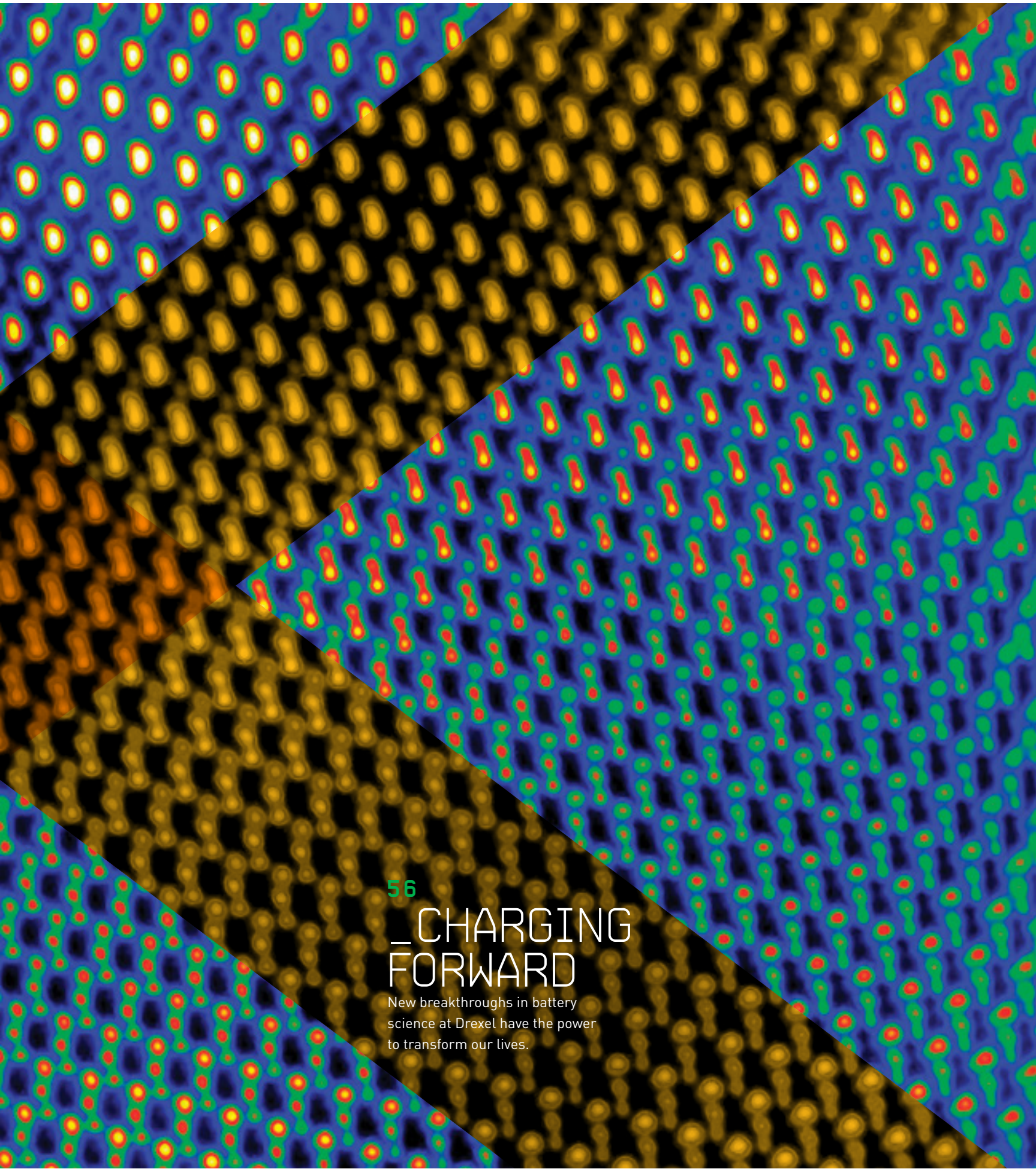


_BLUE TIT
An estimated 20 to 44 million pairs of *Parus caeruleus* live in Europe, congregating largely in woods, parks, hedgerows and gardens across much of the United Kingdom and subsisting on caterpillars, insects, nuts and seeds.

Blue Tit photo © R. Nussbaumer/VIREO / Close up feathers © R. Cartmell/VIREO

_CUSTOM HASSELBLAD
The oldest bird photography in the Academy's collection was donated by the late DuPont President Crawford H. Greenewalt, who recorded some of the earliest professional stop-motion images of birds in flight on his customized camera.

_BIRDING WITH HASSELBLAD

Among the storied artifacts within the Academy of Natural Sciences of Drexel University is ***a custom Hasselblad camera used to record the earliest images in the Academy's collection*** *of ornithological photography.*

The origins of VIREO, one of the world's largest online collections of bird photography, can be traced to a prolific hobbyist who donated thousands of his pioneering images to the Academy of Natural Sciences of Drexel University.

Some 40 years before smartphone and digital cameras made stop-action photography accessible to anyone, DuPont President Crawford H. Greenewalt was on a private mission to record the mechanics of flight on film.

Greenewalt's instrument of choice was his 1950s Hasselblad camera, which he modified with customized lenses, flash bulbs and a tandem tripod. He used a motion-detection sensor to trigger the shutter and bulbs at the precise moment a bird took flight.

The equipment allowed Greenewalt to take stop-action shots of hummingbirds that captured the movement of wings beating dozens of times per second. He shot them on his travels with his family, often accompanied by the creator of the iconic camera brand, Victor Hasselblad himself, who was a friend and fellow birdwatcher.

A volume of Greenewalt's dazzling hummingbird stills — a revelation to audiences at the time — was published by Doubleday in 1960, making him an international sensation.

To bend cameras to his will, Greenewalt borrowed ideas from Hasselblad and Harold Eugene "Doc" Edgerton, the father of multi-flash strobe photography, whom he met through DuPont's involvement in the Manhattan Project. DuPont employees who shared Greenewalt's passion for cutting-edge technology eagerly built refinements for his camera collection, according to his daughter, Nancy Greenewalt Frederick.

_ONLINE
Photos in the VIREO collection can be viewed and licensed at **vireo.ansp.org.**

ORNITHOLOGY

_TRIGGERED
Greenewalt's camera used a motion sensor to activate the camera's shutters and flash bulbs just as a bird came into focus.

"I think they enjoyed it as much as he did," says Frederick, who accompanied her father and Hasselblad, nicknamed "Vickie," on some expeditions.

Greenawalt sometimes traveled with Australian birder John Dunning, who designed a miniature tent in which trapped birds were temporarily placed to stage photo shoots, says Frank Gill, former chair of the Department of Ornithology at the Academy of Natural Sciences of Drexel University.

"It was a very effective and pioneering technique," says Gill. "He opened doors to photography of bird flight with sophistication that very few people had."

By 1979, Greenewalt wanted to create a permanent, curated repository for his photographs that would be accessible to scientists and the public.

"That sparked my interest," Gill says. "No one I knew in academia was doing that."

Gill saw an opportunity to broaden Academy holdings beyond specimen collections and to pique public interest in birds. With his staff, Gill established Visual Resources for Ornithology, or VIREO. The acronym is a play on words that also refers to a family of perching birds found from Canada to Argentina.

Some 9,000 images contributed by Greenewalt, in addition to scores more from Victor Hasselblad, form the original core of VIREO.

Over the years, the collection swelled with contributions from other photographers. It now contains 200,000 images, half of which are digitized. The database includes more than 75% of the 10,000 species of the birds in the world, says Dan Thomas, collection and intellectual property rights manager.

Licensed images from the galleries of species and habitats continue to find their way into myriad guidebooks, field manuals and birding apps.

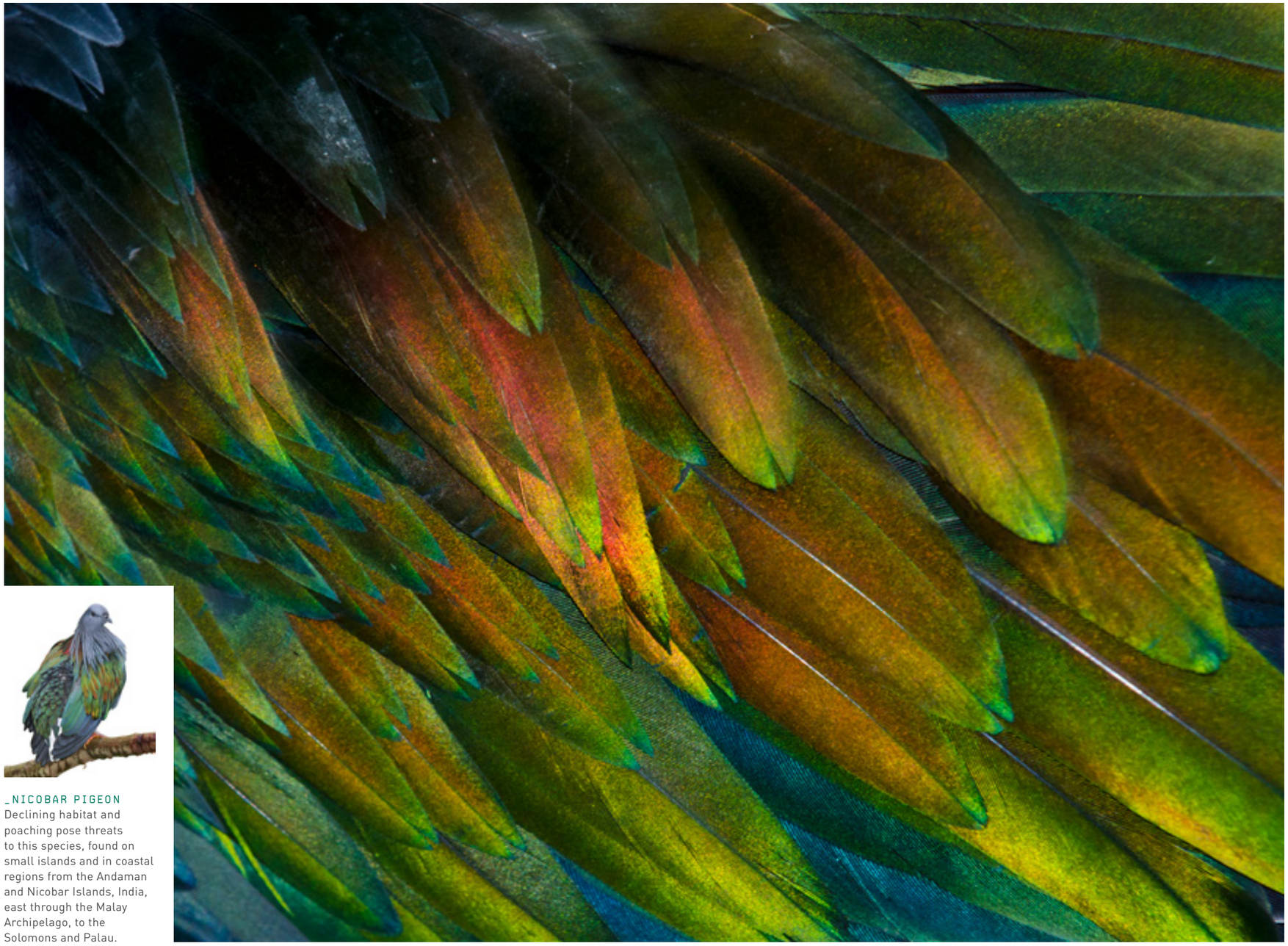
Thousands of users have registered on the VIREO site to create personal collections and view images that aid in identifying birds encountered in the wild, Thomas says. Public viewing access is free and educators can purchase licenses for $5 per image after a $25 minimum. — **SARAH GREENBLATT**

HASSELBLAD CAMERA © JEFF FUSCO

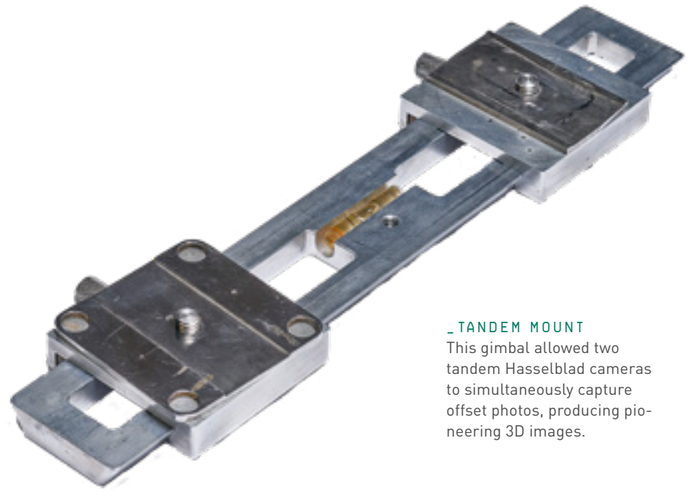
_MALAY PEACOCK-PHEASANT
Shy and elusive, the Malayan peacock-pheasant is endemic to lowland forests of the Malay Peninsula, where it has been evaluated as vulnerable on the International Union for Conservation of Nature Red List of Threatened Species.

MALAY PEACOCK PHEASANT PHOTO © M. HYETT/VIREO / CLOSE UP FEATHERS © D. TIPLING/VIREO

ORNITHOLOGY



_NICOBAR PIGEON
Declining habitat and poaching pose threats to this species, found on small islands and in coastal regions from the Andaman and Nicobar Islands, India, east through the Malay Archipelago, to the Solomons and Palau.



_TANDEM MOUNT
This gimbal allowed two tandem Hasselblad cameras to simultaneously capture offset photos, producing pioneering 3D images.

HASSELBLAD CAMERA © JEFF FUSCO

NICOBAR PIEGEON PHOTO © T. FRIEDEL/VIREO / CLOSE UP FEATHERS © D. TIPLING/VIREO

STROBE_LIGHT
Custom-crafted strobes helped Greenewalt capture birds at the point of flight.

CAMERA IMAGES BY JEFF FUSCO

_SILVER PHEASANT
Black and white feathers distinguish males from the all-brown females in this gregarious, ground-dwelling breed, found largely in Southeast Asia and China, though populations have been introduced in Hawaii and the mainland United States.

SILVER PHEASANT PHOTO © J. FUHRMAN/VIREO / CLOSE UP FEATHERS © K. SCHAFER/VIREO

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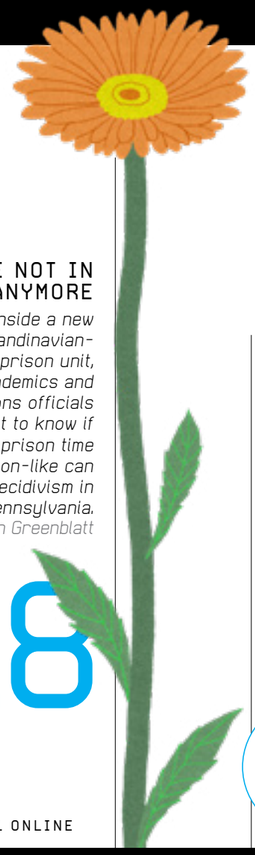

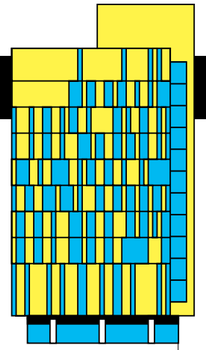

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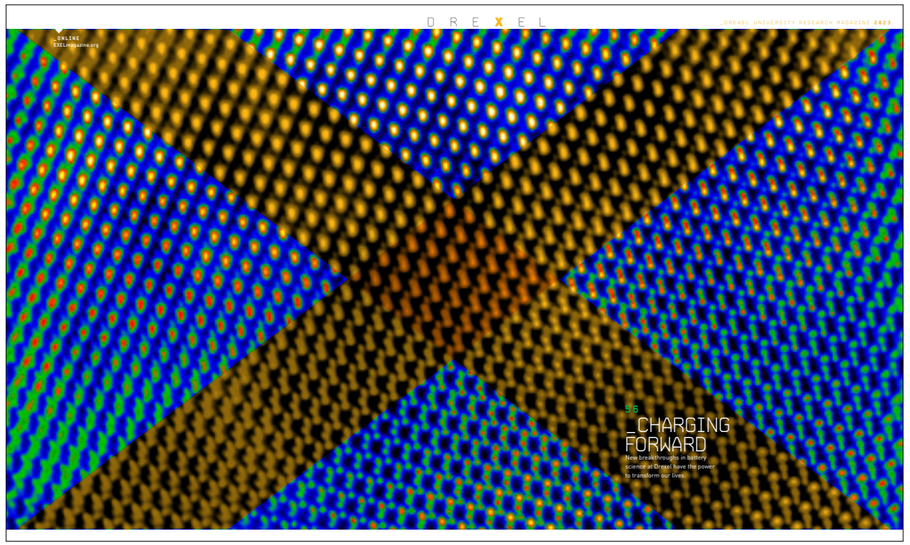
_SCIENCE FOR SUSTAINABILITY

Discovery that powers the future



University of Sydney/Science Photo Library

_ABOUT THE COVER
Crystalline manganese oxide (captured here as a nanoparticle by electron micrograph) is a a form of manganese oxide used in the production of lithium-ion batteries.

As the world faces widening health disparities and mounting weather extremes, Drexel continues to find new ways to put our research and translational expertise to work toward addressing climate crisis, promoting sustainability and supporting environmental justice.

This latest edition of *EXEL* vividly illustrates how our researchers are working toward a safe, healthy and just future. Our scientists are building battery prototypes made of abundant, Earth-friendly materials that are free of human rights conflicts. They're inventing new materials that could be the key to green hydrogen fuel. On the city's streets, they're studying ways to safeguard citizens most impacted by floods and rising temperatures.

Among the many examples in these pages, I'm especially proud to highlight the work of the Environmental Collaboratory, a new interdisciplinary initiative that is bringing science out of the classroom and into the field, where researchers are fighting environmental hazards alongside community organizations in their neighborhoods ("Rowhomes Versus Refineries" on page 24). The first of these projects began here at home, with a group of South Philadelphia activists combatting air pollution, and there are many more projects under way.

Our efforts to help the city prepare for climate change go wider still in our role as a civic anchor institution. With a large consortium of regional stakeholders, we helped to draft a climate resiliency research agenda to protect the region and its most vulnerable citizens from extreme weather effects. And we've joined a new research network of local universities that is bringing our brightest minds together to proactively manage water resources.

The depth of Drexel's capabilities is reflected in $152 million in federally sponsored research expenditures so far this year and the University's continued classification as an R-1 institution.

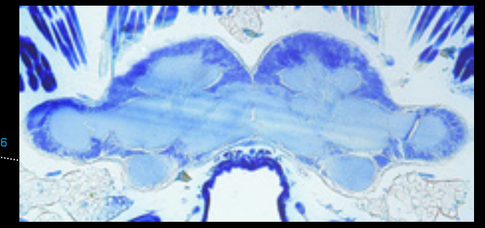
As public agencies, foundations and industry partners look to our University for knowledge and expertise, Drexel will remain focused on strengthening our research infrastructure and our resolve to meet the challenges facing our community, our country and our planet.

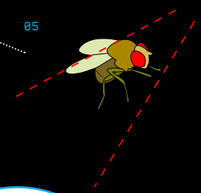
Sincerely,

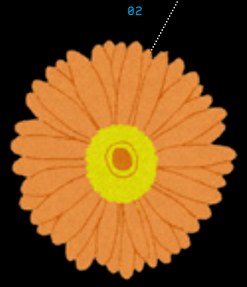
John Fry / President

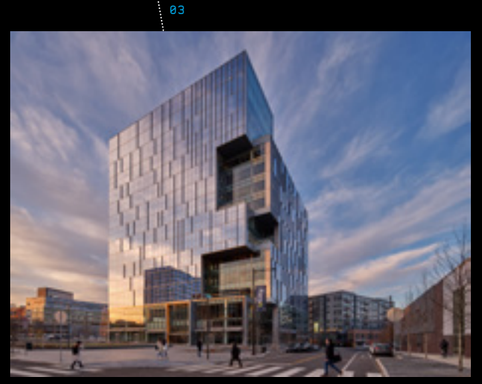
_EXPLORE *EXEL* ONLINE

The online version of EXEL includes exclusive coverage of Drexel's growing research enterprise that you won't want to miss. Find online-only photos, videos and extra content at exelmagazine.org.









HIGHLIGHTS_FROM_THIS_ISSUE
01 Watch as the CEO of Hyperreal describes how the multimedia company produced PepsiCo's fully synthetic metaverse commercial, featuring motion capture shot exclusively at Drexel (starting at approximately 6:30 in the video). 02 See inside Little Scandinavia, a unit of the State Correctional Institution in Chester, Pennsylvania, that has implemented reforms inspired by prison systems in Norway, Sweden and Denmark. 03 Survey new developments in University City that are poised to advance life science research and gene therapy manufacturing in Philadelphia. 04 See how digital forensics researchers uncover hidden "fingerprints" embedded in manipulated deepfake images and videos. 05 Learn how to set up a low-budget optogenetics workshop for STEM education 06 Explore the full-length story about the uncommonly complex brains of dampwood termites, which are exemplars of neural plasticity.

_DESIGNING FOR, AND WITH, THE COMMUNITY

Students experienced co-design during ***an experimental participatory course*** *that tackled inclusion, community and aging.*

How do you design a product for an end user who is nothing like you — who comes from a radically different generation, culture and way of life? Answer: Design *with* the user.

In a course titled "Aging & Design," Assistant Professor June He built a field-based, co-design curriculum that encouraged students to study end users who are unlike themselves, in a setting that fosters relationships, empathy and participation. "Co-design" is a format that involves all stakeholders, ensuring the result meets their needs.

In this case, the students were partnered with older adult members of the Philadelphia Asian community.

"By connecting older adults from Asian communities and interdisciplinary Drexel students, we are creating an inspiring and enriching experience for intergenerational and cross-cultural participants to connect and communicate," says Professor He, who studies design for aging. A pilot grant from the College of Nursing and Health Professions' AgeWell Collaboratory that funded the course will also inform a new Drexel Empathetic Co-Design Lab, which aims to foster participatory design work with diverse communities.

The course attracted design students from the Antoinette Westphal College of Media Arts & Design as well as graduates and undergraduates in biomedical engineering, economics, chemistry and marketing. They prepared for their interactions with the older adults by practicing empathic modeling — a means of cultivating understanding of someone else's physical challenges — by donning special goggles and gloves to simulate the experience of an older adult who suffers from arthritis or low vision.

Teams met with community members at the Wyss Wellness Center to get to know one another through exercises, shared stories and interviews. The students learned about the needs of the older community; the community participants, in turn, were heard and included in the design process.

"I looked forward to each week when we got to work with the older adults; they are so passionate and kind," says Isabella Morse, a senior custom design major with concentrations in environmental studies, psychology and design. "Although there was a language barrier, there was no barrier to the connections we made."

Eventually it was time for the students to draw on knowledge from previous sessions, conversations and design research to produce early-stage design concepts and prototypes, which they tested with the older adults in a final workshop.

Using co-design principles, the students and community members examined the design proposals to spot the strengths, opportunities and challenges of each.

"Ultimately, this product is for the older adults, and the students present it as a gift to them," says He.

_BIRDHOUSE
Students Adam Netburn and Joy Iaconianni worked with Ms. Li, a local seamstress who enjoys crafting and spending time in nature. The students conceived a DIY birdhouse to encourage mindful observation of birds for physical and mental well-being. The birdhouse is made of simple materials and affixes directly to the window, so observers inside their home can watch birds enter the birdhouse.

_SUBSCRIPTION BOX
Students Khue Dao and Uma Patel identified a common theme during their conversations with their community design partners: Older adults from Asian cultures that emphasize family and the collective felt a desire to reconnect to their individuality. Dao and Patel proposed a "subscription box" service. Each box would contain materials and instructions for an activity, craft or personal hobby. Their concept included the idea of partnering with a community organization to distribute a monthly activity box and host workshops or programming.

_PUBLIC PARK
Architecture student Zhengdon "Michael" Zhu and economics major Jahnavi Kalyan proposed a public park in Philadelphia's Chinatown neighborhood. To gather design input and feedback, they brought in a special LEGO kit that included elements specific to Chinese culture and asked their community co-designer to create a model of a park she'd like to visit. The result included an outdoor teahouse, a booksharing space and a basketball court or space for physical activity.

_ORIGAMI PLANTER
Students Maxwell Niehaus and Chau Nguyen proposed an origami-inspired planter designed to be built with a friend or loved one; it's rigged with solar power that makes the planter dance when the sun hits it. The intention is to delight the user while building relationships and memories through shared activity.

_JUNE HE
He is an assistant professor of product design in the Antoinette Westphal College of Media Arts & Design.

_OVERDOSE SURVIVAL: RISKS

Opioid overdoses can cause ***a cycle of cognitive damage*** *that makes overdoses likelier to recur.*

JEREMY LEUNG

Deaths from the nation's opioid crisis overshadow another nightmare for communities and families: the long-term health effects of nonfatal overdoses.

Researchers at the Dana and David Dornsife School of Public Health explored data on opioid overdose survivors, finding that repeated overdosing can lead to neurodegeneration resembling Alzheimer's disease, cognitive and memory problems, and risky behaviors that may lead to future overdoses.

A team including Janna Ataiants, a senior research scientist, and Stephen Lankenau, a professor at Dornsife, gained new insights into the long-term consequences of repeated opioid overdose.

"We found strong evidence in the literature that opioid overdoses lead to these Alzheimer's-like pathologies in the brain," Lankenau says. "We also know that these processes in the body may progress for decades before these symptoms are evident," given lower rates of health care access for many opioid users.

Published in the *International Journal of Drug Policy*, the study notes that rising fatal overdoses "might be only the visible tip of a looming iceberg," since only 3–4% of all overdoses are fatal.

_JANNA ATAIANTS
_STEPHEN LANKENAU
Ataiants is a senior research scientist and Lankenau is a professor in the Dornsife School of Public Health.

_HUG TREE, HAVE GRANOLA

Add healthy eating to the list of ways that ***nature is good*** *for us.*

_BRANDY-JOE MILLIRON
_DANE WARD
Milliron is an associate professor in the College of Nursing and Health Professions and Ward is an assistant teaching professor in the College of Arts and Sciences.

Take a stroll… Stop to smell the roses… We all know that connectedness to nature is good for clearing our heads, staying fit and caring for the environment.

In fact, in late 2020, Canadian doctors made headlines for "prescribing nature," or recommending time outdoors, based on research that suggests people who spent two or more hours in nature per week improved their health and well-being.

It turns out that nature relatedness — simply feeling connected with the natural world — is associated with healthier eating habits, too, according to a study from a transdisciplinary Drexel team, published in the *American Journal of Health Promotion*.

Researchers surveyed more than 300 adults in Philadelphia in 2017 to measure their self-reported connection to nature, including their experience with and perspective of nature, and the foods and beverages they had consumed the previous day. Participants mirrored demographic characteristics (gender, income, education and race) of Philadelphia, as of the 2010 census.

"People with higher nature relatedness were more likely to report healthful dietary intake, including greater dietary variety and higher fruit and vegetable consumption," says Brandy-Joe Milliron, an associate professor in the College of Nursing and Health Professions and lead author.

"This work can impact health promotion practices in two ways," says Milliron. "First, nature-based health promotion interventions may increase nature relatedness across the lifespan and potentially improve dietary intake. And second, augmenting dietary interventions with nature-based activities may lead to greater improvements in dietary quality."

Although future research would need to explore the ways different communities experience and value nature, the findings highlight the potential for leveraging nature-based experiences or interventions such as incorporating green spaces into city planning, integrating nature- and park-prescription programs into health care practices and promoting nature-based experiences in classroom settings, among many others.

_CITY-TO-CITY VAX DISPARITIES

Cities in the West were less likely to exhibit ***wide socioeconomic disparities*** *in citizens' access to the COVID-19 vaccine when it first became available.*

Throughout the COVID-19 pandemic, experts from the Dana and David Dornsife School of Public Health have researched disparities in testing, vaccination, health care access and other markers of the pandemic response.

A September 2022 study in the *American Journal of Epidemiology* examined the period from December 2020 through September 2021, when the U.S. first started distributing the vaccines, and looked at full vaccination rates in neighborhoods of 16 large U.S. cities, including Philadelphia, Austin, San Francisco, Chicago and New York City.

Researchers at Drexel's Urban Health Collaborative applied the Centers for Disease Control's Social Vulnerability Index — a measure that includes socioeconomic, housing, minority status, language and other factors to assess a community's resilience against human suffering and financial loss when faced with a crisis — and found that neighborhoods with higher levels of social vulnerability had the lowest vaccination rates.

Specifically, COVID-19 vaccination coverage was 0.75 times, or 16 percentage points, lower in neighborhoods with the highest social vulnerability, as compared with those with the lowest.

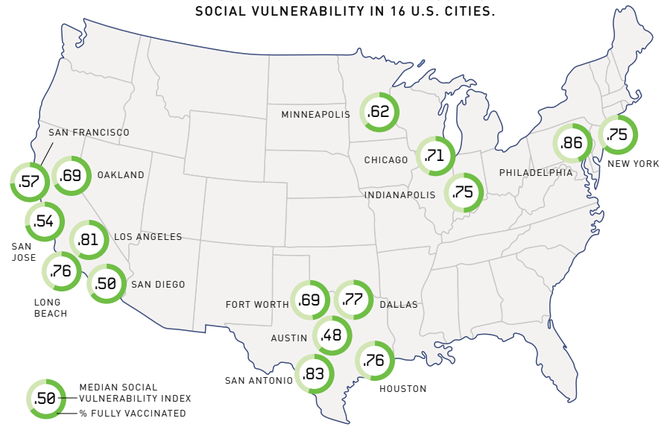
This was expected, the authors acknowledged, however they discovered that cities in the West generally displayed narrower inequities in both the absolute and relative scales.

"This pattern mirrors what we have described before with COVID-19 itself," says lead author Usama Bilal, an assistant professor of epidemiology in the Department of Epidemiology and Biostatistics. "What was surprising is the degree of variability. We found that some cities in California, along with our own city of Philadelphia, had a narrower gap between neighborhoods. We did not study factors driving these narrower inequalities, but we know that California has an extensive COVID-19 equity plan and that some of its cities made an effort to vaccinate people in the more vulnerable neighborhoods."

He hypothesized that Philadelphia performed well because the city prioritized vaccination drives in certain ZIP codes early on. Community groups, such as the Black Doctors COVID-19 Consortium, organized drives to vaccinate Black and Latino citizens.

"We cannot know for sure with our data whether these efforts were the reason for Philadelphia's narrower gap in vaccination, but they are definitely very important initiatives," Bilal says.

VACCINATION RATES IN COMPARISON TO SOCIAL VULNERABILITY IN 16 U.S. CITIES.



_OPIOID IMPROVEMENTS

Pandemic-era changes to prescribing guidelines for the lifesaving drug buprenorphine led to ***improved treatment outcomes*** *for patients with opioid use disorder.*

_ALEXIS M. ROTH
_KATHLEEN WARD
Roth is an associate professor in the Urban Health Collaborative and Ward is a doctorial research fellow.

For those being treated for opioid use disorder, the pandemic had at least one positive outcome: Changes in prescribing guidelines made it easier for patients to obtain the lifesaving drug buprenorphine, enhancing many treatment outcomes.

That was the conclusion of a study of Philadelphia patients, published in *Drug and Alcohol Dependence Reports* by researchers in the Dana and David Dornsife School of Public Health.

The authors analyzed data from medical records and the Pennsylvania Prescription Drug Monitoring Program for 506 patients who received buprenorphine for opioid use disorder at Prevention Point Philadelphia from September 2018 to June 2020.

Patient retention improved during the pandemic after the Drug Enforcement Agency (DEA) reduced barriers to accessing treatment. The changes permitted telemedicine visits, longer prescriptions and fewer drug screening requirements.

"We treated the policy changes as a natural experiment and compared treatment outcomes before and after they took effect," says lead author Kathleen Ward. "The lessened restrictions were associated with people remaining in care for a longer period time. This is a really important finding in support of these policy changes."

The findings could help policymakers improve treatment options for 1.7 million Americans with opioid use disorder.

"For most patients, there are many barriers to accessing and staying engaged in treatment," says senior author and associate professor Alexis M. Roth. "These policy shifts are lifesaving and should remain in place."

3-8x

_IMPROVED OUTCOMES
Patients using telemedicine resources at Prevention Point stayed enrolled an average of 78 days, and those using telemedicine offsite stayed in care an average of 180 days — extending the length of treatment 3–8 times.

AUTISM

_FIVE-MINUTE AUTISM DIAGNOSIS

*Seasoned clinicians can usually spot autism within the **first five minutes of meeting a child**, a finding that opens the door to fast-tracked interventions.*

THE EARLIER A CHILD receives an autism diagnosis, the sooner they and their family benefit from early services. But even though autism is diagnosable by age 2 (or earlier), a backlog among practitioners has meant that the average wait time for a diagnosis is 51 months.

Unfortunately, this means many families lose time before they receive services.

"We really need strategies to lower that age of diagnosis," says Assistant Research Professor Andrea Wieckowski in the A.J. Drexel Autism Institute. "Children who receive high-quality, autism-specific early intervention services make greater developmental gains."

Wieckowski and Diana Robins, professor and director of the institute, studied the accuracy of early and repeated screening for Autism Spectrum Disorder (ASD) during the first five minutes of well-child visits beginning at 12, 15 or 18 months.

They studied clinician interactions with 294 children aged 12–53 months who had been referred for an ASD evaluation. After five minutes observing each child, expert clinicians recorded whether they thought the child would meet criteria for ASD following a complete evaluation, along with their confidence in this impression.

The duo found that a seasoned clinician can usually spot autism within the first five minutes: 92% of positive initial diagnoses turned out to be accurate. And when clinicians were highly confident in a diagnosis, they were typically correct. When they lacked confidence in a "no" diagnosis, the final diagnosis often turned out to be "yes."

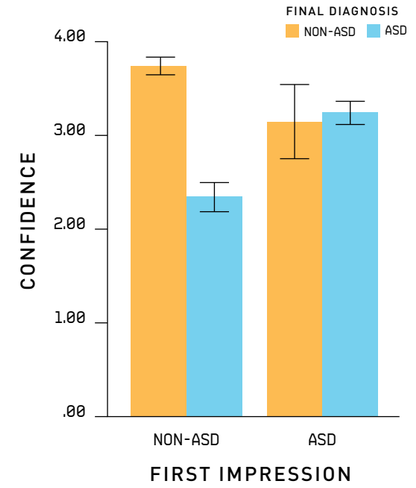
"If an expert clinician thinks the child is on the autism spectrum in the first five minutes, they're probably right," says Robins. "But if they don't think the child is on the autism spectrum in the first five minutes, they should keep looking and get more information."

The study — which appeared in *Autism Research*, the journal of the International Society for Autism Research — has implications for early intervention.

"When it's very clear that a child is likely to have autism, we should fast-track them into the intervention," even if there's a wait list for a full diagnosis, Robins says. The goal is to get more kids into treatment sooner. And by digging deeper into an initial negative assessment, clinicians will prevent more cases from going undetected.

While regulatory and insurance hurdles can slow the process, research like this could help to drive policy changes.

"The A.J. Drexel Autism Institute was the first in the U.S. to focus on the public-health side of autism, rather than on the biomedical realm," Robins says. "Our science can improve lives for autistic individuals much more quickly."



FIRST IMPRESSION

_CLINICIANS' CONFIDENCE
Clinicians' high-confidence hunches about a child are usually correct. When they are less confident, their initial impressions that a child is not on the spectrum tend to be wrong. That means that if their confidence is low, more observation and testing is needed.

MACHINE LEARNING

_KEEPING UP WITH COVID

*Drexel is using machine learning to spot **the rise of dangerous COVID variants** that may emerge in the future.*

DREXEL RESEARCHERS hope to be among the first to spot the signs of the next dangerous COVID variant, thanks to a computer model developed in the College of Engineering.

The model uses machine learning algorithms trained to identify correlations between changes in the genetic sequence of the COVID-19 virus and upticks in transmission, hospitalizations and deaths.

