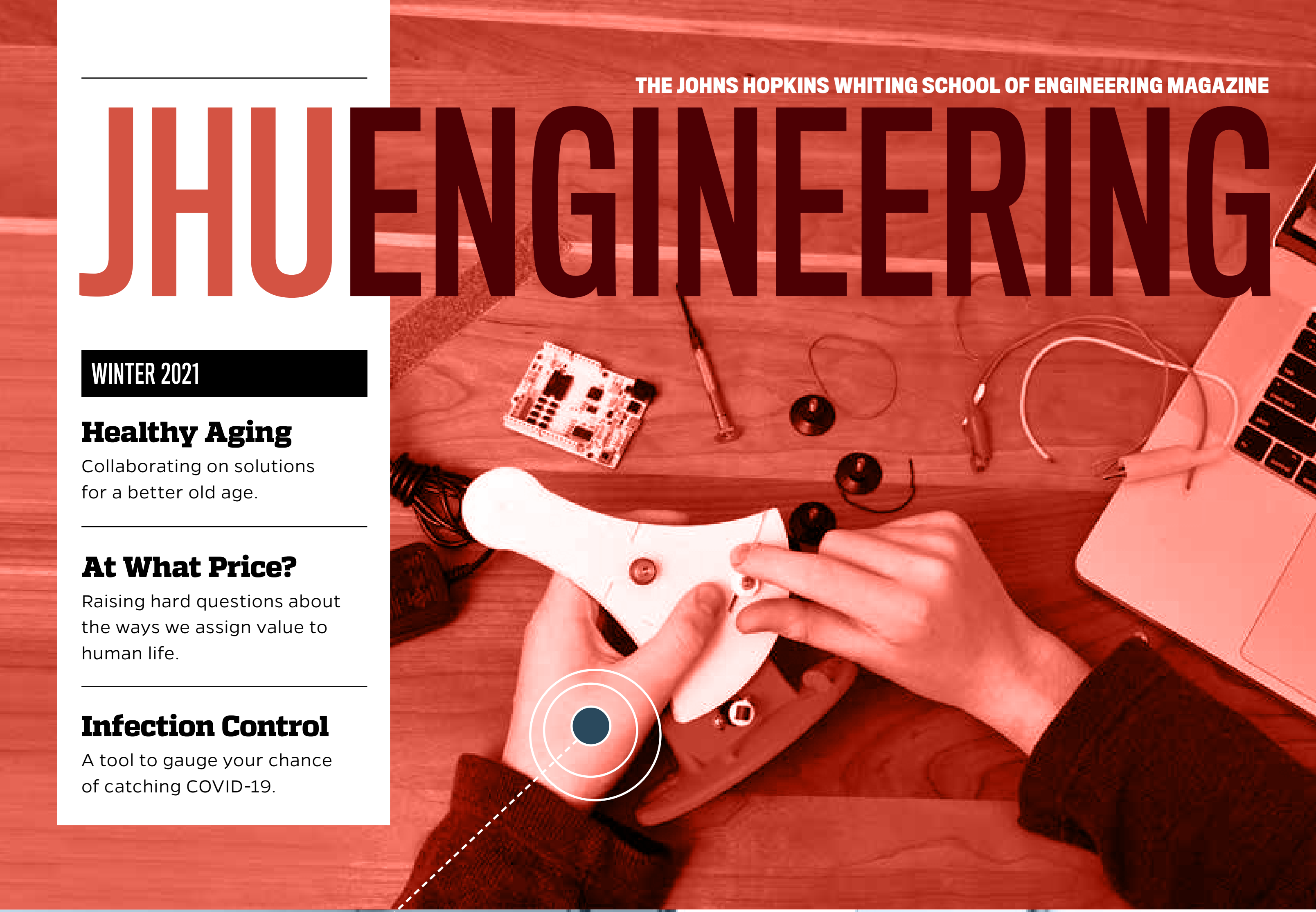
THE JOHNS HOPKINS WHITING SCHOOL OF ENGINEERING MAGAZINE

JHU ENGINEERING



WINTER 2021

Healthy Aging

Collaborating on solutions for a better old age.

At What Price?

Raising hard questions about the ways we assign value to human life.

Infection Control

A tool to gauge your chance of catching COVID-19.

'A Real Adventure'

Flexibility is key to teaching and learning in the age of COVID-19.

FROM THE DEAN

Dear Whiting School Community,

WHILE WE CONTINUE TO WORK THROUGH THE IMPACTS OF COVID-19 ON THE UNIVERSITY—as well as on our lives—a comforting sense of business-as-usual began to take hold as the fall term progressed. In academics, our attention turned from focusing on the logistics of online teaching and learning to digging into course content. Annual events were held and traditions observed, but in new formats. And while our faculty members forge ahead on investigations related to the COVID-19 pandemic, they also continue to pursue new research projects in a wide variety of areas.

Among the most exciting of these new research pursuits is the Johns Hopkins Engineering Aging Alliance, an effort based at the Johns Hopkins Bayview Medical Campus that brings together faculty members and students from across Johns Hopkins to collaborate on projects aimed at improving the health and well-being of our growing aging population. Multiple faculty members and many students at the Whiting School will be involved in the project (see p. 24), underscoring the critical role that engineering is playing in solving many of today's most urgent and inherently complex problems in human health.

Another recent accomplishment I wanted to share is that we have completed the assessment phase of the Excellence in Academic Advising Initiative, defining our top goals, and we now are working on the implementation plan. Revising the structure and delivery of academic advising, providing enhanced training and professional development for advisers, and optimizing the technology tools and systems that support advising are among the efforts defined to provide students with greater support as they pursue their academic goals.

In closing, I want to thank the many of you who stepped up to help support COVID-19 research at the Whiting School. Your generosity during this difficult time is making an impact—fueling advances that are making a real and immediate difference.

Wishing you health and happiness,

ED SCHLESINGER
Benjamin T. Rome Dean

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A GOLDEN AGE (P. 24)

Gash is a conceptual illustrator working for editorial, book, and corporate clients, including *The New Yorker*, MasterCard, *The New York Times*, the United Nations, and *The Wall Street Journal*.

JOAN KATHERINE CRAMER

AT WHAT PRICE? (P. 28)

Cramer, who lives and works in California, is a feature writer and book critic whose articles have appeared in *The New York Times Book Review, Salon.com*, and the *San Francisco Chronicle*, among other publications.

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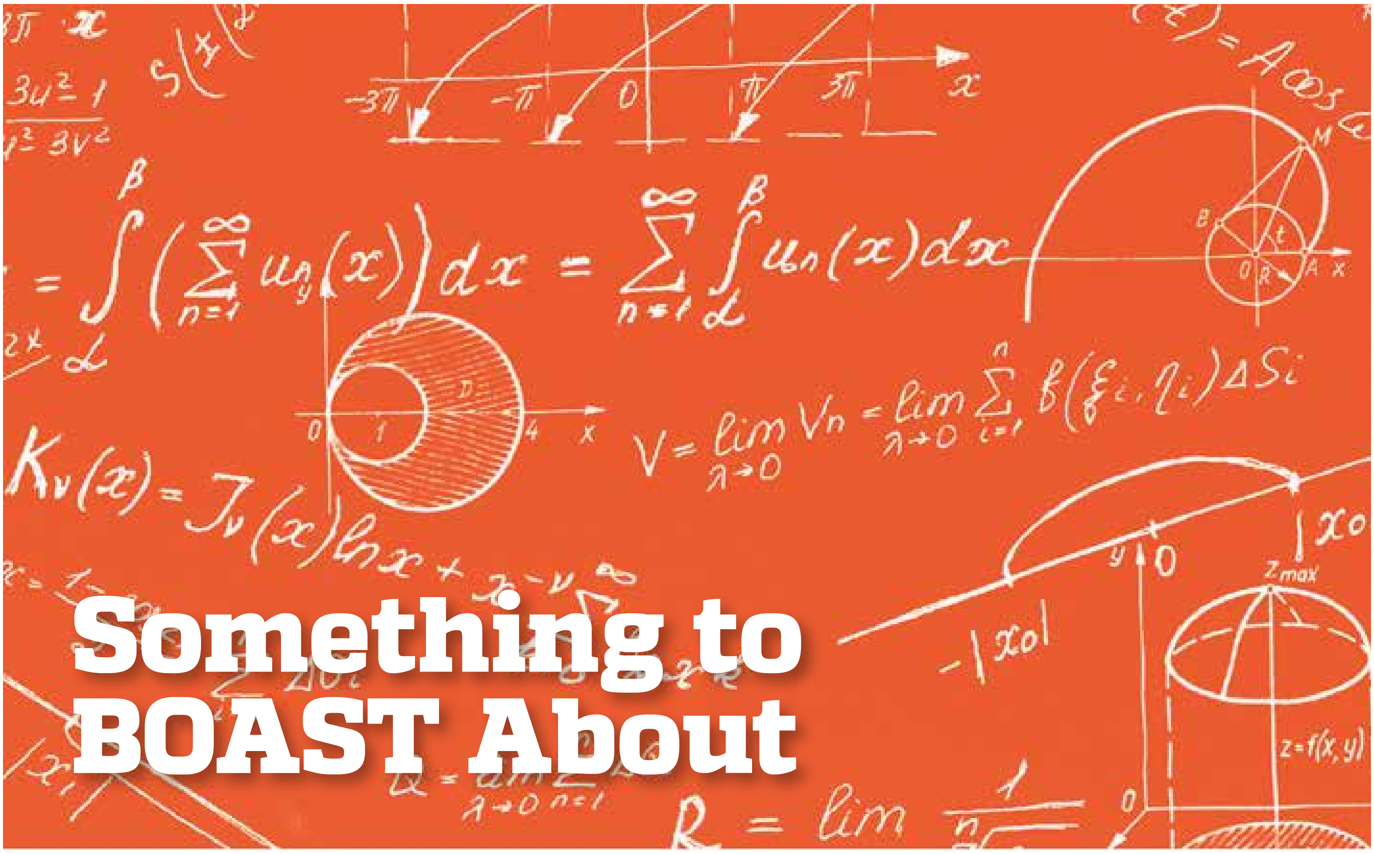
CONTENTS

All COVID-19 safety precautions recommended by the Centers for Disease Control and Prevention were followed in the creation of content for this issue of *JHU Engineering* magazine.



Something to BOAST About

ALGEBRA IS CONSIDERED THE GATEWAY TO ADVANCED MATH classes and also has been shown to correlate with the likelihood of students' pursuing continued education and careers in STEM (science, technology, engineering, and mathematics) subjects.

To help strengthen high school students' confidence and skills in algebra, Johns Hopkins' schools of Engineering and Education are partnering with Notre Dame of Maryland University, Morgan State University, and Baltimore City Public Schools on a new initiative: the Baltimore Online Algebra for Students in Technology program, which is being supported through a $2.36 million grant from the National Science Foundation. Launching in fall 2021, BOAST will combine online lessons, hands-on projects, and activities.

"The goals of the program are to help students to develop an abiding interest in engineering and to support these students in building confidence in their mathematical capacities," says Michael Falk, BOAST's principal investigator and vice dean for undergraduate education at the Whiting School.

Another important aspect of BOAST is the program's focus on diversity, including that of its instructors and staff.

"Research studies have revealed the importance of students having same-race teachers, mentors, and role models," says Christine Newman, assistant dean of engineering educational outreach at the Whiting School and co-principal investigator.

Other BOAST partners include the Johns Hopkins University Applied Physics Laboratory, Building STEPS, Northrop Grumman, and Expanded School Behavioral Health Services.

— AMY WELDON

"The goals of the program are to help students to develop an abiding interest in engineering and to support these students in building confidence in their mathematical capacities."

— MICHAEL FALK

OPPOSITE PAGE (UPPER RIGHT): ED WHITMAN/JOHNS HOPKINS APPLIED PHYSICS LABORATORY.

TELL US WHAT YOU THINK!

