SUMMER 2020

COLLEGE OF COMPUTER, MATHEMATICAL, AND NATURAL SCIENCES

ODYSSEY

MACHINE LEARNING

HARNESSING THE PREDICTIVE POWER OF COMPUTERS

Message from the Dean

Dear Science Terps,

As our communications team was working on this issue of *Odyssey* magazine, COVID-19 began spreading across the globe. As the virus touched our university community—and nearly every community—we thought carefully about whether or not to proceed with this issue. Ultimately, we decided it was important to share the inspiring stories of our faculty members and alumni who are making a difference on the front lines of this pandemic (see pages 4-7). These stories are accompanied by many others, prepared earlier, that tell of our important work in other areas, like machine learning (see pages 8-21).

Despite the disruptions COVID-19 has caused, our college has demonstrated that we can come together and overcome challenges. Building on our experiences shifting to online instruction in spring, faculty members are working vigorously on course innovations for the fall semester. With faculty members and graduate students eager to restart experiments and field work, we have reopened some research labs. The health and safety of our faculty and staff members and students are paramount, and we must balance this with ensuring our students remain on track for the timely completion of their degrees. We will need to continue to rely on the strength of our community in the months ahead as campus reopens and we address the financial difficulties created by the pandemic. We couldn't accomplish all that we do without your support.

So many members of our community have asked me how they can help and have offered support in a multitude of ways. I am deeply grateful. We have many students with unexpected needs and financial obligations. The UMD Student Crisis Fund has provided nearly $1 million of support to more than 1,800 students in need. Yet the need is still great—over 700 requests for support remained unfulfilled at the time this magazine went to print, and there will likely be more once the fall semester begins. If you are able, a gift to this fund via go.umd.edu/crisisfund will provide financial support to students most adversely impacted by the pandemic.

Now more than ever, the world needs fearless ideas, and the world needs Science Terps. Thank you for taking time to focus on the College of Computer, Mathematical, and Natural Sciences. I wish you and your family good health.

Amitabh Varshney
Dean
College of Computer, Mathematical, and Natural Sciences

Photo by John T. Consoli

CONTENTS

Features

3 UMD vs. COVID-19
Our faculty members and alumni are on the front lines, working to make a difference during the COVID-19 pandemic.

6 Machine Learning: Harnessing the Predictive Power of Computers

Sections

20 Student Profiles
Pavan Ravindra
Liz Friedman

24 Faculty Profile
Jacob Bedrossian

26 Alumna Profile
Monique Robinson

28 News

35 Philanthropy Profile
Carol Fullerton

36 Faculty, Staff, Student and Alumni Highlights & In Memoriam

Machine learning illustration (top) by Ayush Pokharel
Plane photo (center) by Liz Friedman
Monique Robinson photo (bottom) courtesy of WWAY

ODYSSEY

Editor: Abby Robinson

Editorial Associates:
Kimbra Cutlip, Leslie Miller and Chelsea Torres

Designer: Faye Levine

DEPARTMENTS:
Department of Astronomy
Department of Atmospheric and Oceanic Science
Department of Biology
Department of Cell Biology and Molecular Genetics
Department of Chemistry and Biochemistry
Department of Computer Science
Department of Entomology
Department of Geology
Department of Mathematics
Department of Physics

Odyssey is published for alumni, friends, faculty, staff and students of the College of Computer, Mathematical, and Natural Sciences. Your comments and feedback are welcome. Please send them to abbyr@umd.edu.

@umdscience
go.umd.edu/fb
go.umd.edu/instagram
go.umd.edu/linkedin
go.umd.edu/youtube

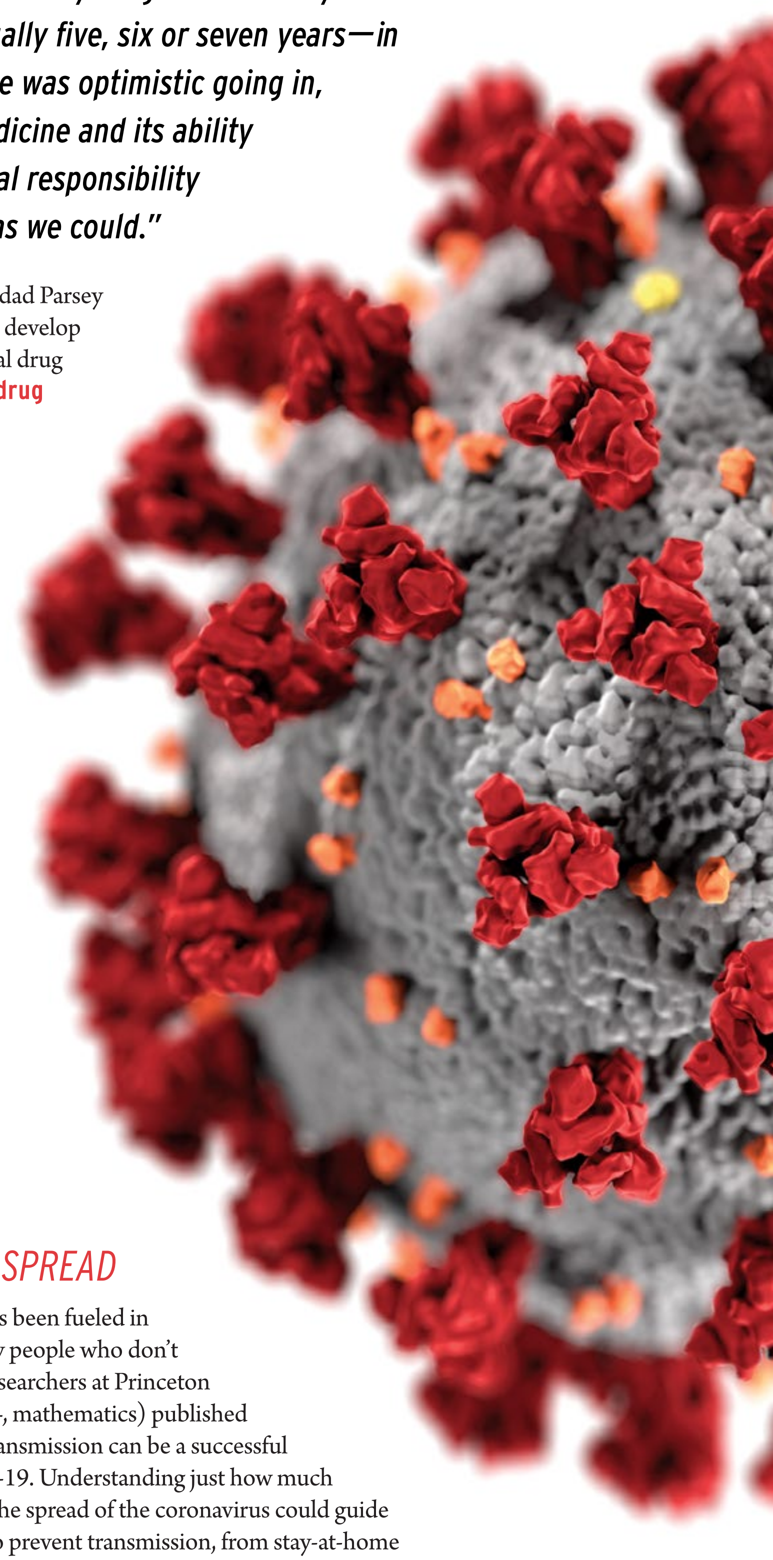
ON THE COVER

Illustration by Ayush Pokharel

FINDING A COVID-19 DRUG THAT WORKS

"With COVID-19, you kind of have to do everything—the entirety of a clinical development that would take usually five, six or seven years—in two or three months...The team here was optimistic going in, knowing what we knew about the medicine and its ability to inhibit the virus, and we felt a real responsibility to try and move as quickly as we could."

Gilead Sciences' Chief Medical Officer Merdad Parsey (B.S. '85, biochemistry) on the all-out effort to develop and test the company's COVID-19 antiviral drug remdesivir. **Learn more: go.umd.edu/covid-drug**



TEAMING UP TO FIGHT COVID-19

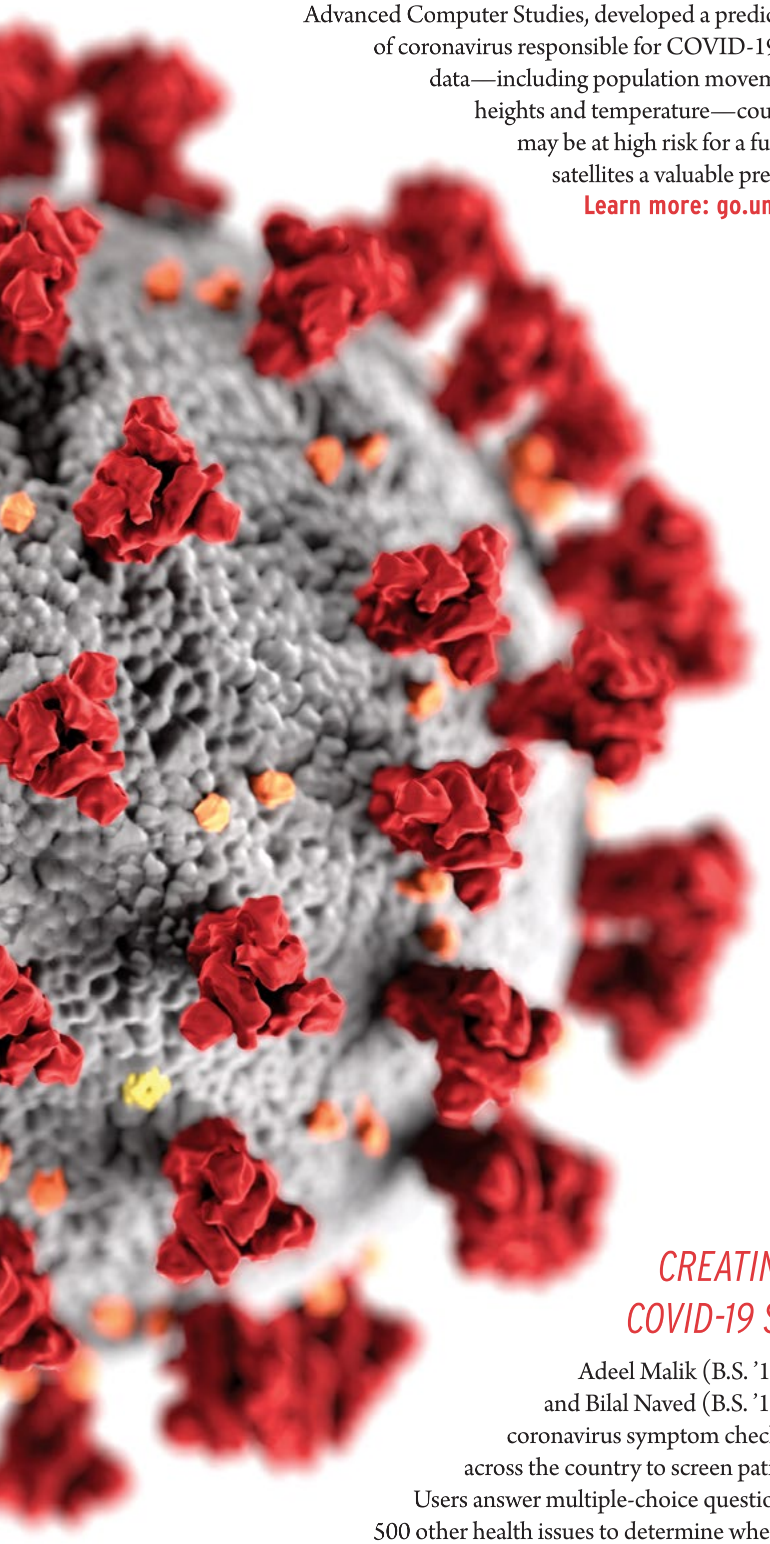
Assistant Professor Margaret Scull and Professor Jeffrey DeStefano from UMD's Department of Cell Biology and Molecular Genetics teamed up to develop new drugs to treat COVID-19, supported by a Coronavirus Research Seed Fund Award from UMD's Division of Research. DeStefano is developing small molecules called aptamers that can bind to coronavirus surface proteins and block the virus from entering cells. Scull will screen these aptamers on a complex cell model her lab developed of the human airway—a primary target of the coronavirus—to see whether they're effective in blocking infection in airway epithelial cells. **Learn more: go.umd.edu/covid-aptamers**

EXPLORING COVID-19'S SILENT SPREAD

COVID-19's rapid worldwide spread has been fueled in part by the virus's ability to be transmitted by people who don't have any apparent symptoms. A team of researchers at Princeton University that includes Simon Levin (Ph.D. '64, mathematics) published a study that found that this stealth phase of transmission can be a successful evolutionary strategy for viruses like COVID-19. Understanding just how much asymptomatic people are contributing to the spread of the coronavirus could guide public health managers as they take steps to prevent transmission, from stay-at-home orders to social distancing. **Learn more: go.umd.edu/covid-spread**

COVID-19 virus by Alissa Eckert and Dan Higgins/CDC

UMD VS. COVID-19



PREDICTING COVID-19 VIA SATELLITE

Rita Colwell, Distinguished University Professor in the University of Maryland Institute for Advanced Computer Studies, developed a predictive model for SARS-CoV-2, the strain of coronavirus responsible for COVID-19. Colwell's team found that satellite data—including population movement, weather conditions, sea-surface heights and temperature—could help identify specific regions that may be at high risk for a future COVID-19 outbreak, making satellites a valuable predictive tool for public health. **Learn more: go.umd.edu/covid-satellite**

SHARING FACES OF THE PANDEMIC

Seattle physician Jessica Lu (B.S. '14, biological sciences) teamed up with a colleague to launch an Instagram account called Frontline COVID-19. The account amplifies the voices of medical professionals on the frontlines of the fight against COVID-19 and provides a place to share their stories and pictures. For the public, it's a behind-the-scenes look at what's going on in hospitals around the world as the outbreak continues. **Learn more: go.umd.edu/covid-faces**

CREATING A POPULAR COVID-19 SCREENING TOOL

Adeel Malik (B.S. '15, biological sciences; B.S. '15, finance) and Bilal Naved (B.S. '15, bioengineering) created an online coronavirus symptom checker called Clearstep that is being used across the country to screen patients for COVID-19 symptoms.

Users answer multiple-choice questions for symptoms of COVID-19 and 500 other health issues to determine whether they need immediate medical attention. Malik and Naved believe that as telemedicine becomes more mainstream, tools like Clearstep will be the new normal in health care.
Learn more: go.umd.edu/covid-clearstep

COVERING COVID-19 NEWS

"When I wrote about the Spanish flu, I never ever thought I'd see people around the world wearing masks. I never thought society would shut down like it has and that schools would close for months."

Gina Kolata (B.S. '69, microbiology; M.A. '73, mathematics), *New York Times* science and medical reporter and author of "Flu: The Story of the Great Influenza Pandemic of 1918 and the Search for the Virus That Caused It," on the challenges of covering the COVID-19 pandemic. **Learn more: go.umd.edu/covid-news**

UNRAVELING THE GENOMIC MYSTERIES OF COVID-19

Biology Professor Michael Cummings received funding from the National Science Foundation to develop new tools and strategies for analyzing genomic data from SARS-CoV-2, the strain of coronavirus responsible for COVID-19. Understanding the genomics of COVID-19 could help scientists track its history and mutations and help public health officials predict where specific strains of the virus might pop up next. **Learn more: go.umd.edu/covid-genomics**

FIGHTING COVID-19 IN THE ER

"It certainly is scary not knowing what could happen on a given day…You just take it one day at a time and try to get through. You hope you don't make any mistakes at work that would cause you to contaminate yourself."

Emergency physician Larry Edelman (B.S. '01, biochemistry) on the fears and challenges of fighting COVID-19 in the ER at Baltimore-area hospitals. **Learn more: go.umd.edu/covid-er**

TRACKING COVID-19'S IMPACT ON AIR POLLUTION

When COVID-19 stay-at-home orders interrupted normal commutes in the D.C. metro area, a unique opportunity arose to study the impact of reduced traffic on air quality. Since March, Atmospheric and Oceanic Science Professor Russell Dickerson and his research team have been working with the National Oceanic and Atmospheric Administration, conducting aerial surveys to measure pollutants and greenhouse gases. Preliminary results show significant differences in air pollution levels before and after the lockdown. **Learn more: go.umd.edu/covid-air**

There's so much more!