The program can quickly hone in on the areas of the genetic sequence that are most likely to be linked to changes in the severity of the variant.

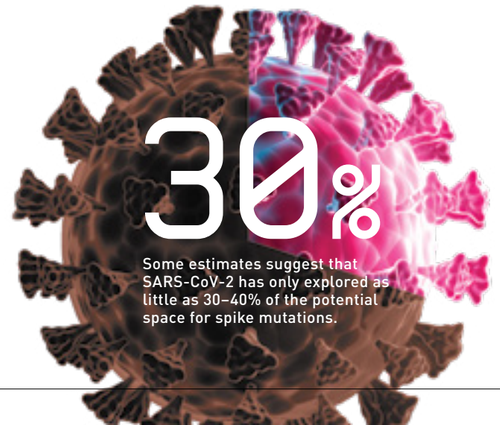
"Our model is more like an early warning system for emerging variants," says Bahrad A. Sokhansanj, an assistant research professor who led development of the computer model. "When we get a sequence, we can make a prediction about risk of severe disease from a variant before labs run experiments with animal models or cell culture, or before enough people get sick that you can collect epidemiological data."

_BAHRAD A. SOKHANSANJ
Sokhansanj is an assistant research professor in the College of Engineering.

Genetic and patient data from the GISAID database — the largest compendium of information on people who have been infected with the coronavirus — were used to train the algorithm.

"Some estimates suggest that SARS-CoV-2 has only explored as little as 30–40% of the potential space for spike mutations," says Gail Rosen, a professor in the College of Engineering who heads Drexel's Ecological and Evolutionary Signal-processing and Informatics Laboratory.

"When you consider that each mutation could impact key virus properties, like virulence and immune evasion, it seems vital to be able to quickly identify these variations and understand what they mean for those who are vulnerable to infection," she says.



_ONLINE
To read the report, visit **drexe.lu/3lsjoJh**

_CLOCK IS TICKING FOR PENNSYLVANIA'S HEALTH

A detailed report from the College of Nursing and Health Professions reveals how **demographic trends in Pennsylvania** stand to worsen access to health care services for many groups in coming years.

THE NUMBER OF OLDER Pennsylvanian adults living in poverty with poor access to health care stands to worsen, according to a 2021 report by AARP Pennsylvania and Drexel's College of Nursing and Health Professions. The report explores how geographic, racial/ethnic and economic factors are combining to restrict health care services throughout the state.

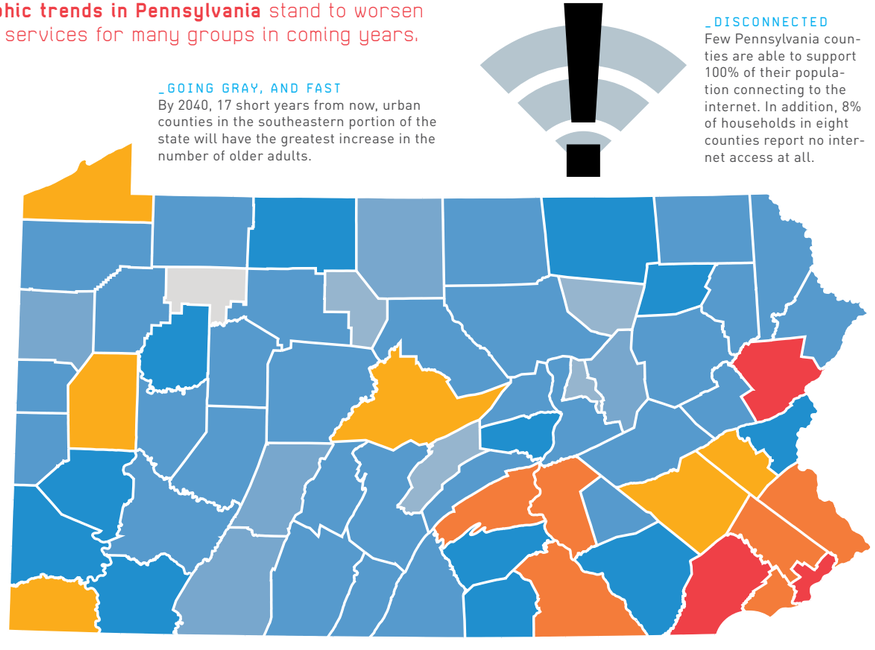
Health inequities are most acute among those living in rural and low resourced areas of the state, and among underrepresented populations who lack access to health care, experience digital divide and contend with health care workforce shortages.

The study draws on interviews with key stakeholders statewide, a comprehensive literature review and analyses of state health databases.

Currently, about 40% of Pennsylvanians are 50 and older, with nearly 19% over the age of 65. Those older adults live predominately in rural areas and are white with low household income. By 2040, however, Pennsylvania will experience exponential growth in its aging population, led by the southeastern part of the state, which is the most populous and diverse region.

"Our research shows that gaps in access to health care and internet will only continue to grow as Pennsylvania's population becomes older and with the increase in number of low-income adults living in the southeastern part of the state," says Rose Ann DiMaria-Ghalili, associate dean for Interprofessional Research and Development at the College of Nursing and Health Professions.

_GOING GRAY, AND FAST
By 2040, 17 short years from now, urban counties in the southeastern portion of the state will have the greatest increase in the number of older adults.



_DISCONNECTED
Few Pennsylvania counties are able to support 100% of their population connecting to the internet. In addition, 8% of households in eight counties report no internet access at all.

_INACCESSIBLE MEDICATION
Each of Pennsylvania's 67 counties has at least one "pharmacy desert," or an area with few to no pharmacies.

"Not only do we need more health professionals and direct care workers, we need to prepare the health care workforce to be culturally competent and capable of addressing age-related health care issues."

-Laura Gitlin, dean emerita of the College of Nursing and Health Professions

We're Not in 'Oz' Anymore

Inside a new *Scandinavian-style* prison unit, academics and corrections officials want to know if making prison time *less* prison-like can *reduce recidivism* in Pennsylvania.

BY SARAH GREENBLATT

ILLUSTRATION BY JAMES STEINBERG

_JORDAN HYATT
Hyatt is an associate professor of criminology and justice studies and director of Drexel's Center for Public Policy.

ON MAY 5, 2022, the then-superintendent of the State Correctional Institution (SCI) at Chester announced that he'd done the unthinkable.

Not only had Kenneth Eason, a corrections veteran of 32 years, sat down to eat a meal with inmates, but he also authorized the purchase of equipment for a kitchen to be shared by some of the incarcerated men.

The prison leader recounted his actions with astonishment during a ribbon-cutting ceremony for "Little Scandinavia," a new unit of SCI Chester that incorporates reforms imported from corrections systems in Norway, Sweden and Denmark. In addition to a communal kitchen, Little Scandinavia features a landscaped green space and 64 well-lighted individual cells outfitted with mini-fridges and modern furniture. Alongside those amenities, officials put new policies in place intended to turn the unit into a more hospitable, home-like environment for the inmates housed there.

The changes were spearheaded by Jordan Hyatt, associate professor of criminology and justice studies and director of Drexel's Center for Public Policy, and Synøve Andersen, a researcher at the University of Oslo and a fellow in the Center for Public Policy. Their efforts are part of the Scandinavian Prison Project (SPP), which aims to document and evaluate SCI Chester's efforts to improve conditions for both inmates and correctional staff and, in the long term, lower recidivism rates.

SPP has brought together corrections officials in Pennsylvania, Norway and Sweden with academics from Drexel, the University of Pennsylvania, the University at Buffalo, the University of Minnesota and Villanova University's Widger School of Law to measure the impact of changes that humanize correctional facilities, in hopes of making inmates' re-entry into the community more successful.

The project represents a capstone of sorts for Hyatt and his colleagues, who have spent years building a broad body of research evaluating policies and programs that affect people in the criminal justice system.

Forging and maintaining this partnership has occupied much of Hyatt's time since 2017, requiring him to navigate diverse organizational and national cultures, to promote accountability infused with compassion and to measure the impact of corrections practices with rigor and precision.

Building Bridges and Trust

Seeds for the SPP were planted in 2015, when Hyatt and Andersen began taking Drexel students on Intensive Courses Abroad in Norway and Sweden to study how corrections practices in those countries differ dramatically from the U.S. prison system. More recently, they added an independent component in Denmark that focuses on harm reduction, including visits to safe-injection sites.

The courses expose students to corrections facilities that look and feel nothing like the grim and violent environments portrayed on television shows like "Oz" or "Orange Is the New Black."

Many Scandinavian prisons are brightly lit and comfortably furnished. Corrections officers are directly involved in day-to-day activities with incarcerated people and may cook, play games or participate in sports with them. In some prisons, incarcerated people and officers use first names. Inmates live in private cells, many of which have bathrooms.

Beyond introducing students to diverse correctional norms, the intensive courses helped lay critical groundwork for research Hyatt sought to pursue with colleagues to understand the Nordic approach and to assess the feasibility and impact of transporting such practices to Pennsylvania prisons.

"Because Drexel provided me with that opportunity, we were able to build stronger ties to the Norwegian and Swedish correctional systems," Hyatt says. "This allowed us to bring folks from that side of the Atlantic into this partnership."

In 2017, Hyatt invited Are Høidal, the governor of an acclaimed prison in Halden, Norway, to the United States to give a presentation in collaboration with John Wetzel, who was then the Pennsylvania Secretary of Corrections. Høidal described how reforms that began in the 1990s had reduced violence in Norwegian prisons and may have helped achieve a recidivism rate of 20% — well below Pennsylvania's 64.7%.

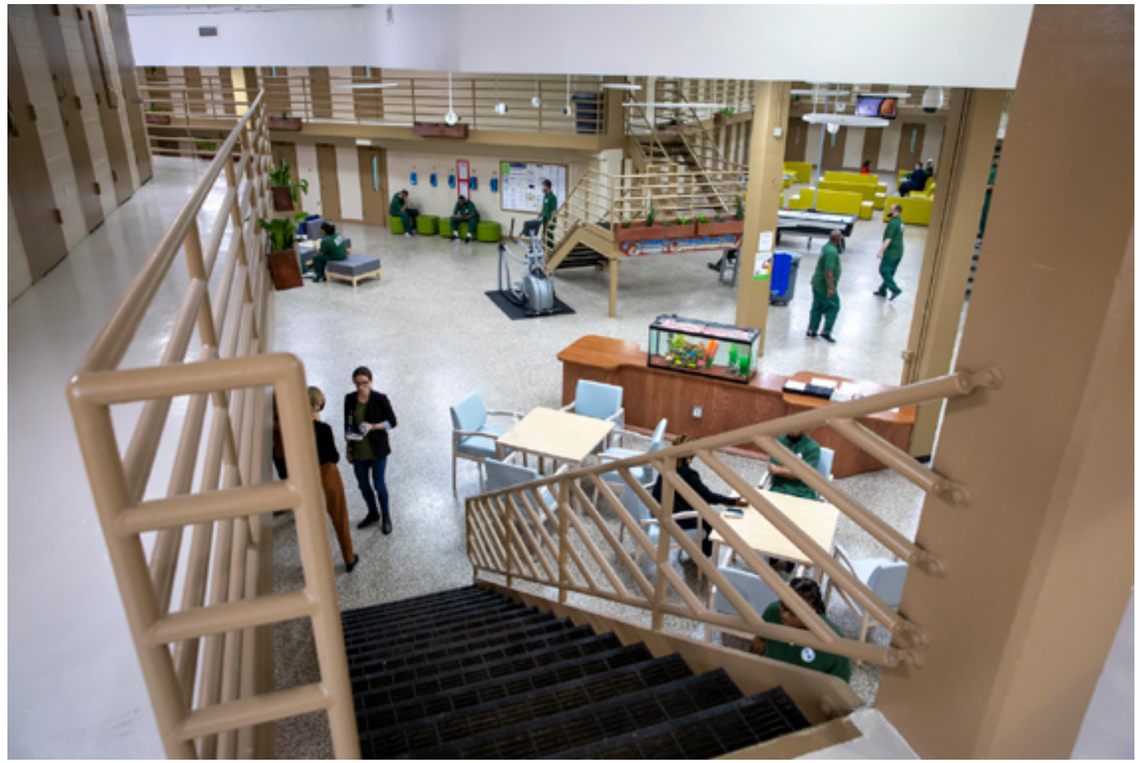
Norway's reforms reflect common European standards that seek to infuse the prison environment with as much normalcy as possible: The same entities that deliver health, education and library services in the broader community also provide them in prison. Inmates and officers commonly eat meals together and work collaboratively to plan for the individuals' return to society.

Hyatt and his colleagues have studied the Scandinavian reforms extensively, publishing their findings in recent editions of *American Criminal Law Review*, *Federal Sentencing Reporter*, *European Journal of Criminology* and *Drug and Alcohol Review*. A key difference between cultures is that while U.S. corrections leaders have tended to treat inmates with increased stridency, eliminating privileges that were previously conferred, Scandinavian officials view losing one's liberty as punishment enough.

A series of planned and fortuitous unplanned opportunities that followed Høidal's visit allowed Hyatt and his colleagues to advance the project. In 2019, the SPP received the blessing of Wetzel, who selected SCI Chester as the site for Little Scandinavia.

Normalcy Behind Bars

In the summer of 2019, Hyatt and Andersen led administrators from the Pennsylvania Department of Corrections and officers from SCI Chester on a three-week immersion in prisons and other facilities in Norway, Sweden and Denmark.



COURTESY OF COMMONWEALTH MEDIA SERVICES

_CULTURE SHIFT
Brightly lit, welcoming spaces in Little Scandinavia set a tone that promotes constructive engagement between incarcerated men and corrections officers.

COURTESY OF COMMONWEALTH MEDIA SERVICES

_TOUCHES OF HOME
The special unit that opened in 2022 includes planter boxes, exercise equipment, an aquarium and a communal kitchen where the men prepare meals they can share.

Upon arriving, some officers voiced their doubts.

"I'm a massive skeptic to this entire project," Officer Tyler Karasinski acknowledges in a video documenting the trip, describing tools in a communal kitchen as "weapon, weapon, weapon."

The officers received intensive training in conflict resolution and physical restraint techniques before working alongside peer mentors in three Norwegian prisons. Meanwhile, corrections leaders toured other high-security facilities in Sweden and Denmark, conferring with their Scandinavian counterparts.

The officers were surprised to find goodwill between inmates and those who hold the keys. The two groups ate meals together and often discussed plans for returning to the community. At times, officers and inmates exercised together.

"I felt like I was in a completely alternate universe," Officer Paige Devane says, describing a lunch of fish cakes she shared with inmates in Norway's Ila Prison.

At Halden prison, officers were also intrigued to find cooking classes, a sound studio, a woodshop and a metal shop. Not only was the atmosphere relaxed, the officers discovered, but the inmates seldom harmed one another.

Hyatt and his colleagues summarized the visitors' impressions in "'We Can Actually Do This:' Adapting Scandinavian Correctional Culture in Pennsylvania," which appeared in *American Criminal Law Review* in 2021.

The authors noted that the Scandinavian corrections model does not exist in a vacuum but reflects the substantial investment that welfare states make in all citizens' well-being. The officers, for their part, noticed that their Norwegian counterparts receive far more training and supervise far fewer inmates than they do. Administrators spotted familiar features like metal detectors in the maximum-security facilities.

Still, both groups returned to Pennsylvania inspired to make changes. Even Karasinski, after playing video games with a Norwegian inmate in solitary confinement, gained a measure of optimism.

"I'm still skeptical of the entire project, if it's going to work in the United States or even here, but I have higher hopes for it now," Karasinski said before leaving Scandinavia. "I really want it to work. I'm looking forward to getting on the block and proving to the Norwegians that we can do better than them."

Bringing the Nordic Model Back Home

Nothing was off the table as the Department of Corrections began devising plans for Little Scandinavia. What could be done to make the physical facility more cheerful? How many inmates would be in each cell? What kind of training would officers receive? And could officers and inmates eat meals together? (Longstanding policy made fraternization grounds for termination.)

In the process, leadership allowed the corrections officers to propose new guidelines.

"The policies and the changes were conceived of and at least partly developed by the correctional officers," Hyatt says, noting that the fraternization policy was completely rewritten to allow meal sharing and informal conversation. "The leaders supported them and participated in that decision, but I think that's something that makes this project unique."

> "I'm still *skeptical* of the entire project, if it's going to work in the United States or even *here*, but I have *higher hopes* for it now. I really want it to *work*. I'm looking forward to getting on the block and proving to the Norwegians that we can do *better* than them."
>
> OFFICER TYLER KARASINSKI

Six men serving life sentences were chosen for what was envisioned as a two-month trial, during which time they would provide input in the design of Little Scandinavia and after which they would serve as peer mentors. While the pandemic upended that timeframe, the project slowly moved forward.

Extensive renovations brightened the unit and introduced new amenities and individual cells.

Importantly, the Department of Corrections agreed to select the unit's 58 additional inhabitants by lottery. This was the fairest process, and it would allow the researchers to make the most meaningful comparisons of outcomes between those living in Little Scandinavia and the general population, Andersen says.

Will It Work?

Ongoing research by Hyatt and his colleagues will measure Little Scandinavia's impact on inmates, correctional staff and — eventually — recidivism rates. Social, economic and cultural differences between the United States and Scandinavia may make it impossible to match Norway's low reported recidivism rate, Hyatt observes, yet opportunities to improve community re-entry outcomes in Pennsylvania are abundant.

In the first half of 2022, Hyatt spent one or two days at SCI Chester each week, conducting research, problem-solving and working with Department of Corrections personnel to refine the model. He leads a team of faculty and staff researchers who will continue to collect data.

Pennsylvania has covered operational costs associated with Little Scandinavia, and the research team garnered additional grant funding from sources including Arnold Ventures and the Nordic Research Council for Criminology.

One study published in *Criminal Justice Studies* in 2021 has already explored morale among corrections personnel. Hyatt joined lead author Veronica Horowitz of the State University of New York at Buffalo and other colleagues to contrast the views of Department of Corrections leaders and officers from SCI Chester before and after their visits to Scandinavia. The officers reported less stress and more desire to go to work after their overseas experience, and attributed their improved mood to appealing food, comfortable uniforms, relaxed contact with inmates and information sharing among staff.

The department's leadership sees tremendous promise in the SPP.

"The Pennsylvania Department of Corrections is very excited about the Little Scandinavia project at SCI Chester," Acting Secretary George Little says. "This collaborative research trial will help us refine best practices to provide safer and more humane correctional operations across the Department. Hopefully, this will lead to better outcomes for residents, re-entrants and our staff."

For men housed in Little Scandinavia, a transformation has already begun.

"I'm excited," says Joseph Spinks, who has been incarcerated for 29 years. "I hope it's a step toward re-entering society."

The simple pleasures of eating banana pancakes and homemade stromboli were a revelation for Kevin Bowman.

"All I've ever seen before was like dark, dismal places," Bowman says. "Yes, we're inmates. But the biggest thing is: We're humans." ✕

ROWHOMES VERSUS REFINERIES

Academics and community members are working together to tackle environmental hazards as part of Drexel's new Environmental Collaboratory, a pioneering initiative that funds research activism.

BY BEN SEAL

_UP IN SMOKE
Flames and smoke engulfed the Philadelphia Energy Solutions Refining Complex on June 21, 2019, after a series of explosions shook homes and caused extensive damage at the refinery. The company later shuttered the 150-year-old site.

Courtesy of Matt Rourke/Associated Press

Carol White was sleeping on the third floor of her house when she felt the explosions. Windows shattered and buildings shook across her South Philadelphia neighborhood as neighbors fled into the street. By the time she opened her front door, ash was falling like rain.

She had never had asthma in the past, but suddenly she found it hard to breathe. Sitting in her home moments later, she felt an intense pressure in her chest. She jumped in her car, chased by ash still drifting through the air, and raced to the hospital.

Four years since her neighborhood woke to the early-morning blasts that destroyed the Philadelphia Energy Solutions (PES) oil refinery, the largest and oldest on the East Coast, the 63-year-old still takes multiple asthma medications to deal with her own personal fallout. Her tears now feel like glass unless she uses prescription eye drops.

The multiple explosions that rocked South and Southwest Philadelphia on June 21, 2019, released more than 3,000 pounds of deadly hydrogen fluoride into the atmosphere, along with more than 600,000 pounds of hydrocarbons. PES was forced to declare bankruptcy and sell the acreage for redevelopment. But for years before a corroded pipe doomed the facility, neighboring communities had been calling for its closure and an investigation of its damaging health effects. After watching so many friends and family grow sick in the refinery's shadows, White calls the surrounding blocks "cancer alley."

Jane Clougherty still recalls her first impression of the air quality when she moved to the nearby Grays Ferry neighborhood in 2016 to join the faculty of Drexel's Dana and David Dornsife School of Public Health as a professor in the Department of Environmental and Occupational Health.

"I was shocked, stunned and appalled by what I smelled," she says.

The neighborhoods near the refinery have for decades been beset on all sides by a combination of polluting sources that Clougherty describes as "a glaring environmental justice concern." Rowhomes have been hemmed in by highways, situated north of an airport and west of a shipping port, with the refinery's billowing exhaust a steady and unwanted companion.

"I've been worried about my own health and really amazed by how little monitoring was happening," Clougherty says, "and how little scientific understanding we had of the very complex combination of pollution sources impacting that area."

Now, as the cleanup and redevelopment of the refinery risk stirring up additional pollutants into the mix, Clougherty is embarking on research to reveal what's at stake. Alongside Sheila Tripathy, senior research scientist at Dornsife School of Public Health, and in partnership with Philly Thrive, an environmental justice advocacy group that includes White and many of her neighbors, Clougherty is conducting monitoring that will finally give community members trustworthy data about the air they breathe.

Their work will receive support from the Environmental Collaboratory, an initiative launched by Drexel last year to apply community-centered solutions to environmental problems. Clougherty and Tripathy's research is one of the Collaboratory's seven inaugural projects that aim to meaningfully improve the quality of life for communities coping with environmental threats.

A STUDY IN SOUTH PHILADELPHIA

Tripathy recalls being shocked by the size of the PES refinery complex when she came to Philadelphia to work with Clougherty as a postdoc fellow in 2017. Driving over the Girard Point Bridge on the way to the Philadelphia International Airport, she marveled at how many people lived within the wind currents that gusted over the refinery's flare stacks.

She eventually became acquainted with the organizers of Philly Thrive, who were working to have the complex shut down. At the time, the refinery was fully operational, and a survey found that 34% of the community members had asthma, more than four times the national average. Heart disease, cancer and other respiratory diseases were rampant.

Even two years after the 2019 explosion, when demolition and cleanup were already underway, the 1,300-acre South Philadelphia facility was still the country's second-worst emitter of benzene, a carcinogen often found alongside other dangerous volatile organic compounds. Though nonoperational, the plant emitted benzene at double the EPA's "action level."

For Tripathy, understanding what White and her neighbors had been through gave her research with Clougherty depth and meaning.

"I met people who lived in the area and heard their stories, heard them talk about their lives and how their families have lived there for generations," says Tripathy. "Seeing that side of it made me feel it was important that someone do more monitoring of the area, so people know what's happening and can use the data to advocate for more monitoring, more studies, and to have government agencies come in and do something."

Tripathy and Clougherty's research, which has funding from the National Institutes of Health in addition to the Collaboratory, will place nearly two dozen thermal desorption tubes on telephone poles in the neighborhoods surrounding the refinery. The tubes contain charcoal filters that will passively collect volatile organic compounds, or VOCs, in the air.

After a week, the air samples will be retrieved and shipped to a Lewis-Clark State College chemist named Nancy Johnston for analysis. Johnston worked on similar research as part of FIREX-AQ, a joint venture between the National Oceanic and Atmospheric Association and NASA that studied how wildfires affect air quality. That research led her to Drexel chemist Ezra Wood, associate professor and chair of the Chemistry Graduate Program Committee, who connected her with Clougherty. Johnston had the ability to measure very low-concentration VOCs with high precision.

The researchers will also use separate instruments to monitor fine particulate matter that will be chemically analyzed by the Wisconsin State Laboratory of Hygiene. The matter is composed of miniscule airborne particles, created by combustion, that can enter the bloodstream and wreak respiratory and cardiovascular havoc.

Courtesy of Bastiaan Slabbers

_SPEAKING OUT
Carol White, a fenceline resident and activist with Philly Thrive, speaks at a community meeting in 2019 organized by Philadelphia's Refinery Advisory Group to discuss the future of the Philadelphia Energy Solutions refinery site.

Their samples will reveal for the first time the variety of pollutants emitted, their patterns across the neighborhood and how pollution concentrations vary over time. By law, the Environmental Protection Agency requires companies to monitor benzene and related VOCs around the fenceline of a refinery, and this has provided communities around the country with a modicum of data about the air they breathe over the years. But the data is severely limited because it measures air quality only around the perimeter of the facility itself and is averaged over two-week periods. In Philadelphia, it has never been provided to community members in a format that they could reliably access and interpret.

With the help of Lisa Frueh, a Dornsife doctoral student in environmental and occupational health, and Karlin Moore, a Dornsife master's student in biostatistics, the research team will rotate the testing units throughout the affected neighborhoods every week to understand how pollution varies across space and time. They will be able to identify where specific metals within the fine particulate matter — such as manganese or lead — may raise particular concern, and how changes in wind patterns affect air quality over the course of the year. Members of Philly Thrive are eager to assist with the field work.

The ultimate goal is to make these findings accessible to ordinary citizens. "If we can translate reports into something that's legible for the people making the decisions," Frueh says, "we can play a supporting role, helping to amplify community concerns that are already there."

After years of searching for the truth from the EPA and the two corporate entities sharing responsibility for remediation of the site — Evergreen Resources Group and Hilco Redevelopment Partners — the people of South Philadelphia will have information they can trust and act upon.

"We are an unbiased third party," says Clougherty. "We've taken the time to make sure they understand and are comfortable with our methods. So if we tell them concentrations have gone down, that can provide relief to them."

A RAFT OF RESEARCH

The Environmental Collaboratory's mission is to bring researchers and community members together to tackle environmental challenges. That means that every research project it funds must address a climate-related or environmental justice problem identified by community members themselves — and co-led by a community-based organization.

Initial funding for the Collaboratory came from a $2 million, two-year grant from the Waverly Street Foundation. Further funding will come from project-based federal grants — it has already received a small prize from the Department of Energy — and co-funding with community-based organiza-

tions, with the eventual goal being an endowment.

All parties involved in Collaboratory projects are expected to take an historical, holistic, human view of environmental issues that examines why problems exist and who they harm.

"If you want to partner with us, everything you do has to be centered in justice and equity and the history of systemic racism," says Mathy Stanislaus, vice provost and executive director of the Collaboratory (see story at right, "Seeker of Solutions"). "Whether you're a biologist or an engineer, it's not a blank slate. There's a history of disparities and disinvestments. You have to take the community as it is, not how you would want it to be."

In addition to Clougherty's air-quality study, the Collaboratory awarded research grants to six other inaugural projects in 2022:

- **BEN KALINA**, an assistant professor of film and television in the Antoinette Westphal College of Media Arts & Design who is also an award-winning producer of climate documentaries, will produce a short film about Eastwick, a low-lying neighborhood of Southwest Philadelphia battered by intense flooding. The film, "The Refugees of Eastwick," will explore environmental justice issues in the context of proposals to relocate the primarily Black residents to higher ground. Kalina is partnering with the Eastwick United Community Development Corp. and the College of Engineering.
- **GWEN OTTINGER**, an associate professor in the Department of Politics who advocates for community-centered science, is partnering with the Open Environmental Data Project on a set of recommendations to make climate-related data more accessible and useful for people interested in climate adaptation and mitigation planning.
- **ELIZABETH WATSON**, an associate professor in Drexel's Department of Biodiversity, Earth and Environmental Science and a senior scientist with the Academy of Natural Sciences of Drexel University, is tackling environmental challenges in San Juan, Puerto Rico. The city's central canal, the Caño Martin Peña, regularly floods, spreading polluted water to the homes of about 2,000 low-income families. She'll collaborate with the Environmental Protection Agency and ENLACE, a Puerto Rican liaison between the public and the government, to analyze flood data and engage community members on how to use it.
- Professor **MICHAEL WARING**, who is head of the Department of Civil, Architectural and Environmental Engineering in the College of Engineering, is collaborating with partners in the College of Engineering, Dornsife School of Public Health and School of Education to develop practical action plans to improve indoor air quality in Philadelphia public schools and help community members advocate for improvements that protect student health.
- Professor **SIMI HOQUE**, who is program head of Architectural Engineering in the College of Engineering, will work with partners including the Energy Coordinating Agency, the Philadelphia Energy Authority and the Built to Last program to analyze how temperature, humidity and health symptoms change after a home is weatherized, with the aim of educating low-income communities on how they can improve indoor air quality.
- As climate change alters behaviors, **NATHALIE MAY**, an associate professor in the College of Medicine, will study how extreme heat, cold and flooding affect residents' use of primary care practices. Collaborating with Esperanza, a North Philadelphia-based organization aimed at pulling people out of poverty, the researchers will offer suggestions to improve primary care infrastructure so increasingly harsh weather conditions don't keep people from seeking needed care.

The Collaboratory is also pursuing funding for a separate effort that will focus on protecting people and places from climate change's impact on flooding and extreme weather through the use of early-warning systems and emergency preparedness and response. The work will be done in consultation with the most vulnerable communities and water utilities in the region.

It is also laying the groundwork for a bipartisan group that will work to advance climate solutions locally, sharing best practices and conducting workshops for government officials who want to implement climate-centered projects such as clean energy or infrastructure adaptations. At every step, Stanislaus wants the Collaboratory to be part of "on-the-ground solution building" that brings along all stakeholders necessary for implementation.

> "If you want to partner with us, everything you do has to be centered in justice and equity and the history of systemic racism. There's a history of disparities and disinvestments. You have to take the community as it is, not how you would want it to be."
>
> **MATHY STANISLAUS**, EXECUTIVE DIRECTOR OF THE COLLABORATORY

The Collaboratory's community-driven approach is "an excellent model" for how to make research meaningful and effective, says Johnston of Lewis-Clark State College: "They're the stakeholders. They're the people affected by the environmental conditions — the air, the water, the soil, their surroundings."

'OUR GRANDCHILDREN'S FUTURE'

When Carol White's mother died of cancer two years ago, Carol couldn't help but wonder if the refinery had something to do with it: She'd been living near the refinery for more than 25 years; her mother had visited so many times, every weekend for years…each breath pulling in poison. Now Carol worries about her grandchildren.

In Philly Thrive, White has found a way to push back against the entities responsible for the pollutants that have harmed her family and friends. And in the Collaboratory's research, she and her neighbors can gain the detailed data, and the means to interpret it, that they need to change their circumstances.

"If we as a community don't come together and fight these people, it's doomed to happen again," White says. "We're fighting more than one devil here. How do you become a survivor if you're not able to find the source of it all? Our children and grandchildren won't have a future, unless we do something now." ✕

_CIVIC SOLUTIONS
Before coming to Drexel to lead the Environmental Collaboratory, Mathy Stanislaus worked for environmental justice with community organizations and for the Environmental Protection Agency.

Seeker of Solutions

The Environmental Collaboratory's inaugural executive director, Vice Provost Mathy Stanislaus, was working on a chemical engineering degree at the City College of New York when two events changed his life's trajectory.

When civil war broke out in his native Sri Lanka, Stanislaus poured himself into refugee assistance. He helped with asylum petitions and enlisted Congressional support on his countrymen's behalf. Everyone he encountered seemed to be a lawyer.

Around the same time, in December 1984, a disaster at a pesticide plant in Bhopal, India, exposed over 500,000 people to methyl isocyanate, a toxic chemical, killing as many as 20,000 people. Watching it all unfold from afar, he decided to pursue a law degree that would link his concerns for human rights and the environment with his chemical engineering studies.

He spent years fighting for environmental justice and community empowerment, serving on the board of the community-driven New York City Environmental Justice Alliance and co-founding a New York-based organization that helped redevelop brownfields, then served two terms in the Obama administration in the EPA's Office of Land and Emergency Management.

He put community needs at the center of every issue he oversaw: brownfields, Superfund sites, recycling, natural disaster and emergency response.

After the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, he spent months in Louisiana learning about local residents' needs and finding ways to keep them informed.

Most recently, he worked at the World Economic Forum — a global consortium of large companies, governments, civic leaders and academics — to address issues including child labor and the authentication of greenhouse gas emissions in the scale-up of electric vehicles and renewable energy.

"I've always approached my work in a human rights paradigm," Stanislaus says. "Environmental practitioners approach it from an environmental practice perspective, and lawyers approach it from a transactional perspective. I view these as tools to enable a human rights-based solution."

For a long time, he felt that academia stood in opposition to much of what he was pursuing. When Columbia University sought to expand into West Harlem in the mid-2000s, he fought the effort as a technical adviser to the local community board, worried about its impact on neighborhood residents in the form of displacement and gentrification.

"I've criticized academia for not respecting communities, not being in service of communities, not studying communities, and not respecting ownership of research products and for displacing communities," Stanislaus says.

So, when he was asked to apply to lead the Collaboratory as executive director, he voiced his vision and his concerns over the course of five months of direct conversations with Drexel's leadership to ensure the Collaboratory's authenticity. "I didn't want to join something that was not real," he says.

Ultimately, he was convinced. He saw a genuine opportunity to scale the wall that stands between academia and the communities he cares so deeply about.

"At this moment of greenwashing and misinformation and disinformation, coupled with the disparities in communities, academia can play a really important role in trust- and solution-building," Stanislaus says. "Traditional academic research needs to continue with assurances of community participation and ownership, but it needs to be complemented by translating and delivering information so community stakeholders can make decisions. Unless you do that, you are effectively taking the decision away from community-based organizations."

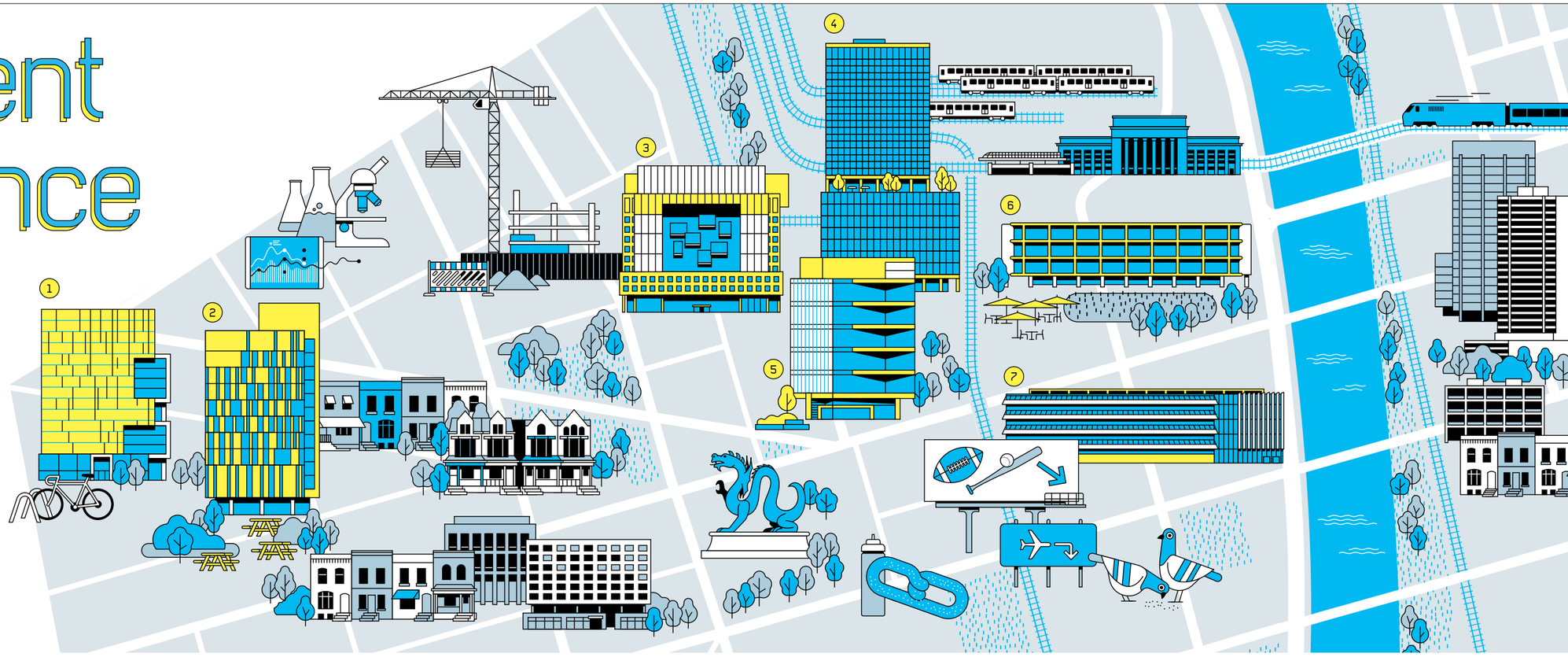
COURTESY OF NB/DEPTCOMM

Land, Talent and Science

West Philadelphia has the history and momentum to lead the region in a life sciences renaissance, and Drexel is building a home for it all.

