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LEHIGH RESEARCH REVIEW

SCHOLARSHIP, DISCOVERY & THOUGHT LEADERSHIP

LEHIGH RESEARCH REVIEW

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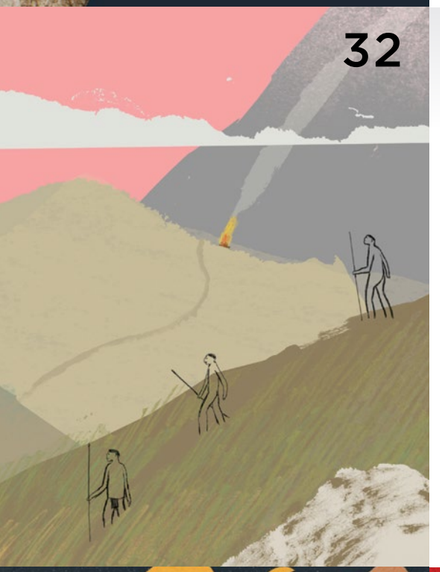
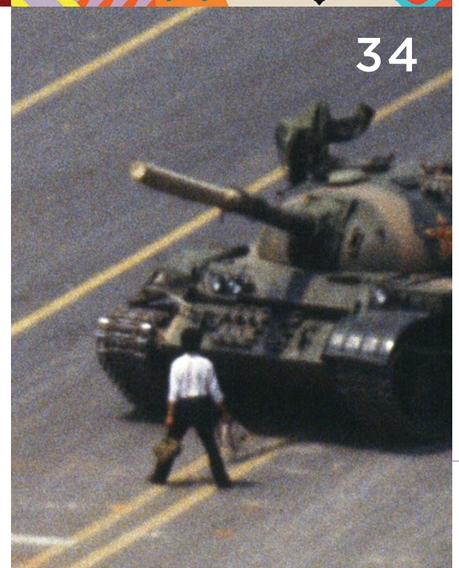




OPTIMISM, BRAVERY & NEW RESOLVE

Research is a decidedly optimistic endeavor. To ask an important question, knowing that if all goes really well we just might find an answer, is an expression of faith in our means of inquiry and our capacities for observation and insight. If we expected the workings of nature, or the motivations of the human heart, or the challenge of their coexistence to yield easy answers, we would be, as they say, in another business.

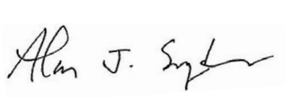
Research is also a decidedly brave endeavor. Our findings may delight or devastate. This is not an endeavor for the faint of heart, or for seekers of quick affirmation. It requires being OK with critique, OK with findings that make you uncomfortable, OK with challenging power, OK with the fact that revising our understanding is a long-haul effort.

Our world calls for such optimism and bravery, and for new resolve. In the past two years, we've witnessed the denouement of a decades-long quest to go, in mere months, from viral genome to working vaccine. Equally, we've been reminded of the limits of technological capacity alone, of the ways in which nature pushes back when we overreach, and we've been reminded of the importance of how we see ourselves in relation to nature and to each other.

> "[RESEARCH] IS NOT AN ENDEAVOR FOR THE FAINT OF HEART, OR FOR SEEKERS OF QUICK AFFIRMATION."

This issue of the *Lehigh Research Review* illustrates, as always, the ability of scholarly work to delight and to devastate, to uncover thrilling new possibilities, and to surface truths about ourselves and our world—both gratifying and troubling—that plead for our attention. We invite you to read about the work of our talented researchers, who continue to offer inspiration and insight through the most challenging times.

Sincerely,



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PUBLIC-HEALTH PROGNOSTICATORS

Biostatistician Thomas McAndrew combines computational models and models of human judgment to build more accurate forecasts.

Written by
Kelly Hochbein

Illustration by
Hvass&Hannibal

Before joining Lehigh's College of Health faculty in 2020, biostatistician Thomas McAndrew was a postdoctoral fellow at the University of Massachusetts at Amherst, developing novel multi-model ensemble algorithms to forecast seasonal influenza for the Centers for Disease Control (CDC) and Health and Human Service regions across the United States. The algorithms he developed combined tens of forecasts into a single forecast of the percent of influenza-like illness to inform public health officials about what the future might hold, enabling them to make informed decisions.

"The idea behind probabilistic forecasting of disease transmission is to build a link between present data available about the disease and the probability of what will happen in the future," McAndrew explains.

But different types of models have different advantages and disadvantages, he says. Computational models work well when data is plentiful, but are restricted by using only structured data. People, on the other hand, aren't limited in that regard. They can obtain information from structured data like a spreadsheet, but they also can collect information from one another, from news and social media, and from personal intuition and experience.

> "IT'S HARD TO MAKE A FORECAST ABOUT THE FUTURE, BUT SO FAR THE CROWD IS DOING AS WELL AS THE COMPUTATIONAL MODELS. THEY HAVE SHOWN AN ABILITY TO BEAT THE MACHINES."

And so McAndrew also gathers information from humans—public-health prognosticators who participate in online communities dedicated to accurately predicting future events. His main goal: combining computational models with models of human judgment to determine how people can contribute to building more accurate forecasts of the future, which can help experts determine the best ways to reduce the negative impact of a particular public health event.

"Every model has access to different amounts of information, and the more information you have, the higher potential to generate a more accurate forecast," he says.

THE HUMAN ADVANTAGE

At different points throughout his career, McAndrew's work has touched on genetics, cardiology, social media and infectious disease. In addition to his seasonal flu and COVID-19 work, he has been a research assistant in oncology and pancreatic cancer trials at the Lombardi Comprehensive Cancer Center in Washington, D.C.; a biostatistician focused on human papillomavirus (HPV) genetics and the relationship to cervical cancer at the Albert Einstein College of Medicine in New York; and an associate director of biostatistics at the Cardiovascular Research Foundation, also in New York, designing and analyzing novel cardiovascular clinical trials of stents and heart valves.

McAndrew describes his diverse pursuits as "taking all the balls and, instead of juggling them, just throwing them all up in the air." However, as disparate as his research focus areas may appear, McAndrew says they are connected.

"They all have a common theme, and that's building," he explains. "I'm a builder. I build things. [At home] I have an outside workshop where I build bookcases, tables and shelves. And I have a computer inside that I sit in front of and use to build models, build data structures, and collect information. … All of my research is about building."

McAndrew initially was drawn to the idea of asking humans to predict infectious disease transmission in Fall 2019. The challenge at that time, however, was that this approach would work best with less data—when data-hungry computational models are at a disadvantage—not more, and so it wouldn't work well with seasonal flu, for which there exists a large amount of data.

Enter COVID-19, along with a remarkable scarcity of data at the beginning of the outbreak.

"COVID was not my specialty because it was no one's specialty," says McAndrew. In early 2020, he and his faculty advisor at UMass, Nicholas G. Reich, used a consensus of expert opinions to predict the early trajectory of the COVID-19 pandemic, including positive cases, hospitalizations and deaths.

As time went on, the experts became more and more accurate—and with limited data.

"We've found that people who are subject-matter experts, experts in the modeling of infectious disease, were able to make accurate forecasts of the cumulative number of deaths in 2020—38 weeks ahead of time, in March 2020," he says. "… [We saw that] people can make long-term forecasts really well,

Thomas McAndrew is a computational scientist working at the intersection of biostatistics and data science, studying ensemble models, expert-prediction and crowdsourcing for forecasting infectious diseases. He received a bachelor's of science in biomathematics from the University of Scranton, a master's degree in biostatistics from Georgetown University and a Ph.D. in mathematical sciences from the University of Vermont.

probably because they're relying on their intuition."

Now at Lehigh, McAndrew's Computational Uncertainty Lab conducts research that he describes as "a blend of stats, data science and humanity, which is really fun."

The team poses several public-health focused questions to groups of people who participate in online forecasting platforms, such as Metaculus and Good Judgment Open (GJO). These platforms offer opportunities for individuals to predict the probabilities of a wide range of real-world events, such as the behavior of the stock market, a country's future political leader and the emergence of new technologies. Although anyone can make a prediction, McAndrew and his team do distinguish subject-matter experts—individuals with experience in public health, epidemiology, infectious disease modeling and the like—from more casual participants.

"[These predictions are] based on structured, objective datasets, subjective information, information they found via some friends, maybe information they think they've picked up from the media. They build a probability distribution, and they submit it to us," McAndrew explains.

McAndrew and his team post two sets of questions to the crowd. The first set of questions they ask includes the same three questions that computational models also forecast the number of: incident confirmed cases, incident deaths, and pediatric and adult hospitalizations two weeks into the future. This allows them to compare predictions made by humans to the computational models. The second set of questions is determined by the "human" element.

"It's about really listening to the news, listening into what friends at the CDC are thinking and talking about," McAndrew explains. "We look to make predictions about what might be important two to three weeks from now."

One recent survey question—"How many incident-confirmed positive cases of COVID-19 in the U.S. will occur at the end of the month?"—invited each participant to provide a probability distribution of what they think that number will be. McAndrew received 914 probability distributions. He took that information and combined it with computational models to build a forecast of cases in the future and shared it with the CDC and other public health organizations.

"What we're seeing is forecasts from humans are at least as accurate right now as forecasts from the computational models," McAndrew says. "That said, we don't have enough proof to say that this will stick statistically, but so far I'm pretty shocked. I expected them to be worse. It's hard to make a forecast about the future, but so far the crowd is doing as well as the computational models. They have shown an ability to beat the machines—it's this very David and Goliath sort of situation."

'PEOPLE ARE STILL USEFUL'

McAndrew notes that people aren't always right, and forecasts sometimes miss the mark.

For example, the team decided to start asking questions about vaccinations in June 2020, just as Pfizer and Moderna were ramping up their vaccine production in the United States.

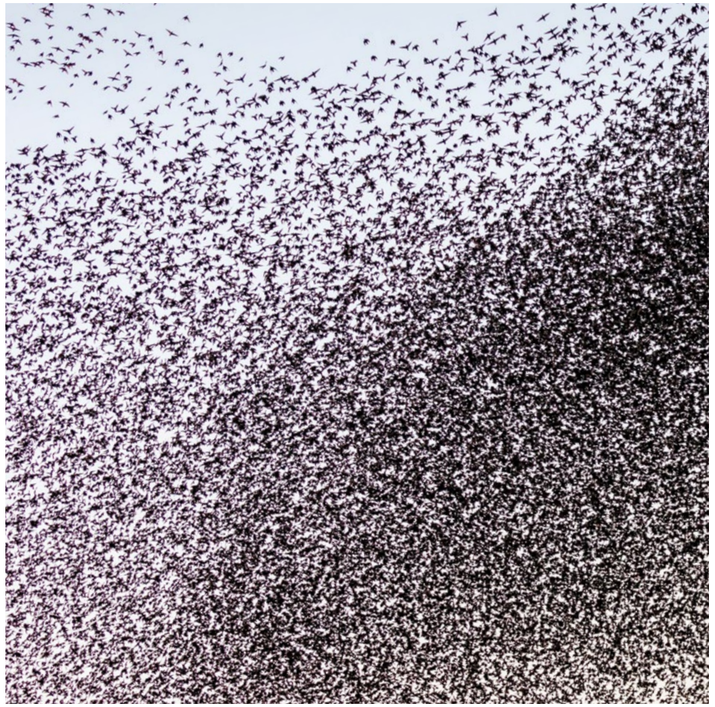
"We thought this might be important for public health officials to know, so we decided to ask questions about the first dose and fully vaccinated folks in the U.S.," says McAndrew.

The team released four surveys between June and September 2020, months before any vaccines would be released, asking participants questions about the number of vaccines that would be produced, when they would be approved, how long it would take to produce 100 million doses and distribute them, and how safe and effective the vaccines would be.

"We had sort of middling results. They were able to get the timing right, but not the efficacy," says McAndrew. "People forecasted the vaccines to be something like 50 or 70% effective, [and the Pfizer and Moderna vaccines are 95% and 94.1% effective, respectively]. So it highlights that forecasting can be hard. They're not amazing all the time. But it still provided the public with information about what could happen in the future."

This humanity-influenced information about the future helps public health officials make better and more informed decisions. However, it also serves another, perhaps less obvious, purpose, McAndrew says.

"I think that there's an overreliance right now on modeling, and how modeling should drive our entire lives. I think my work speaks to that aspect—that people are still useful. I think that it hints at this idea that people are as important, and we still matter. We still have something to offer that computational models don't have access to." ●



PRECISION & PRACTICALITY

Lei Wu develops novel mathematical methods to quantitatively characterize multi-scale models for kinetic theory.

Written by **Kelly Hochbein**

More than 120 years ago at the International Congress of Mathematicians, German mathematician David Hilbert presented a list of 23 then-unsolved problems. Since then, mathematicians the world over have worked to solve them. Today, Lei Wu is tackling the sixth on the list.

Hilbert's sixth problem seeks to axiomatize the branches of physics in which mathematics are prevalent, says Wu, an assistant professor of mathematics. In other words, he is attempting to reveal their inherent truth.

"It tries to put physics into a solid mathematical foundation," he explains. "If you just use a few basic laws like Newton's laws or some basic quantum mechanics laws to describe all the other phenomena … you need to justify whether this is really possible or just somehow an illusion. So, from the mathematical side, we want to rigorously justify: Yeah, this is doable."

Take as an example kinetic theory, which attempts to describe the dynamics of a large number of particles in a space. A researcher can utilize several mathematical approaches to understand the behavior of these particles. Depending on the particular scenario, some methods are better than others, says Wu. He wants to help researchers choose.

One approach, he says, is Newton's second law, through which a scientist might track the position and the velocity of each particle of air in a room. However, a micro-scale model with such large numbers would require a supercomputer, and the size of the room could determine that even a supercomputer might not be the answer: "It looks good, but it's not practical," says Wu.

Another possible approach is the use of thermodynamics or fluid mechanics, which focus on factors such as temperature, pressure and velocity to find a statistical average of the properties, rather than focusing on the behavior of a single particle. This type of macro-scale modeling, however, might not be precise enough.

Kinetic theory invites the question of how to connect the two approaches: Do they describe the same thing? Is it possible that just one is correct? Wu seeks to identify the criterion a researcher can follow to determine under which regime, or circumstance, to use which approach. He focuses on how to study this problem in a bounded domain—that is, when the particles in question come into contact with a natural barrier, such as water filling a drinking glass, flows of air particles passing an airplane wing or neutrons colliding in a nuclear reactor.

"We want to study this kind of phenomenon and give a quantitative description of what happened exactly," he explains. This helps him justify which approach is better for a particular situation.

The right decision matters. Levels of difficulty vary. Computers used for numerical simulations come with time and memory costs that depend on the chosen model. A researcher ultimately should choose the most proper and precise approach possible, says Wu.

"If we use fluid dynamics … and then we know that it is already precise enough in certain regimes, then just use it. We don't need other more precise models. But when in a different regime, we say, well, the kinetic equation is more proper … then you have to choose that. Although it is very difficult, it is still the more precise one. We want to tell you which regime you should use to be more economic and to be more efficient," he explains.

This work is funded by the National Science Foundation. ●

Lei Wu's research interests include partial differential equations, numerical analysis and mathematical physics. He received his Ph.D. in applied mathematics from Brown University and completed a postdoctoral residency at Carnegie Mellon University.

REMAKING THE NERVOUS SYSTEM

Michael Layden turns to the starlet sea anemone to better understand neural development and how the human brain evolved, and potentially improve treatments of central nervous system disorders.

Written by
Kelly Hochbein

Researchers originally targeted *Nematostella vectensis*, the starlet sea anemone, in the search for an organism that could help them understand the evolution of complex bilaterian animals. Bilaterians, which include insects, worms and vertebrates, have body plans built on bilateral symmetry, with sensory organs at the anterior and centralized nervous systems. However, *Nematostella* is also capable of extensive regeneration, and the 2007 publication of its genome opened the door for the anemone to inform our understanding of animal evolution and regeneration.

"Some people describe sea anemones as these primitive animals," says Michael Layden. "But you can use them to ask modern questions."

Layden, an associate professor of biological sciences, uses *Nematostella* to try to answer questions related to nervous system evolution and to understand how neuronal regeneration differs from development, which has implications in how researchers think about regenerative therapy design.

"When I started [my career] … there were lots of good regeneration models," he says. "Hydras had been around for almost 300 years, and planarians are these little crazy worms that you can cut into 211 pieces and get 211 worms. But the problem with those systems is that you cannot really get embryos, so you cannot study development effectively. The animals are incredible for learning about regeneration, but you cannot ask the specific question of how similar and dissimilar regeneration and development are. So that's what attracted me to *Nematostella*."