Browse and read all of our COVID-19 stories online:
go.umd.edu/cmns-covid-19

Larry Edelman photo courtesy of same
Xinrong Ren and Phillip Stratton photo courtesy of same

UMD VS. COVID-19

MAPPING COVID-19 IN REAL TIME

Distinguished University Professor of Computer Science Hanan Samet led a team in developing a novel web application that can track the progression of COVID-19 over space and time. The web application, called NewsStand CoronaViz, is a research prototype that maps COVID-19 outbreaks, based on key variables including the number of infections, active cases, recoveries and deaths that are reported daily in real time from news articles and other sources. **Learn more: go.umd.edu/covid-newsstand**

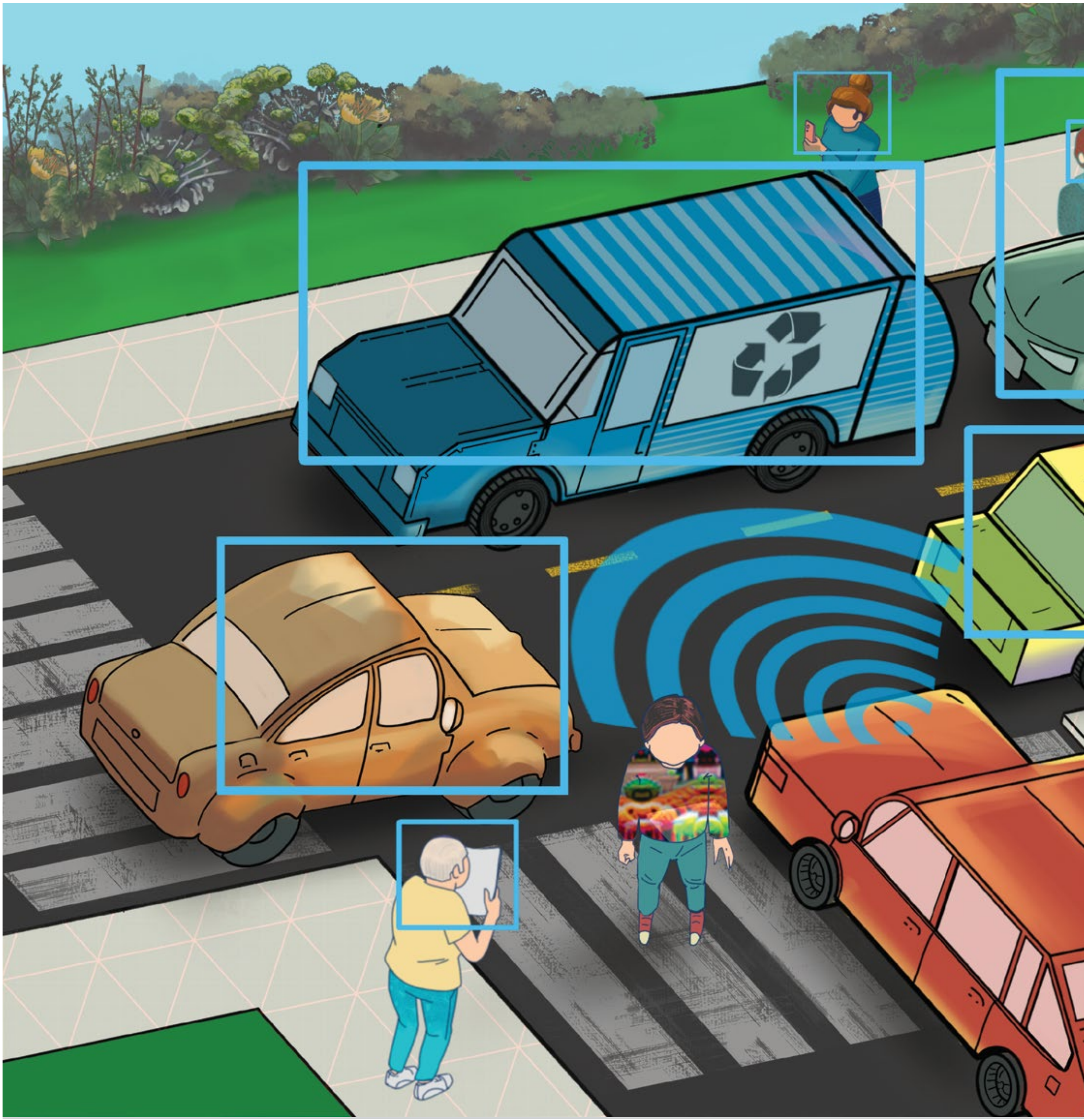
BATTLING COVID-19— AND NOT JUST IN THE LAB

Jonathan Dinman, professor and chair of UMD's Department of Cell Biology and Molecular Genetics, received a Coronavirus Research Seed Fund Award from UMD's Division of Research in April to focus his research on COVID-19, specifically on a viral process called programmed-1 ribosomal frameshifting (-1 PRF), which presents a promising target for antiviral drugs. In an unexpected twist of fate, Dinman's COVID-19 research was interrupted a few weeks later when he got the coronavirus himself. "The irony of the virologist being infected with COVID-19 does not escape me, that's for sure," Dinman said. **Learn more: go.umd.edu/covid-dinman**

PREDICTING PANDEMICS WITH THE POWER OF COMPUTERS

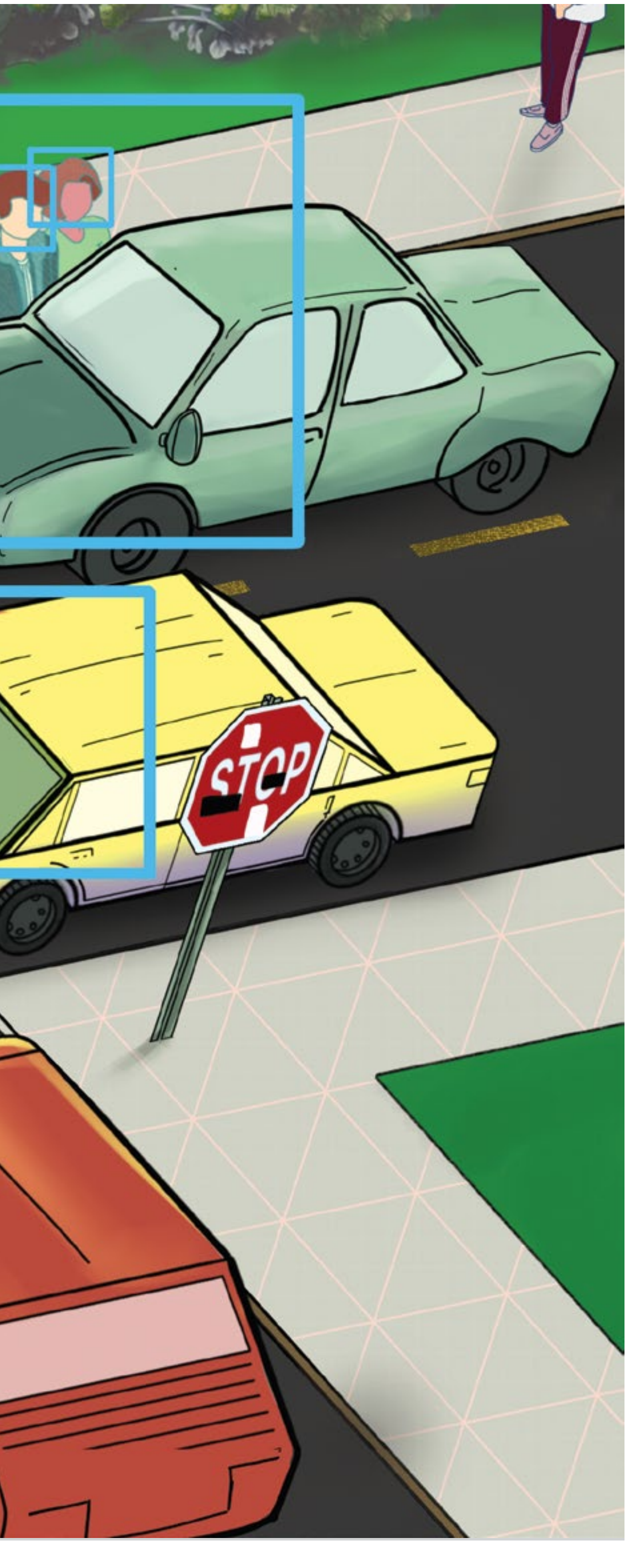
Computer Science Assistant Professor Abhinav Bhatele, Computer Science Distinguished University Professor Aravind Srinivasan and Distinguished University Professor Rita Colwell—who all have appointments in the University of Maryland Institute for Advanced Computer Studies—are collaborating with scientists from across the U.S. to deploy the latest advances in artificial intelligence, machine learning, supercomputing and social science data to fight pandemics. Funded by a $10 million Expeditions grant from the National Science Foundation, the researchers are using these powerful technologies to explore factors that increase the risk of global pandemics like COVID-19, such as trends in globalization, antimicrobial resistance, urbanization and ecological pressures. **Learn more: go.umd.edu/covid-computers**

NewsStand CoronaViz image via coronaviz.umiacs.io



MACHINE LEARNING

HARNESSING THE PREDICTIVE POWER OF COMPUTERS



MACHINE LEARNING IS EVERYWHERE.

It has worked its way into our daily lives, from voice assistants like Siri and Alexa to traffic apps that guide us around gridlock, cars that drive themselves and news stories that pop up on our social media feeds. And there's no end in sight to the potential applications of machine learning–in fraud protection, health care, the stock market and more.

Researchers in the University of Maryland's College of Computer, Mathematical, and Natural Sciences work at the forefront of machine learning technology, where computers analyze data to identify patterns and make decisions with minimal human intervention.

These faculty members are using machine learning for applications that touch many aspects of our lives—from weather prediction and health care to transportation, finance and wildlife conservation. Along the way, they are advancing the science of exactly how computers learn. And they're asking important questions about the impact of machine learning on our everyday lives and society itself.

BY KIMBRA **CUTLIP**

ILLUSTRATIONS BY AYUSH **POKHAREL**

SOHEIL FEIZI

BUILDING DEFENSES

FIGHTING CREDIT CARD FRAUD

Credit or debit? The shift from a cash economy to one reliant on electronic transactions has left many consumers feeling vulnerable to identity theft and bank fraud. And it's no wonder—in 2018, the Federal Trade Commission received over 440,000 reports of identity theft, largely from stolen credit card and social security numbers.

For any consumer, that figure is concerning. But it represents only a tiny fraction of the 44.7 billion credit card transactions processed that same year, which makes fraud the proverbial needle in a haystack–nearly impossible to find.

Computer Science Assistant Professor Soheil Feizi and his collaborators at Capital One are counting on machine learning to address this problem. They are developing a system that can learn to identify fraud without relying on a large number of examples.

One of the most common approaches to machine learning involves presenting a computer with lots of labeled examples of a specific thing and letting the computer learn to identify that thing. For example, a computer learns to recognize human faces by analyzing thousands of labeled images of human and non-human faces and finding the important features needed to distinguish a person from, say, a snowman or a smiley emoji.

The challenge for Feizi and his collaborators is that there are too few examples of fraudulent transactions to provide a reliable training dataset. So, rather than training the system to identify fraud, Feizi is developing a method that asks the machine to identify "normal." Then, the system can flag anything that doesn't fit in. This approach, called "unsupervised learning," lets the machine learn how to find anomalies without being told what anomalies look like.

"The unsupervised model aims to characterize the underlying distribution of the normal data. Learning this distribution aids us in flagging anomalies," explained Feizi, who also holds a joint appointment in the University of Maryland Institute for Advanced Computer Studies (UMIACS).

Feizi's method has proven effective on publicly available data. Now, he is working with Capital One to incorporate the company's proprietary data and eventually deploy the method live on Capital One's system to prevent fraudulent transactions.

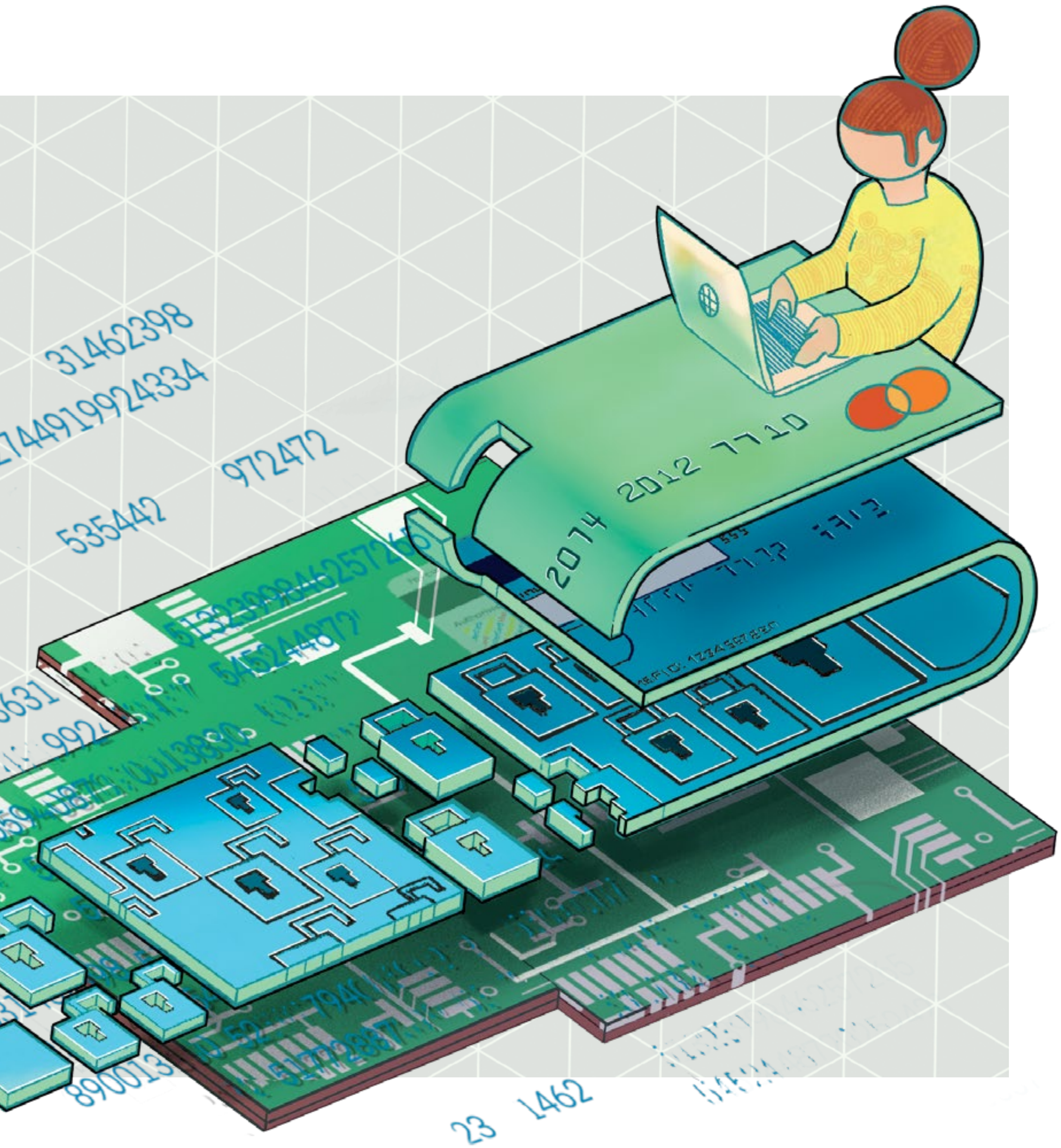
STOPPING PATCH ATTACKS

Imagine a self-driving car that can't recognize a stop sign—not because it can't "see" it, but because someone slapped a three-inch strip of tape on it. Or a security system that can't recognize a weapon concealed in a briefcase simply because someone applied a colorful sticker to the case. Known as patch attacks, such minor disturbances designed to scramble machine learning algorithms could pose significant threats to a world increasingly dependent on computers.

Some computer vision systems are notoriously vulnerable to patch attacks, which has led to an escalating cycle of defenses and counterattacks. Feizi is working to address these vulnerabilities.

"Robustness in machine learning models is an important focus of my lab," Feizi said. "We recently developed mathematically certifiable methods of defending against different types of adversarial attacks, including patch attacks."

Feizi and his team published their code and methods to reliably defend against patch attacks so that the machine learning community could use them and evaluate them. Although hackers will continue to find new ways to disrupt machine learning systems, shutting down patch attacks is a big win for these researchers.



"WE RECENTLY DEVELOPED MATHEMATICALLY CERTIFIABLE METHODS OF DEFENDING AGAINST DIFFERENT TYPES OF ADVERSARIAL ATTACKS, INCLUDING PATCH ATTACKS."

TOM GOLDSTEIN

REVEALING INVISIBLE THREATS

INVENTING AN INVISIBILITY CLOAK

A few years ago, Tom Goldstein had an idea—what if he could make himself invisible? Not invisible to the average person, but invisible to a computer vision system designed to recognize objects like the human form. Such object detectors, which rely on machine learning, are essential for military surveillance, airport security systems and personnel safety programs on large construction sites. Not to mention that self-driving cars depend on these object recognition programs to avoid accidents.

Goldstein, an associate professor in computer science and UMIACS, wanted to know how easy these systems were to break. So he created what he calls an invisibility cloak, a sweatshirt that renders the wearer imperceptible to machine learning-based object detectors—in a sense, invisible.

Goldstein and his team used a machine learning algorithm to create patterns on the sweatshirt that confuse the most common object detectors. When they printed the patterns on paper and held them up to their chests, some of the patterns magically masked their bodies.

One successful pattern looks similar to an impressionist painting of a gathering of people, though an actual painting of a similar scene doesn't fool the computer at all. Another successful pattern looks like a slightly psychedelic version of camouflage.

Goldstein said he doesn't know what makes one pattern work and another fail, but he doesn't have to. He proved his point–visual recognition systems can be fooled.

"I mostly just want to understand what the limitations of the systems are," he said.

And by understanding how to break them, researchers can learn how to better protect them from potential security threats.

IDENTIFYING MARKET VULNERABILITY

In the stock market, most trades are made by bots that use machine learning to predict market trends and strategically place buy and sell orders. That makes them a prime target for attacks, according to Goldstein. In the same way he used machine learning techniques to create patterns that confuse computer vision systems, he is using machine learning techniques to create strategic buy and sell orders that confuse the stock market prediction models that bots rely on.

In one example, using a mock stock market built with historical data, Goldstein's machine learning algorithm learned to strategically sell stocks rising in price at just the right moment so that the market models mistakenly predicted the stock's upward price momentum had stopped. If deployed in the actual stock market, Goldstein's attack could have caused trading bots to buy and sell based on bad information. This type of attack could allow someone to buy more of a company's stock before the price climbed higher. Or it could artificially suppress a company's rising stock value.

Goldstein's research is the first work to demonstrate this type of vulnerability, but he's unsure if this type of attack has actually occurred because financial markets are not transparent.

"Whether or not firms are using these kinds of strategies to manipulate the market is very unclear," he said. "This whole industry is a black box and no one will tell you what they're doing."