BY LINI KADABA

ILLUSTRATION BY AXEL PFAENDER



A far-reaching transformation is under way on Drexel's campus.

In spring 2023, Spark Therapeutics broke ground on land leased from Drexel to build a $575 million, more than 500,000-square-foot gene therapy innovation center that will enable the best and brightest minds in the industry to collaborate and advance the field of gene therapy.

Formed just 10 years ago — and acquired by pharma giant Roche in 2019 for $4.8 billion — Spark has experienced a meteoric rise from a Children's Hospital of Philadelphia spinoff to a standout in the field of life sciences and a leader in gene therapy.

The new facility will serve as Roche's flagship center of excellence for gene therapy manufacturing globally. It will be just a short walk from Spark's other offices and lab facilities, some of which are inside Drexel's historic Bulletin Building at 3025 Market St. within Schuylkill Yards, a mixed-use neighborhood in development by Drexel and Brandywine Realty Trust.

Spark is one of several major organizations in University City that are helping to position Philadelphia as an increasingly popular ecosystem for companies in the field of life sciences, particularly in cell and gene therapy — one in which Drexel is playing a role as a go-to partner for land, talent and science.

That ecosystem — flourishing across the region but notably concentrated in West Philadelphia — is years in the making but has blossomed of late. On the western end of campus, Drexel's development partner Wexford Science & Technology recently completed a 1.3-million-square-foot phase of construction at uCity Square. Adjacent to the 30th Street Station, the first mixed-use high-rise of the Schuylkill Yards innovation district is nearing completion by Brandywine Realty Trust, with another tower built expressly for life sciences well under construction. In 2022, Drexel also signed an agreement with Gattuso Development Partners to build what is expected to be the city's largest life sciences lab facility, designed for start-ups. The $400-million, 500,000-square-foot project has broken ground in the center of campus at the current site of the Buckley Recreational Field, which will be relocated to the grounds of Myers Hall after that dormitory is demolished. Demolition and reconstruction of the new recreational field is anticipated to be complete in summer 2024.

All of these office and lab clusters — uCity Square, Schuylkill Yards and now the Spark and Gattuso buildings — convert previously fallow land into lease revenue or endowment funds for Drexel. And crucially, they promise a classroom-to-workplace conduit worthy of an R-1 research institute.

"What Drexel is doing is quite remarkable," says urban policy expert Bruce Katz, co-founder and inaugural director of the Nowak Metro Finance Lab at Drexel and formerly at the Brookings Institution. "It's playing many roles, a real-estate–building role and a placemaking role. In some ways, it's rebalancing the geography of the city's economy, making 30th Street a new center. It's changing the geography of innovation."

OPEN FLOODGATES

West Philadelphia's life sciences pedigree traces back to the '80s and '90s. After false starts in the field, a fresh explosion of science and investment by research teams at the University of Pennsylvania and Children's Hospital of Philadelphia bore fruits that built the nation's epicenter of cell and gene therapies. Between 2013 and 2018, the Philadelphia region became the top locale for National Institutes of Health grants for cell and gene therapy, according to Philadelphia-based Econsult Solutions Inc.

A string of FDA approvals for cancer, a genetic form of blindness, rare diseases and mRNA vaccines for COVID-19 — beginning with the first U.S. approvals for cell and gene therapies in 2017 — have laid the path for transformative changes in fields once thought impossible to crack.

That history makes the Philadelphia area one of the top three cell and gene therapy hubs in the country, according to ESI. The economic development organization predicts that if universities and private industry collaborate successfully in the coming years, the region's workforce in gene and cell therapy could skyrocket from 4,900 in 2019 to more than 11,200 by 2030.

"If you think of economic growth as a funnel, the top of the funnel is research being done that can yield commercial activity out of the bottom," says Claire Greenwood, an executive director and senior vice president of economic competitiveness at the Chamber

1. ONE UCITY Wexford's commercial lab space for life sciences tentants is now open. 2. HEALTH SCIENCES BUILDING Drexel recently consolidated health sciences programs in this new tower in uCity Square. 3. 3200 CUTHBERT Gattuso Development Partners has broken ground on a life sciences lab facility for startups. 4. 3025 JFK BOULEVARD Brandywine's 28-story "West Tower at Schuylkill Yards" is nearing completion, soon to be followed by a 34-story tower next door. 5. 3151 MARKET STREET A new Brandywine building will soon go up on this parcel. 6. BULLETIN BUILDING Drexel's historic building was renovated into office and lab space for Spark Therapeutics in 2021. 7. SPARK THERAPEUTIC'S GENE THERAPY INNOVATION CENTER Construction is already under way for the more than 500,000-square-foot global gene therapy manufacturing facility.

of Commerce for Greater Philadelphia. "In the past several years, we've seen that research investment yield companies, spinoffs, licenses."

Drexel's piece revolves around its strengths in gene editing and immune engineering, among other areas, says Aleister Saunders, executive vice provost for research and innovation. The University also has its share of spinoffs, particularly in the area of medical devices.

No other regional university supplies more graduates to the life sciences than Drexel, Saunders says.

Saunders cites a recent McKinsey & Co. study that found the highest number of tech workers in the Philadelphia metro area — about 8% of the total — are Dragons. In addition, a 2021 Jones Lang LaSalle analysis ranked Drexel as the leader in preparing students for careers in the life sciences among more than 100 regional colleges and universities. Since 2015, the University has conferred more than 7,800 degrees in programs that prepare students for careers in the life sciences.

"We are helping to drive this revolution," he says.

And Philadelphia has a lot of momentum.

In the past three years, cell and gene therapy companies in the region increased to 45 from 30, says the Chamber's Greenwood. More than half are based within the city limits, including in University City, she estimates.

"The total dollars in the life sciences market are extraordinary, relative to our history," she adds. More than $12 billion was invested across the region in 2021 — an astonishing 250% increase from 2020 that makes the Philadelphia area a leading life sciences market, according to a Big4Bio report. Of that investment, $3.2 billion pinpointed the cell and gene therapy sector. "It's a sign," she says, "of the continued growth and demand to come."

Drexel President John Fry is determined that University researchers and graduates catch this wave.

"Unless we move fast, we're going to miss it," he says. "Groundbreaking cell and gene therapy work is happening all around us. CHOP and Penn's health system are set up to do that…but once the fundamental work is done, those discoveries are made, where do you set yourselves up? Who do you hire?"

If Fry has his way, Drexel will be the answer.

"We're translational," he says. "Our whole job as a university is to figure out how you take great ideas and actually make stuff happen."

Certainly John Gattuso, CEO of his eponymous firm, sees the potential. His Drexel campus building project came about when a major player already in Boston and in the San Francisco Bay area approached him about expansion.

"There was a clear choice of focusing on Philadelphia… in terms of where this company thinks the next most important growth will be," he says. "It speaks to the quality of sciences being done in Philadelphia. It speaks to the talent in Philadelphia."

His optimism is shared by Drexel's other development partners. Brandywine Realty Trust intends to more than double the size of its successful B+labs, a science incubator inside Cira Centre. The incubator, which provides "plug and play" lab space to researchers, will be a resource to the future tenants of Schuylkill Yards buildings that Brandywine is building near 30th Street Station. At completion, the total Schuylkill Yards project could bring approximately 3 million square feet of new construction to the eastern edge of University City.

> "What Drexel is doing is quite remarkable. In some ways, it's rebalancing the geography of the city's economy, making 30th Street a new center. It's changing the geography of innovation."
>
> **BRUCE KATZ**, CO-FOUNDER AND INAUGURAL DIRECTOR OF THE NOWAK METRO FINANCE LAB AT DREXEL

On the west end of campus at 36th Street, Wexford Science & Technology has completed more than 4.5 million square feet in its latest phase of uCity Square, a community of educational, medical, lifestyle and commercial space that includes a neighborhood public school and a 460-unit apartment building called ANOVA at uCity. Last fall was the opening of Drexel's high-rise academic building for programs in nursing, health professions and medicine and this spring saw the completion of One uCity Square, commercial lab space for life sciences tenants including Century Therapeutics, Exponent and Integral Molecular.

Tenant appetites are strong, says Wexford. One uCity Square was built on spec, rare in the city, and was 90% committed before opening in December of last year, says Pete Cramer, Wexford's vice president of development and local market executive.

"We want to be an even better Kendall Square," Cramer says, referring to the tech cradle in Cambridge, Massachusetts. "We're at a pivotal moment in the history of University City — of Philadelphia, really. And Drexel is at the forefront of that growth."

FLOAT ALL BOATS

The success of any innovation district depends on an array of players coming together: developers (Brandywine, Wexford, Gattuso), research communities (Schuylkill Yards, uCity Square), institutional investors (Ventas), nonprofits (Science Center, West Philadelphia Skills Initiative), research institutions (Drexel, Penn) and organizations like Spark.

The community is a central character, too. Every stage of this transformation has included dialogue with resident groups to ensure sensitive, beneficial construction and commitments from developers to hire minority-owned firms. Years before any shovel hit the ground, Drexel administrators were successfully pursuing public and private funds such as PECO grants and a federal Promise Zone designation to support libraries, playgrounds and educational programming at neighborhood schools and to spur economic development in West Philadelphia.

A big reason why these projects have come so far in a little over a decade, many say, is Fry's leadership. In May 2022, the Chamber of Commerce for Greater Philadelphia awarded Fry, who was chairman from 2016 to 2018, its William Penn Award, given to a business executive who has contributed to the betterment of the region.

"Drexel is essential," Cramer says. "When we think of partnerships across the country, President Fry, and the University, is the poster child of who we want to work with. He gets the vision."

In nearly 12 years at Drexel's helm, Fry has unlocked the power of the University's prime real-estate location through the magic of third-party development. At their own expense, developers erect buildings on Drexel-owned land. The University collects ground rents and commitments for civic engagement, as well as options to occupy the space on favorable terms for classrooms, labs and faculty offices. At the end of the long-term leases, ownership of the buildings reverts to Drexel. Some third-party developers have constructed apartments that provide campus housing for students, too.

But the University doesn't want to attract just any tenant.

"If it was only about the real-estate deal," says Alan Greenberger, vice president for real estate and facilities, "we wouldn't worry about it being research or science or technology. We wouldn't be thinking about the *who* part. But we do think about the *who* part."

As Drexel curates its campus, it also has looked to shape the city. The University was among the stakeholders that proposed a Brookings Institution audit of the Market Street corridor to assess entrepreneurship outcomes, industry strengths and research expertise. Based on the recommendations of the 2017 "Connect to Compete" report and at Fry's behest, the chamber launched in 2019 its Cell & Gene Therapy and Connected Health Initiative to accelerate growth in precision medicines and position the region as a top 25 metro.

Such a designation would be transformative for the entire region. The new spaces being built on Drexel's campus will be available to Drexel researchers, alumni and spinoffs, obviously — but other institutions are welcome, too.

"It's another playbook," Fry says. "The playbook is not just flying the Drexel flag and doing all those things that translate Drexel expertise into practical solutions. I'm going to fly the Penn flag, the CHOP flag, the Spark flag. I'm going to fly any flag that's about innovation. The idea is that you have a campus that in and of itself is an innovation district."

This approach, says Paul E. Jensen, executive vice president and Nina Henderson provost, complements Drexel's 2030 Strategic Plan "perfectly, because so much of the plan is about expanding our partnership model to drive innovation in our research and academic programs." He points out that in the fast-moving tech world, staying current can be a challenge. "The great advantage that Drexel has is that we've always been so connected externally. It enables us to build this dynamic aspect of the world into the curriculum."

The University's support network for tech commercialization and industry collaboration — the Coulter Translational Research Partnership Program, Drexel Applied Innovation, Drexel Solutions Institute — also bolsters its appeal as a partner. And with development, workforce growth will follow.

"We're also thinking about the incumbent workforce, apprenticeship training programs that build off our experiential learning approach to train and reskill individuals, including local residents, to ensure that our local community thrives as Market Street is developed," says Anna Koulas, vice president of Drexel Solutions Institute.

That means curricula focused on industry skills; certification programs for lab techs and other non-degree positions that build off Drexel's long history of designing custom executive education degrees and certificate programs and, of course, its world-renowned co-op program. It also means new approaches for Drexel, Koulas says, whether co-designed courses with industry partners; experiential, project-based learning opportunities that enable partners to collaborate with Drexel faculty and students; or designing new certificate and degree programs.

Fry has long championed University City as an economic powerhouse for the city and for the residents of West Philadelphia. "The whole goal here in the end," he says, "is how do you connect innovation and inclusion?"

45

_STEADY GROWTH
In the past three years, cell and gene therapy companies in the region increased to 45 from 30. More than half are based within the city limits, including in University City.

$12B

_HEFTY INVESTMENT
More than $12 billion was invested across the Philadelphia region in 2021 — a 250% increase from 2020 that makes the area a leading life sciences market.

7,800+

_A DRAGON PRESENCE
The University has conferred more than 7,800 degrees in programs that prepare students for careers in the life sciences. Additionally, the highest number of tech workers in the Philadelphia metro area — about 8% of the total — are Dragons.

SHIPS PASSING

There is also the *felicity of vicinity*, so to speak… those serendipitous encounters that foster a new relationship or spark an idea. It's what you hope for when brilliant people mingle.

That vibe is what drew Associate Professor Kara L. Spiller (PhD biomedical engineering '10) to Drexel in 2013.

"I didn't do cell or gene therapy at all; that wasn't on my radar," the immunology engineering scientist says. "But being in this environment and culture, where that is what a lot of people are doing, made me start to think I should incorporate some of those aspects into my own research. I view it as very important to actually impact human health, rather than just writing grants and publishing papers."

Since then, Spiller has collaborated with Mallinckrodt Pharmaceuticals, with operations in Hampton, New Jersey, to investigate the immune response to an engineered skin tissue construct used for burns.

Fry's bet is that bringing all these pieces together will yield a whole that's greater than its parts, with the University at its nucleus.

"In my mind, all of these pieces — people, place, partners — are absolutely necessary for carrying out our mission," he says. "We're building an innovation ecosystem that will help to propel our region to global leadership in the life sciences, and we're laying the path for our researchers, co-op students, graduates and neighbors to participate. Drexel wins when our community and city thrive, too." ✕

Modified from an article that previously appeared in Drexel Magazine *in summer 2022.*

_AI'S NICHE VALUE IN RETAILING

*Researchers have found that **artificial intelligence serves retailers** best from behind the scenes.*

_MATTHEW SCHNEIDER
Schneider is an associate professor in the Bennett S. LeBow College of Business.

Artificial intelligence can play useful roles in retail, if it does not interact with customers, according to a study co-authored by a researcher in the Bennett S. LeBow College of Business.

Businesses benefit when AI-powered "nudge bots" encourage customers to finish online purchases. But while the bots can boost sales, the process may alienate customers who perceive a violation of their privacy, the researchers learned from interviews with senior managers.

In-store AI applications can alarm customers. And shoppers don't know what happens to saved data, which can conflict with a retailer's promise of privacy.

"The initial purpose for collecting data may be very different from the second, third or last purpose, particularly if AI measures millions of patterns," Schneider says. "All they need to do is switch a button and say, 'Now, use the detected emotion to see if people are more likely to steal.'"

Customer-facing AI applications introduce potential bias that could steer companies toward discriminatory acts. For example, Walmart was accused of racial discrimination for locking up Black beauty products, a practice it has since ended.

Conversely, the researchers found less downside to using AI to help customer service representatives aid consumers, to optimize supply chain processes or to analyze data caches.

The study, co-authored by Abhijit Guha of the University of South Carolina; Dhruv Grewal of Babson College; Praveen Kopalle of Dartmouth University; Michael Haenlein of ESCP Business School; Hyunseok Jung and Dinesh Hegde of the University of Arkansas; Rida Moustafa of Walmart and consultant Gary Hawkins, appeared in the *Journal of Retailing* in 2021.

> *"The questions are not about whether AI should be adopted by retailers, but about how, and about who should oversee the ill effects of AI."*
>
> -Matthew Schneider

Despite potential pitfalls, the team concluded that AI will help judicious retailers.

Since retailers want usable data without privacy or bias issues, Schneider says, "the questions are not about whether AI should be adopted by retailers, but about how AI should be adopted, and who should oversee the ill effects of AI," he says.

"Retailers will use video cameras that detect emotions in stores, called facial analysis. AI analyzes it and can detect whether somebody was pleased or not, so retailers can use this to make different decisions within their store, like which products to put on display."

- Matthew Schneider

LAW

_TRUSTWORTHY ARBITRATION

A case study involving stockbrokers suggests ways to make mandatory arbitration a ***more transparent and inclusive*** *process.*

Agreements with banks, retailers and other service providers often force consumers to resolve disputes through arbitration, a process that lacks the transparency of court proceedings and is managed by an overwhelmingly white and male cohort of professionals.

Usually a private process, arbitration can create a perception that disputes are being resolved in a "black box" by individuals who don't represent the community their decisions affect.

Facing growing pressures to diversify, forums that manage mandatory arbitration have added non-white and women professionals to their rosters.

Nicole Iannarone, assistant professor in the Thomas R. Kline School of Law, examined the impact of diversification efforts by the Financial Industry Regulatory Authority (FINRA), a quasi-governmental agency that hosts arbitrations involving investors working with stockbrokers.

FINRA arbitrations are more transparent than most, Iannarone says.

"Every time an arbitration panel makes a decision, it is there for the public to view," she says. "So, we can learn about what is going on in the process, and that can help inform us and consumers, as we study and design other arbitration contexts."

Nonetheless, FINRA historically maintained a homogenous arbitrator pool. The agency began recruiting arbitrators from diverse backgrounds, professions and geographic locations.

_DIVERSITY NEEDED
In a 2014 report from the Public Investor Advocacy Bar Association, whose members represent investors in claims against stockbrokers, 80% of available arbitrators in the agency's pool were men, with an average age of 69.

Annual surveys conducted by an outside consultant have confirmed that FINRA's roster is more diverse.

As a Hispanic woman who had joined FINRA's roster but had not been called on to arbitrate a case, Iannarone decided to study if diverse arbitrators had been brought into the process.

Iannarone sought to find out if newer arbitrators were chosen between 2015 and 2019 to hear cases involving claims valued at less than $100,000, which play an important role in investor protection. Only those with experience hearing larger-dollar, three-arbitrator cases may handle small-claim cases solo.

Iannarone and trained law students built an elaborate database that included the parties and representation for each claim, the location of hearings, and the outcome of each case.

The resulting case study, published in the *Washington Law Review*, found that arbitrators who first appeared on the roster in 2015 rendered fewer than 1% of decisions in smaller-claim investor cases.

Since parties are advised to research arbitrators' histories before selecting them from FINRA-generated lists, Iannarone hypothesizes that newer arbitrators do not get picked because they lack a track record.

Arbitrators' retirements will eventually lead parties to choose from a more diverse cohort, but Iannarone says FINRA could speed things up by providing parties with lists that proportionally include women or members of underrepresented groups or by reviewing its own rules that make it hard for newer arbitrators to serve.

Iannarone says it is also important to examine the potential role of bias.

"We need to study who is being stricken and why," she says, noting the importance of ensuring that arbitrators reflect the small investor pool. "How can investors trust that FINRA is a fair forum when something goes wrong with their stock purchases, if that forum doesn't include anyone with a background like theirs?"

PSYCHOLOGY

_COVERT CLASSROOM BULLIES

Research shows that students are adept at perceiving ***who's being picked on*** *in school and by whom, but that teachers miss the signs.*

_BRIAN DALY
Daly is an associate professor in the College of Arts and Sciences, where he heads the Department of Psychological and Brain Sciences.

A recent study of relational aggression — or attempts to damage a person's social status through shunning or rumor spreading — may explain why teachers sometimes miss signs of bullying, even when it's apparent to students.

In the study, researchers from the Department of Psychological and Brain Sciences in the College of Arts and Sciences, along with colleagues from the Center for Violence Prevention at the Children's Hospital of Philadelphia (CHOP), observed problematic behaviors in third- through fifth-grade classrooms in Philadelphia.

They evaluated students' academic competence, prosocial behavior, popularity and gender and then determined the contribution of each variable to the probability of a student being identified as relationally aggressive by a teacher and/or peers.

Chandler Puhy, a former doctoral student, wrote the study with Associate Professor Brian Daly and two co-authors affiliated with CHOP, Stephen Leff and Tracy E. Waasdorp.

Students with higher academic competence were more likely to be identified as relationally aggressive by their peers, but not by their teacher, and female students were more likely to be identified as relationally aggressive by both their teacher and peers.

The researchers theorized that academic competence could be tied to greater executive functioning — like planning and insight — which could contribute to aggressive behaviors occurring in a more covert manner. Or, alternatively, these students may receive less monitoring from teachers, given their on-task behavior, resulting in fewer opportunities for teachers to observe relational aggression.

Their findings, which were published in *School Mental Health*, could help educators more effectively intervene for those at risk of depression, anxiety, physical complaints and conduct problems that result from aggression.

_SUBTLE SNUBBERS
Ten percent of students were identified as relationally aggressive by their peers, but not by their teacher.

MARKETING

_THE LIMITS OF LIMITED-TIME SALES

Online retailers may not capitalize on ***a traditional marketing tactic*** *that drove generations of shoppers to stores.*

We've all seen brands and companies offer discounts for a limited time only. Are they so commonplace that we tune them out, and does it make a difference whether they're on a sign in a storefront or in an email in your inbox?

Assistant Professor of Marketing Jillian Hmurovic explored these questions in "Examining the Efficacy of Time Scarcity Marketing Promotions in Online Retail," a study she co-authored with Cait Lamberton of the University of Pennsylvania and Kelly Goldsmith of Vanderbilt University, which appeared in the *Journal of Marketing Research* in 2023.

Much of the previous research on the topic had been conducted offline and before the internet made countdown timers ubiquitous.

"I know past research says this tactic should work, but I was having a very negative reaction to it because the timeframe seemed so arbitrary, and that sparked questions of how time scarcity promotions work online and how the traditional effects may change given how these promotions are currently implemented online," Hmurovic says.

Hmurovic and her colleagues compared the effects of online and offline marketing techniques and found that offline marketing tactics do not necessarily translate to online contexts.

Their experiments led them to conclude that time-scarcity promotions tended to perform better when the reason for an offer's timeframe is outside of the retailer's control, such as a holiday or the consumer's birthday.

The researchers also found that online promotions that are closer to expiring perform better than those that offer consumers a longer time horizon.

_MARKET SAVVY SHOPPERS
Researchers believe consumers have become more knowledgeable about urgency sales tactics as online retailing has grown. "There's a point at which you become more skeptical of the deal, and you're less likely and less willing to purchase," says Hmurovic.

_JILLIAN HMUROVIC
Hmurovic is an assistant professor of marketing in the Bennett S. LeBow College of Business.

MANAGEMENT

_PENCIL IT IN

A comparison of paper calendars versus digital calendars showed that ***old-fashioned, hand-written plans*** *are more likely to produce results.*

It's official: If you want to keep an important appointment, you're better off writing it down rather than relying on digital calendars.

In a 2023 study in the *Journal of Consumer Psychology*, Associate Professor of Marketing Yanliu Huang and her colleagues assessed whether individual plans created on paper, versus mobile calendars, were more likely to be executed.

Huang noted that previous studies in consumer behavior indicated that people are more likely to execute a high-quality plan rather than a low-quality one.

"We wanted to measure whether the calendar allows the user to see the whole picture of what they plan to do," says Huang, who collaborated on the study with Bennett S. LeBow College alumnus Zhen Yang (PhD '19) and Vicki G. Morwitz of Columbia Business School. "For example, can they prioritize what they plan to do and make a more efficient arrangement?"

The study employed research assistants who were unaware of the study's hypotheses to conduct separate evaluations.

Their subjects were undergraduate students who received academic credit for recording academic and leisurely activities, homeowners who planned to undertake home-improvement projects, and volunteers who were assigned to complete activities like cooking or gardening.

Across all three groups, an equal number of individuals were randomly assigned either paper or digital calendars. Those using paper calendars reported higher rates of successful task completion.

The researchers suggested that digital developers should design calendar apps that provide users with an overall picture of scheduled events to help users fulfill their plans.

Huang's future research will evaluate online dating habits when using a mobile phone app compared with a website. She will also study how people perceive food items prepared by a human versus a robot.

_PAPER POWER
Paper calendars provide a "big-picture" view that helps planners see everything on their agenda and how new tasks connect or overlap.

_ONLINE
Learn how the algorithm works: **youtube.com/watch?v=jb50wKH-kHg**

_BEYOND BOTTOM LINES

Profitability alone will not win the day in ***boardrooms.***

_XIN DAI
Dai is an associate professor of accounting in the Bennett S. LeBow College of Business.

The bottom line only takes a corporate executive so far.

CEOs who lead effectively in financial *and* social responsibility spheres are most likely to prosper, according to a study co-authored by Xin Dai, an associate professor in the Bennett S. LeBow College of Business.

Dai and her colleagues analyzed the impact of corporate performance in the environmental, social and governance measures filed with the Securities and Exchange Commission on CEO job prospects. The team found that executives will most likely exit when a firm shows declines in those metrics. Tracking departing CEOs' subsequent employment records, the researchers found that executives who have led companies with strong social performance quickly find offers at larger firms that provide higher compensation.

After controlling for financial operations, Dai and colleagues Feng Gao of Rutgers University, Ling Lei Lisic of the Virginia Polytechnic Institute and State University, and Ivy Zhang of the University of California show that CEO turnover is faster when their firms decline on measures such as the environment, community impact, diversity, human rights, employees and products.

Executive turnover slows when performance improves in those areas. The team deemed declines or improvements as significant when the corporate social responsibility (CSR) performance of a firm moves from the top to the bottom, or from the bottom to the top quartile.

Their study, appearing in the *Review of Accounting Studies* in 2023, suggests that boards view good social performance as a positive indicator of CEO ability.

$35,300,000,000,000

The Global Sustainable Alliance estimated in 2020 that the investment industry managed $35.3 trillion of sustainable investment assets, an increase of 15% in two years, equating to 36% of all professionally managed assets worldwide.

_PAY GAPS THRIVE IN NONPROFITS

A study confirmed ***significant pay disparities between male and female leaders*** *in the nonprofit world.*

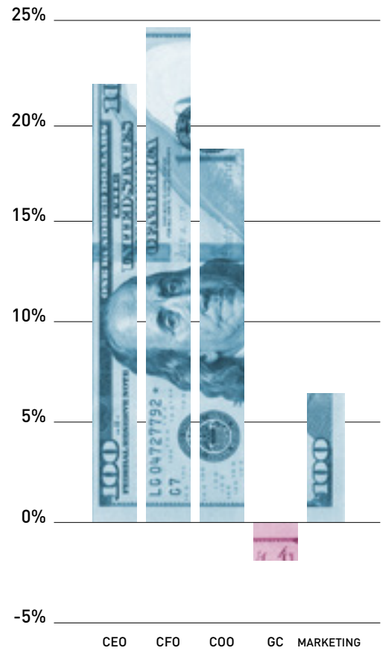
A study examining executive pay at nonprofits found women earn 8.9% less than men and that the gap widens when there is room for salary negotiations.

The study analyzed four years' worth of IRS form 990 filings. After confirming a pay gap, the researchers explored the extent to which real or perceived negotiation opportunities contribute to this difference.

"We may not expect to observe a gender pay gap among the nonprofit sector, even though recent research has found gaps in pay among for-profit executives," says Curtis Hall, an associate professor in the Bennett S. LeBow College of Business. "First, there is more female participation in the nonprofit workforce compared to the for-profit sector. Second, one may expect stakeholders, like donors or boards of directors, to curtail gender pay gaps. But we didn't find this to be enough of a factor."

To gauge the role of negotiation, the researchers studied competing options for the executives, the organizations' constraints in paying executives, the gender composition of its leaders and the pay variability within its executive ranks. Each factor affects negotiation prospects, according to the authors.

They found that external employment options and competition lead to greater gender pay gaps, with male executives more likely to capitalize on patterns in the broader labor market or other opportunities to negotiate more compensation.



_ROLE MATTERS
Median gender pay gaps vary by position.

The pay gap shrinks in nonprofits with a female CEO and/or where women are well represented on boards. The findings, which appeared in the *Review of Accounting Studies* in 2022, suggest that female leadership may increase female employees' willingness to negotiate. Hall's co-authors were Andrew Finley, associate professor at the Robert Day School of Economics and Finance at Claremont McKenna College and former LeBow research assistant Amanda Marino, now at San Diego State University.

"This documents the contexts that influence negotiation on the gender pay gap, which is part of a larger societal issue," Hall says. "Employers should be cognizant of how the environment for negotiating compensation within their organizations can lead to gender-based pay disparities. Perhaps more importantly, business leaders and educators should think about ways to empower female workers to get more out of salary negotiations, which would hopefully help to close gender pay gaps in the future."

_DIGITAL FORENSICS THAT SPOT DEEPFAKES

Teaching computers **how to recognize altered images** could help expose forgeries and combat misinformation that spreads readily online.

The same technology that makes it possible to edit a wine stain out of a photographed shirt also permits mischievous actors to digitally distort images and videos. And when photo-editing crosses the line from sincere to sinister, it can shape viewers' minds in dangerous ways.

Professor Matthew Stamm is a specialist in information forensics who has learned how to pinpoint images that have been altered.

Every detail associated with a digital photo, from the camera that creates an image to the software used in processing it, leaves a "fingerprint," Stamm says.

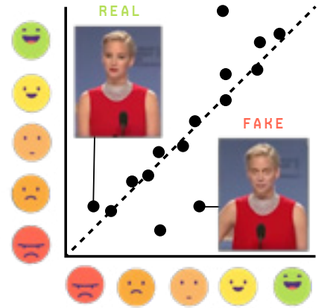
"If contrast adjustment has been done to a photo, we can see the hallmarks of that in our analysis," he explains. "We can even trace elements of the photo not just to the brand and model of camera that took it, but to the individual camera."

Stamm developed an artificial intelligence algorithm to detect fake images and videos by identifying inconsistent forensic fingerprints contained in an image. Using machine learning, he can teach computers how to distinguish originals from forgeries.

Stamm's work on digital and audio deepfakes has appeared recently in journals including *IEEE Transactions on Information Forensics and Security* and *IEEE Transactions on Image Processing*. His work has also led to a partnership with the Defense Advanced Research Projects Agency.

_COMPARING DETAILS
By training a neural network to analyze a pixel's relationship with its neighbors, digital forensics can tell when a face from one photo or video is placed into another from a completely different time and place.

_FORENSIC TRACES
By comparing suspicious portions of an image with reference points that are believed to be authentic, the algorithm detects traces that came from a different camera or were processed differently.



_MOOD MISMATCH
Deepfake videos often feature a disconnect between the emotion in a person's face and voice.

"We can even trace elements of the photo not just to the brand and model of camera that took it, but to the individual camera."

-Matthew Stamm

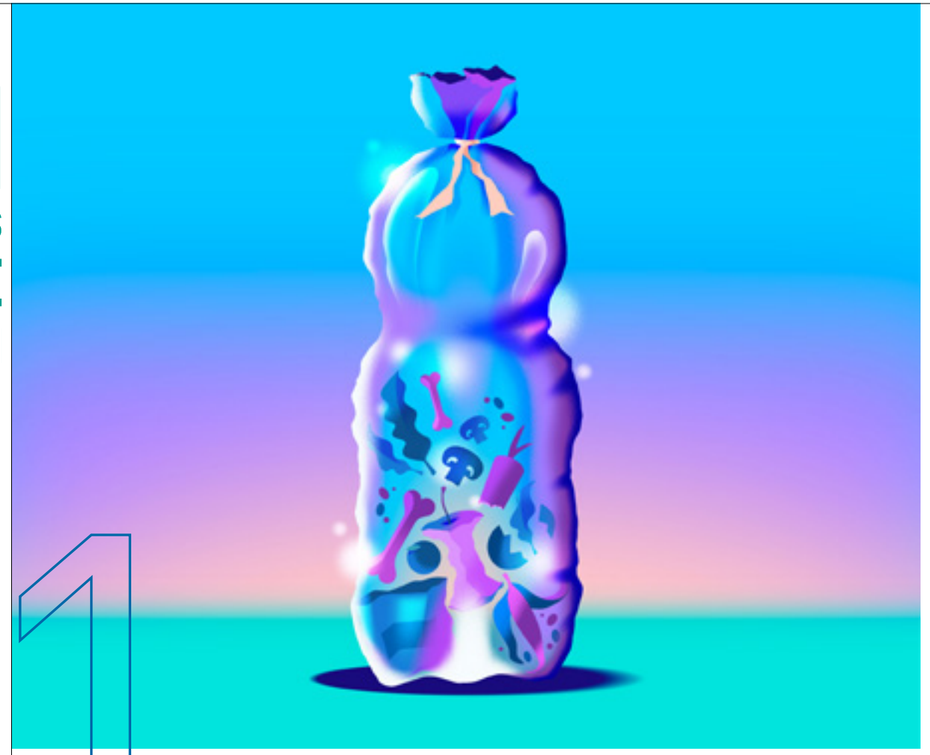
TEN EXPERIMENTS TO SAVE THE EARTH

Futurists believe advances in science and technology will help humanity evade the worst effects of climate change.

Let us hope so. At Drexel, researchers are responding to the perils the planet faces with creativity and collaboration. They're converting industrial food waste into Earth-friendly plastics, training young product designers to forecast the consequences of their output and helping vulnerable citizens adapt to extreme weather, to name a few.

Each of these 10 ideas is exciting in its potential and gives us hope for the future. Because the No. 1 way to save the planet is simply to start *somewhere*.

ILLUSTRATIONS BY OLLIE HIRST



1 MAKE 'PLASTIC' FROM FOOD WASTE

What if there were a plastic that could actually *improve* the environment? Researchers are exploring ways to make the material a little more bio friendly in Drexel's Natural Materials and Polymer Processing Lab, led by Caroline Schauer, associate dean for research and faculty affairs at the College of Engineering and a professor in the Department of Materials Science.

"By 2050, there will be more plastic in the ocean than fish," Schauer says. "That's not that far off."

Some of Schauer's protégés are developing polymer composites made with coffee grounds, spent grains from breweries and distilleries, and cranberry and apple pomace left over from juice-making.

Doctoral student Emma Snelling is focusing on the use of cranberry pomace and spent grains as filler material in polymers made from polylactic acid (PLA), which is synthesized from renewable sources such as corn.

The pomace and spent grain may have the potential to strengthen or otherwise enhance PLA's mechanical properties. This is important, Snelling notes, since recycling plastic diminishes its strength.

Should cranberry pomace prove to be an effective filler for biopolymers like PLA, it could create a durable material that could be repurposed repeatedly.

It would also solve the dilemma of how to dispose of cranberry pomace, which is a problem unique to the United States, Schauer says, because Americans alone have a taste for the sour fruit. Because cranberry growers have, in the past, discarded about one fourth of their annual harvest to sustain market prices, she adds, "we have all of this waste that really doesn't have a good home."

