allowing researchers to take measurements using atomic force microscopy and better understand materials. The product could reinforce current research and generate new research that would have benefits for surgical and materials science applications, not to mention sports.

7 A BETTER UNDERSTANDING OF BONE IMPACTS

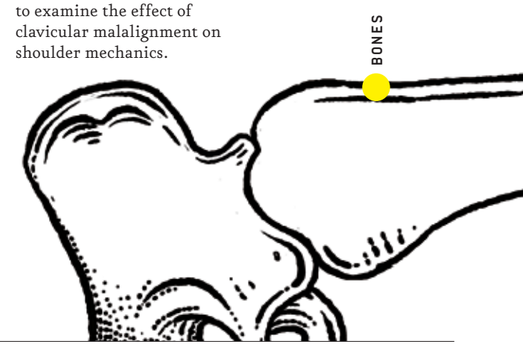
_PROBLEM
There are 200,000 midshaft clavicle fractures each year and the bone alignment is typically off by less than two centimeters. Whether this amount of malalignment impacts shoulder mechanics is not understood. Researchers need a device capable of creating a known malalignment so that studies of cadavers can investigate the impact on shoulder motion.

_SOLUTION
The team created a device with a PVC crossbar and a cantilever beam that fixes the clavicle in place on a cadaver to allow doctors to simulate different amounts of malalignment. The team's prototype minimizes rotation and movement between its components to prevent bending during testing, and was found to withstand the same loads as an intact bone model. The device has the potential to be used in cadaver studies to examine the effect of clavicular malalignment on shoulder mechanics.

8 OPTIMIZING ULTRASOUND FOR BONE RECOVERY

_PROBLEM
Osteoporosis — the decrease of bone density common in elderly patients — makes patients more susceptible to fractures, 2 million of which are caused by the condition each year. Ultrasound is beneficial for wound healing, but the main existing product is expensive, has a limited treatment time and has a non-rechargeable battery pack.

_SOLUTION
By optimizing an ultrasound transducer driver circuit for low frequency and low pressure, the team designed a lightweight, wearable, tether-free and battery-operated product to stimulate bone recovery. The electronic driver successfully created the appropriate tone burst and repetition frequency to be effective, potentially reducing recovery time for patients.



(1) **TEAM** Samantha Cassel, Kelsey Chung, Raymond Dulman, Kelly Fox and Maneesha Sahni / **ADVISER** Associate Professor Amy Throckmorton, School of Biomedical Engineering, Science and Health Systems (2) **TEAM** Sherika Gordon, Sarah Haynes, Jennifer Patten, Khyati Prasad and Ashley Ramirez / **ADVISER** Associate Professor Amy Throckmorton, School of Biomedical Engineering, Science and Health Systems (3) **TEAM** Brandon Eng, James Kirwan, Alexander Mariner, Ravi Shah, Michael Shmukler and Brendan Sweeney / **ADVISERS** Assistant Professor Lin Han, School of Biomedical Engineering, Science and Health Systems; and Biao Han, PhD candidate, School of Biomedical Engineering, Science and Health Systems (4) **TEAM** Zachary Block, Matthew Bolopue, Eric Barbalace, William Dackis and Allison Grasmeder / **ADVISER** Associate Professor Sriram Balasubramanian, School of Biomedical Engineering, Science and Health Systems

(5) **TEAM** Alice Alderson, Luyando Chibwe, Peter Esslinger, Arlene Genevieve Offemaria and Kevin Yeamans / **ADVISER** Professor Wan Shih, School of Biomedical Engineering, Science and Health Systems (6) **TEAM** Jonathan Amora, Tara Jordan, Leif Malm, Kawyn Somachandra and Anthony Young / **ADVISER** Assistant Professor Lin Han, School of Biomedical Engineering, Science and Health Systems (7) **TEAM** Seth Greber, Margaret Gunn, Kristin Irons, Alicia Rusnak and Cassandra Tu / **ADVISER** Associate Teaching Professor Joseph Sarver, School of Biomedical Engineering, Science and Health Systems (8) **TEAM** Ajo Joseph, Kevin Kunju, Mohana Nagda, Neel Patel and Sunil Shah / **ADVISERS** Richard B. Beard Distinguished University Professor Peter Lewin and Assistant Professor Kara Spiller, School of Biomedical Engineering, Science and Health Systems

BRAIN

9

MAPPING NEURAL CONNECTIONS IN THE BRAIN

_PROBLEM

A lot of time, money and effort are spent trying to map the brain and understand its neural connections, but current methods for creating a connectome map are all manual, leaving room for human error and operator bias. The only fully mapped organism is the nematode worm, so an automated mapping process would present significant room for advancement.

_SOLUTION

A computational pipeline that can identify major neural structures, compile the results into a connectome map and adjacency matrix, and perform without technical failures. Using a collection of MATLAB scripts, the team used scanning electron microscope image data as an input; analyzed, filtered and identified the images; and output a connectome map as an image and matrix, identifying more than 96 percent of cell bodies and axonal pixels along the way.

10

A NEW WAY TO DIAGNOSE DYSLEXIA

_PROBLEM

Early diagnosis of language-based learning disabilities is key to treatment, but there is no gold standard at the moment. Dyslexia often comes in tandem with other issues, such as ADHD, that can make it difficult for a child to sit still long enough for psychological and neurological exams to properly diagnose.

_SOLUTION

The infrared spectroscopy system (fNIRS) can allow doctors to measure oxygen levels in the brain, which has different patterns in individuals with dyslexia as compared to regular readers, easing diagnosis. The team designed a wireless device lightweight enough (less than 50 grams) to be wearable and mobile but still transmit the results quantifying an individual's oxygen levels up to 10 meters. In the end, it could give dyslexic students the same opportunities as any of their peers.

11

IDENTIFYING SYNAPSES TO TREAT BRAIN INJURIES

_PROBLEM

Traumatic brain injuries are responsible for nearly one-third of all injury-related deaths and impact 1.7 million people each year. To date, no clinical treatments exist to regenerate damaged synaptic connections. Emerging genetic therapies show some promise in creating new synaptic connections; however, preliminary therapy screening in animals costs too much money and time.

_SOLUTION

The team designed an in vitro, cell culture assay to screen genetically engineered proteins capable of establishing novel synaptic connections. By quantifying synaptic contacts with fluorescent confocal microscopy, the team created an assay that will support future research, presenting a possible step forward for treating traumatic brain injuries.

12

MEASURING BRAIN OXYGENATION TO IDENTIFY TRAUMATIC INJURIES

_PROBLEM

Traumatic brain injury is diagnosed in 2.5 million patients each year using MRI or CT scan machines that are very large and not portable. No point-of-care devices exist to monitor traumatic brain injuries.

_SOLUTION

The team created an oximetry module that can be used to measure oxygenation level in brain tissue using the InfraScan device, including an interface display that allows for easy operation. The device could improve pre-hospital treatment of traumatic brain injuries by allowing health care providers and field clinicians to quickly and effectively evaluate cerebral oxygenation and determine when one has occurred.

PROCEDURAL

13

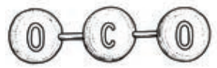
MEASURING A SCALPEL'S FORCE TO MINIMIZE MISUSE

_PROBLEM

Scalpel misuse causes 18 percent of injuries in the operating room. Current training methods for scalpel use include informal apprenticeship, synthetic models and computer simulations. A virtual reality simulator could be a more cost-effective and more portable option for surgical training, but a simulator is only effective if the user can be prepared for a real-world clinical environment by getting accurate force feedback on their scalpel use.

_SOLUTION

Using 3D-printed blade holders capable of testing scalpel blades angled at 0, 25 and 45 degrees, and a platform layered with neoprene rubber and pig skin, the team was able to calculate the average amount of force directly exerted on the skin to create an incision. The work could lay the foundation for transcribing the physical loads applied when making an incision and provide a protocol for acquiring biomechanical data for future uses.



A NEW PROCESS TO PREPARE PATIENTS FOR IMAGE SCANS

_PROBLEM

Traumatic brain injuries can be diagnosed using imaging devices, and one way to prepare for imaging is to induce hypercapnia, a state in which a body contains an excess amount of carbon dioxide. The current technology used to induce hypercapnia is bulky, immobile, takes a long time to set up and uses external gas sources.

_SOLUTION

By recycling a patient's own carbon dioxide in a re-breathing process, similar to what happens when a person breathes into a paper bag over and over, the team designed a device that can effectively achieve and maintain hypercapnic levels of carbon dioxide. Using the patient's own lungs as an external gas source, it could be the first portable, lightweight option to promote early intervention in cases of traumatic brain injury.

15

A STABILIZING SEAT FOR STEROID INJECTIONS

_PROBLEM

There are 9 million epidural steroid injections each year in the United States to relieve pain associated with inflammation, but 47 percent of procedures involve unintentional nerve injury caused by sudden movement. There is no device on the market to stabilize a patient's neck and allow room for medical professionals to safely operate.

_SOLUTION

To increase safety and effectiveness, maximize epidural space while the patient is seated, and provide rigid support to keep the patient in place, the team created a two-part device with a head piece attached to a table via nylon straps and an L-frame with a seat-belt system to slide under a seat cushion. With an adjustable suspension, it would work for any patient, reducing risk by securing their position while allowing for quick release in case of an emergency.

16

ADAPTING INFRARED IMAGING TO RATS

_PROBLEM

Strokes affect 800,000 people every year and are the fifth-leading cause of death in the United States. Research is needed to develop our understanding of the physiology of strokes in order to create more effective preventive measures and regenerative treatments, and that research is conducted in rats. Innovative imaging methods are needed to better assess information from animal models.

_SOLUTION

Infrared imaging is one way to measure the amount of oxygen in brain tissue. By creating a piece of imaging technology small enough to fit on a rat's skull, weighing less than 10 percent of its body weight and allowing unrestrained movement, the team's project opens up research possibilities for studies using infrared imaging on animals. There is a niche market of researchers whose work could greatly benefit from customized devices for such imaging.

(9) **TEAM** Edgar Cardenas, Melissa DuBois, Andrew Kaiser, Rea Parikh and Eaindra Tin Latt / **ADVISER** Research Assistant Professor Will Dampier, College of Medicine (10) **TEAM** Valeria Beckhoff Ferrero, Tushaar Godbole, Eshiemhomo Kadiri, Michael Iskhakov and Durand O'Meara / **ADVISER** Meltem Izzetoglu, research professor, Villanova University (11) **TEAM** Yiyang Deng, Ayan Desai, Xinyi Lu and Sohil Patel / **ADVISER** Assistant Professor Catherine von Reyn, School of Biomedical Engineering, Science and Health Systems (12) **TEAM** Christopher Cox, Murynia Hernandez, Anna Lu, Kaitlyn Money and Beverly Tomita / **ADVISERS** Associate Research Professor Hasan Ayaz, School of Biomedical Engineering, Science and Health Systems; Research Professor Meltem Izzetoglu, Villanova University; H.H. Sun Professor Banu Onaral, School of Biomedical Engineering, Science and Health Systems

(13) **TEAM** Muammar Johnson, Haiyue Lu and Mashaal Syed / **ADVISER** Professor Wan Shih, School of Biomedical Engineering, Science and Health Systems (14) **TEAM** Stephen Brown, Thomas Lightfoot-Vidal, Ashley Malone, Yerram Pratusha Reddy and Joseph Sincavage / **ADVISER** Meltem Izzetoglu, research professor, Villanova University (15) **TEAM** Matthew Bova, Tyler Miller, Ashley Moy, Amanda Tilles and Gregory Toci / **ADVISER** Assistant Teaching Professor Marek Swoboda, School of Biomedical Engineering, Science and Health Systems (16) **TEAM** Daniel Finnegan, Andrew Joseph, Marina Louis, Trevor Montez and Michal Swoboda / **ADVISERS** Professor Kambiz Pourrezaei, School of Biomedical Engineering, Science and Health Systems; and Meltem Izzetoglu, research professor, Villanova University

17

A 3D-PRINTED, REGENERATIVE TRACHEAL BRACE

_PROBLEM

There are no ideal treatments for tracheomalacia, a degenerative disease that leads to the collapse of a person's airways. The existing options are either quick and temporary or can fracture and create further tissue damage. Degenerated tracheal rings need cartilage support from a mechanical structure that can prevent collapse, promote tissue growth and create adhesion.

_SOLUTION

A 3D-printed, C-shaped brace that facilitates the growth of cartilage tissue while resisting the pressure generated during the breathing process. The team's design is porous, in order to allow cartilage cells to migrate and proliferate, with a solid outer layer and an inner scaffold to remain sturdy and promote regeneration. The device would improve a patient's quality of life and offer a permanent, non-pharmacological solution.

18

A SUTURE-SILK SCAFFOLD TO GUIDE NERVE REGENERATION

_PROBLEM

There are 347,000 Americans with spinal cord injuries, and 17,000 more suffer such injuries each year and are at risk of permanent loss of neurological function. There is currently no promising solution to repair spinal cord injuries. In order to restore functionality to damaged nerve fibers, guided direction is required.

_SOLUTION

The team designed a scaffold made of suture silk — which is biocompatible, readily available in many sizes and inexpensive — to guide nerve regeneration through channels that could address sites both near and far from an injury. As a proof of principle, the team demonstrated that nerves did attach to the suture silk, while future development will also aim for directional nerve growth.

19

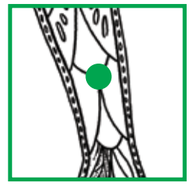
A MELATONIN PUMP ATTUNED TO NATURE'S RHYTHMS

_PROBLEM

Insufficient melatonin can lead to unstable sleep, which can accelerate the symptoms of a patient's disease, especially dementia. Existing solutions to deliver melatonin lack a natural release, and patient noncompliance with current approaches can be as high as 75 percent in elderly populations.

_SOLUTION

In order to deliver sufficient supplemental melatonin in a way that mimics the body's natural circadian rhythms, the team developed a pump that dispenses melatonin through a syringe-style system with a microprocessor and circuitry able to control the melatonin output. If used as a bedside device, it could offer better modulation of melatonin uptake and, therefore, more consistent sleep cycles.



20

DRUG DELIVERY FOR CHRONIC WOUNDS

_PROBLEM

Six-and-a-half million Americans are affected by chronic wounds — those that fail to heal within 12 weeks — and $25 billion a year is spent on treatments, none of which address the underlying physiology. In a normal wound, macrophages create inflammation that helps an injury heal, but chronic wounds don't behave in expected patterns.

_SOLUTION

A topically applied drug delivery system that can be placed on a wound of any size and contains two different mechanisms to address the two different types of macrophages with two different release methods. When combined, the gel, which contains a microparticle slurry, promotes the growth of new blood vessels, allowing tissue to regrow and the wound to heal.

21

SOUND-GUIDED GAIT ADJUSTMENT

_PROBLEM

For a large number of patients in physical therapy for neurological disorders or rehabilitating injuries, an abnormal gait can increase the risk of falls, back pain and other subsequent injuries. But at the moment, there are no mobile solutions to help patients regain a normal walking rhythm.

_SOLUTION

A shoe insole with force sensors that translates the map of an individual's gait into sound that can be played in headphones as he or she walks. A target pattern is played repeatedly prior to walking, then, as the user walks, the rhythm of their current gait is played. By adjusting their walking rhythm to match the target, the individual can use real-time auditory feedback to speed along the rehabilitation or physical therapy process.

(17) **TEAM** Kosha Kumar, Alexandria Neiman, Nicholas Wancio, David Luke Wetnight and Emrecan Yener / **ADVISER** Professor Wan Shih and Michael Frohbergh, both of the School of Biomedical Engineering, Science and Health Systems (18) **TEAM** Liam Barnes, Christopher Brennan, Kalgi Chokshi, Megan Donohue and Angelica Spinelli / **ADVISER** John M. Reid Professor Margaret Wheatley, School of Biomedical Engineering, Science and Health Systems (19) **TEAM** Jordan Bucher, Thomas Donnelly, Sean Jenkins, Samuel Kim and Dalton Lester / **ADVISER** Assistant Teaching Professor Marek Swoboda, School of Biomedical Engineering, Science and Health Systems (20) **TEAM** Matthew Geib, Allison Liptak, Samantha Santos, Anh Trinh and Kathryn Volk / **ADVISERS** Assistant Professor Kara Spiller, School of Biomedical Engineering, Science and Health Systems (21) **TEAM** Samantha Fox, Jaclyn Goulet, Tyler Kern, Cory Quigley and Yang Wan / **ADVISER** Associate Teaching Professor Joseph J. Sarver, School of Biomedical Engineering, Science and Health Systems

22

A MUSCLE-TESTING SIMULATOR TO ELIMINATE SUBJECTIVITY

_PROBLEM

More than 5 million Americans need muscular assessments to gauge the impact of their neurological disabilities. The current 0–5 scale ranges from no movement to normal strength, but translating a patient's muscle strength to the scale is fraught with errors due to subjectivity.

_SOLUTION

An electro-pneumatic device that mimics a healthy adult male arm and can be used as a teaching tool to help clinicians reduce variability. The imitation forearm replicates an individual's range of motion, allows clinicians to set scale values and provides feedback through LED lights. It could increase the reliability of muscle strength assessments and increase the consistency of training, and its portable design would maximize its usefulness.

23

HOT AND COLD MUSCLE THERAPY

_PROBLEM

For patients dealing with muscle pain, cryotherapy (cold) and thermotherapy (heat) are often used at relatively extreme temperatures in an attempt to reduce swelling and address inflammation. Heating pads and ice packs both serve a function, but there is no product that uses both heating and cooling tactics to help patients.

_SOLUTION

The ThermoKloth uses both cryotherapy and thermotherapy in a regulated setting powered by pairing two circuits, one for heating and one for cooling, to address inflammation. The design is a dual-Peltier device that allows users to control the temperature — hot or cold — for application on an injured muscle.

24

A BETTER METHOD TO MEASURE INFANT TREMORS

_PROBLEM

Neonatal abstinence syndrome affects babies whose mothers abused opioids during pregnancy, a group that in 2012 was five times larger than it was in 2000. Among the symptoms is tremors, involuntary rhythm movements that are measured on a 1 to 4 scale. Babies are scored every two to four hours and treatment depends on a total score, but the measurement is subjective and can lead to incorrect methadone or morphine dosage.

_SOLUTION

An ankle-worn device as small as an Apple Watch that can track and quantify a baby's tremors using an accelerometer, then wirelessly transfer data via Bluetooth technology to a computer for analysis. The device could improve treatment accuracy and eliminate subjectivity, ultimately reducing hospital costs and discharging babies sooner.

(22) **TEAM** Oyinkan Aderele, Caleb Gerald, Emily Du, Melissa Frendo-Rosso and Loveena Williams / **ADVISERS** Associate Professor Sriram Balasubramanian, School of Biomedical Engineering, Science and Health Systems; Clinical Specialist Allan M. Glanzman, Children's Hospital of Philadelphia; Attending Physician Matthew P. Kirschen, Children's Hospital of Philadelphia (23) **TEAM** Chung Cheng, Stephen Parsons, Dennis Roy, Uyen Tran and John Yockey / **ADVISER** Professor Ryszard Lec, School of Biomedical Engineering, Science and Health Systems (24) **TEAM** Nsilo Berry, Chris Bijumon, Priyanka Karekar, Josue Manjarrez Linares and Todd Roescher / **ADVISERS** Professor Kambiz Pourrezaei, School of Biomedical Engineering, Science and Health Systems; and Assistant Clinic Professor Barbara Amendolia, College of Nursing and Health Professions

MALACOLOGY

_DIGGING INTO DATA

A massive digitization project by the Academy of Natural Sciences of Drexel University continues to put data about its ***18 million natural specimens at the fingertips*** *of scientists and the public worldwide.* _by Mary Alice Hartsock

Most people know what it's like to struggle to decipher someone else's scribbled handwriting. When you're truly stuck, you can usually follow up with the author in person.