Layden began his career studying nervous system development in *Drosophila*—the fruit fly, which he calls "the poster child for genetics"—at the University of Oregon. There, he encountered researchers interested in linking evolution and development—and discovered *Nematostella*, an organism more genetically similar to humans than *Drosophila*.

"I saw a talk on *Nematostella*, two in a row, actually, that came out of the lab that I ended up doing my postdoc in [at the University of Hawaii at Manoa]," he says. "What I realized was, first of all, this is a weird animal, but they're doing cutting-edge research on it. They are taking advantage of the new era in genomics and are able to ask pretty sophisticated questions. At that time, if it wasn't a mouse, a fly, a zebrafish or a frog, you couldn't do anything in it. But they were doing it in this sea anemone—they were knocking down genes and trying to look at function. And it just kind of hit me that I could still work on the nervous system, I could look at evolution and I could study regeneration, all in this one system."

Layden, who first glimpsed research in action when he was a laboratory dishwasher as an undergraduate at the University of Rochester, has never looked back. He now helms the Layden Lab, which studies neural development in the starlet sea anemone.

"Even to this day, I'm still excited to come to work and see what we're going to learn," he says.

***Nematostella vectensis*, the starlet sea anemone, helps researchers understand animal evolution and regeneration.**

TWO BIG QUESTIONS

Layden and his team aim to answer two questions: First, how was the ancestral nervous system that gave rise to the human brain patterned? And second, how can an organism remake neurons and rewire the nervous system during regeneration?

The answers to these questions may help in developing a better understanding of neurogenesis—the formation of neurons in the brain—and potentially aid in improved treatments of central nervous system disorders.

Michael Layden received his Ph.D. from the University of Oregon and completed a postdoc at the University of Hawaii at Manoa. He is a recipient of a National Science Foundation (NSF) CAREER Award.

To answer the first question, Layden and his team are working to determine how different neurons first were made: "How did cells go from naive to neural? And then how do all the different types of neurons that an organism needs to sense its environment and determine the appropriate response get patterned?"

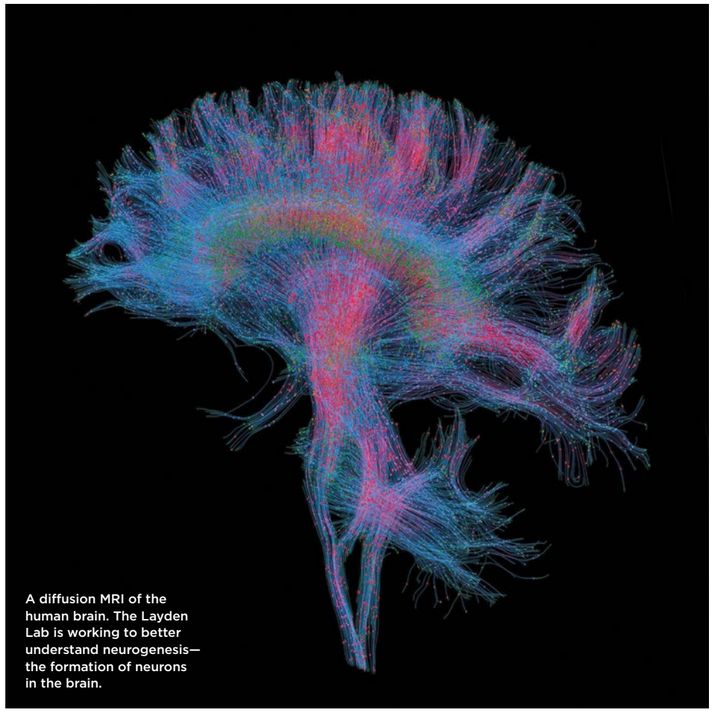
The mechanisms that patterned the ancestral nervous system can help researchers understand whether complex brains evolved once or multiple times, which has significant implications about our understanding of animal evolution, he explains.

"What we think is that by understanding how *Nematostella* patterns its nervous system [and how its relatives pattern theirs] … we can build a theoretical model of what the ancestral system looks like," Layden explains. "That allows us to understand what might have occurred during nervous system evolution. What we're seeing is that patterning we thought was specific to complex brains is actually patterning *Nematostella*, too."

Complex brains, including the human brain, are patterned from the anterior to posterior axis using a gradient of a Wingless-Int (WNT) protein. That gradient then makes the specific domains of the nervous system, which give rise to the forebrain, midbrain, hindbrain and spinal cord. That entire program is already present in *Nematostella*, says Layden.

"For basically 100 years or so, people have said that all brains look like they're patterned the same, so they evolved once. But really, of course they would look like they are patterned the same way, because they are just co-opting something that was already there. It wasn't specific to the brain. So that means that that information cannot be used to say that brains only evolved once.

"We're hoping that by looking at *Nematostella*, we can start to get a better sense of what we can look at in brain development that would be informative to tell us if evolution happened once or multiple times, and potentially how many times. … It's really simple at its core, but it took time for the technology of science to get to the point where people could think about it this way. We are part of that group of newer biologists trying to look at these older questions with new technology," he explains.



A diffusion MRI of the human brain. The Layden Lab is working to better understand neurogenesis—the formation of neurons in the brain.

DEVELOPMENT & REGENERATION

The second question—How do you remake the nervous system through regeneration?—requires a focus on how the neurons in a regenerated animal were made relative to the mechanisms that made those same neurons during embryonic development. Layden and his team use *Nematostella* to compare the processes of development and regeneration.

"It's becoming more apparent that during regeneration, the nervous system—or probably all tissues—is actually not being built with the exact same programs used to construct them during development," Layden says. "It kind of makes sense because the way that animals are patterned is sort of context-specific, and regeneration is different from development. In hindsight it's obvious, but this is a question that researchers struggled with for a long time."

This difference makes a comparison between development and regeneration even more necessary. "We need to know that difference because if you're trying to use regenerative therapies for biomedical intervention and you just force animals down this developmental pathway, it's sort of doomed to fail," Layden explains. "And so, we are now rethinking our approach to regeneration research and regenerative medicine."

During development and regeneration, each neuron undergoes a process that determines its job. This process requires turning parts of the organism's genome on and off in specific ways, which is defined as a gene regulatory network, says Layden. Layden and his team build gene regulatory networks to determine the order that the genes in the *Nematostella* genome are turned on during development and regeneration of different types of neurons. They then compare the two processes.

The team has identified 20 neural genes—known as transcription factors—that act right after a cell switches from naive to neural to start each neuron down its own path during development. They then work to put these genes in order by reducing or taking away the function of one of them and observing what happens to the remaining genes. "So if you take something away and five of the other genes are now all of a sudden at higher levels, then you know that the function of the one you took away was to block the activity of those other five. And, conversely, if you take it away and you see these other 10 genes all are no longer expressed, then you know that the job of the particular gene you took away is to turn those other 10 genes on. Using that logic, we build a preliminary gene regulatory network describing the order in which the genes function," says Layden.

Next, using biochemistry, molecular biology and genomics, the team tries to refine the regulatory networks that govern neuronal patterning.

Regeneration is more challenging to examine than development, says Layden.

"It's not like you have a separate subset of your genome that functions during regeneration and during development. They both are acting in both processes, but they are used in different ways. So if you get rid of a gene, development never happens and you can't study regeneration. Thus, to study regeneration, we need to design approaches that allow us to control whether a gene is disrupted during development or regeneration.

"The first thing we are doing is just making a map of where all our developmental genes are during regeneration. When we do that, we see some very simple patterns. Sometimes, where the gene is turned on during regeneration is different from where it's turned on during development. We know that it can't be functioning exactly the same, just based on that simple observation. We don't know how it's different yet, but we know that it's not the same.

"Other times it appears, based on the expression pattern, that a particular gene probably does something similar in both processes. So we are building that information first, and simultaneously trying to come up with new technologies to take away gene activity during regeneration. To do that, we are adapting tricks that have been used in traditional model systems," he explains.

> "WHEN WE LOOK BROADLY ENOUGH, PATTERNS ALWAYS EMERGE THAT SHAPE OUR UNDERSTANDING OF ALL BIOLOGY AND ADVANCE OUR ABILITY TO POSITIVELY IMPACT HUMAN HEALTH."

The complete answers to these big questions, Layden says, will be found beyond *Nematostella*.

"The answer isn't going to come from only using *Nematostella*. Development and regeneration should be compared in multiple species to identify the patterns in how these processes differ across the tree of life," he says. "When we look broadly enough, patterns always emerge that shape our understanding of all biology and advance our ability to positively impact human health."

Layden received a National Institutes of Health (NIH) R03 in 2016, an R01 award in 2019 and a National Science Foundation (NSF) CAREER Award in 2020 to support this work.

Credit Where It's Due

When Michael Layden and postdoctoral research associates Layla Al-Shaer and Jamie Havrilak were preparing a book chapter about the history of *Nematostella* as a model system, Al-Shaer and Havrilak began a deep dive into the discovery of the sea anemone.

British naturalist and marine biologist Thomas A. Stephenson published the first description of *Nematostella* in 1935. Havrilak noticed that Stephenson attributed the anemone's discovery to "Miss G.F. Selwood," who first found the sea anemone at the Isle of Wight in England and sent the specimens to Stephenson.

"A lot of times in *Nematostella* papers you see Stephenson's name mentioned because he's the one that published the book describing them, but it's only if you dig through his really hard-to-find book that you realize that it was a woman who actually found them," Havrilak explains. "And so we started this hunt for information about her."

Al-Shaer searched ancestry websites for a photo of Selwood, and Havrilak reached out to an archivist at Selwood's alma mater in the United Kingdom for more information. The archivist identified her as Gertrude Fanny Selwood, a lecturer in zoology at Municipal College who had received a bachelor's degree at the University of Birmingham. Even with Selwood's full name, however, Al-Shaer and Havrilak were unable to find any photos—but not for lack of trying.

"[When I lecture], I try to point out when a woman actually did the work and didn't get credit or if she worked for somebody and that person gets cited but she's the one who actually did [the work], just to highlight that women were doing the science," says Havrilak. "*Nematostella* is becoming more established, but a lot of people have never heard of it or don't know a lot about it, so you give a brief history of the model when you're talking to a broad audience. Including Selwood in that history is important."

Says Al-Shaer: "We really wanted to have a picture of [Selwood] to say, 'Look, this woman was out there, trudging around in coastal estuaries, finding these species.'"

CLOSING THE INTERVENTION GAP

Ana Dueñas addresses a gap in services for Latino children with autism who need early intensive behavioral intervention.

Written by
Mary Ellen Alu

Illustration by
Michela Buttignol

In her three years as a social worker in California, Ana Dueñas saw firsthand how Latino families struggled to obtain services for their children with autism, a neurodevelopmental disorder that can cause significant social, communication and behavioral challenges.

Now, as assistant professor of special education in Lehigh's College of Education, Dueñas, along with doctoral students Marisa Solé and Alyssa Blasko, is conducting a pilot study into early intensive behavioral intervention that is tailored to meet the needs of Latino children with autism and their caregivers. The pilot study has the potential to address what Dueñas says is a critical gap in caregiver-mediated interventions for the Latino population in the United States.

According to the Centers for Disease Control and Prevention, about one in 54 children in the United States. has been identified with Autism Spectrum Disorder Dueñas notes that about 185,000 of these children are Latino.

For children with autism, one of the most effective treatments is early intensive behavioral intervention. About 40% to 47% of children who receive early intervention demonstrate substantial gains in communication skills, behavior and IQ, Dueñas notes.

"THERE ARE SO MANY BARRIERS," DUEÑAS SAYS. "ONE IS, OBVIOUSLY, THE SYSTEM IS REALLY COMPLEX, AND NAVIGATING THAT SYSTEM IS DIFFICULT. LANGUAGE BARRIERS ADD TO THAT."

However, she says, few interventions are tailored to meet the needs of Latino families. That results in significant disparities from their non-Latino counterparts, including a delay in the age at which their children are diagnosed, limited access to services and low utilization of services.

"There are so many barriers," Dueñas says. "One is, obviously, the system is really complex, and navigating that system is difficult. Language barriers add to that."

She says Latino families are often at a disadvantage at all steps of the process, including at diagnoses, a prerequisite for services. "Some families are on wait lists to even get those diagnoses, because there are not enough professionals across that continuum of services that speak their language," she says.

Also, many low-income Latino families rely on Medicaid for their children's health insurance, which does not adequately cover diagnostic evaluations in many states, Dueñas notes. Although services are covered in Pennsylvania, for example, a large number of families are on waiting lists, she says.

In the pilot study, Dueñas is partnering with 12 Latino caregivers of children with autism, ages 2 to 5, in delivering services tailored to their needs. The intervention, delivered remotely because of the COVID-19 pandemic, has three components: parent support, parent education and one-on-one coaching. Dueñas and her team are using an ecocultural approach to understand families' needs in the context of their Latino culture.

Dueñas partnered with a family therapist who is Latina and has a child with autism to lead a parent support group. She says the program is adapted from Parents Taking Action, a psycho-educational intervention developed by Sandra Magaña and colleagues at the University of Texas at Austin. The parents also receive 40 hours of training and coursework in the principles of applied behavior analysis, a type of therapy for improving behaviors such as social skills.

"A lot of parents don't really need that much background and education to learn these strategies, to the extent that we teach the paraprofessionals who then come into their homes to work with them," she says. "If they already have that knowledge that a person coming into their home has, it just goes such a long way."

Midway through that training, the parents are coached via headphones during their daily routines with their children, such as in how to work with their children during snack time to improve their children's communication skills. Dueñas says her team collaborates with the parents to set goals.

"It starts to make more sense, how this can be something that they can do throughout their day, as opposed to having to sit down and say, 'Okay, now we're gonna work on language,'" she says.

Dueñas and her team will conduct focus groups at the end of the pilot study to determine what went well and what did not. This work is funded by a Lehigh Faculty Application Grant, and Dueñas plans to seek additional grants to expand the study and to partner with communities to expand the program.

Ana Dueñas is a board-certified behavior analyst. She earned a doctorate in special education from Michigan State University, and a master's in autism and transition to adulthood and a bachelor's in psychology and religious studies from San Diego State University.

REDUCING HEALTH GAPS IN NATIVE POPULATIONS

Christine Makosky Daley and Sean Daley lead a team of researchers partnering with Native communities on a holistic approach to well-being.

American Indians are at a higher risk of developing or dying from tobacco-related diseases, including lung cancer, heart disease and diabetes.

Written by **Lori Friedman** and **Mary Ellen Alu**

American Indians and Alaska Natives die of heart disease, cancer, unintentional injuries and diabetes—the leading causes of death—at higher rates than other Americans, according to the Indian Health Service, an agency of the U.S. Department of Health and Human Services. Overall, the life expectancy of Native people is 5.5 years less than the general U.S. population.

The education gap is also wide. American Indians and Alaska Natives are among the racial/ethnic groups with the highest high school dropout rate, according to the U.S. Department of Education. Of those aged 16 to 24, 9.5% are not enrolled in school and don't have a high school credential.

The health disparities and achievement gaps are interrelated, say tribal health experts Christine Makosky Daley and Sean Daley, faculty members and founding directors of the Institute for Indigenous Studies at Lehigh's College of Health. The Daleys, collaborators and spouses who work with a team of researchers, partner with Native communities on a holistic approach to closing the gaps and promoting well-being.

"Addressing those issues is not just about saving individual people," says Makosky Daley. "It's about taking an entire community and impacting it in such a way that we can reduce those disparities and make the prevalence rates look a bit more similar to other racial or ethnic groups."

Makosky Daley led the Institute's research efforts as co-director before temporarily stepping down to chair the College of Health's new department of community and population health. Daley serves as the Institute's director.

CURBING CIGARETTE SMOKING

A key area of the team's research has centered on curbing commercial tobacco use among American Indians, who, along with Alaska Natives, have the highest prevalence of cigarette smoking compared to all other racial/ethnic groups in the United States. Subsequently, they are at a higher risk of developing or dying from tobacco-related diseases, including lung cancer, heart disease and diabetes, according to the Centers for Disease Control (CDC).

The team's work with All Nations Breath of Life, a 12-week smoking cessation program that Makosky Daley helped to develop beginning in 2004, recognizes that tobacco, along with such plants as sage, cedar and sweet grass, is a sacred plant for many, but not all, American Indian populations. The program has a higher six-month quit rate than any other program for Native Americans, Makosky Daley says.