Meanwhile doctoral student Emily Herbert is studying how bacteria can reduce the novel polymers into, hopefully, Earth-friendly components. Ideally, Herbert says, "you could throw this thing into the garden or the ocean."

Because bacteria have demonstrated a keen appetite for spent grain, composites that contain it would degrade quickly, Schauer says.

"That could be good, if it's a food liner that you use once and then throw away," she says.

From there, Schauer's lab has the capacity to transform their new polymers into consumer good prototypes: "A big focus is on how to produce these things; that's the next step," she says. "Great, you can make a polymer, but how does it become a computer or a cup? That's where we come in."

In three years' time, Schauer estimates, composites being tested and produced in her lab could be ready to attract the interest of commercial producers. From there, such items might just be a year or two from showing up on store shelves. — SARAH GREENBLATT

2 FIND GOOD (RE)USES FOR BAD THINGS

Styrofoam is among the planet's most problematic products. It's neither biodegradable nor recyclable, and when exposed to sunlight or burned, it releases toxic contaminants into the air and water. Worse, it is estimated to make up some 30% of landfill waste and has a lifespan of hundreds of years.

So anything that can give Styrofoam a second life as a nontoxic, biodegradable force for good in the world is a win.

College of Engineering Assistant Professor Yaghoob Amir Farnam has found that blending soybean oil with Styrofoam produces a nontoxic, biodegradeable sealant that can extend the life of roadways.

This could be a boon in the Northeast, where roads and highways suffer from a severe freeze-thaw cycle and road salt.

"So many bridges and roads are made of concrete, which leads to potholes, cracks, corrosion," says Farnam. "In Pennsylvania, we use a lot of salt; we have rain and snow. One of the things to do to improve the durability of concrete is protect it, to put a layer on top so water and corrosive chemicals can't get into the concrete."

With his sponsor, the Indiana Soybean Producers Alliance, Farnam tested a compound, soy methyl ester-polystyrene (SME-PS), as a concrete protectant.

Farnam says the spray already is being used on roadways in the Midwest. His testing determined that it would also work in the Northeast.

"Sealants have been around for decades, but SME-PS is a bio-based protectant that not only improves the durability by physically sealing the surface, but also by blocking concrete surface pores through beneficial non-destructive chemical interactions, which is why it is better," he says.

While the protective spray doesn't eliminate the need for road salt, it could mean less is needed. And it could eliminate potentially hazardous cracks and potholes, Farnam says, which would save states money.

Soybean oil and Styrofoam work well together, Farnam explains, because soybean oil is liquidy and the Styrofoam makes it more viscous.

"Like water plus honey," he says. "It gets into the porous structure of concrete, and it stays there."

Farnam says his road treatment mix won't solve the entire Styrofoam waste problem — after all, the mix is just 3% Styrofoam. "But it could be part of the solution," he says.

> "Our results are very promising. Imagine if it was applied to all roads in Pennsylvania? It could add up to something huge."
>
> –YAGHOOB FARNAM

Farnam plans to encourage state transportation departments to implement the technique, starting with Pennsylvania, which has almost 252,000 miles of roads — making it one of the most highly paved in the country.

"Our results are very promising," he says. "Imagine if it was applied to all roads in Pennsylvania? It could add up to something huge." — AMY WORDEN

3 HELP URBAN DWELLERS ADAPT TO HEAT AND FLOODS

Civil and environmental engineering Professor Franco Montalto and his team of student researchers devise powerful tools to help residents of local neighborhoods cope with scorching heat and flood waters.

His students are working on three projects — in the Hunting Park and Eastwick sections of Philadelphia and in Camden in New Jersey — that could help local partners apply for hundreds of millions of dollars in federal funding and grants to address extreme heat and rising water in vulnerable neighborhoods.

In Philadelphia's Hunting Park neighborhood, a research team is developing cooling strategies urgently needed due to that community's sparse tree canopy, abundant pavement and black tar roofs, and general lack of air conditioning. The project began during the first summer of COVID-19, when public cooling places like libraries, senior centers and pools were closing.

Montalto's research team, working in conjunction with the community group Esperanza, devised a plan to install 130 benches with attached planters and umbrellas, providing shade along several streets. They also distributed sprinklers so residents could cool the pavement during the day, reducing the heat it releases at night, when the so-called "urban heat island" is at its worst.

The program also provided 15 jobs to local residents who were trained in carpentry and horticulture to build the bench planter shade structures. Others were hired by Esperanza to monitor the temperature and humidity of the neighborhood.

The project was so popular, Esperanza kept getting phone calls from people wanting bench planters on their own blocks, Montalto says. Inspired by the program, shade-hungry residents also started requesting more street trees from the Pennsylvania Horticulture Society, Montalto adds.

Montalto and Esperanza have received a third round of funding from the William Penn Foundation to cool three more blocks in Hunting Park and also to extend the project into three other heat-vulnerable neighborhoods.

"Installing 30 umbrellas up and down one block doesn't measurably change air temperature in the community, but it does provide localized relief from the sun's radiation," Montalto says.

"Now, you can actually go outside on a hot day and experience some air movement while you sit under an umbrella. And you get other benefits, like interacting with your neighbors."

The project has a social justice component, too. A study by researchers at the Dana and David Dornsife School of Public Health shows that the heat vulnerability in Philadelphia neighborhoods dominated by Black and low-income residents is likely a legacy of redlining by banks. The study — led by Leah H. Schinasi, Chahita Kanungo, Sharrelle Barber, Loni Tabb and Irene Headen and published in early 2022 by the *Journal of Urban Health* — links a history of institutional racism within the housing market to present-day disparities in heat vulnerability in numerous city neighborhoods.

Another climate impact is worsening floods. In the flood-prone Eastwick section of Philadelphia, Montalto's students are developing

predictive modeling tools that planners can use to assess whether flooding in the community can be reduced by building a levee, trapping stormwater higher up in the watershed or relocating residents to city-owned land on a higher elevation through a land swap similar to one in New Orleans after Hurricane Katrina.

Other students in Montalto's hydrologic and hydraulic modeling class have simulated the flow of wastewater and stormwater through the Cramer Hill neighborhood of Camden, New Jersey, where sewers regularly overflow into the Delaware River. The team is exploring whether sewer overflows and flooding can be reduced by diverting flows from Pennsauken, a municipality to the North, away from Cramer Hill's sewer pipes.

Graduate student Brandon Hensyl worked on the Cramer Hill project with Montalto and almost got stuck there during Hurricane Ida in 2021. The experience brought the issue home for him, as did a resident's comment at a community meeting.

"Someone said, '10 years ago, if they asked what the major problem was in Camden, they would have said crime; if they asked now, people agreed it would be flooding,'" Hensyl recalls.

The Camden County Municipal Utilities Authority asked Montalto's students to present their data to city officials, and they are using it to seek FEMA support for restructuring their sewer system.

"What's unique about what we're doing is the integration of real-world problems and partners into research, teaching and mentorship," Montalto says. "What I'm hearing from students is that they're worried about climate change. They don't want to wait until they graduate to get involved." **— CAREN CHESLER**

4

LEAVE NO COMMUNITY BEHIND

Being green is relatively simple when you have the luxury of options. But many of the world's citizens live in challenging corners of the world — like the residents of Tyonek, Alaska.

Tyonek is a tiny, remote village of Athabaskan-speaking Native Alaskans, located 40 miles from Anchorage and accessible only by boat. Residents there are fed up with their outdated, unreliable — and very costly — energy system.

They want affordable, renewable energy instead — and through a unique nonprofit called Community and College Partners Program (C2P2), students in a Drexel senior capstone class are working to make Tyonek's dream a reality.

The seniors and their faculty advisor Mira Olson, an associate professor in the College of Engineering and a co-founder of Drexel's Peace Engineering program, learned about Tyonek from a contact of Olson's at C2P2.

The nonprofit connects universities — and in some cases, funding — to underserved communities in need of pro bono technical work, with a mission of honoring communities' self-identified needs.

"The community repeatedly expressed interest in developing a renewable energy source to decrease its unaffordable energy costs," says Kathryn Ryan, who's earning her BS in actuarial science through Drexel's custom-design major. "That means we need to design a whole new energy system and understand the upfront costs."

Tyonek's boat-only location increases the cost and complexity of some options, such as wind turbines, which are preferred by the community but would be expensive to transport. So the five students are also exploring solar power, and they've prepared energy costs and savings estimates for the community to evaluate. Next year's class of seniors will take up the project and see it through in consultation with residents.

"Research and innovation should be directed at what society needs, and who are we to say what an individual community needs?" Olson says.

> "Research and innovation should be directed at what society needs, and who are we to say what an individual community needs?"
>
> –MIRA OLSON

"If we want to build something that's useful for people, it should be co-developed with people who will be using it."
— KATIE GILBERT

5

BAN SINGLE-USE PLASTICS

Since the 1970s, the volume of plastics in our garbage has jumped from 2% to 13%, and almost none of that can be recycled, warns College of Arts and Sciences Professor Diane Sicotte.

We can't recycle our way out of the problem, so we must reduce the volume we produce, argues Sicotte, an environmental sociologist who studies the natural gas and petroleum industries.

"Plastic manufacturers put a recycling arrow on the bottom of the container," Sicotte says. "So of course, people think it's recyclable. But the problem is, they are made out of so many different components and formulas. That's why we can't talk about 'plastic;' we have to talk about 'plastics.'"

Those impurities mean that when it's time to recycle plastics into other goods, many can only be downcycled into something less valuable (like a plastic container that's used for a toothbrush handle). So unlike recycled glass, paper and metal, there isn't much of a market for recycled plastics.

The result is that at least 50% of what we say is recycled in the United States is actually discarded or shipped overseas. Plastics wind up in our waterways, in our seafood, and ultimately, in our bodies.

Municipal and statewide bans on plastic shopping bags are growing coast to coast. But Sicotte says it's a mistake to think that this is a problem that can be solved locally.

Instead, she advocates for experimenting with a mix of laws and policy incentives such as those adopted in European countries that have helped reduce waste at the source, increased recycling rates and shifted the costs associated with waste disposal from the public to plastics producers and retailers using plastic packaging.

Her scholarship also calls for passage of federal legislation banning the sale of the most ubiquitous single-use plastic items.
— MIKE UNGER

6

EMPOWER THE CHANGE AGENTS

Since the early 2000s, numerous U.S. cities have made plans to become more sustainable and climate resilient. But city plans aren't usually the key to advancing sustainability, according to Alexis Schulman, a professor in the College of Arts and Sciences who has been studying the specific variables that put local governments on a path to success.

While citywide plans can lead to improvements at the margins, systemic change actually happens through decisions that are much less visible, often made in policy silos and pushed forward by influential individuals and organizations during periods of upheaval, she says.

"What you need are these windows of opportunity precipitated by crises, where change agents can say, 'Hey there's a problem here. I have the solution,'" she says.

Schulman observed such a scenario at the Philadelphia Water Department (PWD) in the late '90s. At the time, the utility was under pressure by the state environmental agency to develop a plan to manage its sewage overflows in compliance with the federal Clean Water Act. Two-thirds of Philadelphia relies on a combined sewer system that collects stormwater and sewage in a single pipe. During rainstorms, this wastewater exceeds the capacity of the system or the treatment plant, and billions of gallons of diluted raw sewage is dumped into local streams and rivers every year.

Typically, a city deals with this problem by building an underground water storage tunnel — which would have cost Philadelphia an estimated $5 billion to $6 billion.

But a middle manager named Howard Neukrug saw a better way, Schulman says.

"He told his team to start exploring other options from the world of stormwater control — controlling stormwater as it falls through infiltration practices and keeping it out of the sewer system entirely," she says.

Neukrug had the blessings of the Water Commissioner and the advantage of working in a city where the water utility was a single integrated authority overseeing all sewage, drinking water and stormwater runoff — a rarity among big cities.

Nonetheless, he faced significant internal opposition from water engineers who were used to doing things the "old way"— with tunnels and pipes. He was able to leverage support for his plan from important external actors, including historically adversarial environmental nonprofits and EPA policymakers, who were increasingly supportive of city efforts to use greenscaping practices to control sewage overflows.

In 2011, after nearly two decades of planning and persuasion, Philadelphia's 25-year plan called Green City Clean Waters was approved — the same year that Neukrug, now recognized as a national authority in the water industry, was named Philadelphia's Water Commissioner.

One decade later, the Philadelphia Water Department is meeting its benchmarks and has installed over 800 projects citywide.

Challenges remain, Schulman says, but the plan has put Philadelphia at the vanguard of investments in green infrastructure.

"It didn't happen because everyone in the water department said, 'We want to be sustainable, this is the right thing to do, or because of Philadelphia's sustainability plan,'" says Schulman. "It happened because of a quirk of history that integrated the utility, it happened because of good timing, and it happened especially because of this internal champion who seized this opportunity to make change." **— MIKE UNGER**

7

URBAN INDOOR 'FOOD MACHINES'

Imagine the carbon savings if cities could grow their own fruit and vegetables year-round in specially built indoor farms downtown, rather than having to ship their food from other parts of the country.

"Most of us in Philadelphia get our produce from California. It's grown and harvested, and then it gets put in a truck and shipped over here. That uses up a lot of gasoline and produces a lot of carbon emissions," says Eugenia Victoria Ellis, a professor emerita with a joint appointment in the Antoinette Westphal College of Arts & Design and in the College of Engineering.

Working with Philadelphia inventor Jack Griffin of The Farm Works, Ellis is developing an indoor hydroponics solution that can bring fresh food much closer to home.

Early attempts at indoor agriculture used the same technology paradigm as ordinary buildings. They were loosely based on greenhouses which are porous, open systems susceptible to moisture migration, mold and pathogens. Griffin is instead engineering his indoor agriculture system, called V-LIFE (value-added localized integrated farming enterprise), not as a building, but as a machine for growing food.

Sounds easy: You put in boxes, water, lighting, and you've got an indoor farm. In fact, it's a bit more complicated than that.

"Strip mall buildings aren't suitable for this," Ellis explains. "These spaces are conditioned for people, whereas you need a grow space to be 75 degrees with 50% humidity. Then when it is time to harvest the produce, it needs to be in a cold room at 38 degrees. So, it's kind of like moving from a tropical jungle to the Arctic north all within one building."

"That's when the alarm went off in my head that there were issues surrounding retrofitting a characteristic strip mall space for indoor agriculture."

–EUGENIA V. ELLIS

She talked to a New York medical-marijuana grower who didn't take all that into account, and whose building subsequently rusted out within a year. "That's when the alarm went off in my head that there were issues surrounding retrofitting a characteristic strip mall space for indoor agriculture," Ellis says.

Around that time, a colleague came to the fore with a key resource.

Dean of the College of Engineering Sharon Walker put her in touch with Ken Fulmer, president and CEO of Philadelphia-based Urban Engineers, a multidisciplinary planning, design, environmental and construction services consulting firm.

Together, they plan on tackling the problem to come up with a design that meets this need.

"The secret is in the building envelope, everything that separates the inside of the building from the outside of the building. It's the structure, it's the material of the inside wall, the outside wall and the insulation," she says. "We'll be working with Urban Engineers to design the building envelope so that water will not condense on the structure and rust out the building."

Ellis was able to develop a tunable LED lighting system for agriculture. "The colors are mixed to optimize the growth and the flavor of the plants," she says. "The lights also move up as the plant grows, so the distance from the light to the plant remains the same throughout the growing process."

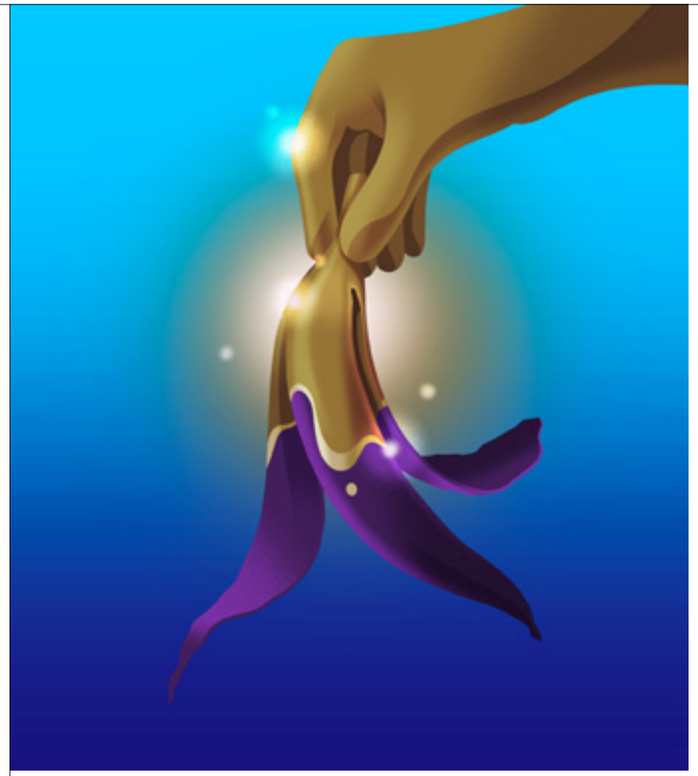
She is also hoping to collaborate with engineering colleagues to develop strategies to use organic waste — such as root balls harvested from millions of plants — to power the building.

"The root balls ferment and create gas, and you can capture the gas and use it to make electricity," Ellis suggests.

At 40,000 square feet — nearly an acre — the building she envisions would also have ample rooftop space for solar panels.

"Essentially, this project shows the potential of being its own bio-loop that uses waste residue as a resource for energy and solar panels to supplement the energy being used by the building to grow food," she says. "The ultimate goal is to design a building that is as carbon neutral as possible for this energy-intensive industry."

— ADAM STONE



8 GIVE FOOD A REDUX

Culinary arts and science Professor Jonathan Deutsch of the College of Nursing and Health Professions is helping to forge an entire industry based on culinary experiments that turn food waste into treasure.

As director of Drexel's Food Lab, Deutsch has long been interested in combining food science and culinary arts to make our food systems more sustainable. He played a critical role in launching the Upcycled Food Association, a group of manufacturers focused on finding wholesome uses and a market for food parts that would otherwise be discarded into compost or landfills. (Using the shorn-off stems and scraps of mushrooms as a flavor and texture additive in a half-plant, half-beef burger, for example.)

The association started with nine members but has grown to more than 165 companies.

"We're now working together globally on this issue (with other universities), but I would say we were the first and are probably the leader on developing upcycled products and measuring consumer acceptance," Deutsch says.

Appealing to consumers is vital. To that end, the association came up with a certification process for products that are upcycled, not unlike the approvals for organically grown foods, so consumers can look for the "UPcycled" label.

Upcycling isn't just a noble cause but an important one. Some 33–40% of food is wasted, representing the largest source of preventable greenhouse gas emissions.

Upcyclers reduce that waste by creating new recipes or food products out of leftovers or cosmetically flawed foods. Del Monte, for instance, sells two types of certified canned green beans that are made from 100% upcycled and sustainably grown vegetables. Matriark Foods sells a broth made from fresh-cut vegetable remnants.

And Renewal Mill uses the spent soybeans and oatmeal left behind after oat and soy milk are made and turns them into high-protein flours that can be used for baking.

"Waste is inevitable; but we shouldn't have such huge amounts of it," Deutsch says.

Drexel isn't only a leader in the movement; the University created one of the newest entrants to the market when two Food Lab alumnae developed a beverage from avocado seeds. Their product, Reveal Avocado Seed Brew, saved over 5,000 pounds of avocado pits from landfills in 2020.

"It tastes and looks like iced tea," Deutsch says. "They essentially created a new ingredient for the food industry that previously had only been a waste ingredient."

Marketers used to believe that if consumers knew they were eating foods that had been deemed "waste" they'd view it negatively or want some kind of discount, says Deutsch. Drexel's research found, to the contrary, that consumers feel good about foods with an environmental benefit, and if products are marketed well and explained well, consumers will actually pay a premium, Deutsch says.

"If you think about it, the hot dog and sausage and those kinds of foods were very much a response to using as much of the product as you can," Deutsch adds. "What's changed, and what's new and exciting, is the marketing of new products as 'upcycled.'" **— CAREN CHESLER**

9 CUT THROUGH CLIMATE APATHY

A class at Drexel is tackling the very real dilemma of climate apathy head-on by testing how different cinema approaches influence film viewers' response to environmental messages — followed by putting theory to practice in a public film festival of their own.

The class, "Climate Films & Advocacy," was co-taught by Ben Kalina, an assistant professor of film and television in the Antoinette Westphal College of Media Arts & Design, and Elizabeth Watson, an associate professor in the College of Arts and Sciences and senior scientist at the Academy of Natural Sciences of Drexel University.

"The goal was to give students a sense of agency in figuring out how to address climate change through communication," says Kalina, who is also an award-winning documentary producer and director.

Kalina and Watson structured the class around weekly film screenings, which culminated in panel discussions involving filmmakers, scientists, practitioners and others that delved into the topics addressed in the films. These conversations were moderated by small groups of the students themselves. The films covered a variety of genres and approaches, so students could reflect on the impact of, for example, hopeful films versus darker ones,

"Pessimism ... may overwhelm people and scare them away."

–LAUREN JACKSON

or character-driven films versus those that are more factually focused.

At the end of the term, students collaboratively organized "Cinema for the Climate," a public film festival that ran in December 2021. At the festival, students distributed pre-film and post-film surveys, to assess how effective the films were in shifting people's attitudes, however slightly.

One student, Lauren Jackson, says the class convinced her that the most effective way to communicate about climate change is by connecting to our universal humanity, rather than sticking to scientific facts or political ideology, she says.

"It is generally much more effective to be practical, encouraging and solution-oriented, as opposed to pessimistic or worst-case scenario oriented, which may overwhelm people and scare them away," she says.

— KATIE GILBERT

10 DESIGN ETHICALLY

The inventor of the ubiquitous K-Cup coffee pods, John Sylvan, doesn't have a Keurig machine himself and has said that he regrets inventing the notoriously wasteful single-use coffees.

Maybe, if he had had a different kind of design education, he would have placed more importance on the waste-stream impact of his idea from the beginning?

That notion — that designers should think before they produce — energized Raja Schaar and Chris Baeza, both program leaders and faculty members in the Antoinette Westphal College of Media Arts & Design, to incorporate a revolutionary ethic into their design courses at Drexel that encourages students to reflect on the ethical and environmental implications of what they bring into the world.

For their course, they created a speculative world-building game inspired by the game "Afro-Rithms from the Future," by Lonny Avi Brooks and Eli Kosminsky. Called "Cli-Fi Futures," their game is based on themes of apocalyptic climate fiction ("cli-fi") and Afrofuturism — a cultural aesthetic that explores the intersection of African diaspora culture with technology to reimagine history and envision a more hopeful future.

"Cli-Fi Futures" uses cautionary tales, doomsday scenarios and real and imagined climate disasters to help designers run hypotheticals that reveal the enduring environmental impact of their prototypes.

"Just because we can design things, ought we?" asks Schaar. "Does this design need to exist in the world? The game connects these ideas. The ultimate goal is to get students to think more critically about their work."

Consider one-for-one fashion brands, where one item is donated for every item purchased. Such companies market a social mission to provide products for marginalized groups, yet many products are made of material that doesn't degrade, or that can't be reused or upcycled.

"Could we build it better? How can we divert product from the landfill?" asks Baeza.

Students crave "applied ethics," which means thinking about "'Who do I become?' or what it means to do no harm," says Baeza.

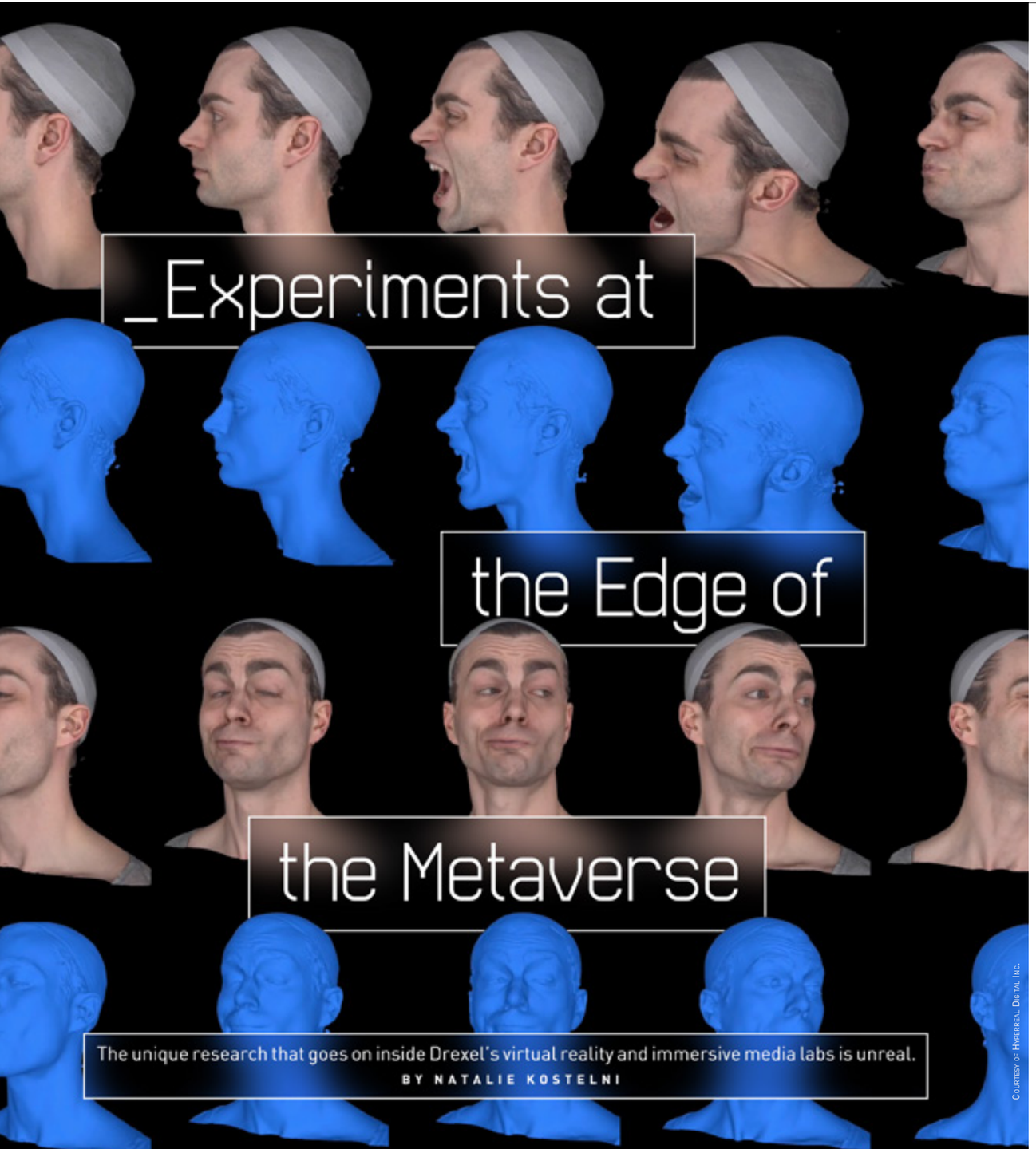
"Cli-Fi Futures" is made up of "tension" cards (migration/racial equity/ecotopia) that ask participants to set priorities in designing a fictional world for better or worse, by mixing "inspiration" cards (food systems/sustainable housing/education) and "objects" (shoes/drones/trash cans) to factor in the role of design.

The two have presented their game at conferences and workshops around the country to high school students, academics, industry leaders and even a design thinking group within the Department of Defense.

In one classroom scenario, students imagined themselves as the inventors of plastic, once seen as life-changing and now recognized as having a catastrophic impact on the environment.

"Given what we know today, might they have made different decisions? Can we be more sensitive, predictive, way further out?" Baeza asks.

— AMY WORDEN



The unique research that goes on inside Drexel's virtual reality and immersive media labs is unreal.

BY NATALIE KOSTELNI

Courtesy of Hyperreal Digital Inc.

One weekend in late October, a highly confidential mission was underway inside Drexel's Animation Capture & Effects Lab in West Philadelphia. The group of students present were all sworn to secrecy, as was Assistant Professor of Digital Media Nick Jushchyshyn, who oversees the lab.

Such is the protocol when Jushchyshyn opens the lab to industry partners. On this particular Saturday last year, he and his students were collaborating with Hyperreal Digital Inc., a New York-based metaverse entertainment company known as a pioneer in the creation of hyper-realistic digital humans for films, commercials and video games. From time to time, technology companies ask Hyperreal to test cutting-edge equipment, and when they do, CEO Remington Scott brings them to Drexel.

"When we do these tests, it's super secretive," says Scott. "Every time I go in there, no one outside of the lab can know what we're working on."

The work on this day involved bringing the late rap star Notorious B.I.G. back into living color.

Scott and his team had previously shot footage of a virtual concert performed by a hyper-realistic avatar of Notorious B.I.G., commissioned by a unit of Meta to mark what would have been Biggie's 50th birthday.

But as Scott was later processing the footage, watching the avatar's performance, he realized something was off. "We weren't looking at it through a virtual camera controlled by a human," Scott observed. "It was missing this breathing, moving human element behind the camera."

So, Scott made a trip to Drexel, and Jushchyshyn and his team of students went to work. As Scott held a virtual camera, he was able to reframe the rap star with new shots and angles. The virtual, simulated concert was released on Dec. 16, 2022.

Hyperreal turns to Drexel's ACE Lab — and its companion, the Immersive Research Lab (IRL), also run by Jushchyshyn — because the labs have what Scott needs: A fully equipped professional motion-capture studio with equipment seldom found outside the entertainment industry.

The facilities at Drexel are unique and rare for the East Coast, let alone for a university.

"When Nick showed me the facilities at Drexel, I couldn't get over the standard he was setting and the technology available in his lab," Scott says. "I was blown away. It's world class and the students are up and running and ready to be engaged. Having those talented minds that are learning, asking the right questions, thinking something through and playing around with the technology is extremely liberating."

SYNTHETIC HUMANS®
Virtual reality company Hyperreal Digital Inc. collaborates with Drexel's Animation Capture & Effects Lab on the creation of synthetic human actors used in metaverse advertising by brands like PepsiCo.

BUILT FOR THE FUTURE

The ACE Lab and IRL in the Antoinette Westphal College of Media Arts & Design focus on the study and research of immersive media such as virtual reality (VR), augmented reality (AR), immersive projection, virtual creation and production.

The quality of the labs' equipment underscores Drexel's commitment to training students in the field of study.

Students have access to dozens of AR headsets from a range of manufacturers; numerous 360° cameras systems including monoscopic, stereoscopic and volumetric; and motion-capture systems from Vicon and OptiTrack, two of the leading brands. While regular Macs and PCs are part of the equipment, so are HP-Z VR Backpack computers that users wear to move around virtual spaces. There are three different screening rooms including motion capture and green screen studios.

Jushchyshyn envisions eventually having an LED wall in the studio to display real-time computer graphics — a forest, a mountain, a desert — at a pace of 60 frames a second, which produces clear images and can be used as backgrounds when filming. "It's a wish list item," he smiles.

LED walls cost between $500,000 to $1 million and, though the funds have yet to be secured, Jushchyshyn has prepared the lab for the technology by having additional electrical wiring installed earlier this year to support it.

"We're always thinking about cutting-edge technology even though we don't always have every piece of it here," he says.

It was this mindset that positioned Drexel to be a leader in VR and AR production. In September 2012, the University, with Jushchyshyn's guidance, established a studio with a green screen wall, motion-capture system and other equipment to do virtual production in television and film.

The studio included technology that allowed computer graphics and line movement to occur simultaneously, which was uncommon. Most production facilities stationed them in separate spaces rather than a single room. "This was on the vanguard then and now," Jushchyshyn says.

The following year, in 2013, several standout graduate students who would go on to successful careers in the field urged Westphal College to bolster the facility further. "We were building these facilities to facilitate their research," Jushchyshyn recalls. "It was also a strategic interest for us as a department and as a college."

Melissa Cell (BS digital media '12) was one the standouts. She's now technical supervisor at the Los Angeles-based digital production company Digital Domain and known for "X-Men: Days of Future Past," "Spider-Man: Homecoming," "Thor: Ragnarok," among others. Another, Glenn Winters (MS digital media '13), is now manager of virtual production at Rockstar Games in New York, the maker of "Grand Theft Auto," "L.A. Noire" and "Red Dead Redemption." Third was Girish Balakrishnan (BS digital media '12, MS digital media '13), who for his master's thesis proved that you could collaborate on making a film with someone in a different location, a novel idea at the time. He is now director of virtual production at Netflix.

"Girish was one of the first students to go through this studio; that was 10 years ago, and we have never let up," Jushchyshyn says.

What has helped keep Drexel ahead of other universities is a combination of the University's network of alumni working in the entertainment industry on the West Coast, its educational philosophy to integrate industry as a partner, and Jushchyshyn's personal involvement in feature films.

Raised in Upper Darby, Jushchyshyn (BS '93) received his undergraduate degree in commerce and engineering from Drexel and an MFA from the Academy of Art University in San Francisco. His film career didn't start until later in his life, though as a child, Jushchyshyn's interest in visual effects was sparked after seeing a television special documenting how "Star Wars" was made.

"It was an amazing, seemingly magical world created with blood, sweat and tears, a pile of junk and a lot of creativity," he recalls.

But a career in that magical world seemed elusive, so upon graduation, Jushchyshyn went to work for what is now Teledyne Princeton Instruments, a maker of digital camera technology. That experience exposed him to the inner workings of the devices and ended up serving as a building block to his work in filmmaking. He began making software for the cameras and, when desktop computers came on the scene, explored ways to make production more efficient. When not at work, Jushchyshyn tinkered with creating computer graphics by self-studying on a Commodore 64, an 8-bit home computer popular in the 1980s.

Around the same time, the film industry was transitioning to new technology, and the skills Jushchyshyn developed at work and through his hobbies proved valuable. He made a move into feature films and spent more than two decades building a portfolio of credits that include being on the team that won an Academy Award in 2008 for the best visual effects for "The Curious Case of Benjamin Button." His other credits include "The Girl with the Dragon Tattoo," "I Am Number Four" and "The Road."

Jushchyshyn joined Drexel in January 2012 part-time and moved into a full-time position that September. Three years later, he convinced the department that Drexel and a group of students should attend Siggraph, an annual industry conference in Los Angeles focused on computer graphics and interactive techniques.

During that trip, the group toured studios and visited Balakrishnan, who was then working at a virtual and digital production company, to learn about the field. The tours enlightened Jushchyshyn on the direction of the industry and where Drexel needed to go. He concluded that no school was teaching animation, virtual reality and augmented reality and convinced Drexel to launch a degree program in 2018 focused on digital media and virtual production.

"The program was unique — in the world," Jushchyshyn says. "That's what makes it special; it doesn't exist anywhere else."

While other schools have since adopted similar programs, Drexel's remains distinct. Other schools typically incorporate these disciplines as a small part of a more generalized program or into game design and animation programs, which tend to be focused on the needs of the entertainment industry.

Drexel distinguishes itself by having a dedicated degree program specifically focused on preparing students to be well-versed in the most critical production tools for metaverse media creation, Jushchyshyn says. That means teaching them about motion capture, real-world virtualization and visualization, real-time 3D computer graphics and human interaction, VR, AR and other immersive technologies. Students then apply these tools across a spectrum of industries including entertainment, medicine, education, industrial design, travel, hospitality, merchandising and branding, among others.

Since 2016, Drexel has had a booth at Siggraph staffed by students. It has led to job opportunities for them. It also keeps Drexel's capabilities in the spotlight.

Regina Mae "Redg" Libunao, a fourth-year student, took a course on 3D programming for animation and was hooked. She's majoring in animated visual effects and participated in the Motion Capture Club at the ACE Lab. Aside from motion-capture work, Libunao has been gaining experience on character rigging, which is a bridge from model to animation. A model of a human or animal needs to be "rigged" with virtual bones before it can be animated.