But what if that isn't an option, and your ability to decipher those notes could shape scientific history?

Drexel University students Nicholas Blase and Valerie Coghlan (since graduated) faced this problem while working in the Academy's Botany Collection. Their job was to examine images of printed or handwritten labels and packets holding lichens and bryophytes and enter information from these labels into a searchable database.

Their work was part of a larger project underway at the Academy to make its specimens available to anyone online. Through digitization, data distributed among millions of individual specimens are converted into digital records that include scientific names; dates and locations of its collection; the collector's name; and other relevant data.

In the Botany Collection, Blase and Coghlan worked to database 200 specimens per day using software that "reads" typed specimen labels from digital images.

"This goal was often met as long as there were no troublesome labels," says Blase. "But common slowdowns included getting caught up on deciphering handwriting for a large string of specimens."

NO. 94109_S. TASMANIENSIS

NO. 56531_U. RETUSUS

NO. 54248_C. HIANS

IMAGES BY PAUL CALLOMON, ACADEMY OF NATURAL SCIENCES

SHELLS_IN_SEPIA

The Academy of Natural Sciences recently finished digitizing its entire Malacology Collection of 10 million shells, one of the largest in the world, with funds from the National Science Foundation. The collection dates back to the Academy's founding in 1812, when one of its founders donated a box of shells and madrepores (reef-building corals). Since then, the shell collection has grown considerably and now occupies more than 250 cabinets containing more than 13,000 drawers and 10 million specimens, together weighing more than 55 tons. The collection represents every region of the world and is a priceless resource for scientists in many disciplines. It is fully searchable online through the Academy's website, ansp.org, and more than 5,000 of the most scientifically important specimens can be viewed as high-definition images on any web browser.

MALACOLOGY

NO. 50351_S. BITUBERCULATUS

NO. 35160_V. VESPERTILIO

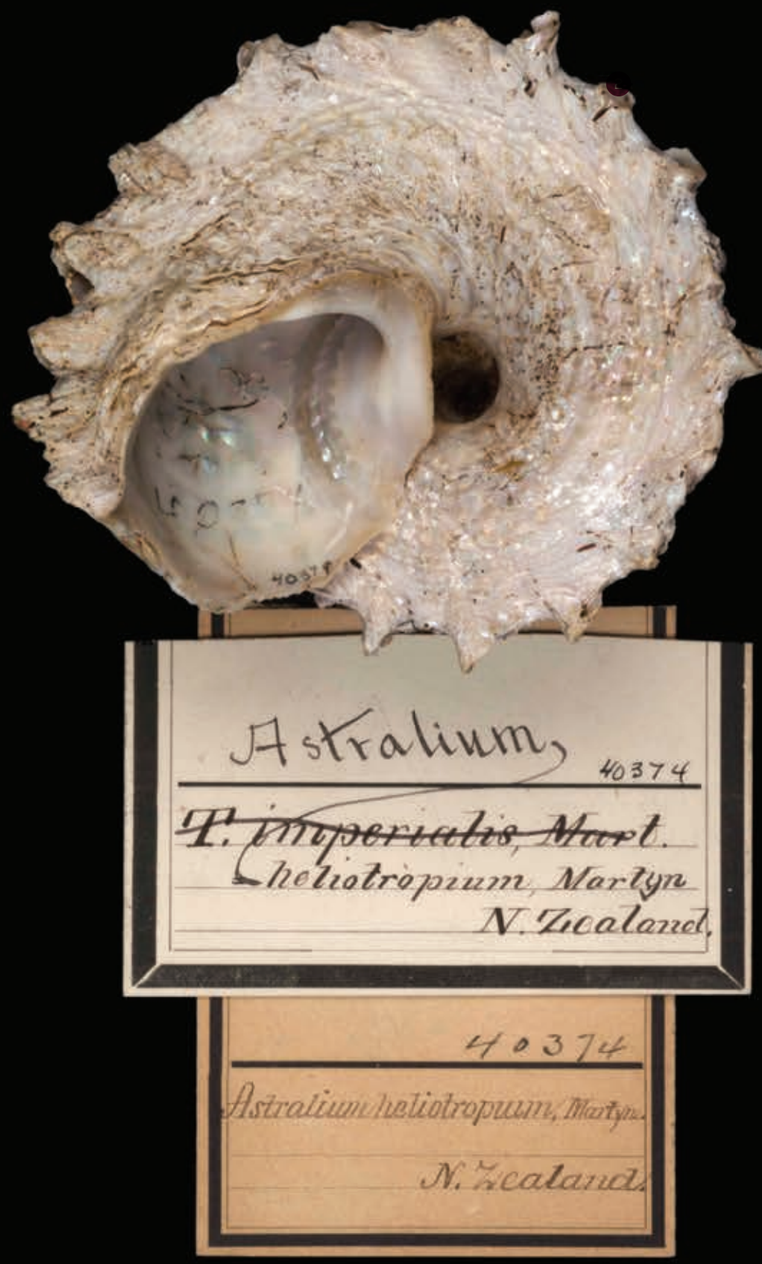
NO. 36059_M. CORNUTUS

Many of the specimens in the collection are decades or centuries old, and finding the correct answers requires researching historical records and venturing into the collection to investigate the specimen packets in person.

Accuracy is essential, especially in digitization projects focused on type specimens, which are used to establish the application of names to species. For type specimens, even before data is entered, staffers must dig into the historical records to confirm that they have the type and investigate whether anyone has reconsidered the specimen's classification since its naming.

Most Academy collections are also adding digital images to their specimen data — a task that has become more urgent in the past two decades. Academy ichthyologists use high-resolution micro CT (computerized tomography) scans to create 3D images that can be rotated and sliced into sections digitally, making the images especially useful for examining small specimens. Many departments take high-resolution photographs of specimens using a digital camera and special lighting, while others use flatbed scanners. The high-quality images also offer curious amateur naturalists the chance to view the specimens as many times as they like.

"Natural history tends to present itself to the world in books, documents and scholarly publications," says Paul Callomon, collection manager of malacology, invertebrate paleontology and general invertebrates at the Academy of Natural Sciences.



NO. 40374_A. HELIOTROPIUM

NO. 147139_C. ESONTROPIA

NO. 55974_S. IMPERIALIS

_THE LAST MILE

_by Adam Stone _photos by Tommy Leonardi

_MIHIR SHAH
Shah is a 2000 computer engineering graduate and co-founder of the Philadelphia-based biomedical company UE LifeSciences.

THE ROAD TO EARLY BREAST CANCER DETECTION IS PARTICULARLY ROUGH IN DEVELOPING COUNTRIES, WHERE SCARCE MEDICAL RESOURCES, POVERTY AND CULTURAL TABOOS ARE OBSTACLES TO WOMEN LEARNING THEIR DIAGNOSES BEFORE IT'S TOO LATE. BUT AN INGENIOUS NEW HAND-HELD MEDICAL DEVICE PIONEERED AT DREXEL IS COVERING THE DISTANCE BETWEEN DIAGNOSIS AND SURVIVAL.

Jus Wadhwa, MD, remembers one woman in particular: A 38-year-old house cleaner; she had had the lump in her breast for months.

But she was poor, working all the time, running her home and supporting her family. She didn't have time or money for a mammogram. She was afraid of the radiation.

This was all too familiar to Wadhwa.

When Wadhwa heads out into the slums of Pune, India, the oncologist knows what she will see. Broken-down residences. Alcoholism. Failed infrastructure. Over 100,000 people who don't have a toilet within walking distance. It's the women who hold it all together, and they're the ones Wadhwa is here to see.

She and her helpers from the breast cancer advocacy organization Aastha Group arrive early in the morning, commandeering space in community centers or in private homes. They set up examination tables and privacy curtains and by 10 a.m. the women start arriving, unwinding their saris as they describe their medical histories. Before the day is out the team will perform 100 to 125 breast screenings. In the case of that 38-year-old woman, this led to an early diagnosis and successful treatment: A life saved.

"If we hadn't been there she would have been diagnosed much later, if at all, and the outcomes would have been very different," says Wadhwa.

For this win, she credits iBreastExam, a handheld, battery-operated breast scanner born at Drexel. The iBreastExam is no heavier than a paperback book, is so easy to use it operates with just an on/off switch, and is capable of producing individual scans for pennies on the dollar. Unlike hospital mammograms, it is painless and uses no radiation. Yet it is as effective as a mammogram at detecting abnormal breast lumps.

Its size, affordability and simplicity make it uniquely suited to reach what health care workers call "the last mile."

Sometimes literal, sometimes figurative, "the last mile" refers to the vast gulf of adverse conditions that can separate people from basic medical attention — and it has profound health consequences for women in the developing world. In the United States, successful early detection drives breast cancer survival rates of 80 percent, but that rate falls to just 40 percent in countries like India, according to the World Health Organization.

"[The iBreastExam] has been a blessing for us and a boon for the whole community," says Wadhwa. "Lots of people are trying to motivate women to come forward, but we have been more successful than most, and it's only because of this device."

THE FIRST STEPS

The iBreastExam was built around technology invented by Drexel professors and is being rolled out internationally by Drexel computer engineering grad Mihir Shah '00 through the Philadelphia-based biomedical company he co-founded, UE LifeSciences.

Field operators trained by UE LifeSciences have screened more than 120,000 women and successfully identified more than 100 cases of breast cancer. The iBreastExam has been deployed in India, Myanmar, Botswana and Mexico so far and will soon be available in at least eight other countries in Southeast Asia and Africa. The company recently inked a global distribution agreement with GE Healthcare, the world's largest purveyor of women's health imaging products, to expand the device's reach.

Though the device has been on the market for just two years, the story of how it went from a professor's lab bench to clinics and community health fairs around the world is tied to Shah's personal story, and goes back nearly 20 years to when he came to Drexel as a student from Mumbai at age 18.

When Shah entered Drexel as a freshman in 1996, he spoke only adequate English: It's his third language, after Gujarati and Hindi. He came seeking a computer engineering degree, even though he'd only ever used a laptop twice. A self-described "straight B+" student, he didn't seem cut out for academic stardom. But his family had scrappy business instincts: His dad was a "trader," which in India meant he cobbled together a middle-class living buying and selling used textile manufacturing equipment. It took a Drexel scholarship, all the family's savings and some high-interest loans to bring Shah to the United States for a shot at success.

Over the next several years, a series of fortunate connections, deliberate gambles and persistence put Shah in the way of fate over and over again, equipping him with all of the tools he would eventually need to succeed at tech commercialization.

His first break emerged from a networking event for students interested in entrepreneurship, where Shah was pulled into a project writing real estate appraisal software for Drexel alumnus Mark Silverman '86. A few years later, Silverman helped Shah compete in Drexel's business plan competition. Shah and his partner won the contest and earned $5,000 and office space in Drexel's new business incubator, the Baiada Institute for Entrepreneurship, run by the Close School of Entrepreneurship — becoming the incubator's first tenants in 2002.

Being in Baiada put them alongside staff from Drexel's Office of Technology Commercialization, some of whom have remained mentors to this day. "We'd share lunches and learn what tech transfer is," Shah recalls. "I was amazed: Are you telling me that the best technologies invented at the University could be commercialized by someone like me? I'm thinking, 'That's what I want to do.'"

He spent some time in the following years exploring technology trends, working on projects around GPS tracking and other areas, but he was searching for something bigger. He was also becoming more embedded in Drexel's venture ecosystem, getting to know the players in tech commercialization. One was Banu Onaral, who served as the founding director of Drexel's School of Biomedical Engineering, Science and Health Systems and who spearheaded the Coulter-Drexel Translational Research Partnership Program — a major Drexel conduit for bringing faculty inventions to market.

Onaral, who is now a senior presidential adviser for global innovation partnerships at Drexel focused on emerging economies, says she championed Shah because she could see that he had his heart and mind set on making a difference in the lives of the underserved and unprivileged.

"He had what it took to effect change in health care," she recalls thinking. "He just needed to be tested on the ground."

In 2004, Onaral invited Shah to take a prototype of a non-invasive cardiac monitoring device to India for clinical evaluation. "They wanted real-life data, and I could make that happen by taking it to India," Shah says.

The catch: he would have to come up with $25,000 to "buy" the prototype that he took with him. Shah, then 26, pulled together his earnings from his earlier real estate software venture and booked a working vacation.

"I called seven or eight top-notch cardiologists in Mumbai, introducing myself as an entrepreneur from the United States and describing this medical invention," he recalls. "I showed them the brochure and used fancy words like 'clinical collaborator,' when all I really needed was a doctor to try it out."

The next thing he knew, he was in the operating theater getting scrubbed.

"I saw a live birth take place. I saw open heart surgery. All these people were benefitting from the cardiologist constantly looking at this machine," recalls Shah. "When I saw real life patients benefitting from this technology, I was hooked. I decided to drop everything I was doing and pursue medical technology development and commercialization."

He returned to Drexel with 60 case studies, enough data for Drexel's tech transfer office to get the device licensed to a U.S.-based med-tech company. He'd found his niche.

And then, in late 2006, his soon-to-be mother-in-law in India was diagnosed with breast cancer.

THE PATH TO DISCOVERY

The wedding was just six months away when Shah's mother-in-law learned the disease was already at stage 2. It was invasive, and it had moved into her lymph nodes. She underwent surgery, then six months of chemotherapy. At the wedding, she wore a wig.

Over the following years, Shah learned of eight other women among his friends and family who were diagnosed with breast cancer. Four didn't make it. "India's national average is similar: for every two women diagnosed, one doesn't survive," Shah says.

"You cannot escape it when breast cancer happens so close to your home," he says. He began educating himself about the disease: Where does it come from? How is it detected?

"I started learning there was this huge disparity of outcomes for women in the developed world versus the developing world. In the United States, my mother-in-law's case

FIELD_KIT
The iBreastExam is sold as a kit for less than $10,000. It is packaged in a leather case that includes the handheld breast scanner and a smartphone that runs an app for analyzing test results and cloud storage.

PERSONAL_JOURNEY

Shah left Mumbai to study at Drexel in 1996 at age 18. Over the next two decades, using technology, contacts and resources at Drexel, he built a safe, low-cost portable breast cancer detection device that is saving lives in the developing world.

would have had an 80 percent survival rate, but in India it was 50," he says.

Why the disparity? Early detection is a big reason. In India, like many developing countries, women can't always travel to a faraway clinic for a screening. Cultural taboos may discourage exposure to radiation. Mammography is expensive and India has 10 times fewer radiologists than the United States, serving a population four times larger.

As Shah learned more, he found that early detection is also stymied by breast density. When the tissues of the breast are densely wound, radiation from the mammogram cannot penetrate them — and tumors go undetected.

Naturally dense breasts are common among young women, women of certain ethnicities such as Asians, and about 40 percent of women over 40. The sensitivity of a mammography machine, which can be as high as 80 to 98 percent, drops to between 30 and 64 percent in women with very dense breasts, according to the Radiological Society of North America.

As chance would have it, faculty researchers at Drexel were experimenting with technology that could address just this problem.

In the School of Biomedical Engineering, Science and Health Systems, Professor Wan Shih had been studying a phenomenon called "piezoelectrical effect" for a couple of decades and inventing piezoelectric devices in collaboration with her husband, Dr. Wei-Heng Shih of Drexel's Department of Materials Science and Engineering. Piezoelectric effect refers to the ability of certain materials to generate an electrical charge when pressure is applied. One novel piezoelectric device they invented is a finger-like, flexible tissue stiffness sensor.

Together with doctoral candidates Hakki Yegingil and Xin Xu, Wei-Heng Shih, and surgeon Ari Brooks, MD, director of the Integrated Breast Center at the Pennsylvania Hospital, Shih investigated how this piezoelectric tissue stiffness sensor could be used to detect tumors. Their innovation was to engineer the tool in such a way that it could detect the ever-so-slightly-harder mass of a tumor within the surrounding tissues.

The technology can detect tiny early tumors, even in dense breasts, making it perfect for early detection in all women — young, old and across all ethnicities.

"That's something entirely new," she says. "Without this, the only way to quantify tissue stiffness is after the tissue is cut out from the human body. Now you have an instrument that you can use to measure the stiffness of tissue on a living human being."

Shih and her co-researchers obtained a patent for a "soft material stiffness" sensor in 2009 — one year after being herself diagnosed with aggressive ductal carcinoma of the breast and undergoing treatment.

By this time, Shah was serving as a Drexel entrepreneur-in-residence and had begun working — with his UE LifeSciences co-founder Matt Campisi (an introduction made by his mentor Onaral) — on a different non-invasive breast cancer detection tool that used thermal imaging to spot telltale concentrations of heat that indicate a tumor.

Shah thought that that tool, called the NoTouch BreastScan, would be cleared by the Food and Drug Administration in a few months. Instead, the FDA lingered over it for two and a half years while the agency fretted that it would confuse consumers and deter them from getting mammograms. Then, the FDA said no.

"That was the darkest part," Shah remembers. "I had no Plan B." He and Campisi had started the company with a $150,000 friends and family fund — practically nothing for a med-tech startup. For three years their head of operations went without a salary. A year and a half into it, Campisi was offered a six-figure salary by another company. Campisi turned it down, saying he believed in Shah and the mission. No pressure.

"There's a resilience and team bonding that only failure can make happen," Shah says of the experience. "Now when something doesn't go the way we expect, we couldn't care less."

They wrote a letter to the FDA explaining the situation and incredibly, that worked. The FDA cleared NoTouch BreastScan in August 2012.

But by then Shah had been introduced to Shih and her piezoelectrical sensor technology through his involvement with Drexel's Coulter-Drexel Translational Research Partnership Program. He immediately saw the technology could reach women in their community better than the more cumbersome and costly NoTouch BreastScan.

Major med-tech companies were interested, too. Shah went to the Shihs and to Alexey Melishchuk, the associate director of licensing in Drexel's Office of Technology Commercialization, which managed the University's intellectual property, and he promised, "This technology would be one among many for those large companies, but I'll make it my life's work."

He got the license.

THE ROAD TO MARKET

Still, UE LifeSciences needed funds.

"We had licensed the technology from Drexel but had no money to develop it ourselves," says Shah. "Our first machine wasn't yet FDA cleared so we had all these bills to pay and our first working product was still in limbo."

An assist from Drexel saved the day. A mentor in the Office of Technology Commercialization, Senior Associate Vice Provost and Executive Director of Technology Commercialization Bob McGrath, tipped Shah off to a Pennsylvania Department of Health call for grant proposals, and as luck would have it, the state specifically wanted to fund cancer detection.

"That Pennsylvania grant was akin to the one shot that Luke Skywalker got in 'Star Wars' to destroy the Death Star — that one chance in a million to hit the target," recalls Shah.