Continue the conversation online, using **#JHUEngineering** on Facebook and Twitter!

Data Democratizer

Lauren Gardner, the developer of the COVID-19 Dashboard, which has come to define the public's understanding of the global scale and impact of COVID-19, was named one of the 100 most influential people in the world by *Time*, which also named JHU's COVID-19 Resource Center a 2020 Best Invention.

According to *Time*, when she and her graduate student Ensheng Dong saw a lack of reliable data tracking around the novel coronavirus, they decided to develop a real-time dashboard themselves—in one day.

The map created by Gardner and her team is used by governments, media, researchers, and the public, and, when it launched in January 2020, quickly became the go-to resource for people the world over.

"Dr. Gardner's work exemplifies the ethos of Johns Hopkins: entrepreneurial, pioneering, interdisciplinary research that improves and advances the human condition," said Johns Hopkins University President Ronald J. Daniels, in his congratulations to Gardner for receiving the honor.

Leana Wen, former Baltimore health commissioner and an expert in pandemic preparedness and response, who wrote Gardner's citation in *Time*, stated, "In the face of an existential threat, Lauren took action. She didn't wait for others—she stepped up first. She democratized data and filled a void of public-health leadership. Lives will be saved because of her proactive work."

Lauren Gardner, addressing congressional staffers and reporters

An Online Master's in Artificial Intelligence

THE WHITING SCHOOL'S ENGINEERING FOR PROFESSIONALS PROGRAMS HAS LAUNCHED A FULLY ONLINE MASTER'S DEGREE PROGRAM IN ARTIFICIAL INTELLIGENCE, one of only a few such programs of its kind in the country.

The curriculum, designed to provide practicing scientists and engineers with AI-specific skills that can be applied in health care, manufacturing, government, and other sectors, covers applications in natural language processing, robotics, neural networks, computer intelligence, and expert systems.

John Piorkowski, the program chair and a chief AI architect at the Johns Hopkins University Applied Physics Laboratory, told *The Wall Street Journal*: "I don't think there is a field not impacted by [AI]. Whatever the new normal looks like after COVID, there is going to be more automation." Ten courses are required to complete the master's degree program; a certificate can be earned by completing four courses.

Making Online Learning More Accessible

HIGHER EDUCATION INSTRUCTORS AROUND THE WORLD NOW HAVE free access to a course that—fittingly enough—teaches them how to create accessible course work for remote learning.

The Coursera course, Inclusive Online Teaching, is the product of a partnership between the Johns Hopkins University Applied Physics Laboratory and the Whiting School's Engineering for Professionals programs. It is designed by Paul Huckett, the Whiting School's assistant dean of learning design and innovation, and Brian Klaas, an instructor in the Bloomberg School of Public Health.

Inclusive Online Teaching provides structural and technological advice to help faculty members create an online teaching environment that overcomes students' barriers to learning, such as unconscious bias, lack of motivation, and learning styles that conflict with an all-digital environment.

According to Huckett, incorporating inclusive teaching practices into the classroom benefits all students. "If you follow these practices," he says, "you make learning better for everyone. If we think about our courses in the basis of design, then accessibility isn't something retroactive; it becomes an integral part of the way that we teach."

— **JACOB DENOBEL**

> "If you follow these practices, you make learning better for everyone. If we think about our courses in the basis of design, then accessibility isn't something retroactive; it becomes an integral part of the way that we teach."
>
> **— PAUL HUCKETT**

OPPOSITE PAGE (FACULTY AWARDS TOP TO BOTTOM) COURTESY OF YUN CHEN, WILL KIRK/HOMEWOODPHOTO.JHU.EDU; ('OF TWO MINDS' TOP TO BOTTOM) WILL KIRK/HOMEWOODPHOTO.JHU.EDU, GINA WADAS.

TELL US WHAT YOU THINK!

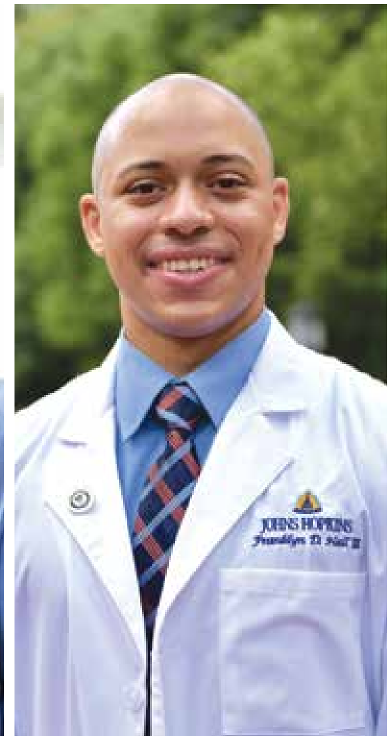
Continue the conversation online, using **#JHUEngineering** on Facebook and Twitter!

FACULTY AWARDS

YUN CHEN, assistant professor in the Department of Mechanical Engineering, received the National Institutes of Health's Trailblazer Award, which recognizes innovative early-career researchers tackling high-risk, potentially high-impact projects. Chen will use the award to develop a tension-sensitive drug release system that targets only diseased cells, a process that promises to enhance the efficacy of treatments for diseases including cancer, kidney disease, and dementia.

RYAN HUANG, assistant professor in the Department of Computer Science, is a recipient of the National Science Foundation's Early CAREER Award, which recognizes early-stage scholars with high levels of promise and excellence. Huang's award will support his project, "Towards Gray-Fault Tolerant Cloud through Harnessing and Enhancing System Observability," which aims to improve the availability of modern cloud system infrastructure.

SHARON GERECHT



FRANKLYN HALL

Of Two Minds

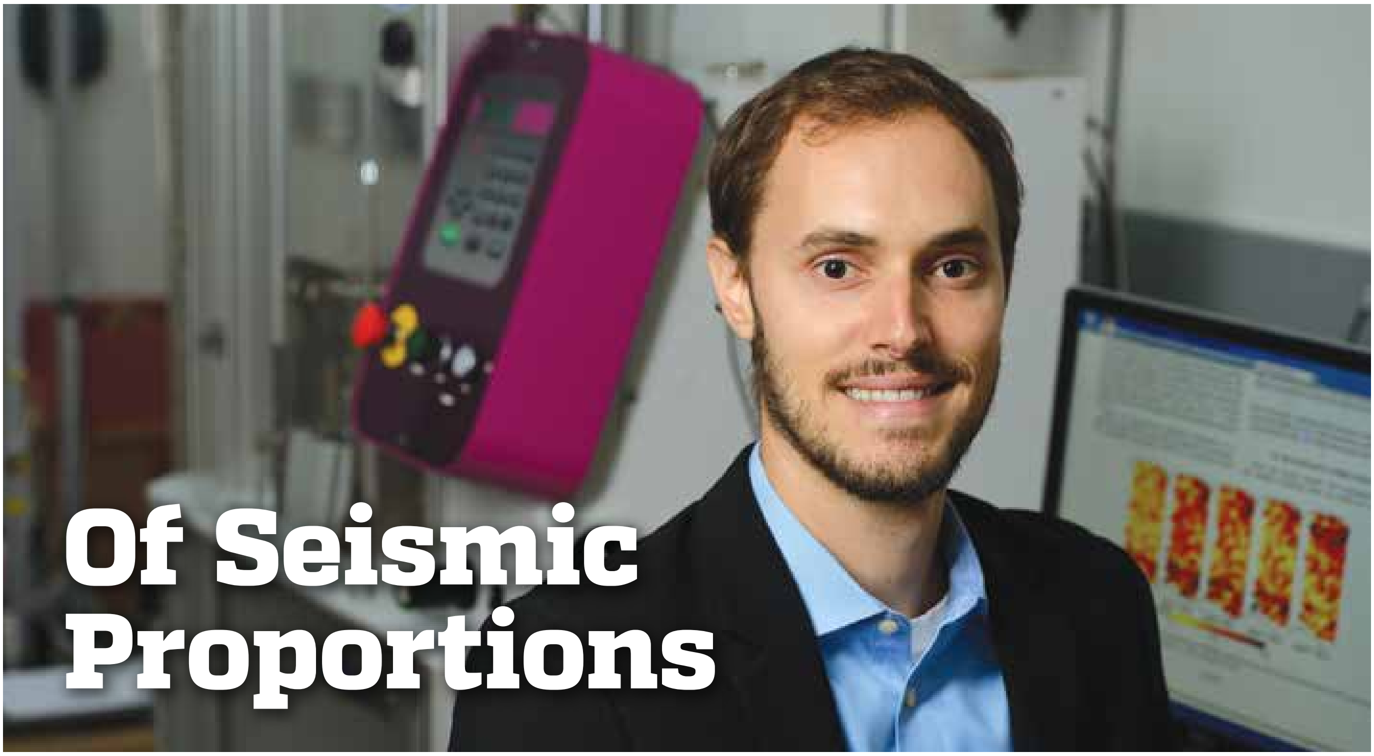
THE HOWARD HUGHES MEDICAL INSTITUTE'S GILLIAM FELLOWSHIPS ARE AWARDED TO STUDENT-MENTOR PAIRS AND RECOGNIZE STUDENTS who have the potential to be leaders in their fields, while also supporting the development of a more inclusive academic scientific ecosystem.

This year, the Whiting School's Sharon Gerecht, the Edward J. Schaefer Professor of Engineering, and her advisee, biomedical engineering doctoral student Franklyn Hall, received this honor.

The award provides each student-mentor pair $50,000 annually for three years. Gerecht, who is also director of the Institute for NanoBioTechnology, will use the funds to create professional development activities and training for students from backgrounds that are traditionally underrepresented in the sciences and for their faculty mentors.

Hall will use the funds to help create in vitro models for patients with the genetic disorder Marfan syndrome. "The fellowship allows me to overcome the limitations of the materials and techniques used in the lab today to pursue challenging scientific questions as I work to complete my thesis," says Hall.

IMPACT



Of Seismic Proportions

Ryan Hurley

UNDERSTANDING THE WAY THAT A WAVE MOVES THROUGH GRANULAR MATERIALS HAS VAST implications for modern science. After all, scientists use such stress wave propagation to detect the magnitude of earthquakes, locate oil and gas reservoirs, design acoustic insulation, and develop materials for compacting powders.

A study by a team that includes Ryan Hurley, an assistant professor of mechanical engineering, offers important insights into the way stress wave propagation unfolds. Using X-ray measurements and analyses, the team has shown that velocity scaling and dispersion in wave transmission is based on particle arrangements and chains of force between them, while reduction of wave intensity is caused mainly from particle arrangements alone.

"Our study provides a better understanding of how the fine-scale structure of a granular material is related to the behavior of waves propagating through them," says Hurley. "This knowledge is of fundamental importance in the study of seismic signals from landslides and earthquakes, in the nondestructive evaluation of soils in civil engineering, and in the fabrication of materials with desired wave properties in materials science."

Hurley conceived of this line of research while a postdoc at Lawrence Livermore National Laboratory, collaborating with a team that included physicist Eric Herbold. The experiments and analysis were later performed by Hurley and Whiting School postdoc Chongpu Zhai after Hurley moved to Johns Hopkins, with experimental assistance and continued discussions with Herbold. Their study appeared recently in the online edition of the journal *Proceedings of the National Academy of Sciences*.

Research from the late 1950s describes what may be happening to material underlying wave propagation, but the new research provides evidence for why.

"The novel experimental aspect of this work is the use of in situ X-ray measurements to obtain packing structure, particle stress, and interparticle forces throughout a granular material during the simultaneous measurement of ultrasound transmission," says Hurley. "These measurements are the highest-fidelity dataset to date investigating ultrasound, forces, and structure in granular materials."

Adds Zhai, the study's lead author: "These experiments, along with the supporting simulations, allow us to reveal why wave speeds in granular materials change as a function of pressure and to quantify the effects of particular particle-scale phenomena on macroscopic wave behavior."