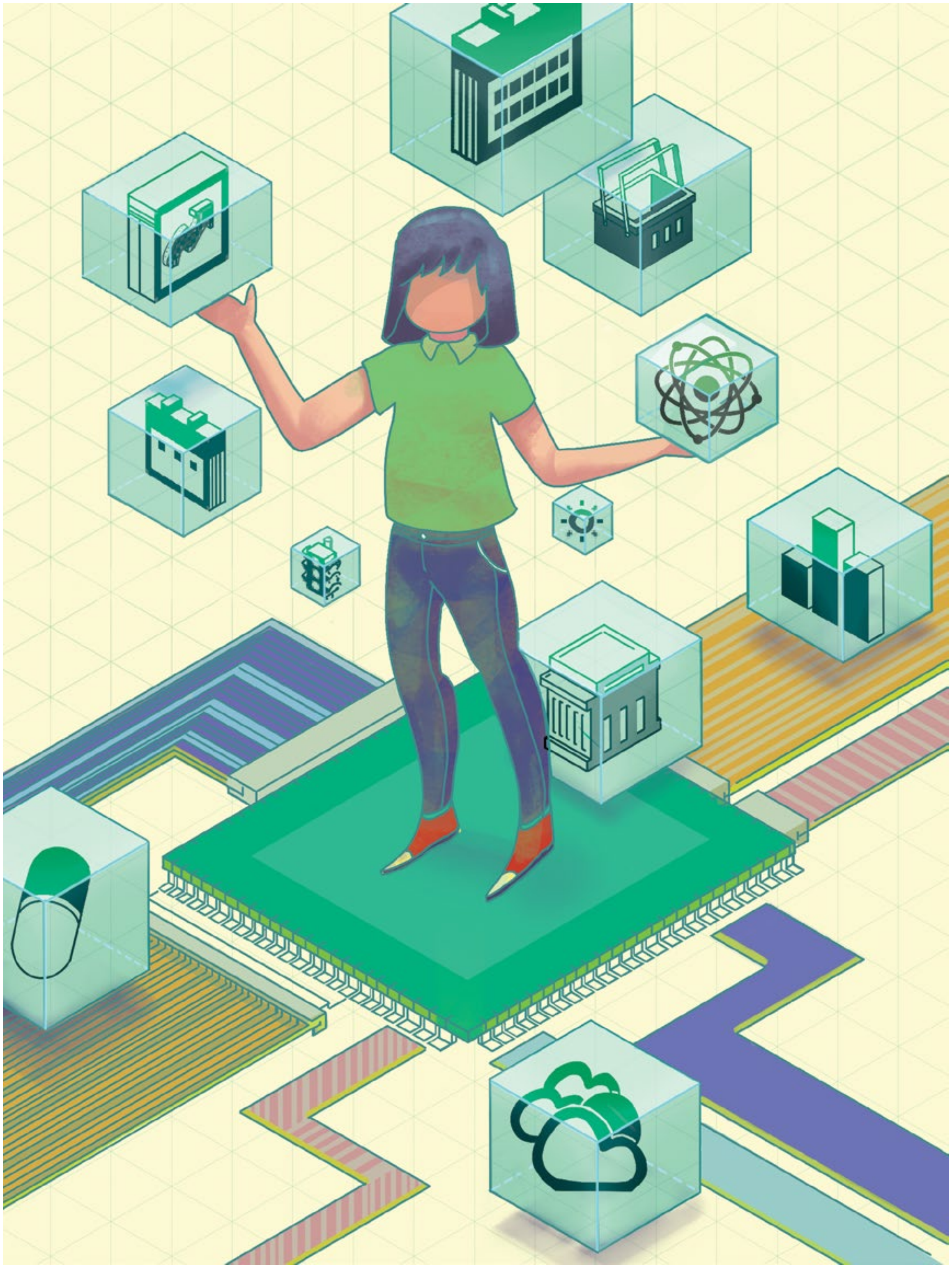
What's more, it is unclear what legal framework computer-driven manipulation of the stock market would fall under. Most of the laws that regulate market manipulation are based on intent, and it's difficult to ascribe intent to a computer.

"If a complex computer system makes a buy-sell order, how can we say whether it was to profit off the sale, which would be legal, or manipulate other agents, which would be illegal?" Goldstein asked.

In many ways, society is in uncharted waters here, and that's what motivates Goldstein.

"For me, this research is about awareness. If this is possible, it would be nice to have some sort of public discussion about it," he said. "Maybe we need a regulatory framework that makes it clear what sort of behaviors are allowed and what sort of behaviors aren't, and we should be having these conversations."

"MAYBE WE NEED A REGULATORY FRAMEWORK THAT MAKES IT CLEAR WHAT SORT OF BEHAVIORS ARE ALLOWED AND WHAT SORT OF BEHAVIORS AREN'T..."



MICHELLE GIRVAN

CREATING BETTER FORECASTS

If you've ever had your weekend plans soaked after a "clear and sunny" forecast, you know that predicting the future is, well, complicated.

Physics Professor Michelle Girvan is exploring how machine learning technology—with its ability to find patterns and make predictions about complex systems—can help improve such forecasts. And it's not just weather forecasts that can benefit from Girvan's work. The methods she is developing can help predict anything—from sunspots and stock markets to the spread of infectious disease—as long as there is data about how those things have changed over time.

Her approach to better predictions combines machine learning technology with traditional mathematical models that are based on the knowledge of how something works. To understand how this hybrid approach could yield a more accurate forecast, Girvan applied the approach to simulated systems.

"We expected that the two methods combined would do better than either method individually, but the combined effect we saw was so much greater than we anticipated," said Girvan, who holds joint appointments in the Institute for Physical Science and Technology and the Institute for Research in Electronics and Applied Physics.

"WE EXPECTED THAT THE TWO METHODS COMBINED WOULD DO BETTER THAN EITHER METHOD INDIVIDUALLY, BUT THE COMBINED EFFECT WE SAW WAS SO MUCH GREATER THAN WE ANTICIPATED."

Traditional knowledge-based forecast models start with measurements of current and recent conditions. In the case of weather, that includes things like temperature, humidity, pressure and wind speed. Then, the models predict how conditions will change over time by applying known relationships between the variables. For weather, this means incorporating the laws of physics, like how fast heat rises and how much water the air can hold.

Machine learning models take a different approach. They crunch through massive amounts of current and historical data looking for patterns and then make predictions based on those patterns. In the case of weather, machine learning models forecast future conditions by assuming current conditions will progress by following the same patterns found in previous weather data. These models have no "knowledge" of the physics involved.

Girvan found that combining the two approaches resulted in faster and smarter forecasts, even when only limited data was available. This hybrid model could offer a significant improvement in detailed short-term predictions while also providing a picture of expected long-term behavior.

In addition, combining machine learning with other forecast models can help to identify strengths and weaknesses of each system. By analyzing the differences in how a mathematical model and an algorithm perform on their own and when coupled together, Girvan is gaining a better understanding of how the different systems work.

Girvan's forecast: predicting the future may soon be much easier thanks to machine learning.

DAVID JACOBS

FILLING IN THE ____________

As COVID-19 swept the globe and people were forced into isolation to slow the spread of the virus, they scrambled to find new ways to connect. Work teams collaborated through video conference calls. Friends watched their favorite shows at the same time while video chatting. Grandparents blew kisses to their families on computer screens. Still, it wasn't the same. Humans are social beings.

What if these same people could feel like they were actually in the same room, collaborating at the same table or watching the same television? What if trainers could walk around their virtual students during a Zoom fitness class? Would a more realistic social experience ease the feelings of isolation and distance that so many have felt during the COVID-19 pandemic?

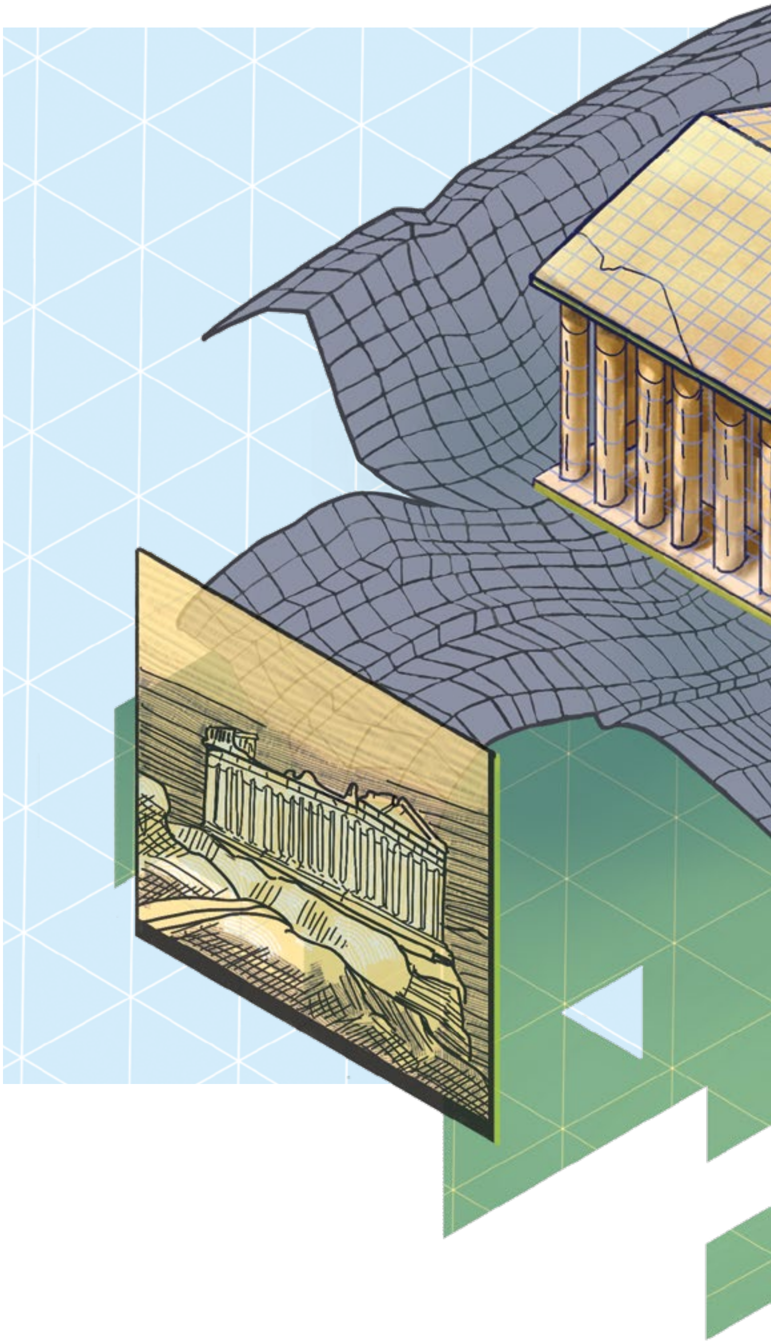
David Jacobs, a professor in computer science and UMIACS, is developing technology that could one day provide just such realism through a virtual reality headset. Turning 2D images like those on a video screen into 3D reconstructions is a complex process. It involves distinguishing color shifts from shadows; anticipating contour, texture and depth; and filling in missing information that our brains automatically assume when we look at a picture. While artists spend hours creating simple 3D models, Jacobs is automating the process with machine learning.

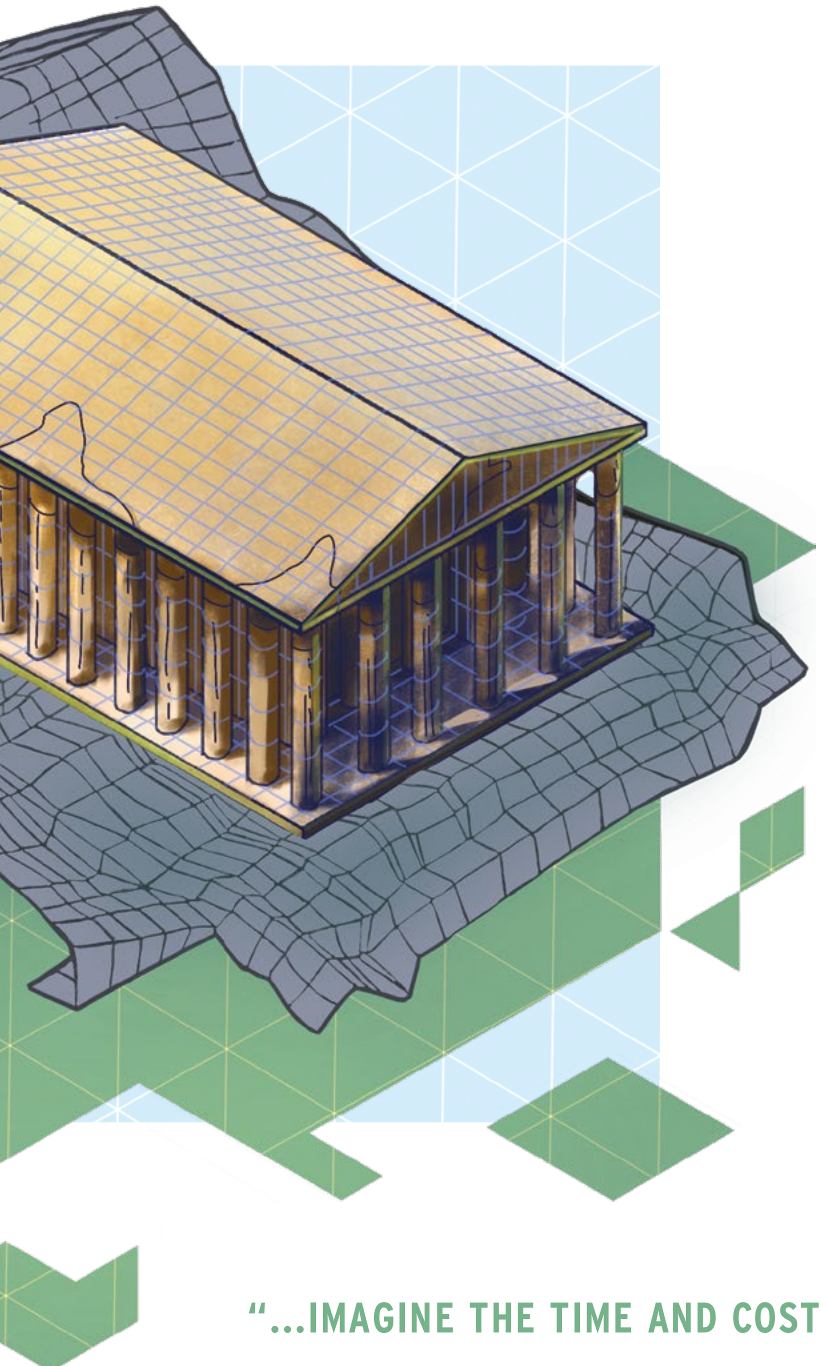
"3D reconstruction of people, objects and natural scenes is difficult because images are created by a complex interplay of lighting, shapes and the materials things are made from," said Jacobs, who is also director of UMD's Center for Machine Learning. "In real life, all these properties vary throughout the scene, so modeling and accurately capturing them from 2D images is a big challenge."

In addition to helping people maintain closeness during times of physical distancing, machine learning-based 3D rendering systems have countless other potential applications—like allowing doctors to noninvasively "see" internal organs or creating computer games and movies more easily and less expensively.

"Suppose I'm creating a game or a movie and I want a scene in the Parthenon," Jacobs explained. "Today, that would be an expensive project. Graphic designers would have to create the Parthenon by hand for a 3D game, or a movie production would require a live shoot on-site. But imagine the time and cost savings if I could just take some photos of the Parthenon and have a computer build an accurate 3D model."

Thanks to Jacobs' research, we may soon see the world in a whole new dimension.





THE CENTER FOR MACHINE LEARNING

The Center for Machine Learning launched in 2019 to unify and enhance the many machine learning activities underway at the University of Maryland.

Faculty members from mathematics, chemistry, biology, physics, linguistics and computer science are developing applications and technology for machine learning, and the multidisciplinary center provides a central hub for them to collaborate and leverage shared resources.

"We want the center to be a focal point across the campus where faculty, students and visiting scholars can come to learn about the latest technologies and theoretical applications based in machine learning," said the center's director, David Jacobs. Jacobs is a professor of computer science with a joint appointment in UMIACS.

Researchers involved with the center are developing new applications in computer vision, finance, natural language processing and other areas. They are also conducting research to advance machine learning theory and improve the technology behind machine learning and deep neural networks, which are modeled off networks in the brain and are capable of processing massive amounts of data.

"No one really knows why neural networks work as well as they do," Jacobs said. "We want to better understand the properties of deep learning and neural networks. We want to learn how to build better neural networks, train them better and understand their weaknesses."

Located in the Brendan Iribe Center for Computer Science and Engineering, the center leverages the powerful computational infrastructure of UMIACS, which provides computing resources as well as technical and administrative support. The College of Computer, Mathematical, and Natural Sciences provided initial funding for the center along with additional support from inaugural partner Capital One.

"...IMAGINE THE TIME AND COST SAVINGS IF I COULD JUST TAKE SOME PHOTOS OF THE PARTHENON AND HAVE A COMPUTER BUILD AN ACCURATE 3D MODEL."

FEATURE

JOHN DICKERSON

IMPROVING ORGAN EXCHANGES

When a patient needs an organ transplant, the best-case scenario is to find someone—usually a family member or close friend—who has the same blood and tissue type as the patient and is willing to volunteer as an organ donor. The path to that best-case scenario isn't as easy as it might seem, though.

Say a woman in Chicago needs a kidney and her husband is willing to donate, but he is not a match for his wife. What if, by donating his kidney to another patient with a willing but incompatible donor in, say, Los Angeles, he could help his wife at the same time? That's exactly how organ exchanges work. In this case, the husband in Chicago would donate his kidney to the patient in Los Angeles, and in return, his wife would get a kidney through the exchange from that patient's paired donor who wasn't a match for their loved one.

Over the past decade, organ exchange programs have saved thousands of lives by matching people who need organs with willing donors—typically total strangers.

But the system is challenging. How should an organ exchange decide who to prioritize and by how much, when matching patients to donors? By health condition? By age? By proximity? Should someone's lifestyle or ability to pay for the procedure affect that person's prioritization in this central matching system?

John Dickerson, an assistant professor in the Department of Computer Science and UMIACS, believes new ideas from machine learning, melded with known concepts from economics, can help organ exchanges answer those difficult questions and more.

Dickerson has been working with organ exchanges worldwide to develop machine learning systems that recommend an organ-matching policy that will best meet an exchange's objectives and treat patients as fairly and equitably as possible.

"Let's say an exchange's objective is to maximize the number of people who are matched, and they want to give a little bit of priority to pediatric patients, and they want to tie-break toward people who have been waiting around longer," Dickerson said. "How do we elicit those priorities, and how do we translate those into mathematics, which these machine-learning-based techniques require to be able to operate?"