Shah had never written a grant proposal before, but with Shih's well-recognized invention, her technical proposal, and his business plan, he went head to head against other technologies to compete for the grant money. He vividly recalls the phone call in February 2012 telling him he had won.

"That's when life changed," Shah recalls. "It took me a while just to adjust my mindset. I thought it must be one of my friends playing a prank. But I opened my email and there it was in official words."

Later, at a formal ceremony handing over the $878,000 grant, the state Secretary of Health took Shah aside. "He told me, this is your golden ticket. Spend this money as if it's your own. We are trusting that you will build a product that will save lives," Shah remembers.

Shah and Campisi put together a team of 27 clinicians, researchers, engineers and coders in the United States and India and began building.

Shah knew that to succeed commercially, the device would have to be portable enough to serve remote villages. It would have to be simple enough for any community health worker to use it without a doctor or radiologist. It had to connect wirelessly to the internet and use small data files. It had to be rugged in humid and hot environments. It had to be impervious to breast density.

All that, and it also had to be "ridiculously affordable," Shah says.

In two and a half years, they had the iBreastExam.

With FDA clearance in hand, and approval for medical use in Europe, his company now employs over 70 people in the United States, India and Malaysia.

Two key numbers help to explain the adoption of the new screening test: 85 and 92.

"It has been through four clinical studies and has shown over 85 percent sensitivity and over 92 percent specificity," Shah says. "Both of those are measures for the detection of breast lumps and lesions. Sensitivity means you can detect a lump when it is there, you don't miss it. Specificity means you can tell when it is *not* there: It means you have fewer false alarms."

Another key figure: $2. That's how much it costs to administer an individual scan with the device, versus mammography fees that typically range from $6 to $30 per screening.

In line with these findings, the World Health Organization included iBreastExam in its inventory of promising diagnostic tools, lauding the device for its "extreme sensitivity" and noting that it "demonstrates significant potential as a low-cost screening tool in low-resource environments."

That low cost, paired with the fact that virtually anyone can perform the exam, makes the new tool perfect for developing countries. "Your health workers may be people who were picked from the local area, who volunteer and try to make an impact," says Brooks, one of the researchers who developed the underlying technology. "If you assign those people to do breast exams and you give them a device that can make that detection, you have the chance to make a huge impact."

"What we are doing always has a greater purpose, to serve humanity in general," says Donna De Carolis, dean of the Close School of Entrepreneurship, referring to the University's entrepreneurial and tech commercialization pathways. "Scientists and engineers understand that the work they do will ultimately impact the human condition for the better. Then we add this other piece by thinking about the commercial pathways as a means to turn those dreams into a reality."

Things are picking up speed now for UE LifeSciences. A big piece of the commercial puzzle fell into place in summer 2016, when Shah was invited by Terri Bresenham, chief innovation officer at GE Healthcare and the head of its Sustainable Healthcare Solutions effort, to give a demonstration of iBreastExam's technology. GE Healthcare had been scouting startups for emerging technologies to help serve people in developing countries.

Shah presented to a room packed with about 80 executives, including the heads of its mammography, utrasound and MRI divisions. Diplomatically, he described ways that their mechanisms fell short in some parts of the world, and how iBreastExam — affordable, mobile, simple — was filling in the gaps.

"And I kind of see Terri sit more upright in her chair," recalls Shah. "I had her right in front of me, with the head of the ultrasound business sitting next to her. I could physically, visibly see their expressions change. She started looking behind at her colleagues, like, 'Are you seeing this?' And she had a little smile on her face."

Bresenham was thinking it was one of the best ideas she'd heard in a long time. In November 2017, GE Healthcare inked a deal to distribute iBreastExam in more than 25 countries in Southeast Asia, South Asia and Africa as an adjunctive tool in its healthcare portfolio — expanding screenings to more than 500 million women in developing countries.

The opportunity to impact health on such a global scale would never have materialized without the support mechanisms at Drexel, says Shah.

"It's not just about an entrepreneur with guts of steel; it's not just an engineering team," he says. "Even a visionary needs support to take an unfunded idea through proof of concept, to develop a business model around an emerging technology even before it has a viable revenue stream.

"That means programs that are willing to invest just to push the science forward. That's how we got a breast surgeon and a PhD student to convert their theses and hypotheses into something that actually *does* something. And you need an entrepreneurial environment where there is a tech commercialization office willing to make the early bets, to invest in faculty's intellectual property. You need programs like we have at Drexel."

_by Lauren Ingeno

THE CHEMICALS THEY CARRY

Thousands of U.S. soldiers returned from the 1991 Persian Gulf War with a mysterious, incurable illness. To find answers, College of Medicine researchers are reprogramming veterans' cells.

iPS_CELLS
Laboratory-grown stem cells — called induced pluripotent or iPS cells — are adult cells that have been genetically reprogrammed to behave like embryonic stem cells. Drexel researchers believe these modified cells could hold answers to the debilitating cluster of symptoms that have plagued many veterans since they returned from the first Gulf War in 1991.

ARMY VETERAN Lynn Santosuosso donated her blood to science last spring. From a Boston University lab, her cells were sent to the school's Center for Regenerative Medicine, where scientists inserted into them four carefully chosen genes.

The modification transformed the cells, reversing them back to their infancy and making them ripe with research potential.

Laboratory-grown stem cells — called induced pluripotent or iPS cells — are adult cells that have been genetically reprogrammed to behave like embryonic stem cells. They not only proliferate indefinitely inside a petri dish, but can also differentiate into any type of cell in the human body.

From Boston, Santosuosso's iPS cells then journeyed 300 miles to Drexel's College of Medicine in Philadelphia. There, a team of neuroscientists altered them once again — this time, into neurons.

The Drexel researchers believe these modified cells could hold answers to the debilitating cluster of symptoms that have plagued Santosuosso and her peers since they returned from the first Gulf War in 1991. It is estimated that 250,000 of the 700,000 veterans deployed in the conflict suffer from what is now known as Gulf War Illness.

"We see this as an urgent situation; these veterans have been suffering for more than 30 years," says Peter Baas, a professor in the Department of Neurobiology and Anatomy, who is leading the Gulf War Illness research efforts at Drexel. "Until now, a real challenge for the research community was developing models to study this disease."

The pluripotent stem cell lines offer scientists, for the first time, the opportunity to identify the neurological underpinnings of Gulf War Illness and to develop treatments to reverse it.

UNHEALTHY WINDS OF WAR

After 10 years in the Army Reserve, Santosuosso was called up for active duty in November 1990 during Operation Desert Storm. She was overseas for six months, stationed north of King Khalid Military City in Saudi Arabia.

Outside her tent, the sound of air raid sirens and chemical alarms frequently filled the air. But long-term environmental health risks were the last thing on her mind.

"The only thing you're thinking about is what your mission is and doing your job," the 56-year-old engineering technician says now.

When she returned home to New England, Santosuosso began forgetting where she put things and losing her words mid-conversation. She experienced migraines, an unrelenting cough and difficulty sleeping. Often, she woke up in the middle of the night unable to breathe.

Around the same time, Kimberly Sullivan, who was training as a neuropsychologist at the VA Boston Healthcare System, was noticing similar cognitive problems in the veterans whom she evaluated.

"They all were coming back with these unexplained symptoms," says Sullivan, now a research assistant professor at Boston University. Veterans complained of fatigue, headaches, joint pain, indigestion, insomnia, dizziness, respiratory disorders and memory problems. "Fewer than 10 percent of the veterans we saw were diagnosed with post-traumatic stress disorder, so clearly something else was happening," she says.

Officials in the Department of Defense (DoD) questioned whether the strange symptoms could be tied to chemical pollutants that had affected the veterans' central nervous system. The DoD subsequently funded a study for Sullivan and a research team to conduct follow-up interviews and cognitive evaluations with any men and women who had handled pesticides during the war.

A series of studies and investigations later revealed that the Gulf War veterans were exposed to combinations of toxic pesticides — used, among other purposes, to treat uniforms, and as insect repellent on the skin — as well as pyridostigmine bromide (PB) pills and anthrax vaccines. The military had prescribed the "PB" pills using a waiver from the Food and Drug Administration, which allowed the troops to take the otherwise non-approved prophylactic as prevention against nerve agent poisoning. In 1996, reports uncovered that the United States' 1991 bombings of an ammunitions storage depot in Khamisiyah, Iraq, had unintentionally released a wave of sarin nerve gas. The gas had drifted southward more than 300 miles to Saudi Arabia — where 100,000 American troops were stationed.

"They were exposed to a toxic soup of chemicals," Sullivan says. "We didn't understand then what a mixture like that could do. The thought was that if there wasn't a major poisoning event, then there wouldn't be chronic health outcomes. We now know that is not the case."

Since those early revelations, Sullivan has dedicated her research to finding out more about the origins of Gulf War Illness and how to help veterans affected by it.

Santosuosso connected with Sullivan's research group in the late '90s and has been participating in studies at Boston University ever since. But despite a willingness to volunteer her body for science, she has received little effective treatment for her symptoms, which she believes have grown worse over the years. In three years, she'll be able to retire from her job at the Portsmouth Naval Shipyard in Maine.

"Hopefully I can continue working that long," she says. Between fibromyalgia, chronic fatigue and memory issues, she says it's becoming more difficult to remain productive. "It is frustrating as hell some days."

A SCIENTIFIC METAMORPHOSIS

Drexel's Peter Baas knew little about Gulf War Illness 10 years ago.

He came to study the disease through his career investigating microtubules — hollow cylinders that provide important structure and shape to a cell, and also act as railways that transport organelles throughout cellular cytoplasm. When neurons have microtubule abnormalities, a lot can go wrong in the brain and central nervous system. In Alzheimer's disease, for instance, chemical changes cause a protein called tau to detach from microtubules, making the neurons dysfunctional.

In 2006, the DoD was offering grants for research scientists to study Gulf War Illness. Baas applied for and earned the funding, hypothesizing that microtubule-related proteins could play a role in the neurodegenerative disease. He was soon invited to take part in the Gulf War Illness Consortium, funded by the DoD and led by Sullivan. The consortium, which is still active today, consists of researchers from 10 institutions working to solve the mystery of Gulf War Illness through clinical and animal studies.

But although living patients and animals provide a range of opportunities to study the disease, the researchers' lack of postmortem brain tissue created barriers for testing mechanistic hypotheses and screening therapeutic compounds.

"I think what became more and more obvious, is that the DoD was getting a little dubious about the use of rats and mice to study Gulf War Illness, because there seemed to be some genetic and epigenetic factors to the disease," Baas explains. "Why did some soldiers get sick, while others who were exposed equally, did not? Was there some kind of predisposition to the disease?"

Not only is it difficult to study genetic factors of disease within animals, but rats are also poor models for studying neurodegeneration more generally.

"Human neurons are just not the same as the cells in rats or mice," Baas says. "For example, the tau protein that goes awry in Alzheimer's makes neurofibrillary tangles. In rodents, the tau doesn't make those same tangles. So, certain key disease mechanisms are not re-capitulated in animals very well."

A breakthrough in the study of human cells occurred in 2006, thanks to Nobel Prize-winning research by Japanese scientist Shinya Yamanaka.

It was Yamanaka who first "reprogrammed" adult stem cells into induced pluripotent stem cell lines. Though originally intended for clinical application, these cells have become a critical tool for biological research.

Now, the Gulf War Illness researchers will be the first team in the world to study blood cells obtained from 300 veteran volunteers and modified using Yamanaka's technique. With the correct combination of growth factors, scientists can manipulate the induced pluripotent stem cells into any type of cell they wish to investigate. And, because pluripotent cell lines are essentially immortal, they can be harvested for an unlimited number of studies. The reprogrammed stem cells will be housed in a biorepository at Boston University and made accessible to any researcher in the world.

Most importantly, the cells are derived directly from the patients affected by Gulf War Illness, which means they harbor the wide array of genetic factors that may contribute to the disease, says Liang "Oscar" Qiang, a research assistant professor in the College of Medicine.

"The big advantage of using patient-derived calls is that many diseases cannot be traced to just one gene mutation, but rather are due to the complex interactions of genes," says Qiang, Drexel's iPS cell expert. "Susceptibility of these diseases may also be based on epigenetic factors, which cannot be looked at in animal models. These cell lines will preserve the complete genetic composition of those affected by the disease."

"THEY ALL WERE COMING BACK WITH THESE UNEXPLAINED SYMPTOMS. FEWER THAN 10 PERCENT OF THE VETERANS WE SAW WERE DIAGNOSED WITH POST-TRAUMATIC STRESS DISORDER, SO CLEARLY SOMETHING ELSE WAS HAPPENING."

TREATING A TOXIC WORLD

In preliminary studies that used iPS cells (though not ones derived from Gulf War veterans), Baas and his research team have already identified a potential treatment for Gulf War Illness symptoms.

In one investigation, Drexel researchers asked whether elevated stress hormone levels could contribute to the effects of organophosphate (OP) chemicals — like the sarin used in pesticides and nerve agents during the war. To test their theory, the scientists treated cultures of neurons with an analog of sarin called diisopropyl fluorophosphate, along with cortisol. Within the neurons, the team was looking for deficits in the activity of microtubules.

Their results, published in the scientific journal *Traffic* in 2017, showed that even low levels of exposure to organophosphates can lead to lasting functional deficits. The sarin analog reduced the transport of mitochondria in the neurons, as well as the release of the neurotransmitter dopamine. Pre-existing levels of the stress hormone cortisol worsened these deficits even further.

The researchers were able to correct the deficits using Tubacin, a drug that preserves normal cellular function by restoring microtubule acetylation and correcting changes in microtubule structure. This suggests that microtubules could serve as a desirable structural target for Gulf War Illness treatment.

Surprisingly, the researchers also found that once they corrected the microtubules deficit, defects in dopamine release also markedly improved. Fluctuations in dopamine are thought to be connected to many of the neurological symptoms that Gulf War Illness sufferers face, including insomnia, cognitive problems and headaches. The study suggests that dopamine alterations after toxin exposure are in part due to changes in microtubules, and restoring microtubule function to a more normal state could help to alleviate symptoms.

"The fact that a microtubule-based therapy would correct the problem with dopamine release is very encouraging," Baas says.

In future studies, the cells derived from Gulf War veterans will offer the researchers a clearer picture of how microtubule-based therapies might affect the illness. In addition to microtubules, they are investigating how other targets, such as tau proteins, may play a role in the disease.

The good news, Baas says, is that once a target is identified, it is likely that an FDA-approved drug already exists to treat the problem. However, the treatment would still likely have to go through vigorous clinical trials in order for the Department of Veterans Affairs to approve it for use on Gulf War Illness patients. Sullivan, Baas and the rest of the Gulf War Illness Consortium team are poised to begin these clinical trials once the most promising treatments are identified.

For Baas, finding a therapy that will help veterans like Lynn Santosuosso is the ultimate goal, but the possibilities for research don't end there. The wide use of organophosphates as pesticides and herbicides across the world adds another layer of urgency to understanding the risks of ongoing chemical exposure. Extremely toxic chemicals are still used regularly in places like India and China, and organophosphates have also been used in public health applications in some countries, for example to combat West Nile virus. Not to mention, bioterrorism remains an ever-present threat.

"We're living in an increasingly toxic world," Baas says. "It's likely that this kind of disease is going to repeat itself if we don't educate ourselves to its causes, as well as how to prevent and treat it."

_FIGHTING FIRE-AND TIGHT BUDGETS

When fire departments better understand ***the costs of specific injuries*** *to their personnel, they can use their budgets more wisely and save hundreds of thousands of dollars.*

_JENNIFER TAYLOR
_LONI PHILIP TABB
_SHANNON WIDMAN
Taylor and Tabb are associate professors in the Dornsife School of Public Health, and Widman (MPH '10) was formerly project manager at the Center for Firefighter Injury Research and Safety Trends.

For fire departments operating with limited resources, every dollar counts. But fire departments and their municipalities could be shorting their budgets by hundreds of thousands of dollars because of the inability to accurately count firefighter injury data and properly plan ahead, according to a new study by Drexel researchers.

Combining data from four databases to look at injury occurrence and reporting in the Philadelphia Fire Department, researchers from the Center for Firefighter Injury Research and Safety Trends (FIRST) in the Dornsife School of Public Health discovered that once injuries were more accurately coded, the difference in workers' compensation costs was as much as $1 million for some injuries.

"It is very important for fire departments to understand causes and cost of injury to ensure their limited budget is being properly distributed," says Jennifer Taylor, FIRST center director and senior author on the study published in *Injury Prevention*. "If departments can accurately pinpoint specific injuries that lead to specific costs, they are empowered to prioritize decisions when considering prevention."

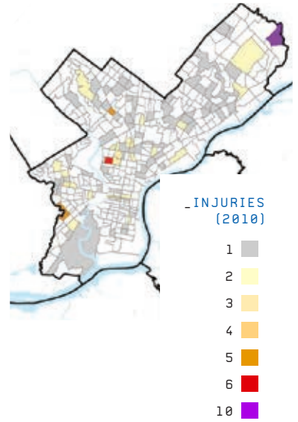
The study linked information from human resources records, dispatch data, workers' compensation records and the records of the first report of firefighter or paramedic injuries. By doing so, they were able to track injuries across the data sets, allowing for more accurate counting and classification.

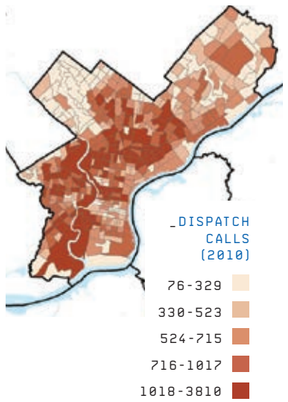
The team found that the most costly injuries were strains, falls and burns. Workers' compensation due to burn injuries was undervalued by $750,000, while strain injuries were undervalued by $1 million.

"The cause of injury resulting in the most numerous claims may not result in the highest costs," says Shannon Widman, project manager at FIRST and lead author. "A smaller number of more serious injuries may result in higher costs to departments and municipalities."

BRIAN SULLIVAN

BURN_RATE
The team found that the most costly injuries were strains, falls and burns. Workers' compensation due to burn injuries was undervalued by $750,000, while strain injuries were undervalued by $1 million.





MAPPING_INJURIES
Researchers found that significant variability exists across Philadelphia when looking at the number of injuries relative to the number of calls in a given census tract.

AUTISM

_PCBs IN THE WOMB

*A class of **chemical compounds banned** more than 40 years ago is still increasing the likelihood of children born with neurodevelopment disorders.*

Despite being banned in the 1970s, chemicals used in certain pesticides and in consumer goods may still be affecting babies, acccording to a new study from the A.J. Drexel Autism Institute.

_KRISTEN LYALL
Lyall is an assistant professor in the A.J. Drexel Autism Institute.

Children born after exposure to the highest levels of certain PCBs during pregnancy were roughly 80 percent more likely to be diagnosed with autism than those with the lowest levels of exposure, researchers found.

Although PCBs are no longer produced in the United States, they can remain in the environment and become absorbed in the fat of animals that humans eat.

80%

Increased likelihood of children born with autism after being exposed to the highest levels of certain PCBs during their mother's pregnancy.

Along with a team of researchers from the California Department of Public Health, the Kaiser Permanente Division of Research and the National Center for Environmental Health, Lyall looked at a sample of children born in Southern California between 2000 and 2003.