— LISA DENIKE ERCOLANO AND ANNE STARK

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Raimond L. Winslow

The new research indicates that septic shock likely begins much earlier than when the final stage of the deadly condition is currently understood to start.

Earlier Warning for Septic Shock

SEPSIS AND SEPTIC SHOCK ARE THE LEADING CAUSES OF IN-HOSPITAL DEATHS. BUT EARLIER IDENTIFICATION of this deadly condition could soon get easier, thanks to recent findings from a team of Johns Hopkins biomedical engineers.

The researchers have shown that hospitals can more accurately classify patients with sepsis into four distinct categories that prioritize early interventions for those who are closest to the rapid period of septic shock when infection overwhelms the immune systems, leading to organ failure and death.

"We were able to reliably assign patients to these risk categories based on their risk score trajectories," says Ran Liu, a doctoral student in biomedical engineering and lead author for the study. The research, published in the *eLife* online journal, was supervised by Liu's adviser, Raimond L. Winslow, the Raj and Neera Singh Professor of Biomedical Engineering and director of the Institute for Computational Medicine.

The research utilized more than two dozen physiological indicators from more than 200,000 individual admissions at 208 U.S. hospitals. While the discovery of an "algorithmic definition" of septic shock requires more study, the findings will help clarify the current ambiguous guidance in the field, the researchers believe.

The new research indicates that septic shock likely begins much earlier than when the final stage of the deadly condition is currently understood to start.

"The transition from sepsis to pre-septic shock on average occurs on a rapid time scale, with a sharp increase in risk occurring within 30 to 60 minutes immediately preceding time of early warning," the study states.

The quick change is indicated by rapid shifts in blood pressure, lactate levels, and heart rate. With the immune system overwhelmed by infection, the body begins to lose all ability to halt a patient's plummeting trajectory.

The researchers state that they believe septic shock actually begins in that period currently known as "pre-shock."

"When patients enter what we have previously called the pre-shock state, they are in fact in a state of septic shock," the researchers note. Members in the highest risk category "are in a state of septic shock on average 10 hours before they satisfy the current clinical definition of shock."

The team members recommend that more hospitals begin implementing automated early warning technology. Systems capable of assigning distinct risk categories determined by data would provide a "clear and objective definition" of septic shock, they say, and eliminate disagreements among medical staff about onset.

— DOUG DONOVAN

Safer Heart Procedures: Seeing the Light

Muyinatu Bell

AN IMAGING TECHNIQUE THAT USES LIGHT AND SOUND COULD someday replace current methods that require potentially harmful radiation, according to the results of a new study led by Muyinatu Bell, assistant professor of electrical and computer engineering.

The findings detail success in a heart procedure but can potentially be applied to any procedure that uses a catheter, such as in vitro fertilization, or surgeries using the da Vinci robot, where clinicians need a clearer view of large vessels. The research was published in *IEEE Transactions on Medical Imaging*.

"This is the first time anyone has shown that photoacoustic imaging can be performed in a live animal heart with anatomy and size similar to that of humans. The results are highly promising for future iterations of this technology," says Bell, director of the Photoacoustic & Ultrasonic Systems Engineering Lab.

Bell's team of PULSE Lab members and cardiologist collaborators tested the technology during a cardiac intervention in which a long, thin catheter is inserted into a vein or artery, then threaded up to the heart to diagnose and treat various heart diseases, such as abnormal heartbeats.

Currently, providers most commonly use a technique called fluoroscopy, a sort of X-ray movie that requires ionizing radiation, which can be harmful to both the patient and the provider. This technique can only show the shadow of where the catheter tip is and doesn't provide detailed information about depth.

Photoacoustic imaging uses light and sound to produce images. When energy from a pulsed laser lights up an area in the body, that light is absorbed by photoabsorbers within the tissue, such as the protein that carries oxygen in blood (hemoglobin), which results in a small temperature rise. This increase in temperature creates rapid heat expansion, which generates a sound wave. The sound wave can then be received by an ultrasound probe and reconstructed into an image.

Past studies of photoacoustic imaging mostly looked at its use outside of the body, such as for dermatology procedures, and few have tried using such imaging with a laser light placed internally. Bell's team wanted to explore how photoacoustic imaging could be used to reduce radiation exposure by testing a new robotic system to automatically track the photoacoustic signal.

For this study, Bell's team first placed an optical fiber inside a catheter's hollow core, with one end of the fiber connected to a laser to transmit light; this way, the optical fiber's visualization coincided with the visualization of the catheter tip.

Bell's team then performed cardiac catheterization on two pigs under anesthesia and used fluoroscopy initially to map the catheter's path on its way to the heart. The researchers also successfully used robotic technology to hold the

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"This is the first time anyone has shown that photoacoustic imaging can be performed in a live animal heart with anatomy and size similar to that of humans. The results are highly promising for future iterations of this technology."

— MUYINATU BELL

ultrasound probe and maintain constant visualization of the photoacoustic signal, receiving image feedback every few millimeters.

Finally, the team looked at the pig's cardiac tissue after the procedures and found no laser-related damage. While the researchers need to perform more experiments to determine whether the robotic photoacoustic imaging system can be miniaturized and used to navigate more complicated pathways, as well as perform clinical trials to definitively prove safety, they say these findings are a promising step forward.

"We envision that ultimately, this technology will be a complete system that serves the fourfold purpose of guiding cardiologists toward the heart, determining their precise locations within the body, confirming contact of catheter tips with heart tissue, and concluding whether damaged hearts have been repaired during cardiac radiofrequency ablation procedures," says Bell.

— **CHANAPA TANTIBANCHACHAI**

3 Questions

Interview by Doug Donovan

Approximately 8% of Americans, most of them children, suffer from rare diseases, with many of these conditions having a genetic cause. In more than half of those cases, the genetic roots of these maladies are not clear. In addition, many more Americans are living with more subtle, genetically influenced health ailments that are not understood—in part because standard practices for collecting patient samples don't capture the impact of more genetic variants.

Alexis Battle, associate professor of biomedical engineering, and her team have developed software that, if paired with expanded sample collection practices, could help identify more causes of genetic disorders.

1 Why is this work important?

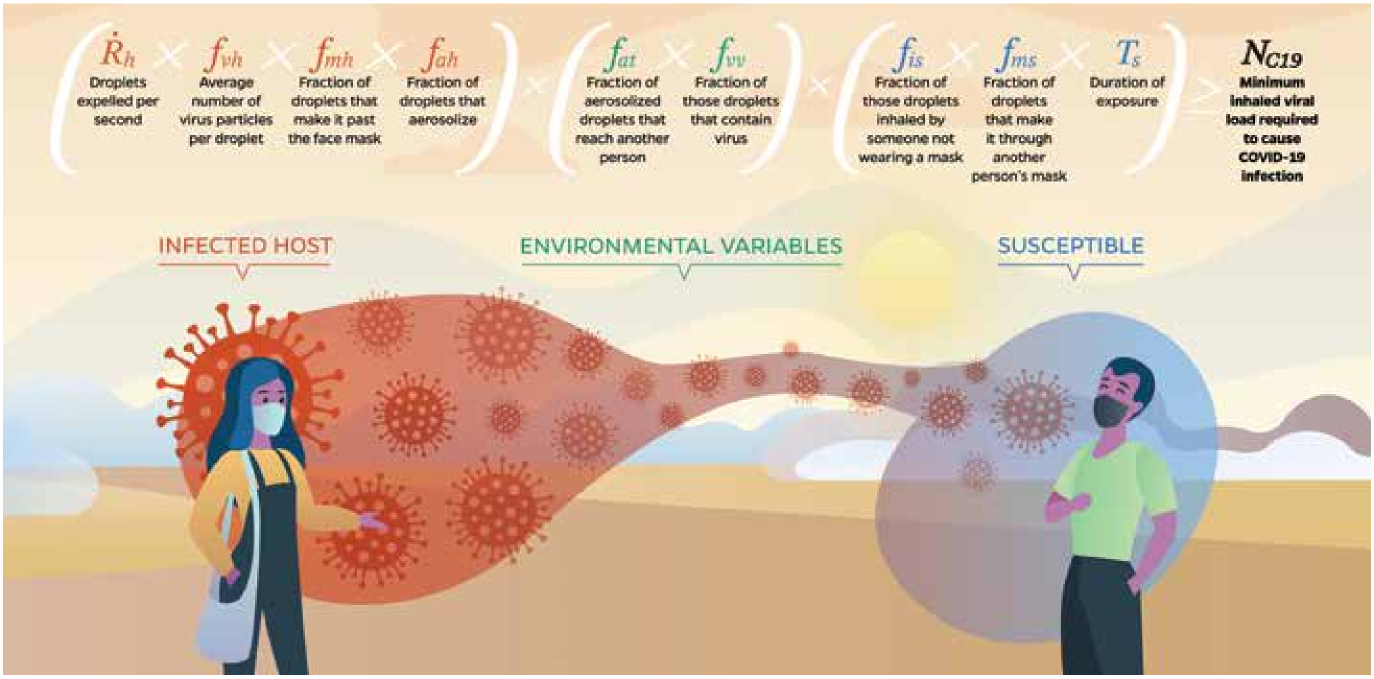
We really don't know how many people are out there walking around with a genetic aberration that is causing them health issues. They go completely undiagnosed, meaning we cannot find the genetic cause of their problems. Everyone has around 50,000 variants that are rare in the population, and we have absolutely no idea what most of [those variants] are doing. If you collect gene expression data, which shows which proteins are being produced in a patient's cells at what levels, we're going to be able to identify what's going on at a much higher rate.

2 How does your software tackle this challenge?

Our computational system, called Watershed, scours reams of genetic data along with gene expression to predict the functions of variants from individuals' genomes. We validated these predictions experimentally and applied the findings in order to assess the rare variants captured in massive genetic studies, such as the UK Biobank, the Million Veteran Program, and the Jackson Heart Study. What we found has helped reveal which rare variants may be having an impact. Our results were published in *Science* in September and are part of the National Institutes of Health's Genotype-Tissue Expression project.

3 Does this work advance the field of personal genomics?

Yes, I think that's fair to say. Characterizing rare variants that occur in the noncoding parts of the genome that currently are not evaluated represents an important advance in the field of personal genomics, which focuses on the sequencing and analysis of individuals' genomes. Any improvement we can make in this area has implications for public health; even pointing to what the genetic cause of an illness is gives parents and patients a huge sense of relief and understanding, and can point to possible therapeutics.



Formulating Your Chances of Catching COVID-19

IN 1961, ASTRONOMER FRANK DRAKE DEVELOPED A SIMPLE EQUATION—CONSISTING OF ONLY SEVEN variables—to estimate the probability of finding extraterrestrial civilizations in the Milky Way. Today, inspired by the Drake equation, fluid mechanics experts at the Whiting School of Engineering have developed a formula to answer the question of the moment: What determines someone's chances of catching COVID-19?

In a paper published in *Physics of Fluids*, the researchers present a mathematical model to estimate the risk of airborne transmission of COVID-19. Insights from this new model could help assess how well preventive efforts, like mask wearing and social distancing, are protecting us in different transmission scenarios.

"There's still much confusion about the transmission pathways of COVID-19. This is partly because there is no common 'language' that makes it easy to understand the risk factors involved," says Rajat Mittal, coauthor of the paper and a professor in the Department of Mechanical Engineering.

"What really needs to happen for one to get infected? If we can visualize this process more clearly and in a quantitative manner, we can make better decisions about which activities to resume and which to avoid."

What's becoming clear is that COVID-19 is most commonly spread from person to person through the air, via small respiratory droplets generated by coughing, sneezing, talking, or breathing, according to a commentary published by 239 scientists in *Clinical Infectious Diseases*.

But the risk of getting infected with COVID-19 depends heavily on the circumstances, Mittal says. The team's model considers 10 transmission variables, including the breathing rates of the infected and noninfected persons, the number of virus-carrying droplets expelled, the surrounding environment, and the exposure time. Multiplied together, these variables yield a calculation of the possibility that an individual will be infected with COVID-19.