"American Indians are really the only group of people that we know of who view tobacco in a different light than many others," she says. "Tobacco's a sacred plant to many Native people … and so the idea of smoking has a different connotation."

The program, led by Native people, combines weekly in-person group support with individual telephone counseling. Participants also receive educational brochures on topics that include stress and weight management, and coping with withdrawal. The program also includes a choice of pharmacotherapy, as well as incentives such as flute music to help with stress reduction.

"We talk about tobacco as being sacred and being an important part of life, and being one of the first medicines out there, so you shouldn't disrespect it by smoking it recreationally," Makosky Daley says. "Many times when you're using tobacco for ceremony, you're not even smoking it. You're burning it. … We talk about that and actively say, 'By smoking recreationally, you're disrespecting a sacred plant, and that's not okay.' It's a different messaging that we use."

The team initially tested the program for efficacy in reservation communities through a randomized trial. It then implemented a study of 312 participants in multi-tribal, urban communities, where views on tobacco vary; the cessation rates were similar or better, Makosky Daley says.

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Christine Makosky Daley earned a doctorate in applied medical anthropology from the University of Connecticut, a master's in health and social behavior from the Harvard School of Public Health, a master's in medical anthropology from Arizona State University and a bachelor's in anthropology from Douglass College at Rutgers University.

In the multi-tribal study, researchers followed up with participants at six months and 12 months to assess whether they continued to abstain from recreational cigarette smoking. The study took place primarily in Kansas and Missouri, with additional sites in Colorado, Texas and Michigan—areas that have high smoking rates and high mortality from lung cancer.

According to the findings published in *Nicotine & Tobacco*, 53% of participants who completed the program were abstinent at 12 weeks (end of the program); at six months, 31% of retained participants had quit smoking; at 12 months, 34% of those reached were smoke-free.

"WE BELIEVE THAT A COMMUNITY CANNOT BE TRULY HEALTHY UNTIL INDIVIDUALS IN THAT COMMUNITY BEGIN TO TAKE A LEADERSHIP ROLE IN IMPROVING AND MAINTAINING HEALTH."

The interventions are ongoing. "Participants work really well together," Makosky Daley says. "They have fantastic discussions about their different beliefs, and how tobacco is sacred for some people and not for others and used in different ways. ... So the fact that people were able to come together and have these wonderful discussions seemed to really help them."

A next step is an implementation trial in four urban and reservation communities, funded by the National Institute on Drug Abuse (NIDA).

"We're heading into the communities, teaching them how to run the program, and they are implementing it themselves, which is really cool," Makosky Daley says. "In research, it's great to be able to say, 'We did this in a research study in a controlled setting and it worked.' It's even better to be able to say, 'In the real world, we hand this program to communities, and they can run it and keep it sustainable.' So now we're checking for sustainability. We're seeing if we hand it to communities and teach them how to run it, can they? Is the program going to work in a real-world setting, when the researchers are very hands-off?"

Additionally, the researchers will conduct a randomized trial of an individualized, phone-based version of the smoking cessation program, also funded by NIDA. A pilot test of the program, which aims to provide participants with more flexibility, had similar quit rates to the group-based program. Makosky Daley says she is hopeful it will work.

"We believe that a community cannot be truly healthy until individuals in that community begin to take a leadership role in improving and maintaining health," Makosky Daley says. "This can only be accomplished when the educational attainment of the community is enhanced, and the true empowerment of community members occurs." ●

An Institute for Indigenous Studies

Tribal health experts Christine Makosky Daley and Sean Daley established the Institute for Indigenous Studies at Lehigh's College of Health in 2021, initially serving as co-directors. Makosky Daley led the Institute's research endeavors before temporarily stepping down to chair the college's new department of community and population health, while Daley led the Institute's educational programs. Daley now serves as director.

The Institute's work takes a "holistic health approach" that aligns with a definition of health often used by Indigenous peoples themselves, they say.

"Our definition goes beyond the World Health Organization's stance that health is a state of complete physical, mental and social well-being," Daley says. "We add to their definition emotional, spiritual, community and environmental—both natural and built—aspects of health."

The new Institute merged the Center for American Indian Community Health, founded and led by Makosky Daley at the University of Kansas Medical Center in Kansas City, Kan., and the Center for American Indian Studies, founded and led by Daley at Johnson County Community College in Overland Park, Kan. The Institute builds on the legacy of both centers.

"Native peoples are often relegated to stereotypes and mascots, or seen as relics of the past," says Daley. "Having an institute that educates people, at Lehigh University, the greater Lehigh Valley area and beyond, about contemporary Indigenous peoples and their communities would help break down the misconceptions and stereotypes."

Eight research scientists who worked with the Daleys in Kansas joined them at the Institute: Justin Begaye, MSW, MPA (Navajo); Ryan Goeckner, MA; Jordyn Gunville, MPH (Cheyenne River Sioux); River Gunville, BS (Cheyenne River Sioux); Jason Hale, MA (Prairie Band Potawatomi); Charley Lewis, MPH (Paiute/Navajo); Joseph Pacheco, MPH, ABD (Quechua/Cherokee); and Luke Swimmer, MBA (Eastern Band Cherokee). In addition, Eduardo J. Gómez, associate professor and director of undergraduate programs at the College of Health, joined the Institute, bringing his expertise in health policy and a global focus.

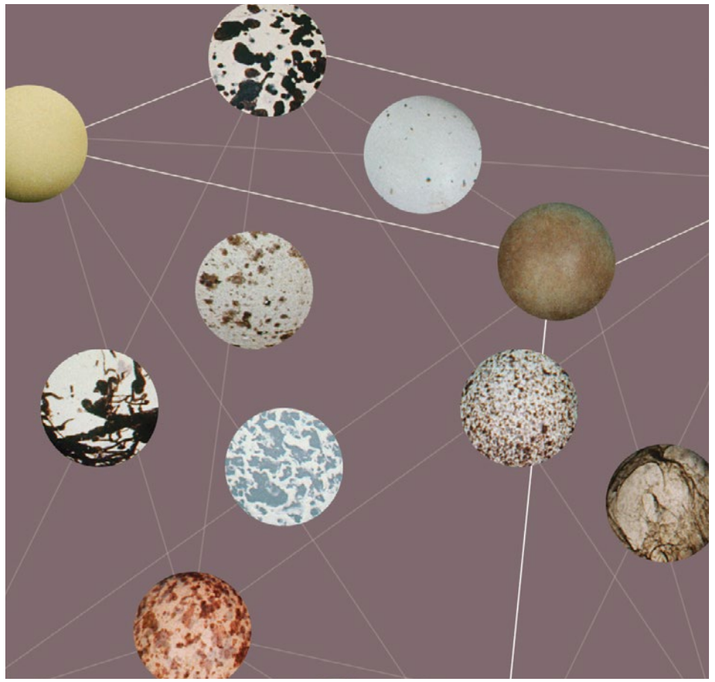
Among its projects, the Institute is expanding its COVID-19 prevention efforts, through funding from the Patient-Centered Outcomes Research Institute. This effort includes a survey of 1,000 American Indians about knowledge, attitudes and behaviors surrounding the pandemic.

Additionally, the Institute is conducting a phenomenological study of the lived experience of COVID-19 among reservation-dwelling American Indians in the U.S. "Native Voices" will become a full-length book detailing the Native experience during the pandemic.

"One of the problems when you look at data, in general, in public health, [is that] the American Indian voice is not there, and the American Indian statistics are not there. They get lumped in with other racial or ethnic groups," Makosky Daley says. "It's really important to be able to have data specific to that community ... so that any interventions, any health issues, can be addressed in these communities."

—Lori Friedman and Mary Ellen Alu

Sean Daley earned a doctorate in sociocultural anthropology from the University of Connecticut, a master's in American Indian studies from the University of Arizona, and a bachelor's in American Indian studies and anthropology from Livingston College at Rutgers University.



PREDICTING SUCCESSFUL MATERIALS DESIGN

Ganesh Balasubramanian applies computational modeling and predictive engineering to understand the mechanical properties of multi-principal element alloys.

Written by **Lori Friedman**

Illustration by **Kurt Hansen**

For as long as people have been making things, engineers have worked to improve them, often by designing materials that are stronger, more resilient and less costly to produce.

Understanding the mechanical properties of advanced materials—materials with unique or enhanced properties—has taken on new importance because advanced materials, usually at the nanoscale or smaller, have the potential to drive improvements in consumer products such as device screens and computer chips, and in areas such as air travel, space exploration, solar energy production and medical devices.

"When looking at the structure of materials, you have different pieces that adhere together or arrange themselves, like building blocks," says Ganesh Balasubramanian, an associate professor of mechanical engineering and mechanics whose lab focuses on understanding the mechanical properties of advanced materials through computational and experimental methods. "For materials at the atomic scale, the technology is advanced enough that we can actually manipulate where atoms sit together."

Changing those patterns can change key properties, such as a material's elasticity, or electrical and thermal conductivity.

Balasubramanian's lab creates computational models to describe how atoms fit together in order to address design challenges by creating samples, testing the material and applying what they learn.

"However, if we keep doing these models for each and every type of material that we come across, it will just take ages," says Balasubramanian.

So Balasubramanian has added a new and potentially groundbreaking step: predictive engineering. Prediction leverages data and advanced computing to speed the process exponentially.

"When the samples we create are tested and the experiments tell us the samples are good, we have achieved our objective," says Balasubramanian. "If the experiments tell us they are not good, then that can be used to reinstruct and inform the models."

His team is primarily applying the predict-build-test-repeat approach to a promising material class known as high-entropy alloys, a subset of multi-principal element alloys. This new class of materials are alloys formed by mixing varying proportions of multiple elements. Preliminary studies have demonstrated that multi-principal element alloys have superior mechanical strength and hardness, making them ideal for turbine blades, medical implants, and as a protective coating on components like ship surfaces and aerospace parts.

Balasubramanian, working with colleagues at Ames Laboratory, recently developed a hybrid version of an algorithm called the Cuckoo Search to overcome the limitations of current models and accelerate the computational modeling of complex alloys. The Cuckoo Search is inspired by the evolutionary strategy of Cuckoo birds.

"In evolutionary biology, traits compete down the generations to create new generations," says Balasubramanian. "That can describe the process of creating materials with the best traits, too. Using predictive methods such as the Cuckoo Search speeds up that process."

In this most recent work, the predictive process sped search time for materials design 13,000-fold.

"What took about a day to accomplish can now be done in seconds," says Balasubramanian. ●

Ganesh Balasubramanian's research interests are in advanced energy and structural materials, nanoscale transport and mechanics, and predictive engineering. He received his Ph.D. from Virginia Tech and was a postdoctoral research associate in theoretical physical chemistry at TU Darmstadt in Germany. Balasubramanian is a 2020 recipient of an NSF CAREER Award.

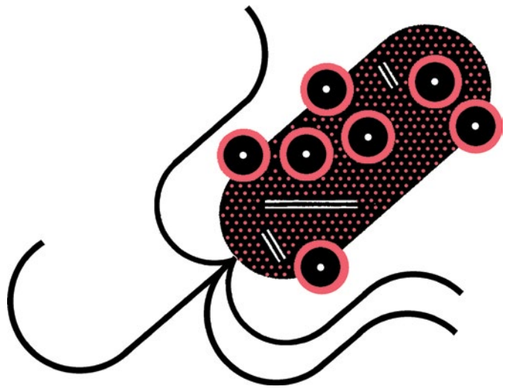
HARNESSING THE POWER OF BACTERIA

Angela Brown's research seeks to hijack bacteria's machinery to develop a better drug-delivery system that could help combat antibiotic resistance.

Written by
Lori Friedman

Illustration by
Raymond Biesinger

Bacterial infections can take hold in the body when a pathogenic, or disease-causing, microorganism enters and delivers toxins to healthy human cells. One way bacteria accomplish this is by releasing vesicles, which act as tiny envelopes transporting toxins and other virulence factors—molecules that help infection take hold—to host cells. The virulence factors allow the bacteria to effectively infect healthy human cells and make people sick.



The rapid emergence of antibiotic-resistant bacteria—bacteria that do not respond to currently available antibiotic treatment—is a worldwide problem that is only expected to worsen. The Centers for Disease Control and Prevention (CDC) estimates that almost three million people in the U.S. develop antibiotic-resistant bacterial infections each year, with more than 35,000 dying as a result. Developing new antibiotic drugs is a long and expensive process and not widely seen as an effective long-term solution. Anti-virulence strategies that seek to disarm bacteria's virulence factors are one possible approach.

"The idea of an anti-virulence strategy is to eliminate those virulence factors or inhibit the function of those so the bacteria don't have those advantages," says Angela Brown, an associate professor of chemical and biomolecular engineering whose research has focused on anti-virulence strategies. "Then the immune system could have time to clear the infection before it takes hold."

Recently, Brown's research has taken a promising turn. She is now leveraging her extensive knowledge of bacterial vesicles to develop a better drug-delivery system that could help combat antibiotic resistance.

Brown and her team are harnessing the power of outer membrane vesicles—which are continuously shed by Gram-negative bacteria, the most difficult to treat—to deliver drugs directly to cells. Such a system could decrease the rate of resistance by, among other outcomes, improving delivery to bacteria that are particularly difficult to treat with antibiotics, including those that have developed certain resistance traits.

"Bacterial vesicles as a delivery system have a number of advantages," says Brown. "They are really stable, and they have a natural ability to deliver large molecules to other cells."

Although other researchers have demonstrated the feasibility of using outer membrane vesicles to deliver medicines, the method has its limitations. Brown's team is working on a way to overcome those limitations by combining the best properties of outer membrane vesicles with another promising drug-delivery strategy: liposomes. Liposomes are synthetically created, nanometer-scale, spherical vesicles that are attractive as drug-delivery vehicles because of their solubility and low toxicity. Liposomes' stability, however, is limited.

"We want to combine liposomes and outer membrane vesicles to create 'semi-synthetic outer membrane vesicles,'" says Brown. "This will result in a delivery system that maintains the advantages of each system while overcoming the limitations of each."

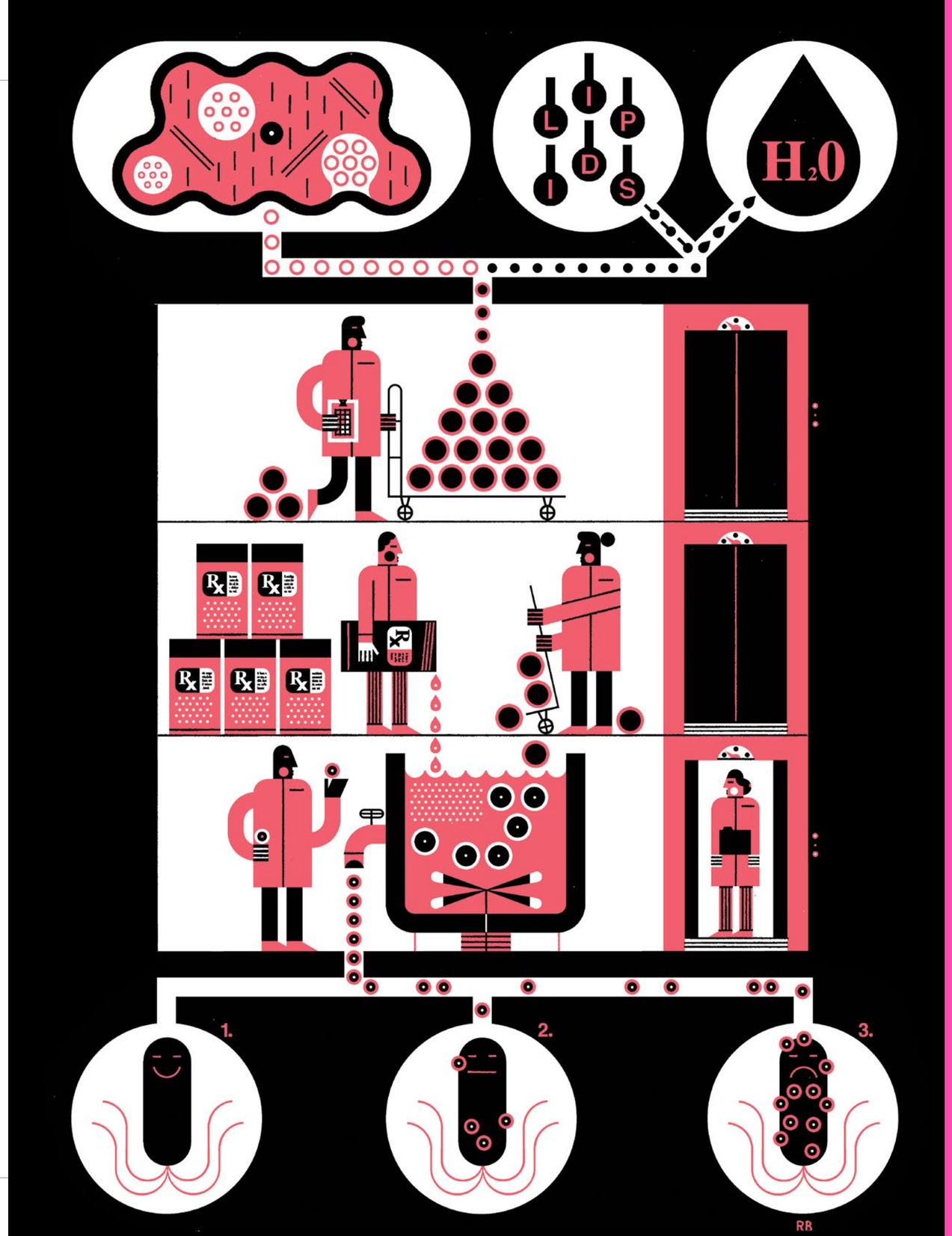
Currently, Brown and her team are focused on optimizing the process of loading the drugs into the semi-synthetic vesicles.