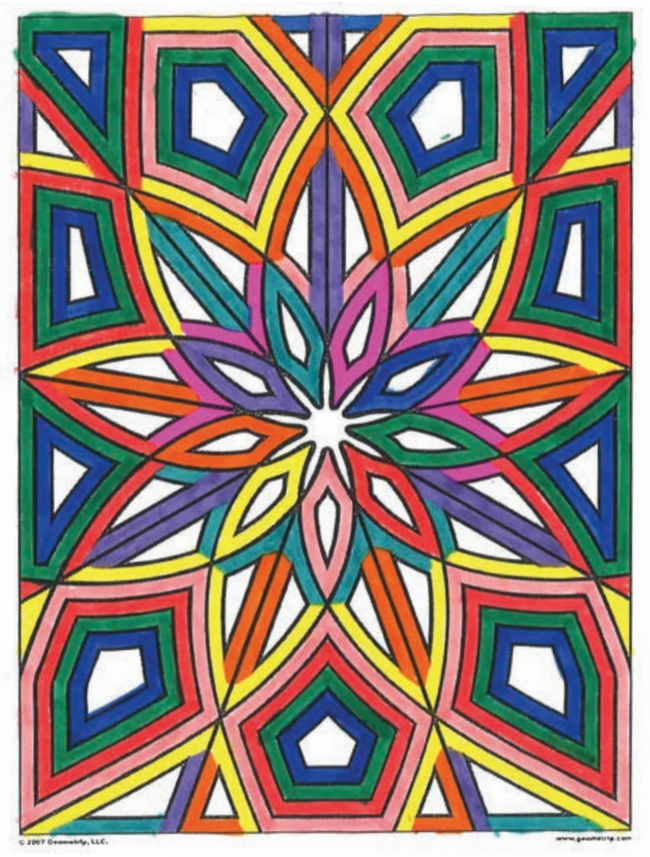
Blood tests taken during the second trimester of the mothers' pregnancies showed that two compounds in particular — PCB 138/158 and PCB 153 — stood out as being significantly linked with autism risk. Children with the highest in utero levels of the compounds were between 79 and 82 percent more likely to have an autism diagnosis than those with the lowest levels. High levels of two other compounds, PCB 170 and PCB 180, were also associated with approximately 50 percent greater likelihood of an autism diagnosis.

"The results suggest that prenatal exposure to these chemicals above a certain level may influence neurodevelopment in adverse ways," Lyall says.

MENTAL HEALTH

_THE BOOK ON COLORING

*Adult coloring books can have **positive effects on a person's stress levels,** but they're no substitute for actual art therapy.*



You might be able to lower your stress level with one of the adult coloring books that have become so popular in recent years, but if you want to truly change your situation, they can't match the power of art therapy, according to a new study.

Drexel researchers found that although coloring books are often advertised as "art therapy," the positive effects they provide are not nearly as potent as involving an actual art therapist and dealing with growth and relationships.

Girija Kaimal, assistant professor in the College of Nursing and Health Professions, led a study that compared two 40-minute exercises each performed by a group of participants — one consisting of pure coloring and the other involving direct input from an art therapist — to see if one or the other led to significant differences in mood and stress levels.

"The main takeaway is that coloring has some limited benefits like reducing stress and negative mental states," Kaimal says. "But it does not shift anything else of substance, develop relationships, nor result in any personal development."

In the coloring exercise, participants colored in a pattern or design, while in the other exercise they were put in an open studio situation facilitated by an art therapist, and given guidance and support to process the experience and artwork. They were able to make any type of art they wished.

"The main takeaway is that coloring has some limited benefits...But it does not shift anything else of substance, develop relationships, nor result in any personal development."
– Girija Kaimal

By reviewing surveys taken before and after the sessions, the researchers found that perceived stress levels and negative mental states went down by roughly the same levels for both exercises. But the participants also displayed a roughly 7 percent increase in self-efficacy from the open studio sessions, along with a 4 percent increase in creative agency and a 25 percent increase in positive feelings. Coloring had no effect on those responses.

"Coloring might allow for some reduction in distress or negativity, but since it is a structured task, it might not allow for further creative expression, discovery and exploration, which we think is associated with the positive mood improvements we saw in the open studio condition," Kaimal says.

AUTISM

_$11M GRANT

Early detection is critical for children with autism spectrum disorder so they can get intervention that targets their needs. A Drexel researcher has received a grant for a study seeking to demonstrate the improved outcomes that can result from early detection and intervention.

The Autism Centers of Excellence grant for $11.4 million will fund work by Diana Robins, a professor in the A.J. Drexel Autism Institute, seeking to link improved outcomes for children with autism directly to early detection and treatment.

Getting autism-specific treatment instead of just general treatment, like speech therapy, is important for young children on the spectrum, Robins says.

"Research indicates that children with autism respond best to intensive autism-specific treatment that involves one-on-one delivery from an expert, with specific goals targeting communication, social engagement and play," Robins says. "Research also shows that children who start autism-specific intervention at younger ages make better progress than children who start when they are older."

This study will link early childhood detection strategies to early intervention to see how children's outcomes are affected by the time they reach kindergarten.

Among the areas that will be studied once the children in the study reach age 5 are their overall kindergarten readiness, social interaction skills and the quality of interactions they have with their parents.

JUSTICE

_UNEQUAL FORCE

*In response to a study that gained widespread attention, a Drexel researcher looked closer at population-level data and found that **white males are significantly less likely to be killed** by police than males of color.*

Black males are nearly three times as likely to be killed by police as white males, and Hispanic males are more than one-and-a-half times as likely to fall victim, according to a new Drexel study that looked at population-level data.

_JAMES BUEHLER
Buehler is a clinical professor in the Dornsife School of Public Health.

Professor James Buehler conducted his study in response to widespread interpretations of a study released in the summer of 2016 by Roland G. Fryer. Many people interpreted Fryer's study, which looked at situations in which lethal force might be used, as finding that there was no racial difference in "legal intervention deaths" as a result of police encounters. Buehler felt that the study left out an important part of the whole picture.

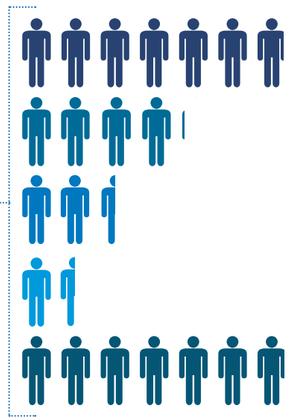
Buehler's follow-up study, published in the *American Journal of Public Health*, used national records from the Centers for Disease Control and Prevention's Wide-Ranging Online Data for Epidemiology Research database from 2010–14. Of the 2,285 deaths attributed to law enforcement action over that five-year period (1.5 per million in U.S. population per year), 96 percent were males 10 years or older.

The chart below shows that the racial disparity among those deaths, though, was striking:

The numbers show that black males are 2.8 times as likely to die by police action as white males, and Hispanic males are 1.7 times as likely. Although American Indians and Alaska natives accounted for just 2 percent of the deaths, their rate was comparable to the rate seen among black males.

"As a public health person, any large disparity in health is a concern to me," Buehler says. "Awareness of these differences should encourage ongoing attention to find solutions to this problem."

NUMBER OF DEATHS BY POLICE PER MILLION IN POPULATION (2010-2014)



According to Buehler's study, the numbers show that black males are 2.8 times as likely to die by police action as white males, and Hispanic males are 1.7 times as likely. Although American Indians and Alaska natives accounted for just 2 percent of the deaths, their rate was comparable to the rate seen among black males.

_WELL CENTER OPENS

*A **new research center** aims to untangle Americans' often problematic relationship with food.*

Seventy percent of the country is overweight or obese and half the population achieves so little physical activity that they are considered sedentary. Meanwhile, eating disorders like anorexia nervosa and bulimia nervosa have serious — even deadly — health consequences, and existing treatments fail to help many patients.

"We'll have the opportunity to bring together scientists from multiple disciplines, including psychology, nutrition, neuroscience, computer sciences and biology. Developments in technology and behavior-change science make this an exciting time to work on these critical public health issues."

- Evan Forman

Into this morass of food-related challenges steps Drexel's new Center for Weight, Eating and Lifestyle Science, known as the WELL Center. It was launched to develop, test and share new behavioral and technological solutions for treating obesity and eating disorders. The center is opening at a critical time, says Director Evan Forman, a professor of psychology in the College of Arts and Sciences.

"We'll have the opportunity to bring together scientists from multiple disciplines, including psychology, nutrition, neuroscience, computer sciences and biology," Forman says. "Developments in technology and behavior-change science make this an exciting time to work on these critical public health issues."

From designing apps that train users to resist urges, to advancing new therapies for patients with bulimia, Forman and his colleagues are seeking unique, evidence-based methods that will create lasting lifestyle changes.

In addition to conducting research and training emerging scientists, the WELL Center includes a clinical arm that provides evidence-based treatments for weight loss and eating disorders. Clinicians also provide nutritional counseling and evaluations for those considering bariatric surgery.

A main research focus of the WELL Center is to develop technologies, such as smartphone apps, that do a better job than existing programs of helping individuals change their habits.

"Giving people tracking and prescriptions is helpful, but not at all sufficient to help them make substantive, lasting changes," Forman says.

_UNNATURAL METHANE GAS

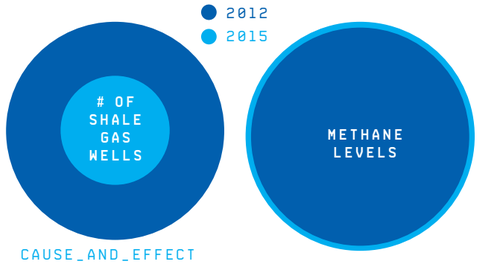
*Despite a dip in the number of new wells being drilled in the Marcellus Shale, **the amount of methane in the air in rural parts of Pennsylvania** is on the rise.*

Emissions of natural gas-related pollutants are getting worse across the section of Pennsylvania that sits atop the Marcellus Shale, the largest gas field in the country. Atmospheric methane levels are increasing despite a decline in the number of new natural gas wells in the region, Drexel researchers have found. Their study noted a substantial increase from 2012 to 2015 in measurements of methane and other air pollutants taken three years apart in the rural areas of Pennsylvania that have been the target of natural gas development over the last decade.

"Methane is increasing globally, but the rate of increase for this region is much more rapid than global increases," says study leader Peter DeCarlo, an associate professor who studies atmospheric chemistry in the College of Engineering and College of Arts and Sciences. "The rapid increase in methane is likely due to the increased production of natural gas from the region, which has increased significantly over the 2012–2015 period. With the increased background levels of methane, the relative climate benefit of natural gas over coal for power production is reduced."

Since the first shale gas wells were drilled in the Marcellus Shale, a region that diagonally bisects the state from the northeast to the southwest, there have been concerns about the environmental effects of unlocking new stores of fossil fuel by an unconventional method called hydraulic fracturing, or fracking. Nearly a decade later, researchers are still working to understand just how the chemicals released — and those used to release them — are lingering in the water and air.

_PETER DECARLO
DeCarlo is an associate professor in the College of Engineering and the College of Arts and Sciences.



CAUSE_AND_EFFECT
While the number of new wells drilled between 2012 and 2015 halved, methane levels still rose by 100 parts per billion.

The study, published in the journal *Elementa: Science of the Anthropocene*, is the latest in a series conducted by DeCarlo and the Drexel Air Resources Research Lab. The team traversed the Marcellus Shale region using Drexel's Mobile Laboratory, a Ford cargo van equipped with the necessary equipment to measure concentrations of chemicals and particles in the air at one- to 10-second intervals while driving.

Initial measurements taken in 2012 showed methane levels at 1,960 parts per billion — roughly 50 parts per billion higher than would be expected in a rural area without natural gas development. By 2015, that concentration jumped another 100 parts per billion. Over that time period, production of natural gas from the region more than doubled, despite the fact that there were about half as many new wells drilled in 2015 as in 2012, according to Pennsylvania Department of Environmental Protection figures cited in the paper.

"Though the rate at which new wells are being drilled and completed has slowed down, the overall infrastructure and production has increased," DeCarlo says. "That means that the volume of gas moving through pipelines, compressor stations and processing plants is increasing. If the leakage rate of methane is constant per cubic foot of gas, it would not be surprising that the background methane has increased as much as it has while other pollutants like carbon monoxide, which is more associated with drilling and trucking, are showing a decline."

_CALL YOUR SENATORS

Party identification plays a significant role in determining how U.S. senators vote on legislation that impacts public health.

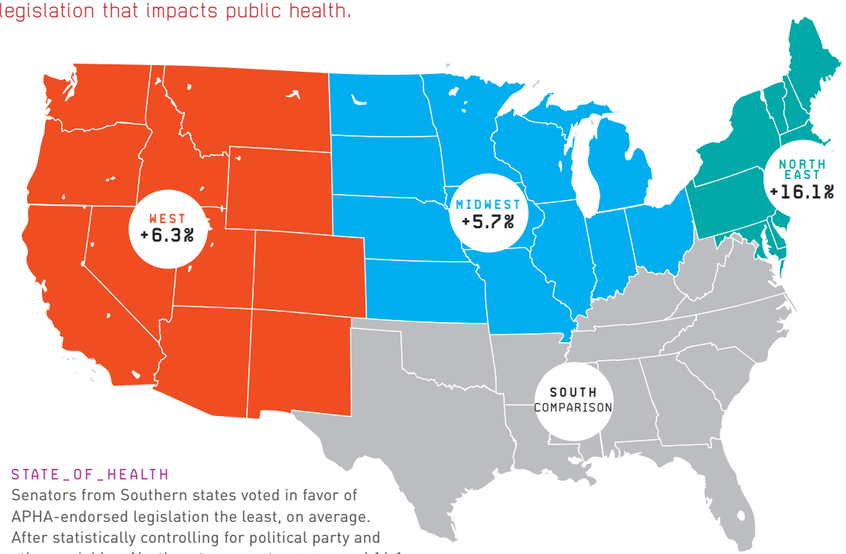
Even when it comes to public health, our representatives in the U.S. Senate are starkly polarized.

Democratic senators are more than four times as likely to use their vote to positively impact public health policies than their Republican colleagues, according to a study by Dornsife School of Public Health researchers.

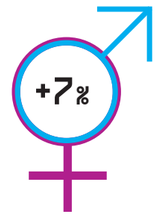
"The findings are concerning, but not surprising," says Assistant Professor Jonathan Purtle. "They empirically show that the political polarization of public health policy is indeed as bad as it anecdotally seems — and has been bad for at least 15 years."

To measure the differences in public health support, Purtle, along with Assistant Research Professor Neal Goldstein and a pair of then graduate students — Eli Edson and Annamarie Hand — examined when senators voted in line with the desires of the American Public Health Association. They used the Annual Congressional Record to identify bills introduced into Congress that could have major effects — good or bad — on public health, and then record whether each senator voted that way.

The team did not just look at party affiliation, but also measured demographic data, including each senator's gender, the state they represent and what region that state is in.



STATE_OF_HEALTH
Senators from Southern states voted in favor of APHA-endorsed legislation the least, on average. After statistically controlling for political party and other variables, Northeastern senators averaged 16.1 percentage points higher when it came to voting for APHA's policy recommendations than their Southern colleagues; Western senators averaged 6.3 percentage points higher and Midwestern senators came in at 5.7 percentage points higher.



After statistically controlling for political party, geographic region and other factors, it was determined that female senators actually averaged 7.1 percentage points higher than their male colleagues when it came to voting for positive public health measures.

_WHAT IS THE APHA?
The American Public Health Association is a nonpartisan, 140-year-old professional organization advocating for improved national public health.

_AGREE TO DISAGREE
Looking at data from 1998 through 2013, Dornsife School of Public Health researchers found that the average split between Republican and Democratic support is a whopping 67 percentage points when it comes to legislation endorsed by the APHA. Democrats voted in line with the APHA's recommendations 88.3 percent of the time, on average, while Republicans' average was just 21.3 percent.

AN INTERVIEW WITH

_MODERNITY

The materials and technologies that put modernity in motion are exhilarating, but they have consequences that must be managed, warns Drexel sociologist and mobility theorist Mimi Sheller. _by Ben Seal with Mimi Sheller _photos by David Arky

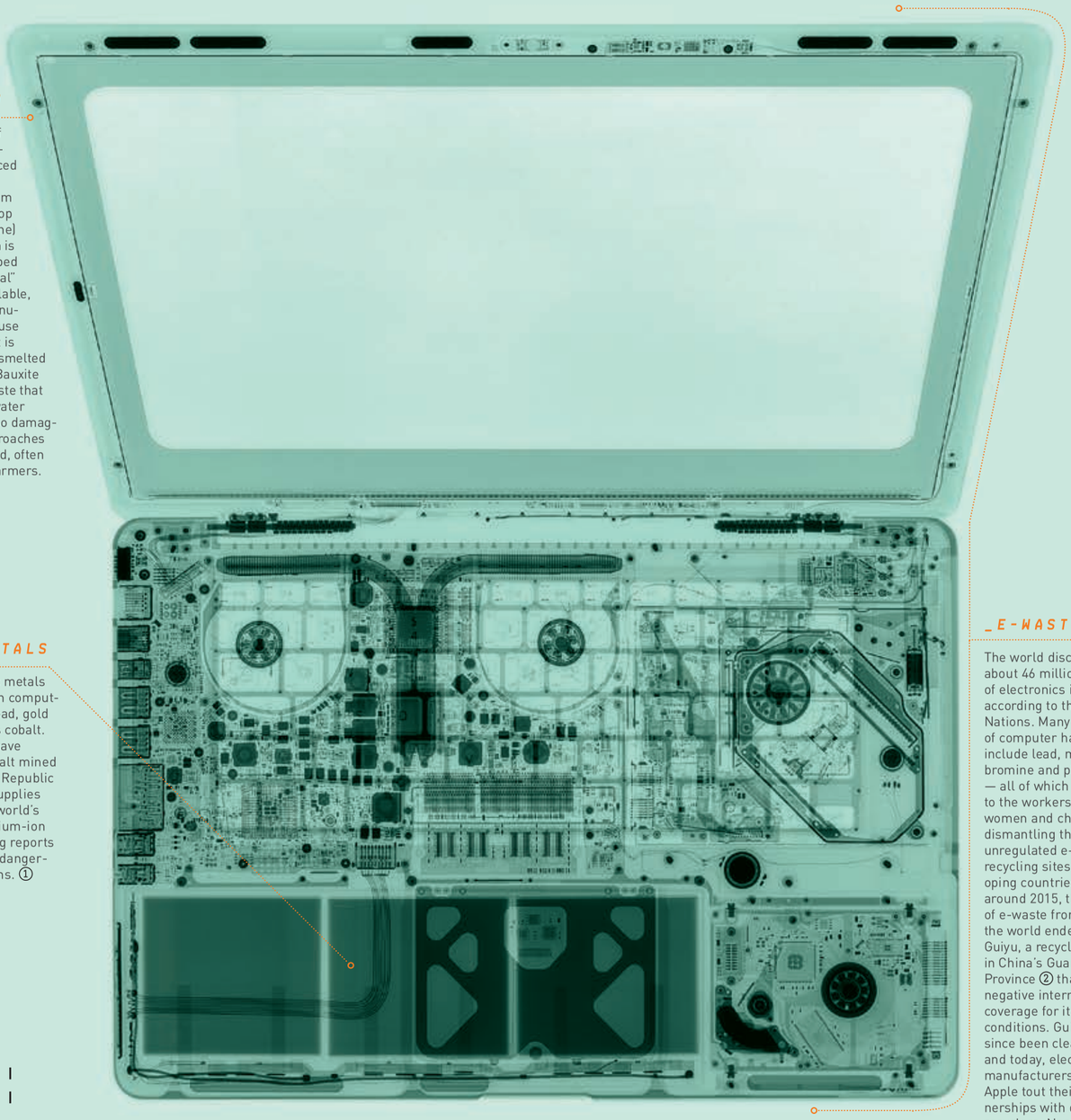
In a world that is constantly on the move, Mimi Sheller studies the systems that make progress possible, for better and for worse.