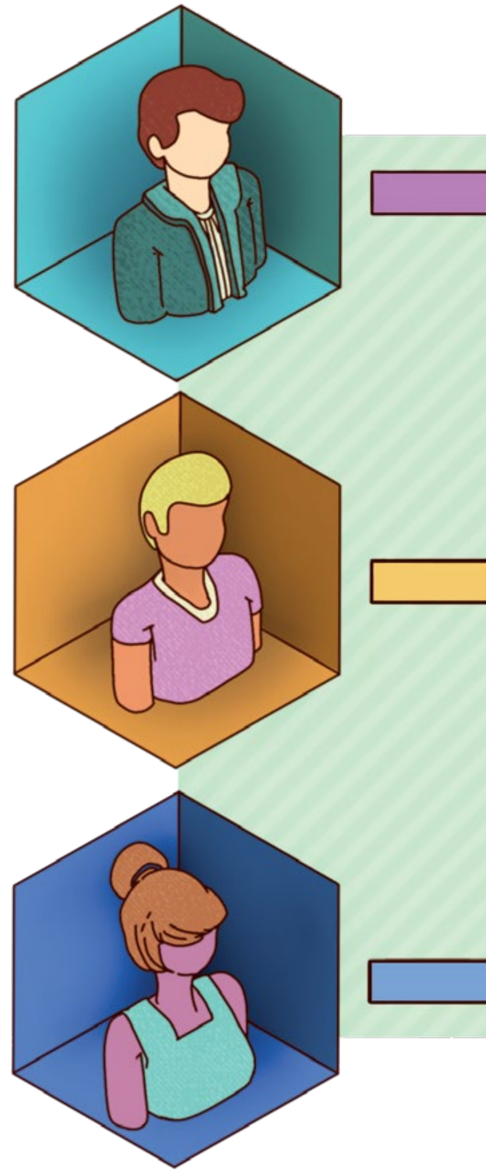
Dickerson's algorithms take an exchange's objectives and determine the best policy to meet them. Then, he takes it a step further and uses machine learning to help understand the possible impacts of that policy over time, giving organ exchange programs a clearer picture of the potential, and perhaps unintended, consequences of their policy decisions.

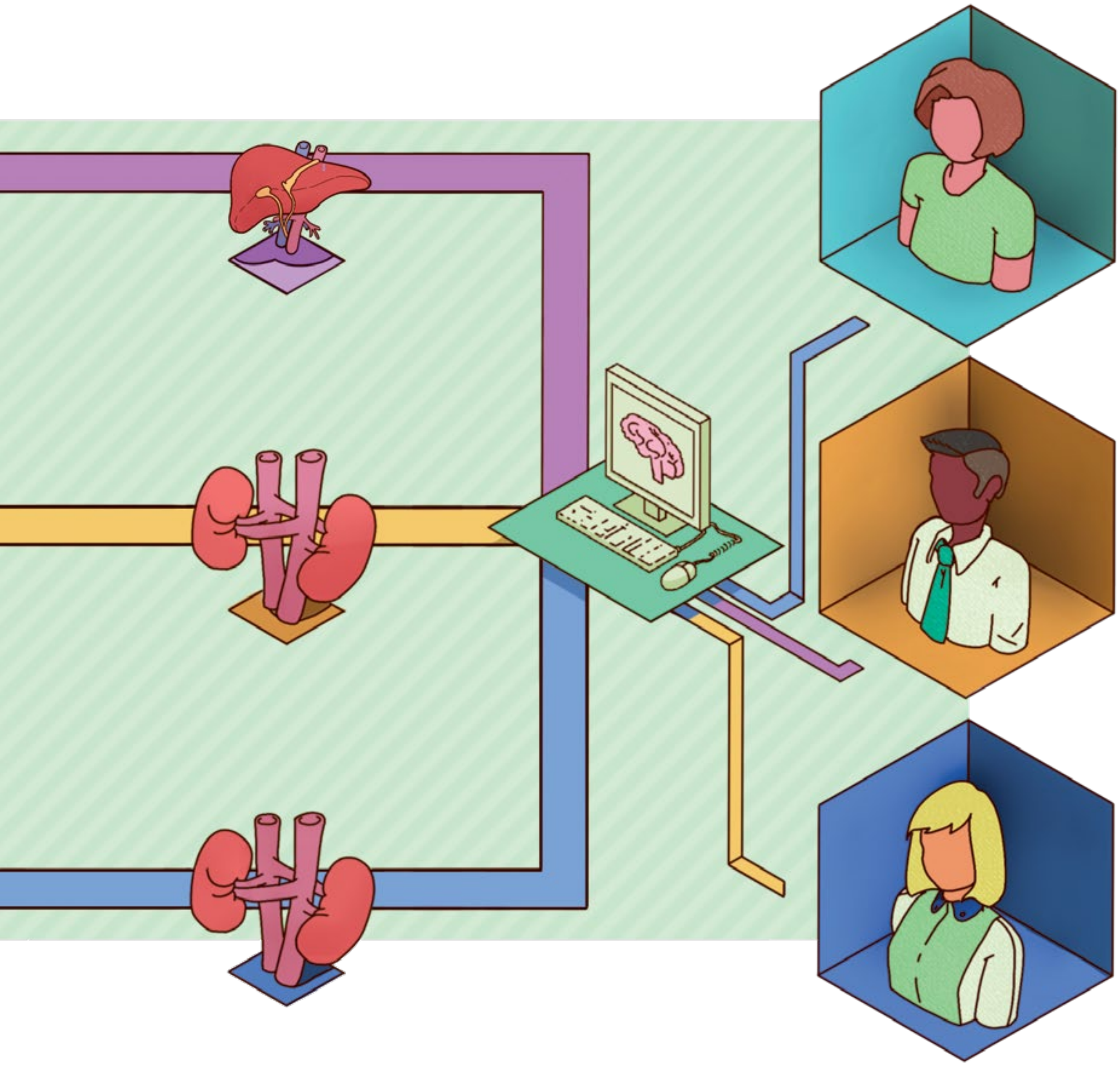
For example, if an organ exchange decides to prioritize pediatric patients, it could give a 10-year-old boy a chance at a healthy life. But what if that organ could have gone to a single parent struggling to support four children? Or, in the case of some exchanges, what if that organ could have triggered a multi-party swap that resulted in two or more parties receiving lifesaving organs, instead of just the one 10-year-old boy?

In another example, deprioritizing people with certain health conditions could mean that, over time, survival rates drop in people from a certain demographic because they are more prone to that condition.

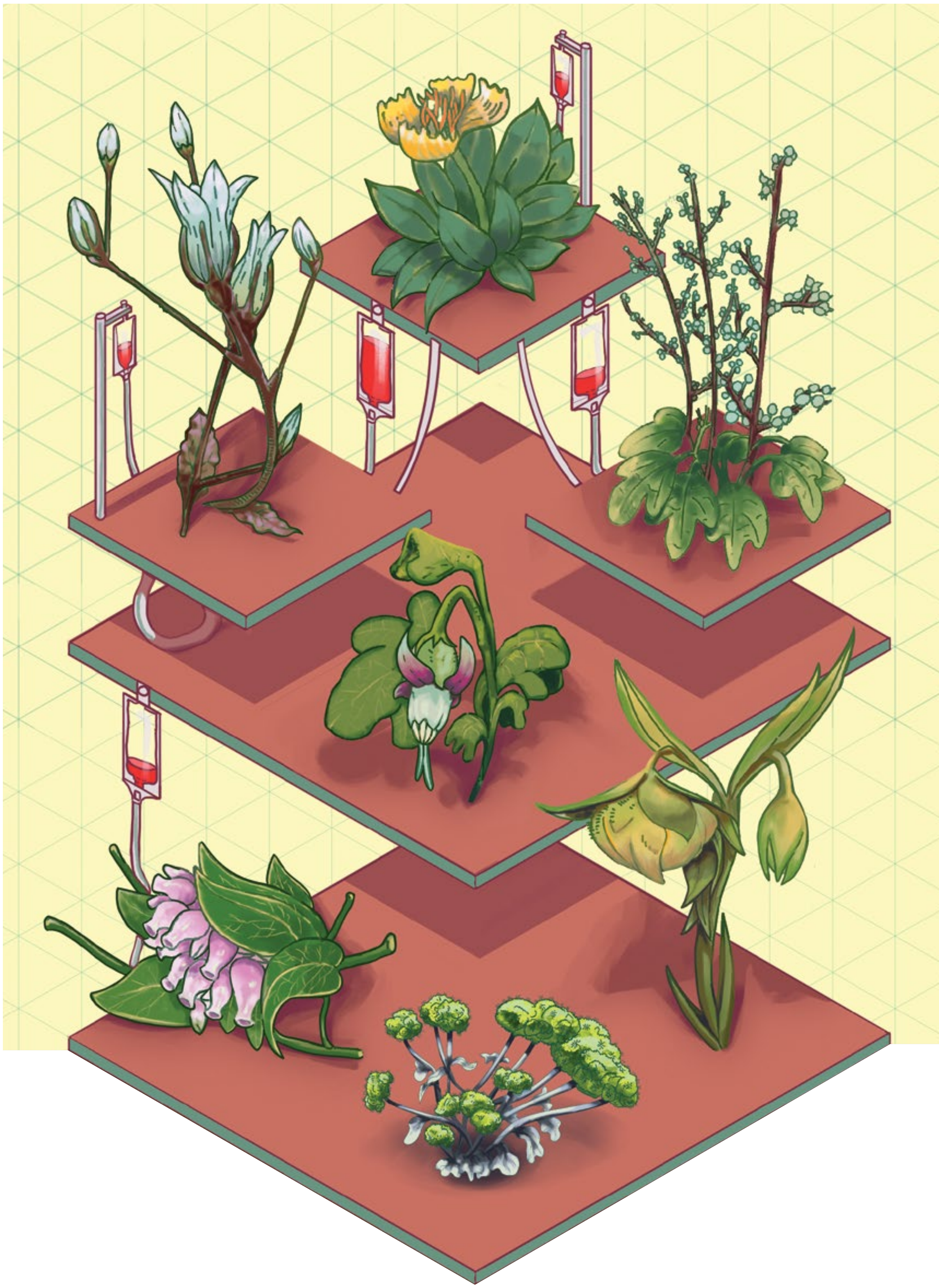
Armed with the information that Dickerson's machine learning analysis provides, organ exchanges can try to reduce the likelihood of specific unintended outcomes by making adjustments to their objectives and organ-matching policies. The goal, according to Dickerson, is to make a successful system work even better.

"The dream, of course, is to help organ exchanges maximize their matches, while increasing donation success and ensuring that matches more closely align to the values of the stakeholders involved in a particular exchange," he said.





"THE DREAM, OF COURSE, IS TO HELP ORGAN EXCHANGES MAXIMIZE THEIR MATCHES, WHILE INCREASING DONATION SUCCESS..."



ANAHÍ ESPÍNDOLA

FINDING THREATENED SPECIES

We are living in an age of mass extinction. Scientists estimate wildlife populations have plunged by 60% in the last 40 years. It is impossible to know how many species of plants and animals are threatened with extinction, but identifying which are most at risk of disappearing is a challenge Anahí Espíndola is taking on with the help of machine learning.

An assistant professor of entomology, Espíndola is developing machine learning tools that conservation organizations and resource managers can use to predict which species are most likely to need conservation.

"When you have an enormous number of species to consider and only limited resources to assess their conservation needs, this method allows you to decide where to prioritize," Espíndola said.

> **"WHEN YOU HAVE AN ENORMOUS NUMBER OF SPECIES TO CONSIDER AND ONLY LIMITED RESOURCES TO ASSESS THEIR CONSERVATION NEEDS, THIS METHOD ALLOWS YOU TO DECIDE WHERE TO PRIORITIZE."**

Conservation of a species is no simple matter. It involves countless ideas about what should be done and what sacrifices society is willing to make to save a plant or animal. Before any conservation action is taken, a detailed assessment must be made of the species and the threat level it faces. Such assessments are time-consuming and expensive, so resource managers and conservationists choose which species to assess and what order to assess them in. Often, they rely on educated guesses or they conduct a systematic assessment of all species within a large group—all bees in Europe, for example.

But educated guesses can be misleading. Sometimes a species that appears rare may not be threatened, and one that appears abundant may actually face a critical danger. On the other hand, broad, systematic assessments spend valuable resources on species known to not need protection. This is where Espíndola hopes machine learning can help.

Machines are masters of finding patterns in data. So Espíndola created and trained a machine learning algorithm to evaluate 150,000 species of plants from all corners of the world. The system identified more than 15,000 species that were highly likely to meet the criteria for one of the at-risk categories in the International Union for Conservation of Nature's Red List of Threatened Species.

"Our method isn't meant to replace formal assessments," Espíndola said. "It's a tool that can help prioritize the process, because you're never going to be able to assess all species. So, we're helping resource managers and conservationists make an informed choice by calculating the probability that a given species is at risk."

Espíndola's initial work predicted that 10% of the world's plants are likely in need of conservation and should be prioritized for assessment. Now, with increasing interest in her research from state and local resource managers, Espíndola is applying the same technology at the local level. She recently assessed the status of all known bee species in the state of Maryland to assist in focusing conservation efforts. The work confirmed some known at-risk species and identified a few others that state managers should assess more closely.

One of the most useful features of Espíndola's machine learning system is the simplicity of the system itself.

"It's very accessible," she said. "You don't need access to crazy clusters and computing power. It can run on a laptop. You just need data and the biological knowledge to evaluate the machine learning predictions."

In the fight to conserve at-risk species, machine learning could make a world of difference. ■

PAVAN RAVINDRA

SOLVES EQUATIONS—AND RUBIK'S CUBES

The room was totally silent as Pavan Ravindra decided what his move would be. Would he try the techniques he perfected in practice or throw caution to the wind and just go for it? The timer started, and Ravindra's fingers began to move as fast as lightning, flipping the cube and matching every side, color by color. Just 5.58 seconds later, the crowd erupted into cheers. Ravindra had just become one of the fastest Rubik's cube-solvers in the world.

At UMD, the junior biochemistry and computer science dual-degree student has to solve complicated problems on a daily basis. But none of them are as exciting to watch as when he tackles the complexities of a Rubik's cube and makes finding the solution look like child's play.

Ravindra, a 2020 Goldwater Scholar, started solving Rubik's cubes way back in the third grade. By the time he got to high school, he was solving them for speed and entering competitions.

"In ninth grade, I met a kid in one of my classes who was solving a Rubik's cube pretty quickly," Ravindra recalled. "At that time, he was averaging around 15 seconds and I was around 30 seconds, so he was really impressive."

Ravindra joined the Rubik's Cube club at River Hill High School in Clarksville, Maryland, and he started developing techniques for increasing his speed, which takes practice and patience.

"It's like learning to play basketball," he explained. "First you learn how to dribble, and then once you're comfortable with dribbling, you learn how to do other things. With learning to solve a Rubik's cube, first you learn the different ways to solve it, then you begin trying to optimize to find the fastest solution."

As one of the fastest Rubik's cube-solvers in the game, Ravindra has competed in countless competitions, including the 2015 United States National Championships where he finished in the top 10 and had one of the fastest single-solve times in the world—5.58 seconds.

At UMD, Ravindra discovered that he could apply the skills he mastered solving Rubik's cube to his research with Pratyush Tiwary, an assistant professor in the Department of Chemistry and Biochemistry and the Institute for Physical Science and Technology.

Last summer, Ravindra was working in the lab with biophysics graduate student Zachary Smith, trying to find a way to describe proteins and chemical systems more generally.

"I realized that this problem of describing the system, using a minimal set of parameters, is difficult and is usually done manually," Ravindra said.

Eventually, Ravindra found the solution, developing an algorithm he named AMINO, Automatic Mutual Information Noise Omission.

"Researchers can now use AMINO to hopefully overcome the barrier of needing information beforehand about the system they are looking at," Ravindra said.

AMINO was an important milestone for Ravindra for another reason—the discovery led to his first first-author scientific paper, which was published online in the journal *Molecular Systems Design & Engineering* in November 2019.

"It feels great to have made something that other people can use," Ravindra said of his publication. "I know this is just my first step into research, but I also know that I'll be making many more contributions in the future, so this was a great learning experience for me."

Ravindra continues to expand on his research in Tiwary's lab while taking advanced graduate student-level classes.

"Along with graduate students in my lab, Pavan continues to apply AMINO to different ambitious and relevant problems, such as how molecules fundamental to life—proteins, DNA and RNA—adopt different shapes and forms," Tiwary said. "Predicting this flexibility is often the key to designing effective, nontoxic drugs for different diseases. Pavan's method is helping make it possible to predict this flexibility in an inexpensive, effective and insightful manner."

It's no secret to anyone who knows him—Ravindra loves to win. Whether he's tackling a Rubik's cube for time or solving a complex problem in the lab, it's his love of challenges that drives him to succeed.

"The challenge is the fun part to me," Ravindra said. "I find competing and succeeding super rewarding."

And these days, you could say, all the right pieces are falling into place. ■

–CHELSEA TORRES

Photo by John T. Consoli

ANTARCTICA ADVENTURE

A Physics Ph.D. Student's Search for Neutrinos

As the twin-engine plane began its approach for landing on the icy runway, Liz Friedman watched a crew member put on an oxygen mask. At that moment, the University of Maryland physics Ph.D. student knew she was in for the experience of a lifetime. Exiting the aircraft, Friedman braced herself for the bone-chilling temperature outside—a frigid 20 degrees below zero. Nothing she'd ever experienced could prepare her for this.

"I was very nervous when I stepped off the plane," Friedman said. "There's the first moment when you're really afraid, but then I got outside and thought 'this isn't that bad.'"

In December 2015, Friedman embarked on her first monthlong research expedition to the South Pole. Her goal: deploy crucial hardware for detecting neutrinos, a key piece of research for her Ph.D.

In Antarctica, Friedman worked at the IceCube Neutrino Observatory, the first facility of its kind to measure neutrinos—massless, chargeless particles that almost never interact with matter—from beyond our solar system. It was designed to observe the cosmos from deep within the South Pole ice.