"We want to investigate different molecular weights and different hydrophobicities—molecules' tendency to dissolve or not dissolve in water—and determine what is the best technique to get those particular drugs loaded," says Brown. "The idea is to make the vesicles more easily modifiable in the future by developing a method that could be applied to a broad range of bacterial infections and antibiotic treatments."

Brown is already laying the groundwork to apply her group's knowledge to address the challenge of treating an emerging multidrug-resistant pathogen, *Stenotrophomonas maltophilia*, that can cause a variety of severe infections in immunocompromised patients.

"The membrane of *Stenotrophomonas maltophilia* is especially difficult for antibiotics to penetrate, so only certain antibiotics can cross," says Brown. "But if we have these vesicles that naturally fuse with the membrane, like outer membrane vesicles do, we could overcome that resistance pathway."

Brown's novel biomaterials-based strategy could become a useful tool for slowing down the rate of antibiotic resistance. If successful, it could even prove to be a new way to repurpose antibiotics that are already in use. ●



Angela Brown's research focuses on understanding the mechanisms of bacterial virulence factors during disease pathogenesis to identify targets for the prevention of bacterial diseases and develop biologically inspired therapeutic agents. She received her Ph.D. from Drexel University.

MODELING CATASTROPHES

Lehigh researchers leverage their collaborative experience in probabilistic modeling to sharpen their focus on catastrophe modeling, a discipline not traditionally explored in academia.

Tornadoes tore a path of destruction through Tuscaloosa, Al. on April 27, 2011, killing more than 200 people.

Written by **Kelly Hochbein**

Early on the morning of January 17, 1994, a magnitude 6.7 earthquake rocked California's San Fernando Valley. The Northridge Earthquake killed at least 57 people, injured thousands and resulted in tens of billions of dollars in damage. The cause of this particular quake—one crustal block moving over a second crustal block—produced extremely powerful ground shaking, making it even more destructive.

To recover from the devastation of a rare disaster like the Northridge Earthquake, individuals and communities need to be able to rebuild quickly while navigating tremendous loss. This comes at a cost, most often covered by insurance, and the speed with which insurers make payments can impact the long-term recovery of a region. To operate effectively, insurance companies must prepare for the unknown, predicting the future without much information from events of the past. They do this with catastrophe modeling.

In cases of standard coverage, insurers look for patterns in their extensive claims data to calculate an individual customer's likelihood of having to make a claim. This straightforward process works well in determining a customer's auto insurance premium. It is not, however, effective in the case of rare events such as earthquakes, for which insurers cannot conduct statistical analyses of historical claims and losses. With a catastrophe, "what if?" becomes the critical question.

"The necessary premise—that we have a lot of past claims data that we can use to inform our models—basically disappears. Because these are, by definition, rare events, there is not going to be a large amount of past data. [Insurers] cannot use their normal way of operation," says Paolo Bocchini, associate professor of civil and environmental engineering.

"If we don't have much data, we can't do traditional modeling based on lots of data to figure out what the underlying relationships are among the events and their impacts and so on," says Brian Davison, professor of computer science and engineering.

A rigorous probabilistic approach to the study of disasters and their consequences, catastrophe modeling, or CatModeling, attempts to estimate potential events and their associated risks, including financial losses. Researchers take what they know about a particular scenario and incorporate methods from a variety of disciplines to make predictions about the likelihood of certain outcomes. In the case of a hurricane, for example, researchers might gather data about past hurricane activity and details about the infrastructure in a particular region. They then build a model to predict the likelihood of the region experiencing losses in a similar storm in the future, as well as the potential cost of recovery from those losses. Beyond natural disasters, decision-makers can use information from CatModeling to plan for rare events such as pandemics, financial crises and political unrest.

Unlike most disciplines, which are born in academia and then applied in industry, says Bocchini, catastrophe modeling was born in the insurance sector as "a sister to actuarial science." The information it generates can help insurance companies estimate losses and calculate premiums. Its use is not limited to the insurance industry, and it can help leaders at all levels make the best possible decisions about how to protect and ensure the recovery of their communities.

"Natural disasters, political unrest, pandemics—these are all kinds of events that could benefit from planning for the future and trying to anticipate what damage they can do to society for multiple factors: from a financial perspective, from a social perspective on the well-being of people, from physical damage to infrastructure if we talk about hurricanes or earthquakes. These can have an immediate impact on what functions in our communities," says Daniel Conus, associate professor of mathematics.

Bocchini, Davison, Conus and their colleagues at Lehigh are leveraging a wealth of experience and expertise in their respective fields and their collaborative experience in probabilistic modeling to sharpen their focus on CatModeling, a discipline traditionally not explored in academia.

BUILDING ON EXISTING EXPERTISE

Lehigh has had teams of researchers studying disaster resilience for years. Led by Bocchini, the university's Probabilistic Modeling Group has built momentum in its work, developed relationships with collaborators in industry and academia, and secured funding for a variety of projects. Eventually, the group began receiving grants for applications of probabilistic modeling to catastrophe

Hurricane Irene devastated parts of New Jersey in August 2011. Severe flooding and power outages forced thousands of residents into shelters.

Paolo Bocchini's research activity is related to the use of probabilistic concepts, computational mechanics, operations research and other mathematical tools in civil engineering problems. He received his Ph.D. from the University of Bologna after completing a dual-advisor program at Columbia University, where he had been a visiting scholar.

modeling. This prompted Bocchini and his colleagues to narrow their focus and assemble a catastrophe modeling team based on ongoing Lehigh efforts.

Among the probabilistic modeling efforts is "Probabilistic Resilience Assessment of Interdependent Systems (PRAISys)," a five-year project that used a probabilistic approach to examine how interdependent infrastructure systems work together during and after an extreme event, such as a natural disaster. The PRAISys platform combines models of individual infrastructure systems—such as power distribution systems, transportation networks and communications systems—with models of their interdependencies to allow researchers to assess the resilience

Tuscaloosa, Al., April 28, 2011

of the systems under uncertainty.

"We essentially built a simulator for how communities will act and respond to catastrophic events and how they would repair their infrastructure and how long it might take," explains Davison, whose own research focuses on machine learning and its applications in a variety of domains. "Given that it is a simulator, you can simulate anything: You can change the environment, you can change your investments or the way things are configured and see how that would impact your resilience, your ability to adapt and respond to the failures that result from a flood or from a tornado or earthquake."

The project, an interdisciplinary collaboration between Lehigh researchers and researchers from Florida Atlantic University and Georgia State University, involved 58 scholars and was funded by the National Science Foundation. It resulted in a number of publications, conference proceedings and book chapters, including papers co-authored by former postdoctoral fellow Wenjuan Sun, Bocchini and Davison in *Structure and Infrastructure Engineering*, *Journal of Infrastructure Systems* and *Sustainable and Resilient Infrastructure*, among others.

Sun coordinated the project, communicating the research progress between different groups and merging them into a final deliverable: the PRAISys platform.

"The work itself is very interesting," says Sun. "I hope what we did here can be helpful. … At the very least it built the foundation for the improvement of CatModeling at Lehigh."

Although the financial support for the project has ended, the work continues, Bocchini says. "The idea was to develop a platform for interconnected infrastructure systems. We were looking at power, telecommunication and electricity and studying how they are affected by disaster, how they can be damaged, how the decision-making takes place, and how they are recovered—with all the uncertainties that this process obviously involves. The idea was to be able to combine and predict the impact of different choices."

For example, a power company must decide which transmission towers to retrofit to withstand a severe storm. Is this the right investment? Or is it better to invest in more cranes to repair failed equipment more quickly? Should they focus instead on mobile generators to power critical facilities? PRAISys can help company leadership determine how to best allocate resources today to improve the system's resilience tomorrow.

"These are very, very different types of investments, and normally they are not compared because there were no models that could put all of them together. So we tried to create a platform that had all these features, so analysts can introduce different types of changes to the model and see which one is most effective. I think this was really a first, and the platform is available for download," Bocchini explains. "This is just the beginning."

Although CatModeling started with natural disasters, it can also be applied to other rare events, including infectious disease outbreaks. Bocchini and his colleagues, including former Lehigh researcher Javier Buceta, currently at the Institute for Integrative Systems Biology (I2SysBio) at the University of Valencia in Spain, are applying the traditional steps of CatModeling to frame Ebola virus outbreaks in Africa and attempt to forecast their impacts. In particular, they try to predict the spread of Ebola in various cities within a broad geographic region. Focusing on bat-transmitted Ebola spillover to humans, they combine a variety of methodologies, including probabilistic regional hazard modeling and big-data analysis, to determine the cities most at risk and what officials in those areas might do to minimize that risk. Their model utilizes bat birth and death rates, the rate of Ebola infection in bats and their recovery rates, bat mobility, seasonal changes and data about the availability of food and shelter for bats in a particular location.

This project is supported by the National Institutes of Health and was initially funded by a Lehigh Collaborative Research (CORE) grant. It has resulted in several publications, including a 2018 paper in *Scientific Reports* that proposes the team's predictive spatial distribution framework and demonstrates its ability to predict where and when an Ebola outbreak is likely to appear. A preprint on arXiv outlines the team's use of regression and machine learning techniques to analyze survey data that they personally collected in Africa with a team of undergraduate students; identify the features that best predict an individual's tendency toward behaviors that expose them to Ebola infection; and develop a predictive model about spillover risk statistics that researchers can calibrate for different regions, including Sierra Leone.

Tuscaloosa, Al., April 28, 2011

THE BEST CHOICES FOR TOMORROW, TODAY

CatModeling is an application of probabilistic modeling, which incorporates random variables and probability distributions into models of events, taking into account uncertainties. Researchers "try to look at the future and determine what is the likelihood of something happening [and] what is the choice that we make today that will have the highest likelihood to be a good choice tomorrow," explains Bocchini.

The approach is rooted in mathematics but has applications across many disciplines, including engineering, science and the social sciences.

Conus brings theoretical expertise to the team's work. Unlike statistics, which involves collecting data from the past and trying to explain what happens out of the data, "probability takes sort of the reverse approach," he explains. "We're actually trying to come up with a mathematical model that can explain from a theoretical basis what we expect would happen even before we collect the data."

Prior to his work in CatModeling, Conus worked on mathematical finance and models for particle physics, which, he says, sound drastically different, but they rely on the same mathematical tools. "The approach we take is that what happens in a catastrophe is that you have a lot of small entities that play a role and impact what happens in the big picture. Essentially, the heart of the mathematical techniques that we use is to take all those small effects, and instead of modeling every single one of them, to actually put it together and try to come up with models and equations that describe the big picture without having to look down on every single little entity that makes up the model," he says.

For any kind of disaster, CatModeling includes the probabilities of different event scenarios, levels of intensity, the region's vulnerability to damage and the potential financial impact.

Liyang Ma '20 Ph.D. used intensity measure maps to determine the performance of structures under the conditions of particular catastrophes while working on his doctorate with Bocchini as his advisor. Now a Lehigh postdoctoral fellow working specifically on catastrophe modeling, he develops these maps for different hazards, such as the wind speed, storm-surge level or earthquake magnitude of a region.

"How do I produce very good maps that can represent these catastrophes more precisely [and] more accurately so that when people do [work related to] how structures behave in a hazard, they can get better or more accurate results?" he asks.

For these maps to be representative, he explains, researchers use Monte Carlo simulations to generate a large set of maps given the uncertainty of an event like an earthquake. His goal is to select a smaller set of the most representative maps for that hazard.

Postdoctoral fellow Haifeng Wang, who received his Ph.D. from the University of Buffalo, focuses on wind field simulation. "From a single wind speed, I can generate a large number of wind fields, stochastic pressure fields for a building," he says. Wang collaborates with Ma by providing the wind load field of an entire building for use in structural response analysis.

"Hazards nowadays become more intense and severe, and human societies are more vulnerable," says Ma. "In the past, people didn't need electricity or the internet. Nowadays they need those things. They need hot water. When a hazard

Daniel Conus' research is in the field of stochastic analysis, more precisely on intermittency of stochastic PDEs. He received his Ph.D. from the Swiss Federal Institute of Technology (Lausanne).

Brian Davison's research interests include search, mining, recommendation and classification problems in text, on datasets, on the web and in social networks. Davison received his Ph.D. from Rutgers University and is a recipient of the NSF CAREER Award.

strikes, like a hurricane, people will be without power for days. So the goal is to make society better prepared for those hazards. ... Catastrophe modeling is a new area that has a bright future for civil engineers."

CatModeling invites collaboration across disciplines, challenging researchers to determine the most relevant questions to ask, explains Conus.

"That brings in all sorts of other disciplines that are not necessarily hard science and engineering, but disciplines in the humanities and the social sciences, to decide what is the relevant question if a major hurricane came on the East Coast," he says. "Are we really worried about the solvency of the insurance company? Maybe that's what an economist would answer, but as a society is that the very first question we should answer? Or should we focus on the remaining buildings? How many people can they host to make sure everyone has a shelter? ... What are the right questions to ask and to model? And then, once you have answers, you can start leading to policy creation. What's the policy that we should develop to try and diminish the impact or make it better for people?"

> "THE WORLD HAS PEOPLE WHO ARE INTERESTED IN CATASTROPHE MODELING...BUT WHAT WAS INTERESTING WAS THAT THERE WAS, IN THE U.S., AT LEAST, NO FOCUS AREA FOR THAT."

Several Lehigh faculty in the social sciences have joined the effort, forming a parallel group to collaborate on projects related to community resilience. In March 2020, members of this group, including Jessecae Marsh, associate professor of psychology; Dominic Packer, professor of psychology; and David Casagrande, professor of anthropology; in collaboration with Bocchini, Davison, and others within Lehigh's Institute for Cyber Physical Infrastructure and Energy (I-CPIE), shifted the focus of their planned project on community resilience and recovery in the areas of North Carolina affected in 2018 by Hurricane Florence to the COVID-19 pandemic unfolding in their midst. The team conducted a real-time longitudinal investigation of how individuals in the United States perceive, respond to, and recover from the impact of COVID-19, with the aim of understanding whether traditional metrics align with the lived experience of individuals living in communities recovering from a catastrophe.

EMBRACING OPPORTUNITY

In recent years, major insurance companies have started to build their own catastrophe modeling departments to better prepare for extreme events. This has increased demand for professionals in the field. As a significant next step, the team has received a Lehigh Research Futures grant to tackle this next challenge: the launch of the Catastrophe Modeling Center and the development of an academic program in catastrophe modeling at Lehigh.

"The world has people who are interested in catastrophe modeling in industry, in consulting and occasional academics," says Davison. "But what was interesting was that there was, in the U.S., at least, no focus area for that. And it seemed like it was a good match for what our experiences said we could do at Lehigh. [Establishing] an academic program in that area would be novel."

In addition to postdoctoral fellows Ma and Wang, four Lehigh doctoral students are currently focused on CatModeling. Even without a formal program, the CatModeling team already has had several students graduate and take positions in or related to this field, including at the two largest CatModeling firms in the world. The establishment of an educational component to the team's work would strengthen that pipeline.