"It's a lot of fun," she says. "Motion-capture systems are used by actual companies who do this type of work. It's not accessible to a lot of people and not a lot of schools have that. If you have experience with this while you are at school, you're one step ahead in getting a job."

"The program was unique – in the world. That's what makes it special; it doesn't exist anywhere else."

NICK JUSHCHYSHYN *ASSISTANT PROFESSOR OF DIGITAL MEDIA*

SIMULATIONS FOR SCIENCE, COMMERCE AND INSTRUCTION

The ACE Lab leverages its technology to assist in groundbreaking research across the University — going far beyond just entertainment, sports and video games.

Roughly five years ago, for example, the lab began working with Drexel's College of Nursing and Health Professions to create a simulated hospital emergency room and palliative care clinic to teach nursing skills to students. Actors, captured as digital characters, perform as patients in realistic health care scenarios.

"It looks exactly like a hospital emergency room or clinic, but they are in VR and don't need to be restaged over and over again," Jushchyshyn explains.

That work set the stage for new applications driven by the pandemic. When everything shifted to remote, the ACE Lab worked with the College of Engineering to create a VR learning environment. Jushchyshyn shot photos of equipment and tools in the engineering labs, which were reconstructed by digital media students into 3D replicas to be used by instructors in their online courses.

Drexel dance instructors who found Zoom too limiting during the pandemic asked Jushchyshyn to record them demonstrating correct and incorrect dance forms using motion-capture. An unexpected pedagogical advantage of the recordings was that each pose could be slowed, stopped or magnified.

Meanwhile in Drexel's School of Biomedical Engineering, Science and Health Systems and the School of Education, engineering students were having difficulty visualizing how flat and two-dimensional diagrams translated into 3D objects, called stereoscopic depth perception. The lab created VR experiences to test students' spatial awareness using the Purdue Spatial Visualization Test and to enable them to practice translating a 2D object into a 3D object.

"Even in the real world, you can't interactively hold a 3D object and see a 2D object — but we can do that in VR because of its stereoscopic depth," Jushchyshyn says. "We did extensive research and a complete study on that."

The lab has several projects underway with Longwood Gardens, the former duPont estate and botanical gardens outside of Philadelphia.

In one project, the lab developed an immersive virtual experience of the gardens and assessed its effectiveness scientifically. A Drexel team used neuroimaging technology to measure how engaged visitors were when experiencing the virtual reality version versus, visitors strolling the grounds in person. The study measured participants' blood flow in real time and contrasted the data.

The project began during the pandemic, when visitors were hesitant to venture into crowds and Longwood wanted to reach a broader audience. Longwood brokered the arrangement through Drexel Solutions Institute and involved faculty from Westphal College; Bennett S. LeBow College of Business; the School of Education; and the School of Biomedical Engineering, Science and Health Systems.

"This is what I love doing at Drexel," Jushchyshyn says. "It's multidisciplinary. It's unusual for an R1 research institution to have access to an A-list or triple-A creative design facility. Schools of that caliber are traditionally dedicated art-and-design schools not directly connected to an R1 institution."

Jushchyshyn recalls presenting his work at a conference and afterward receiving inquiries from art-and-design schools asking how he got access to, say, a medical and nursing school. "We're literally right in the middle of all of this," he says. "I feel that Drexel, if not absolutely unique, is exceptionally rare to have that under a single roof, and that is the way Drexel operates. It's often extremely siloed at other institutions."

The visitor experience project for Longwood spawned another to develop a virtual learning experience to enhance Longwood's K-12 educational programming.

"If we can find new ways to share nature with those who don't have ready access to it and to do it in a meaningful way such as through virtual reality, and to bring it to life for them, we can help people," says Paul B. Redman, president and CEO of Longwood Gardens.

The Drexel-Longwood partnership also inspired a course, "Beyond the Walls," taught by Jushchyshyn during the winter 2023 term. Students created a high-definition, computer-animated visualization of various aspects of Longwood's historic Peirce-du Pont House as another way to enhance visitors' experience. The course was facilitated by Drexel's new Innovation Engine, an initiative of the Provost's Office focused on multidisciplinary, experiential learning among students, faculty and external industry or nonprofit partners.

The labs' capabilities are being further explored as a tool for learning and providing insights for academia and industry. A study called "Virtual Shoes: Using Virtual Reality to Enhance Safety and Foster Better Design for Older Adults in the Built Environment" secured a $10,000 grant from the AgeWell Collaboratory in Drexel's College of Nursing and Health Professions.

The researchers are using VR to show design students what it is like for an older adult to view the built environment with diminished eyesight, compared with seeing something with 20/20 vision. The contrast is often startling to the students.

The VR production the lab undertakes is also spilling over into the mainstream — about 50% of its partnership work is with organizations outside of the entertainment industry.

The allure of the "metaverse" is a big draw. An undisclosed, international consulting firm recently turned to the lab to explore what metaverse commerce could potentially look like, for example. And a law firm, BakerHostetler, turned to the ACE Lab in November 2022 to help prep for a virtual conference it hosted. Two attorneys spent a day in the lab wearing motion-capture suits embedded with sensors to collect data that was used to design their avatars.

_CONNECT

To learn how external companies can partner with Drexel faculty and students, email Drexel Solutions Institute at **DSI@Drexel.edu** or visit **drexel.edu/solutions-institute/**.

PEPSI, MAGIC GLOVES AND MORE

The B.I.G. concert wasn't the first collaboration between Hyperreal and Jushchyshyn's labs.

Scott had previously visited Drexel to work on a fully virtual PepsiCo commercial that was made to demonstrate that every detail — hamburger, car, street — could be created in a lab: no actors, no set, no perishables.

"We're testing out what the future of metaverse in advertising will be," says Scott. "As we were doing motion capture, Nick was able to broadcast to the creative team at PepsiCo and they were able to make creative decisions. We could show them in real time and adjust cameras and performance remotely."

More recently, Scott returned to Drexel to test out a pair of high-fidelity motion-capture gloves from a New Zealand company called StretchSense that record data on intricate finger movements. A guitarist was brought into the lab and recorded as he played with the gloves on, moving his fingers along the neck of a guitar. Musicians can use the gloves to capture the process of their performance, akin to a musical signature, which can be copyrighted for the emerging metaverse economy.

"Understanding the latest technologies being developed in an industry gives students and everyone involved in the test the ability to understand how we can use it or improve on it," Scott says. "Students can understand the complete process. The students get it and that creates really good talent and leaders of the future."

While other facilities Scott has used on the West Coast may offer more redundancy and personnel, the scale of the Drexel lab and involvement with students has worked well for Hyperreal's needs, he says.

"It's more about research and development, testing different things, thinking through a concept and seeing it come to life," Scott says. "We're in a laboratory." ✕

Watch how Hyperreal produced a fully synthetic metaverse commercial for PepsiCo using motion capture shot at Drexel: **https://vimeo.com/799687175**

_HOW TO STUDY A CONDO COLLAPSE

When Champlain Towers South in Surfside, Florida, collapsed in 2021, a Drexel structural engineer ***put his expertise to use investigating the causes of the disaster*** *with the journalists covering the event.*

The 2021 collapse of the Champlain Towers South in Surfside, Florida, resulted in 98 deaths and three searing questions: What caused the condominium complex to fall? Could it have been avoided? What measures would prevent such a tragedy in the future?

In the disaster's aftermath, reporters turned to seasoned engineers for answers. By studying the original building design, screening video footage of the collapse and scrutinizing photographs of the rubble, experts like College of Engineering Professor Abieyuwa Aghayere provided insights to inform survivors and area residents.

Within six hours of the collapse, Aghayere took a call from Sarah Blaskey, an investigative reporter from the *Miami Herald*. So began a collaboration that involved frequent — sometimes daily — contact, as details about the building's design, construction and failure continued to emerge.

Aghayere assessed the original building designs, where he immediately noticed narrow columns that incorporated an excessive percentage of steel rebar. He advised Blaskey that rebar clustered too closely together could leave insufficient space for a good concrete pour, allowing air pockets to form. The designs also called for just ¾ inch of concrete to cover rebar in the slabs. Aghayere explained that twice as much was needed to protect the steel from corrosive seawater that can seep through the porous material.

As new details emerged over the course of a year, Aghayere explained how a combination of design and construction errors likely caused the disaster to Blaskey and her colleagues, as well as to reporters from the *New York Times*, *Wall Street Journal*, CNN, *USA Today*, Voice of America and other outlets. His insights helped shape a Smithsonian Channel documentary streaming on Paramount+, "Ten Steps to Disaster: Surfside Condo Collapse."

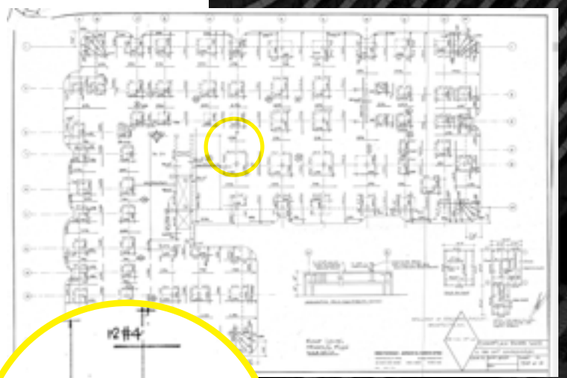
The torrent of stories on the complex's design, construction and maintenance deficiencies that Blaskey and her team produced earned them a Pulitzer Prize for breaking news.

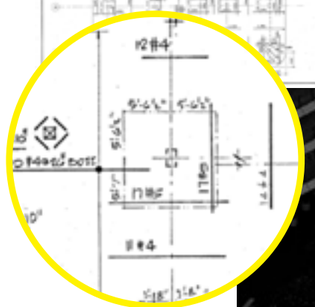
"Every time a new thing would come up, he would patiently walk me through it," Blaskey says, adding that he performed calculations, created drawings and used hand-crafted models during zoom sessions. "He was absolutely essential to this investigation."

Though an official probe launched in 2021 will take years to complete, findings that the newspaper uncovered with Aghayere's help have already produced results.

Survivors received a settlement of more than $1 billion, and Florida adopted an inspection program establishing stricter inspection requirements for condos that exceed three stories.

_ABIEYUWA AGHAYERE
Aghayere is a professor of civil, architectural and environmental engineering in the College of Engineering.





_PLAN EXAMINED
Aghayere assessed the original building designs and immediately noticed narrow columns with an excessive percentage of steel rebar. Rebar clustered too closely together could leave insufficient space for a good concrete pour, allowing air pockets to form.

_FAULTY TOWERS
Substandard, narrow columns supporting the pool deck were the first to collapse. An inadequate number of reinforced vertical shear walls compounded instability in the east side of the tower.

Jeff Fusco

ENVIRONMENTAL ENGINEERING

_FOREVER CONTAMINATED

*The **microbes that break down waste** may explain how "forever chemicals" end up in soil and water.*

_CHRISTOPHER SALES
_ASA LEWIS
Sales is an associate professor and Lewis is a former doctoral student in the College of Engineering.

"Forever chemicals" are everywhere — water, soil, crops, animals, even in the blood of 97% of Americans — and researchers in the College of Engineering have a theory as to how they got there.

Recent findings suggest that the microbes that break down biodegradable waste are likely complicit in the release of the notorious per- and polyfluoroalkyl substances (PFAS). Once in the environment, the chemicals remain a permanent hazard to human health.

In *Environmental Science Processes & Impacts*, the group explained how PFAS can leach out of fertilizer made from recycled waste with the help of microbial decomposition.

The research could help to explain how PFAS accumulates in the soil, crops

*"PFAS can leach from **biosolids** in wastewater treatment."*

and groundwater. Fertilizer made from treated sewage waste is used widely on farms and residential land.

"We know that microbes exist in biosolid sludge even after the stabilization treatment process, and given the role they play in the decomposition of organic compounds…we wanted to examine how microbial weathering of these organic compounds can impact PFAS leaching potential," says Associate Professor Christopher Sales, who co-authored the study with doctoral student Asa Lewis.

They collected treated biosolid samples and tested each to determine its initial level of organic matter, proteins, lipids and PFAS. Samples were then placed in an environmentally controlled chamber for three months to undergo microbial activity.

Samples with the highest level of microbial activity also demonstrated the highest level of PFAS partitioning. The results demonstrated this increase is likely due to the microbes breaking down proteins and lipids in the biosolid, which allows the PFAS to spread, or partition, as water passes through.

"This…supports that regulation or advanced treatment in wastewater treatment plants is needed to reduce impacts to the environment," says Lewis.

ELECTRICAL ENGINEERING

_THIS EXTRA-CURRICULAR IS THE BOMB

*A first-year electrical engineering major has assembled **a robotics team to construct rovers** for precision tasks.*

Meet LR-2 Trojan, one of two rovers being built by a team of students who call their group Raptor Robotics.

The LR-2 can defuse landmines, says Andrew DeLuca, an electrical engineering major who conceived of the project while interning with a robotics organization in the Netherlands before college. Since coming to Drexel, he has acquired an undisclosed amount of funding and organized a build team of 32 students from across disciplines, with involvement from some faculty members.

Existing sensors used to detect improvised explosive devices (IEDs) can be attached to the rover. Once the rover finds an IED, it can plant a deactivation device next to it, move away and trigger deactivation. The landmine will be cleared without a living being coming close to it.

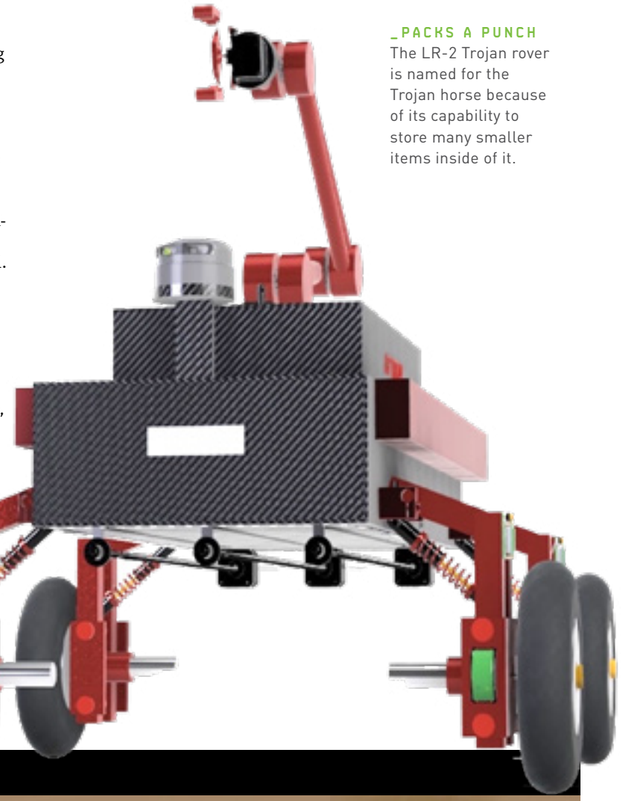
"We're saving lives and time and money, and you can send a fleet of these rovers to clear a field that would take a long time for people to clear," DeLuca says.

DeLuca intends to bring the LR-2 Trojan to market before he graduates. The team plans to have a prototype ready by the end of the 2022–23 academic year so they can spend the following year experimenting and improving upon it.

The team has also started a concept design for a second rover intended for agriculture — "a water, seed and feed rover," says DeLuca. "We initially started to develop the LR-2 rover for multi-use, but we found the most efficient way was to just make two separate rovers."

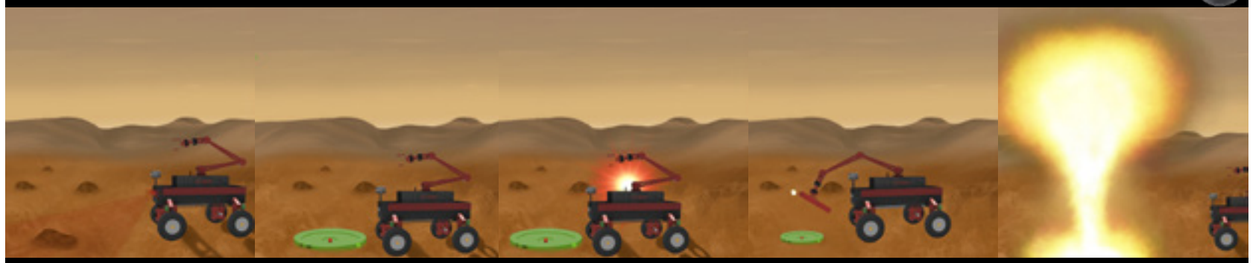
DeLuca has been building ever since he was a child, with blocks and Legos, and got into robotics later. He built his first robot at age 11 and in the 10th grade, he built a hydroponic system for growing food after a stint teaching math and science in a Gambian village that suffered from poor soil.

"Robotics is a really great, hands-on way of learning about a lot of different subsystems of technology," DeLuca says. "It incorporates not just the hardware, but software, and creative and logical thinking. It combines all of that into an interesting, hands-on project."



_PACKS A PUNCH
The LR-2 Trojan rover is named for the Trojan horse because of its capability to store many smaller items inside of it.

LANDMINE_DEACTIVATION



1 SCAN
The rover scans the area for landmines.

2 TARGET
Once a landmine is detected, the rover moves to the position of the landmine.

3 CHECK
The rover verifies there are no people nearby. If there are, the rover clears the area with its warning alarm.

4 DISARM
The rover sets its deactivation mode, opens its top hatch, and navigates an arm to grip the deactivation explosive and place it next to the landmine.

5 TRAVEL
The rover moves a safe distance away and sets off the deactivation explosive, destroying the landmine.

COMPUTER SCIENCE

_ALGO KNITS FOR SMART FABRICS

*Researchers are **translating the loops and twists of knitting into a digital algorithm** – a key step in the process of incorporating new technologies into "smart" textiles.*

It turns out that the stitches that generations of grandmothers have lovingly knitted into sweaters, mittens and baby booties can inform the design and production of functional fabrics.

David Breen, a professor in the College of Computing & Informatics, led a team that created a suite of algorithms for modeling pathways that yarn takes within a knitted textile. A computer-based modeling and simulation tool created by Breen's team, called TopoKnit, can provide functional fabric designers and producers with the equivalent of an architectural blueprint.

TopoKnit translates stitch commands — like knit, purl and transfer — as they would appear in a knitting pattern or the program of a digital knitting machine, into a map that shows where the yarn travels, loop by loop, and how it interacts with adjacent loops as the textile is formed. The resulting diagram, called a topology graph, allows designers to pinpoint where a piece of yarn is, with respect to the overall plane of the textile, at any given point within it.

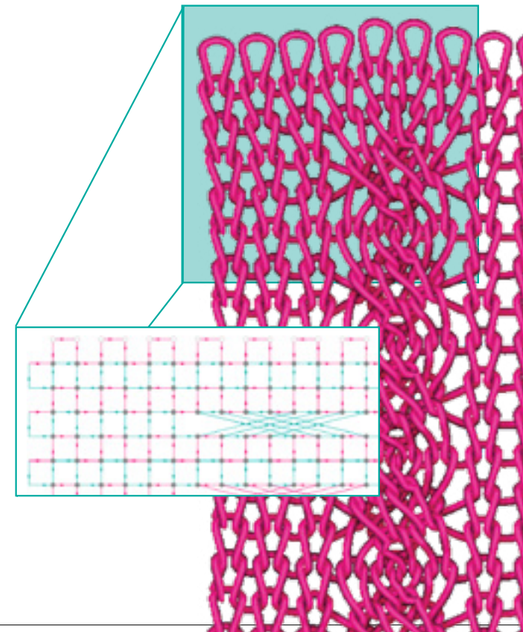
This breakthrough provides textile designers and producers with thread-level detail they need for digital sampling and precision manufacturing of everything from high-performance and technical military gear to high-end fashion concepts.

Building up this baseline design information for knitting comes as researchers show increased interest in knit-and-purl stitches as a basis for making functional fabrics. Breen suggests this is partly because knitting supports more intricate yarn interactions than weaving — an enormous advantage when creating electric circuits.

In addition, knitting makes it easier to generate 3D shapes without added manufacturing steps, such as cutting and sewing.

"Knitted fabrics…give designers more entry points to manipulate the material, which makes it very promising for building in new functionality," says Breen.

_DAVID BREEN
Breen is a professor of computer science in the College of Computing & Informatics.



_SMART STITCHES
TopoKnit is a suite of algorithms that translates stitch commands — like knit, purl and transfer — as they would appear in a knitting pattern into a map that shows where the yarn travels, loop by loop, and how it interacts with adjacent loops as the textile is formed.

CHEMICAL ENGINEERING

_EFFICIENT MERCURY REMOVAL

*A material developed at Drexel can **remove even low levels of mercury** in contaminated bodies of water.*

_MASOUD SOROUSH
Soroush is a professor of chemical and biological engineering in the College of Engineering.

Not only is mercury incredibly toxic, but the elusive mineral — appropriately nicknamed quicksilver — has unique abilities to quickly alter its chemical form, making it difficult to remove from waterways where it collects and persists, threatening marine life and human health.

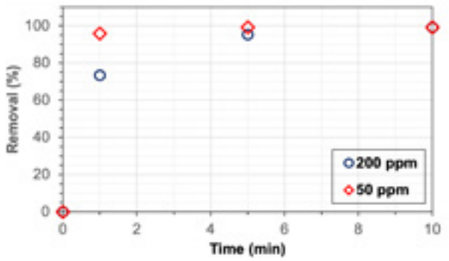
Mercury pollution has become so pervasive that health authorities recommend avoiding eating certain species of fish altogether.

A Drexel-led team has discovered a simple and effective new technique for removing mercury using a surface-modified MXene. MXenes are a family of two-dimensional nanomaterials with exceptional properties.

College of Engineering Professor Masoud Soroush and his colleagues at Drexel and Temple University modified the surface of titanium carbide MXene flakes — which bear a negative chemical charge — to produce an adsorbent that faster attracts and retains positively charged mercury ions.

By synthesizing carboxylated titanium carbide MXene, Soroush and his team were able to remove 95% of mercury ions from a water sample contaminated at a concentration of 50 parts per million within just one minute — faster and more effectively than adsorbents in current use.

Their method, described in the *Journal of Hazardous Materials*, showed that the material is sufficiently effective and efficient to be used in large-scale wastewater treatment.



_MXENE ADSORPTION
This adsorption time study shows the removal percentage of mercury ions from a 200 parts per million (ppm) and 50 ppm solution over time.

_ POWER PATCH FOR WEARABLE TECH

*The successful design of a **working, flexible supercapacitor** brings researchers one step closer to making wearable textile technology a reality.*

_YURY GOGOTSI
_GENEVIEVE DION
Gogotsi is the Distinguished University and Bach professor in the College of Engineering and director of the A.J. Drexel Nanomaterials Institute. Dion is professor and director of Drexel's Center for Functional Fabrics.

A team has had success incorporating MXene, a conductive two-dimensional material discovered at Drexel in 2011, into a textile-based supercapacitor that can charge in minutes and then power an Arduino microcontroller temperature sensor while transmitting data for almost two hours.

"This is a significant development for wearable technology," says Yury Gogotsi, Distinguished University and Bach professor in the College of Engineering. "To fully integrate technology into fabric, we must also be able to seamlessly integrate its power source — our invention shows the path forward for textile energy-storage devices."

To create the supercapacitor, the team simply dipped small swatches of woven cotton textile into a MXene dispersion in water, then layered on a lithium chloride electrolyte gel. Each supercapacitor cell consists of two layers of MXene-coated textile with an electrolyte separator also made of cotton textile. To make a patch with a useful amount of power, the team stacked five cells to create a power pack capable of charging to 6 volts.

"While there are many materials out there that can be integrated into textiles…textiles can easily be coated with MXene without using chemical additives — or additional production steps," says co-author Tetiana Hryhorchuk, a doctoral researcher in the college. "As a result, our supercapacitor showed a high-energy density and enabled functional applications such as powering programmable electronics."

The best-performing textile supercapacitor powered an Arduino Pro Mini 3.3V microcontroller that was able to wirelessly transmit temperature every 30 seconds for 96 minutes. And it maintained this level of performance consistently for more than 20 days.

This is one of the highest total power outputs on record for a textile energy device, the team notes, but it can still improve. In further work, they plan to test different electrolytes and textile electrode configurations to boost voltage, as well as new wearable designs.

The achievement was described in the Royal Society of Chemistry's *Journal of Materials Chemistry A*, in a report co-authored with Gogotsi's graduate and postdoctoral students; Genevieve Dion, professor and director of the Center for Functional Fabrics; and researchers from Accenture Labs in California.

_POWER PATCH
This flexible textile supercapacitor patch can power a microcontroller and wirelessly transmit data for nearly two hours without a recharge.

_ONLINE
To learn more about BIOMED Summer academy visit: **bit.ly/42Yb98d**

_SHOESTRING SCIENCE, WITH A SMARTPHONE

A simple, **easily replicated science experiment for high schoolers** proves that neuroscience research doesn't have to be an expensive endeavor.

There's no doubt that a rich/poor divide plagues education, especially in equipment-heavy STEM fields. But a high school summer camp curriculum created in Drexel's School of Biomedical Engineering, Science and Health Systems, called BIOMED Summer Academy, proves that with a little ingenuity, high-end educational neuroscience research can be affordable.

Professor Catherine von Reyn regularly hosts BIOMED Summer Academy for 11th and 12th graders, who work with students in her Neural Circuit Engineering Lab, using high-speed videography to detect the responses and movements of *Drosophila* fruit flies.

Over the years, she has perfected a workshop that any educator can replicate to teach students how nerve cells trigger behaviors.

But instead of using high-speed cameras that can cost in the tens of thousands of dollars, the students are able to use their own phones.

"This is how we can make this research accessible to high school students," von Reyn explains.

Her goal is to introduce the high schoolers to neurotechnology and neuroscience concepts — e.g. What is a neuron? What is a neural circuit? What is a sensorimotor transformation? What is optogenetics? Optogenetics is a research technique that uses light stimuli and genetic intervention to study how neurons activate underlying behaviors.

Her workshop is designed to help the students discover how rapid sensory transformation happens, using fruit flies as the test subjects.

She published the results of her workshops in *PLOS ONE*, along with instructions other educators can use to replicate her course.

The goal, from von Reyn's perspective? "We want to see the students participate in the learning process versus simply receiving and memorizing" data.

_THE EQUIPMENT SET-UP
Teams are equipped with an Arduino electronics board (1) that uses sensors and actuators to teach students about current, voltage and fundamentals of programming. Then, using their smartphones mounted to cardboard anchored by stereoscope mounts, students capture the flies' rapid movements (2) at the point where the flies' senses trigger them into action.

_IN POSITION
Flies are tethered to a tungsten wire using UV glue, cured under a UV light. The other end of the tungsten wire is inserted into a piece of clay for positioning.

Fruit flies are used in the experiments because their nervous systems are similar to humans.

_THE EXPERIMENT
The experiment begins when a student hits record on their cell phone. That triggers a motion sensor that tells the Arduino to shine an LED light on the fly. Neurons within the fly that have been genetically engineered to be light sensitive are activated by the light, and students observe the fly's behavior to determine what the neurons are doing.

Luo L., et al. (2022) An optogenetics device with smartphone video capture to introduce neurotechnology and systems neuroscience to high school students. PLoS ONE 17(5): e0267834

_The Path to Lift-off

Following the accidental discovery of a stable sulfur-based battery – the electronic industry's white whale – chemical engineer Vibha Kalra is now finetuning her findings in hopes of one day commercializing a battery that can power aerial drones.

BY CHRISTINA HERNANDEZ SHERWOOD

In the mid-1980s, Sony executives were under pressure.

The corporation was racing to develop a high-density, rechargeable battery that could power its electronics again and again. But Union Carbide had just pulled out of their R&D joint venture and a rival Japanese firm already had a battery prototype, recounts Charles J. Murray in the book "Long Hard Road: The Lithium-Ion Battery and the Electric Car." In 1987, the head of Sony's battery development subsidiary, Keizaburo Tozawa, shifted to high gear, assigning six separate research groups to focus solely on this mission. Two and a half years later, Sony announced its "dream battery," a rechargeable lithium-ion battery that was safer and more powerful than its competitors.

Fast-forward three decades: These revolutionary lithium-ion batteries, first used in Sony camcorders, now power everything from the smartphones in our pockets to the electric cars in our driveways. They have seen vast improvements over the past 30 years — most notably in the amount of energy they can store — and are still considered the gold standard rechargeable battery.

But every technology has its limits, and the lithium-ion battery is bumping up against its limits in the electric vehicle market. For a lithium-ion battery to store more energy — to run longer between charges — it must weigh more. While that increased weight isn't much of a problem in small electronics, it is an issue in vehicles. The lithium-ion battery powering a Tesla, for instance, weighs more than 1,000 pounds and accounts for as much as half of the car's total cost.

"That's not sustainable," says Vibha Kalra, who is the George B. Francis Chair Professor and director of the PhD Program in Drexel's Department of Chemical and Biological Engineering within the College of Engineering. "When you try to translate the same technology into larger vehicles, it's not going to be sustainable with respect to both weight and cost. A pickup truck would require at least twice the battery storage of a sedan. A commercial truck could require almost tenfold."

Kalra is working to bridge this gap. In her decade-long journey to create and commercialize a new generation of rechargeable batteries, Kalra has performed hundreds of experiments, interviewed dozens of industry experts, received close to $7 million in grants and funding, logged countless hours working with tech commercialization experts in Drexel's Office of Research & Innovation, and secured three patents, with 11 more pending.

Though the work isn't over, the path of Kalra's research discovery from lab bench to a top commercial prospect exemplifies the power of academic entrepreneurship in supercharging faculty careers and expanding the University's research enterprise.

"It gives a good picture of what it's like to take a really early-stage, interesting technology to the point where it's ready to make its way into a

ILLUSTRATIONS BY RYAN OLBRYSH

company," says Robert McGrath, senior associate vice provost for intellectual property and agreements in Drexel Applied Innovation, the technology transfer division of the Office of Research & Innovation. "Getting to market [is hopefully] not far behind."

THE DISCOVERY

Chemical engineers have long been intrigued by the potential of combining lithium with sulfur to make a new kind of battery. The opportunity is enticing: Lithium-sulfur batteries have the potential to store more than five times the energy of their lithium-ion counterparts. As a widely abundant material, sulfur is super cheap. It's also benign, unlike some heavy metals and materials that face environmental and humanitarian issues as well as looming shortages.

All of this promises an affordable, abundant, lighter, greener battery — with spectacular performance in everyday electronics. Imagine running your laptop for three times as long, or getting the same run time from a laptop that weighed a third less. An electric car with a lithium-sulfur battery would have a range of 1,500 miles, versus 500 miles for a lithium-ion battery of the same weight.

But Kalra and other researchers were stumped by a critical obstacle to using sulfur. Both lithium-ion and lithium-sulfur batteries contain a liquid, called electrolyte, that transports lithium ions from one side of the battery to the other, enabling its charge and discharge cycle. Most experimenters studying lithium-sulfur batteries have favored ether electrolyte, because it plays well with sulfur. However, it has a low boiling point, making it too dangerous for practical use.

Kalra and her PhD student decided to ditch ether electrolyte in favor of carbonate electrolyte, which has been used in lithium-ion batteries for 30 years.

"It's the path of least resistance," Kalra explains. "Rather than pushing for the industry adoption of a new electrolyte, our goal was to make a cathode that could work in the pre-existing Li-ion electrolyte system."

Of course, it isn't as easy as swapping one electrolyte for the other. When Kalra first put carbonate electrolyte in an experimental lithium-sulfur battery, the battery shut down after its first cycle. To counteract the adverse reaction between sulfur and carbonate electrolyte, the team tried to isolate sulfur from the carbonate by enmeshing it in a carbon nanofiber substrate using a vapor deposition technique.

They didn't get the result they expected. But as they explain in their paper published in *Communications Chemistry*, what they got instead was a game changer: a rare form of crystalized sulfur, called monoclinic gamma sulfur, that is stable at room temperature. Long-term stability of this form of sulfur had never been achieved in a lab before.

"As we began the test [of the cathode], it started running beautifully — something we did not expect," Kalra recalls. "In fact, we tested it over and over again — 50–100 times — to ensure we were really seeing what we thought we were seeing."

When the team put their stable sulfur into a battery, they were able to cycle it 4,000 times, or the equivalent of 10 years of use, without losing performance. In contrast, a typical lithium-ion battery can cycle 2,000 times and has only a third of the energy density.

With the discovery confirmed, Kalra called Drexel Applied Innovation.

FIRST STEPS

Drexel Applied Innovation is the university's tech transfer office. Kalra had been on the office's radar since she first met McGrath in 2011. At that first meeting, Kalra didn't have a discovery yet, but she told McGrath what he could expect from her lab.

"I thought it was relevant," McGrath says, "but as with most of the things coming out of a university lab, it was probably ahead of its time. It usually takes a good five, 10 years — and in some cases 15 — for industry to catch up to where universities happen to be going."

Kalra continued meeting with the team over the next several years, keeping staff updated on her research. Elizabeth Poppert, a licensing manager for Drexel Applied Innovation, says Kalra was initially skeptical that industry would be interested in her lithium-sulfur work.

"But after talking to some of our strategic partners, and seeing their excitement, it made her understand that maybe technologies that are still a way away could attract industry," Poppert says.

The buzz from industry partners convinced the University's Office of Research & Innovation to provide her with $100,000 in early-stage support.

Sensing the commercial potential for her work, Kalra also reached out frequently to the University's media relations team to publicize her findings. A member of that team, Britt Faulstick, helped to translate her findings for the public.

In 2017, one of his articles happened to catch the eye of a company that reached out to Kalra about a licensing agreement. They ultimately decided to sponsor her research up to $1 million.

"This is a great example of what we're hoping to achieve through the media relations process," says Faulstick, executive director of news and media relations in the University Marketing & Communications division. "Not only did promoting her work open exciting opportunities for Dr. Kalra, but it also raised awareness of the quality of research taking place at Drexel."

> *"As with most of the things coming out of a university lab, it was ahead of its time. It usually takes a good five, 10 years – and in some cases 15 – for industry to catch up to where universities happen to be going."*
>
> **ROBERT MCGRATH**, SENIOR ASSOCIATE VICE PROVOST FOR INTELLECTUAL PROPERTY AND AGREEMENTS, DREXEL APPLIED INNOVATION

The partnership enabled Kalra to access equipment that would grow her experimental batteries from tiny coin cells to larger pouch cells, a key step on the path to commercialization. She ramped up her research, performing dozens of fundamental studies — from electrochemistry analysis to postmortem spectroscopy — to confirm and understand her discovery.

At the same time, the team at Drexel Applied Innovation kicked their efforts into high gear. "When the company came knocking on her door," McGrath says, "that was validation."

Kalra had already filed a provisional application by then, but it was time to ramp up the process.

THE PATENTS

When a faculty member contacts Drexel Applied Innovation with a potential discovery — as more than 100 typically do each year — the team uses two crucial questions to decide whether to take on the project: Is the discovery new, and therefore, patentable? And would industry be interested?

The Drexel Applied Innovation team set to work answering the first question for Kalra's technology. With the help of patent attorneys and input from Kalra, the team searched for potential competitors. After submitting each of Kalra's three patent applications, the team braced for an almost-certain initial rejection. Then the team, including Kalra, revised each application to address the patent office's objections.

"It's a significant amount of time," McGrath says. "I don't want to say it's not for the faint of heart, but it is when you have classes to teach and research to do and professional development and faculty service. The folks who do it are committed to seeing their technologies go somewhere."

Kalra was eventually issued all three patents in 2021, each taking two to four years from initial application to final approval. McGrath called this timeframe "actually pretty reasonable" considering he's seen others that have taken more than a decade.

Fortunately, Drexel Applied Innovation's second question — did the discovery have industry appeal? — had already been answered by Kalra's new corporate partner. "It wasn't lip service," McGrath says. "It spoke volumes about [Kalra] and the expertise of her laboratory that the company's investment, at the time, may have been one of the largest single-year industry-sponsored research projects Drexel had done."

Eventually, though, the company decided to move its business away from batteries, and the licensing agreement came to an amicable end.