"IceCube takes advantage of the pristine South Pole ice to measure a signature of neutrino interactions," Friedman explained. "If a neutrino has enough energy, it can disturb the nuclei in the ice and create a flash of blue light known as 'Cherenkov radiation.' This effect is similar to a duck creating a wake on the surface of a pond, or a plane breaking the speed of sound and leaving a cone of dust. In this case, we get a cone of blue light—the Cherenkov radiation—that points back to where the neutrinos came from."

By studying the neutrinos that IceCube detects, scientists can learn

Photos courtesy of Liz Friedman

about the nature of astrophysical phenomena occurring millions, or even billions, of light-years from Earth. The origin of neutrinos is unknown, but gamma-ray bursts, active galactic nuclei and blazars are potential sources.

The IceCube Lab itself looks like it's straight out of a science fiction film. It's a large, angular structure in the middle of the vast, icy landscape that's anchored with two large steel columns and stairs with platforms between them.

But the real magic happens nearly 2,500 meters below the surface. There, more than 5,000 digital optical modules (DOMs) connect to vertical "strings" frozen into 86 boreholes, arrayed over a cubic kilometer at various depths. Each "string" contains 60 DOMs designed to detect neutrinos.

IceCube demonstrated that neutrino astronomy was possible, which led to the construction of several more neutrino telescopes. That's where Friedman comes in. She was there deploying crucial hardware for a neutrino telescope that will be used to try to set the record for the highest energy neutrino ever detected.

But Friedman's South Pole adventures included more than scientific discovery. In this remote waystation, thousands of miles from anything that looked like home, she found a warmth and comradery with her coworkers.

One of her best memories—Christmas dinner at the South Pole.

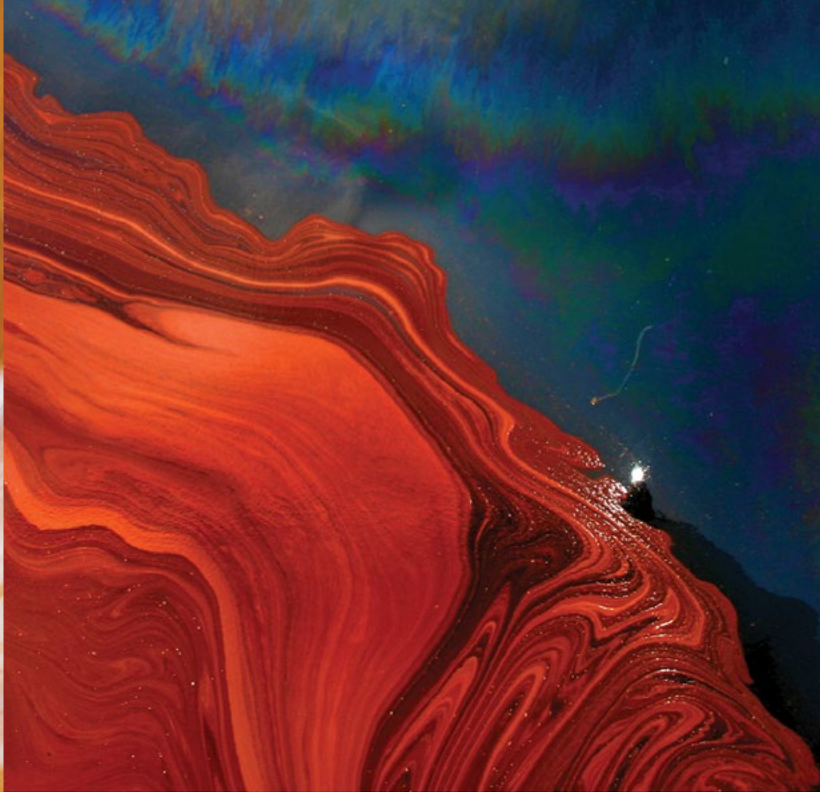
"The dinner was incredible. The cooks were able to create a Michelin-quality meal out of frozen food from airplane cargo," Friedman recalled. "And the best part is that everyone played a role in the meal. People volunteered to set up decorations, serve wine, and clean dishes. It's a real community and that means so much during the holidays when we are all so far from home."

But the icy wonder—and exhilarating cold—of the South Pole is something she'll never forget.

"The most surprising thing was how much fun stuff there was to do," she said. "It's a really nice, social place. I really miss it." ■

—CHELSEA TORRES

LIZ FRIEDMAN



Laying Down the Laws

Mathematics professor explains the natural world with rigorous equations

Jacob Bedrossian isn't intimidated by the impossible. The University of Maryland professor of mathematics earned his Ph.D. less than a decade ago, but he has already tackled two major projects that mathematicians said couldn't be done. By proving them wrong, Bedrossian and his collaborators established new frameworks that could eventually solve some of the most difficult challenges in physics—understanding turbulence.

Bedrossian studies stability and mixing in fluids and plasmas, which can be thought of as gases made up of charged particles. Much of his recent research focuses on turbulence, which can be seen in the chaotic flow of air in a billowing cloud or the eddies swirling in a flowing stream. Although turbulence is most often considered a phenomenon best understood through empirical laws of physics, Bedrossian sees turbulence as a mathematical question. Well, many, many mathematical questions, actually.

Last December, Bedrossian and UMD postdoctoral fellows Alex Blumenthal and Samuel Punshon-Smith (Ph.D. '17, applied mathematics and statistics, and scientific computation) presented the last part of a nearly 200-page mathematical proof to explain one small, but fundamental, law that physicists use when describing turbulence. The work, which described Batchelor's law, was a first step toward proving that turbulence, and perhaps other aspects of chaotic systems, can be explained by rigorous mathematics.

Although physicists have long used mathematical equations to describe the physical world—think of Einstein's $E=mc^2$—the underlying principles of many physical laws aren't supported by detailed mathematical proofs. Such proofs are generally considered too difficult to solve, especially when it comes to chaotic systems.

But the work of Bedrossian and his team demonstrates it is possible to truly understand and explain some of the most complex natural phenomena through rigorous mathematics. A more complete mathematical understanding of the laws of turbulence could mean that engineers may one day be able to design a better jet with mathematical equations rather than costly experimental testing, or weather forecast models could more precisely predict the paths of hurricanes.

Bedrossian's approach to tackling turbulence was to incorporate four branches of mathematics that rarely interact to such a degree. Punshon-Smith, now at Brown University, contributed his expertise in probability. Blumenthal applied his expertise in dynamical systems and ergodic theory, a branch of mathematics that includes chaos theory. Bedrossian brought his knowledge of partial differential equations, along with his strong intuition for physics born of a long-standing passion for reading physics and engineering literature. All three mathematicians were essential to solving the problem.

"When we started, it was a sort of fantasy," said Bedrossian, who also has a joint appointment in the Center for Scientific Computation and Mathematical Modeling. "We thought it would be great to one day prove this law, but now, a year and a half later, we've done it, and we're looking to see how far we can go."

The new level of collaboration that the team brought to this issue sets the stage for developing mathematical proofs

Cream swirling in coffee by Seiko/Shutterstock
Deepwater Horizon oil spill by David L. Valentine/UCSB/NSF

CHAOTIC MIXING: FROM YOUR KITCHEN TO OUTER SPACE

(L-R) CREAM MIXING WITH COFFEE, THE DEEPWATER HORIZON OIL SPILL, THE VORTICES OF JUPITER AND A BALTIC SEA ALGAL BLOOM ALL EXHIBIT STRIKINGLY SIMILAR EFFECTS OF CHAOTIC MIXING.

to explain other unproven laws of turbulence. The problems Bedrossian is working on and his method of reaching across disciplines poses both opportunities and challenges.

"You have to be prepared to work outside your field as needed," Bedrossian said. "You need to understand a little bit about several branches of mathematics. And you really need to understand physics literature."

Sometimes the challenge is in figuring out how to talk about something in mathematical terms for the first time. That's a unique position for someone who says he wasn't good at math and didn't like it in primary school.

When he entered college at Case Western Reserve, Bedrossian intended to be a physics major. But during an upper-level required math course, he began to see the language of mathematics differently.

"When I was young, I assumed everything except for maybe advanced quantum mechanics had already been solved mathematically," he said. "I was fascinated by the way relatively simple physical laws could lead to very subtle, complicated phenomena, and that even though we understood the laws, we couldn't really understand the phenomena they predicted. We didn't have the rigorous mathematical equations for them."

Bedrossian began to look at the world through a mathematician's lens.

"I realized, you can't do science without math," he said. "Once you give me the equation for a physical law, it may still be a physics problem, but it now lives in mathematics. I can ask and answer questions about it using mathematics and only mathematics."

Bedrossian's fearless approach to tackling physics with math early in his career led him to question why vortices such as tornadoes and hurricanes maintain a remarkably stable structure despite their existence in the midst of an otherwise wildly chaotic system.

"It's a very complicated answer," he said, "but our work was the first mathematical work that showed one aspect, the stretching of momentum, contributing to the stability of a vortex."

Solving difficult problems has earned Bedrossian accolades throughout his career, including a Sloan Research Fellowship, a National Science Foundation Faculty Early Career Development Award, and a Simons Fellowship. He also recently received the IMA Prize from the Institute for Mathematics and its Applications, which recognizes an early-career mathematical scientist who has made a transformative impact on the field, and the inaugural Peter Lax award from the 2020 International Conference on Hyperbolic Problems.

During the upcoming academic year, Bedrossian plans to spend a sabbatical at the Courant Institute at New York University with his Simons Fellowship support. While there, he will continue pushing boundaries, exploring the physical world and seeking explanations through rigorous mathematics.

"There are so many fundamental things that we do not understand about how nature works," Bedrossian said. "And that's what makes my job fun." ■ *–KIMBRA CUTLIP*

Storms on Jupiter by NASA/JPL-Caltech/SwRI/MSSS/Gerald Eichstädt/Seán Doran
Baltic Sea algal blooms photo by ESA, CC BY-2.0

WEATHERING THE STORM

MEET TV METEOROLOGIST MONIQUE ROBINSON

As Hurricane Florence neared the shoreline in Wilmington, North Carolina, Monique Robinson (B.A. '17, broadcast journalism; B.S. '18, atmospheric and oceanic science) sat on the floor in her apartment wondering how she ended up there.

Her car was the only one left in the parking lot outside. The rest of the city had already evacuated to dodge the storm's wrath. But Robinson was still in her home, packing up and trying to protect what she could before heading back to work to cover the approaching hurricane for local TV station WWAY.

Robinson had only been a broadcast meteorologist for two months when Hurricane Florence threatened to devastate the area in 2018. Days before the storm hit, her mother called, encouraging her to return home to Somerset, New Jersey, to get out of harm's way. Robinson admits she was scared.

But as she was packing, the gospel song "He Has His Hands on You" by Marvin Sapp began to play and she spontaneously fell to her knees. For her, it was a sign that God was going to protect her and everything was going to be okay.

"I'm so thankful that I made it through," Robinson said of that time. "If I decided to drive home to Jersey, it would have undermined all of the hard work that I did."

When Robinson arrived at the University of Maryland in fall 2013, she didn't envision herself becoming a broadcast meteorologist. She enrolled as a broadcast journalism major and knew she wanted to be on television, but she wasn't sure in what capacity. It wasn't until she took a weather and climate course taught by Atmospheric and Oceanic Science Assistant Professor Timothy Canty as an elective that she discovered her love for weather.

"Tim is a great teacher, and he was able to break down lightning and the thermodynamics of weather phenomena in a way that really intrigued me," Robinson said. "I was so fascinated by it and thought to myself, 'What if I join this major?'"

That semester, Robinson became the first person in the university's history to pursue degrees in both broadcast journalism and atmospheric and oceanic science.

"I grew up being a lover of science and math, and that's probably why, when I was doing just journalism, I didn't feel completely fulfilled by it," Robinson said. "Once I added my atmospheric and oceanic science major, I felt complete."

However, majoring in both subjects was no easy feat.

"It was very complicated, because these majors did not overlap at all," she recalled. "I literally had to start from scratch in terms of requirements for my science degree. Journalism had more writing requirements, while atmospheric and oceanic science required me to take physics and math courses."

Balancing two different passions was challenging. People told her she wouldn't succeed.

"I had someone tell me they saw no potential in me as a journalist, which really lit a fire under me, and that's when I started getting really serious about being a broadcast meteorologist," Robinson recalled. "At that same time, I had people saying to me, 'Why would you want to work so hard to obtain a science degree and pursue a career that doesn't put all of your science and math background to use?'"

Fortunately, Robinson received strong support and encouragement from the person who got her interested in weather in the first place—her advisor Timothy Canty.

"When I first told him that I wanted to be a broadcast meteorologist, he told me, 'I don't know anyone in this field but I'm going to email some people and help you out. I want you to be great,'" she recalled.

One thing Robinson knew she needed to be successful was experience working in front of a green screen—that green-colored backdrop news stations use to display digital weather maps and images behind the person on camera. There were no opportunities on campus for her to practice with a green screen, so she took matters into her own hands.

"I went to the fabric store and I picked up some green fabric, and I put it up in my kitchen and I just started practicing doing the weather in my apartment," she said.

When she showed Canty what she was doing, he told her that the department had a television monitor laying around that she could use. And it was with that green fabric and television monitor that she started the university's first broadcast meteorology club (called UMD Weather Talks), developed a reel to showcase her talents and landed her first post-graduation job in North Carolina.

"My news director found all of that stuff on YouTube and called and asked if I could move to Wilmington," she said.

Accepting that position launched Robinson's career.

"Two months into me coming here to Wilmington, that's when Hurricane Florence came," she said. "We were the closest ABC station covering it, so friends and family and old acquaintances saw me broadcast on ABC affiliate channels across the nation covering a storm that was coming to this area."

Robinson's work covering Hurricane Florence and its aftermath earned her two Associated Press awards.

"I went from being in an apartment kitchen with crappy green fabric to someone announcing my name and being on television," she recalled holding back tears. "I look back and think, 'Wow, I've won two awards from this.' People who had evacuated to Canada emailed me and said, 'I'm watching you right now because I'm worried about what's going on in my home. I'm just so thankful that you're there covering it and giving us a breakdown of exactly what's going on.'"

Knowing that she's able to help people experiencing fear and uncertainty makes her hard work as a broadcast meteorologist worthwhile.

"Stuff like that makes me feel like God said, 'Monique, this is why I wanted you to stay in Wilmington. This is why I sent you there,'" she said. ■ *–CHELSEA TORRES*

Monique Robinson photo courtesy of WWAY
Satellite image of Hurricane Florence by NASA

(L-R) CHRISTOPHER JARZYNSKI, JAMES FARQUHAR

Professors Elected to the National Academy of Sciences

Distinguished University Professors James Farquhar and Christopher Jarzynski were elected to the National Academy of Sciences in 2019 and 2020, respectively. They are now members of a select group of 2,403 scientists around the country—including 16 from UMD's College of Computer, Mathematical, and Natural Sciences—recognized for their influential research and elected by their peers.

Farquhar, who holds appointments in geology and the Earth System Science Interdisciplinary Center, was recognized for his influential research in sulfur isotope geochemistry. He has authored publications that address geochemical processes on Earth and elsewhere in the solar system, spanning a variety of eras from modern to ancient.

Farquhar is best known for discovering the geochemical signal that traces the long-term history of atmospheric oxygen. More recently, Farquhar and his colleagues found that Earth's early atmosphere spent about a million years filled with a methane-rich haze.

In January 2019, Farquhar and his collaborators developed a new, more accurate system to study the history of large volcanic eruptions over the past 2,600 years. These large eruptions can launch particles into the stratosphere, more than 6 miles above Earth's surface, where they can reflect sunlight and temporarily cool the planet.

For his next phase of work, Farquhar will team up with several collaborators at UMD to focus on methane in Earth's modern atmosphere, using a new, state-of-the-art, high-resolution instrument called Panorama that was set up on campus earlier this year.

Jarzynski holds appointments in chemistry and biochemistry, physics, and the Institute for Physical Science and Technology.

He is a statistical physicist and theoretical chemist who models the random motions of atoms and molecules using mathematics and statistics. Working at the boundary between chemistry and physics, Jarzynski studies how the laws of thermodynamics—originally developed to describe the operation of steam engines—apply to complex microscopic systems such as living cells and artificial nanoscale machines.

Jarzynski is well known for developing an equation to express the second law of thermodynamics for systems at the molecular scale. The equation is known as the Jarzynski equality. Published in the journal *Physical Review Letters* in 1997, the paper that introduced his equation has been cited in scientific literature more than 4,000 times.

The first experimental test of the Jarzynski equality involved the use of optical tweezers, which use laser beams to manipulate extremely small objects like biological molecules. When the inventors of optical tweezers won the Nobel Prize in 2018, the Nobel Committee for Physics noted the Jarzynski equality as an important example of an application of the invention.

More recently, Jarzynski's research has led to a new method for measuring "free energy"—the energy available to any system to perform useful work—in extremely small systems. This research is fundamental to new technologies and may lay the foundation for development of molecular- and quantum-scale machines.

In addition to his election to the National Academy of Sciences, Jarzynski was also awarded Guggenheim and Simons Fellowships this year.

Christopher Jarzynski photo by Lisa Helfert
James Farquhar photo courtesy of same

New Professional Master's Programs in Data Science and Machine Learning

The University of Maryland now offers master's programs in data science and machine learning that can be completed in less than two years.

Designed specifically for working professionals, courses are taught in the evenings. Successful graduates will apply the tools and techniques they learn to a wide variety of real-world problems in areas such as biology, security, weather and climate, social networking, medicine, engineering, information technology, marketing, finance and telecommunications.

The data science and machine learning programs are run by the Science Academy, launched in 2019 by the College of Computer, Mathematical, and Natural Sciences (CMNS) to meet a regional demand for a modern workforce with expertise in specialized areas of science and mathematics.

"Working professionals in nearly every field need data-related skills to stay current and advance in their careers," said CMNS Dean Amitabh Varshney. "Science Academy programs cater to a workforce that recognizesthe need for the knowledge and expertise that are required to compete in the 21st-century global economy."