The proposed formula is called the Contagion Airborne Transmission inequality.

"The CAT inequality is particularly useful because it translates the complex fluid dynamical transport process into a string of simple terms that is easy to understand," says Charles Meneveau, the Louis M. Sardella Professor of Mechanical Engineering and coauthor of the study. "As we've seen, communicating science clearly is of paramount importance in public health and environmental crises like the one we are facing now."

The team adds that the model can be useful to quantify the value of mask wearing and social distancing. If both people are wearing N95 masks, the risk of transmission is reduced by a factor of 400—that's less than a 1% chance of getting the virus. But even a simple cloth mask will significantly reduce transmission probability, according to the model. The team also found that social distancing has a linear correlation to risk; if you double the distance, you double the protection factor, or reduce your risk by half.

— CATHERINE GRAHAM

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- **4,946 students** have completed an Engineering Innovation Course
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"IT HELPED ME REALIZE PRECISELY THE FIELD I LIKE AND WHAT ASPECTS OF ENGINEERING ARE INTERESTING TO ME."
LEAH B.–EEI STUDENT

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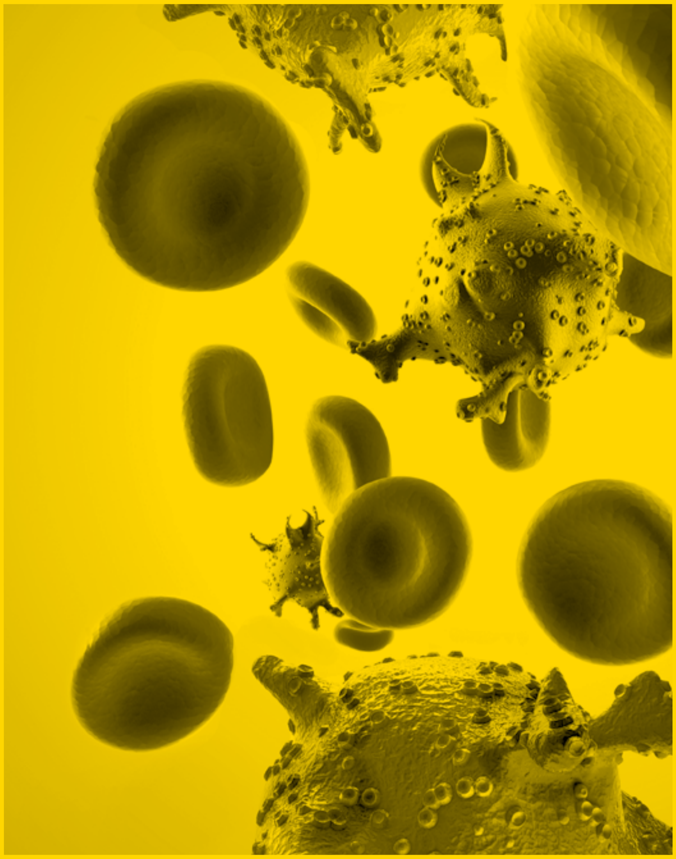
of ENGINEERING


artificial



1 GET A LOAD OF THIS

Jeff Wang, a professor of mechanical engineering and member of the Institute for NanoBioTechnology, is developing an inexpensive, portable, and user-friendly rapid diagnostic device that can be used for self-testing the viral load of people living with HIV/AIDS.

Knowing one's viral load (the amount of virus in the bloodstream) is necessary to maximize the efficacy of antiretroviral therapies, which can slow disease progression and improve outcomes, as well as to assess an individual's risk of transmitting the disease. However, being able to conduct regular viral load testing has long been one of the biggest challenges to global HIV/AIDS management—a fact that is particularly true for people in low-resource settings.

Wang's device uses lab-on-a-chip technology to miniaturize every aspect of the testing process—from using finger-stick blood samples to employing magnetofluidic technology, a process that enables simplification of the device's instrumentation as it relies on magnetic particles to process the biofluid samples. Currently, Wang is planning on conducting validation studies of the diagnostic device in multiple sites, including in Kampala, Uganda, with a goal for translating the technology for home-based HIV viral loading testing.

— ABBY LATTES

2 FROM HIGHWAYS TO HIGH-RISES

With the need for resilient structures more critical than ever, two faculty members in the Department of Civil and Systems Engineering are analyzing four high-performance "advanced" steels, developed for the automotive industry, for their potential use as studs and joists in buildings.

The steels are four times stronger than those commonly used in construction today and also could provide improved fire resistance while reducing environmental impact, note Benjamin Schafer and Thomas Gernay.

"We're aiming to find a material that exhibits great performance under the wide range of loading conditions encountered in building applications, including heavy loads, deformations, and extreme temperatures," says Gernay, who also is a fellow in the Hopkins Extreme Materials Institute. "The ideal material will be strong enough to enable innovative architectural designs while creating lighter structures that reduce carbon emissions in transit."

While Gernay and Schafer are working toward nonproprietary solutions that could be used to inform building codes, they also are in discussions with companies that are intrigued by the potential applications of their findings.

— JESSICA ADER

3 A ONE-TWO PUNCH FOR TUMORS

Traditional cancer therapies designed to stimulate the immune system or mimic its normal functions are often ineffective in defending against certain cancers.

To solve this problem, Honggang Cui, an associate professor of chemical and biomolecular engineering and member of the Institute for NanoBioTechnology, is leading a team in developing a dual chemo-immunotherapy treatment that is designed to create an immune-responsive environment through targeted, sustained release of a cancer immunotherapy drug.

Cui's approach is to create a self-assembling hydrogel version of the chemotherapy drug camptothecin, which can be administered directly into a tumor and released over a two-month period. The hydrogel form enables Cui to incorporate cyclic dinucleotide c-di-AMP, a molecule that activates cell signaling pathways to stimulate an immune response. The CPT and CDA work synergistically to destroy the tumor, which causes inflammation, a natural immune response that attracts more immune cells to the tumor site to penetrate and further destroy it.

This novel therapy already has been tested on mice with a variety of tumor types, and the results showed near tumor regression in most models, with no obvious side effects.

— GINA WADAS

AV Cart

1. 55"/50" Monitors

Two 55" x 50" monitors enhance the instructor's ability to engage more effectively with their entire class as well as one-on-one with students.

2. LED Lights & Microphones

A professional **LED light panel** provides consistent, even light, and **stereo shotgun mics** capture crisp audio, while allowing the instructor to move freely around the studio.

Desk/Podium

3. Adjustable Standing Desk

A **mobile standing desk** serves as the command center for instruction.

4. Zoom Room Controller

The **Zoom room controller** serves as a universal controller for the entire studio, enabling the instructor to change Zoom settings and switch between studio technologies as needed.

5. Document Camera

The **document camera** enables the instructor to share detailed views of 3-D objects, such as circuit boards and device design components, as well as hand-written diagrams and equations.

6. Touch Display

With the **interactive touch display,** faculty members can annotate content on their laptop while sharing it with the class.

Whiteboard & Whiteboard Camera

Not visible here: The **whiteboard camera** removes glare and shadow, allowing faculty members to share clean, high-definition images of what is written on their whiteboards.

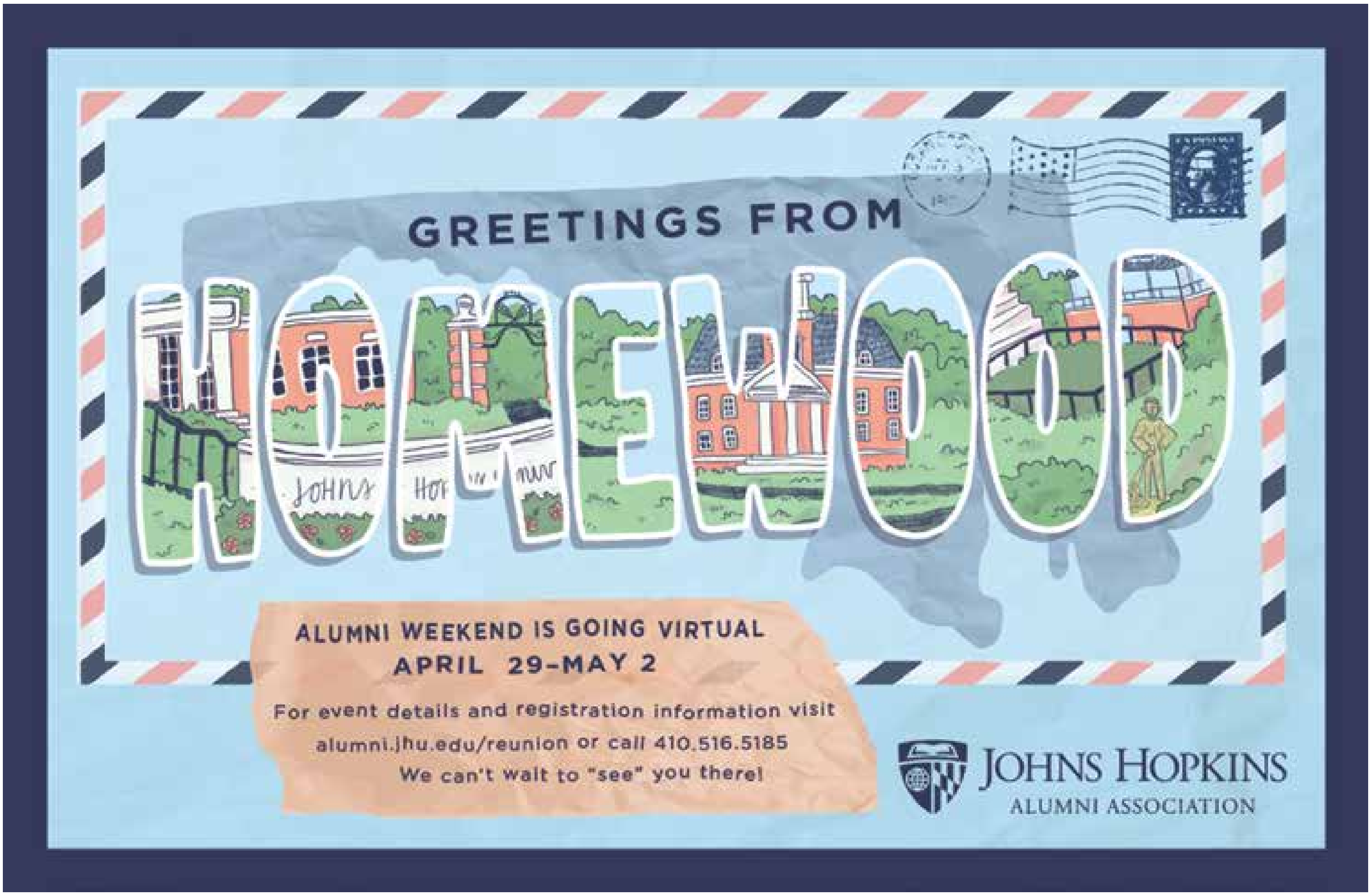
TECH TOOLS

Live, from JHU...

When Johns Hopkins University announced that the fall semester would take place entirely online, the Whiting School of Engineering built 34 state-of-the-art remote learning studios to provide faculty and students with the most effective, high-quality remote teaching and learning experiences for live, online course delivery. Outfitted with features including enhanced video capabilities, large displays that allow students 360-degree views of the instructor and the whiteboard, and high-tech audio equipment, 130 instructors taught some 250 classes in the studios throughout the fall—with great reviews from students and faculty members alike.

— ABBY LATTES

Gretar Tryggvason, the Charles A. Miller, Jr. Distinguished Professor and head of the Department of Mechanical Engineering, teaches in one of the Whiting School's new remote learning studios.


GREETINGS FROM
HOMEWOOD
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“You are doing the same thing as you would if you were in the room—it’s just that this robot is giving you a very long arm.”