ENTREPRENEUR-IN-TRAINING

Nonetheless, Kalra had proven her technology had industry appeal. The next step was to home in on the ideal industry niche for her lithium-sulfur batteries. At that point, electric vehicles were still the frontrunner.

Kalra received a National Science Foundation Partnership for Innovation grant, which helps academics move their technologies toward commercialization. A key aspect of the program is participation in National Science Foundation I-Corps, a customer discovery entrepreneurial training program. NSF I-Corps is designed to help faculty determine who outside academia would care — and how much — about their innovation, says Shintaro Kaido, vice provost for innovation and executive director of Drexel Applied Innovation. (Drexel became a member of the $15 million NSF I-Corps Hub Northeast Region in 2022.)

"[Kalra's] innovation with lithium-sulfur has interesting properties that current lithium-ion batteries don't," Kaido says. "How is the technology's unique value proposition poised to solve problems that current lithium battery technologies can't address?"

The professor was eager to interact with industry again, which is critical to the technology transfer process, says Poppert. "We can do some initial interrogations to determine if there's interest," she says, "but if we can't engage the faculty to participate, then it's not going to go anywhere."

Kalra didn't go through I-Corps alone. Her first step was to form a team that was meant to simulate an early-stage startup. Kalra was the technical lead. Her graduate student was the entrepreneurial lead. Poppert and Mohammad Balapour, who is entrepreneur in residence at Drexel Applied Innovation, signed on as mentors.

The team tapped into their professional networks and searched LinkedIn for contacts at dozens of companies across the entire battery ecosystem, ranging from material suppliers to battery manufacturers to end-application firms. All told, the team conducted 106 interviews — giving them deep knowledge of the complex battery landscape.

"It provided a depth of understanding of how that industry works and the challenges of bringing a new innovation to that industry," Poppert says. "You want to innovate to create a solution that people actually care about."

While it was clear the industry cared about electric vehicles, the team learned that the market is rigid, with many partnerships already locked in. Although the electric vehicle market is still part of the team's long-term strategy, their first target industry shifted from land to sky.

"The results of I-Corps were phenomenal," Kalra says. "We discovered this niche application of aerospace and aviation where such a product could be targeted as a test case."

Unmanned vehicles like drones face less stringent safety standards than electric vehicles, making the smaller niche market an easier initial target for a new technology like Kalra's. Plus, battery weight becomes more important in an object that's meant to leave the ground, so the lightness of her lithium-sulfur batteries had obvious appeal to aerospace.

"It's not the massive market initially, but we can do some things now to get into the smaller market," McGrath says. "Then when the [electric vehicle] industry comes around, we're going to be in a good position to capitalize on that."

LAUNCHING A STARTUP?

While the team was going through the I-Corps process, Drexel's internal news team published another story about her research — and once again, it attracted attention from a would-be partner.

The team was approached by an entrepreneur who is now in good faith discussions with Drexel as he develops strategic partners and works to form a company. It could still be months before a deal is signed, if at all.

"At the end of the day, we want to make sure the deal we do with the partner is the right partner for [Kalra], the right partner for Drexel," McGrath says, "and it puts the technology in the best position to be successful and come to market." (If a startup is formed, it could take advantage of the University's new Innovation Fund, which will invest $150,000 in up to four Drexel-born startups each year.)

As possible commercialization moves forward on the business side, Kalra's science is also pushing toward that goal. Her mission now is to ensure her technology can be productized — that is, can it be repeated at scale in a way that is both cost efficient and meets performance requirements?

"It's one thing to do [this work] on a bench," Poppert says. "It's much different to be able to do millions or billions of products and know it's cost effective and you've got the supply in order and the production capability to meet the demand. So much more goes into the business aspect of [tech transfer]."

So Kalra is back in the lab performing extensive experiments on each of the many individual components of her lithium-sulfur battery, and on the battery as a whole. She needs to scale up each component as she works toward her first big milestone: building a prototype, which brings its own set of material and assembly challenges.

But such is the excitement and uncertainty of bringing scientific discoveries to market. Despite years of work and much progress, it's still an open question whether Kalra's technology will take off and one day power drones in the sky.

"It could fill a very interesting spot in that ever-changing landscape of stored energy innovation," Kaido reflects. "We're really excited, but the truth is, we don't know." ✕

_The Great Conductor

A global network of scientists has coalesced around the desire to solve big energy problems with tiny nanomaterials discovered at Drexel.

BY BEN SEAL

PART I: THE DISCOVERY

The story of the nanomaterial that could change the world begins with failure.

In 2010, in a lab inside Drexel's Department of Materials Science and Engineering, first-year PhD student Michael Naguib was trying to squeeze lithium ions into the atoms-thin silicon layers of a material called a MAX phase, in hopes of creating a new battery material for the U.S. Department of Energy. He wanted to take advantage of the potential of MAX phases — carbides and nitrides that merge the properties of metal and ceramic materials — to create a battery anode that would be more robust than state-of-the-art graphite.

Under the co-supervision of Michel Barsoum, who first revealed the properties of MAX phases in the 1990s, and Yury Gogotsi, who was studying the use of carbons produced by selective removal of metals from carbides — including MAX phases — for electrochemical energy storage, Naguib began experimenting.

Thinking particle size could be standing in the way, he first subjected MAX phases to a high-energy collision procedure to break them down to the nanoscale, but he found no improvement in performance. He attempted next to create vacancies in the MAX phases, removing the thin silicon or metal layer in the middle of their sandwiched structure to offer lithium entry. Yet each attempt failed to demonstrate the necessary electrochemical activity.

Finally, he tried etching MAX phases in hydrofluoric acid, hoping to both reduce the particle size and extract the metal layers. The results opened a new era in materials science.

At first, what he got looked as if it might be graphene, an atom-thick form of carbon that had recently been the subject of a Nobel Prize. But it turned out to be something far more exciting. Though they had failed in their attempt to get lithium into MAX phases, the researchers had discovered something special: a two-dimensional sheet of transition metal carbide that further experimentation developed into an entire family of highly conductive, mechanically robust, water-dispersible and tunable materials that are now being explored by researchers acrossthe world for their potential to change how science approaches energy storage, technology, medicine, environmental remediation and more. The trio named it MXenes, a splice of "MAX phases" (without the A metal, which was dissolved in acid) and "graphene."

"There's always a role of serendipity in scientific discoveries," says 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. "But, as Pasteur said, 'Fortune favors the prepared mind.'"

Next, they set out to learn as much as they could. Every graduate student around suddenly took an interest, looking to join the team with Gogotsi and Barsoum, Distinguished Professor in the Department of Materials Science and Engineering.

"We called it, between us, the MXene vortex," Gogotsi says. "Anybody who came close to it would be sucked in. People quickly realized it was very novel and very important. They saw the sparkle in our eyes when we talked about it."

In the decade-plus since the discovery, the vortex has expanded to attract the interest of researchers at hundreds of institutions in more than 90 countries on six continents. Through research collaborations, international conventions, alumni networks and no small amount of enthusiasm orchestrated by Gogotsi, researchers around the world have coalesced around an international effort to uncover the extraordinary range of possibilities presented by MXenes' unique traits.

"We have the building blocks," Gogotsi says. "Now, we need to learn how to use them to build new technologies."

PART II: A TEENAGER IN LOVE

Gogotsi grew up in Kyiv, Ukraine, when it was still part of the Soviet Union. His father, George, a mechanical engineer, encouraged him to take apart telephones and other common devices to understand how the world around him worked. His love of science, though, centered on chemistry. He missed the opportunity to get a textbook for his eighth-grade class, but it didn't stop him from learning everything he could.

"I was a natural, imbibing all the knowledge," Gogotsi says. "I didn't need a textbook because everything was clear to me."

From the moment he discovered chemistry, he knew his life would be in the sciences. As he watched the instructor of his local chemistry club turn a copper coin into silver by coating it with mercury and create chaos by throwing sodium into water, he experienced something like love at first sight.

After his father introduced him to metallurgy, where he could merge his devotion to chemistry and his fascination with high temperatures, he went to Kyiv Polytechnic Institute, where he earned a master's degree in metallurgy and a PhD in physical chemistry, setting the stage for a career studying materials chemistry and ceramics. In the process, he learned a lesson that has stuck with him ever since.

At the time, not long after the global oil crisis of the 1970s, researchers around the world were searching for ways to replace the metal in car engines with more efficient, lighter and more heat-resistant ceramics. In an era of hulking gas guzzlers, their work was viewed as critical to society's path forward. And they achieved their goal, building prototypes in the 1980s that led to the world's first car with a ceramic turbocharger and the testing of full ceramic engines.

But the ceramic engine never took off. It was an engineering marvel that couldn't overcome challenges with manufacturing, cost and mass production. Oil prices stabilized, metallic engines improved and, ultimately, there was no need for ceramics in engines.

"Not everything we make that's good from an engineering standpoint becomes industrial," Gogotsi says.

More than three decades later, he's working to ensure that MXenes don't suffer the same fate.

As soon as Mikhail Gorbachev opened the doors to the Soviet Union, Gogotsi eagerly left to continue his studies on a Humboldt Research Fellowship at the Karlsruhe Institute of Technology in Germany. Before joining Drexel in 2000, he moved between institutions in Japan, Norway, Germany and Chicago, learning more at each step about the most advanced materials in the world. His search led him to carbon nanomaterials, which he focused on for more than 20 years before the discovery of MXenes. That was a moment that changed his life.

"It's very difficult to imagine the excitement of seeing something no one else in the world has ever seen," Gogotsi says. "It's an unbelievable feeling."

He compares scientific discovery to the feeling some people chase by cliff-jumping or climbing mountains. When he sits down to write a paper describing a new finding, he puts everything else aside to work through the night until he's emptied all of his ideas onto the page. Only then can he take a deep breath and turn his attention elsewhere.

"It's the novelty of it," Gogotsi says. "And the more novel it is, the more unusual, the more exciting."

In MXenes, he had found with Barsoum and Naguib something entirely new.

PART III: THE VORTEX EXPANDS

If it was immediately clear to the team at Drexel that this was a major discovery, the scientific community took slightly longer to realize it. Their paper detailing the findings was rejected from two journals by editors who doubted whether MXenes could outperform other two-dimensional materials. It was only accepted by a third journal, *Advanced Materials*, after a second review on appeal. Years later, the journal's editor approached Gogotsi at a conference with a bottle of champagne, celebrating what has since become one of the most cited papers in the field. It earned a 10th anniversary retrospective in *Advanced Materials* in 2021.

In that time, the MXene family has expanded to include dozens of different materials, depending on which ingredients are used in the process. For Gogotsi, this is both a blessing and a challenge. The variation from one MXene to the next is essential to the materials' tunability — their capacity to be everything to everyone, depending on the task at hand. MXenes are "a kind of black box," Chong-Min Koo, a professor in the School of Advanced Materials Science and Engineering at South Korea's Sungkyunkwan University, says. With each attempt to apply the material in a new setting, new behaviors are uncovered.

But that elasticity also means no one research group could possibly explore MXenes' potential in full. Instead, Gogotsi has become a spokesperson

— a salesperson, even — urging collaborators around the world to take part in the pursuit.

Valeria Nicolosi, chair of nanomaterials and advanced microscopy at the School of Chemistry in Trinity College Dublin, began her career studying graphene. After listening to Gogotsi speak at a conference of The Electrochemical Society in Hawaii, she knew she wanted to work with MXenes.

She quickly realized they are easier to process and handle than other two-dimensional nanomaterials, allowing her lab to use MXene solutions — two-dimensional flakes suspended in common solvents like water — to print on plastics, silicon, textiles and fabrics. She and her colleagues can now attempt research that had previously been impossible. Like so many others, they have joined the worldwide MXene team.

"He has created a network that is a sort of family," Nicolosi says. "We are all part of this lab. We share objectives and we share this common goal, which is making progress."

Gogotsi has a "gift of sharing," Nicolosi says. Where some scientists are protective of their knowledge, he spreads his far and wide. Collaborators describe a leader who is generous, supportive and always available to share in the exploration of new ideas.

"He's a really amazing captain," says Maksym Pogorielov, head of the research center and leader of the biomaterials research group at Sumy State University in Ukraine. "I don't know if he sleeps or not, but usually he replies to any email within five minutes."

When he first met Gogotsi at a conference five years ago, Pogorielov says, "his presentation absolutely turned my world." With a background in medicine and biology,

Pogorielov's work focuses on tissue engineering. MXenes' unique combination of mechanical, thermal, optical and electrical properties have opened new doors in his research, allowing his lab to explore cancer therapy and tissue regeneration while dreaming of other applications to study in time.

Flavia Vitale, assistant professor of neurology and physical medicine and rehabilitation at the University of Pennsylvania, immediately recognized the potential of MXenes to change bioelectronics while watching Gogotsi speak at Penn's Singh Center for Nanotechnology in 2016.

At the end of the seminar, she ran to him so she didn't miss the chance to test out the materials as soon as possible. Within weeks, they began working together and soon after became the first to propose MXenes' use in biomedical devices ranging from invasive brain implants to wearable technology.

Gogotsi was eager to share a bottle of MXenes with Vitale's students, she says, but more important than that was his willingness to share his expertise and modify MXenes to suit the needs of a particular project.

"He is always available and he's extremely interested in growing and connecting the community of people working with and on MXenes," Vitale says.

Gogotsi serves as a mentor to a wide range of students, colleagues and collaborators, many of whom spend time in his lab and then move on to roles in academia, national laboratories and companies where they can expand the pursuit of MXenes' potential. At a Materials Research Society conference in San Francisco this spring, he saw three former postdoctoral researchers — Gleb Yushin, Junjie Niu and Majid Beidaghi, who have since become tenured faculty at other U.S. institutions, he says.

As the MXene family moves into its second generation, Gogotsi's lab recently welcomed postdoc Yuan Zhang on a Feodor Lynen Research Fellowship from the Humboldt Foundation. Zhang's PhD at Germany's Saarland University was advised by Volker Presser, who co-authored the first MXene paper while on the same fellowship in the same lab more than a decade ago.

"The main product of universities is not research, not papers, not patents," Gogotsi says. "The main product of universities is people. So the main job for us is teaching and training a new generation of researchers."

Lucia Gemma Delogu, associate professor in biochemistry at the University of Padua in Italy, calls Gogotsi "a never-ending source of learning." She was already familiar with MXenes before Vitale, a close friend, introduced her to Gogotsi. After working with other materials for years, including graphene, she found that MXenes have the biocompatible characteristics she needs to investigate the potential for single-cell mass cytometry — an emerging technique for the analyzing and targeting of cells or tissues — to aid in immune regulation. MXenes offer more channels for communication with cells than other materials because of their incredible conductivity.

"I didn't even know this existed until Lucia found our work," Gogotsi says. "These things happen all the time. That's why I'm tirelessly talking to people all over the world. There are smart people everywhere."

Over the past few years, Gogotsi has sought to bring those people together at Drexel by establishing, with Barsoum, the first two international MXene conferences on American soil. (He co-chaired four such conferences that have taken place in China, where roughly 10 times as many MXene-related papers are published each year, he says.)

In 2020, Drexel hosted a virtual conference with more than 2,000 participants and launched a series of weeklong online courses teaching researchers how to make and characterize MXenes. Last year, the in-person second edition of the conference brought to campus hundreds of scientists, journal editors and representatives from industry and funding agencies to discuss the progress thus far and how to push MXenes further. Among the issues raised at the conference was the need to improve MXene synthesis; and in its wake, two papers on the topic have already been published this year in *Science* magazine, the leading U.S. venue for publishing groundbreaking science.

MXene sessions and symposia have also begun to appear at other major conferences, Gogotsi says, including those run by the Materials Research Society, American Chemical Society and the Graphene Conferences.

"MXenes are coming of age," Gogotsi says.

When he's not traveling to conferences, seminars and lectures, Gogotsi often uses the internet to extend his reach. He recently wrapped a five-week online course for students, scientists and the public at Sumy State University in Ukraine, as part of a broader effort to support his homeland in wartime.

Gogotsi's effort to promote MXenes is partly driven by the search for what he calls a "killer application" — the use case that will force the materials onto the international stage for industrial manufacture. At the moment, MXenes are largely the province of academic scientists as research on methods to scale up production continues. For now, there is a chicken-and-egg scenario at play: many applications will require mass-scale manufacture of MXenes, but nobody is making them at an industrial scale until a proven application necessitates their manufacture.

Fullerenes, discovered in 1985 and the subject of a Nobel Prize in chemistry in 1996, serve as a cautionary tale in this regard. They are carbon atoms bound in the form of a soccer ball and their discovery introduced numerous new carbon structures for scientists to study. But although they have found some niche applications, Gogotsi says, they haven't resulted in the type of broad, practical uses that would make them a household name.

In a relatively short period of time, MXenes appear to be moving in a better direction, but the journey is still ongoing.

"The only way to solve this chicken-and-egg problem — this dog trying to catch its tail — is bottom up, for the scientific community to show that it's worth investing in this," Nicolosi says. "From there, everything will start."

PART IV: LIMITLESS POSSIBILITY

While the search for a killer application carries on, MXenes have become integral to research in a range of important fields, including biomedical devices, electromagnetic interference (EMI) shielding, printable electronics, functional fabrics, water desalination and, of course, energy harvesting and storage — their raison d'être.

"It's practically limitless at the moment," says Seon Jun Kim, a senior research scientist at the Korea Institute of Science and Technology who worked in Gogotsi's lab as a visiting researcher during his PhD in 2014 and returned four years later as a postdoc.

Murata Manufacturing Co., a nearly $40 billion Japanese producer of advanced electronics, was the first industrial partner to buy into MXenes, beginning in 2016 to invest in research at Drexel and license some of the numerous patents Gogotsi and his colleagues have acquired. As the company continues to work toward the production of parts utilizing MXenes' strengths, others have also expressed interest.

"So much research that goes on in academic labs never sees the light of day — it never crosses that valley of death to get into the commercial marketplace — and really quickly, we had a commercial partner who was trying to do just that," says Aleister Saunders, Drexel's executive vice provost for research and innovation.

For now, though, MXenes are primarily being explored in academic labs, where so much has already been discovered and so much is still to come. To many in the MXene vortex, EMI shielding — protecting electromagnetic signals from being disrupted or disruptive — offers the clearest path for these materials to leave their mark.

In early 2016, Gogotsi was still focused on using MXenes for energy storage when he listened to Koo, the Korean professor, discuss his research on EMI shielding during a seminar at Drexel. Gogotsi promptly offered him materials to test, and Koo found that MXenes delivered much better results than the composites he had been using. In a matter of months, they had published a paper in *Science* detailing the unique shielding benefits of MXenes' layered microstructure — the first time a top journal had published research on EMI shielding. Within about five years, this paper became the most cited publication in the EMI shielding field.

In a world defined by our reliance on electronic and internet-connected devices, there is a growing need for thinner and lighter materials to shield that cacophony of signals. As a building block, MXenes' use in EMI shielding could make them ubiquitous. Because of the ease with which they can be printed and processed, combined with their inherent electrical properties, they could contribute to significant leaps forward in the realm of energy storage and harvesting.

In some respects, the medical possibilities of MXenes are even more meaningful. In the early stages of their collaboration, Vitale and Gogotsi found that MXenes could be used to record brain activity as well as state-of-the-art materials like gold and platinum — or in some respects even easier and cheaper, according to Vitale. MXenes could be used to create both wearable and implantable devices with incredible customizability in terms of size, shape and application, she says — tracking brain, heart or muscle activity more simply than is currently done, all without any specialized equipment.

Various projects investigating the possibilities are now being funded by the National Institutes of Health and industry partners, including Vitale's NIH-backed development of MXene-based brain sensors that would be so easy to use that patients could do so at home or in low-resource settings without specialized neurology centers. Vitale is also developing non-invasive muscle sensors that could help identify tendon or skeletal disorders or better inform rehabilitation.

"I'm very excited about the potential of MXenes to democratize medicine and at the same time, personalize health care," Vitale says.

Pogorielov, who is investigating the use of MXenes in photothermal

therapy to treat cancer, suggests that they could be compared with antibiotics because of the diversity of powerful properties they have already displayed in a short period of time. Penicillin was discovered in 1928 and was first used as a treatment in 1941. The first research about MXenes' potential in biology and medicine, Pogorielov notes, is only six years old.

Elsewhere, MXenes are being studied for their ability to serve as gas sensors, owing to their conductivity and ability to offer gas molecules more surface sites on which to be absorbed. Kim, at KIST, is exploring the development of gas sensors that work at room temperature, which could be implanted in wearable devices or printed onto clothing to detect pollutants in the air, helping to protect people from exposure to toxins.

"The range of applications is what astounds me," Sharon Walker, dean of Drexel's College of Engineering, says of MXenes. "It clearly hit a nerve in a positive way. People are identifying it as materials that can solve the issues they have."

PART V: A DOOR OPENS

Before the discovery of MXenes, Gogotsi had done plenty of work in which he took great pride, including seminal contributions to materials for electrochemical capacitors, which are widely used in industry for high-rate energy harvesting and storage. With his Drexel colleague, Gary Friedman, professor of electrical and computer engineering, he had made advances in the ability to conduct high-resolution analysis of single cells and demonstrated how to use carbon nanotubes as tiny syringe needles to enter the nucleus of a cell. But reproducing the procedures was too difficult, and the research community didn't follow up on his work.

With MXenes, however, he proved with Barsoum, Naguib, his students and post-docs that materials can be designed atom by atom, combining elements and structures in whatever composition is desired, like a farmer offering chefs around the world the exact ingredients they want to make the dish of their dreams. Theoretically, he says, there are at least a thousand ways to craft a MXene to its user's preference, each with its own unique potential.

"The sky is the limit," Gogotsi says. "We really opened a totally new way of designing and making two-dimensional materials."

When Naguib considers the discovery of MXenes, he describes experiencing "something like euphoria," he reflects. "…This feeling that you are pushing forward, opening the door for people, and you see behind you thousands of people are entering."

Those people are the community of MXene researchers reaching across boundaries of space and science to use some of the smallest materials in the world to solve some of its biggest challenges, with Gogotsi their great conductor.

He's now far removed from the young boy who fell in love with chemistry back in Ukraine, but he retains all of the same energy. Like a poet who writes because he feels compelled, Gogotsi can't fathom doing anything else but continuing to explore the potential of MXenes and encourage the community he's built to do the same.

"It's a true passion for science," he says. "This is life." ✕

_A Simpler, Greener Wonder Material?

One of the most intriguing new materials to emerge from MXene co-inventor Michel Barsoum's lab isn't a MXene at all. But it could be just as revolutionary as the nanomaterial that inspired it.

BY BEN SEAL

Michel W. Barsoum is among the trio of Drexel scientists who discovered MXenes in 2011, but these days he's captivated by something else: a new method to make nanomaterials he's dubbed HDN that could be the key to sustainable, affordable hydrogen generation.

Like MXenes, nanomaterials made using this approach come with unique and customizable properties. But unlike MXenes, this method requires nothing more than inexpensive, abundant materials, modest heat and time. And it has significant potential for energy, water purification and environmental remediation, says Barsoum, Distinguished Professor in the Department of Materials Science and Engineering in Drexel's College of Engineering.

For Hussein Badr, who pioneered the HDN technique in Barsoum's lab, the simplicity of its formula is what makes it so special. Years ago, when he was a research assistant at Cairo University, he was brought short by one of the biggest limitations of MXenes. Like many research labs in countries with limited resources, his had no fume hood — an essential tool for working with hydrofluoric acid, the highly toxic chemical required to synthesize MXenes. The acid is so corrosive it will dissolve a glass container, and its fumes can kill if inhaled in large amounts.

That experience remained with the Egyptian native after he came to Drexel as a doctoral student to study under Barsoum. Barsoum had discovered MXenes with fellow researcher Yury Gogotsi and their doctoral student Michael Naguib a dozen years earlier, and before that, he developed MXenes' three-dimensional precursor, MAX phases.

"We are losing half of the [world's researchers] because we're using one nasty chemical," Badr says of hydrofluoric acid.

The difficulties of working with the acid were not lost on Barsoum, either, nor on industry partners who were challenging him to find safe, scalable ways to make MXenes.

In 2019, Barsoum and Badr set out to find a method that could eliminate flourine from MXene synthesis.

One year and hundreds of experiments later, Badr stumbled onto a simple and versatile new recipe for making nanomaterials: Place any titanium-containing material, such as titanium boride, and an organic salt, such as tetramethylammonium hydroxide, into a plastic bottle. Heat it to between 50 and 80 degrees Celsius for a few days. Then wash it in alcohol to restore its pH to a workable level.

Through this "idiot-proof" process, as Barsoum describes it, emerges what he and Badr have termed a "hydroxide-derived nanomaterial," or HDN. A wide variety of compounds, not only titanium, but also silicon or manganese or iron compounds, can be converted into a plethora of low dimensional materials by simply reacting them in a high pH solution. Barsoum's focus is on titanium dioxide for now. Additional steps can be incorporated into the process to control the crystallinity, structure and morphology of the final product.

The recipe yields strands of atoms-thin titanium dioxide that Barsoum likens to a familiar food — "the finest spaghetti ever made," he says. Allowing the alcohol to evaporate results in a balled-up collection of those spaghetti strands. Diluting the material in water, instead, creates a colloidal suspension that, when filtered, results in broader two-dimensional rafts that look something like lasagna noodles composed of individual spaghetti strands, featuring an impressive surface area that holds incredible potential.

Each form offers its own properties, giving researchers the ability to finely tune their creation, depending on its intended purpose.

The food metaphors are apt, given that the entire process requires basic tools available to any home cook. Badr used to tell people it was as easy as boiling an egg. It's actually even easier, he points out, because less heat is needed.

"It may sound mundane, but I love the idea that I can make a nanomaterial by the kilogram in my kitchen," Barsoum says. "Those words have never been spoken in a single sentence before."

After learning how to make HDNs, Barsoum and Badr turned to exploring what they could accomplish with them, using funding from the National Science Foundation, the U.S. Army, Drexel and an industry partner.

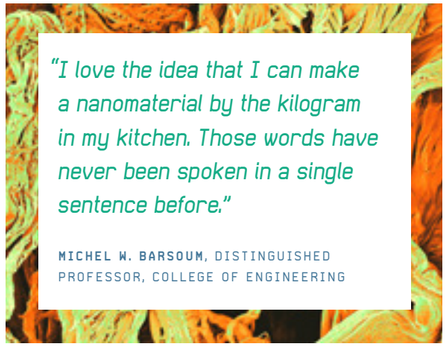
Today, nanoscale titanium dioxide — known as P25 — is widely considered the gold standard in some of the applications that are being explored here. Given the easy path to creating the HDN version and its superior properties, including a surface area 20 times greater than commercially sold P25, the entire history of scientific research and thousands of papers on a huge range of topics and applications for the material could be replicated, Badr says. Using the more powerful HDN version could potentially set new standards in many applications.

Perhaps the most meaningful possible application for HDNs is as a stable and inexpensive catalyst in reactions that generate hydrogen. When HDNs in their "spaghetti" form are placed in water and methanol and exposed to sunlight, they create hydrogen at a rate at least one order of magnitude better than than titanium dioxide, Barsoum says.

Considering the Department of Energy's quest to reduce the cost of clean hydrogen to $1 per kilogram in the next decade, the potential for clean energy is clear.

BATTERY SCIENCE

Imagine a next-generation solar panel system: "In a few years, if this works as well as we think it will, we could be looking at shallow swimming pools in a sunny spot in your yard that generate hydrogen from the sun," Barsoum says. "Once you have the hydrogen, you can now put it in your tank and run your car on hydrogen. The exhaust is water. This so-called solar hydrogen economy has been and remains, a dream of mankind for a long time."



> *"I love the idea that I can make a nanomaterial by the kilogram in my kitchen. Those words have never been spoken in a single sentence before."*
>
> **MICHEL W. BARSOUM**, DISTINGUISHED PROFESSOR, COLLEGE OF ENGINEERING

HDNs have also proven to be more efficient than standard methods for a process called dye degradation, which can help prevent harmful chemicals from being released into the ecosystem. Because of their high surface area, HDNs can absorb roughly one gram of dye per gram of material — a major step forward. The materials have shown a similar propensity for absorbing uranium from water, which would be a boon to the nuclear industry and in the protection of drinking water systems.

The materials are also biocompatible, opening the door to their use in the biomedical field. They have already been tested and showed promise in cancer therapy, immune cell activation and stem cell differentiation, Badr says.

Just a few short years since the discovery of HDNs, multiple patents have been submitted, and papers are rolling in for Barsoum and his colleagues as they continue to explore the materials' potential and the mechanisms behind the way they work. The group has already improved their recipe to simplify the process and make it even more affordable.

Meanwhile, they now have more than 100 collaborators around the world — a number that grows as scientists discover the ease of working with the material. Badr says he has spoken with researchers in Benin, Egypt, Saudi Arabia and Morocco, among others, who have now learned to make their own HDNs. With industry partners taking interest as well, HDNs are firmly on the fast track.

"Making a kilogram of any new material, let alone a nanomaterial in your 'kitchen' two or three years after discovery is a huge deal," says Barsoum.

"The fact that within a year or two of our discovery, we're talking to people about commercialization proves our scalability, affordability, process, ease of making them, stability and technical results," Badr says. "It also shows that the real world is interested in what we're doing." ✕

_Charging While Driving

Drexel is leading the development of a more forgiving wireless charging system for electric vehicles that could one day enable in-road charging.

An international team led by engineers at Drexel is tackling EV "range anxiety" with a vision of ubiquitous wireless charging built directly into roads.

Their project, reported in the journal *IEEE Transactions on Industrial Electronics*, offers a solution to one of the fundamental physical challenges facing all wireless charging technology: misalignment.

Anyone who has accidentally placed their phone on a charging pad a little off kilter — and returned to find it uncharged — can relate. Getting an electric vehicle to line up perfectly over a wireless charger can be an even more challenging task.

The researchers, from Drexel's College of Engineering and from Shanghai Jiao Tong University, Zhejiang University and Northwestern Polytechnical University in China, designed a more forgiving charging system that is versatile enough to adjust the way it delivers an inductive charge, so that it can accommodate misalignment and various levels of battery charge.

Inductive charging works by using an electromagnetic field to transfer power, similar to the way wind or water might push a turbine to generate electricity. An induction coil receives the electromagnetic "push" from the charger and transforms that vibration into energy that charges a battery.

But, like a misaligned turbine that misses the full force of the wind or water, inductive charging coils that are not properly coupled will not efficiently charge the battery and — with enough misalignment — they may fail to activate the charging process at all.

What the researchers discovered, however, is a method that allows for control over to the frequency of the field, or how quickly or slowly the voltage is being transferred, which can be adjusted for misalignment or how charged the battery is.

"Think about our wireless charging challenge like trying to fill a small glass with water under a tap that's going at full blast," explains Fei Lu, an assistant professor at Drexel who is one of the lead researchers. "It can be quite tricky, because if you don't hold it directly under the tap a lot of water will miss the glass. And once it is nearly full, the force of the stream will splash water out of the glass without it ever being filled to the brim."

"The key to our system is that it provides more control over the tap — or the charging power, as it were — so it's easier to direct more of the flow into the glass and slow it down as the glass becomes full," she says.

They tested the system on both charged and uncharged batteries, under well-aligned and misaligned conditions. The prototype was able to provide a stable power input from 0 to 3.3 kilowatts, which is the standard charging range for plug-in EV charging, with nearly 96% efficiency — on par with commercial wireless chargers and only slightly below that of plug-in chargers.

"Being able to vary the voltage yet maintain the power of the charging system means that this process could be used to efficiently charge both near-dead batteries and those that just need a top-off," Lu says. "We see this as a critical step in making inductive charging more resilient in real-world conditions." — **BRITT FAULSTICK**

_Behold the Battery Chassis

A battery that doubles as the car frame, combined with its own integrated cooling system, would solve the weight, capacity and durability limits of conventional electric vehicle batteries.

Packing enough energy into a battery to power a car puts a lot of pressure on the storage devices that, for the last century or so, have mainly been tasked with running small appliances and electronics. The stress is getting to them — manifested in malfunctions, diminished performance and even meltdowns.

Researchers are devising ways to improve battery performance by taking some of the literal heat off them.

A team led by Assistant Professor Ahmad Najafi outlined an approach for incorporating a blood-vessel–like cooling network into the packaging of a new generation of solid carbon-fiber–based batteries.

Their method, described in the journal *Composites Part B: Engineering*, relies on using solid batteries — a thin, carbon fiber-based version of the larger lithium-ion batteries widely used in electric vehicles — that can be cleverly incorporated into the physical structure of the vehicle chassis.

Replacing portions of the car frame with a carbon-fiber composite that functions both as a structural component and as a battery could reduce the overall weight of the vehicle as well as improve its energy-storage capacity. Trimming car weight by just 10% can boost mileage efficiency between charges by an estimated 6–8%.

There's just one problem: Heat.

"Heat generation will be substantially higher in structural batteries in comparison with standard lithium-ion batteries," Najafi explains. This is because the conductivity of the polymer electrolyte they use as their medium of electron transit is much smaller than that of the liquid electrolytes used in lithium-ion batteries. So electrons are forced to move more slowly through the polymer and, as a result, they generate more heat as the battery discharges.

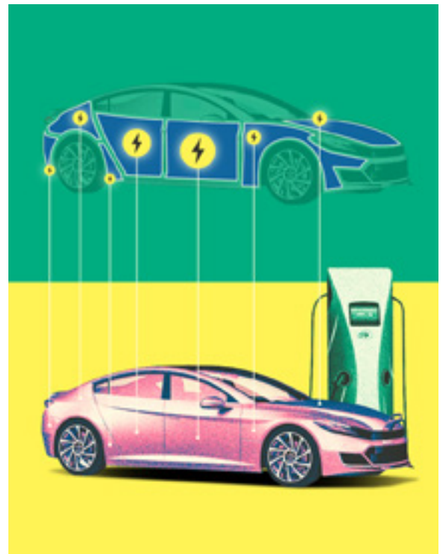
Some kind of thermal-management system, therefore, is necessary.

Najafi's research group has been developing special composite materials for heat management for a number of years. Their work draws on nature's own cooling method: the vascular system. Modifying a design tool they invented to plot the optimal "microvascular" network, the researchers were able to design cooling composites that would work as part of the structural battery packaging currently being tested by companies like Tesla, Volvo and Volkswagen.

"These composites function something like a radiator in an internal combustion engine vehicle," Najafi says. "The coolant draws in the heat and pulls it away from the battery composite as it moves through the network of microchannels."

Sandwiching the structural batteries between layers of cooling microvascular composites can stabilize their temperature and extend their functional time and power range.

Computer models show their system could improve the driving range of a Tesla model S by as much as 23%. But the team notes that the real value of their work is its ability to glean the best combination of battery size and weight — including enough cooling capacity to keep it functioning — for any electric vehicle in production now and any future designs. — **BRITT FAULSTICK**



_A TURN TOWARD CUSTOM ANKLE IMPLANTS

An engineering professor opened ***the door to durable, custom joint replacements*** *after correcting a long-held misunderstanding of ankle anatomy.*

_SORIN SIEGLER
_BRIAN GARVEY
Siegler is a professor of mechanical engineering and mechanics in the College of Engineering. Garvey (BS/MS '12) is senior vice president of restor3d.

An ankle implant inspired by the insights of Sorin Siegler, a mechanical engineering professor in Drexel's College of Engineering, is continuing its forward march into new areas of personalized medicine. And so, nimbly now, are the patients who have received the pioneering implant.

The Kinos Axiom Total Ankle System received FDA approval in June 2020, clearing the way for orthopedic surgeons to implant the devices in patients with arthritic or injured ankles. As of July 2022, more than 200 patients had received the ankle implants, with many surgeons clamoring to provide them.

The implants reflect a discovery Siegler made in 2013 that upended the medical community's understanding of ankle anatomy. Siegler used MRIs, CT scans and 3D renderings of the scans to demonstrate how the talus bone that forms the centerpiece of the ankle joint is shaped and oriented differently than what had been believed for many decades. In so doing, he helped revive interest in ankle replacement surgery, which had accrued a poor track record and fallen out of favor. For years, many patients with damaged ankles opted instead to undergo fusions, which robbed them of the flexibility to run, jump or dance.