Science Academy master's programs are led by faculty members in CMNS and the A. James Clark School of Engineering:

- Michael Cummings, professor in biology and the university's Institute for Advanced Computer Studies (UMIACS); director of the Center for Bioinformatics and Computational Biology
- David Jacobs, professor in computer science and UMIACS; director of the Center for Machine Learning
- Sennur Ulukus, Anthony Ephremides Professor in Information Sciences and Systems in the Department of Electrical and Computer Engineering

"Our long-term goal is to expand access to the university's expertise," said Amy Chester, director of the Science Academy. "Science Academy programs will respond to the learning and training needs of professionals across industries and in government."

For more information, visit scienceacademy.umd.edu.

Senior Awarded Winston Churchill Scholarship

Tanay Wakhare, who graduated in May with bachelor's degrees in mathematics and computer science and a University Honors citation, was awarded a 2020 Winston Churchill Scholarship. Fifteen students receive the scholarships nationally each year, and four UMD students have received the award since 2018.

The scholarship–valued at around $60,000–covers all educational fees and provides living and travel allowances for Wakhare to pursue a one-year master's degree in advanced computer science at the University of Cambridge in the United Kingdom. There, he will join the Artificial Intelligence (AI) Group in the Computer Laboratory.

"I think that a lot of fundamental AI breakthroughs have occurred within the last decade and that it has the potential to really change society," Wakhare said. "It's a place where my mathematical research background can be put to good use."

During high school, Wakhare worked at the National Institute of Standards and Technology and met Christophe Vignat, a professor of physics at the Université Paris-Saclay and an invited professor of mathematics at Tulane University, at a conference. Since that chance meeting, Vignat and Wakhare have collaborated on several papers on number theory and combinatorics–a branch of mathematics that focuses on counting.

"Tanay is an exceptionally talented young mathematician–by far the best student I have ever met in my career," Vignat said. "He has a very promising future in mathematics."

Wakhare has published 12 research papers, submitted eight papers for publication and is preparing two additional papers for publication.

He has also taught multiple Student Initiated Courses–known as STICs–on number theory. He first taught "Mathematics of Ramanujan," about an Indian pioneer in number theory, and went on to teach "Proofs from the Book" and "The Mathematics of Erdos," both on the study of counting.

When Wakhare returns from Cambridge, he plans to pursue a Ph.D. with funding from the National Science Foundation Graduate Research Fellowship he was awarded this spring.

Tanay Wakhare photo by Faye Levine

New Chemistry Wing to Advance Research Frontiers and Train Students

Wing one of the 1960s-era chemistry building is coming down and will be replaced by a state-of-the-art facility.

The new 105,000 square-foot wing will expand the scope of physical and analytical chemistry research in the Department of Chemistry and Biochemistry, support new approaches in materials synthesis and characterization, and create the collaborative environment necessary for harnessing discoveries into transformative applications.

Both the state of Maryland and the university recognize the value that this new facility will bring. They committed $103 million and $16 million, respectively, to construction. Current plans involve tearing down the current wing in summer 2021 and moving faculty members into their new home by early 2024.

"We're very excited about the opportunities this new building offers," said Department Chair Janice Reutt-Robey. "The facility is being designed to enable things we haven't been able to do before. For example, air handling systems engineered specifically for modern lab work will allow us to achieve very precise temperature and humidity control for the first time in the chemistry complex."

The wing will include research space for 20 faculty members and their students as well as light-filled offices and collaboration areas. The facility will bolster key research into areas such as nanomaterials, energy and environmental chemistry, soft materials and biologics. According to Reutt-Robey, one of the overarching principles guiding the development of the new building is the promotion of green, or sustainable, chemistry.

"This new building will allow us to transform the ideas and expertise of our amazing faculty and students into chemical discoveries that will create new knowledge and benefit society," Reutt-Robey said.

We Need Your Help!

While we have the base budget to construct the building, we need to raise private funding to outfit these new research labs with state-of-the-art equipment and keep them up to date for years to come.

If you are interested in helping us, visit:

go.umd.edu/chemrenovationfund

To talk about additional opportunities, such as naming a research lab or other space in the new facility, please contact Cheri Meadows at **301.405.9624** or **meadows@umd.edu**.

Chemistry Wing illustration by Ballinger

NOAA Awards College $175 Million for Earth System Studies

The University of Maryland created the Cooperative Institute for Satellite Earth System Studies (CISESS) with a five-year, $175 million cooperative funding agreement from the National Oceanic and Atmospheric Administration (NOAA).

A national consortium of more than two dozen academic and nonprofit institutions led by UMD's Earth System Science Interdisciplinary Center (ESSIC), CISESS aims to understand how the natural atmosphere-ocean-land-biosphere components of Earth interact with human activities as a coupled system.

"The creation of CISESS demonstrates the importance of pursuing Earth system research to help improve how society perceives and is affected by the natural environment," said CISESS Deputy Director Hugo Berbery, a research professor in ESSIC. "The capabilities and strengths of CISESS institutions offer an innovative organizational approach commensurate with the breadth and complexity of the challenges of the Earth system to our environment and global society."

CISESS builds on NOAA's long-term partnership with UMD, which includes the Cooperative Institute for Climate and Satellites from 2009 to 2019 and the Cooperative Institute for Climate Studies from 1984 to 2009.

CISESS research activities will cover three themes: satellite services, Earth system observations and services, and Earth system research. The activities proposed for the themes are interconnected and tightly coupled to allow for rapid feedback, prototyping and development.

For example, CISESS researchers will use environmental data from satellites to develop new, more accurate products that help NOAA improve weather and climate forecasts and build resilience to extreme events. The researchers will also monitor the oceans, the atmosphere, and the cryosphere and share that information so that it can be used in environmental decision-making.

Alliance Aims to Accelerate State's Leadership in Quantum Science

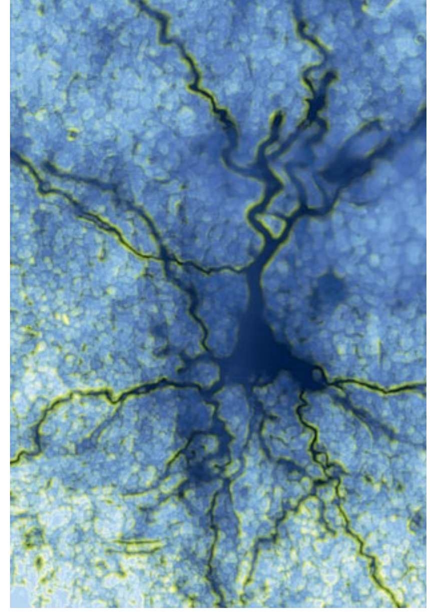
The Maryland Quantum Alliance—a regional consortium of quantum scientists and engineers from across academia, national laboratories and industry—launched in January 2020 with an event in the Maryland House of Delegates Office Building and was recognized on the floor of the House of Delegates.

Led by the University of Maryland, members of this alliance will drive quantum science discovery and innovation, develop pioneering quantum technologies, and train the quantum workforce of tomorrow for the state of Maryland, the region and the nation.

In addition to UMD, the Maryland Quantum Alliance includes Amazon Web Services, Booz Allen Hamilton, the CCDC Army Research Laboratory, George Mason University, IBM, IonQ, Johns Hopkins University and its Applied Physics Laboratory, Lockheed Martin, MITRE, Morgan State University, the National Institute of Standards and Technology, Northrop Grumman, Qrypt, Quantopo, and the University of Maryland, Baltimore County.

The alliance comes at a pivotal time when quantum science research is expanding beyond physics into materials science, engineering, computer science and chemistry. Scientists are finding ways to exploit quantum physics to build powerful computers, develop secure communication networks and improve sensing capabilities. In the future, quantum technology may also impact fields like artificial intelligence and medicine.

Already a major hub for quantum science and technology, UMD has five collaborative research centers focused on different aspects of quantum science and technology: the Joint Quantum Institute, Joint Center for Quantum Information and Computer Science, Quantum Technology Center, Quantum Materials Center, and Condensed Matter Theory Center.



Adding Neuroscience? It Was a No-brainer

Around 300 prospective freshmen applied to enter the University of Maryland's new neuroscience major launching this fall, and around 50 are expected to enroll in it.

The major is a cross-disciplinary collaboration between the Department of Biology in the College of Computer, Mathematical, and Natural Sciences (CMNS) and the Department of Psychology in the College of Behavioral and Social Sciences.

"We're excited about this new opportunity for undergraduates that has grown out of the strengths of the campus's broad expertise in neuroscience," said CMNS Dean Amitabh Varshney. "This major is the first of several we are exploring that focus on interdisciplinary areas of study that cross traditional college boundaries."

There's no shortage of great neuroscience courses already on the UMD campus, according to Hilary Bierman, co-director of the neuroscience major and a senior lecturer in biology, but students who wanted to sign up for them sometimes had to wait years.

"What there wasn't before was a mechanism for students to take neuroscience courses early in their undergraduate programs," she said. "In other majors, the neuro courses tended to come later on, and you didn't have access to all the amazing neuro courses offered in psychology and in kinesiology and in philosophy of consciousness and others."

The new major will allow both earlier access to courses and a more specific focus, with students eventually selecting between a cognitive-behavioral track and a molecular-cellular-physiological track.

Microscopy image by Patrick Kanold

College Appoints New Leaders

The chairs and directors began their new roles on July 1, 2020.

Sumant Nigam, Chair, Department of Atmospheric & Oceanic Science (AOSC)

Nigam joined UMD in 1987 as a research faculty member and became a tenured professor in 2003. He holds a joint appointment in the Earth System Science Interdisciplinary Center.

"I look forward to elevating AOSC's campus and national presence, including its academic gravitas and research heft, in the coming years," Nigam said. "Enhancing the academic enterprise will require offering exciting new courses and a renewed commitment to graduate and undergraduate teaching and recruitment."

As chair, Nigam will oversee academic, administrative and budgetary matters for the department, which has 14 tenured/tenure-track faculty members, 31 professional-track faculty members, over 100 students and annual research funding of nearly $5 million.

Nigam is a fellow of the American Meteorological Society and the Royal Meteorological Society. An active educator and mentor, Nigam has advised over three dozen undergraduate and graduate students at UMD. He also chaired the AOSC graduate admissions committee since 2003.

A climate scientist, Nigam uses observational analysis, theory and dynamical modeling to gain insights into the structure and mechanisms of midlatitude climate variability, ocean-atmosphere interactions, droughts and deserts, monsoon variability and global warming.

Before being awarded a 2020 Fulbright-Nehru Fellowship, Nigam chaired the American Meteorological Society's Committee on Climate Variability and Change and led the drafting of its 2019 Information Statement on Climate Change.

He has also served on the National Center for Atmospheric Research (NCAR) Advisory Panel, chaired the advisory panel for NCAR's Climate and Global Dynamics Laboratory, and co-chaired the Climate Variability Working Group of NCAR's Community Climate System Model.

Nigam was a Jefferson Science Fellow at the National Academy of Sciences and served as a member of the Academy's Board on Atmospheric Sciences and Climate and its Climate Research Committee. He also served as director of the National Science Foundation's Large-scale Dynamic Meteorology Program.

Ellen Williams, Director, Earth System Science Interdisciplinary Center (ESSIC)

Williams is a Distinguished University Professor in the Department of Physics and the Institute for Physical Science and Technology. She is a member of the National Academy of Sciences, a foreign member of the Royal Society (London), and a fellow of the American Association for the Advancement of Science, the American Academy of Arts and Sciences, the American Physical Society and the American Vacuum Society.

Williams came to UMD in 1981 for a postdoctoral fellowship and rose to the rank of professor by 1991. She established an internationally recognized research program in experimental surface science and pioneered the use of powerful scanning tunneling microscopy to study the surface of materials.

From 2010 to 2014, Williams served as chief scientist for British Petroleum (BP), where her work included sustainability studies. In 2014, she was confirmed by the U.S. Senate as director of the Advanced Research Projects Agency-Energy (ARPA-E) and led the agency in its mission to advance high-potential, high-impact clean energy technologies. Since Williams returned to UMD in 2017, she has been working on bridging policy and technology perspectives for clean energy innovation.

"[ESSIC's] mission is core to addressing the issues of climate change in the context of the world's ecosystem," Williams said. "I am looking forward to working with ESSIC's talented scientists in this crucially important mission."

Established in 1999 through a cooperative agreement with the Earth Sciences Division at NASA's Goddard Space Flight Center, ESSIC supports research, teaching and career training in Earth system science. ESSIC also administers the Cooperative Institute for Satellite Earth System Studies, a joint center with NOAA's National Environmental Satellite and Data Information Service. ESSIC has 18 academic faculty members, over 140 professional-track research faculty members and annual research awards of more than $45 million.

Photos by Lisa Helfert

Joshua Singer, Interim Chair, Department of Biology

Singer joined the department as an assistant professor in 2012 and was promoted to associate professor in 2014 and to professor in 2018.

He just concluded a three-year term as director of the university's Program in Neuroscience and Cognitive Science. In this role, he led an interdisciplinary graduate program of more than 130 faculty advisors and nearly 50 graduate students. The faculty advisors span more than 20 campus departments and units, as well as nearby research institutions. He also sits on the steering committee of the university's Brain and Behavior Initiative.

"Recent events have made it clear that the next several years will be particularly challenging, but I think they will also provide us with the incentive to reflect on our strengths and to motivate us to build collaborations, both within the department and across the university," Singer said.

During his career, Singer has mentored 60 undergraduates, doctoral students and postdoctoral researchers. His research focuses on understanding the principles of signaling within neural circuits. The majority of his work uses the mammalian retina as a model system for understanding how the output of a neural circuit reflects the behaviors of the individual synapses and neurons that compose it. In his research, he combines anatomical and physiological analyses and makes use of several methodologies for observing circuit organization on a large scale. Recently, he expanded his inquiries to include circuits in brain areas that regulate behavior in a light-dependent way.

Konstantina Trivisa, Director, Institute for Physical Science and Technology (IPST)

Trivisa is a professor of mathematics with joint appointments in IPST and the Center for Scientific Computation and Mathematical Modeling. She has served as associate director of IPST since 2014 and previously served as director of the Applied Mathematics, and Statistics, and Scientific Computation graduate program.

IPST's mission is to pursue interdisciplinary research and education in emerging areas at the boundaries between physics, chemistry, the mathematical and life sciences, and engineering.

"Some of my immediate goals will be to help catalyze a vibrant new interdisciplinary research direction that will engage IPST faculty from several of our participating academic units, increase our fundraising efforts, and pursue new cross-sector partnerships while strengthening existing ones," Trivisa said.

IPST supports UMD's graduate degree programs in chemical physics, biophysics and applied mathematics, as well as two National Science Foundation (NSF) graduate training programs: UMD's Physics of Living Systems node and the Computation and Mathematics for Biological Networks program. The institute also supports the Burgers Program for Fluid Dynamics and the NCI-UMD Partnership for Integrative Cancer Research.

Trivisa has won several awards, including a Sloan Research Fellowship, Presidential Early Career Award for Scientists and Engineers, NSF Faculty Early Career Development award, and Simons Fellowship. In 2018, she received UMD's Outstanding Director of Graduate Studies award. She was also selected as an ADVANCE Professor and Leadership Fellow for her work on diversity and inclusion issues.

Doron Levy, Chair, Department of Mathematics

Levy served as interim department chair for the past year. During that time, he hired four faculty members and secured a $6.5 million estate gift that establishes the Herbert A. Hauptman Endowed Graduate Fellowship Program (see p. 39). Levy also expanded the department's K-12 outreach program and its role in the college's professional master's degree programs in data science and machine learning. During the spring semester, Levy successfully led the department's shift to teaching 10,000 students online due to the COVID-19 pandemic.

"We are facing great challenges ahead and I am confident that we will emerge stronger and better," Levy said of the department, which has over 100 tenured/tenure-track and professional-track faculty members plus nearly 800 undergraduate majors and 200 graduate students.

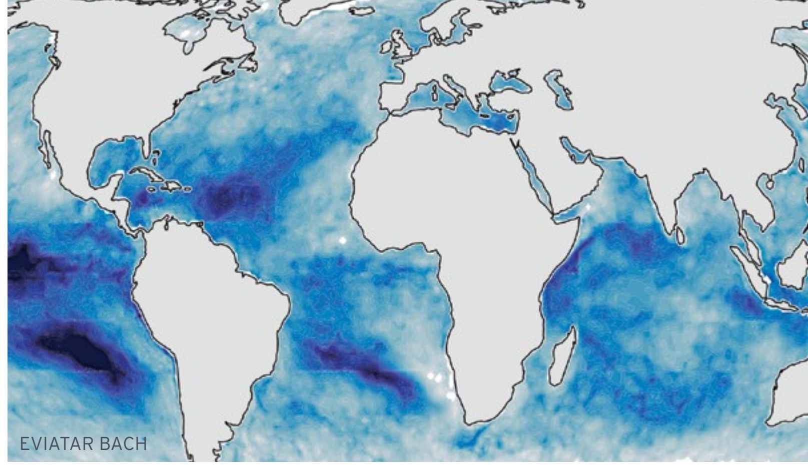
Levy joined the department as an associate professor in 2007 and was promoted to professor in 2011. He holds a joint appointment in the Center for Scientific Computation and Mathematical Modeling and serves as a co-director of the NCI-UMD Partnership for Integrative Cancer Research.

Levy also serves on the board of governors for the Institute for Mathematics and its Applications and the board of directors for the Society for Mathematical Biology. His research focuses on biomedical applications of mathematics with a particular interest in cancer dynamics, drug resistance, immunology, imaging and cell motility.

Among his many distinctions, Levy was named a Big Ten Academic Leadership Program Fellow, Pauli Fellow, Guggenheim Fellow, and UMD Distinguished Scholar-Teacher.

Joshua Singer photo courtesy of same
Konstantina Trivisa photo by Faye Levine
Doron Levy photo by Lisa Helfert

#UMDdiscovers


EVIATAR BACH


NASA/ESA/HUBBLE HERITAGE TEAM

Our faculty members and students discover new knowledge by pursuing fearless ideas. Read on for 10 stories of fearless science since our last issue—one from each of our departments.