"The intent would be that the students that are in such a program would be prepared for careers in catastrophe modeling. Today they sort of come at it from the side—they might be a statistician or [work in] financial modeling or insurance, but they don't have all these things come together. You need to have an interdisciplinary education to really prepare you for catastrophe modeling," says Davison.

Lehigh faculty have partnered with colleagues at Rice University, Stanford University and Florida Atlantic University, as well as AIG General Insurance, on this work.

"The opportunity for us to create this network with the other universities [is valuable in and of itself]," says Bocchini. "Writing a proposal together provided the opportunity to clarify ideas, roles [and] participants."

This collaboration extends to advising the team's postdoctoral fellows. Ma is co-supervised by Bocchini and Conus, Wang by Bocchini and faculty at Rice University.

"We're trying to make these connections by using people to bridge gaps," Bocchini says.

Since 2020, members of the team have published seven papers and a book chapter on CatModeling, and the group is planning a workshop for Spring 2022 that will include colleagues and collaborators in academia and the insurance industry. The team also has begun collaborating with faculty from Lehigh's College of Health, making CatModeling an even broader initiative at the university.

Says Bocchini: "There is this entire field, this entire discipline that we need to be a part of. I think academia has built all the building blocks and then we have completely delegated to the industry the job of assembling the pieces and making it a science. I think we can play an important role in this." ●

EYE OF THE BEHOLDER

Eugene Han analyzes eye movements to integrate theories of phenomenological aesthetics with the psychology of perception.

Written by **Kelly Hochbein**

Illustration by **Leonie Bos**

Eye-tracking cameras allow researchers in the field of psychology to measure changes in subjects' eye movements and analyze how they process visual information. Eugene Han, an assistant professor of architecture, takes a different approach.

Han uses the cameras as a creative tool to analyze eye movements and visualize the different ways people see art and architecture. His eye-tracking studies have explored in a variety of ways how people look at, for example, images, sculptures and passages through building complexes.

"My focus certainly is not about discovering generalities or what makes our minds work. That's definitely an interest, but at the end of the day, mine are design projects. I think everyone has something to say and to contribute with how they see," he explains.

Han's exploration of perception and eye tracking was born of coincidence—one that allowed him to merge his technical interest in eye-tracking cameras with his historical interest in aesthetic perception. While a doctoral student at Yale, he purchased a low-cost device for tracking eye movement and tested its efficacy on his students. Around the same time, the writings of 19th-century German art theorist Konrad Fiedler and his peers inspired Han to analyze the role of visual perception in aesthetics.

"[Fiedler] spoke heavily about the role of perception, how in aesthetic theory we needed to include the process of seeing, the act of seeing—[that] it wasn't immediate and it wasn't the same for everyone," he says.

In one of Han's studies, cameras track participants' eye movements in a darkened room as they view a series of images. He uses a triangulation method to measure and map where each subject looks while viewing each image or object. Once he has that data, Han writes programs to develop two-dimensional visualizations that represent his findings.

His current work involves mapping eye movements within spaces. In this study, participants wear an eye-tracking device connected to a cable. Han maps where they look as they walk around a space and in three-dimensions.

"Tracking people's perception of spaces goes back to the basics of architecture," says Han. "As opposed to an image that's projected on a monitor in a darkened room, when you actually walk through a space that's outdoors, the number of variables is exponential."

When a person is experiencing a space, ambient conditions such as lighting, temperature and acoustics come to the forefront.

"As an investigator, but also as an architect and a designer, you realize that you can never be in control of all those variables," Han explains. "The amount of complexity is something you just have to embrace in your buildings. You have to be cognizant of it, but you also have to embrace that people will view and perceive your buildings in very different ways."

Han recognizes the inherent danger in using tools such as eye-tracking cameras to optimize design. It's the complete opposite of what he's trying to do, he says.

"I'm trying to emphasize that, as architects, we should support interactions of our own projects that exceed, go beyond and surprise our own understanding that the creator is not always in control," he continues.

"I always liken perception to reading. When we look at buildings, we're reading buildings. And in that note, when we think of the word 'author,' the word comes from 'authority.' And I think there's that danger as architects, we think that we have certain authority in how people should use or perceive or understand our buildings. If anything, we just promote [and] provoke manifolds of reading." ●

Eugene Han's design and research are driven by problems of form in architecture, through the integration of aesthetics with computation. He received his M.Arch. from the Architectural Association in London and a Ph.D. from Yale University.

READING THE ROOM

Esther Lindström examines instructional practices for teaching reading to students with intellectual and developmental disabilities.

Written by
Kelly Hochbein

Illustration by
Ben Jones

Until recently, the predominant method of teaching children with intellectual or developmental disabilities (IDD) to read was to teach them one word at a time: Students would focus on and memorize a single word before moving on to another word. However, that approach may limit students in the long run. Researchers over the past decade have discovered that students with IDD respond well to learning phonics and the foundational components of reading, much like students with reading disabilities and typically developing readers do, with some adaptations to reflect their specific needs.

Esther Lindström, assistant professor of special education, is interested in how

educators can move those research findings to the classroom. Her doctoral dissertation is an observation study of reading instruction for students with IDD in which she examined how teachers were spending their time "when they say they're doing reading instruction."

Lindström sought to describe the content and quality of reading instruction provided by seven special education teachers to 17 students with IDD in self-contained kindergarten through third grade classrooms.

"If we know what it takes to teach reading well to this population, how much time are they allocating to foundational skills like phonics or fluency, as opposed to vocabulary and comprehension?" Lindström asked. "We don't know what the specific formula would be, and it's not necessarily the same for every child. … But we would want to make sure that those foundational skills are being addressed rather than just a whole word approach or just reading comprehension, for example. We would want to make sure that phonics and phonemic awareness are being taught explicitly."

In an effort to better meet the needs of students with IDD in a self-contained setting, Lindström adapted an observational tool originally intended for use in a large classroom with students who are typically developing or who have reading disabilities. She made video recordings of typical classroom instruction focused on phonics and word study, vocabulary and comprehension, and other areas. Then, she and her team coded 2,901 minutes of instruction for the nature of the instructional content, the quality of instruction and how engaged students were in that instruction. Overall, the team found that teachers were spending some time on foundational skills, but that more time and effort is needed to support students with IDD as they develop as readers. For example, because students with IDD may take longer to learn what sounds certain letters make, their teachers might spend more time on this and add more intensive supports so that they can apply it to unfamiliar words and contexts.

Lindström asked the teachers how they thought that they were spending their time in instruction. She found differences between the activities teachers reported doing and what the team actually observed. "What that highlighted for me was a mismatch as far as how the teachers understood fluency, for example, and what that would look like and how it was being enacted in their classrooms," she says.

In addition, Lindström observed that the teachers were spending more time on behavior management and transitioning between instructional activities than on reading instruction, and more so than teachers who work with other populations of students.

"Children with intellectual disability tend to have more difficulties with task engagement, and they might be more likely to engage in escape-oriented behaviors. So, when schoolwork gets hard, then they might present with more challenging behaviors in order to stop the task," she explains. "There were teachers who felt comfortable meeting the academic needs of the kids, but then the behavior was really challenging, or vice versa, that they felt comfortable addressing behavior but then they weren't trained in teaching academics. Part of that was about how we train our special ed teachers"—a system that varies by state and institution. This work appears in the journal *Research in Developmental Disabilities*.

Lindström's research is supported by an Early Career Research Award from the Institute of Education Sciences' (IES) National Center for Special Education Research.

Esther Lindström's research focuses on examining and improving instructional practices for students with disabilities, supporting special educators in providing research-based reading instruction, and using assessments to systematically identify student needs and individualize instruction. She received her Ph.D. from Vanderbilt University.

THE SOCIAL MOVEMENTS BEHIND PROTEST

Anthony DiMaggio studies the progression of social movements in the United States since 2008.

Written by
Stephen Gross

Illustration by
Jimmy Turrell

In the last decade, protest has become mainstream in America—both on the left and right sides of the political spectrum, says political scientist and activist Anthony DiMaggio. Not since the 1960s has the United States seen such a "never-ending wave of protests."

Shortly after the 2008 financial crisis came the Tea Party protests over taxation and government spending, followed by protests over Wisconsin Gov. Scott Walker's collective bargaining legislation. Next was Occupy Wall Street (economic inequality), the Fight for 15 (minimum wage), Black Lives Matter (police brutality), anti-Trump protests and the #MeToo movement (sexual harassment in the workplace). Demonstrations over environmental concerns also have occurred throughout.

In his book, "Rebellion in America: Citizen Uprisings, the News Media, and the Politics of Plutocracy," DiMaggio, an associate professor of political science, dissects the progression of recent social movements, along with the populism of both Sen. Bernie Sanders on the left and former President Donald Trump on the right. He uses his experiences—at Tea Party protests, the Capitol building in Madison, Wis., and anti-Trump protests—along with media reports and public opinion data to understand the motivating and driving factors for those involved in each of the movements.

Researchers do not have a great understanding of how social movements impact the political process, DiMaggio says.

"We risk, especially in these disciplines like political science, coming off as really disconnected and aloof from reality when these things are happening under our noses and people aren't writing about them," DiMaggio says.

Although people are protesting at a rate not seen since the 1960s, mass public opinion is much different today. DiMaggio writes in his book that in 2018 nearly 60% of Americans "were upset enough over an issue that they were willing to protest." In the 1960s, he notes, a majority of the population held unfavorable views of civil rights and anti-war protests. Today's movements include multiple issues within them, most notably with anti-Trump protests.

"You've got people who are concerned with misogyny and sexism, people who are concerned with things like racism and xenophobia, people who are concerned with healthcare as an economic issue, and so that's where it's getting interesting," DiMaggio says. "People are starting to cross-pollinate these movements, which were pretty separate waves in the '50s, '60s and '70s. First was civil rights, and then on the back of that was anti-war, and then by the time that was winding down, you had women's rights and then environmentalism. ... Now with Donald Trump, when he was in office, separate movements started coming together."

DiMaggio makes four main arguments. The first is that intersectionality—the study of different types of identity and how they intersect—matters. Intersectionality is crucial to understanding movements on both sides of the political spectrum, but it's largely ignored and dismissed by political scientists and sociologists, says DiMaggio. The second argument is that social transformation occurs through mass movements that utilize the media to communicate their values and shift public opinion. The third is

that leftist social movements are mainly responsible for promoting progressive societal transformation, as opposed to political parties or government institutions. Finally, DiMaggio argues that grassroots populism during the 2010s was primarily a leftist phenomenon, while corporations and business elites fueled and had more impact on populism on the far-right. Right-wing social movements exist, but they're smaller than progressive ones, DiMaggio explains, because they're often assembled from the top down.

DiMaggio's hope, he says, is that his work can inspire important and necessary scholarly engagement.

"If a book like this can't break through in political science and elsewhere—when all of these protests are happening and it's so in people's faces—then I don't think it's probably going to happen for my discipline," he says.

Anthony DiMaggio's research is interdisciplinary, and is based in the fields of political science, political sociology and political communication. He received his Ph.D. from the University of Illinois-Chicago.

UNINTENDED CONSEQUENCES

Muzhe Yang explores how various external factors during pregnancy impact maternal, fetal and infant health.

Yang studies several factors that impact infant birth weight.

Written by **Kelly Hochbein**

"As an economist, I am always thinking about trade-offs," says Muzhe Yang. "There are always benefits and costs associated with our decision-making. And what we do as a single person can affect other people."

Such trade-offs, particularly those that impact human health, can have far-reaching effects. In recent years, Yang, the Charles William MacFarlane Professor of Economics in Lehigh's College of Business, has focused his research on trade-offs related to externalities that can have significant impacts on babies, even before they are born. Yang examines conditions that affect maternal, fetal and infant health, including maternal employment, long commutes and various types of pollution.

Yang's interest in maternal-fetal health began when he published a paper in the journal *Economics & Human Biology* in 2015. The study examined the impact of California's paid family leave on mothers' breastfeeding behaviors, and found that rates of breastfeeding through the first three, six and nine months of infancy increased by 10–20 percentage points after the implementation of paid family leave.

"When I did that study, I learned that the U.S. is the only high-income country that does not guarantee paid leave to new mothers," he says. "I was shocked to learn that the U.S. is ranked very last on every measure of family-friendly policies of all high-income countries."

Yang also learned the impact his work could have on policy. The Council of the District of Columbia cited that 2015 paper in its own paid family leave legislation, which became effective in 2017.

"This experience led me to realize that what we do as researchers actually can influence policy-making," says Yang.

MOTHERS AT WORK

Since 2015, Yang has conducted several studies related to how working outside the home can impact pregnant women and their babies. In a 2019 paper in *Economics & Human Biology*, he and his colleague, Yang Wang of the University of Wisconsin-Madison, report the findings of the first empirical study on the effect of long commutes during pregnancy on infant health. Using unique data on women's home addresses and the addresses of their employers during pregnancy, they found that a 10-mile increase in travel distance raises the probability of low birth weight (LBW, birth weight below 2,500 grams or 5.5 pounds) by 0.9 percentage points, and the probability of intrauterine growth restriction by 0.6 percentage points.

"These results are possibly driven by the maternal stress induced by the long commute that can happen on a regular basis. Our findings add new evidence to the literature regarding the relationship between maternal stress during pregnancy and adverse birth outcomes by focusing on the understudied chronic stress induced by long commutes, rather than the stress triggered by a one-time significant event, such as a natural disaster, which has been the focus of previous studies," the team writes.

In addition, the team found evidence that long commutes during pregnancy impede women from obtaining proper prenatal care. Women with long commutes have fewer prenatal visits, a reduced likelihood of completing the first prenatal checkup within the first trimester, and an increased likelihood of delaying the first prenatal checkup into the third trimester or not obtaining any prenatal care at all.

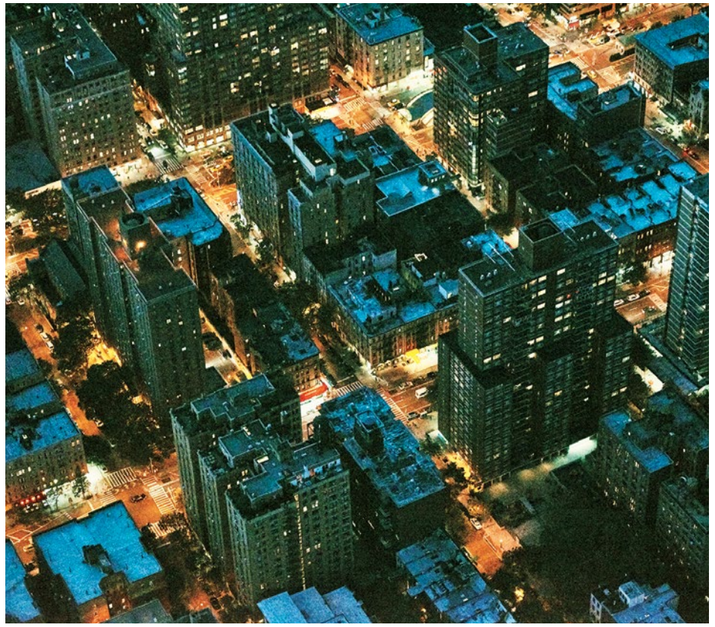
"Those who travel a long distance to work started prenatal care later than recommended," Yang explains. "... This

Muzhe Yang's research aims to provide empirical evidence on causal relations that have policy implications. He received his Ph.D. from the University of California, Berkeley.

also raises the importance of facilitating the utilization of prenatal care. One direction the policymaker could consider is expanding maternity leave to cover the prenatal period."

"Remote working doesn't necessarily make prenatal care easier to obtain," says Yang, "so it is still an important policy question regarding how to facilitate the use of prenatal care, even when remote working becomes a permanent option."

In addition to long commute times, the nature of the work itself can impact fetal health. In a paper published in 2020 in the *Review of Economics of the Household*, Yang and Dhaval M. Dave of Bentley University provide empirical evidence of the effects of working during pregnancy



on maternal and fetal health. Comparing pregnancy, birth outcome and maternal employment data from the New Jersey Department of Health with the Metabolic Equivalent of Task—a measure of the strenuousness of mothers' work activities—Yang and Dave found that working in a relatively more strenuous job during pregnancy increases the likelihood of an adverse birth outcome by 1.5 percentage points. Specifically, mothers with strenuous jobs had a 17% increase in the likelihood of having a baby with a condition called fetal macrosomia (i.e., birth weight over 4,000 grams or 8.8 pounds). Fetal macrosomia is associated with an increased risk of the child being overweight in adolescence, as well as an increased risk of breast cancer for the mother.