Kinos Medical, the company established in 2017 to develop and commercialize implants based on Siegler's discovery, launched the product in late 2020. Kinos then was acquired by and merged in May 2021 with restor3d [sic], a North Carolina-based developer of personalized orthopedics.

The merger is making it possible to revolutionize treatment for patients who need ankle replacements, says Brian Garvey, BS/MS '12, a former student of Siegler's and founder of Kinos who now serves as senior vice president of product development and a board member at restor3d.

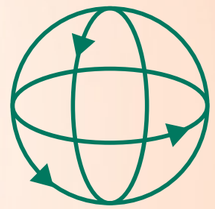
"Our implant is the first to provide motion in all three anatomic planes," Garvey says, referring to clockwise and counterclockwise foot rotation, the ability to walk en pointe and flex the toes upward and to turn the sole inward or outward.

The company's expertise in 3D printing will allow for the design of implants customized to individual ankles, Garvey says, while its ongoing partnership with Drexel supports research to evaluate diverse aspects of biomechanics, which will strengthen the diagnosis and treatment of orthopedic patients. In addition, he adds, biomaterials restor3d is developing will allow implants to last longer, making them suitable for use in younger patients.

The ongoing research in Siegler's lab has helped restor3d establish an advanced manufacturing model that the company aims to adapt to other joints.

"We hope to keep providing this new and advanced technology to the surgeons and the patients who need it the most," Garvey says.

_NO FRICTION
The implant is constructed of two metal parts that sandwich a plastic component in the middle.



_WALK, SPIN, HOP
This ankle implant is the first to provide motion in all three anatomic planes, referring to clockwise and counterclockwise foot rotation, the ability to walk en pointe and flex the toes upward, and to turn the sole inward or outward.

_FIGHTING ADDICTION STIGMA

*Students at the College of Medicine are **destigmatizing opioid use disorder** to improve overdose reversal training and advocate for new treatments.*

BRIAN STAUFFER

In the face of a relentless epidemic, an overdose-prevention group staffed by College of Medicine students has evolved beyond street medicine into research and publications aimed at tackling stigmas that harm the recovery chances of those addicted to opioids.

The Naloxone Outreach Project formed in 2017 to show businesses and residents in neighborhoods hard hit by the opioid crisis how to administer Narcan, a life-saving overdose reversal treatment. The project is run through the College of Medicine's Health Outreach Project.

The Naloxone Outreach Project students have since made important contributions to overdose prevention research by examining ways to reduce stigmas surrounding opioid use disorder.

For instance, they measured the impact of training designed to promote empathy among health care professionals and medical students. In one study, they joined peers from Cooper Medical School of Rowan University in providing naloxone training in tandem with education about the history and causes of the opioid epidemic.

"I think the training does a great job of going into the history of the opioid crisis, and humanizing people with opioid use disorder," says Associate Professor Annette Gadegbeku, who advised the students.

The 2022 study, appearing in the *Harm Reduction Journal*, measured the impact of combining stigma-reducing education with overdose reversal training.

"Our training is more involved and holistic than simply showing participants: 'Here's how to use Narcan,'" says medical student and doctoral candidate Ben Haslund-Gourley. "In almost every instance, participants increased their desire to empathize and help people after the training."

Later that year, Drexel students published longitudinal research in the *Harm Reduction Journal* that demonstrated that some effects of that training diminish over the course of three months, suggesting the need for ongoing reinforcement and follow-up.

The group continues to press scientists and practitioners in their field for better medical solutions to the crisis. In a September 2022 article in *Chemical Engineering Progress*, Haslund-Gourley, his classmate Kyle Samson and Professor Sujata Bhatia called upon the medical and chemical engineering communities to invest in research into non-addictive alternatives to opioids, to expand access to medications that treat addiction and to combat stigma against opioid use disorder among doctors.

"More physicians should re-examine their preconceptions and beliefs surrounding individuals with opioid use disorder," they wrote. "Individuals with opioid use disorder are human beings stuck in a destructive loop of dangerous decisions because they lack better alternatives. It is the role of physicians to provide treatments, support and respect for all individuals."

_ESTROGEN AND BRAIN INJURY

*Targeting hormones may help **alleviate or prevent depression** in women and girls with brain injuries.*

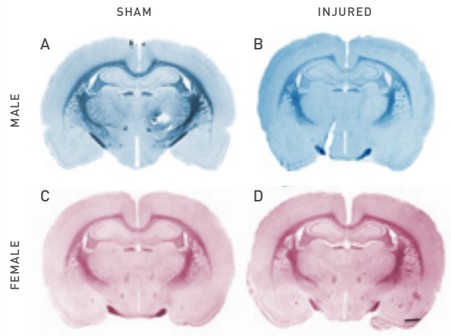
Researchers in the College of Medicine who have studied traumatic brain injuries for decades are revealing new insights about how and why the brains of male and female concussion patients recover differently.

Using swim and maze tests, Professor Ramesh Raghupathi and colleagues found that female rats with past adolescent traumatic brain injury were more likely to develop depression-like behavior in adulthood than their male counterparts. They also found that this behavior — recorded six weeks after the injury — took place during the estrus phase of the reproductive cycle, which occurs after estrogen and progesterone hormone levels drop in the body, suggesting a depression-like characteristic.

The team took this knowledge a step further, blocking estrogen and progesterone receptors with the drugs tamoxifen and mifepristone during the proestrus phase, when these hormones would otherwise be at their highest levels. This intervention prevented depression-like behaviors that previously occured only in specific phases of the reproductive cycle — right after the increase in estrogen and progesterone.

"Hormones play a critical role in regulating depression after a traumatic brain injury," says Raghupathi, who reported his findings in the *Journal of Neuroscience Research* in 2022. "Therapies that target these hormones may help alleviate or even prevent depression for millions of women and girls suffering from a history of these brain injuries."

The researchers determined that the behavioral changes were triggered by a combination of injury and hormones in the estrous period — not the injury or reproductive cycle alone.



When young male and female rats experience traumatic brain injury (shown in brain slices B,D), female rats were more likely to succumb to subsequent depression. It is theorized that regulating hormones during the proestrus phase may be a more targeted treatment than long-term anti-depressants.

_PATCHED UP HEARTS

*Motivated by the delicacy of infant heart surgery, an interdisciplinary team patented **an internal patch that makes repeat operations safer** and faster.*

The natural hazards of performing open-heart surgery multiply when the patient needs repeat operations, as when an infant is born with congenital defects.

"Scar tissue is the enemy," says College of Medicine Assistant Professor Randy Stevens, noting that tissue that develops during the healing process can nearly fuse the heart with the sternum itself. Complicating matters further is the fact that the pericardium — a sac protecting the heart — must be opened during an initial cardiac surgery, leaving the organ vulnerable to any slip of the knife.

As a pediatric cardiothoracic surgeon, Stevens hoped to make re-sternotomies easier for surgeons and safer for patients. He was also aware that colleagues performing the procedure on adults sometimes opt for inserting a stent through a groin, which is less risky but may have a short-lived payoff.

He envisioned a patch that could protect the pericardium and incorporate a built-in guidance track that would help steer the surgical tools his peers use during re-sternotomies.

Using paper napkins and plastic drinking straws, he fashioned a rudimentary model in the shape of a butterfly. He deliberately included a fold in the napkin, to accommodate organ growth. This is a critical step, since neonates with severe congenital conditions such as tetralogy of Fallot with pulmonary atresia — the condition with which comedian Jimmy Kimmel's son was born — are likely to need multiple surgeries.

This rudimentary diagram forms the basis of the patent for Randy Stevens' pediatric surgical patch.

The prototype includes accordion pleats and tubes that can be used to guide surgical tools.

A fold in the material of the patch allows it to expand as a child's chest grows. Stevens' preliminary design made from napkins and drinking straws guided later prototypes.

The patch remains inside the patient's chest cavity for protection after each surgery, allowing any future surgery to be performed with a built-in tool kit. Because the butterfly patch gets attached to the sternum, it provides an enduring layer of protection between the knife and the heart.

Tubes incorporated into the patch form channels into which attachments for a saw ease and speed the surgical process. This is vitally important, since time is of the essence during open-heart surgery.

To craft a workable design from his sketches, Stevens turned to Amy Throckmorton, professor of biomedical engineering and director of the BioCirc Research Laboratory in the School of Biomedical Engineering, Science and Health Systems. Having dedicated her career to devising new therapeutic strategies for pediatric patients, Throckmorton has gained extensive know-how in designing and patenting cardiovascular pumps and other medical devices.

Throckmorton invited undergraduate design students Youssef Jouichate, Rahul Akkem, Felix Agbavor, Shamayel Alroomi and Daniel Graciano to design, build and test a prototype of the butterfly patch that includes accordion pleats and tubes that can be used to guide surgical tools.

After patenting the design in December 2021, the team is leveraging Drexel's Coulter-Drexel Translational Research Partnership to steer the butterfly patch toward commercialization. The group engaged a market research consultancy that conferred with 10 cardiac surgical specialists who agreed the need is great among pediatric patients. Next step: Attract a company interested in manufacturing the patch and revolutionizing re-sternotomy procedures for pediatric patients.

_FINDING EARLY ALZHEIMER'S

*The natural language AI algorithms behind the chatbot program ChatGPT can help doctors **spot early Alzheimer's disease**, researchers find.*

_HUALOU LIANG
_FELIX AGBAVOR
Liang is a professor of biomedical engineering in the School of Biomedical Engineering, Science & Health Systems. Agbavor, a doctoral student, collaborated on the research.

A team from Drexel's School of Biomedical Engineering, Science and Health Systems has used a popular chatbot program to identify clues from spontaneous speech that predict early stages of dementia, with 80% accuracy.

The team's work, reported in the journal *PLOS Digital Health*, is the latest in a series of efforts to show the effectiveness of natural language processing programs in spotting speech delays and other verbal tics that are indicative of neurodegenerative disorders.

The researchers tested their theory by training OpenAI's GPT-3 with recorded speech transcripts from people exhibiting varying stages of Alzheimer's decline. From that, GPT-3 generated a characteristic profile of Alzheimer's speech. That was then used to retrain the program — turning it into an Alzheimer's disease screening machine.

The process was demonstrated to reliably predict those who have Alzheimer's disease and those who don't.

The team also found that GPT-3 was 20% more accurate in predicting the severity of disease than an alternative analysis based solely on the acoustic features of the recordings, such as pauses, voice strength and slurring.

The team's findings could speed Alzheimer's diagnosis, currently a lengthy process that involves a medical history review and a host of physical and neurological tests. Spotting the disease early would give patients more options for therapeutics and support.

To build on these promising results, the researchers are planning to develop a pre-screening tool that could be used at home or in a doctor's office.

_AN EARLY TEST FOR LYME

*A prize-winning new test for **Lyme disease** could help doctors make a speedy diagnosis of the tick-borne disease.*

_MARY ANN COMUNALE
Comunale is an assistant professor in the Department of Microbiology & Immunology in the College of Medicine and director of the Center for Scientific Communications and Outreach.

College of Medicine researchers have devised a test that can detect Lyme disease when the infection is still ripe for treatment with antibiotics.

Doctors have long struggled to diagnose Lyme because it becomes virtually indiscernible once the *Borrelia burgdorferi* bacteria that carry it enters the bloodstream. Standard testing misses the early stages of infection about half the time, and the tell-tale bullseye rash associated it with does not always appear. The disease therefore often goes undiagnosed until it's too late for antibiotics to have the greatest effect.

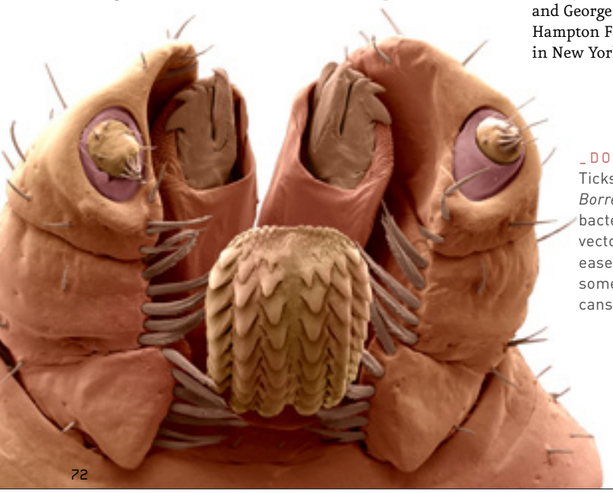
A team led by Assistant Professor Mary Ann Comunale devised a diagnostic test that focuses on the behavior of glycans, carbohydrate-based modifications found on proteins which react to an infection by promoting the immune response. The team found that Lyme actually has an opposite effect on glycans, which hinders the immune response and buys the disease more time to spread in the body.

"The test specifically focuses on the Lyme bacteria's dysregulation of the immune system before the body produces antibodies to the bacterial antigens, in a process known as seroconversion," Comunale says. "This allows for earlier detection than other tests. The test will also monitor response to a treatment and can distinguish between diseases with similar symptoms."

The method — which does not depend on the detection of *Borrelia*-specific antibodies — emerged as one of 10 top performers in the LymeX prize competition sponsored by the U.S. Department of Health and Human Services and the Stephen and Alexandra Cohen Foundation to accelerate the development of Lyme disease diagnostics.

Early results indicate that Drexel's method could be more than 80% accurate at detecting a Lyme infection in its early stages and that it can differentiate between a past infection and reinfection.

The prize award from LymeX and support from the Coulter-Drexel Translational Research Partnership Program are aiding Comunale and her team, which includes doctoral students Benjamin Haslund-Gourley and Jintong Hou; Joris Beld, assistant professor of microbiology, College of Medicine; Kevin Owens, associate professor of chemistry, College of Arts and Sciences; Anand Mehta of the Medical University of South Carolina; and George Dempsey of East Hampton Family Medicine in New York.



_DOGGED BITERS
Ticks carrying the *Borrelia burgdorferi* bacteria are a prime vector for Lyme disease, which infects some 500,000 Americans annually.

_EDITING GENES TO CURE HIV

*Three Drexel scientists are playing instrumental roles in a nationwide quest to **conquer HIV using CRISPR** gene-editing technology.*

Researchers in the College of Medicine are advancing a multi-institutional, NIH-funded effort to use CRISPR gene-editing technology to cure HIV.

A cure for HIV would improve and extend the lives of some 38 million infected people worldwide. While existing antiviral therapies suppress HIV effectively, they must be taken daily for the duration of a patient's life, carrying long-term toxicity, cost and stigma.

Three faculty members — Brian Wigdahl, Michael Nonnemacher and Will Dampier — are developing a treatment that targets a large swath of HIV virus strains known as quasi–species, using CRISPR/Cas9.

CRISPR uses a protein called Cas9 and a guide RNA (gRNA) to target the HIV "hiding" in host DNA. The researchers have found a way to target sequences in the HIV provirus located in the chromosomes of infected cells and then produce irreversible edits that prevent virus replication or eliminate the virus from the cell altogether.

By removing the virus from the host cell, Dampier says, "CRISPR fits into a cure strategy niche that no other treatment can fulfill."

By targeting the viral quasispecies present in people living with HIV, the treatment could help a broad spectrum of individuals. Dampier and Nonnemacher spearheaded a group who devised an algorithm to identify gRNAs with the greatest potential to work with CRISPR. To design the algorithm, they gleaned gene-sequencing data from individuals treated through the Partnership Comprehensive Care Practice that the College of Medicine established in 1993 to serve Philadelphia residents.

> "CRISPR fits into a cure strategy niche that no other treatment can fulfill."
> -WILL DAMPIER

The trio are among a "supergroup" — including investigators at Temple University and other academic institutions, a research institute, and a biotech company developing the CRISPR for Cure project — that has been awarded $4.8 million annually for five years from the National Institutes of Health.

It may take a combination of therapeutic strategies to achieve a "cure," Wigdahl says, explaining that effective cell and gene therapies may be needed to enhance HIV immune control mechanisms and eliminate the viral genome from infected cells, in addition to vehicles that can deliver therapies to the tissue and circulating cell reservoirs where the virus hides.

_STARVING BREAST CANCER IN THE BRAIN

Cancer biologist Mauricio Reginato is studying an enzyme that could be key to **stopping breast cancer cells** once they spread to the brain.

There is an urgent need for novel treatments for breast cancer brain metastasis, which can kill within months.

Professor Mauricio Reginato, his colleagues and student researchers have made promising discoveries involving the enzyme acetyl-CoA synthetase 2 (ACSS2). This enzyme converts acetate into acetyl-CoA, a source of energy for brain tumors because most sugar in the human body is consumed by the brain.

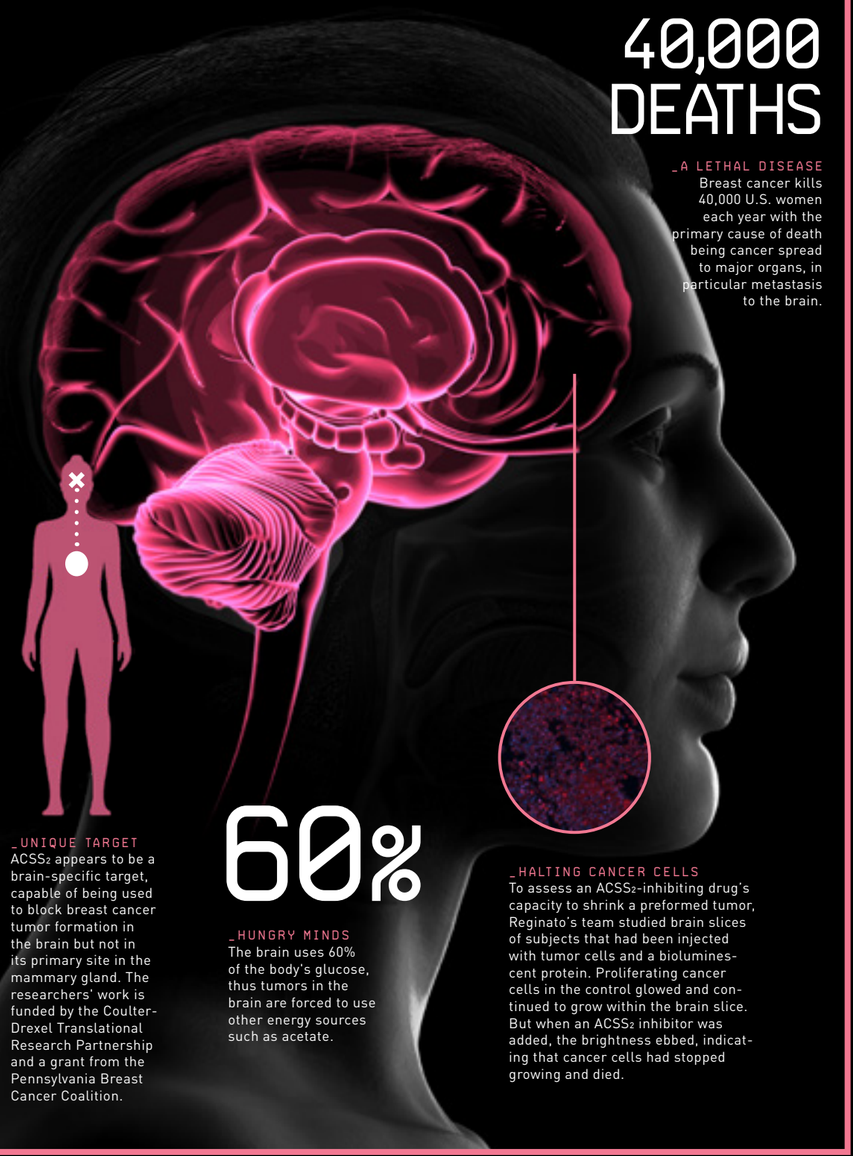
"Tumor cells use the sugar glucose as a source for fuel," Reginato explains. "But in the brain, they're outcompeted, so they have to use other metabolic sources, like glutamine or acetate."

The team was trying to target ACSS2 to prevent tumor growth, when they saw that it was not only stopping the growth but also causing cell death.

They successfully validated their results genetically in brain tumors and reported findings in the journal *Oncogene* in 2022.

Reginato ultimately hopes to block tumor cells with drugs targeting ACSS2, by elevating proteins that kill off cancer cells.

He and colleagues have developed compounds that can cross the blood-brain barrier while targeting ACSS2 and are currently testing whether these new drugs will work synergistically with current treatments such as radiation or FDA-approved drugs.



40,000 DEATHS

_A LETHAL DISEASE
Breast cancer kills 40,000 U.S. women each year with the primary cause of death being cancer spread to major organs, in particular metastasis to the brain.

_UNIQUE TARGET
$ACSS_2$ appears to be a brain-specific target, capable of being used to block breast cancer tumor formation in the brain but not in its primary site in the mammary gland. The researchers' work is funded by the Coulter-Drexel Translational Research Partnership and a grant from the Pennsylvania Breast Cancer Coalition.

60%

_HUNGRY MINDS
The brain uses 60% of the body's glucose, thus tumors in the brain are forced to use other energy sources such as acetate.

_HALTING CANCER CELLS
To assess an $ACSS_2$-inhibiting drug's capacity to shrink a preformed tumor, Reginato's team studied brain slices of subjects that had been injected with tumor cells and a bioluminescent protein. Proliferating cancer cells in the control glowed and continued to grow within the brain slice. But when an $ACSS_2$ inhibitor was added, the brightness ebbed, indicating that cancer cells had stopped growing and died.

PUTTING THE 'TREAT' INTO TREATMENT

MOVE OVER, ENSURE. THE FOOD LAB IS CHURNING OUT LIQUID **NUTRITION SUPPLEMENTS** FOR CANCER PATIENTS OR THE ELDERLY THAT LOOK AND TASTE LIKE **DELICIOUS ICE CREAM DESSERTS**.

WRITTEN BY **BEN SEAL** PHOTO ILLUSTRATION BY **DOUG CHAYKA**

WE ALL KNOW ICE CREAM IS THERAPY for the soul. It spreads joy, brings people together and can brighten any mood. But what if it were literally part of a healthy treatment plan for disease or poor nutrition?

That's the question the Drexel Food Lab is attempting to answer with its latest innovation: an ice cream packed with health benefits that can make people feel good in more ways than one.

By delivering protein, calories, vitamins and nutrients in a tasty package with modest levels of fat and sugar, the "functional ice cream" dreamed up by Food Lab Director Jonathan Deutsch and a team of staff and students can stand in for protein drinks like Ensure and Boost that may fall short on the deliciousness scale for many patients. The Food Lab's frozen concoction could win over an audience including elderly individuals in need of extra nutrition, cancer patients hoping to maintain their health during treatment and even athletes — basically, anyone who would benefit from a burst of nutrients in a flavorful form.

"We want this to be something that can make people feel good and be delicious," says Food Lab Manager Rachel Sherman. Her favorite flavor? Heath bar crunch.

The ice cream has been in development for five years and evolved out of a conversation between Deutsch (favorite flavor: chocolate) and an executive at the Minnesota-based insurer UnitedHealth Group. The company was discouraged by how much health care money was wasted on supplements that stack up, unused, in the corners of people's homes. What would entice those people to actually ingest the nutrition they need?

Deutsch, who is a professor in the departments of Food

and Hospitality Management and Nutrition Sciences, was the right person to turn to in search of a solution. The Food Lab works on projects with attributes of sustainability, access or health. The request from UnitedHealth fit squarely into the last group, so Deutsch got to work with his team.

The project boiled down to a simple question, says Robert McGrath, the senior associate vice provost for technology management at Drexel Applied Innovation, which oversees tech commercialization at the University: "Can you deliver a similar outcome in a tastier package?"

Deutsch turned the question over to students in his food product development course in fall 2017 and worked with them to find foods that might fit the bill. The research involved experimenting with several ideas for functional food products that could replace the common (and commonly disliked) oral liquid nutrition supplements: a Nutella-style chocolate spread, coffee creamers, a trail mix-inspired quickbread full of seeds and fruit, high-protein pancakes and waffles, and smoothies.

"We had a lot of good ideas," Deutsch says, "but not all of them were feasible and not all of them were appealing."

Ice cream, however, consistently scored well in consumer testing — no surprise there. The Food Lab found it could offer the same macronutrient profile found in Ensure and Boost drinks, but in a food that fit nicely into people's lifestyle. It could be shared with friends and family as part of a meal, eliminating the isolation some patients feel while supping on nutritional shakes. And it fit more naturally into a daily habits, especially among the elderly.

Through ethnographic research with seniors over the age of 80, students learned that the "early-bird special" stereotype among elderly individuals is based in real behavior. Seniors they interviewed tended to eat dinner around 5 p.m. and sit down with a bowl of ice cream to watch television around 8 p.m. A shake might not have a place in that routine, but a serving of chocolate ice cream with brownie chunks sure does.

THE RECIPE

The Food Lab's high-protein ice cream is not the first of its kind to market, Deutsch says, but he believes it offers consumers an improvement on anything currently available.

Some options currently on the market use protein in the ice cream itself, which creates a graininess — not the creamy base everyone craves. And no one offers functional ice cream with "inclusions" — the chunks of goodness that make ice cream a textural treat.

"You go through your entire adult life having the flavors you want," Deutsch explains — flavors like butter pecan, rocky road and moose tracks — "and then you have to eat something therapeutic and it has no texture and nothing interesting going on."

The Food Lab's ice cream keeps things culinary by including a brownie mix-in developed by former Drexel Food Lab manager Alexandra Zeitz Romey that is the primary source of its nutritional benefits.

With a general concept of the functional ice cream in place, the project turned over to Sherman, a former pastry chef who serves as research chef for the Food Lab. Testing and refining an ice cream recipe was right in her wheelhouse.

"I love ice cream," Sherman says. "It's one of my favorite things to play with and to make."

Using nutrition software, she identified the various flours and powders that could pack a punch in the brownie bits that go into the ice creams, eventually landing on chickpea flour, sunflower seeds, flax oil and a fiber supplement called Fibersol as the key ingredients, alongside chocolate and cocoa powder. With students' help, she tested at least 20 recipes to reach the right result, using focus groups to ensure each flavor would delight the tastebuds. The lab developed recipes for chocolate, vanilla, strawberry, cherry and banana. ("We weren't sure about banana," Sherman says, "but bananas add so much texture that they were actually really perfect for this kind of ice cream.")

> "You go through your entire adult life having the flavors you want and then you have to eat something therapeutic and it has no texture and nothing interesting going on."
>
> **JONATHAN DEUTSCH** FOOD LAB DIRECTOR

The classic vanilla and chocolate flavors will be first to be released.

THE RESEARCH

With an ice cream recipe in hand, Deutsch sought the support that could take it from the Food Lab's freezers to consumers' couches. He turned to Kathie Jordan, the then-head of the Coulter-Drexel Translational Research Partnership program, to secure a $165,000 grant for a clinical trial to demonstrate the ice cream's potential.

The Coulter program typically supports the development of medical devices and diagnostics, small-molecule therapeutics and products in the wellness space, but, as Jordan (favorite flavor: coffee) points out, "This one really meets a medical need."

Deutsch gathered an interdisciplinary team that paired the Food Lab with Rose Ann DiMaria-Ghalili, professor and senior associate dean for research in the College of Nursing and Health Professions, who would lead the trial; Kathleen Fisher, a professor focused on nursing; Brandy-Joe Milliron, an associate professor focused on nutrition; and partners from the private sector who would help take the ice cream to market.

With a cohort of older adults, the clinical trial sought to compare the ice cream against the top oral liquid nutrition supplements. They used health effects for comparison — using gauges like grip strength, frailty measures and weight maintenance. They also compared the products on what Deutsch calls "palate fatigue."

Because the ice cream doesn't need approval from the U.S. Food and Drug Administration, the clinical trial isn't required for commercialization, but "we don't want to market something that we don't feel good about," Deutsch says. The goal is to demonstrate that the ice cream can make a meaningful difference for patients while overcoming the unappealing flavor and format that dooms most supplements to the back shelves of patients' pantries.

THE MARKET

In her research on nutrition in cancer survivorship, Milliron (favorite flavor: coffee) hears a common complaint from patients and caregivers when standard nutrition supplements come up: "They don't taste good," they say. When patients don't eat them, they may continue to lose weight, and are at risk of treatment delays due to weight loss.

She thinks the Food Lab's ice cream could reach far beyond senior citizens in need of a nutritional boost.

"We have colleagues at the different cancer centers in the city, and when they learned about this project the common response is, 'Sign us up. Our patients need this product,'" Milliron says.

When her father had dementia and congestive heart failure, she watched as boxes of Boost piled up around the house. But the Food Lab's functional ice cream is much more likely to become part of a patient's daily diet — and part of the path to better health.

"This type of intervention can be tailored to many populations," Milliron says.

Fisher (favorite flavor: chocolate chip) thinks functional ice cream could also win over athletes and people who are very active. And in speaking with a Drexel faculty member whose daughter had jaw surgery, she realized it could also help prevent postoperative weight loss, which is often as high as 20 to 25 pounds.

With a potentially big market, Deutsch is now focused on getting the ice cream into the freezer aisle and into the hands of doctors who might otherwise tell their patients to seek out an oral liquid nutrition supplement. Drexel Applied Innovation's McGrath is helping out, leaning on Deutsch's long history of relationships in the food industry to find a group of partners with deep expertise in health care, food service and product development. Together, they are in the process of forming a company that will take the Food Lab's ice cream through all the steps of commercialization: manufacturing, packaging, marketing, storage and distribution.

> "We have colleagues at the different cancer centers in the city, and when they learned about this project the common response is, 'Sign us up. Our patients need this product.'"
>
> **BRANDY-JOE MILLIRON** ASSOCIATE PROFESSOR

McGrath (favorite flavor: coffee with chocolate chips) has been working with the Food Lab for seven years and has been part of nearly 40 collaborations between Deutsch's team and industry partners in the last few years.

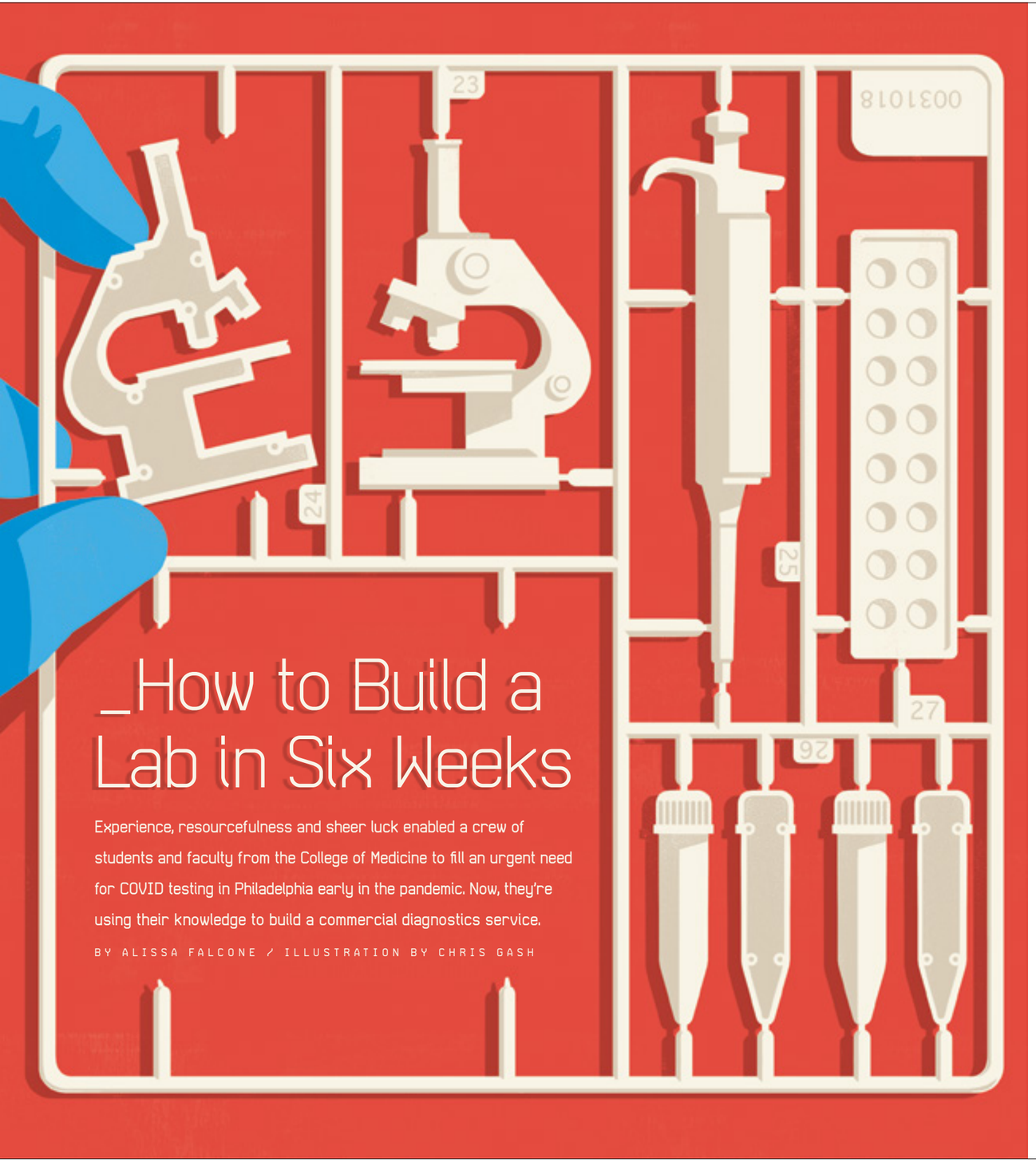
"They see an opportunity to have an impact and they take it," McGrath says of the Food Lab.

Food Lab research projects typically begin with someone from private industry asking for culinary innovation to solve a problem in the market. While much of the technology transfer that takes place needs many years to materialize, the Food Lab's work happens on a much less painstaking timeline.

"The beauty of culinary arts and what Jon does is you can go from an idea to a prototype that won't kill you in a matter of days or weeks," McGrath says.

The ice cream could be available within a year-and-a-half, says McGrath, giving patients of all stripes a welcome alternative in the search for nutritional stability. For the Food Lab's collaborators, dessert has never sounded so sweet.

"It's food as medicine at its finest," Milliron says. ✕



_How to Build a Lab in Six Weeks

Experience, resourcefulness and sheer luck enabled a crew of students and faculty from the College of Medicine to fill an urgent need for COVID testing in Philadelphia early in the pandemic. Now, they're using their knowledge to build a commercial diagnostics service.

BY ALISSA FALCONE / ILLUSTRATION BY CHRIS GASH

It was Aug. 15, 2020, five months into the lockdown, and Garth Ehrlich was desperate to get away.

"I hadn't been out of my condo and couldn't take it anymore," recalls Ehrlich, who is a professor of microbiology and immunology, and otolaryngology, in Drexel's College of Medicine. He loaded up his car and hit the road for his friends' farm in the Midwest, where he planned to relax for his first vacation in six months.

"And then," he recalls, "I got a call from the chair of my department."

Chuck Cairns, the Walter H. and Leonore Annenberg Dean of the College of Medicine and senior vice president for medical affairs, wanted Ehrlich and his group, along with Brian Wigdahl, professor and chair of the Department of Microbiology & Immunology, to set up a SARS-CoV-2 testing lab, and he wanted it operational in six weeks. But there was no lab space, instruments, personnel, certified systems or accreditation to fulfill this request, which meant the clock was *really* ticking.

Still driving, Ehrlich began to make calls. He spoke to his lab manager and placed requests to find space on the University's campus in Philadelphia. By the time he reached his friends' farm, he was talking to manufacturers to get price quotes for lab instruments.

The lockdown retreat became a working vacation that changed the next few years of Ehrlich's life. The facility he began assembling that day became the Pathology Diagnostics Laboratory (since renamed Drexel Medicine Diagnostics Laboratory), which would go on to process as much as 10% of all polymerase chain reaction (PCR) tests in Philadelphia and 10% of all SARS-CoV-2 sequencing statewide. The lab made it possible for students to return to campus a few months later, helped Philadelphia and Drexel partners monitor new variants, and transformed several academic careers.