As the director of Drexel's Center for Mobilities Research and Policy and a professor in the College of Arts and Sciences, her broad research and publications provide a deeper understanding of the forces that shape the way modern societies travel, communicate and consume.

Sheller is president of the International Association for the History of Transport, Traffic and Mobility and co-editor of *Mobilities*, a journal she co-founded in 2006 to delve into the interdisciplinary field of study she helped establish. She is author and co-editor of nine books, including the monographs "Aluminum Dreams: The Making of Light Modernity" and "Citizenship from Below." She is currently completing two new books, "Mobility Justice: The Politics of Movement in an Age of Extremes" and "Island Futures." She is also working on a documentary with Jamaican film director Esther Figueroa on the global aluminum industry. This year, she delivered keynote addresses at conferences and workshops in Australia, Brazil, Canada, the Netherlands, Denmark and Italy, and gave the Society & Space plenary lecture at the American Association of Geographers Annual Meeting.

EXEL asked Sheller to expound on how society's reliance on materials like aluminum play into the way we live.

_WHAT'S IN YOUR COMPUTER?



_ALUMINUM

The 2008 launch of the "unibody" MacBook Pro* introduced sleek, lightweight machined aluminum casings to the laptop (and later, cellphone) market. Aluminum is sometimes described as a "green material" because it is recyclable, however, most manufactured products use primary metal that is electrochemically smelted from bauxite ore. Bauxite mining creates waste that can contaminate water supplies, and it also damages forests and encroaches on agricultural land, often displacing small farmers.

_OTHER METALS

Other problematic metals commonly found in computer parts include lead, gold and alloys such as cobalt. Some producers have stopped using cobalt mined in the Democratic Republic of Congo, which supplies 60 percent of the world's cobalt used in lithium-ion batteries, following reports of child labor and dangerous work conditions. ①

_E-WASTE

The world discarded about 46 million tons of electronics in 2014, according to the United Nations. Many pieces of computer hardware include lead, mercury, bromine and phthalates — all of which are toxic to the workers (including women and children) dismantling them in unregulated e-waste recycling sites in developing countries. Up until around 2015, the majority of e-waste from around the world ended up in Guiyu, a recycling district in China's Guangdong Province ② that received negative international coverage for its toxic conditions. Guiyu has since been cleaned up and today, electronics manufacturers including Apple tout their partnerships with domestic recyclers. Nonetheless, a 2015 sting operation by Seattle-based environmental watchdog Basel Action Network revealed that some U.S. recycling was a sham. BAN hid GPS trackers in 200 pieces of obsolete electronics and dropped them off at e-waste collection centers; about a third of the e-waste ended up at unregulated developing-world sites. ③

Q: IN YOUR BOOK "ALUMINUM DREAMS," YOU WRITE ABOUT HOW ALUMINUM SHAPED THE 20TH CENTURY AS IT BECAME UBIQUITOUS. HOW DID IT OPEN UP NEW POSSIBILITIES FOR PROGRESS IN THE MODERN WORLD, AND IS THAT CHANGING IN THE 21ST CENTURY?

A: *The electricity grid, the buildings we live and work in, the satellites and gadgets we use to communicate, the way people and goods move from place to place, the power, speed, mobility and conveniences that we take for granted — all are made possible by aluminum. It underpins our material culture and our ideas of what it means to be modern. Aluminum first became available on a large scale in the early 20th century and quickly became a crucial material for streamlined vehicles, lighter packaging, mobile homes, new flight capabilities, high-tech military technologies, and the dawn of the Space Age. In addition to literally putting the world in motion, these new practices of mobility also generated visual representations and aesthetics of aerodynamic speed, accelerated mobility and technological futurism. By the 1950s, the gleam of aluminum surfaces was found on everything from Airstream trailers to kitchenware, and from rockets to airport lounges.*

Today it remains a crucial material in new cars, food packaging, laptop computers, building construction and, of course, airplanes, spaceships and satellites. In some ways it has been eclipsed by the novelty of new materials such as titanium, carbon composites and nanomaterials (although some of these still make use of aluminum); yet we still depend on aluminum all the time in more mundane ways, such as for sports equipment (bikes, boats, bats); medical equipment (crutches, walkers, artificial limbs); and things like chairs, ladders and window frames. Look around and you will probably see some aluminum!

①REISINGER, DON. "CHILD LABOR REVELATION PROMPTS APPLE TO MAKE SUPPLIER POLICY CHANGE." FORTUNE. HTTP://WWW.FORTUNE.COM/2017/03/03/APPLE-COBALT-CHILD-LABOR/ (PUBLISHED MARCH 3, 2017, AND ACCESSED JULY 27, 2017). ② STANDAERT, MICHAEL. "CHINA'S NOTORIOUS E-WASTE VILLAGE DISAPPEARS ALMOST OVERNIGHT." BLOOMBERG. HTTPS://WWW.BNA.COM/CHINAS-NOTORIOUS-EWASTE-N57982065266/ (PUBLISHED DEC. 17, 2015, AND ACCESSED AUG. 1, 2017). ③"SCAM RECYCLING: E-DUMPING ON ASIA BY U.S. RECYCLERS." BASEL ACTION NETWORK. HTTP://WIKI.BAN.ORG/IMAGES/1/12/SCAMRECYCLINGREPORT-WEB.PDF (PUBLISHED SEPT. 15, 2016, AND ACCESSED AUG. 1, 2017).

* APPLE INC., AS ONE OF THE LARGEST PRODUCERS OF POPULAR ELECTRONICS, IS REPRESENTED HERE MERELY AS A SYMBOL OF THE LARGER HIGH-TECH CONSUMER GOODS INDUSTRY.

HOW DOES OUR RELIANCE ON ALUMINUM IMPACT OUR ENVIRONMENT AND HEALTH?

One-twelfth of the earth's crust is aluminum, making it the third-most-common element after oxygen and silicon, but it is extremely difficult to get it into pure form. The main source is bauxite ore, which is first processed into alumina, and then smelted into aluminum. Bauxite mining is an open-pit process that leads to deforestation and leaves behind toxic "red mud" lakes.

To quantify it, each ton of aluminum produced requires four tons of bauxite ore to be strip-mined, crushed, washed and refined into alumina, creating about four tons of caustic red mud residue, which can seep into surface and groundwater. Dust from aluminum refining causes respiratory damage, and portside alumina spills have damaged coral reefs.

Aluminum smelting is one of the most energy-intensive production processes on earth. Smelting uses an electrolytic process in which a high current is passed through dissolved alumina. The electrochemical smelting of aluminum from refined bauxite ore requires between 13,500 and 17,000 kilowatt-hours of electricity per ton, more energy than any other kind of metal processing. To put this in perspective, making one soda can is said to require the equivalent of one-quarter of the can's volume in gasoline to produce.

Because of its high demand for electricity, the process of producing aluminum creates on average 13 tons of carbon dioxide emissions per ton of aluminum. The aluminum industry emits about 1 percent of global emissions of man-made greenhouse gases. Smelters are also responsible for 90 percent of all tetrafluoromethane, and 65 percent of all hexafluoroethane emissions worldwide. These perfluorinated compounds have global warming potentials that are 6,500 to 9,200 times higher than carbon dioxide. Communities living near the industry around the world have increased asthma levels near bauxite mines, indications of multiple-chemical sensitivity around alumina refineries, and exposure to toxic waste such as fluoride and cyanide near aluminum smelters.

Some people also believe that ingesting or absorbing aluminum has human health impacts. It is not only found in our kitchenware and food packaging, but also occurs in powdered form in many cosmetics and deodorants, and is an adjuvant in vaccines. Accumulations of aluminum have been found in the brain tissue of people suffering from Alzheimer's disease and have been connected to other neurological disorders, as well as showing possible links to breast cancer.

WHAT COULD BE DONE TO LIMIT WASTE AND MITIGATE SOME OF THE CONSEQUENCES OF ALUMINUM MINING?

Architects, designers and engineers today still embrace aluminum as a sustainable "green metal" because of the energy efficiencies it enables, despite the pollution and human rights violations coincident with the industry around the world. In many places there are protests against the industry, including at bauxite mining areas in India, Guinea and Jamaica, and against smelters in Trinidad, South Africa, Canada and Iceland.

There are several ways that industry and citizens can try to mitigate these negative impacts. First, we could recycle all the consumer products we use with aluminum in them, especially cans. Melting down used aluminum requires only 5 percent as much energy as making it from ore. No one should ever put an aluminum can in the trash. We also need to simply use the metal more efficiently, insist on building with recycled aluminum, make products in which various metals can easily be separated out at the end of their lifecycle, and recover as much as possible from already-existing sources, such as so-called "urban mining," which digs through landfills.

Beyond that, though, we also need to regulate the industry more carefully so that it doesn't just move to places with little protection and get away with environmental and human rights violations. There are voluntary programs like the Extractive Industries Transparency Initiative, which enrolls countries in reporting on companies operating in their territory.

But we also need to ask ourselves when we buy a product: Where did this come from and how did it get there? Who is affected by the materials in the products I am using? We need to put pressure on companies to be more transparent about what they are doing, where they are doing it, and how they are treating both workers and surrounding communities.

AS A SOCIOLOGIST, WHAT ROLE DO YOU BELIEVE THE SOCIAL SCIENCES CAN PLAY IN UNDERSTANDING HOW TO BALANCE THE BENEFITS AND HAZARDS OF THESE MATERIALS?

In my own work, I have tried to make people more aware of their involvement in larger systems of circulation of materials, whether it's aluminum, the movement of energy or the impacts of tourism. Technology never operates on its own, but is always about how people use it, how we put things together and make them work.

If we want to make changes in complex systems we first have to be aware of them, but then we also need to develop specific and local forms of interaction, disruption or envisioning alternatives. This could take the form of citizen science, participatory art projects, community workshops to deliberate over new solutions, or community-based action research.

I am currently working with Jamaican filmmaker Esther Figueroa on a documentary called "Fly Me to the Moon" that will try to bring together audiences in different parts of the world to understand how they are connected by aluminum. I have often worked with artists, for example, to creatively engage people to think about their context differently or to link disparate groups together. And my forthcoming book "Mobility Justice" seeks to develop policies for greater equality and justice in all kinds of mobility systems, from the scale of the body, the street and the city to extended infrastructures and planetary ecologies.

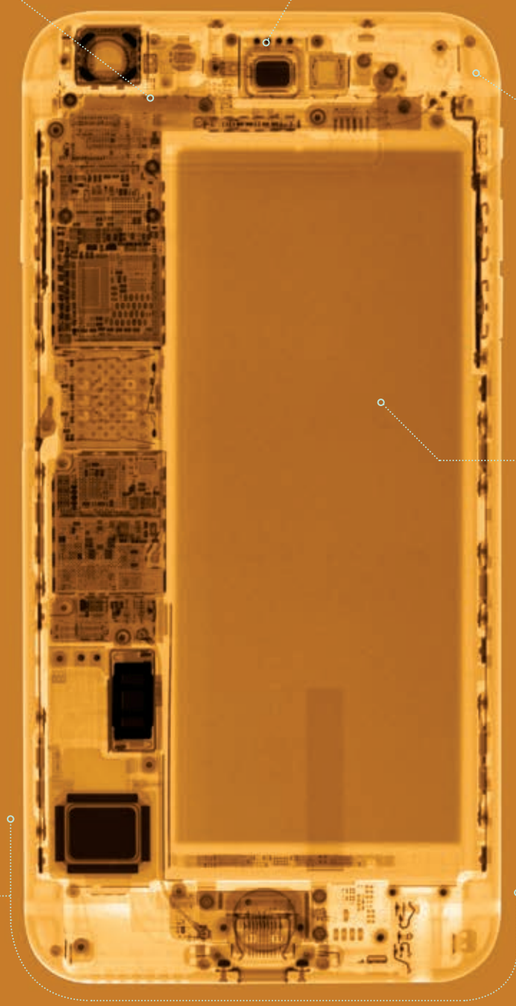
At a recent conference of the International Association for the History of Transport, Traffic and Mobility (of which I am president) our theme was "Mobile Utopia: Pasts, Presents and Futures." We conducted an arts exhibition, as well as "mobile utopia experiments" in which we invited groups of people to enact different ways of moving.

DO YOU FEEL PESSIMISTIC OR OPTIMISTIC ABOUT THE DIRECTION THAT MATERIAL PRODUCTION WILL TAKE HUMANITY?

I am both pessimistic about the current system of material production and also optimistic over the longer term that we will be forced to make a change because we will have to. This is what the futurist Buckminster Fuller called "emergence by emergency."

When the current system stops working (whether because of climate change disruptions, energy shortages or social conflict), we will need to find more energy-efficient and less wasteful ways of doing things. In the meantime, it is important to continue to develop alternatives — not only alternative technologies but also alternative social practices — as the foundations for a new socio-technical system to evolve.

_WHAT'S IN YOUR PHONE?



(1) KAIMAN, JONATHAN. "RARE EARTH MINING IN CHINA: THE BLEAK SOCIAL AND ENVIRONMENTAL COSTS." THE GUARDIAN. HTTPS://WWW.THEGUARDIAN.COM/SUSTAINABLE-BUSINESS/RARE-EARTH-MINING-CHINA-SOCIAL-ENVIRONMENTAL-COSTS (PUBLISHED MARCH 20, 2014, AND ACCESSED AUG. 1, 2017). (2) BROWING, LYNNLEY. "WHERE APPLE GETS THE TANTALUM FOR YOUR IPHONE." NEWSWEEK. HTTP://WWW.NEWSWEEK.COM/2015/02/13/WHERE-APPLE-GETS-TANTALUM-YOUR-IPHONE-304351.HTML (PUBLISHED FEB. 4, 2015, AND ACCESSED JULY 31, 2017). (3) MONT, JOE. "SEC BACKS AWAY FROM CONFLICT MINERALS RULE ENFORCEMENT." COMPLIANCE WEEK. HTTPS://WWW.COMPLIANCEWEEK.COM/BLOGS/THE-FILING-CABINET/SEC-BACKS-AWAY-FROM-CONFLICT-MINERALS-RULE-ENFORCEMENT#.WX-XPA2ZNAY (PUBLISHED APRIL 10, 2017, AND ACCESSED JULY 31, 2017).

_JOINT RESOLUTION

Where do you go to learn how not to build a medical implant? In Drexel's ***Implant Research Center, failed joint implants collected from across the country*** *are studied for clues to design improvements that could benefit patients.*

Like coroners investigating a suspicious death, the biomedical engineers at Drexel's Implant Research Center carefully pore over each palm-sized ball, cylinder and screw that is delivered to 3401 Market St. Their job is to figure out just what went wrong with these orthopedic, spine and cardiovascular implants — objects, some still covered in blood, that once resided inside human bodies.

The center currently holds more than 6,500 implants donated from 15 hospitals from Pennsylvania, Ohio, New Jersey, Nevada, Texas, Kentucky, Maryland and Tennessee. Each implant is accompanied by its own case file, which includes the patient's demographics, why the device was removed and X-ray images.

Some implant failures are due to patients' health and others are surgery-related. Many of the devices simply were not built to endure.

"We want to capture why implants don't last as long as they could in some patients," says Steven Kurtz, the center's director and a research professor in the School of Biomedical Engineering, Science and Health Systems.

Drexel's is one of the only standalone retrieval programs in the country, meaning it receives implants from multiple health systems instead of just one. That's important, Kurtz says, because it allows his team to study the "full landscape" of implants.

"Each hospital tends to have its favorite brand of implant," Kurtz says. "And these hospitals send us every implant for every reason that they were removed, rather than reasons biased by what the surgeon has an interest in inspecting."

One of the biggest concerns related to implants is metal release resulting from taper fretting and corrosion, which can threaten the longevity of an implant. The Implant Research Center engineers are interested to find out why these devices corrode. By testing the implants they retrieve, they can figure out which types of additives or materials may slow wear and tear.

Infection is another serious complication of implantable medical devices. Currently, the researchers are looking at the optimal ways to reduce or eliminate bacteria on the surfaces of spinal and orthopedic devices.

Implants were once used primarily in elderly patients and only needed to last up to 20 years, but that demographic is now changing.

"People are living longer and want to stay active for more years, which means younger people are receiving implants that may need to last for multiple decades," says Daniel MacDonald, the center's deputy director and a PhD candidate in the School of Biomedical Engineering, Science and Health Systems. "We want to be able to improve the design for the next generation of patients."

_STEVEN KURTZ
_DANIEL MACDONALD
Kurtz is director of the Implant Research Center and a research professor in the School of Biomedical Engineering, Science and Health Systems. MacDonald is deputy director of the center and a PhD candidate in the School of Biomedical Engineering, Science and Health Systems.

FAILED_IMPLANTS
Shown here is a small sampling of implants from Drexel's Implant Research Center. The center currently holds more than 6,500 implants donated from 15 hospitals from Pennsylvania, Ohio, New Jersey, Nevada, Texas, Kentucky, Maryland and Tennessee. Each implant is accompanied by its own case file, which includes the patient's demographics, why the device was removed and X-ray images.

_YOUTH MOVEMENT

Drexel researchers believe youth coaches should teach young athletes ***better movement techniques*** *that will reduce lower-body injuries.*

Every young athlete shares the same deep-seated fear when they step onto the field of play: a knee injury, especially a tear of the anterior cruciate ligament, and the taxing rehabilitation process that comes with it.

Prevention is key. A new study conducted by researchers at Drexel's College of Medicine, the University of Connecticut and California State University in Fresno shows that when youth coaches receive even a small amount of education about preventive training, they can be as effective as professional athletic trainers at mitigating poor movement behavior and preventing injury in young soccer athletes.

To find out whether a 90-minute educational workshop could be an effective way to train coaches in injury prevention, the researchers randomly assigned 12 youth soccer teams to two groups. During the fall season, one group had athletic trainers lead the teams through a program before every practice, while the control group performed its normal warmup. Prior to the subsequent spring season, the coaches for all the teams attended a preventive training program and were instructed to implement the training prior to practices and games.

The athletes were graded before and after each season using a system that evaluated specific jump-landing tasks in order to predict injury risk. According to the results, the training program enhanced movement technique for the majority of soccer players, regardless of whether they were on teams that employed athletic trainers for preventive training. There was also no difference in score improvements between the fall and spring season, suggesting that well-trained coaches can be as effective as professionals at implementing injury-prevention warmups.