8/5/20, "NBC NIGHTLY NEWS"
Russell Taylor '70, John C. Malone Professor, Department of Computer Science, talking about robots that can perform certain tasks in the intensive care unit to help human health care workers distance themselves from patients with COVID-19.

“Among all the different places where one can get infected, flights might actually be one of the safest places to be.”

10/15/20, ABC, "GOOD MORNING AMERICA"
Rajat Mittal, Department of Mechanical Engineering, on a Department of Defense and United Airlines study of the possible spread of virus-laden droplets during flights.

“That’s something where the robot really shines—precision, repeatability.”

9/10/20, *THE WALL STREET JOURNAL*
Axel Krieger, Department of Mechanical Engineering, on the use of robots and devices that can perform surgical tasks with minimal human oversight.

“There is a lot of old stuff and it is not bad just because it is old.”

9/8/20, *FORTUNE*
Jason Eisner, Department of Computer Science, on the use of Datalog, a programming language based in symbolic artificial intelligence that was invented in 1972 to overcome some problems in AI work.

“If you’ve ever been around people laying asphalt, you smell it. It’s clear something is getting into the air when that happens.”

9/2/20, *U.S. NEWS & WORLD REPORT*
Peter DeCarlo, Department of Environmental Health and Engineering, on the role of sunlight in releasing chemical compounds in asphalt that contribute to air pollution.

‘A ADVENT

REAL 'URE'

HANDS-ON AT HOME

“Hapkits”—kinesthetic devices that allow users to input motion and feel the forces they program—were mailed to the homes of students in Jeremy Brown’s Haptics class. Some of the parts and tools of the Hapkits are shown here.

Flexibility and fortitude are the name of the game as faculty and students adjust to learning in the age of COVID-19.

WRITTEN BY LISA D. ERCOLANO
PHOTOGRAPHY BY WILL KIRK

> "Honestly, at that point, we were flying by the seat of our pants, but we were determined to do a good job, so we put a lot of energy and attention to it, and it ended up working out really well."
>
> – Jeremy Brown, John C. Malone Assistant Professor in the Department of Mechanical Engineering

SINCE THE COVID-19 PANDEMIC suddenly forced all teaching and learning to go virtual in mid-March, faculty members have gotten a crash course in what works—and what doesn't—in remote teaching and learning.

Jeremy Brown, for instance, learned the importance of making sure your microphone is turned on while recording a lecture via Zoom—something he neglected to do one day early on because of the stress of adapting a curriculum to a remote format while maintaining his active research program, all with two small children underfoot at home.

"I did the whole lecture and discovered it had no sound," says Brown, the John C. Malone Assistant Professor in the Department of Mechanical Engineering. "Lesson learned: Check the mic before you record."

On their way to becoming adept in remote teaching, faculty members have adapted course content to new formats, adjusted grading rubrics, tweaked syllabi, and (via experience and intensive training by dedicated support staff) gained mastery of new strategies, pedagogies, and technologies—all in the name of ensuring they deliver rich, engaging, Johns Hopkins-quality content to students remoting in from Baltimore to Beijing.

"Our faculty showed great dedication during this transition. The result has been an explosion of innovation," says Michael Falk, professor of materials science and vice dean for undergraduate education. "More than a few faculty members have told me that they plan to continue some of the instructional practices they piloted, including increasing one-on-one meetings with students and utilizing cutting-edge software tools, even after in-person classes return."

Armed with knowledge acquired during hours of training and practice, more than 130 engineering faculty members chose to teach their fall courses from the sophisticated, new, state-of-the-art remote teaching studios the Whiting School built on campus over the summer.

These spaces—equipped with multiple camera and screen options, Zoom room controllers, lighting panels, and professional-quality microphones (See "Tech Tools," p. 14)—are a far cry from the makeshift offices faculty members rushed to set up last March when in-person instruction was suspended. At that point, many worked from their kitchen tables or in spare bedrooms, with boisterous young children darting in and out, or spouses and recently-returned-home adult children vying for bandwidth at desks nearby.

"This has been a real adventure in so many ways," says Joanne Selinski, associate teaching professor and director of undergraduate studies in the Department of Computer Science. She jury-rigged a desk at home from an ironing board and a Corona beer box; the ironing board afforded her flexibility in seating positions, and the box allowed her laptop enough height that she could stand while delivering lectures.

"The challenges to adjust to all this in a landscape where plans were constantly changing meant a lot of stress at the beginning, for sure," she says. "We are all working harder than ever before to make sure that our students get everything they need, expect, and deserve."

MARCH MADNESS

Before the pandemic, few faculty members, other than those working in the school's Engineering for Professionals' online programs, had much experience teaching remotely.

"I had recorded a few lectures for Blackboard, sure, but that was about it. Suddenly, I had to figure out a whole new thing," Brown says.

At the time, Brown was teaching two courses that typically include hands-on, team-based projects carried out in the lab. For example, one year for their final project, students in his Mechatronics course (mostly undergraduates) designed and built autonomous robots that played hockey against each other.

Initially, Brown was hopeful that his Mechatronics students could temporarily work from home using computer-aided design to brainstorm and test designs, then return in mid-April ready to build in the real world. But as the pandemic galloped on, it became apparent that neither students nor faculty would be returning to campus anytime soon.

"We were starting to see the proverbial writing on the wall that we would not be coming back during the spring semester. My essential question then was: How do you teach hands-on courses in an all-virtual environment?" Brown says.

He briefly considered having the Mechatronics students finish the spring semester refining their CAD designs but worried that this was inherently unfair to students who were less familiar with CAD software than others.

Consulting with his teaching assistants (whom he calls "amazing" and "awesome"), Brown decided that the students would instead use a tool called Simscape, which allows users to create a virtual copy of the physical world and then simulate mechanical interactions with it.

"Honestly, at that point, we were flying by the seat of our pants, but we were determined to do a good job, so we put a lot of energy and attention to it, and it ended up working out really well," he says.

For their final project, Mechatronics students used Simscape to build virtual robots, which they navigated through a virtual maze.

"I was very impressed with the projects," says Brown. "Even though students were not meeting and working physically in a lab, they were able to do the conceptual work around building systems. And throughout the process, I also personally gained knowledge and expertise about remote teaching and learning."

Selinski was also teaching two classes—Gateway Computing: Java, and User Interfaces and Mobile Applications—when COVID-19 closed the campus.

Gateway was already configured as a "flipped" class, with the mostly first-year students in her sections listening to pre-recorded lectures and doing assigned readings on their own time and then coming to class to work individually and in teams on exercises under the guidance of Selinski and her teaching assistants. In March, students in her User Interfaces course were just entering its project portion, which is less about lectures and content delivery and more about breaking into teams to write Android apps based on lessons learned earlier in the semester.

"Having to put Gateway online was challenging, because I was no longer in the same room with students, looking at their programs and helping them solve problems as I sat or stood right there with them," she says. "So we basically took the class to Zoom and explored many of the tools available, such as breakout rooms, to meet and work on their class exercises. It wasn't in-person, but it worked."

"Suddenly, I had to figure out a whole new thing."

– Jeremy Brown taught from home last spring, while keeping his children entertained with science projects he devised for them.

Shifting the 45-student User Interfaces class to a remote setting was a bit less challenging for a simple reason: She already knew most of the second- and third-year students, so it was easier to engage with them in the virtual environment. Selinski held the class via Zoom at its regularly scheduled time, recording it for students in China and other time zones, and built in project days.

"The students' final results were very strong, and I was proud of them," Selinksi says. "Those of us in computer science were fortunate, in that our courses don't rely as much on a physical component. For us, there were probably only a handful of classes that were strongly impacted by our not being able to meet in person. That said, there were plenty of challenges—for faculty and for students."

SMOOTHING OUT STRESSORS

The switch to remote learning was challenging for students as well. Some returned to homes without regular internet access. Others were distracted and anxious because immediate family members or relatives were battling COVID-19, or their families were experiencing financial stress.

To help support students, the university offered Wi-Fi hotspots and other technology support, as well as discounts on computer purchases and financial aid to help cover the costs associated with the purchase of new laptops. The Center for Educational Resources also provided students with practical information on online learning, from how to use Zoom to strategies for setting up a dedicated workspace at home.

Brown became aware that some students also had access to devices such as 3-D printers

"One of the best things about being in the studios [at Homewood] is that I could see all my students' faces, unlike in the spring, where I was teaching from home via Zoom, with my little laptop on my ironing board desk."

– Joanne Selinski, associate teaching professor and director of undergraduate studies in the Department of Computer Science

Selinski in her home teaching "studio"

while others did not, leading him to think harder about the whole issue of equity of resources when creating assignments or projects.

"It wouldn't be fair if one student did better than another gradewise because of different resources," he says.

Selinski dealt with similar issues among her students, who, like Brown's, were remoting in from various time zones around the world. One student, who shared their bedroom with siblings, had to log in from a closet, the only private space in their home. Others expressed embarrassment about their home environments, which they feared their classmates could see via Zoom.

"I made a point of showing students how they could put up a virtual background in Zoom so that no one had to see their private space," she explains. "Of course, we all know that not every student has the ideal home learning environment, but it doesn't hurt to be reminded."

A FRUITFUL FALL

The baptism by fire into the world of remote teaching that Selinski and Brown experienced, combined with in-depth training sessions provided by the school, reaped benefits in the fall, with some 250 courses being taught from the teaching studios on campus. (Support staff conducted nearly 200 one-on-one training sessions in the new studios with faculty members over the summer and during the first week of the fall term.) Like their colleagues across the Whiting School, both faculty members charged into fall 2020 armed with expertise and confidence, ready to teach their classes from the new studios.

"One of the best things about being in the studios [at Homewood] is that I could see all my students' faces, unlike in the spring, where I was teaching from home via Zoom, with my little laptop on my ironing board desk," says Selinski.

As in the spring, her fall Gateway class was flipped. But this time, Selinski says the remote teaching techniques she learned on the fly and through training sessions in the spring and summer meant she knew exactly how to keep students engaged in the virtual environment.

"I knew one challenge was going to be getting students comfortable with remote learning and with each other and the class," she says. "So, on day one of fall, we played with all the Zoom tools together. I had them raise their hands, answer polls, and then I had them go into breakout rooms and talk to each other, figuring out who lives close to each other, who has the same birthday, who likes the same movies—that kind of thing. I wanted them to get to know each other, because I knew that would pay off in later classes. It did."

First-year student Zal Ekinci remembers that first class well. He said that the exercises not only helped him begin to get to know his classmates but also reassured him that he was going to be OK in his first college-level computer science class.

"One thing that Professor Selinski did was take a poll to ask the class who had done some programming and who hadn't. Though I had come in with some programming experience, it wasn't a lot, and seeing that we were all in the same boat, I knew that I could make progress alongside my peers," says the Riverdale, New Jersey, resident.

Brown, too, used the flipped classroom model for his fall Haptics class, with class time devoted to interactive sessions designed specifically around interactions between professor and student, and between student and student.

"I did everything from bring demos to do for the students to having them demonstrate things. We did pseudohaptic experiments together, and I had them team up to do the same," Brown says. "I used a lot of polls in real time, to see what they are understanding or not getting, as well as asked them to answer multiple-choice questions and fill-in-the-blanks. This led to many fruitful and animated conversations with the students."

Kathleen D'Souza, a student in Brown's fall Haptics class, found the class very engaging.

"I was really impressed by the flexibility of Dr. Brown to meet all students' needs; the ability to have conversations in class or during his office hours really enhanced my learning experience," says D'Souza, a systems engineer at Boeing in Seattle, who took the class as part of Engineering for Professionals' mechanical engineering graduate program.

D'Souza was particularly enthusiastic about the class's use of Hapkits, which are kinesthetic devices that allow users to input motion and feel the forces that they program. Brown uses these kits every year (even in person) and personally mailed kits to D'Souza and each student in his fall Haptics class.