Two years later, with the pandemic in retreat, the lab's creators have repurposed it as a new commercial testing service. This time, though, they have more than six weeks — and they have their own footsteps to follow.

STEP 1 Take Stock of What You Have

At the time Ehrlich got his call, Drexel was teaching remotely, and the streets of Philadelphia had gone quiet. The University's Student Health Center was offering limited COVID testing for certain groups (Dragons working in clinical settings, for example) that it paid a private company to analyze.

For everyone's safety, Drexel leaders wanted students and employees to remain remote until the University had testing capability with same-day results of its own.

Ehrlich had some experience creating a clinical molecular diagnostics lab for the University of Pittsburgh's pathology department, but that was about 25 years ago. "It wasn't something that I was planning on ever doing again," he admits, "but I was happy to do it because I did feel that we were doing something good for the University and the community."

For the undertaking, he partnered with Azad Ahmed, a long-time colleague from his University of Pittsburgh days who helps him run the Genomics Core Facility (GCF), Drexel's gene sequencing and bioinformatics service core. The GCF houses instrumentation platforms for DNA and RNA sequencing — so Drexel could analyze positive SARS-CoV-2 tests and identify the variant.

But Drexel would need a way to collect those samples, extract the RNA from them, convert the RNA to DNA for sequencing, monitor the sample at every step of its testing and surveillance journey, and ultimately notify individuals of a positive or negative result.

"We had no space, no equipment, no personnel, no protocols, no nothing," says Ehrlich.

What they *did* have was Jaroslaw "Jarek" E. Król and Donald "DJ" Hall (PhD '20).

Król was the Center for Genomics lab manager and the first person Ehrlich called. An assistant professor in the Department of Microbiology and Immunology, Król played a major role in setting up the lab and served as lab mentor to Hall, who had just graduated from Drexel with a chemistry doctoral degree in summer 2020. Hall had been planning to do a research postdoc with Ehrlich, but when the pandemic shut down the University, he took on the role of operations director of the new coronavirus lab.

"Originally, I'm a medicinal chemist, not a clinical chemist, so I had never worked in a clinical lab," says Hall. "But I volunteered to help because this got me out of the house, which was something I really needed."

In a matter of hours, they had assembled a lab startup team. That was the easy part. *Tick, tick, tick…*

STEP 2 Source All of the Necessary Parts

Ehrlich's unit had been one of the first to close at the University when the pandemic arrived. Now it was the first to reopen.

The team decided that they would take over Drexel's former Clinical and Anatomic Pathology Labs, on the 5th floor of the New College Building in Center City, and combine that with Ahmed's GCF labs on the 17th floor. The shuttered lab hadn't been used in almost a year, a casualty of the 2019 bankruptcy and closure of Hahnemann University Hospital, which had been the lab's main source of specimens.

Alone in the vacant downtown building, Ahmed, Hall and Król sat through demonstration after demonstration of devices from various manufacturers, while Ehrlich, who was at high risk, advised from home. The team selected supplies and equipment from two different companies, to offset any possible supply chain lags.

One of the companies, Tetracore, already had an immunology research collaboration with the College of Medicine and had been recommended to the College of Medicine's Dean Cairns by MyOwnMed, a digital platform that he worked with to create Drexel's symptom-tracking app, the Drexel Health Checker, in April 2020.

"We were able to leverage ongoing research partnerships to immediate impact through these incredibly important connections with MyOwnMed on the software development side and Tetracore on the testing supply side," says Cairns. "It resulted in a pretty remarkable collaboration."

Drexel spent about $2 million of the federal coronavirus relief funding it received to equip the lab. A few weeks into the six-week deadline, things were getting checked off a massively important to-do list.

But there was still a lot to do and even more to learn.

One very large hurdle they faced was accreditation. Most of the team were scientists whose work had never required them to link their samples to patient information. But now they would need to handle "real people" specimens and issue test results.

"To do that, there are two different types of accreditations you need to run the lab: You need a clinical lab permit from the state, and you need a pathologist in the lab as a medical director," says Professor Cheryl Hanau, who is the Richard Shuman, MD, Chair of the Department of Pathology & Laboratory Medicine. "Fortunately, there was one pathologist left at Drexel: me."

Hanau had been the medical director of the former Anatomic Pathology Lab when Hahnemann closed and everything became "extinct," as she

remembers it. After the hospital's bankruptcy, the lab closed, but Hanau decided to stay at Drexel on a reduced salary as a professor and academic chair of the Pathology Department, with no clinical responsibilities and no reason to work as part of a lab … until now.

Thankfully, her name was still on the lab's two accreditations and state permit. Thankfully, she had maintained an active Pennsylvania medical license. Thankfully, she had stored all the lab's processes and documentation. *Thankfully*, she was just as willing as everyone else to jump in and help.

STEP 3 Put the Pieces Together

Through lots (and lots) of phone calls, Hanau learned that Drexel could reactivate its license from the Clinical Laboratory Improvement Amendments (CLIA) and its Clinical Lab Permit from the Commonwealth of Pennsylvania. Drexel would also need a new accreditation certificate from the College of American Pathologists (CAP), which is authorized by CLIA to ensure the quality of the lab through inspections and proficiency testing.

"When I called CAP, the first thing they asked was what state the lab was in, because each state has different rules for accreditation," remembers Hanau. "When I said 'Pennsylvania,' the person on the phone said, 'Oh, I'm so sorry.'"

She learned that Drexel's lab permit was valid and could be reactivated, but that the state would have to inspect the space before it could function — and that could take up to a year due to an inspector shortage.

In the meantime, the team had plenty left to do. The lab needed a new laboratory information system to track specimens, because it had previously relied on Hahnemann's system. Joshua Earl, an assistant professor in the Department of Microbiology & Immunology in the College of Medicine and GCF's head of bioinformatics, stepped in to create a software system to support the lab's operations.

The lab also needed an electronic health record — also formerly supplied by Hahnemann for hospital-based specimens — to order and schedule tests as well as to report the results to the patient and other stakeholders, such as the city and Drexel's contact-tracing team. They modified the Drexel Health Checker app that Cairns had created with MyOwnMed; now, the app could be used to schedule a test and receive results. Behind the scenes, the app would generate a label for the sample to be tracked during the testing process.

The necessary regulations, standard operating procedures, worksheets, reporting forms and other rules had all been saved by Hanau, but everything needed to be updated for the new lab.

"I've never heard of this happening anywhere else before," Hall says of the process. "We went from nothing to running samples for surveillance in just a few weeks, to reinstating our CLIA license and running diagnostics and becoming CAP accredited in just over a year."

CAP accreditation aside, the lab was ready to begin testing on Oct. 1 (and to begin surveillance on Oct. 11), on schedule. It opened as the Pathology Diagnostics Laboratory with lab personnel running tests by hand at first, uncapping and transferring samples themselves, until automated machinery arrived later.

"Three months after we ran our first test on Oct. 1, we went from doing a handful to over 1,000 a day and over 5,000 a week," says Ehrlich.

The CLIA and the state licenses were approved in December (CAP accreditation came later). By then, Drexel had opened three COVID testing sites on campus, staffed with students and faculty from the College of Nursing and Health Professions and the College of Medicine.

With that, the University could safely invite Dragons back to campus in January 2021.

> "We went from nothing to running samples for surveillance in just a few weeks, to reinstating our license and running diagnostics and becoming accredited in just over a year."
>
> DONALD "DJ" HALL (PHD '20)
> *LAB DIRECTOR*

STEP 4 Ramp Up and Step Up

While Omicron raged in the winter of 2021, the Pathology Diagnostics Laboratory was running up to 1,200 tests a day.

With variant fears running high, others in the city took notice of Drexel's lab.

Joshua Chang Mell, an assistant professor in the College of Medicine, and longtime collaborator Paul J. Planet, an assistant professor at the University of Pennsylvania and co-director of the Children's Hospital of Philadelphia (CHOP)'s Microbial Archive and Cryocollection, had wanted to use their experience sequencing bacterial pathogens to help in some way.

Near the end of 2020, they had submitted a grant to the Centers for Disease Control and Prevention (CDC) to track variants by sequencing samples collected at CHOP. That collaboration was funded and expanded to include the Philadelphia Department of Public Health (PDPH), when they began sequencing specimens collected at some of the city's sites, like public schools, nursing homes and prisons.

But while the PDPH could run diagnostics tests, it didn't have a sequencing lab. And while CHOP had sequencing capabilities, Drexel's lab was superior at extracting RNA, Planet says, so Drexel eventually took over the extraction and sequencing of samples.

"Before the pandemic, I had worked with all of the Drexel people as collaborators and researchers, and I saw that they did a really excellent job at setting up that lab, so it didn't really make sense that we weren't working together when we were doing these parallel things," says Mell, who jokes that he and Planet were the lab's first customers.

"We found that the infrastructure for extraction led to better results if we brought it to Drexel," says Planet. "It certainly takes more time to transfer samples between the two campuses, but it actually winds up being better overall quality and is more efficient."

The CHOP-collected specimens would go to Drexel for extraction, back to CHOP to be prepared in libraries, back to Drexel for sequencing, and then back to CHOP for final analysis. The entire process took a few days to a week.

The "coolest period of time in the collaboration," Mell recalls, was the race to find Omicron in the city. The new variant was finally collected at CHOP's drive-through site in early December 2021 and sequenced by Drexel a few days later. In mid-December, Omicron was detected in less than 1% of their samples, but within a few weeks it made up 90% of positive COVID tests.

"We had this really crazy period of time where everything was moving at factory speed," says Mell.

Demand for testing was so high then — around Drexel's winter break, too — that the lab went from reporting diagnostic results within eight hours to 24 hours.

But this wasn't the Pathology Diagnostics Laboratory's first time weathering a surge, and as cases rose, the staff developed a time-saving trick. They discovered they could use their stockpile of older PCR tests, which had been made obsolete by the Delta variant, to pre-screen samples for a gene known to be part of the Omicron spike protein, which allowed them to quickly identify the new variant without having to run DNA sequencing.

STEP 5 Survey What You Have Created

From fall 2020 to fall 2022, the Pathology Diagnostics Laboratory ran about 130,000 diagnostic tests, as well as thousands of sequencing procedures for the University, CHOP and the city. At one point, the lab produced 5–10% of the sequencing for all of Pennsylvania. The lab also saved Drexel considerable money: its cost to run a test was $21 compared to $120 charged by vendors.

The team's experience, connections, resourcefulness — and willingness to drop everything to take on the task — was an enormous service during the pandemic. The lab enabled a safe return to campus, allowed student-athletes to participate in group sports, provided gold standard testing when tests were scarce, and informed the University's safety decisions. During the Omicron surge, data from the lab convinced Drexel to modify its winter academic schedule, for example.

"For the first year and a half of the lab's existence, we were constantly racing just to meet the marks," says Ehrlich. "It was really just a heroic effort by the team to meet these ever-increasing targets with both sophistication and numbers."

The lab's work began to wind down as at-home tests became more available and policies for mandatory gateway testing changed. By summer 2022, the lab was testing only 70 to 80 samples a month. In December 2022, Drexel closed all but one of its testing centers.

STEP 6 Keep Adapting

In July 2022, Philadelphia opened its own sequencing and bioinformatic lab with a CDC grant, making it one of only four public health labs of its kind in the country.

When the city was assembling its lab, its employees contacted the Pathology Diagnostics Laboratory and the GCF for tours, demonstrations and consultations.

The city ended up buying the same system and platform for reading sequences, the same automated pipettors to put samples into tubes and the same liquid handlers for transferring the samples. One vendor even called Hall to thank him for the referrals.

"Drexel is really on the forefront of a lot of stuff that we can learn from," says Bernadette Matthis, director of the city's new Public Health Laboratory. "We had a good foundation for what direction to proceed in."

As for the Pathology Diagnostics Laboratory, it has outlasted the pandemic.

With a luxurious 12 months to prepare, the team is transforming it into a full-service diagnostic lab to test for infectious diseases, genomics and toxicology — allowing it to serve as both a research resource and a revenue source for the University.

> "We can provide a service that's state of the art, agile and adaptive. That's the experience and expertise our people learned from COVID."
>
> CHUCK CAIRNS
> *DEAN, DREXEL COLLEGE OF MEDICINE*

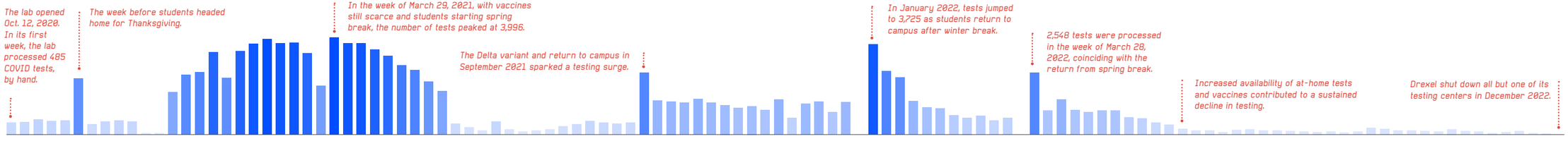
Its new name is the Drexel Medicine Diagnostics Laboratory, and it is slated to open in summer 2023.

"Nothing ever stays the same and the paperwork is always constant, but there are lots of opportunities to learn," Ehrlich reflects. "The lab's expansion will leverage the University's investment in time, personnel and instrumentation for building up the lab."

Cairns, the College of Medicine dean, hopes the new lab can serve Drexel's colleges and schools and offer a chance for Drexel to branch out.

"If you think about research with impact as innovation, it shows that we have the innovation ability to do it," he says. "We proved we could do it in COVID with an unknown agent. Imagine if we do it with a known genetic target. We can provide a service that's state-of-the-art, agile and adaptive. That's the experience and expertise our people learned from COVID." ✕

TESTING TIMELINE
The lab's workload waxed and waned with the cycles of Drexel's quarter system.



PALEONTOLOGY

_FOSSIL REVEALS FISH-TO-LAND TRANSITION

Fossils found by an amateur paleontologist belonged to a ***lobe-finned, transitional fish*** *that lived in streams and along coastlines some 380 to 360 million years ago.*

Roadcuts along Pennsylvania highways have once again offered a window into the evolutionary history of vertebrates.

Professor Ted Daeschler and his colleagues provided expertise after York resident James J. Smaling found large, well-preserved fossil bones in a roadcut exposure along the westbound lanes of Route 322 in Centre County.

"Jim and his fossil-collecting buddy, the late Jim Forster, delivered about 250 pounds of red sandstone in several large blocks to the Academy's paleontology lab, beginning the process of assessing the fossils, splitting the rocks to reveal additional fossils, and the detailed work of fossil preparation and preservation," says Daeschler.

"While tristichopterids have a fish-like look… they're actually disconnected from the modern concept of a fish and are more closely related to vertebrates with limbs, fingers, and toes."

-Jason Downs

They quickly determined that the find belonged to the group called tristichopterids, which are lobe-finned fish.

Smaling's find — which included high-quality cranial and fin material as well as body scales — is a previously unknown species within the *Langlieria* group. The new species *Langlieria smalingi*, named in honor of its discoverer, was described and published in the *Proceedings of the Academy of Natural Sciences of Philadelphia* in 2022.

The new species aligns more closely to humans and other limbed vertebrates than to fish as we view them today, says Jason Downs, a research associate at the Academy and a co-author of the paper.

"While tristichopterids have a fish-like look — meaning they have fins, swim and breathe with gills — they're actually disconnected from the modern concept of a fish and are more closely related to vertebrates with limbs, fingers, and toes," Downs explains.

The tristichopterids fit into the tree of life among a great diversity of lobe-finned fish that lived in streams and along coastlines in the middle and late part of the Devonian Period. They were large, predatory fish, a meter or more in length.

Downs and Daeschler are examining the Devonian age to build a more complete understanding of the transition from aquatic to terrestrial environments that occurred in that era.

_TED DAESCHLER
Daeschler is a professor in the Department of Biodiversity, Earth and Environmental Science in the College of Arts and Sciences and curator and chair of Vertebrate Zoology in the Academy of Natural Sciences of Drexel University.

_FISH OUT OF WATER
The bones discovered in North Central Pennsylvania belonged to the group called tristichopterids, a lobe-finned fish. The new species aligns more closely to humans and other limbed vertebrates than to modern fish.

_ROADSIDE ATTRACTION
Tristichopterid fossils have been collected in Tioga, Lycoming, Clinton and Centre counties in Pennsylvania. "To understand the present, we have to first understand the past, so the mind needs to reconstruct Pennsylvania with muddy streams washing from east to west in a subtropical environment — really a very different place than we are familiar with," Daeschler says. "Pennsylvania has really good rocks formed in the stream systems from that time period, and that's what we are after."

_MODERN-DAY DOUSING ROD

*A patented device uses **sound waves to identify lead** in underground water pipes, a boon to aging cities.*

Walk on any street in Philadelphia, and you're walking on layers of history — and pipes. Lots and lots of pipes.

"There are literally hundreds of thousands of pipes that are underwater service lines buried in older cities," says Kurt Sjoblom, formerly in the Department of Civil, Architectural and Environmental Engineering. "Utility companies have no idea whether they're lead, steel or copper."

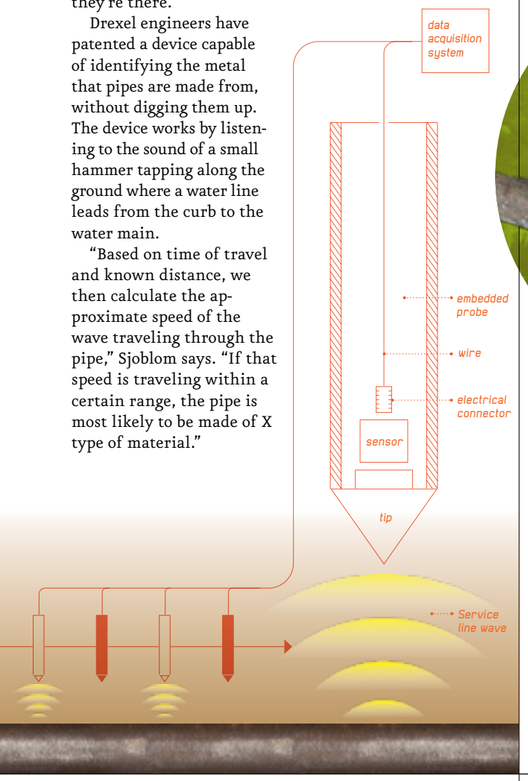
And while utility companies are required to remove any pipes they uncover that are made of lead, there's no easy way to know they're there.

Drexel engineers have patented a device capable of identifying the metal that pipes are made from, without digging them up. The device works by listening to the sound of a small hammer tapping along the ground where a water line leads from the curb to the water main.

"Based on time of travel and known distance, we then calculate the approximate speed of the wave traveling through the pipe," Sjoblom says. "If that speed is traveling within a certain range, the pipe is most likely to be made of X type of material."

After the 2015 water contamination crisis in Flint, Michigan, department head Chuck Haas challenged engineering faculty to come up with solutions. Sjoblom had already been toying with using sound waves to identify buried infrastructure, but he wasn't even thinking of lead pipes.

The device has been tested on water lines in New Jersey, and the researchers are working on the best configuration and number of listening devices a setup should have.



_ANTIQUE DATA CONFIRMS OWL DISCOVERY

*DNA from a **173-year-old museum specimen** at the Academy of Natural Sciences of Drexel University enabled ornithologists to describe two new species of Brazilian screech owl.*

_JASON WECKSTEIN
Weckstein is associate curator of Ornithology in the Academy of Natural Sciences of Drexel University and an associate professor in the College of Arts and Sciences.

_THERESE A. CATANACH
Catanach is a postdoctoral researcher in the Academy's Ornithology Department.

_SPECIES IN PERIL
Both of the newly described species face threats from deforestation, but the Alagoas screech owl, above, is already likely critically endangered.

An international team of researchers has described two never-before-recognized screech owl species: Xingu (*Megascops stangiae*) and Alagoas (*Megascops alagoensis*) living in precarious ecosystems within the Brazilian rainforest.

"The Xingu screech owl is endemic to the south side of the Amazon River in a region known for its infamous arc of deforestation, and the Alagoas screech owl is found in a few remaining fragments of isolated Atlantic Forest in northeastern Brazil," says Associate Professor Jason Weckstein, who collaborated with a team of scientists on research published in *Zootaxa*.

The description of the new species resulted from years of work by scientists from Brazil and Finland, as well as the United States. The scientists were Sidnei M. Dantas, who led the study as part of his doctoral work at the Goeldi Museum in Belém, Brazil; Joiciane N. Oliveira of the Universidade Federal do Pará in Brazil; Alexandre Aleixo of the University of Helsinki; John Bates, curator of birds at the Field Museum of Natural History in Chicago; Weckstein and his colleague, postdoctoral researcher Therese Catanach.

The team analyzed recordings of screech-owl vocalizations from across the distributions of these birds and paired these

Scientists' analysis clarified that the screech-owl vocalizations from different regions were distinct from each other.

analyses with specimens and tissue samples.

The scientists' analysis clarified that the screech-owl vocalizations from different regions were distinct from each other.

Catanach and Weckstein then compared DNA that Dantas sequenced from frozen tissue collections with that of a 173-year-old tawny-bellied screech owl specimen in an Academy collection, which is a lectotype — a kind of icon for the species.

The lectotype, which was designated as a type specimen for *Megascops watsonii*, could then be included in the genealogy of screech owl species that the team published as part of the study, Weckstein says. In the future, this will provide a point of comparison for scientists studying the DNA of screech owls.

"That eastern Amazonia region is on its way to being in trouble, if we don't take care of things," Weckstein says.

_SAFE SKYLINES FOR BIRDS

*Ornithologists are collaborating with companies to **monitor and reduce bird collisions** with buildings in the Philadelphia region.*

On Oct. 2, 2020, thousands of migratory birds died after colliding with buildings in Center City Philadelphia. The event inspired the creation of Bird Safe Philly, a coalition of groups that monitor bird strikes in the region, educate the public and promote a "lights out" campaign and exterior glass treatments.

Building collisions cause about one billion bird deaths in the U.S. each year, says Jason Weckstein, associate curator of Ornithology at the Academy of Natural Sciences of Drexel University and associate professor of the Department for Biodiversity, Earth and Environmental Science in the College of Arts and Sciences. Buildings are the second-biggest killer of wild birds, after feral and free-range domestic cats, he adds.

Bird Safe Philly is a partnership between Delaware Valley Ornithological Club, Audubon Mid-Atlantic, Valley Forge Audubon Society, Wyncote Audubon Society and the Academy.

They're promoting a Lights Out Philly campaign to urge building owners and managers to extinguish unnecessary artificial lights during spring and fall migratory seasons. Pockets of data gathered in several cities that maintain Lights Out programs demonstrate that the intervention can reduce bird deaths from building collisions by as much as 80%.

"We don't know why, but some birds are attracted to light," Weckstein says. "It could be because birds that migrate at night actually use the stars for navigation."

Constellations serve as a compass for migrating birds, Weckstein says, and glass surfaces in illuminated skylines might scramble their calibrations.

An estimated 1,000 collisions with buildings and windows can occur in just one four-square-block area in downtown Philly each year.

Now in its third year, Lights Out Philly has gained support from a growing number of building owners and managers, including Comcast Spectacor, the Pennsylvania Convention Center Authority and Brandywine Realty Trust.

Bird Safe Philly also promotes the installation of treated or patterned glass, motion-sensitive lighting, shades and other measures that individual residents as well as commercial builders and property managers can take to make buildings more bird-friendly year-round.

Nature lovers can also contribute to a monitoring program the partnership has established to document and tally bird deaths and injuries through the iNaturalist app.

_EVOLVING ON THE FLY

*Short-lived pea aphids are giving Drexel researchers a real-time window into how **temperature change** influences evolution.*

A study tracked the prevalence of symbiotic bacteria in pea aphids in order to glean insights into how evolutionary forces — and temperature change — affect biodiversity across generations.

Aphids host a symbiotic bacteria, or endosymbiont, called *Hamiltonella defensa* in their blood and internal tissues that safeguards pea aphids from parasitoid egg-laying wasps. Females can pass on *Hamiltonella defensa* to their offspring, yet not all pea aphids inherit the bacteria.

"Sometimes it just takes a handful of generations for evolution to unfold," says Professor Jacob A. Russell, senior author of a study that appeared in *Molecular Ecology* in 2021. "We were motivated to try to understand why this one endosymbiont is maintained in these populations, why is it never lost and why it doesn't just go to 100% frequency."

The team — initially led by former student Andrew H. Smith (PhD environmental science '16) — subjected aphid samples collected from alfalfa fields over the course of six months to routine molecular screening.

_JACOB RUSSELL
Russell is a professor in the Department of Biology in the College of Arts and Sciences.

Although growth in the parasite population modestly increased *Hamiltonella* prevalence, the team discovered that temperature drove the most notable shifts in the bacteria's presence and in how it functioned.

Hamiltonella clearly helped the aphids if the temperature was warm. However, in cooler temperatures, it was estimated that the bacteria harmed them.

This work is among the first to show that maternally transmitted microbes — which are found in most insect species — respond to the pendulum-like nature of changing environments across the seasons. Given the longer-term trends in global climate, it is possible, too, that endosymbionts may govern the future success of insect species in our rapidly warming world.

BIODIVERSITY

_DO SEA TURTLES NEED SHADE?

A technique conservationists use to ***preserve sea turtle populations*** *could backfire if implemented too broadly.*

_JAMES. R. SPOTILA
Spotila is emeritus L.D. Betz Chair Professor of Environmental Science in the Department of Biodiversity, Earth, and Environmental Science in the College of Arts and Sciences.

It's common for conservationists to shade the nests of sea turtles in an effort to increase the survival rate of hatchlings, but a new study finds that the practice could actually undermine the reptiles' long-term population size if not carefully monitored.

Building shade structures over the nests of leatherback turtles, *Dermochelys coriacea*, at hatcheries on tropical and subtropical beaches has been shown to raise survival rates among hatchlings. However, the practice also alters the sex ratio of egg clutches; higher temperatures produce a greater proportion of females.

Some conservationists have favored the intervention, reflecting an assumption that saving more hatchlings and reducing the tendency toward female bias in hatchling sex ratios will boost leatherback numbers, according to an article co-authored by Professor Emeritus James R. Spotila of the Department of Biodiversity, Earth and Environmental Science.

The researchers noted, however, that female-biased primary sex ratios appear to occur naturally at most nesting beaches, and they concluded that reducing female biases could harm efforts to sustain leatherback turtles' numbers.

Spotila published the study in *Biological Conservation* with co-authors Pilar Tomillo Santidrián of the Institut Mediterrani d'Estudis Avançats; Bryan P. Wallace of Ecolibrium; Frank V. Paladino of Purdue University, and Meritxell Genovart of the Centro de Estudios Avanzados de Blanes.

The team examined data from leatherback turtles nesting at Playa Grande, Costa Rica, where populations have declined.

Modeling revealed that decreasing nest temperatures under many scenarios would produce short-term increases in hatchling rates but a long-term decline in the number of nesting females and in total population size.

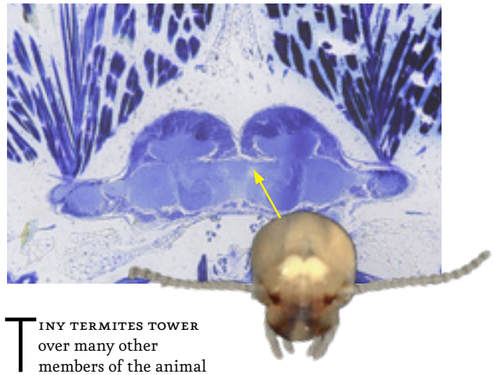
The researchers concluded that shading would be beneficial only if mean nest temperatures rise more than 2 degrees Celsius, as in a climate change scenario. In that event, extreme female biases could result in non-fertilized eggs and high embryo and hatchling mortality.

Their study also confirmed that altering sex ratios by producing more males in hatcheries could be detrimental for sea turtle conservation.

_TOO COOL?
Models of sea turtle clutches in Costa Rica showed that shading the nests would have an undesirable impact on turtle populations in the long term.

ENTOMOLOGY

_EVER-READY BRAINIACS



Termite brains have a "mushroom body," visible in the purple-tinted photomicrograph. It's a commmand center enabling termites to dig, chew, build, mate and etc. The distinct mushroom body shape can be seen in the photograph (below) of a dampwood termite's head.

Tiny termites tower over many other members of the animal kingdom in one respect: the mutability of their brains.

Living inside logs, tree stumps, fence posts or utility poles, most dampwood termites, or *Zootermopsis*, never see the light of day.

Still, they are some of the most developmentally complex and flexible animals out there, according to Sean O'Donnell, a professor in the Department of Biodiversity, Earth and Environmental Science.

Like other insects, dampwood termites' brains contain structures called mushroom bodies, which serve as a command center that enables them to dig, chew, build, mate, fly or defend the nest.

The mushroom bodies of individual *Zootermopsis* differ from one another, based on social roles they fill, and they also change as the insect matures.

Their neural plasticity follows multiple stages of molting before the termites emerge as workers, soldiers or reproductives. Each colony features just one king and one queen. But numerous other members of the colony have a latent capacity to reproduce, too, with the potential to become replacement reproductives, should the king or queen die.

In a 2022 study in *Insect Sociaux*, O'Donnell and colleagues Susan J. Bulova and Meghan Barrett measured the brains of different caste members. The researchers found that dampwood termites with the largest mushroom bodies are the worker nymphs — suggesting how cognitively demanding it is to perform tasks for the colony. Other classes of reproductives had smaller mushroom bodies.

O'Donnell's team also traced unexpected developmental routes.

"Some individuals can molt into being a soldier and then apparently switch to becoming a reproductive," O'Donnell says. "That's the last thing you expect to happen. It shows they have even more flexibility than we realized."

_ONLINE
To access NOAA's "Heat Watch Philadelphia" report, visit **http://drexe.lu/3BLmwoR**

_TAKING THE CITY'S TEMPERATURE

Fifty **"citizen scientists" volunteered to traverse Philadelphia's streets** with instruments that scan for heat islands, in a hunt to locate climate change hotspots.

Citizen scientists from local community groups joined researchers from the Academy of Natural Sciences of Drexel University to document extreme heat and air quality across Philadelphia neighborhoods as part of an urban heat mapping project funded by the National Oceanic and Atmospheric Administration (NOAA).

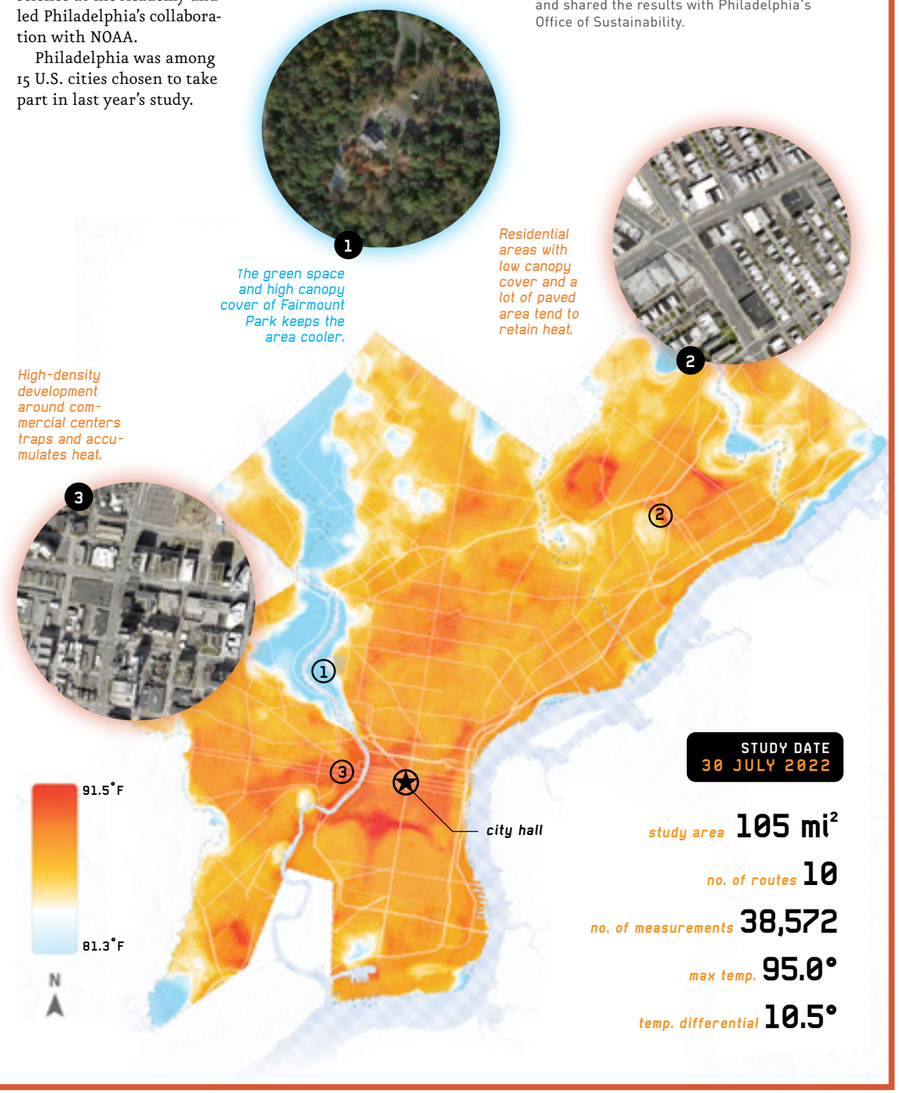
Working in pairs, teams traversed the city along specific routes, using special sensors mounted to their cars to measure temperatures and particulates. Pinpointing hotspots on one day, the researchers gathered data that can inform the development of strategies to prepare for climate change.

Similar heat map campaigns have been conducted in 35 communities across the U.S. over the past five years. In 2021, 799 community scientists took 1.2 million measurements in 24 communities. Cities from past campaigns have used their data to develop heat action plans, add city cooling stations, educate residents and policymakers and inform new research.

Cities typically face higher temperatures than suburban and rural areas, and the negative effects of heat and pollution are often the worst in low-income areas with little tree cover. The data will help city officials and community advocates target resources where they are needed the most, according to Richard Johnson, who in 2022 served as director of community science at the Academy and led Philadelphia's collaboration with NOAA.

Philadelphia was among 15 U.S. cities chosen to take part in last year's study.

_URBAN HEAT MAPPING
NOAA published a report of its findings and shared the results with Philadelphia's Office of Sustainability.



_ABOUT DREXEL

_STARTUP SPACES
This year, Drexel broke ground on a new life sciences building with its partner Gattuso Development Partners. Located in the heart of campus, the 11-story building will house startups and lab space. It is expected to be the largest of its kind in Philadelphia.

Founded in 1891 in Philadelphia, Drexel is a comprehensive urban university of more than 22,000 students with one of the country's most established co-operative education programs.

Drexel is a leader in experiential, technology-infused education and cross-disciplinary research. The University's recognized excellence in translational research is supported by the Coulter Foundation through the Coulter-Drexel Translational Research Partnership Program and by $152 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 16 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. In partnership with Tower Health, Drexel medical students train at St. Christopher's Hospital for Children and at new state-of-the-art facility in West Reading, Pennsylvania.

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 Applied Innovation, the Innovation Center @ 3401 Market Street, the Charles D. Close School of Entrepreneurship and the Baiada Institute for Entrepreneurship.

Drexel operates out of its 123-acre University City Campus in West Philadelphia and through five additional locations: the Center City Campus including the Academy of Natural Sciences of Drexel University, the West Reading Campus and Queen Lane Campus in East Falls for the College of Medicine, the Malvern Campus for the Bennett S. LeBow College of Business, and through its online platform.

_ONLINE
Learn more about Drexel University at **drexel.edu**.

_ ONLINE
EXELmagazine.org