"We now know that if we use a shorter duration prevention program for coaches (10 to 15 minutes), we can help reduce the risk of injury, and coaches are willing to do them," says Thomas Trojian, a professor in the College of Medicine and chief medical officer for Drexel Athletics.

SCORING_SYSTEM
The Landing Error Scoring System is a clinical assessment tool used to identify individuals at risk for lower extremity problems, such as an ACL injury.

_MOVEMENT MATTERS

Drexel researchers are seeking a better understanding of ***how cancer cells move*** *so their spread can ultimately be slowed.*

Cancer's deadly nature lies largely in its ability to spread. When doctors can keep tumors contained and protect unaffected organs in the body, they can reduce cancer's lethality.

So it follows that if doctors were able to pinpoint tumor cells and stop them in their tracks, it would go a long way toward limiting the damage done by cancer.

_RYAN PETRIE
Petrie is an assistant professor in the College of Arts and Sciences.

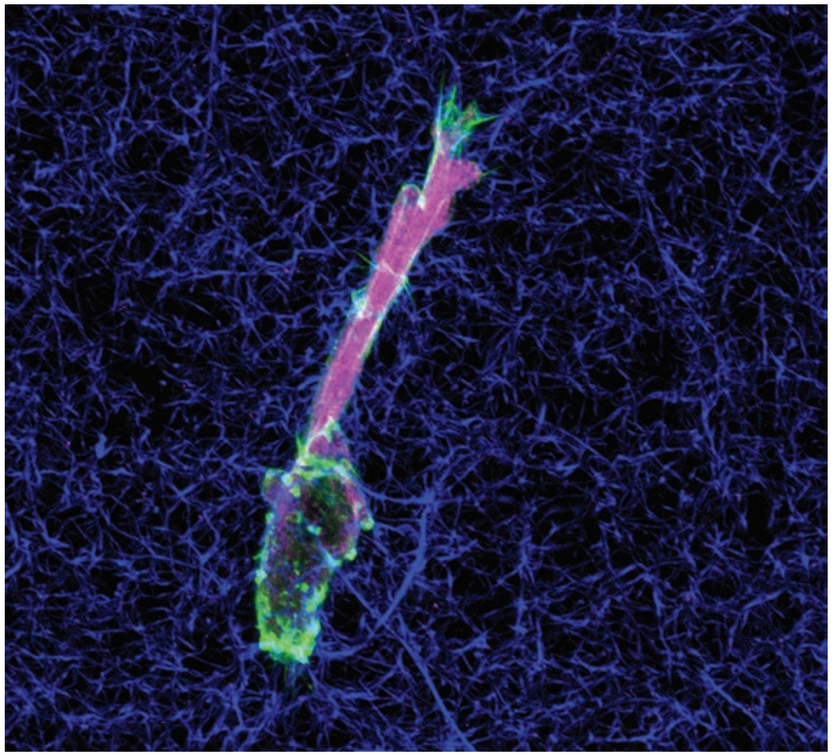
New research from Drexel's College of Arts and Sciences could have implications for the study of cancer cell migration by showing that certain tumor cells (fibrosarcoma) are unable to perform a certain kind of movement that normal connective tissue cells can perform.

Since cells' nuclei are big and rigid, they can't easily squeeze through three-dimensional structures. When such a structure (called a matrix at the cellular level) is encountered, normal cells can switch to a form of movement that creates a pressure differential inside the cell by moving the nucleus, like a piston in an engine. But a team led by Ryan Petrie, an assistant professor in the College of Arts and Sciences, found that fibrosarcoma cells can't perform the piston-style movement when certain protease enzymes are present and highly active. The tumor cells are left to effectively chew their way through the matrix.

"Cell migration is a lethal characteristic of metastatic tumors, where malignant cells begin to move inappropriately and spread through the body to form secondary tumors," Petrie says. "To fully understand the mechanisms which drive normal and pathological cell movement, we must study cell migration in three-dimensional environments, such as the ones found in our tissues."

The research has implications beyond just fighting cancer cells.

"Promoting movement of fibroblasts in specific three-dimensional tissues like dermis [skin] and cartilage could help to heal difficult-to-treat wounds," Petrie explains. "Understanding the fundamental molecular mechanisms driving the movement of these cell types will be essential for designing rational therapeutic strategies in the future."



ON_THE_MARCH
A microscopic image of a tumor cell migrating through collagen. Petrie's research studied cell movement — and lack thereof — in rat tail and cattle skin collagen.

CANCER: RYAN PETRIE, TAKEN IN THE DREXEL CELL IMAGING CENTER.

_BABY'S BREATH

For infants born with bronchopulmonary dysplasia, a chronic lung disease that affects up to 15,000 premature babies each year in the United States, what heals can also hurt. The supplemental oxygen physicians administer to compensate for the babies' developing lungs can increase pulmonary damage, causing lifelong complications.

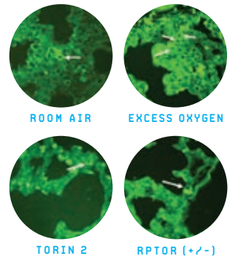
Researchers from Drexel and Yale University have found that by inducing autophagy — a process that allows cells to survive environmental stress by disassembling and repurposing less essential components — they are able to decrease lung injury in mice exposed to high concentrations of oxygen. The study, published in the *American Journal of Respiratory Cell and Molecular Biology*, offers a potential new solution for preventing conditions like bronchopulmonary dysplasia.

"When a cell is under extreme stress, autophagy is a self-sacrificing, protective response. The cell conserves energy by getting rid of its nonessential organelles," says Vineet Bhandari, a faculty member in the College of Medicine and chief of neonatal medicine at St. Christopher's Hospital for Children. "We thought that if we were able to enhance autophagy in the lungs, then we could decrease cell death. And that's exactly what we saw."

To test if increasing cell self-destruction in the lungs could actually decrease cell death — and ultimately prevent lung injury — Bhandari and his team targeted a regular protein called RPTOR, which, when inhibited, is responsible for triggering autophagy. Using genetic manipulation and drug treatment, the researchers increased autophagy in newborn mice exposed to high levels of supplemental oxygen. The increase in autophagy protected the cells from dying and increased survival in the mouse models of bronchopulmonary dysplasia.

The researchers also tested human lung tissue of premature infants with the disease and found similar levels of increased autophagy, suggesting it is a natural process that could be modulated to improve health outcomes, Bhandari says. The next steps will be to replicate the results and eventually test the method in clinical trials with human patients.

"We thought if we could enhance autophagy in the lungs, then we could decrease cell death. And that's exactly what we saw."



When mouse lungs are exposed to high concentrations of supplemental oxygen, there is increased cell death, as noted by increased bright green staining of the protein in the upper right photo. When autophagy is increased by using a drug (Torin2) or by genetic methods, cell death decreases.

_HEALING SOUND WAVES

A battery-powered applicator – as small and light as a watch – is the ***first portable device to heal chronic wounds*** *with low-frequency ultrasound.*

Chronic wounds affect up to 6 million patients in the United States and more than $20 billion is spent on their treatment each year, so even modest reductions in healing time are beneficial.

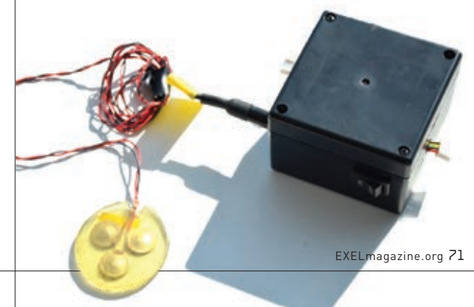
A team of Drexel researchers have an ideal solution. They've developed an inexpensive, wristwatch-size instrument that can speed up slow-healing injuries. Since the device is compact, lightweight and portable, patients may one day be able to use it in their homes, avoiding the high costs and other inconveniences associated with frequent doctor's office visits.

The device heals by sending low-frequency — 20 kilohertz (kHz) — ultrasonic sound waves directly to the chronic wound, where ultrasound has been shown to stimulate blood flow and reduce swelling.

The device was developed by a team headed by Peter Lewin, the Richard B. Beard distinguished university professor in the School of Biomedical Engineering, Science and Health Systems; and Michael S. Weingarten, professor of surgery and chief of vasular surgery at the College of Medicine and medical director of the Comprehensive Limb Salvage and Wound Healing Program at Drexel; with several faculty affiliated with the School of Biomedical Engineering, Science and Health Systems: Rose Ann DiMaria-Ghalili, professor of nursing in the College of Nursing and Health Professions; Michael Neidrauer, research assistant professor; and Leonid Zubkov, research professor.

In 2013, the researchers tested the device on 20 patients from Weingarten's wound healing clinic. Applying the ultrasound at a frequency of 20kHz for 15-minute intervals proved to be the most effective combination of energy and duration. All five patients in the group that received this combination of treatment had healed completely by the end of the four-week treatment period. Overall, the study demonstrated that the new treatment improved healing by 15 percent per week.

Based on those results, the National Institutes of Health awarded the team about $3 million to test the therapy on 120 patients over five years, starting in 2017. By using diagnostic monitoring of blood flow in the wound tissue, the clinical trial will also determine how nutrition and inflammation impact wound closure, making treatment customization a possibility.



_BUG ZAPPER

*Two **new antimalarial drugs** increase cholesterol in a malaria parasite's plasma membrane, making it too stiff to pass through the bloodstream.*

How do you kill a malaria parasite? Clog it with cholesterol.

A team led by Akhil Vaidya, a professor in the College of Medicine and director of the Center for Molecular Parasitology, has discovered an unusual mechanism that allows two new antimalarial drugs to operate. By giving the parasite's skin a boost in cholesterol, the drugs prevent it from easily slipping through the human bloodstream to infect red blood cells. The drugs also seem to trick the parasite into reproducing prematurely, rendering it inert.

Malaria is caused by *Plasmodium* parasites that invade a victim's red blood cells when the victim is bitten by an infected mosquito.

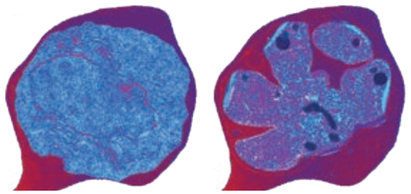
Several drugs under development interrupt this life cycle, including a class of compounds Vaidya discovered in 2014, which he and his team found increase levels of sodium within a parasite's cells, causing them to swell and erupt.

But until recently, scientists didn't understand why this kills the parasite. To find an answer, the researchers first tested the properties of the *Plasmodium* plasma membrane — the parasite's outer skin — before and after exposure to antimalarial drugs.

They hypothesized that the naturally low cholesterol content of the *Plasmodium* membrane permits greater flexibility for the parasite to travel through the bloodstream, and that the sodium increase caused by the drugs somehow interferes with that elasticity.

Just two hours after treatment, the scientists saw that many of the parasites showed fragmented nuclei and interior membranes — precursors to cell division — without any sign that the parasite's genome had multiplied. By prematurely inducing this signaling event, the drugs effectively halt the parasite's advances.

"Nobody suspected something like this to be the mode of action," says Vaidya, who published the findings in *PLOS Pathogens*. "The mechanism is a lot more complicated and interesting than we originally thought."



DIVISIVE_EFFECT
After two hours of exposure to new antimalarial drugs, the malaria parasite shows signs of premature division.

_DOUBLE DUTY

The discovery that a particular protein doesn't just give cells jobs but also sticks around to teach them to perform their new assignments could provide insight into schizophrenia.

A team of Drexel researchers discovered that the protein, called TCF4, remains present in cells after neurogenesis — the process by which jobless cells are turned into signal-carrying neurons that transmit information through the body. Scientists believed that TCF4 degraded and disappeared at that stage, but researchers found that TCF4 actually sticks around and restricts the number of synapses these neurons make, effectively instructing the cells' job performance.

The protein is called "Daughterless" in *Drosophila*, or fruit flies, where its persistence was discovered.

"We think that TCF4 is most likely involved in helping to form the proper number of synapses a neuron makes, so that the information flow in the nervous system doesn't get confused and dysfunctional," says Daniel Marenda, associate professor in the College of Arts and Sciences and a program director at the National Science Foundation. "When you lose these proteins, you suddenly get too many synapses and it disrupts nervous system function."

The findings are particularly important because of the association TCF4 gene variants have with schizophrenia and Pitt-Hopkins Syndrome, a neurodevelopmental disorder.

There is also evidence that neurons making too many synapses are associated with autism.

_THEORY OF EVOLUTION

*Researchers have made progress in understanding **how a common pathogen causes the chronic lung infections** in cystic fibrosis patients.*

_JOSHUA CHANG MELL
Mell is an assistant professor in the College of Medicine.

Cystic fibrosis is the world's most common fatal genetic disorder, caused by a gene mutation that leads to a buildup of mucus in the lungs and creates an optimal environment for some bacteria to thrive. Among those bacteria is *Burkholderia cenocepacia*, a deadly species that is easily transmitted and often resistant to antibiotics.

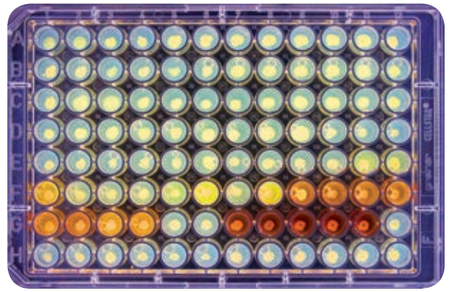
Researchers had a poor understanding of how the bacteria adapt to a cystic fibrosis lung to sustain long-term chronic infections, but scientists from Drexel and the University of British Columbia, in a study published in *Genome Research*, provided the pathogen's first comprehensive genome-phenome analyses.

The researchers collected 215 bacterial samples over time from 16 cystic fibrosis patients and found that long-term infection leads to significant genetic and physical changes, such as progressive declines in bacterial motility and changes in biofilm formation.

"By looking at changes in the genome over time, we could see patterns," says study co-corresponding author Joshua Chang Mell.

Researchers were surprised to find that some bacterial traits typically associated with pathogenesis (namely motility and biofilm formation) actually became less pronounced over time.

"This suggests that one way the bacterium may be adapting to long-term chronic lung infection is by becoming less aggressive and thus potentially more able to avoid the immune system," Mell says.



DEADLY_COLONY
Colorized image of colony morphologies of 96 *Burkholderia cenocepacia* isolates from cystic fibrosis patients.

Malaria: EM by Isabelle Coppens pseudo-colored by Avinash Vaidya. Burkholderia: Amy Lee and Adrianna Paiero

_FINAL DESTINATION

A new study reveals a key facilitator that helps neurons arrive safely as they travel through the human brain – and could provide insight into how disorders develop.

A neuron's journey from its birthplace to a distant location within the brain is essential for all of our most basic physiological functions: sight, hearing, touch, etc.

A new study from Drexel researchers sheds light on the parts of the brain that help make that journey — and everything that relies on it — possible. The sliding movements of a small group of cellular structures — called microtubules — play a key role in keeping neurons on a smooth, proper trajectory, according to research from a team led by Peter Baas, a professor in the College of Medicine and the study's principal investigator.

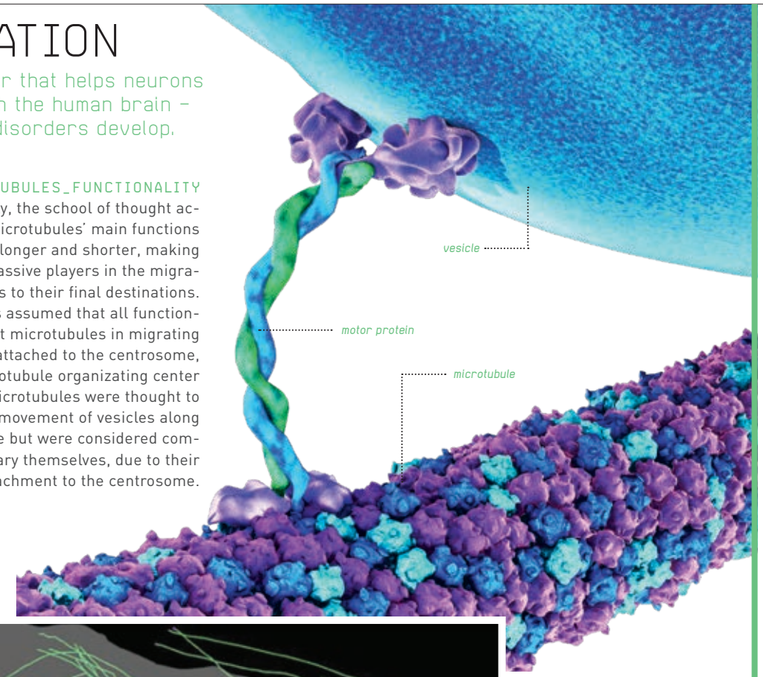
The discovery could ultimately help scientists better understand how neurons gone astray contribute to neurodevelopmental disorders, Baas says.

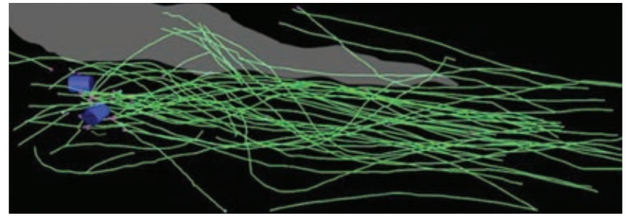
"This study is important for understanding how a healthy brain is organized," Baas says. "If neurons do not know when to start migrating, or where to go, or if the axons don't grow long enough, that sort of thing can give way to disorders such as autism."

By manipulating levels of key proteins, the researchers now know that even the smallest alterations can greatly change the morphology and migratory behavior of a neuron, which can translate to developmental problems.

MICROTUBULES_FUNCTIONALITY

Until recently, the school of thought accepted that microtubules' main functions were to grow longer and shorter, making them merely passive players in the migration of neurons to their final destinations. Researchers assumed that all functionally relevant microtubules in migrating neurons were attached to the centrosome, the main microtubule organizing center of a cell. Microtubules were thought to support the movement of vesicles along their surface but were considered completely stationary themselves, due to their attachment to the centrosome.



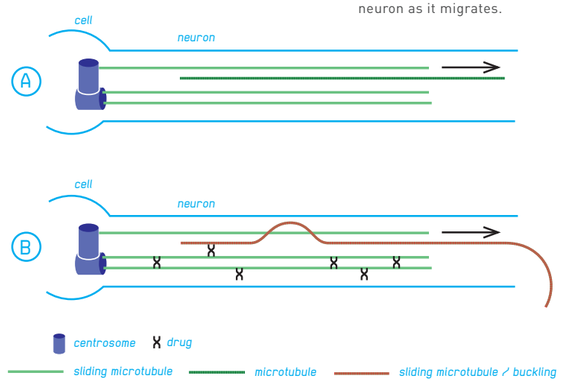


_NEW DISCOVERY
Using electron tomography as well as live-cell imaging — the most rigorous imaging methods available —the researchers found that a small group of microtubules (green) were not attached to the centrosome (blue), and that motor proteins can actually slide these unattached microtubules within the neuron as it migrates.

A_LITTLE_SLIDING_IS_KEY

Ⓐ Researchers found that migrating neurons display a small amount of microtubule sliding and migrate on a consistent path.

Ⓑ By adding a drug that keeps the microtubules from sliding, the researchers saw that the neurons frequently changed direction and buckled, instead of migrating in a simple, straight line. "That little bit of sliding that normally occurs is really important for maneuverability," Baas says.