"One of my concerns about remote learning was the lack of hands-on experience, but this class took that fear away," D'Souza says. "I found the flow of the virtual class very natural and comparable to in-person classes that I took as an undergrad. I also found the flipped classroom makes it much easier to ask questions during the interactive sessions."

Brown likes the flipped classroom model too. In fact, he is planning to keep it when classes eventually return to campus.

"I am seeing there is a lot to be said about recording the lecture ahead of time, giving students time to view and digest it, and showing up in person to talk about it, ask questions, and really engage actively with the material," he says.

"This just goes to show that every experience—even a pandemic—can be a learning opportunity for us all." ▪

ILLUSTRATIONS BY
CHRIS GASH

A GOLDEN AGE

With the aging of the baby boomer generation and improving life expectancy, our nation is experiencing a seismic demographic shift. So the launch this year of the new Johns Hopkins Engineering Aging Alliance couldn't be timelier. Based at Johns Hopkins Bayview Medical Center, it will bring together student engineers to work in "innovation incubators" with students from the schools of Nursing, Public Health, and Medicine, guided by clinician-mentors from the School of Medicine. The vision: to break down existing silos so that clinicians can identify the health problems their aging patients face and engineers can come up with carefully tailored solutions—solutions that will move quickly into pilot studies and clinical trials.

Much of the new work will build on existing research advances at the Whiting School in areas such as artificial intelligence, image recognition, machine vision, and chemical and biomolecular engineering. In the briefs that follow, we capture just some of ways that Johns Hopkins engineers are already laying the groundwork for a happier, healthier old age.

WITH REPORTING BY LISA DENIKE ERCOLANO, GINA WADAS, SUE DE PASQUALE, CATHERINE GRAHAM, AND ABBY LATTES

A LEG UP ON HIP FRACTURES

Hip fractures can be deadly for older adults; the one-year mortality rate after sustaining a hip fracture has been estimated to be 23%. One proposed method to prevent hip fractures in patients with osteoporosis is to strengthen the femur by injecting it with bone cement, a procedure known as femoroplasty. Led by Russell Taylor (CS) and Mehran Armand (MechE), Johns Hopkins researchers are developing robotic technology that will allow surgeons to personalize surgical plans for femoroplasty patients. A major innovation of their prototype is an enhanced vision system that offers multiple views of the femur for preoperative planning. — CG

FIGURING SPEECH

While an early diagnosis of Parkinson's disease provides the greatest potential benefits for therapies that may slow or stop the disease's progression and improve a patient's quality of life, identifying early PD remains a challenging task. Clinical diagnosis is based mainly on a physician's assessment of motor signs, including changes to the voice—changes that often are observable only years after significant neurological damage already has occurred. Najim Dehak (ECE) and his team are working with neurologists to enable accurate, early diagnosis of PD using speech processing and machine learning tools capable of identifying PD-specific changes to speech that cannot be perceived by the human ear. Already, using this technology, the researchers can identify PD with 94% accuracy. — AL

GETTING MOVING BEFORE SURGERY

Major surgery puts older patients at high risk of complications. While preliminary studies indicate that physical conditioning before surgery leads to fewer complications, shorter recoveries, and lower costs, such findings have been compromised by unreliable data gathering and compliance, notes Anton Dabhura (CS). With colleagues from the School of Medicine, he developed a platform for gathering accurate patient activity data via wearable monitors and sharing this information with patients. In a current study, he is investigating whether data feedback impacts patients' presurgical activity levels and if there is an association between the frequency, duration, and timing of presurgical activity and clinical outcomes. — AL

AN APP FOR PARKINSON'S

A difficulty doctors face in helping patients effectively manage Parkinson's disease is that symptoms fluctuate—worse one day, better the next. A smartphone app developed by Suchi Saria (CS) could help doctors get a more accurate picture of patient symptoms over time. Patients daily complete five tasks that evaluate their gait, voice, finger movement, balance, and reaction time, and the app uses a novel machine learning approach to calculate a score. Doctors hope this precise and detailed data will inform more effective and individualized treatment for patients with PD. — LDE

SWIMMING WITH BANDIT THE DOLPHIN

After a stroke, many patients suffer from weakness on one side of their body. But there appears to be a window of time when the brain can trigger a phase of self-repair. Could Bandit the dolphin help in that recovery process? John Krakauer and Omar Ahmad, founders of the KATA Design studio in Neurology, along with their collaborators, have shown that it can. They have developed an immersive, interactive video game that uses a novel form of animation combined with exploratory arm movements and varying levels of cognitive challenge to rehabilitate arm and hand movement following stroke. Recently, the researchers took Bandit from the hospital rehab setting and into the community with a clinical trial involving healthy older people to see whether those who play the game see improvement in their cognitive and physical health. — SD

HEARTS IN SPACE

Beating heart tissues—contained in a specially designed tissue chip the size of a small cellphone—spent about a month at the International Space Station last spring as part of a research project led by Deok-Ho Kim (BME). Space's low-gravity environment can cause changes in the human body that are similar to accelerated aging processes, which allowed Kim and colleagues to study age-related heart conditions—conditions that might take years to develop on Earth. "We hope the results can help us better understand and someday counteract the aging process," says Kim, whose team used human induced pluripotent stem cells to grow the heart muscle cells in a bioengineered chip that mimics the function of the adult human heart. In their work's second phase, the researchers hope to send heart tissues back to the ISS in about two years to test a variety of drugs "to see which ones will best ameliorate the potentially harmful effects of microgravity on cardiac function," says Johns Hopkins postdoctoral fellow Jonathan Tsui. — SD

BIOMARKER FOR BRAIN ATROPHY

While cerebral atrophy can be a normal part of the aging process, abnormal cerebral atrophy can signal the presence of debilitating neurological diseases, including Alzheimer's, Parkinson's, and Huntington's. Because early and accurate diagnosis is key to managing all of these conditions, being able to differentiate between normal and abnormal atrophy is important. Jerry Prince (ECE) has developed ACAPULCO, a program that can automatically and precisely measure regional cerebellar volumes. "It will enable us to establish a baseline from which disease could be assessed," Prince says. "It will be added to the 'arsenal' of imaging biomarkers that are used routinely to both diagnose and assess treatment." — AL

EARLIER CLUES TO ALZHEIMER'S

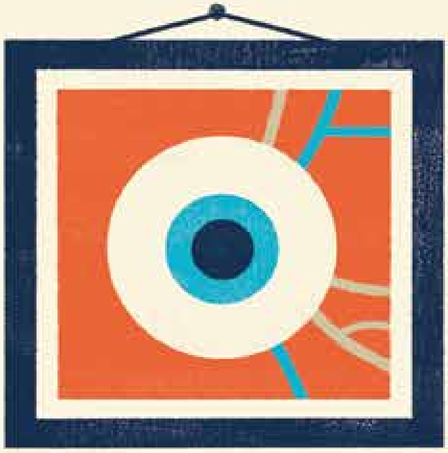
An estimated 5.7 million people over age 65 in the United States are living with the devastation of Alzheimer's disease, and the quest for a cure has been elusive. Early detection could help people better prepare and even guide potential treatments, note Michael Miller (BME) and Laurent Younes (AMS), who are investigating ways to detect Alzheimer's risk in patients before symptoms—such as cognitive impairment—appear. By combining brain MRI data and cerebrospinal fluid analysis with cognitive testing, they have identified significant change points that precede symptom onset, including biochemical and anatomic changes. These can present a decade or more before clinical symptoms are observed. — AL

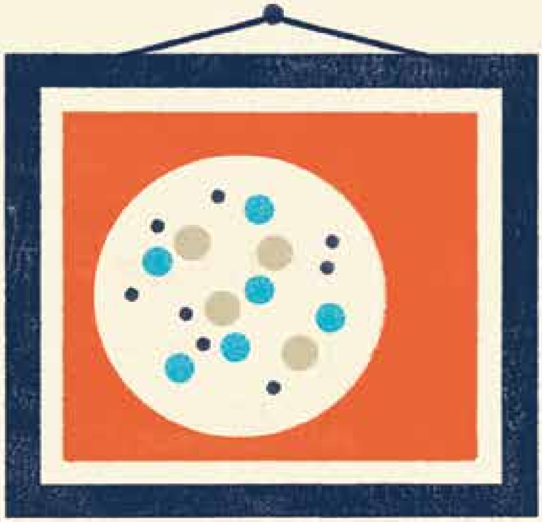
TISSUE MECHANICS AND REJUVENATION

As we age, our tissues not only change their strength and elasticity but also lose their ability to heal, which could ultimately lead to tissue dysfunction. Researchers like Sharon Gerecht (ChemBE) study how the aging extracellular matrix —the complex network into which cells reside in all tissues and organs—regulates cell behavior, ultimately leading to tissue dysfunction. The team is focusing on understanding how these processes impact the function of the blood vessels throughout our body. The researchers engineer biomaterials with altered structural and mechanical properties and interface them with human stem cells to recapitulate aging tissue in the lab. They aim to identify therapeutic targets and develop stem cell grafts to slow (or even reverse) the ravages of aging on our tissues. — SD

GOING TO THE WALL

Older adults are at greater risk of many eye diseases and ailments, including cataracts, macular degeneration, and glaucoma. Understanding the biomechanical mechanisms that drive these age-related eye conditions will bring researchers closer to developing better treatment options, notes Vicky Nguyen (MechE). To this end, she is using a combination of experimental methods and computational modeling to characterize the effects of age and disease on various eye structures. A current study led by Nguyen aims to measure the strain response to pressure of the optic nerve head, a key contributor to glaucoma. Insights from this work are guiding the development of new therapeutic interventions for glaucoma that alter the mechanical properties of the eye wall to slow the progression of optic nerve damage. — CG





WHEN CELLS GO WRONG

Some 70% of cancer deaths occur in people older than 65, and advancing age is a risk factor for diseases ranging from cardiovascular disorders and diabetes to arthritis. But why? What is it about aging that makes people susceptible to disease? Denis Wirtz (ChemBE), an expert in the molecular and biophysical mechanisms of cell motility and nuclear dynamics, is delving into the role that cellular dysfunction plays in the aging process. His goal is to tease apart what is happening at the cellular level to identify biomarkers that predict the onset of aging-related disorders so therapies can eventually mitigate them. — LDE

A WINDOW INTO DISEASE

As cells age, they accumulate genetic and molecular changes that lead to dysfunctions and manifest as disease. Jude Phillip (BME), a researcher in the Institute for NanoBioTechnology, investigates how these changes set the groundwork for disease development, including cancer and frailty. “As integrators of molecular signals, cells offer a unique window into disease biology,” Phillip says. With a better understanding of the structures and behaviors of aging cells, Phillip aims to develop strategies and technologies to target, delay, and mitigate aging’s harmful effects, modifying aging’s unhealthy trajectory. — GW

At What Price?

In his latest book, data scientist Howard Friedman raises some hard questions as he examines the many ways we assign value to human life—making some people's lives worth more than others.

Interview by Joan Katherine Cramer

What is the worth of a human life? Most of us would probably say "priceless." But in his new book, *Ultimate Price: The Value We Place on Life* (UC Press, 2020), renowned statistician, data scientist, and health economist Howard Friedman MS '98, PhD '99 examines all of the ways, hidden and overt, that we affix a finite value to human existence.

Every day, whether we know it or not, courts, insurance companies, governments, and manufacturers make decisions about how much each of our lives is worth. More important, says Friedman, those decisions often are based on questionable assumptions—that, for instance, age, race, gender, location, education, income, and other factors make some people's lives worth more than others. And these assumptions tend to exacerbate existing inequalities.

The author or coauthor of a dozen books, Friedman has worked as a data scientist in the corporate, academic, and public sectors. He led teams of statisticians, analysts, and programmers at Capital One. Since 2007, he has served as a technical specialist for the United Nations, and he is currently an associate professor at Columbia University, where he teaches at both Columbia's Mailman School of Public Health and Data Science Institute.