Six Quiet Galaxies Rapidly Change into Bright Quasars

A new study could settle the debate about what produces the light coming from low-ionization nuclear emission-line region (LINER) galaxies, which account for about a third of nearby galaxies. Using the Zwicky Transient Facility, a team led by **ASTRONOMY** Associate Professor Suvi Gezari observed six mild-mannered LINER galaxies suddenly and surprisingly transforming into ravenous quasars–the brightest of all active galactic nuclei. The team's results suggest that LINER galaxies host a dormant black hole that can suddenly begin consuming surrounding gas and dust and transform into a quasar. Changes like these have been extremely rare to observe on the timescale of human experience.

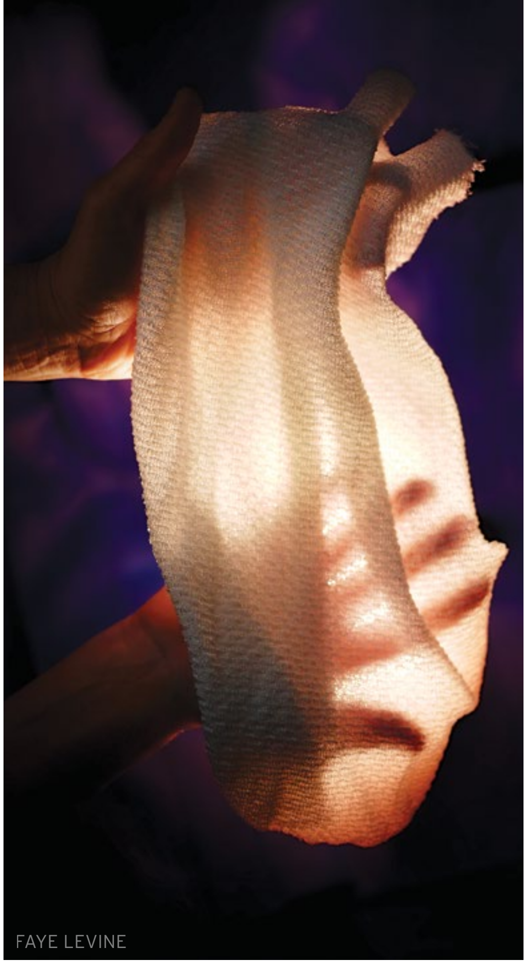
LEARN MORE:
go.umd.edu/quasars

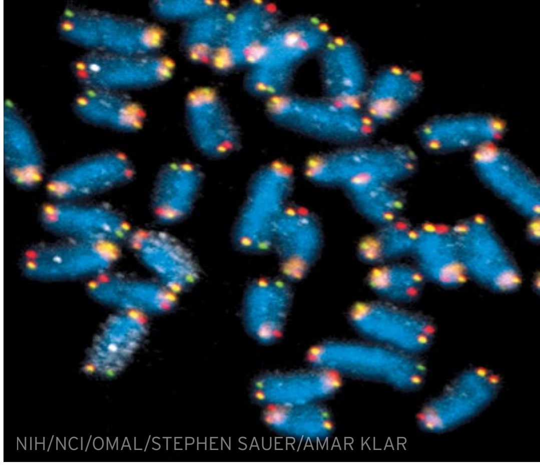
Mutual Prediction of Atmospheres and Oceans

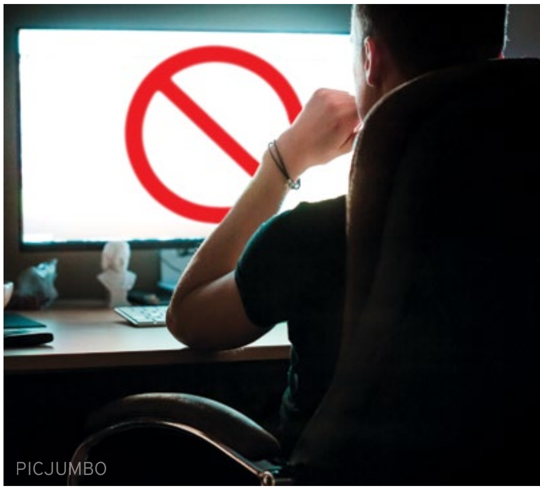
In a study led by **ATMOSPHERIC AND OCEANIC SCIENCE** graduate student Eviatar Bach, UMD scientists drew on a classic statement often heard in introductory statistics classes that "correlation is not causation." They carried out a novel statistical analysis to develop the first global picture showing how the ocean helps predict the low-level atmosphere and vice versa, in both the tropics and extratropics. Their finding of a statistically significant signature of the ocean on the atmosphere nearly everywhere in the extratropics is notable because it is difficult to demonstrate with dynamic models of atmospheric and oceanic circulation.

LEARN MORE:
go.umd.edu/mutual


KAREN WARKENTIN


FAYE LEVINE


NIH/NCI/OMAL/STEPHEN SAUER/AMAR KLAR


PICJUMBO

When Frogs Die Off, Snake Diversity Plummets

Since 1998, more than 500 amphibian species have declined in numbers, including 90 that have gone extinct, due to the fungal pathogen *Batrachochytrium,* commonly known as chytrid. A new study co-authored by **BIOLOGY** Professor Karen Lips showed that after chytrid swept through a national park near El Copé, Panama, in 2004 decimating frog populations, the number of snake species declined dramatically, causing the snake community to become more homogeneous. This work emphasizes the importance of long-term studies to understand the invisible, cascading effects of species extinctions.

LEARN MORE:
go.umd.edu/dieoff

Enzyme That Promotes Cancer Also Protects Healthy Cells

A study published by **CELL BIOLOGY AND MOLECULAR GENETICS** Associate Professor Kan Cao and National Institutes of Health leaders Francis Collins and Richard Hodes revealed a new role for the enzyme telomerase. Scientists knew telomerase protected certain cells that divide regularly, such as embryonic cells, but they thought it was turned off in all other cells, except in cancerous tumors where it promotes unlimited cell division. The new study found that telomerase reactivates in normal adult cells at a critical point in the aging process. Just before cell death, a burst of telomerase buffers cells from the stresses of aging, slowing the process and reducing DNA damage that could lead to cancer.

LEARN MORE:
go.umd.edu/enzyme

New Fabric Automatically Cools or Insulates

Despite having fabrics with high-tech thermal properties that keep marathon runners cool or alpine hikers warm, **CHEMISTRY AND BIOCHEMISTRY** Professor YuHuang Wang and **PHYSICS** Professor Min Ouyang created the first fabric that can automatically regulate the amount of heat that passes through it. The fabric was made from specially engineered yarn coated with a conductive metal. When conditions are warm and moist, such as those near a sweating body, the strands of yarn compact and activate the coating, which allows heat to pass through. When conditions become cooler and drier, the fabric reduces the heat that escapes.

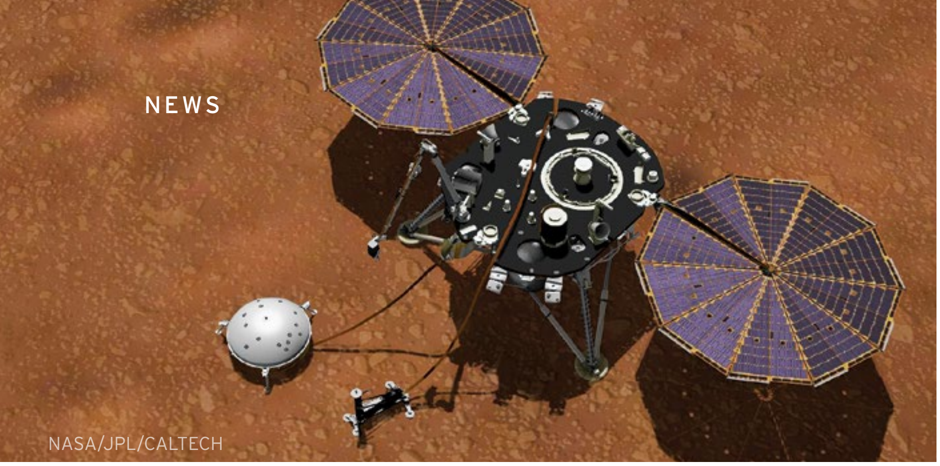
LEARN MORE:
go.umd.edu/fabric

AI System Automatically Evolves to Evade Internet Censorship

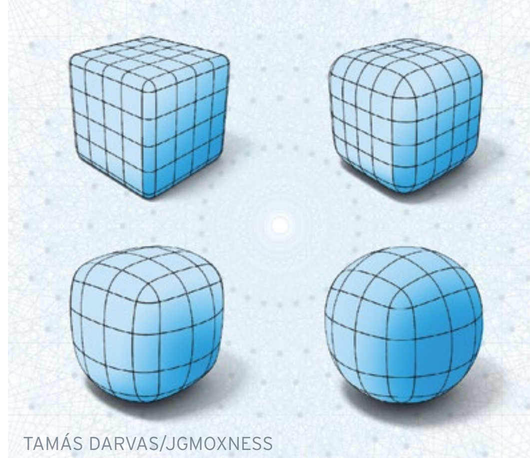
Internet censorship by authoritarian governments prohibits free and open access to information for millions of people around the world. New work by **COMPUTER SCIENCE** Assistant Professor Dave Levin and Ph.D. student Kevin Bock (B.S. '17, M.S. '18, computer science) could shift the balance of the censorship race. They developed a tool called Geneva (short for Genetic Evasion)—a biologically inspired type of artificial intelligence—which automatically learns how to circumvent censorship. Tested in China, India and Kazakhstan, Geneva found dozens of ways to circumvent censorship by exploiting gaps in censors' logic and finding bugs that the researchers say would have been virtually impossible for humans to find manually.

LEARN MORE:
go.umd.edu/censorship

NEWS

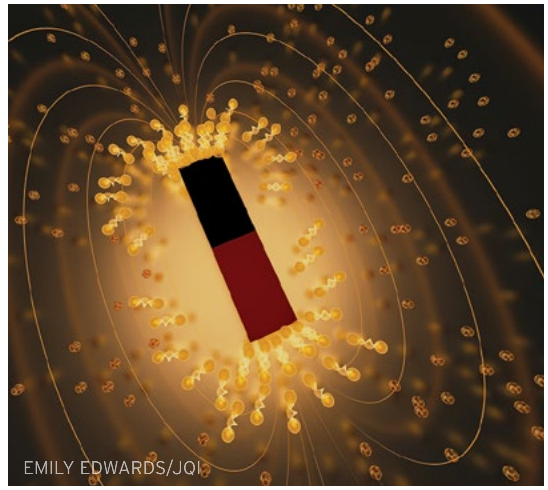


NASA/JPL/CALTECH



TAMÁS DARVAS/JGMOXNESS

JOHN T. CONSOLI



EMILY EDWARDS/JQI

Transgenic Fungus Rapidly Killed Malaria Mosquitoes in West African Study

Distinguished University Professor of **ENTOMOLOGY** Raymond St. Leger, Brian Lovett (Ph.D. '19, entomology) and colleagues in Burkina Faso genetically modified a naturally occurring fungal pathogen to deliver a lethal, insect-specific toxin to malaria mosquitoes. They tested the fungi in Burkina Faso in a screened enclosure designed to mimic conditions of a rural village. The study showed that treatment with the engineered fungi killed roughly 75% of insecticide-resistant mosquitoes and caused an established mosquito population to collapse in 45 days. The American Association for the Advancement of Science (AAAS) awarded the study's authors its 2019 Newcomb Cleveland Prize, which honors the most impactful paper published in AAAS's flagship journal *Science* during the previous year.

LEARN MORE:
go.umd.edu/transgenic

First Direct Seismic Measurements of Mars Reveal a Geologically Active Planet

The first reports of seismic activity and ground vibrations on Mars revealed a moderate level of seismic activity, between that of Earth and the moon. **GEOLOGY** Associate Professors Vedran Lekić and Nicholas Schmerr helped analyze data acquired by a Mars probe over 235 Martian days, which showed 174 seismic events, or marsquakes. Of those, 150 were high-frequency events that produced ground shaking similar to that recorded on the moon by the Apollo program. The other 24 quakes were predominantly low-frequency events; three showed two distinct wave patterns similar to quakes on Earth caused by the movement of tectonic plates.

LEARN MORE:
go.umd.edu/seismic

The Intricate Connection Between Constant Curvature and Symmetries

The most basic shapes in geometry, such as spheres and cylinders, have constant curvature. They also have many symmetries: spheres stay the same under any rotation and cylinders don't change if a rotation is applied to the central axis. In a new paper, **MATHEMATICS** Assistant Professor Tamás Darvas extended this work to infinite dimensional geometries, which appear in physical applications that range from fluid dynamics to quantum mechanics. He showed that the infinite dimensional space of Kähler metrics has almost no symmetries, despite having constant curvature. This result shows that for infinite dimensional shapes, the fundamental connection between constant curvature and the existence of symmetries is much more intricate than expected.

LEARN MORE:
go.umd.edu/shapes

Rare "Lazarus Superconductivity" Observed in Rediscovered Material

PHYSICS Professor Johnpierre Paglione and collaborators at the National Institute of Standards and Technology, the National High Magnetic Field Laboratory and the University of Oxford observed a rare phenomenon called re-entrant superconductivity in the material uranium ditelluride. Nicknamed "Lazarus superconductivity" after the biblical figure who rose from the dead, the phenomenon occurs when a superconducting state arises, breaks down, then re-emerges in a material due to a change in a specific parameter—in this case, the application of a very strong magnetic field. The discovery furthers the case for uranium ditelluride as a promising material for use in quantum computers.

LEARN MORE:
go.umd.edu/lazarus

(L-R) PAST VICE PRESIDENT JACKIE LEWIS, PAST PRESIDENT WALLACE D. LOH, CAROL FULLERTON, DEAN AMITABH VARSHNEY, MATHEMATICS CHAIR DORON LEVY

$6.5 Million Estate Gift to Mathematics Honors Alumnus Herbert A. Hauptman

The University of Maryland's Department of Mathematics received a $6.5 million estate gift from Carol Fullerton that honors the memory of her late father, Herbert A. Hauptman (Ph.D. '55, mathematics). The gift will establish the Herbert A. Hauptman Endowed Graduate Fellowship Program in the department.

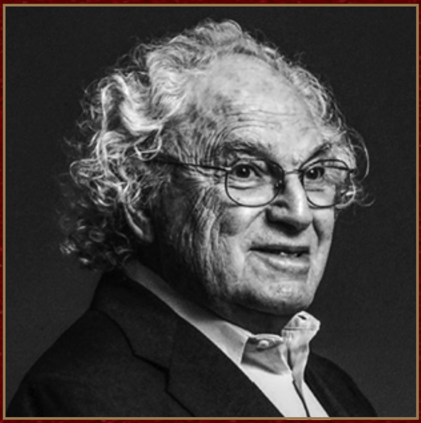
"The gift is a transformative moment in the history of our department," said Doron Levy, chair of the Department of Mathematics. "It will provide us with the resources needed to elevate the experience of our Ph.D. students. We are so proud to be Herbert Hauptman's alma mater, and we believe that the gift will allow us to carry on his legacy for many years to come."

Hauptman and Jerome Karle were awarded the Nobel Prize in chemistry in 1985 for "outstanding achievements in the development of direct methods for the determination of crystal structures."

The road to these achievements began in 1947 when Hauptman began collaborating with Karle—who worked at the Naval Research Laboratory—on X-ray crystallography, a technique used to determine the structure of molecules.

At the time, X-ray crystallography could only determine certain simple molecular structures. Hauptman and Karle developed equations that made it possible to directly determine the structure of larger molecules, such as proteins, using X-rays. This work advanced biological and medical research.

Hauptman lived in the Washington area until he joined the Medical Foundation of Buffalo in 1970, later becoming the organization's president. In 1994, the foundation was renamed the Hauptman-Woodward Medical Research Institute in honor of Hauptman and Helen Woodward Rivas, who helped establish the foundation.



HERBERT A. HAUPTMAN

Fullerton (M.A. '75, Ph.D. '87, human development education) was just five years old when her father received his doctoral degree at Maryland.

"I had a sense of what was happening at the time, but I didn't know the ramifications of what he was doing," Fullerton told *The Washington Post* in 1985.

She recalls her father doing work on the dining room table when she was a child. One day, she tried to play a joke on him by adding a minus sign to one of his formulas. But he knew right away, she said.

Fullerton's generous gift supports *Fearless Ideas: The Campaign for Maryland*, UMD's $1.5 billion fundraising campaign focused on elevating and expanding the university's mission of service, enhancing academic distinction and bolstering UMD's leading-edge research enterprise. Fullerton's gift is the single largest gift ever to the Department of Mathematics.

"It is even more meaningful that Carol and her father are both alumni of this great university," said Wallace D. Loh, UMD's president at the time. "This gift will not only have a positive impact on the Department of Mathematics, but also on the state of Maryland. It will enable us to continue attracting and retaining the best and brightest graduate students in mathematics, which will help our university further drive the economic engine of the state."

Photo of signing by John T. Consoli / Herbert Hauptman photo courtesy of Mike Telesco

Two were elected to the National Academy of Sciences.

- **JAMES FARQUHAR**, geology
- **CHRISTOPHER JARZYNSKI**, chemistry and biochemistry

Farquhar was also elected fellow of the American Geophysical Union. Jarzynski was also awarded Guggenheim and Simons Fellowships.

Six received National Science Foundation Faculty Early Career Development (CAREER) awards.

- **SOHEIL FEIZI**, computer science
- **DAVE LEVIN**, computer science
- **MICHELLE MAZUREK**, computer science
- **MYLES POULIN**, chemistry and biochemistry
- **PRATAP TOKEKAR**, computer science
- **XIAODI WU**, computer science

Four were elected legacy fellows of the American Astronomical Society.

- **DRAKE DEMING**, astronomy
- **GRACE DEMING**, astronomy
- **GERRY SHARE**, astronomy
- **PETER TEUBEN**, astronomy

Two were inducted into the IEEE Visualization Academy.

- **BEN SHNEIDERMAN**, computer science
- **AMITABH VARSHNEY**, computer science

Five made the Web of Science Group's list of Highly Cited Researchers.

- **SANKAR DAS SARMA**, **CHRISTOPHER MONROE**, **IAN SPIELMAN**, physics
- **DENNIS VANENGELSDORP**, entomology
- **CHUNSHENG WANG**, chemistry and biochemistry

DANIEL ABADI, computer science, received a "test of time" award from the Very Large Data Bases (VLDB) Endowment Inc. for a paper he co-authored in 2009.