KENDRA RAY
Ray is a 2017 doctoral graduate of the College of Nursing and Health Professions and a board-certified music therapist. She is a creative arts therapist at Menorah Center for Rehabilitation and Nursing Care in Brooklyn.

ALONE IN THE DARK

BUT NOW YOU'VE COME A - LONG

*Can the **power of music help people with dementia reconnect** with the world around them? College of Nursing and Health Professions recent doctoral graduate Kendra Ray and her colleagues know that it can, because they see it every day.*

BY CAROLYN SAYRE / ILLUSTRATION BY SAMUEL HOSKINS

WHEN BEATRICE HARRISON first came to Menorah Center for Rehabilitation and Nursing Care in Brooklyn more than a year ago, she was depressed. The 94-year-old had difficulty thinking clearly and chose to spend most days alone in her room — eating by herself and watching old television shows.

Then she met Kendra Ray, a board-certified music therapist and New York state-licensed creative arts therapist at Menorah. During their first session, Ray played the melody to "I Have Dreamed" on her flute, written by Beatrice's favorite artist, Frank Sinatra.

I HAVE DREAMED THAT YOUR ARMS ARE LOVELY / AND I HAVE DREAMED WHAT A JOY YOU'LL BE / I HAVE DREAMED EV'RY WORD YOU'LL WHISPER / WHEN YOU'RE CLOSE, CLOSE TO ME

"When Kendra plays music, I go into another world," says Beatrice, eyes moist. "I feel my mind calm and my body start to move. I feel like I am 20 again, seeing Frankie with my mother at the Paramount Theater in New York City. I can still remember the miles of people lined up to see him. He brought the house down that night."

In the months since Beatrice began music therapy, she has come alive again, the staff say. She appears happier, participates in activities and socializes at mealtime.

Her weekly sessions have also had a profound effect on her memory. Beatrice suffers from dementia, and she often forgets her own age; but when she hears a familiar tune, her caregivers say that it is as if a light turns on in her mind. That simple Sinatra ballad not only invoked a story about the concert, but it offered a gateway into dozens of lost memories from her youth, including childhood piano lessons, her father's career as a singing waiter, seeing "Man of La Mancha" on Broadway and watching Julie Andrews.

With the door to the past ajar, Ray begins to play a song from "The Sound of Music."

I GO TO THE HILLS WHEN MY HEART IS LONELY / I KNOW I WILL HEAR WHAT I'VE HEARD BEFORE / MY HEART WILL BE BLESSED WITH THE SOUND OF MUSIC / AND I'LL SING ONCE MORE

For Beatrice, and for so many other residents, the power of music helps them do just that — "sing" once more.

For the past nine years, as part of a music therapy program at Menorah, Ray has worked with patients who have dementia to remember their pasts through music. Many of them suffer from the slow neurodegenerative symptoms of Alzheimer's disease, which destroys brain cells and leads to cognitive decline, impaired judgment and difficulty with daily activities.

Ray is not only a music therapist, she's also a young researcher and influential author in the field, who used her experiences at Menorah to inform her studies as a doctoral student in the Creative Arts Therapies program in Drexel's College of Nursing and Health Professions. She says that Drexel's program, which is one of only a few in the Northeast, helped her hone the research writing skills she needed to publish her music therapy observations in scientific journals.

One of her studies, which was part of a three-year study funded by the New York State Department of Health, found that after only two weeks of music therapy, symptoms of depression decreased 38 percent and feelings of agitation declined 16 percent in nursing home residents with dementia. Since then, Ray and her team have developed a music-assisted care training manual that is being adopted by more than 600 nursing homes throughout New York, as well as additional facilities across the nation and overseas in Canada, Israel, Spain and Nigeria.

"Music therapy is a bridge for communication that would otherwise have been lost in people with dementia," says Ray, a longtime musician who aspired to be a nurse as a child. "Hearing that familiar song activates an area of muscle memory in the brain and helps them find the words they are searching for."

I CAN SEE CLEARLY NOW THE RAIN IS GONE

Philosophers dating back to Aristotle and Plato have believed that music promotes healing. References to music therapy can be found in medicine as early as 1789, and the profession formally organized after World War II, when musicians started visiting veterans' hospitals. Physicians noticed that patients were comforted when they heard familiar songs and hired musicians to play in the wards. Today, there are more than 6,000 credentialed music therapists nationwide.

Since the birth of the music therapy profession in the 1940s, research has continually affirmed its profound physiological and psychological benefits. Studies have shown song has the power to calm the heart rate in premature infants, coordinate movements in individuals with Parkinson's disease, decrease anxiety and pain in cancer patients, and regulate breathing in individuals with lung disease.

"Through music therapy, we are able to do things where routine pharmacological agents or conventional medical regimens may prove limited," says Joanne Loewy, director of the Louis Armstrong Center for Music and Medicine at New York City–based Mount Sinai Health System, who teaches music and medicine to Drexel graduate students.

Studies show that music activates large areas of the brain. In fact, when brain activity is examined in real time using a functional magnetic resonance imaging scan, areas related to movement, planning, attention and memory immediately light up when music is played. These functions are some of the first faculties to be affected by dementia.

"There is evidence of a music memory in the brain's neural pathways that is robust and can be preserved or reactivated when other mechanisms in the brain are lost," says Loewy. "When people are plugged into music, they are turned on and tuned in — it is the difference between a battery, which might be temporary and run out (a usual thought), and being plugged into a constant current of electricity, fueled by melody, rhythm and contextual circumstances, which include the place and time affiliates where the music's imprint was first made."

Remarkably, this response is seen in every stage of dementia, says Ray. Patients with mild cases can improve cognitive skills such as memory, language and attention; while those with moderate symptoms become more engaged and participative, which greatly improves their quality of life.

"With the power of music, residents retain their dignity because they remember who they are and where they have been in the past," explains Ray. "This helps ground the patient in the present when they are confused. From this, we see a decrease in the symptoms of dementia, including agitation, feelings of sadness, hallucinations and wandering."

That was certainly the case with Donald Miller, 76, a jazz musician who once traveled the world. His health deteriorated after he lost the love of his life to cancer. When he came to Menorah, Donald was lost, depressed, heartbroken and in great physical pain.

"Through music therapy, we see him starting to come back," says his sister, Fran Miller. "Donald wants to be involved, he wants to be alive and he is engaged again."

But perhaps the most extraordinary effects occur in the later stages of dementia.

"Even when language has deteriorated to the point that a person has lost the ability to speak, miraculously the music memory stays intact," explains Ayelet Dassa, director of Creative Arts Therapies and Research at the Ramat-Gan Alzheimer's Research and Treatment Center in Israel who co-wrote a book chapter about music therapy with Ray (it was recently published in *Update on Dementia*). "These individuals are able to communicate through music when words fail. Songs help them relive past experience. It is magical to witness the entire world come alive again in their brain."

THEY CAN'T TAKE THAT AWAY FROM ME

That magic is apparent in Abe M., an 80-year-old resident at Menorah. When Ray first walks into his room, Abe appears lackluster under the stark white bed sheet. His breathing is deep and haggard.

Ray takes out her guitar and begins to strum the strings.

"Do you know this song?" she asks.

"Yes," he responds as the corner of his lips perk up.

Abe's wide eyes fixate on Ray, his chest begins to rise and fall calmly, and his hands move slightly yet rhythmically to the beat.

MANY NIGHTS I'D SIT BY MY WINDOW / WAITING FOR SOMEONE TO SING ME HIS SONG / SO MANY DREAMS I KEPT DEEP INSIDE ME / ALONE IN THE DARK, BUT NOW YOU'VE COME ALONG

"You light up my life," he sings, filling in the last line of the chorus. When the music stops, Abe's body animates as if it were a wind-up toy waiting to turn on and he claps loudly in appreciation.

"Kendra lights up my life when she comes here," he says. "I just love music."

Three years ago, when Abe first came into nursing care, he was disoriented and would scream constantly for help. After three months of music therapy, he became calmer and was easier to bathe and dress.

"I have come a long way, baby," he says in jest — a part of his humorous personality that reappears when he is with Ray. "Back then, I could not even move my hands. Now, look at me move."

Part of Ray's technique is to create a playlist for each resident's tastes and personality. A self-proclaimed romantic, Abe's favorites are love songs, so Ray uses songs like "The Power of Love" to help him connect with his emotions. She also selects uplifting songs when the individual's mood is sad or anxious. Using flute, guitar, maracas and drums, Ray creates an uplifting, calming ambiance.

"To achieve good outcomes in people with dementia, we need to do more than just play their preferred song," explains Ray. "We want them to associate a song with an emotion or situation that they are dealing with. When I first sang to Abe, all he would do was cry. Over time, we developed a therapeutic relationship and a safe space where he could process those feelings. Music became his release."

By using word associations within song lyrics, Ray has also been able to help Abe tap into past experiences. Over time, as they have developed a rapport, Abe has delved further into these memories including trips to Scandinavia, working as a construction plumber and his close relationship with his brother.

LEAN ON ME WHEN YOU'RE NOT STRONG

Over the years, Ray has helped more than 100 residents through the power of song. But a few years ago, she wanted to do more. She knew the statistics were daunting. There are more than 5 million people living with Alzheimer's disease and dementia in the United States and only 7,500 music therapists nationwide. Furthermore, nearly 50 percent of all residents in nursing homes suffer from symptoms of dementia.

"Unfortunately, very few of these music therapists work in nursing homes where their work can improve the lives of residents with dementia," explains Ray. "To reach more residents, we needed to train nursing assistants to use music. Nursing assistants spend the most time with residents and when they integrate music into their care, it can significantly reduce symptoms of agitation and depression."

To help educate nurses and other caregivers, Ray and her colleagues used funding from the state of New York to develop a curriculum called "Music Therapy: Keys to Dementia Care," which has been implemented in facilities throughout the United States and the world. The training manual teaches caregivers how to use singing and background music to make people more alert and receptive to care in stressful situations such as bathing, dressing or wound care. For example, the booklet lists songs that can create a calming atmosphere for residents, including "Somewhere Over the Rainbow" or "Beyond the Sea." It also encourages caregivers to tailor music to the individual.

The protocol was used to train dozens of registered nurses and certified nursing assistants (CNA) at Menorah. Shernett Williams, a CNA, says music-assisted care training has been particularly helpful with bathing — an activity only 10 percent of nursing home residents can perform independently.

"When residents are agitated, we turn on the iPod and immediately we see them calm down," she explains. "Some of my residents refuse to participate in any activities, but when there is music they listen and sing along."

Ray's work has also had an impact abroad. Melissa Mercadal-Brotons, director of the Music Therapy Program at the Escola Superior de Música de Catalunya in Spain, has used her book to train over 300 professional caregivers in 13 nursing homes throughout the country.

"Kendra Ray's work has been inspirational in helping us develop a way for caregivers to use music in their daily work and what elements to consider when selecting music to use," says Mercadal-Brotons. "Residents are more cooperative and content, which makes the caregivers' job feel more satisfying."

In the future, Ray hopes to extend music-assisted care training and education to family caregivers, who are integral to the long-term care process. By 2050, the number of people age 65 and older with Alzheimer's disease is expected to triple, and Ray and Dassa of the Ramat-Gan Alzheimer's Research and Treatment Center believe it is essential that families find ways to integrate music at home.

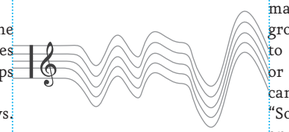
SOME WERE BORN TO SING THE BLUES

When Ray places Donald Miller's saxophone on the bedside table, it's clear he's eager for an audience. He opens the case, assembles the pieces and licks the bottom piece like a maestro. The nurse picks up a rain stick to play along. He insists they play "Misty" — and only "Misty" — and blows with all his might.

I'M AS HELPLESS AS A KITTEN UP A TREE / AND I FEEL LIKE I'M CLINGING TO A CLOUD / I CAN'T UNDERSTAND / I GET MISTY, JUST HOLDING YOUR HAND

Ray asks him about the song choice. "It reminds me of the old days when I was hanging out with my friends in Bermuda playing jazz," says Donald. "That, and I like Clint Eastwood."

He gazes outside at the rain falling on the windowpane and lets out a slow, deep breath. His body reclines back in the chair as though a weight has been lifted off his shoulders, if only for a few moments. It is obvious from his demeanor that the lyrics represent so much more. For Donald and so many others, the world, it appears, is just a little brighter when it is filled with music.



MUSIC THERAPY: WHAT THE RESEARCH SAYS

Music interventions help alleviate symptoms of anxiety, pain and fatigue in cancer patients, while also boosting their quality of life, according to a systematic review of the science of music therapy.

Led by Joke Bradt, associate professor in Drexel's College of Nursing and Health Professions, a team reviewed controlled clinical trials that examined the impact of music therapy (a personalized music experience offered by trained music therapists) and music medicine (listening to prerecorded music provided by a doctor or nurse) on psychological and physical outcomes in people with cancer.

"We found that music therapy interventions specifically help improve patients' quality of life," explains Bradt. "These are important findings as these outcomes play an important role in patients' overall well-being."

The researchers reviewed a total of 52 trials, constituting 3,731 participants with cancer. Twenty-three of the trials were categorized as music therapy and the remaining 29 were classified as music medicine interventions.

One of the most impactful findings was that music interventions of all kinds resulted in a moderate-to-strong effect in reducing patients' anxiety.

When it came to pain reduction, the researchers found a large treatment benefit; for fatigue, a small-to-moderate treatment effect was found.

_ONLINE
To read the full-length articles that appear in this section, visit **EXELmagazine.org.**

HUNGER

_DON'T WASTE THAT FOOD

Products made from surplus ingredients *that would otherwise contribute to the nation's food waste can be transformed into recipes that are appealing to consumers.*

_JONATHAN DEUTSCH
_HASAN AYAZ
_RAJNEESH SURI
Deutsch is a professor in the Center for Food and Hospitality Management and in the Department of Nutrition Sciences in the College of Nursing and Health Professions; Ayaz is an associate research professor in the School of Biomedical Engineering, Science and Health Systems; and Suri is a professor and vice dean for research and strategic partnerships in the LeBow College of Business.

TERM:

VALUE-ADDED SURPLUS PRODUCT *(VASP)*

A food category coined by researchers to describe foods created from surplus ingredients or ingredients obtained during the manufacturing of other foods.

American households are estimated to collectively throw away 80 billion pounds of food each year. Many ingredients are also discarded during the manufacturing process and perfectly edible produce deemed ugly doesn't make it to grocery displays. Meanwhile, more than 42 million Americans experience food insecurity.

To address the problem, Drexel researchers set out to learn whether people would eat products made from what would have become food waste. They found out that consumers might even prefer it.

The research sought to discover if foods made from surplus ingredients — termed value-added surplus products (VASP) — that would have been otherwise wasted can offer environmental, nutritional, financial and gastronomic benefits if appropriately marketed to consumers.

"There is an economic, environmental and cultural argument for keeping food, when possible, as food and not trash," says Jonathan Deutsch, a professor in the Center for Food and Hospitality Management and in the Department of Nutrition Sciences in the College of Nursing and Health Professions.

"Converting surplus foods into value-added products will feed people, create opportunities for employment and entrepreneurship, and lower the environmental impact of wasted resources," says Deutsch, who has created "upcycled" products with the Drexel Food Lab in the past.

The researchers conducted a series of tests as a first attempt to understand a consumer's decision-making process with respect to the new food category of value-added surplus foods. They examined three product cues for value-added surplus products: product description, label and benefit (to self or others).

The results showed that participants clearly identified value-added surplus foods as a unique category with unique perception, separate from organic and conventional categories, and that they believed consuming valued-added surplus products would generate benefits for people other than themselves.

Not only could these types of foods be a good thing for society as a whole, but they could also prove lucrative.

"Depending upon how you communicate such products, they might also be able to fetch a price premium, like those afforded to organic foods," says Rajneesh Suri, professor and vice dean for research and strategic partnerships in the LeBow College of Business.

TRENDY_SPREAD
Rescued Relish is a prototype for a condiment made from excess grocery produce and distributed by Philabundance, a Philadelphia anti-hunger organization, under the brand name Abundantly Good.

DREXEL FOOD LAB

EQUALITY

_SIDELINES BIAS

A new study helps illuminate ***why fewer women are coaching college sport teams*** *than in years past.*

As the number of women coaching in college athletics dwindles, a study commissioned by the Women's Sports Foundation and co-authored by a Drexel sport management professor highlights some of the professional challenges female coaches face.

"Beyond X's & O's: Gender Bias and Coaches of Women's College Sports" is one of the first studies to measure the issue of systemic gender bias in the coaching of women's college sports. In a survey of more than 2,500 college coaches, Drexel's Center for Sport Management Professor Ellen Staurowsky and her co-authors found that there is, in fact, a systemic gender bias directed at female coaches of women's teams; it is not sporadic or limited to a few institutions. As a result, women face limitations in pay and professional advancement in the coaching workplace.

And it's a trend showing no signs of improvement.

There are more women competing and working in college sports than ever before, but women are still underrepresented in significant leadership roles. In 1972, more than 90 percent of the coaches of women's teams were female. Today, only 43 percent are (typically only two in 10 head coaches are women).

According to the researchers' findings, men are given more professional advantages than women: The vast majority of female coaches (80 percent) agree that it's easier for men to get top-level jobs, negotiate salary increases (91 percent), be promoted (70 percent) and secure multi-year contracts (67 percent).

Meanwhile, advocating for fairness has consequences, the study found. Many female coaches expressed fear of unfair treatment, retaliation and loss of their jobs if they express Title IX concerns to athletic department leaders or university administrators.

"The findings are consistent with earlier studies I've done that strongly suggest cultures within college sport workplaces suppress discussions regarding gender equity and Title IX compliance and are threatening to the women working in those environments," Staurowsky says. "Given the low percentages of women who serve as head coaches in college athletic departments, this offers some context to consider in terms of their hiring, promotion and retention."

_DWINDLING NUMBERS
In 1972, more than 90 percent of the coaches of women's teams were female. Today, only 43 percent are female.

EDUCATION

_MAKING SPACE FOR ALL

School "makerspaces" have enormous potential to foster learning and engagement, but need to be inclusive of all learners.

_KAREEM EDOUARD
_KATELYN ALDERFER
_BRIAN SMITH
_YOUNGMOO KIM
Edouard is a senior research fellow of learning innovation in the Expressive and Creative Interaction Technologies (ExCITe) Center; Alderfer is a doctoral candidate in the School of Education; Smith is a professor in the School of Education; Kim is a professor of electrical and computer engineering and director of the ExCITe Center.

Drexel researchers in the ExCITe Center's Learning Innovation initiative have completed a first-of-its-kind, year-long investigation visiting 30 K–12 education "makerspaces" across eight metropolitan regions to study what approaches work best, and for whom.

Through in-depth interviews with and observation of students, instructors and leadership, the researchers found encouraging indicators for increased student engagement in school through makerspace participation and development of a "maker mindset" that focuses on creation, iteration, agency and collaboration.

They also found room for improvement. One insight was the discovery of troubling inclusivity indicators, particularly regarding gender. Student participation rates change between grade school, where participation is nearly equal by gender, and high school, where male students outnumber females by a factor of three. In addition, program leaders and instructors remain predominantly male.