Friedman believes in the value of measurement, of data analytics, but hopes that shedding light on the unfairness inherent in many models we use to determine the value of a human life will inspire us to use these tools to instead promote equality.

In his latest book, Friedman examines the many ways we affix a value to human existence.

Howard Friedman MS '98, PhD '99

Q: What inspired you to write *Ultimate Price*?

A: Many of us were touched in different ways after 9/11. Like many native New Yorkers, I know people who died that day. But when Congress created the September 11th Victim Compensation Fund, where dollar figures were put on people's lives and some were deemed 30 times more valuable than others, it really struck a chord with me. Kenneth Feinberg, the attorney who was appointed to administer the fund, was saddled with the limitation that he had to assign an economic value to each life, and though he did his best to narrow the range, he nonetheless came up with a calculation in which the value of those lives ranged from $250,000 to more than $7 million. The existence of the fund as well as the broad range of payouts were both very controversial. Only a few years after he had administered that fund, Mr. Feinberg argued that it would have been simpler and more acceptable to have paid those 9/11 families the same amount of money for each victim, rich or poor, young or old. When he was later appointed to administer the compensation fund for the victims of the 2013 Boston Marathon bombing, he did exactly that, ensuring that the families of the victims were all paid the same amount. It was a real statement of equality, and a real tribute to his leadership and integrity to follow through on his own statements.

After 9/11, I started seeing that the way we value human life has been a common thread running through all of my work, and a few years ago, I realized there was a book there.

Q: What did you expect to find, and what surprised you?

A: I was well aware of inequality. It was a big theme in *The Measure of a Nation* [his 2012 book that compared American performance in health, education, safety, and other quality of life issues against the performances of 13 other industrialized nations].

But what surprised me was just how extreme the discrepancies are in how human life is valued. Look at the tragedy in Bhopal, India [the 1984 gas leak at a Union Carbide pesticide plant in which more than a half-million people were exposed to toxic fumes and many thousands died or were disabled], and how those lives were valued at tens of thousands of dollars. And contrast it to the more recent Toyota case [involving unintended acceleration], where the lives lost were valued at tens of millions of dollars each. There's a difference in time and in the economic systems of the two countries, but not enough to explain the massive difference in magnitude.

The theme that runs through *Ultimate Price* is that lives that are less valued are less likely to be protected. And that's where this goes from being an interesting theoretical exercise to a real-world fact—that if a company feels like they're going to lose tens of millions of dollars per preventable death, they're going to invest a lot more in safety than if they're losing only tens of thousands.

The infamous Ford Pinto is a great example of this. Ford knew that the car, which it introduced and sold during the 1970s, could burst into flames if hit from behind but came up with what has since become a notorious cost-benefit analysis—which was leaked at the time to the press—designed to convince regulators that making the car safer would cost substantially more than the value of the human lives lost. Of course, they miscalculated. Even if you don't consider the moral implications, the monetary cost assigned to those lives in the lawsuits that Ford faced for many years afterward, as well as the public outrage and its impact on their reputation, clearly exceeded anything it might have cost them to improve the safety of the car.

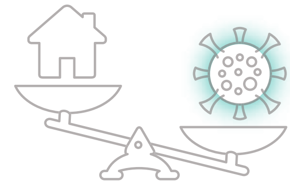
Q: What is your hope for the impact of your book?

A: I want to raise people's awareness of the fact that price tags are put on life all the time, whether they be cost-benefit calculations affecting the safety of cars and other consumer products, jury awards in wrongful death suits, how health insurance companies decide what drugs and medical procedures to cover, and even how stringent regulators will be in assuring you clean air and water. I want people to know that these price tags are often unfair and that if you don't address these inequities, you are going to have situations where people's lives are put at risk unnecessarily.

U.S. regulatory agencies routinely perform cost-benefit analyses when they are creating and enforcing regulations, and it is generally the policy to value all lives equally in making those calculations. So there was a huge outcry when the George W. Bush administration proposed cutting the value of a senior life to about half the standard value. Opponents called it the "senior death discount," and, in the face of that public outrage, the administration eventually backed down.

I want people to realize that they can understand these algorithms. Everyone doesn't necessarily need to review the details of the equations, but you can understand the key assumptions, the key inputs, and the main outputs. I want people to know it's OK to challenge experts. I'm not encouraging an anti-science approach—we have seen how dangerous and short-sighted that can often become. But I do encourage people to become informed, to learn enough about the science to go in and say, "You are assuming this. We don't think it's true. And here are the reasons why we challenge this assumption." And then make the technical people defend their work. Maybe the scientists can defend the assumptions, or maybe there are opportunities to improve the modeling.

I'm not so idealistic as to think unfairness will magically disappear, but I do know that when enough people realize something is fundamentally unfair, they can take action and seek to address this inequity.



Q: How do you see your findings about inequality playing out in the COVID-19 pandemic?

A: It turns out that COVID is not the great equalizer but is, in fact, exacerbating inequality. In New York City, there was no question that people who could afford to rent or own a second home away from the city would fare much better than people who had to physically travel to their jobs, often on public transportation. Not just in New York, but in many places, minority groups often had much higher infection rates due to population tendencies related to employment, transportation requirements, and physical living environments.

And there are economic inequities. People in the most privileged positions are the most likely to be able to work remotely and the least likely to lose their jobs. And then there's testing. When you heard that Tom Hanks and NBA players were able to get tested, while at the same time, most of us could not get tested, it was hard not to get the message that their lives are more valuable than the lives of the less wealthy and less privileged.

Q: What do you think of the projection models we've seen?

A: JHU is definitely leading in terms of having some of the highest-quality analytics work related to COVID, and I'm very proud of what they've done. On the other hand, some groups that got a tremendous amount of media attention produced models that were, at least initially, horrendously wrong in terms of their predictions.

The problem with making projections about the United States is we have so many local variations of behavior, and we don't have true enforcement. It's not just that we don't have a collective policy; it's that as a nation we don't necessarily have a feeling of being collective, that we're all in this game together, whether it's COVID or life. I contrast it with a lot of the countries that have really had tremendous success—not just New Zealand, because it's a small island and it's different, but countries like Vietnam, where there's a substantial population and they've been able to work as a society to aggressively control COVID-19. There are lots of best practices we could learn from other countries, and I wish, as a nation, we'd be willing. I just don't think culturally we are that good at doing that. It's what I argued in *The Measure of a Nation*. We tend to like to go our own way even when other countries are clearly, clearly doing massively better than we are.

One key take-home from the initial data on COVID mortality and economic impact is that the countries that have been the most successful at controlling COVID mortality are also more likely to have had better economic performance. It is a stark reminder that investing in public health is not only the right thing to do from a human rights perspective but also makes good economic sense. ■

A Human-Centered Approach to Artificial Intelligence

WHAT DO ZOOM, THE IPHONE, AND THE JOHNS HOPKINS COVID-19 TRACKER HAVE IN COMMON? They all "offer a pleasant and smooth user experience," according to Mathias Unberath, an assistant professor of computer science.

To prepare future engineers to design similar technologies, Unberath developed a new course on human-centered design for artificial intelligence systems, which was offered last spring for the first time. The course teaches students to design, develop, and train an AI system that could benefit someone's life or help solve a real problem.

"Students must design their algorithms with the end user's needs and wants in mind. What true problems are people facing, and how do people want to interact with technology?" says Unberath, a member of the Malone Center for Engineering in Healthcare.

One student team created an application to boost the quality of early education for children. "Barry" is a virtual talking teddy bear that collaboratively creates new stories with children using AI. It uses GPT-2, a state-of-the-art dialogue generation model created by OpenAI.

The team members—fourth-year computer science majors Idean Labib, Eyan Goldman, and Dorothy Hu—trained their model on a custom dataset built from children's stories and excluded certain words to ensure the stories would always be kid-friendly.

Hu says that until COVID-19 forced everything online in the middle of the spring semester, the team had intended that Barry take the form of a physical stuffed animal. But the pandemic revealed to the team a new path forward for their design.

"Young children now need to be educated at home, and we realized parents might not have the resources to do this themselves," Hu says. "Our research problem then became: How can we help parents educate their children during this pandemic? So, Barry became an online learning partner that users can easily access at home."

Other student solutions that could be useful during the ongoing pandemic included an app that helps users learn a language in a context they care about. For example, while browsing an online forum such as Reddit, a user can ask the bot to translate any content on that site into the language they want to see. Other designs included a system that maximizes the efficiency of grocery store runs and Terrazzo, an online platform to improve the way university professors track their students' comprehension and progress in course material.

— CATHERINE GRAHAM

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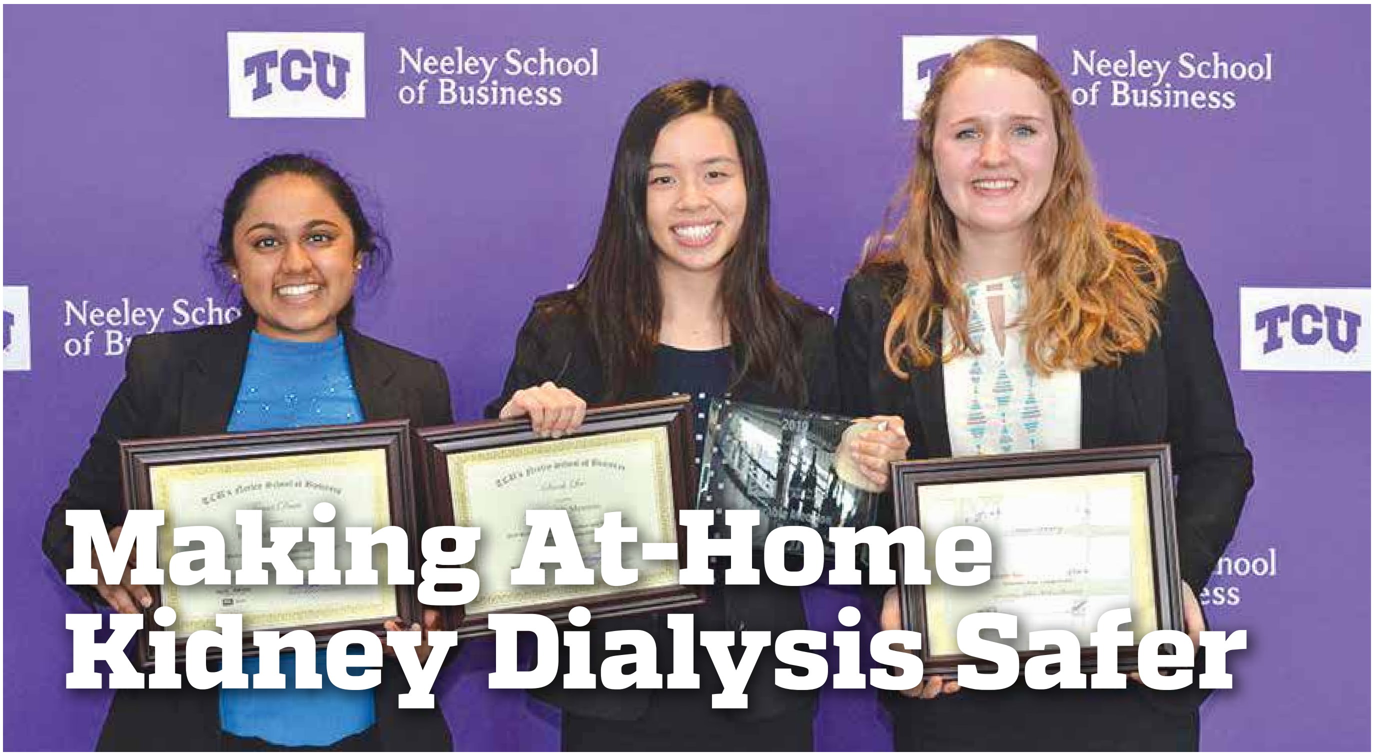
Making At-Home Kidney Dialysis Safer



Members of the Relavo team, from left: Tejasvi Desai, Sarah Lee, and Anna Bailey

RELAVO, A COMPANY FOUNDED BY JOHNS HOPKINS UNDERGRADUATES, has been awarded a $500,000 KidneyX prize to develop a product that reduces the risk of contamination during at-home kidney dialysis treatments.