The data from the New Jersey Department of Health provided the researchers an "opportunity to look at an empirical setting where the laws regarding reasonable accommodations for pregnant women are already in place," Yang explains. "Yet we still find evidence that working in a strenuous job during pregnancy can increase the risk of having adverse birth outcomes."

This finding, the team writes, "highlights a possible deficiency of existing accommodation laws intended to protect pregnant workers."

Says Yang: "As of September 2020, only 30 states plus D.C. and four cities, including Philadelphia and New York City, had passed laws requiring employers to provide reasonable accommodations to women affected by pregnancy. Well, even in states where accommodation laws are in place, such as New Jersey, adverse birth outcomes may still happen because of this uncertainty in the interpretation of what 'reasonable accommodation' means."

Yang notes that some argue that the Pregnancy Discrimination Act of 1978, which prohibits discrimination based on pregnancy in any aspect of employment, can be used to protect pregnant women, but it is "definitely not sufficient."

"Under the Pregnancy Discrimination Act, an employer is not required to provide accommodations to pregnant women unless those accommodations have been provided to other employees who have similar limitations that are not caused by pregnancy," he says. "So it is about equal treatment, but the interpretation of equal treatment really varies by the situation."

THE IMPACT OF NOISE EXPOSURE

In another study, Yang and his colleagues, Laura M. Argys of the University of Colorado Denver and Susan L. Averett of Lafayette College, explored the impact of noise pollution—specifically airplane noise—on fetal health.

The Federal Aviation Administration (FAA), through its Next Generation Air Transportation System (NextGen) initiative, has implemented a number of new technologies, including the use of satellite monitoring to guide airplanes from takeoff to landing. This approach optimizes routes and allows more planes to be in the air, with some at even lower altitudes (when using the fuel-saving gradual descent method for landing) due to precision satellite monitoring.

"[NextGen] will, in principle, make all the flights more efficient—more direct flights, shorter flight distances, saving fuel," says Yang. "Unfortunately, this will make people living underneath the flight path become victims of noise pollution when the flight paths become more concentrated."

The team used home addresses listed on birth records to identify residences situated in locations of concentrated flight patterns near Newark Liberty International Airport (EWR), and examined the fetal health impact of increased noise levels in those areas. Using birth data from 2004 to 2016, Yang and his colleagues found that the likelihood of a baby having a LBW increased by 1.6 percentage points when the mother lived close to the airport, in the direction of the runway, during the time when the airport was actively implementing NextGen.

"Loud noise activates a human's central stress response system, the hypothalamic pituitary adrenal axis, and can cause sleep disruption, an increase in stress hormones, and elevated heart rate and blood pressure," Yang explains. During pregnancy, a woman's central stress responses become more sensitive. "As a result, pregnant women are particularly vulnerable to noise because of this increased sensitivity to noise," he says.

"Our finding has important policy implications for the trade-off between flight pattern optimization and human health in light of the long-term impact of LBW on later life outcomes," the team writes in a paper published in the *Journal of Environmental Economics and Management*. "... Although the immediate impact is on fetal health, this can have far-reaching impacts on adult health. Attention to this unintended consequence is especially important in light of the many efficiency benefits attributed to NextGen."

SEEING THE LIGHT

Yang has also discovered that light pollution can impact fetal health—yet another example of a trade-off for policymakers to consider. In many countries, he says, nighttime brightness is seen as a sign of economic prosperity.

"In a lot of economic studies," he explains, "we use satellite data where we can see how bright the night sky really is for a particular country or a particular region to measure economic growth."

However, this symbol of prosperity can have unintended consequences.

Exposure to artificial light at night (ALAN) can disrupt the production of the sleep hormone melatonin, which regulates a human's sleep-wake cycles. The resulting sleep disruptions lead to adverse health outcomes. This is true, Yang has found, for birth outcomes as well. In a recent study, "Light pollution, sleep deprivation, and infant health at birth," Yang partnered again with colleagues Argys and Averett and found that light pollution can increase the likelihood of preterm (i.e., gestation under 37 weeks) birth by 12.9%.

The study—the first to uncover the fetal health impact of light pollution based on a direct measure of skyglow, the artificial brightening of the night sky in a built-up area—appeared in the *Southern Economic Journal*.

Previous studies have focused predominantly on night-shift work, and researchers have inferred workers' exposure to light rather than measuring the light pollution in question. Yang and his colleagues used a direct measure of skyglow gathered from the Loss of the Night project, which invites "citizen scientists" to use an app to identify stars they are able to see in the night sky. The team confirmed the quality of the skyglow measurements and the negative correlation between skyglow and sleep with data on sleep deprivation from the 500 Cities Project, a joint initiative of the Centers for Disease Control and Prevention (CDC), the Robert Wood Johnson Foundation, and the CDC Foundation that provides city-level and census tract-level estimates for 27 chronic disease measures.

They then compared this information with birth records from the New Jersey Department of Health of all live births in the state between 2011 and 2015. These data included information about the birth mothers, including residential ZIP codes.

"There are two components to our study's findings," Yang explains. "One is the impact of skyglow on sleep deprivation through the disruption of the biological clock, and the other is the impact of sleep deprivation on adverse birth outcomes through inflammation that can result from poor sleep."

The team found evidence of reduced birth weight, shortened gestational length and increases in preterm births associated with increased skyglow. They also found male fetuses to be more vulnerable to maternal exposure to skyglow than female fetuses.

"Light pollution is not a small problem," says Yang. "It is an ongoing and also worldwide problem. In my study, I saw that in many cities in the U.S., artificial lighting at night is almost 10 times brighter than natural nighttime. There have been studies showing that in recent years there has been an increase in light pollution in many countries."

Arguing that a nation doesn't have to sacrifice good health in the name of economic growth, Yang cites a comparison of ALAN in Germany to the United States.

"There are studies showing that cities in the U.S. use many times more artificial light at night, per capita, than cities in Germany," he explains. "Some of the difference in lighting use could be explained by the fact that cities in Germany are lit much more conservatively at night. This comparison helped me realize, well, we don't have to pay the price of economic growth for better health. There are alternative ways. We actually should be better observers of other [nations], see what others do with the trade-off and then see what we can learn from them," he says.

To Yang, this work is much more than academic—it can be life-changing.

"I see my research efforts as a way of speaking for the vulnerable members of society, such as infants and pregnant women," he says. "It also reminds me of this kind of social responsibility: We are doing research, we are finding new results, and this can be really meaningful. It can, in some way, change people's lives. I think we need to be aware of our social responsibility of conducting research."

A TOOTH & A TIMELINE

David Anastasio's examination of ancient lake sediments in southern Spain clarifies ages of human migrations out of northern Africa.

Written by
Carina Sitkus
Illustration by
Luke Best

David Anastasio's collaborative research project has potentially significant implications for our understanding of how early humans migrated from Africa and the subsequent peopling of Europe—and it began with the discovery of an old tooth in a farmer's nightstand in southern Spain.

Anastasio, professor of earth and environmental sciences, was conducting research on mountain formation and landscape changes in southern Spain when he and a fellow geologist, Josep Parés from the Spanish National Lab of Human Evolution, took a detour to collect rocks from the Guadix-Baza Basin, the site of the largest ancient lake in Europe. Near the small Spanish village of Orce, they revisited the site of a tooth found in the basin, which the farmer's son rediscovered after his father's passing.

"The question became 'how old is this tooth?' And I said, 'I think I have an angle that could let us figure it out,'" Anastasio says.

The resulting project includes collaborators from the Lab of Human Evolution and the University of Granada, among others.

Human artifacts found in northern and southern Spain, Anastasio explains, provide important clues about the path and timeline of human migration. A common theory claims the earliest Europeans traveled an eastern route around the Mediterranean Sea, through Israel and Jordan, but an alternative route out of northern Africa, through Gibraltar and into southern Spain, gives the tooth and stone tools found in the basin great significance.

Using rock magnetic cyclostratigraphy, magnetic polarity stratigraphy, and electron spin resonance dating, the team of researchers is dating the archeological remains found around the basin. These combined approaches are necessary to date early human remains that are likely more than one million years old, says Anastasio.

This combination of dating methods will date the human artifacts and surrounding lake sediments to within 20,000 years. Anastasio's use of cyclostratigraphy, the study of astronomically driven cyclic variations within the sedimentary record, was both serendipitous and novel.

"I have been using the record of the magnetism in rocks as a way of figuring out their concentration of dust," Anastasio explains, joking that in the mid-2000s he noticed his house was dusty and then he happened to attend the talk of a scientist who was tracking Siberian dust in ice to measure melting glaciers on Greenland. It occurred to Anastasio that atmospheric dust varies with climatic conditions and accumulates in sediments and rocks. He taught himself to take the necessary measurements using a colleague's lab equipment and found that there was a cyclic pattern of this environmental variability.

"So one of the things I've been doing for the last 15 years is using this kind of cyclic behavior to determine how fast sediments are accumulating to study tectonic processes," says Anastasio.

Now he is applying the same techniques to date archeological sites. Looking at the rocks that surround the human artifacts, Anastasio can analyze how much time is gathered in the layers of sediment and their relationship to the layer where an ancient tooth was found to determine its age. Monica Powers '20 helped collect and analyze the data.

There is still some disagreement between the various methods, Anastasio explains. The goal of the next stage of research is to collect more data to reconcile these differences.

"By establishing the ages of these human remains, then you can start asking anthropological questions about why you think humans migrated this way," says Anastasio. "[And] in frontier science, you're trying to sort out the methods while you're trying to sort out the answers."

David Anastasio's research focuses on structural geology and tectonics. He received his Ph.D. from Johns Hopkins University.

THE OTHER SIDE OF CENSORSHIP

Thomas Chen explores how 30 years of censorship of Chinese literature and film related to the Tiananmen Square Massacre have shaped public discourse.

Written by
Lori Friedman

Much has been written about the destructive side of censorship in the People's Republic of China, under the leadership of the Chinese Communist Party. In his book forthcoming from Columbia University Press in 2022, "Made in Censorship: The Tiananmen Movement in Chinese Literature and Film," Thomas Chen, assistant professor of Chinese, focuses on the underexplored topic of what state censorship creates.

"Censorship is not only repressive and forbidding, but also productive in a sense, producing certain phenomena and certain ways of reading and writing," he says.

A protester stands in front of tanks the day after government troops used violence to suppress demonstrations in Tiananmen Square.

Chen examines the past 30 years of state censorship of Chinese literature and film related to the Tiananmen movement and how such censorship has shaped public discourse. He focuses on Tiananmen because it was "a watershed moment in modern Chinese history" and "it remains one of the most verboten topics in China today," says Chen.

On June 4, 1989, widespread demonstrations for social and political reforms, centered in Beijing's Tiananmen Square, were crushed by government troops. While the protests had been going on for many weeks, it was on June 4 that the government sent troops to Tiananmen Square to suppress the student-led uprising with assault rifles and tanks. Hundreds of civilians, at least, were killed.

Chen's first chapter focuses on the "flood of propaganda" produced by the state after the massacre. "Propaganda can be viewed as one of the components, along with more destructive means, of maintaining a certain discourse in contemporary China," says Chen.

He examines a collection of literary reportage on the "heroic deeds" of government troops called "Songs of the Republic's Guardians," and a television documentary called "Flutter, Flag of the Republic," both edited by the People's Liberation Army in 1989. They "fashion a narrative that tries to recall the people to the Party's embrace and to restore the state's legitimacy after the massacre of civilians," says Chen.

The second chapter is devoted to underground works, originating from the periphery of Chinese society, that offer an alternative narrative. He examines two films produced in secret and distributed independently, Wang Guangli's documentary "I Graduated" (1992) and Tang Xiaobai's fiction-feature "Conjugation" (2001), as well as Sheng Keyi's "Death Fugue" (2011), a novel rejected by over a dozen book publishers before appearing in a literary journal.

"Both in spite of and because of censorship," says Chen, "they challenge the authorized account, confronting memories of bloodshed and exposing the role of state violence not just in the massacre but also in the return to 'normalcy' afterwards."

Chen looks at two films that, while not underground, address controversial topics and include political and sexual content. While Chinese media is critical of authors and filmmakers who are perceived as leveraging the West's "banned in China" label for profit-making, he says, "Ever since the economic reforms of the early 1980s, the government has been behind promoting capitalist commercialization. It is the government itself that wants to depoliticize the act of censorship and make it about money and profit."

Finally, Chen examines the rise of online culture and subcultures, illuminating how state censorship has given rise to new literary forms that co-opt "... the system of symbols such as the parenthesis, ellipsis, and blank square—□—that perform removal and elision in literature." He focuses on two books: Jia Pingwa's "Ruined City" (1993), which, Chen says, was "... a publishing sensation when it first appeared, not least because of the blank squares strewn throughout the text to designate sex scenes taken out," and Hu Fayun's "Such Is This World@sars.come," about a woman's exploration of cyberspace during the 2002-2003 SARS epidemic.

"Prohibition and proselytization go hand in hand," says Chen, arguing that if an "opening up" of discourse on Tiananmen were to occur, the government would lean into the proselytizing aspect of censorship, giving new weight to the official narrative and making it a "tale told not only with mutes but also with trumpets of triumph."

Thomas Chen's research interests include world literature and cinema, translation studies and historiography. He received his Ph.D. in comparative literature from UCLA.

Tiananmen Square, May 1989. Thomas Chen examines state censorship of Chinese literature and film related to the Tiananmen movement.

A MORE SUSTAINABLE HUMAN-NATURE AFFAIR

Y.C. Ethan Yang works with a team of researchers incorporating data on human behavior into a climate-risk modeling framework to improve resilience of critical water, food and energy systems.

Written by
Lori Friedman

Illustration by
Masha Krasnova-Shabaeva

Can human beings and the natural environment find a way to coexist? Deteriorating U.S. infrastructure coupled with extreme weather events—and other effects of climate change—have heightened the stakes involved in achieving such harmony. While technological advances may help mitigate negative impacts, peaceful coexistence may depend on what actions humans are willing to take.

That's why Y.C. Ethan Yang, a civil and environmental engineer working on issues at the food-water-energy nexus, incorporates data on human behavior into the computer modeling he uses to help improve the resilience of our life-sustaining systems. Such data, however, can be hard to come by.

"We can measure the rainfall, we can measure the temperature, et cetera—but the human behavior data is really, really difficult to get," says Yang. "I actually work with a lot of social scientists as well as psychologists to try to figure out the best way to incorporate their data into our models in order to simulate human behavior better."

Almost all of our systems are interdependent, explains Yang, citing the interdependency of the water and energy sectors as an example.

"When we generate power, no matter the source, we need water for cooling purposes," he explains. "So, the energy sector depends on the water sector in order to function. We also need energy to treat our raw waters for drinking purposes, and to send treated water from the treatment plant to homes and businesses. So, the water sector depends on the energy sector too."

An adverse event in one system, explains Yang, can cause "a cascade event."

"WE CAN MEASURE THE RAINFALL, WE CAN MEASURE THE TEMPERATURE, ET CETERA—BUT THE HUMAN BEHAVIOR DATA IS REALLY, REALLY DIFFICULT TO GET."

HOUSTON, WE HAVE A PROBLEM

The February 2021 power crisis in Texas offers a case in point. Unexpected low temperatures caused by a series of severe winter storms produced a massive electricity generation failure. This, in turn, led to shortages of water, food and heat. Regions unaccustomed to extreme heat, like states and cities in the Northeast, are also subject to the possibility of multi-system breakdowns.

"We actually use the models to simulate this: What's the risk that we might face, especially under the climate change impact conditions?" says Yang. "And then we try to identify what kinds of policies can be implemented or actions taken to mitigate this kind of cascade effect."

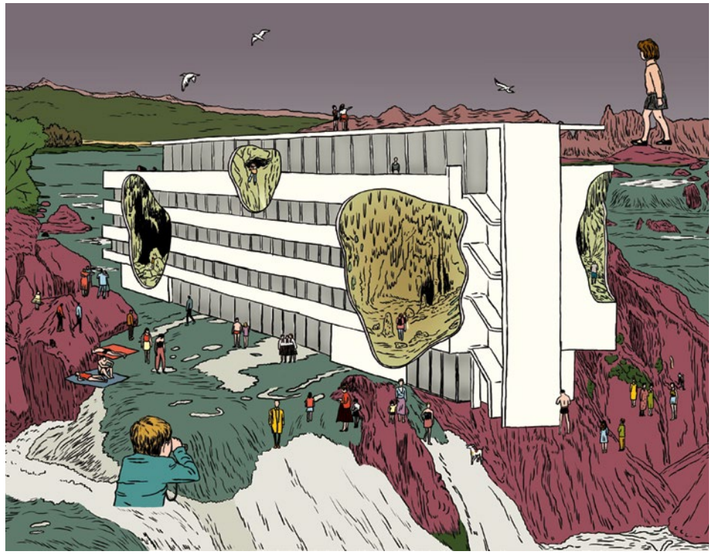
Yang and his group are working with Houston Advanced Research Center (HARC) and the University of Houston on a project designed to increase the resilience of the Houston area's energy systems. The team is developing a modeling framework that advances systems-level understanding of the impacts of climate change on electrical power infrastructure with support from an Alfred P. Sloan Foundation research grant.