OTHER HIGHLIGHTS FROM THE REPORT:

- The culture of a makerspace has a direct impact on student learning. Rather than choosing equipment or specific projects, designers of new makerspaces should first consider the kind of learning culture they seek to create.
- Makerspaces can positively impact English language learners and students facing disciplinary issues, but the language and imagery used for recruitment is often gendered and noninclusive, affecting who participates.
- Within school makerspaces, hosting unstructured open hours outside of class encourages greater exploration, positive risk-taking and collaboration for a wider range of students.
- Students frequently use skills learned in makerspaces to improve other aspects of the school and local community, such as student government activities, classroom maintenance and sports facilities.

INFORMATICS

_CAN DATA HAVE AN AGENDA?

If we're not careful in ***how big data is collected****, the samples we use to improve public policy will only reinforce existing problems.*

Big data is supposed to solve what ails us: from telling us what book we might want to read next to directing police to where a crime is likely to be committed.

But if the data from which those predictions are made is slanted, the results will be, too, and continue to reinforce a status quo that keeps people and communities disenfranchised.

For example, consider the example of algorithms that determine where to send patrol cars.

"These decisions are going to be based on historical data, and that historical data includes information about where we were previously heavily policing," says Julia Stoyanovich in the College of Computing & Informatics. "The reason we send police cars is not necessarily because crime is more pervasive in those areas, but because in the past, we were over-policing those areas."

Stoyanovich is the lead researcher on a new study funded by the National Science Foundation that will establish foundational principles of responsible data management, which includes fairness, transparency and data protection. The project, called Data Responsibly, is working to ensure not just the accuracy of the models but also that the data on which they depend respects relevant laws, societal norms and impacts on the people from whom the data are collected.

"Suppose you have a judge who is racist. After a while, it becomes clear that all African Americans get longer sentences by that judge," says Stoyanovich.

Identifying the culprit in those harsher sentences is not hard: it's that judge. "In the case of data-driven analytics, it isn't really clear how we can detect that results are biased, whose fault it is, and how to correct it. If big data systems are racist, that racism is very scalable," she says. "The effects are going to be an entire county, for example, not just a few particular cases the judge hears."

By creating guidelines that detect and mitigate biases at the start in the way data are collected, Stoyanovich and her team hope that bias can be kept out of the system before the algorithm spits out results that will sustain those biases on a larger scale.

"What we need are different ways of looking at the data analysis pipeline, step by step," she says.

_JULIA STOYANOVICH
Stoyanovich is an assistant professor of computer science in Drexel's College of Computing & Informatics.

"What we need are different ways of looking at the data analysis pipeline, step by step."
-Julia Stoyanovich

ECONOMICS

_GYM VIG

Now there's proof you can't even ***pay people to go workout.***

A new study co-authored by Mark Stehr, an associate professor in the School of Economics at the LeBow College of Business, found that paying new gym members as an incentive to work out more often had little impact in changing their exercise habits.

The paper, forthcoming in the *Journal of Health Economics*, described a study that randomized 836 new members of a private gym into four groups. One received a $30 payment regardless of the number of times they went to the gym in their first six weeks as members; the other three groups received a payment if they attended the gym at least nine times over the first six weeks. The payments were a $30 Amazon gift card, a $60 Amazon gift card or an item from Amazon that was worth $30.

The authors decided to study a group of people who had already engaged in costly actions such as joining a gym and paying membership fees, signaling an intention to use the gym. They found that additional incentives for visits early during a new gym membership were only marginally effective at helping people to increase their exercise, and had no effect on the number of visits after the incentive period.

"People greatly overestimate the amount they will exercise," Stehr says. "This over-optimism is counterproductive, because it allows people to avoid taking hard steps that are necessary to meet their goals."

SOCIOLOGY

_INSTA-SUPPORT

Instagram has become ***a destination for some people*** *making sensitive and stigmatized self-disclosures.*

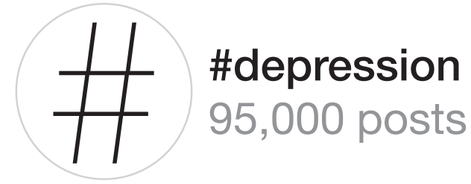
Despite all the negative criticism social media attracts, it can still be a force for good, or so Drexel researchers found in studying the way Instagram users lean on the site to help find solace from depression.

Even in today's technology-connected society, people are hesitant to talk about their painful experiences and suffering for fear of being stigmatized. Doctoral candidate Nazanin Andalibi and associate professor Andrea Forte, both of the College of Computing & Informatics, observed that one way people in pain are overcoming silence is by using pictures on Instagram to help explain feelings and experiences that are often too painful or complicated to put into words.

Forte and Andalibi had previously observed similar self-disclosure and support-seeking behavior among Reddit users.

"We wanted to see how people might behave differently on a more image-centric site, rather than one that is driven solely by textual posts and comments," Andalibi says.

To investigate the matter, Forte and Andalibi examined the responses to a sample of 800 Instagram posts pulled from more than 95,000 photos tagged with "#depression" that were posted by 24,920 unique users over the course of a month. The findings — which Andalibi and Forte co-authored with Pinar Ozturk, who was a doctoral candidate at Stevens Institute of Technology at the time — indicate that not only are people using Instagram to make sensitive disclosures, but they are also getting mostly positive support from people on the site, and little in the way of negative or aggressive comments.



Over the course of a month, researchers examined responses to a sample of 800 Instagram posts pulled from more than 95,000 photos tagged with "#depression" that were posted by 24,920 unique users.

"The period of thinking online life is not 'real life' has passed, and these spaces have the potential to play meaningful roles in people's lives in many ways, especially in times of distress," Andalibi says. "It is important to design social technologies that can foster support and wellbeing, and mitigate abuse and harm."

EDUCATION

_THE SCIENCE OF CO-OP

Drexel is leading a group of higher-educational institutions to study ***how experiential learning*** *affects educational outcomes.*

Everyone talks about the value of hands-on experience, but how do you actually *measure* the impact of co-op programs, civic engagement, study abroad or undergraduate research?

Schools across the country are hungry for data to evaluate how, when and for whom these different modes work best.

In 2017, Drexel took the first steps toward studying the efficacy and impact of experiential learning in a rigorous way when it and two partner schools received a $40,000, two-year initial grant for a longitudinal, cross-institutional research project titled, "Tracking Experiential Learning Outcomes Across Three CAA Campuses." This project seeks to track experiential learning outcomes across Drexel, the College of Charleston and the University of North Carolina-Wilmington.

The three schools aim to develop a single validated tool to collect data across a wide variety of experiential learning activities.

"We believe that this project will allow us to refocus how we talk about and engage in experiential education and will guide us in how we create model cross-institutional collaborations in pedagogy research."

– N. John DiNardo, special advisor to the provost and a faculty fellow in Drexel's Center for the Advancement of STEM Teaching and Learning Excellence.

This initiative will also establish a centralized hub of data that will grow over time, allowing deeper understanding of experiential learning outcomes in education. With a successful pilot established, the partners hope to eventually roll the instrument out nationwide.

YOUNG_SCIENTISTS
Biology students engaged in undergraduate research at Drexel.

MERGERS

_SEEING GREEN

Research consistently shows that when CEOs of takeover target firms receive extra benefits during mergers, takeover premiums are lower.

LeBow College of Business professor Eliezer Fich says this is often interpreted as a conflict of interest: target CEOs sacrifice premiums for personal gain.

However, Fich argues, this research does not tell the whole story. He recently co-authored an article examining merger bonuses, which indicates that when target CEOs get bonuses, acquirers pay less but also get less in the form of low synergies — the gains that are created when two companies merge.

Fich says this evidence suggests that bonuses are used to revise compensation contracts when takeovers generate small synergy gains, helping firms circumvent conflicts of interest between target CEOs and their shareholders.

"More often, the bonuses are present in situations where the target firm was a hard-to-sell company that was not very appealing to potential acquirers," Fich says.

An important consideration, Fich says, is that the merger often eliminates the target CEO's job. An extra payment is sometimes necessary to get the target CEOs to consent to an acquisition.

Fich notes that, on average, the evidence related to merger bonuses is not consistent with payments being used to "bribe" target CEOs.

"Oftentimes, the bonus is a reward for achieving something that was hard to do," Fich says.

JUSTICE

_ADJUDICATING GENOCIDE

A study of ***the way nations confront the aftermath of genocide*** *reveals new ideas about the best path to peace.*

_RACHEL LÓPEZ
López is an associate professor of law and director of the Community Lawyering Clinic in the Thomas R. Kline School of Law.

Legal scholars often position truth commissions as an alternative to seeking justice, but Associate Professor Rachel López found a much more symbiotic relationship between the two that could be revelatory for countries trying to heal from mass atrocities.

López spent six months as a Fulbright Scholar and six months as a Schell Fellow at Yale Law School researching transitional justice in countries addressing the human rights violations of predecessor regimes. Specifically, she looked at the interplay between traditional criminal courts and truth commissions, which are non-prosecutorial efforts to confront wrongdoing and heal a nation.

López analyzed the judicial record of the cases that led to convictions tied to the 36-year-long conflict in Guatemala responsible for an estimated 200,000 deaths, and interviewed judges, prosecutors and human rights attorneys involved in the legal proceedings.

Two truth commissions released reports that documented the human rights abuses that occurred in Guatemala, and those narratives, she found, played a significant role in aiding the criminal justice system — a complementary relationship that had previously gone unobserved by legal scholars.

Such findings could influence the way nations such as Colombia and El Salvador pursue peace and justice following their civil wars, she says.

"There is recent research by two political scientists that showed that empirically when you employ a variety of mechanisms — truth commissions, reparations, amnesties and trials — you get better results for human rights and democratic consolidation," she says. "But there was little understanding of why there was that difference."

"I'm hopeful my research can give insights into how the interaction of the various approaches to post-conflict justice can be improved in practice, and also raise some questions about how we can build justice systems that better integrate these approaches," López says.

200,000

Estimated number of indigenous Mayans and Ladinos in Guatemala killed in a decades-long genocide perpetrated by a U.S.-backed military regime.

DESIGN

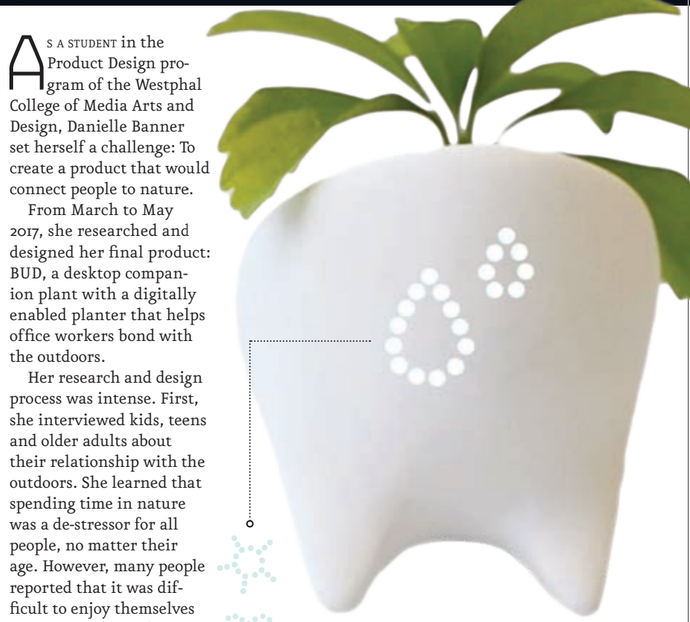
_A BUDDING IDEA

As a student in the Product Design program of the Westphal College of Media Arts and Design, Danielle Banner set herself a challenge: To create a product that would connect people to nature.

From March to May 2017, she researched and designed her final product: BUD, a desktop companion plant with a digitally enabled planter that helps office workers bond with the outdoors.

Her research and design process was intense. First, she interviewed kids, teens and older adults about their relationship with the outdoors. She learned that spending time in nature was a de-stressor for all people, no matter their age. However, many people reported that it was difficult to enjoy themselves outdoors because of work and other commitments.

The first prototype of BUD had interactive touch screens and "faces" that would communicate with people, but it didn't test well for a few reasons, Banner says. "I was trying to integrate technology with nature in a way that wasn't distracting...but this was distracting. I wanted to make BUD more of a companion rather than something impersonal," she says.



The BUD comes with an app to helps users set breaks to go outdoors with their BUD throughout the day.

BEST_BUD
Banner developed 20 to 30 small clay models and five full-scale models before settling on the final design and name. "I love puns, and this is both a desk buddy and it features a budding plant," she says.

_DANIELLE BANNER
Banner is a product design major in the Westphal College of Media Arts & Design.

Her final version was compact, had "legs," could interact with other BUDs, and included a seed pack so users could choose their plant variety.

"She did a good job of trying to understand people's needs. ...I see it being marketable," says Michael Glaser, an associate professor who runs the Product Design program. The project earned Banner an A.

The Product Design program is young but alumni have created successful ideas. A couple students have sold their concepts or started a company. One former student created glasses for people with seasonal affective disorder. In 2017, a student focused on turning fabric waste into pulp and worked with the Department of Materials Science and Engineering in the College of Engineering to turn those fibers into biodegradable furniture.

The program's philosophy is to let students see where ideas take them — always with the end-user in mind. "We start with community first, then move on to the process and then the outcomes," says Glaser. "The student has to convince us that they made a decision based on a user's needs."

_ONLINE
To see how BUD and its app work, visit **EXELmagazine.org.**

BRANDING

_WHAT'S IN A NAME (BRAND)?

The ***relationship between internet search results and a brand's success*** *is more complex than common wisdom suggests.*

_ELEA MCDONNELL FEIT
Feit is an assistant professor of marketing in the LeBow College of Business.

It's long been believed in the advertising world that the number of times a brand's name is used in internet searches can predict sales for that brand. But new research from Drexel University, Brigham Young University and Google shows there is a lot more to consider when looking at the large number of search queries that include brand names.

"This research adds to the mounting evidence that we can track brands more passively using new data sources like brand search.

–Elea McDonnell Feit

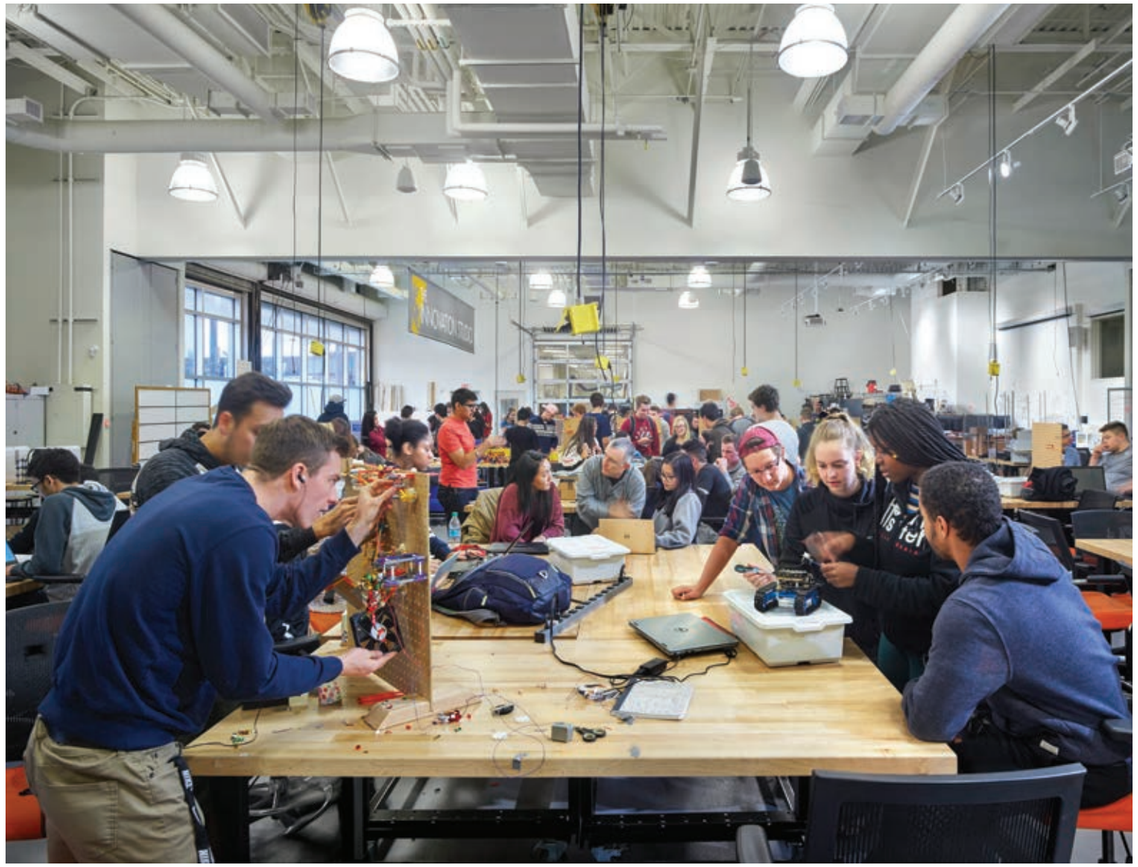
By studying more than 1,500 Google users who opted in to have their searches related to smartphones and cars tracked for eight weeks, then linking the information to a traditional brand attitude survey, the researchers came away with findings that could be vital to marketers.

"Marketers have long used brand attitude surveys to monitor brand health, but surveys are expensive and fewer and fewer people want to answer them," says Elea McDonnell Feit, an assistant professor of marketing in the LeBow College of Business. "This research adds to the mounting evidence that we can track brands more passively using new data sources like brand search."

The study found that users who are actively shopping in a category are more likely to search for any brand. However, as users move from being aware of a brand to intending to purchase a brand, they are increasingly more likely to search for that brand — with the greatest gains as customers go from recognition to familiarity and from familiarity to consideration. For example, someone who is just beginning to consider purchasing a car is more likely to start with a general search that does not include any brands. As the consumer narrows their decision before a purchase, they will start searching for a specific brand.

The researchers also found that users who own and use a particular car or smartphone are much more likely to search for that brand, even when they are not actively shopping. This suggests that a substantial volume of brand search in these categories is not related to shopping at all — something marketers should keep in mind if they see a sudden spike in search traffic for their brand.

_ABOUT DREXEL



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INNOVATION_STUDIO
Since 2014, Drexel has invested $49 million and delivered approximately 40,000 square feet of new and improved research laboratory space, including work and design spaces for student innovation.

Founded in 1891 in Philadelphia, Drexel is a comprehensive urban university of more than 24,000 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 Program and by $108 million in sponsored research awards last year.

Drexel enrolls students in on-campus and online programs leading to associate's, bachelor's, master's, doctoral and professional degrees (including MDs and JDs) in 17 colleges and schools. Drexel also has some of the richest specimen and artifact collections in the world through the Academy of Natural Sciences of Drexel University, America's oldest natural history museum.

Drexel advances its culture of innovation by encouraging multidisciplinary collaboration, technology commercialization and entrepreneurship — an approach exemplified by the ExCITe Center, the interdisciplinary A.J. Drexel Institutes, Drexel Ventures, the Innovation Center @ 3401 Market Street, the Close School of Entrepreneurship and the Baiada Institute for Entrepreneurship.

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.

_ONLINE
Learn more about Drexel University at **drexel.edu.**