JACOB BEDROSSIAN, mathematics, received a Simons Fellowship.

ZOHREH DAVOUDI, physics, received a Sloan Research Fellowship.

LAUREN FRANKEL, entomology, received a National Science Foundation Graduate Research Fellowship.

S. JAMES GATES JR., physics, is president-elect of the American Physical Society.

SUVI GEZARI, astronomy, was named Kavli Foundation Plenary Lecturer at 235th American Astronomical Society Meeting.

ALEXEY GORSHKOV, physics, received a Presidential Early Career Award for Scientists and Engineers.

MOHAMMAD T. HAJIAGHAYI, computer science, was elected fellow of the IEEE and the European Association for Theoretical Computer Science. He also won a Guggenheim Fellowship.

EUGENIA KALNAY, atmospheric and oceanic science, received the American Geophysical Union's Roger Revelle Medal.

A. JAY KAUFMAN, geology, received a Fulbright Foundation Global Scholar Award.

LEONID KORALOV, mathematics, received a Simons Fellowship.

DAVE LEVIN, computer science, received an Undergraduate Research Mentoring Award from the National Center for Women & Information Technology.

DINESH MANOCHA, computer science, received the Pierre Bézier Award from the Solid Modeling Association.

RABI MOHAPATRA, physics, published a paper named one of the three most influential titles in the first 50 years of *Physical Review D*.

LAURENT MONTÉSI, geology, was appointed editor-in-chief of the journal *JGR-Planets*.

AMY MULLIN, chemistry and biochemistry, was elected fellow of The Optical Society. She is also serving as chair-elect of the American Physical Society's Division of Chemical Physics.

MAILE NEEL, entomology, received the Society for Conservation Biology's Edward T. LaRoe III Memorial Award.

CATHERINE PLAISANT, UMIACS, received the Association for Computing Machinery Special Interest Group on Computer Human Interaction's Lifetime Service Award.

MIHAI POP, computer science, was named fellow of the Association for Computing Machinery.

KAREN RENNICH, entomology, received the Eastern Apicultural Society of North America's Roger A. Morse Award.

EFRAIN RODRIGUEZ, chemistry and biochemistry, received the 2019 Etter Early Career Award from the American Crystallographic Association.

PETER SHAWHAN, physics, was elected fellow of the American Physical Society.

ARAVIND SRINIVASAN, computer science, was elected fellow of the American Mathematical Society, fellow of the Society for Industrial and Applied Mathematics, and member of Academia Europaea.

RAYMOND ST. LEGER, entomology, was elected fellow of the Entomological Society of America. He also shared the American Association for the Advancement of Science's Newcomb Cleveland Prize for the most impactful paper published in the journal *Science* during the previous year.

RICHARD WALKER, geology, received the American Geophysical Union's Hess Medal.

LAI-XI WANG, chemistry and biochemistry, was elected fellow of the American Chemical Society.

ELLEN WILLIAMS, physics, was elected fellow of the American Association for the Advancement of Science.

WENLU ZHU, geology, was awarded the European Geosciences Union's Louis Néel Medal.

Fourteen received National Science Foundation Graduate Research Fellowships.

- **MAKANA CASTILLO-MARTIN**, **JASON FAN**, **NICHOLAS FRANZESE**, **LILLIAN HUANG**, computer science graduate students
- **MAX FERLAUTO**, **KATIE REDING**, entomology graduate students
- **ANNA GRAFOV**, **NICHOLAS PONIATOWSKI**, **MARK ZIC**, physics majors
- **CALEB HARADA**, astronomy and physics major
- **MICHAEL NASTAC**, physics and mathematics major
- **WILLIAM NGUYEN**, geology major
- **CAITLYN SINGAM**, biological sciences major
- **TANAY WAKHARE**, mathematics and computer science major

Wakhare also received a Winston Churchill Scholarship. Nastac also received a National Defense Science and Engineering Graduate Fellowship, Department of Energy Computational Science Graduate Fellowship, and a Clarendon Scholarship from the University of Oxford. Ferlauto was also named a Smithsonian Institute Fellow and received a Joan Mosenthal DeWind Award from the Xerces Society.

Four were named Goldwater Scholars.

- **JESSE MATTHEWS**, mathematics and chemical engineering major
- **SCOTT MOROCH**, physics major
- **SEUNGTAEK DANIEL OH**, biological sciences major
- **PAVAN RAVINDRA**, biochemistry and computer science major

Five were named NOAA Hollings Scholars.

- **JOHN CAHILL**, atmospheric and oceanic science major
- **CIARA DONEGAN**, atmospheric and oceanic science major
- **MAYA FIELDS**, atmospheric and oceanic science major
- **CLAIRISSE REIHER**, atmospheric and oceanic science major
- **SAM VARGA**, atmospheric and oceanic science major

Three were named Fulbright Scholars.

- **ANNA GRAFOV**, physics major
- **KRITHIKA RAMANATHAN**, computer science major
- **EDWIN ZHANG**, biological sciences major

Three were selected for funding by the Department of Energy's Office of Science Graduate Student Research program.

- **JOHN COLLINI**, physics graduate student
- **KRISTI ENGEL** (B.S. '13, physics; B.S. '13, astronomy; M.S. '19, physics), physics graduate student
- **ELI MIZRACHI**, physics graduate student

HARRY ARNOLD, physics graduate student, received a 2019 Future Investigators in NASA Earth and Space Science and Technology award.

MIA BENNETT, computer science major, received a U.S. Department of State Foreign Affairs Information Technology Fellowship.

KIANTÉ BRANTLEY, computer science graduate student, received a Microsoft Research Ph.D. Fellowship.

MAÏGANE DIOP, biological sciences major, was a Rhodes Scholarship finalist.

ADITI DUBEY, entomology graduate student, was awarded an Ecological Society of America's Science Policy Fellowship.

ALIREZA FARHADI, computer science graduate student, received a Facebook Fellowship.

STEPHANIE GNEWUCH, chemistry graduate student, received an American Crystallography Association Pauling Poster Prize.

COURTNEY GRIMES, chemistry graduate student, received a National Organization for the Professional Advancement of Black Chemists and Chemical Engineers Travel Award.

ALEX HANSON, computer science graduate student, received a Department of Defense National Defense Science and Engineering Graduate Fellowship.

KAYLEIGH HARVEY, geology graduate student, received the GeoPRISMS American Geophysical Union (AGU) Student Prize for best poster presentation at an AGU meeting.

QUANCHENG HUANG, geology graduate student, received an Outstanding Student Presentation Award by the American Geophysical Union (AGU) for a presentation at the AGU Fall Meeting.

JIE LI, chemistry graduate student, received the Washington Chromatography Discussion Group Guiochon Student Award and COSMOS Club Foundation Fellowship Award.

GUSSIE MACCRACKEN, entomology graduate student, received an NSF Postdoctoral Research Fellowship in Biology.

MAYDA NATHAN, entomology graduate student, received the Ecological Society of America's Katherine S. McCarter Graduate Student Policy Award.

ELIZABETH PAUL, physics graduate student, was selected as a Presidential Postdoctoral Research Fellow at Princeton University.

MARY PITMAN, chemistry graduate student, received the NIH Center for Cancer Research/National Cancer Institute Outstanding Ph.D. Student Award.

ERIKA PORTERO, chemistry graduate student, received a Tomas Hirschfeld Scholar Award for the SciX conference and an American Society for Mass Spectrometry Travel Award.

EDDIE SCHOUTE, computer science graduate student, received an IBM Ph.D. Fellowship.

Three received National Science Foundation Graduate Research Fellowships.

- **LILY DURKEE** (B.S. '18, biological sciences)
- **DEIAA HARRAZ** (B.S. '18, chemistry; B.S. '18, chemical engineering)
- **JOHN MARTYN** (B.S. '19, physics)

ANDREA BELZ (B.S. '93, physics) now serves as director of the National Science Foundation's Industrial Innovation and Partnerships Division.

DAMIAN BLAZY (B.S. '02, physics) is a principal in the Los Angeles office of OpenGate Capital.

MICHAEL BOGDAN (B.S. '93, chemistry; B.S. '93, zoology) was elected vice president of the Aesthetic Surgery Education and Research Foundation.

ELISE CAWLEY (B.S. '85, mathematics) joined the Fannie and John Hertz Foundation's board of directors.

JAMIE RAPPAPORT CLARK (M.S. '83, marine estuarine environmental sciences), Defenders of Wildlife president and CEO, received the San Diego Zoo Global Conservation Medal for Lifetime Achievement.

JENNIFER COTTING (M.S. '00, conservation) is now director of UMD's Environmental Finance Center.

JOEL DAHLIN (Ph.D. '15, physics), a postdoctoral fellow at NASA's Goddard Space Flight Center, was awarded the Ronald C. Davidson Award for Plasma Physics from AIP Publishing.

JUDITH DOTSON (B.S. '85, computer science), an executive vice president at Booz Allen Hamilton, now leads the company's national security business.

ZACHARY ELDREDGE (Ph.D. '19, physics) received an Oak Ridge Institute for Science and Education Fellowship.

BRAD ETTINGER (B.S. '84, biochemistry; B.S. '87, chemical engineering) was named vice president of marketing communications for the International Society for Pharmaceutical Engineering.

ALEXEI FEDOTOV (Ph.D. '97, physics) received the Science & Technology Award from Brookhaven National Lab.

GARY GAROFALO (B.S. '83, computer science) is chief operating officer at Public Consulting Group, Inc.

CARMALA GARZIONE (B.S. '84, geology) is now associate provost for faculty affairs at the Rochester Institute of Technology.

RYAN GOTT (Ph.D. '16, entomology) received an Ecological Society of America Science Policy Fellowship. He works at the Phipps Conservatory.

TERI QUINN GRAY (Ph.D. '94, chemistry) joined the Zip Code Wilmington board. She is a global integration leader at DuPont.

SUSAN GREGURICK (Ph.D. '95, chemistry) is associate director of data science at the National Institutes of Health.

DAVID GWYN (B.S. '89, computer science) was promoted to worldwide sales chief operating officer at the enterprise cloud computing company Nutanix.

SALMAN HABIB (M.S. '85, Ph.D. '88, physics), who works at the U.S. Department of Energy's Argonne National Laboratory, was named an Argonne Distinguished Fellow.

MARK HARLEY (B.S. '07, physics) joined the faculty of Watchung Hills Regional High School in Warren, N.J., as a physics teacher.

JORDAN HOROWITZ (Ph.D. '10, physics) won the Irwin Oppenheim Award from the American Physical Society. He is on the faculty at the University of Michigan.

PHILIP ISETT (B.S. '08, mathematics; B.A. '08, economics), faculty member at Caltech, received the Clay Research Award from the Clay Mathematics Institute.

RUTH KASTNER (B.S. '82, M.S. '92, physics) published "Adventures in Quantumland."

NIPUN KOTTAGE (B.S. '19, biochemistry; B.S. '19, anthropology) was a Rhodes Scholarship finalist.

JAMES LAVINE (Ph.D. '71, physics) published "Time-Dependent Quantum Mechanics of Two-Level Systems."

XIAOMING LIU (M.S. '09, Ph.D. '13, geology), an assistant professor at the University of North Carolina, received a National Science Foundation Faculty Early Career Development (CAREER) award.

BRIAN LOVETT (Ph.D. '19, entomology) shared the American Association for the Advancement of Science's Newcomb Cleveland Prize for the most impactful paper published in the journal *Science* during the previous year.

MAULIK MAJMUDAR (B.S. '99, biochemistry) is Amazon's chief medical officer.

TOBIN MARKS (B.S. '66, chemistry) was elected to the European Academy of Sciences. He is on the faculty at Northwestern University.

THOMAS MASON (B.S. '89, physics) and **WILLIE MAY** (Ph.D. '77, chemistry) were elected fellows of the American Association for the Advancement of Science. Mason is on the faculty at UCLA. May is Morgan State University's vice president of research.

JOHN DIRK NIES (Ph.D. '78, chemistry) authored "Floriescence: Foundations for Human Flourishing on a Thriving Planet."

RICHARD PALCZYNSKI (M.S. '71, mathematics) joined the advisory board for Care Bridge International. He is founder and president of SeaTower Insurance Consulting Services, LLC.

MICHAEL PALMER (B.S. '87, computer science) joined the board of directors at Newtopia. He is CEO of Exhale Advisors.

ALUMNI HIGHLIGHTS

MERDAD PARSEY (B.S. '85, biochemistry) is chief medical officer at Gilead Sciences.

ANA MARIA REY (Ph.D. '04, physics) was named Blavatnik National Laureate in Physical Sciences & Engineering. She is on the faculty at the University of Colorado Boulder.

SARAH RICHARDSON (B.S. '04, biological sciences) received the Next Generation Award from the Association for Women in Science. She is CEO of MicroByre.

GARETH ROBERG-CLARK (Ph.D. '19, physics) received a National Energy Research Scientific Computing Center Early Career HPC Achievement Award.

SLAWA ROKICKI (B.S. '05, mathematics) joined the Rutgers School of Public Health as an instructor in the Department of Health Behavior, Society, and Policy.

KELLY SEIDL (B.S. '10, computer science) is chief technology officer of BillGO.

MICHAEL SEVERINO (B.S. '87, biochemistry) was appointed to the Avantor, Inc. board of directors. He is vice chairman and president of the biopharmaceutical company AbbVie Inc.

FORREST SHULL (M.S. '96, Ph.D. '98, computer science), who works in Carnegie Mellon University's Software Engineering Institute, is IEEE Computer Society 2020 president-elect.

LUCIA SIMONELLI (Ph.D. '16, applied mathematics and statistics, and scientific computation) received an American Mathematical Society Congressional Fellowship.

EMILY WEINERT (Ph.D. '06, chemistry) joined the faculty of Penn State's Department of Biochemistry and Molecular Biology.

TONGHAI YANG (Ph.D. '95, mathematics) was elected fellow of the American Mathematical Society. He is on the faculty at the University of Wisconsin.

IN MEMORIAM

CARLOS BERENSTEIN, mathematics, died Aug. 24, 2019. He came to UMD in 1973 and retired in 2009.

JANET DAS SARMA, physics, died Dec. 2, 2019. She managed the Condensed Matter Theory Center for the last decade.

TODD DRUMM (Ph.D. '90, mathematics) died Mar. 27, 2020. He was an associate professor at Howard University.

LEONA DUNKLEE, physics, died Mar. 18, 2019. She was an account clerk who was active in planning departmental events.

DAVID FALK, physics, died June 10, 2020. In addition to his department service, he also served as assistant vice provost from 1981 until he retired in 1992.

WILLIAM FISHBEIN (Ph.D. '66, biochemistry), died Mar. 6, 2020. He retired as chief of biochemistry at the Armed Forces Institute of Pathology in 2004.

DAVID FREEMAN, chemistry and biochemistry, died Oct. 28, 2019. He was on the UMD faculty for 25 years.

HANS GRIEM, physics, died Oct. 2, 2019. A noted expert in high-temperature plasmas and spectroscopy, he served on the UMD faculty from 1957 to 1994.

JAMES HUHEEY, chemistry and biochemistry, died Feb. 4, 2020. He joined the UMD faculty in 1965 and retired in 1995.

UDAYADITYA KONWAR, physics major, died July 29, 2019.

ROBERT PARK, physics, died Apr. 29, 2020. He joined UMD in 1974 and served as chair of the Department of Physics and Astronomy from 1978-82, retiring in 2008.

WILLIAM PURDEY, chemistry and biochemistry, died Oct. 30, 2019. He was on the UMD faculty from 1958 to 1976.

GREGORY RUCHTI (B.S. '03, physics and astronomy) died May 13, 2019. He was a data scientist at Veracity Forecasting and Analysis in Alexandria, Va.

LAWRENCE SCHMID, physics, died Nov. 4, 2019. He was a visiting research scientist at UMD and a theoretical physicist who worked for NASA.

AKASH JANI SHAH, biological sciences major, died Mar. 16, 2020. He was awarded a posthumous degree during the May 2020 Commencement.

JOSEPH SUCHER, physics, died Oct. 18, 2019. A faculty member in the department for 41 years, he was a Distinguished Scholar-Teacher and the poet laureate of the department.

ALFRED VIOLA (Ph.D. '55, chemistry) died May 15, 2020, from complications related to COVID-19. He was an emeritus professor at Northeastern University, where he taught organic chemistry for 41 years.

PETER WALPOLE, physics, died Nov. 5, 2019. He worked on the Cosmic Ray Energetics and Mass (CREAM) and Boron And Carbon Cosmic rays in the Upper Stratosphere (BACCUS) experiments.

LINCOLN WATKINS (B.S. '51, physics) died Mar. 6, 2020. He designed hovering missile compensation systems for submarines at Electric Boat until he retired in 1992.

LEEPO YU (Ph.D. '69, physics), died Apr. 28, 2020. She worked 36 years for NIH's National Institute of Arthritis and Musculoskeletal and Skin Diseases before retiring in 2009.

MARY ZIPF (Ph.D. '73, microbiology) died Aug. 11, 2019. She taught biology for 50 years at the College of Mount St. Vincent in the Bronx.

ALUMNI NOTES ARE WELCOME. Please send them to Odyssey, CMNS Dean's Office, University of Maryland, 2300 Symons Hall, College Park, MD 20742. Email information to abbyr@umd.edu.

COLLEGE OF
COMPUTER, MATHEMATICAL,
& NATURAL SCIENCES

University of Maryland
2300 Symons Hall
7998 Regents Drive
College Park, MD 20742-5520

Nobel laureate Herbert Hauptman (Ph.D. '55, mathematics) forever changed the field of X-ray crystallography.

Now, an estate gift to establish the ***Herbert A. Hauptman Endowed Graduate Fellowship Program*** will leave an indelible mark on UMD's Department of Mathematics in perpetuity.

To discuss how you can support Fearless Science Terps while creating your legacy, contact Megan Carnell at 301-405-0205 or mcarnell@umd.edu or call the Office of Gift Planning at 1-866-646-4UMD.

To read about the planned gift that honors Herbert Hauptman, see p. 39.

Photo by John T. Consoli