Called the Pythias framework, the model will analyze the impact of climate risks such as extreme weather events, accelerating temperatures and water scarcity on power systems. Pythias will integrate that information with complex physical and socioeconomic models, and a state-of-the-art decision-making model to arrive at a novel approach to power system planning and management. The goal is to address how climate change will affect the long-term planning and management of power systems and needed steps to mitigate climate-related risks.

Yang will bring his expertise in agent-based modeling and will lead that part of the effort. An agent-based model simulates the actions and interactions of autonomous agents—individuals or groups of individuals—in order to understand the behavior of a system and what governs its outcomes. The HARC-led project will try to understand the ability of individual actors within the system to adapt to external conditions and make internal changes to the system to cope with potential hazards or respond to their consequences. The "agents," in this case, are the power-generation companies.

As more extreme weather events are anticipated, municipalities are trying to "expect the unexpected" and plan now for better resilience and reliability under changing conditions.

Y.C. Ethan Yang's research interests include water resources systems analysis, the water-energy-food nexus, agent-based modeling, climate change risk assessment and urban stormwater management. He received his Ph.D. from the University of Illinois at Urbana-Champaign and is a recipient of the NSF CAREER Award.



URBAN FLOODING: TOO MUCH WATER ALL AT ONCE

While the Houston project is largely focused on improving the resilience of energy systems, most of Yang's work is focused on water.

One such project, funded by an NSF CAREER Award, is in its first of five years and focuses on addressing challenges closer to home. Yang and his team are working with Bethlehem Township, Pa., the most flood-prone municipality in the Lehigh Valley region, on a framework to help mitigate urban flooding. This work could become a model for other municipalities in the region and across the country.

According to a recent report by the Center for Disaster Resilience at the University of Maryland, flooding caused by excessive stormwater runoff in developed areas where the water doesn't have anywhere to go is widespread and costly—and, perhaps, an even greater challenge than extreme flooding events.

"The reason we have these stormwater flooding issues is not because we don't have drainage systems—we do," says Yang. "The problem is that too much water is coming down at the same time and our system cannot handle it. So, the solution is actually to try to delay that timing a little bit to avoid flooding."

Bethlehem Township's government is looking to do just that. Part of that effort is a program that encourages homeowners to implement low-tech, low-cost measures such as rain barrels, which capture rainwater from a homeowner's roof to be used later, and rain gardens, which are collections of shrubs, perennials, and flowers planted on a natural slope that temporarily hold and soak in rainwater runoff. While the township looks to implement a stormwater fee to residents and issue credits to those who undertake mitigation efforts, Yang and his team will survey and interview local residents to assess their willingness to participate in such a program in exchange for reduced stormwater fees.

"Sometimes the models show good results, but the most challenging part is convincing people to take action," says Yang.

Yang will again use an agent-based modeling approach to simulate both the natural process of how rainfall generates runoff and the location of potential flood zones within the township, as well as property owners' behavior, in order to design a flood mitigation program that works. ●

Building a "Smart," Resilient Campus

A group of Lehigh undergraduate students are working with Yang on a stormwater mitigation project designed to help the campus achieve one of the goals outlined in Lehigh's Sustainability Strategic Plan 2030: develop a Stormwater Management Plan (SMP) by the end of 2021 that identifies green infrastructure and low-impact development (LID) projects, and provides guidelines for the design team to help mitigate stormwater runoff impacts and treat rainwater as a resource rather than as a waste product.

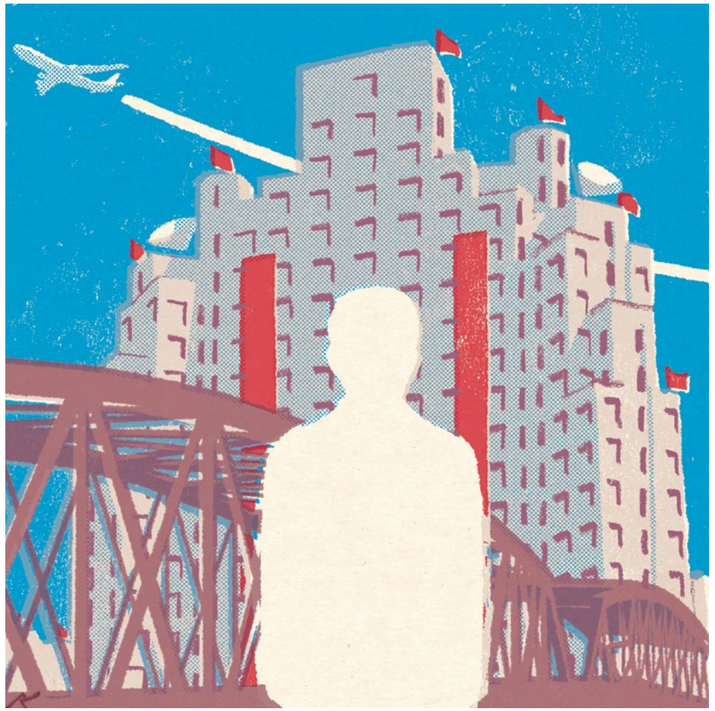
The students and Yang will work toward upgrading the existing green infrastructure on campus, such as several water retention basins designed to collect rainwater and delay its release into the city's drainage system. Their first project aims to achieve a better understanding of the effectiveness of the water retention basin on Lehigh's Goodman campus. Step one is to install several "smart" sensors at the facility in order to obtain real-time measurements. This will have the additional benefit of testing the custom sensors that Yang and the students are building.

"Our idea is: So, we have these basins, but we don't really know how they function, how much water they collect, how long they can delay the stormwater drainage and how much water we should be releasing for maximum impact," says Yang. "We won't know these details unless we install our sensors up there to do the measuring."

Some of the students will be working on the project as part of the Campus Sustainable Impact Fellowship, a partnership between the Office of Creative Inquiry and the Office of Sustainability to provide students with hands-on experiential learning through campus sustainability projects. Part of the 2030 strategic plan is to utilize the campus as a living laboratory to advance campus sustainability.

Sustainability is at the heart of Yang's efforts, and the frameworks he builds are designed to provide the information that institutions and governments need to determine how best to upgrade existing facilities to improve their resilience.

Adds Yang: "Our team wants to ask them: Are you thinking about upgrading the facilities that you have now in order to improve their resiliency and reliability? Maybe an event won't happen for the next 20 or 50 years, but it's a risk management issue. Are you willing to invest in something now to prevent future problems?"



ACCIDENTAL TOURISTS

Andreea Kiss and her colleagues examine the cognitive underpinnings of firm international opportunity recognition.

Written by
Kelly Hochbein

Illustration by
Tatsuro Kiuchi

Some entrepreneurs plan to internationalize from the earliest stages of business development, adopting a proactive decision-making approach to identifying opportunities for expansion into other countries. Others are not so deliberate but somehow find success in internationalization.

"Most of [the field of international entrepreneurship] is focused on proactive decision-making, and most of what we teach is focused on that," says Andreea Kiss, the Frank L. Magee Distinguished Professor of Management. "But we know from experience ... that things are not always as straightforward or planned or systematic as we think they are. There's a lot of serendipity involved."

Kiss and her colleagues from the University of Victoria, Canada—Wade M. Danis, Sudhir Nair and Roy Suddaby—wanted to understand the cognitive underpinnings of how entrepreneurs identify and exploit unexpected opportunities for international exchange. They published their findings in the *International Small Business Journal: Researching Entrepreneurship*.

The researchers adopted a multiple case study approach and collected data from small- and medium-sized firms located in Bulgaria, Romania and India that began their internationalization without an initial plan to do so. They conducted several rounds of interviews and analyzed the content of the interview transcripts to identify causal statements (sentences including words such as "because" and "if") and build the causal maps that the entrepreneurs "navigate the world with."

"It's based on the idea that how we think is how we talk or write," Kiss explains.

She and her colleagues divided the opportunity recognition process into several different stages: opportunity identification, evaluation and exploitation. Different cognitive processes are at play at each of these different stages, says Kiss.

"Those that discover opportunities serendipitously seem to be more attuned to the external environment, so they take a deterministic view, while proactive decision-makers are more focused on their own knowledge. They are more internally motivated, and their view of the world is that they influence the world, so they try to manipulate the process," she explains. At the evaluation and exploitation stage, serendipitous entrepreneurs rely on effectual logic, focusing on affordable losses and leveraging existing resources to meet unexpected demand.

When it came to subsequent opportunities to internationalize, the entrepreneurs took different approaches.

"We thought that maybe after they engaged in one of these serendipitous events, they would immediately update their causal logics and focus more on planning and discovering these opportunities proactively. Interestingly, some of them did and some didn't," says Kiss.

This difference can be related to whether the entrepreneur deemed the first opportunity successful or not successful enough, she says. It can also be related to the entrepreneur's level of cognitive complexity. In addition, the team found that, planned or unplanned, the outcomes for small firms might be quite similar in terms of sales or trajectories or the number of countries they enter.

"From a practical perspective, our study suggests that although entrepreneurs should make careful, cost-effective investments in information that signals the value of opportunities, opportunities can be discovered without active search," the team writes. "Entrepreneurs need to find the right balance between attending to and dismissing unexpected contingencies and investing in cognitive abilities such as complexity to improve the outcomes of this process over time." ●

Andreea Kiss' research is situated at the intersection of entrepreneurship, strategy, and international business and is focused on understanding how firms, in particular new firms, adapt to dynamic and uncertain environments. She received her Ph.D. from Georgia State University.

A VICIOUS CYCLE

Kaitlin Anderson explores the relationship between disciplinary responses to student behavior and students' academic outcomes.

Written by
Kelly Hochbein

Illustration by
Keith Negley

A school can suspend a student for a number of offenses—fighting, disorderly conduct, insubordination, truancy, vandalism—temporarily removing the student from either the classroom or the school building for a set amount of time. But how do suspensions impact student outcomes such as achievement or grade retention?

"We often make very strong assumptions about the causal impact of something like a suspension on these outcomes, because it's very intuitive to suggest that if a kid is not in school, they can't learn," says Kaitlin Anderson, an assistant professor of educational leadership. "And if the actual negative academic consequences precede the misbehavior—for example, if students are already struggling in school, they already are disengaged from school, they already don't feel like their teachers respect or want them there—then they might act up in school." In this case, the consequence can be suspension.

Anderson calls this a "vicious cycle," as these other factors related to misbehavior make it challenging to identify the causal relationship between suspensions and negative student outcomes. Studies have demonstrated that exclusionary discipline correlates with negative student outcomes, Anderson says, but "we still aren't really fully able to capture that causal relationship because it is so entangled in that cycle."

In an effort to better understand the relationship between disciplinary responses and academic outcomes, Anderson and her colleagues, Gary W. Ritter, now Dean of the School of Education at St. Louis University, and Gema Zamarro, Professor and 21st Century Endowed Chair in Teacher Quality at the University of Arkansas, examined 10 years of student-level demographic, achievement and disciplinary data from all K–12 public schools in Arkansas. The team estimated the relationship between seven types of disciplinary responses and student math test scores and grade retention, controlling for the type of behavioral infraction. This approach, the team writes in a paper published in the journal *Educational Researcher*, seeks to disentangle "the impact of the consequence from the underlying factors causing misbehavior." This is a contribution over most prior work that generally looks at the relationship between receiving a suspension and student outcomes, without considering what led to the suspension in the first place.

> "AS A TEACHER, I SAW HOW SYSTEMS AND POLICIES WERE REALLY INEQUITABLY PROVIDING OPPORTUNITIES TO CERTAIN GROUPS OF STUDENTS AND NOT OTHERS."

Their results control for observable characteristics that might also contribute to the type of consequence chosen—gender, race, ethnicity, special education status, English proficiency, grade level, the school they attend, and even behavioral history—and compared students who received different consequences for the same infraction. This enabled the team to account for selection into consequence type and to "get more at the 'all else equal' or that *ceteris paribus* relationship between the consequence and those student outcomes," says Anderson.

The team found that less exclusionary consequences, such as Saturday school or detention, are associated with better outcomes relative to in-school or out-of-school suspensions, but note the need for future studies to understand which approaches are most successful. The data also indicates that the association between suspensions, expulsions and negative academic outcomes may be larger for students from historically underserved backgrounds. Additionally, the team found that a student's first disciplinary consequence in a given year is associated with larger academic declines, suggesting that preventative strategies or those that provide alternatives to exclusions for first-time infractions could be an effective strategy.

Despite accounting for selection into consequence types to the extent possible, the researchers still suggest using caution when interpreting the results, as there still are unobservable factors that can contribute to the choice of a consequence. "We still can't really call it a causal relationship, but [these exclusionary consequences are] related to more negative outcomes, both in terms of test scores and grade retention," Anderson says. "... We should be aiming to reduce our reliance on those exclusionary practices, but we also need to be thinking about what we do in a more preventative or supportive way to reduce the need for discipline referrals to begin with.

"As a teacher, I saw how systems and policies were really inequitably providing opportunities to certain groups of students and not others," she says.

Kaitlin Anderson's research focuses on policies affecting educational equity and opportunity. She earned her Ph.D. from the University of Arkansas and was a postdoctoral research associate in the Education Policy Innovation Collaborative at Michigan State University.

DOES DISTRACTION EQUAL INTEREST?

Through a series of manipulated experiments, Daniel Zane investigates what happens to consumers when distracted by a background ad while multitasking.

Written by
Emily Collins

Illustration by
Neha Kavan

In today's technology-driven world, people are prone to multitasking. According to a 2015 survey by Accenture, even when simply watching television, 87% of people are using other devices at the same time. One way businesses compete for consumer attention is through background ads—such as those that appear on the sides of web pages—and consumers come across thousands of these ads every day while watching TV, checking social media and browsing the internet. What happens when a consumer completing a focal task is distracted by one of the background ads they encounter?

For starters, background ads can have a positive impact. Daniel Zane, assistant professor of marketing, found that distracting background ads can lead consumers to hold more favorable brand evaluations, resulting in increased brand interest, higher ratings of the brand's attributes, and a more positive attitude toward the brand.

"We know that when people multitask, their attention shifts back and forth between the multiple things going on. And interestingly, past research in psychology shows that while people think they are quite good at multitasking, on average, we are actually pretty bad at it," explains Zane. "We believed that when consumers find themselves unexpectedly distracted by background ads, which is bound to happen, this might be a noteworthy experience that they look to explain."

Through a series of manipulated experiments, Zane and his colleagues, Robert W. Smith of Tilburg University in the Netherlands and Rebecca Walker Reczek of The Ohio State University, were able to test how distracted participants perceived themselves to be by a background ad. The experiments had consumers engage in a focal task, such as browsing the internet, while simulating a radio listening experience to present background ads in a realistic way. In one manipulation, the researchers set expectations about how distracting the ads would be before participants listened. In the second, they told participants that they were more or less distracted than others after they heard the ad.

"The content of the ad was held totally constant, so consumers are drawing these conclusions about the brands solely based on their mental experience of being distracted or not and regardless of the content of the ad," explains Zane.

The study, "The Meaning of Distraction: How Metacognitive Inferences from Distraction during Multitasking Affect Brand Evaluations," appears in the *Journal of Consumer Research*, and reports the team's finding that participants who perceived themselves to be highly distracted by the background ad reported greater interest in the advertised brand and were likely to engage with that brand on social media.

This research is the first to focus on multitasking in the customer domain with an emphasis on advertising. Both marketers and consumers can benefit from this research, as the results shed light on how marketers can capture the interest of consumers and how consumers can better understand the mental process driving their interest and purchasing decisions.

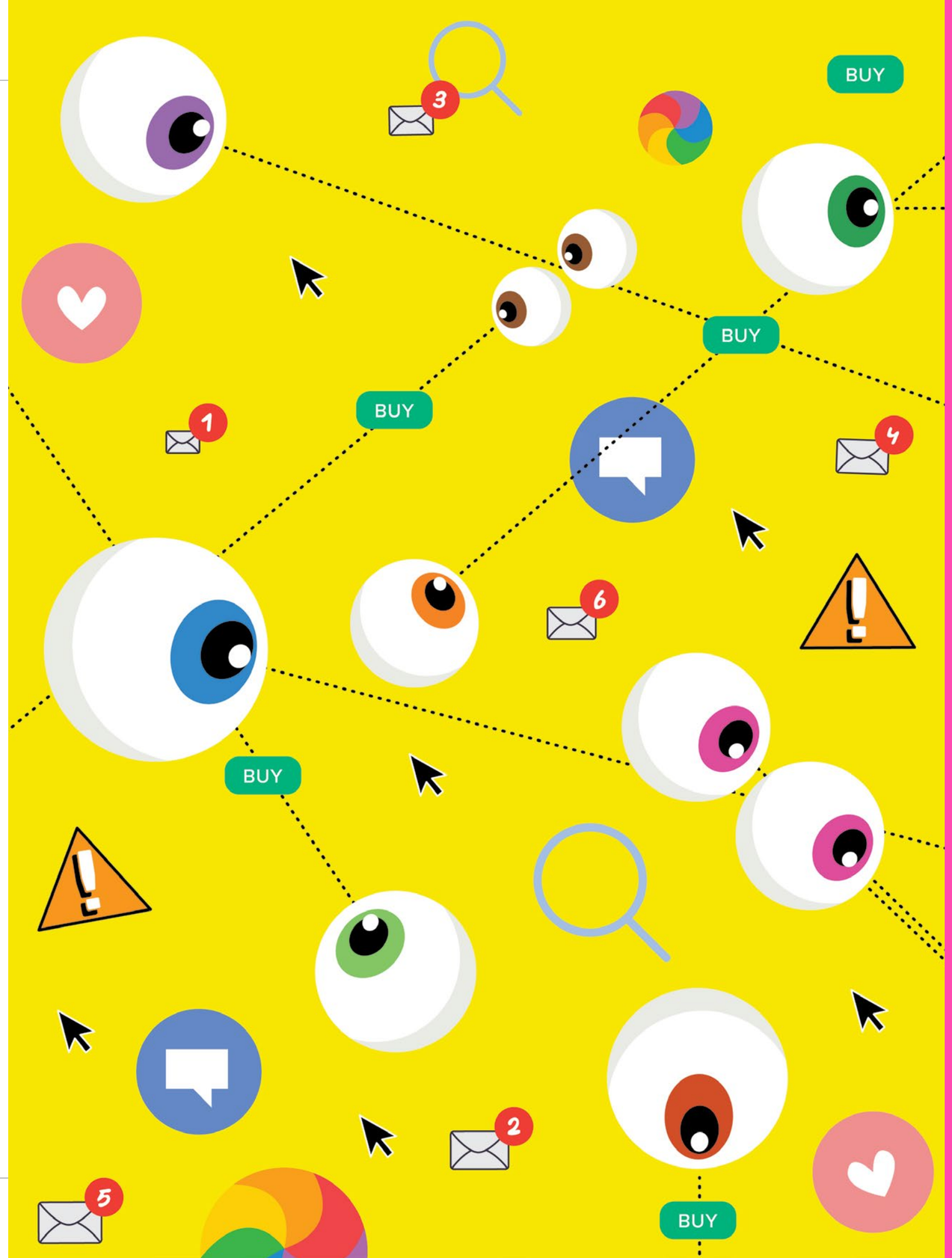
"The good news for marketers is that in a world where their advertisements are bound to be in the background at times, all is not lost," says Zane. "Consumers can still positively react to a brand solely based on their internal experience of noticing that their attention keeps shifting away from whatever they are focused on and toward the ad."

Zane warns that the takeaway for marketers isn't as simple as making ads as distracting as possible. There are limitations.

For consumers, being distracted by an ad might result in a favorable brand evaluation, but they should remember that just because they are distracted does not mean they are truly interested and should buy the product, he adds.

"What if you are distracted by the ad simply because multitasking is nearly impossible or because it's late at night after a long day of work and you simply can't keep your attention in one place? In our society where we all constantly multitask, it's worth it to reflect on these sorts of questions in order to make sure our opinions of brands and consumption choices are authentic," says Zane.

Daniel Zane studies consumer behavior, and his research interests include inference-making, self-perceptions and ethical decision-making. He received his Ph.D. from The Ohio State University and previously worked as a marketing analyst for Harte-Hanks.



EMBRACING WASTE

Mary Foltz examines the ways several postmodern authors produce scatological works to critique how humans treat each other and the natural world and invite readers to embrace their excremental selves.

The work of artist Kara Walker inspired some of Foltz's writing.

Written by **Lori Friedman**

Artwork by **Kara Walker**

"There is no big secret about sh*t: most people do not like it," writes Mary Foltz, associate professor of English, in her book, "Contemporary American Literature and Excremental Culture: American Sh*t." Foltz, whose expertise is in American literature post-1945, explores how authors in the postmodern era have employed excremental culture to engage with urgent issues such as institutional racism, environmental justice and militarism.

"These representations of waste and bathroom humor that keep coming up in fiction are actually calling us as readers to a deep engagement with our fear of our status as bodies, and specifically as waste-producing bodies," says Foltz. "That fear really maps out onto a larger cultural problem in which we don't want to think about not only bodily waste, but the other kinds of waste our cities, our regions and our nation are producing."

Foltz explores representations of waste in five post-1960 American novels: Ishmael Reed's "The Free-Lance Pallbearers" (1967), Jonathan Franzen's "The Corrections" (2001), Gloria Naylor's "Linden Hills" (1985), Don DeLillo's "Underworld" (1997) and Samuel R. Delany's "The Mad Man" (1994).

In Reed's book a character named Harry Sam, a stand-in for "Uncle Sam," rules a city from a toilet throne. While he sits on this throne, he is leaking a range of waste materials: sewage, industrial waste, military waste, even dead bodies. In addition to its critique of environmental degradation, says Foltz, the book also addressed how, according to Reed, African American communities in the United States are treated like human waste.

"You get this nationalist figure that's just laying waste to the environmental world and just dumping on African American communities," says Foltz. "It speaks to the importance of thinking about environmental issues in relationship to which communities unequally bear the burden of our processes of disposal."

The chapter exploring Naylor's book is titled "Fleeing the Excremental Stain Through Acquisition: Getting to the Bottom of Black Suburban Splendor in Gloria Naylor's 'Linden Hills.'" In the novel, one of the young Black male characters is nicknamed White and another is called Sh*t.

"Naylor is really playing with constructions of race and fantasies about racial difference," says Foltz. "She also employs metaphors of waste to critique how we understand value through capitalism in the U.S."

Part of Foltz's discussion of DeLillo's "Underworld" focuses on the character of Nick and "... his employment as a waste broker in detailed accounts of his movement from the United States to Semipalatinsk Polygon, now known as National Nuclear Center of Kazakhstan, where his company and others seek to dispose of toxic waste," writes Foltz.

DeLillo, says Foltz, is interested in the connection between weapons and waste. "He is linking communities like the Kazakh communities that were utilized for the testing of nuclear weapons to the fact that they then became places where nations want to dispose of their waste."

Foltz says these works are calling on readers to embrace themselves as waste-producing beings and to engage more strongly with waste disposal systems for the sake of life and the bioregions that sustain it. She expresses hope that themes of waste in postmodern literature offer a way to, she writes, "resurrect the vulnerable excremental body as the fertile way back to the world and each other."

Mary Foltz specializes in contemporary American literature with a specific focus on ecocriticism, postmodern fiction and theory, and queer fiction and theory. She received her Ph.D. from the University at Buffalo.

DEPORTATION NATION

Historian Emily Pope-Obeda explores U.S. deportation practices and their impacts, focusing on the 1920s when deportation "came of age."

Pope-Obeda examines deportations in the 1920s, a time she calls "a turning point in the U.S. deportation apparatus."

Written by **Lori Friedman**

Illustration by **Valerie Chiang**

A statue called "Future" sits outside the entrance to the U.S. National Archives in Washington, D.C., where government records are preserved and housed. Carved in limestone and completed by sculptor Robert Ingersoll Aitken in 1935, it depicts a woman sitting with an open book on her lap. The pages are blank, to be filled with the history that has yet to be written. A line from William Shakespeare, "What is past is prologue," is inscribed in the pedestal to announce the reason for the archive's existence: The past set the stage for this present moment. This present moment will set the stage for the future.

Inside the building, historian Emily Pope-Obeda sits, on occasion, combing through the paper records of the Immigration and Naturalization Services (INS). Pope-Obeda goes digging through this "terribly organized record set" in search of a better understanding of deportation practices of the past which set the stage for today and tomorrow.

She is looking specifically at practices of the 1920s for her current book project, based on extensive research, including "... hundreds and hundreds of individual case files," she says. "A lot of the work of this is trying to take those hundreds of case files and map out patterns across them and see some of the ways those practices played out by group, by location, regional offices, all those things. I supplement that by looking at organizational records, often from immigrant rights organizations or legal aid organizations that represented immigrants in deportation proceedings."

Pope-Obeda also searches through historical newspaper databases to gain a sense of how deportation was depicted and imagined.

According to Pope-Obeda, the 1920s was a turning point in the U.S. deportation apparatus, a time when the U.S. government undertook a focused effort to streamline and centralize operations to address populations it perceived as threats. It is when, according to Mae Ngai, a scholar who has studied U.S. immigration policies of the 20th century, deportation "came of age."

The '20s saw a significant rise in the number of people being deported, preceded by "... an intense persecution of suspected communists or other radicals in 1919," says Pope-Obeda. In the 1930s, the discussion around deportation became more euphemistic. Removal of migrant populations was often referred to as a "voluntary departure," or as "repatriation," which is what the mass deportations of Mexicans and Mexican Americans during that period were called.

The records reveal stories of conflict, says Pope-Obeda. Much of the friction was born out of a collision between federal policies and the realities of local practices. This was true on the mainland and in U.S. territories, including Puerto Rico and the U.S. Virgin Islands, as well as Hawaii and Alaska, which were not yet states.

"You often see a very different set of local agendas," says Pope-Obeda. "In some of these places the territorial officials push back against the U.S. government and say, 'Sure, you have certain ideas about who is and who isn't welcome. But this is Alaska in the 1920s. We need labor. We're not really as concerned over their legal crossing status.'"

Sometimes local agendas also included efforts that were less official and more "vigilante" in nature.

"In a lot of places you see—and this may seem familiar from moments in a more contemporary era—a really overzealous effort to police immigrants by local populations," she says.

Pope-Obeda cites a number of examples in which not only did local labor interests collide with federal policies, but they also intersected with racist attitudes, such as in Arizona in the 1920s.

"One of the main scenarios I look at in the chapter on local agendas is a group that expressed a major fear that European communists were going to come to Arizona and upset the supposedly 'docile' Mexican labor force," she says. "You see all of these different layers of racism coming out."

DEPORTATION AS A TOOL OF SOCIAL CONTROL

Not only was the U.S. government enhancing the deportation apparatus during the 1920s, but the period also marked a moment of growth in state power and control over populations more generally, says Pope-Obeda. Deportation was one aspect of that growth. At times it was used by those in power as a form of labor control.

"The U.S. is often willing to encourage or turn a blind eye to laborers coming into the country, often without authorization, but then is able to—and still does in current eras—wield deportation as a mechanism to shut down labor organizing or protest against abusive workplaces," says Pope-Obeda. "Some of the early deportations were targeted at people who were kind of upsetting the workplace."

Emily Pope-Obeda's research and teaching interests center around migration and migration control, race and ethnicity, and labor and working class history. She received her Ph.D. in history from the University of Illinois at Urbana-Champaign and was a postdoctoral fellow at the James Weldon Johnson Institute at Emory University.

Among many Black-immigrant leaders "removed through bureaucratic immigration technicalities" was Jamaican-born political activist Marcus Garvey, who was deported in 1927.

Attempts to control poverty were also part of the discussions among local officials, she explains, revolving around fears of immigrants becoming dependents.

"And, obviously, we still see so much of this in the rhetoric: 'Oh, these are people who are just, you know, going to drop babies and use our public benefits,' and all this—despite the fact that, of course, they aren't eligible for most public benefits," says Pope-Obeda. "You see this push and pull between wanting cheap immigrant labor and never wanting the consequences of people who may at times need to demand something of the state."

"THERE WAS SO MUCH THAT STOOD OUT ABOUT THOSE CASE FILES IN THE WAYS BLACK IMMIGRANTS WERE CLEARLY TREATED IN THEIR HEARINGS, THE TYPES OF CRITERIA THAT WERE USED AGAINST THEM."

In addition to looking at deportation's role in international relations, nation-building and local control, Pope-Obeda also explores the role of institutions in deportation practices. These include jails and prisons, but also "... ostensibly benevolent institutions like hospitals and asylums that played a huge role in apprehending and referring deportees during the era, ushering in a new level of the surveillance state being used against people."

THE RISE OF THE CARCERAL STATE

Many of the individual case files that Pope-Obeda came across in her research were of Black immigrants or, as the INS defined it at that point, "African, Black."

"There was so much that stood out about those case files in the ways Black immigrants were clearly treated in their hearings, the types of criteria that were used against them," she says. "One of the things I'm focusing on is not only the really, really high rates of the use of the categories of 'likely to become a public charge' and 'a public charge'—which were both very much about policing immigrant poverty and this fear that these non-White immigrants would be a burden on the state financially—but also this really explicit and racialized sexual policing, anxieties about supposed over-reproduction, things like that, sexual promiscuity, that were very much overtly racially colored in those hearings."

For her next book project, Pope-Obeda will trace the arc of deportation of Black immigrants specifically, from the early 20th century into the 21st century, with the 1920s as a period that played a pivotal role in the history of the carceral state and carceral institutions in the U.S.

Pope-Obeda points to instances involving Black leaders like Jamaican-born political activist Marcus Garvey, who was deported in 1927. She also cites examples from the 1950s and 1960s, such as the deportation of journalist and feminist Claudia Jones, a Trinidadian communist labor leader, and a number of other Black activists, some of whom were radicals involved in labor organizing.

"There were deportations of a lot of very well-known Black immigrant radical leaders or major public figures who were essentially silenced by being removed through bureaucratic immigration technicalities," says Pope-Obeda.

While access to the National Archives has been limited due to COVID-19, Pope-Obeda hopes she will find herself back in the building on Pennsylvania Avenue soon. Because the records she has been looking through are more than 75 years old, access to them has been comparatively easy. INS reorganized and centralized the materials in the 1950s, she says, so while the records from the later periods might be better organized, they may also be more challenging to access.

"One of the good things about a really disorganized records set is it means more happy accidents," says Pope-Obeda, "more pulling a box because you think it has one thing, but finding something unexpected but productive."

Whatever Pope-Obeda finds, the records will tell stories about the nation's past and, therefore, its present, stories that may even inform the way forward. ●

Interdisciplinarity & Antibiotic Resistance

In 2018, Lehigh's Research Futures investment programs funded a team of researchers pursuing an interdisciplinary exploration of antibiotic resistance through reading and cross-disciplinary discussion. Today, three members of that team continue their work, now supported by a grant from the Andrew W. Mellon Humanities Lab.

Angela Brown, associate professor of chemical and biomolecular engineering; Sharon Friedman, professor of journalism and communication; and Lorenzo Servitje, associate professor of English and health, medicine and society, are working with Amanda Greene, the Andrew W. Mellon Postdoctoral Research Associate, on a project that examines components of the language, history and narratives of antibiotics related to their individual expertise. Each team member observes and participates in the other's work to advance the study of antibiotic resistance.

Friedman, for example, studies how current research is and will be understood and communicated across disciplines and to lay audiences. She learned from Servitje, who studies the development of society's conceptualization of antibiosis, "about the literature and history surrounding antibiotics, which altered my thinking about the topic to include a more science-in-society approach." From Brown, whose expertise centers on the experimentation and engineering of specific materials and methods for the implementation of antivirulence, Servitje gained a new appreciation for "the potential for innovation in antibiotic alternatives and alternative delivery mechanisms." Close examination of the language scientists and engineers use in this field "has opened new systems of knowledge to explore in terms of history, rhetoric, and figuration," he says.

For more about this and other interdisciplinary work, visit **humanitieslab.lehigh.edu**.

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—Lorenzo Servitje

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