The COVID-19 pandemic has sparked a new sense of urgency to expand access to at-home dialysis, ensuring that vulnerable patients won't have to visit in-person dialysis clinics for treatment, notes team leader Sarah Lee ’19 (BME), now a mechanical engineering graduate student.

“Kidney failure patients are high risk for complications from COVID-19—yet nearly half a million people in the U.S. still have to travel to dialysis clinics several times a week just to survive,” she says. “And with the risks for long-term kidney complications due to COVID-19, even in patients with no history of kidney disease, there is definitely a communitywide focus in supporting these patients now and in the future.”

Peritoneal dialysis is a form of kidney replacement therapy that patients self-administer at home, and studies have shown that it gives patients a better quality of life than other forms of dialysis. Despite its advantages, it remains underutilized due to higher risk of contamination that can lead to infection. To address this problem, the Relavo team developed PeritoneX, an affordable, disposable device that disinfects contaminated connection points before PD treatment begins.

KidneyX, also called the Kidney Innovation Accelerator, is a public-private partnership between the U.S. Department of Health and Human Services and the American Society of Nephrology. Established in April 2018, KidneyX prize competitions aim to accelerate the development of innovative solutions that can prevent, diagnose, and/or treat kidney diseases.

The Relavo team was one of six winners of the KidneyX Redesign Dialysis Phase 2 competition, which built off an inaugural prize competition and challenged participants to build and test prototypes that can replicate normal kidney functions or improve dialysis access. Lee says the KidneyX prize will primarily fund the team’s product development efforts and will pay salaries, allowing the company co-founders to work on the project full time.

This fall, Relavo participated in two global startup accelerator programs: the MassChallenge Boston program and the MedTech Innovator Accelerator, the largest accelerator for medical technology. Out of 1,000 applicants to the MedTech program, Relavo was selected as one of 50 showcase companies and one of 29 early-stage companies chosen to be part of its intensive accelerator program.

— CG

> "Setting up the network included onboarding new members and providing the appropriate 3-D printing feedback to ensure they could get the shields into production."
> **— CHRIS SHALLAL**

Banding Together to Help Front-Line Providers

LATE LAST SPRING, CHRIS SHALLAL JUGGLED HIS PREPARATION FOR FINAL EXAMS WITH A multicampus effort to create and provide durable, reusable face shields to health care workers at the Johns Hopkins Hospital.

To help fill the hospital's urgent need for personal protective equipment due to the COVID-19 pandemic, the Johns Hopkins Consolidated Service Center recruited volunteers to assemble disposable foam face shields.

Shallal, a fourth-year biomedical engineering student, noted that the foam headbands used for these face shields do not hold up to prolonged wear and must be disposed of after a single use because the porous material could potentially trap hazardous particles. So, he and his engineering classmates at Health 3-D—a social venture co-founded by Shallal and classmate Kirby Leo '20 that uses 3-D printing to improve health care products—submitted a proposal to the Johns Hopkins COVID-19 Research Response Program, detailing their plan to manufacture a more durable headband that would allow face shields to be worn multiple times. The student team was guided by biomedical engineering faculty mentors Elizabeth Logsdon and Warren Grayson.

The proposal was accepted, and the students were provided $10,000 to use toward printing materials. To make the headbands, the team uses extra-tough PETG filament, known for its strength and stability. It can be wiped down with basic cleaning agents, such as isopropanol, bleach, or ethanol, without affecting its durability.

Working with the Johns Hopkins COVID-19 Command Center, Shallal built a network of approximately 30 people and more than 55 3-D printers to create the reusable headbands using a printing design created by the Johns Hopkins University Applied Physics Laboratory.

Once printed, the headbands are dropped off at designated checkpoints and delivered to the Central Supply Chain warehouse, where a transparent shield and elastic band are attached to complete the new, more durable face shields, which are distributed into the hospital system.

"Setting up the network included onboarding new members and providing the appropriate 3-D printing feedback to ensure they could get the shields into production," says Shallal.

He and his team are looking to increase production by recruiting more members and activating more printers. They are also considering other manufacturing methods, like vacuum forming or industrial casting and molding.

— SARAH TARNEY

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A Soft Solution

Helena Hahn

WHEN COVID-19 FORCED THE SHUTDOWN OF IN-PERSON CLASSES LAST MARCH, Helena Hahn—a fourth-year student in the Department of Electrical and Computer Engineering and a member of James West's lab—was anxious to continue conducting research.

When she heard about a project underway by three graduate students in the department who were finalists in the Collegiate Inventors Competition, Hahn saw an opportunity to contribute.

The graduate student team—Adebayo Eisape, Ian McLane, and Valerie Rennoll—wanted to create a "soft electronics" version of their acoustic sensor capable of improving everything from Zoom calls to vital sign monitoring by screening out background noise.

"I saw a video demonstration of the sensor, and its ability to focus in on the target sound was really impressive," says Hahn.

The team members welcomed her to the project. "We felt this would be a way to both expose Helena to a new area of research and help with moving the transducer design forward," Rennoll says.

Soft electronics are used to build electronic circuits that can bend and conform to various shapes. The original iteration of the sensor includes printed circuit boards, which are rigid, but a soft electronics version would allow the team's sensor to be used in a device that patients could wear to track their vital signs or for other biomedical uses.

After reading through a few academic papers, Hahn devised a plan to integrate soft electronics into the team's existing device using FEP conductive foil: a thin, flexible film that can be cut and stretched.

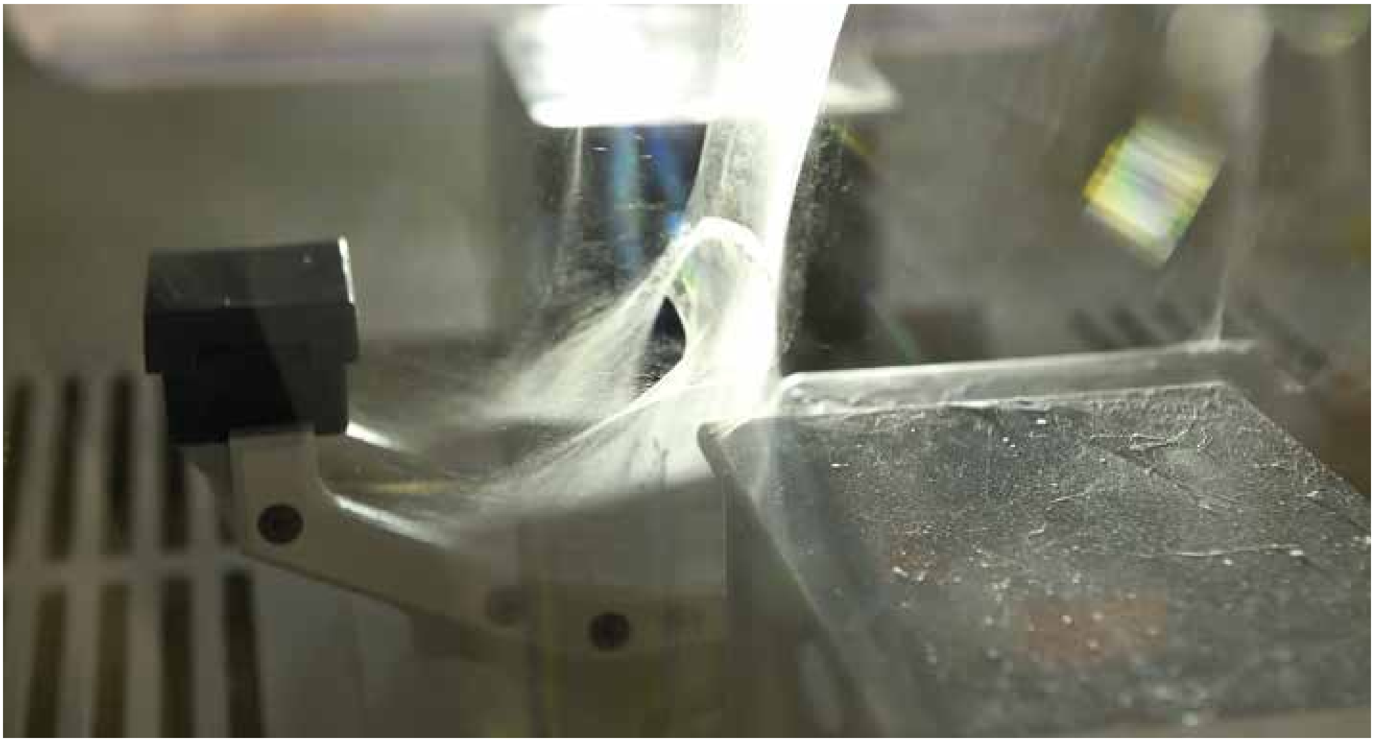
She is creating her design for the new version on her computer in her Baltimore County home. Then she will use a "cut-and-paste" method to integrate soft electronics with the acoustic transducer. Unlike alternate approaches for fabricating soft electronics, this method does not require chemicals and can be executed with a Cricut Maker, which is a computer -controlled cutting machine popular in the home crafting community.

"The entire procedure is dry and desktop, so it's more time- and cost-effective than standard microelectronic fabrication processes," she says.

It is still early days in what is expected to be a yearlong project. So far, Hahn has drafted layout designs and has started practicing with the Cricut Maker, which the West lab provided for her.

"I really enjoy learning about what the others are up to, and they give me insightful feedback and recommendations on my projects," Hahn says. "I feel very fortunate to have found a way to participate in research remotely."

— **WICK EISENBERG**



Mask Mania

WHEN THE COVID-19 PANDEMIC MADE ITS WAY TO THE UNITED STATES, STEPHEN FARIAS PhD '14 began thinking of ways to help.

As director of engineering at DiPole Materials, an electrospinning company in the Baltimore neighborhood of Pigtown, his mind immediately jumped to the company's Elmarco machine, which creates electrospun nanofibers for commercial prototyping or small-scale production. The machine, he realized, is also capable of manufacturing nanofibers with filtering capabilities similar to those of an N95 mask.

DiPole's representatives pitched the project to investors and quickly received the funding they needed. The last piece of the puzzle was who would do the actual labor. To make as many filters as possible, the Elmarco machine needed to run 24 hours a day, which would overburden DiPole's full-time staff.

DiPole put out a call to students from local colleges, asking if anyone with experience handling chemicals would like to help. The group received an overwhelming response, particularly from Johns Hopkins students. In total, 13 current students and graduates from the Whiting School of Engineering and Krieger School of Arts and Sciences began working on the project.

Though the project features students from a number of local colleges, the sizable contributions from Johns Hopkins students is just the latest in a history of collaboration between the university and the company. James West, a professor of electrical and computer engineering at the Whiting School, helped co-found DiPole in 2015, and the company's first piece of technology originated in his lab. In addition to Farias, the company has hired multiple Johns Hopkins alumni in recent years.

The majority of the Johns Hopkins students perform quality control for the project, ensuring that the material being produced by the Elmarco machine meets filtering specifications.

"We make enough material for about 2,000 mask filters per day," Farias says. "Once the filters are created, we send fabric rolls of our materials to other [mask] manufacturers that put it into the final mask products. We are distributing to several local mask fabrication companies, as well as some large local and domestic textile manufacturers."

Other Whiting School alumni who have joined Farias on the project are Matthew Davenport '13 and James Shamul '17, MS '18.

— WE

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Advancing Health Care in Africa

Adegoke Olubusi MS '16

IN AN AGE WHEN MOST PEOPLE CARRY A TINY COMPUTER IN THEIR POCKETS AT ALL TIMES, medical records in African countries remain mired in paper, making critical data inaccessible to doctors, hospitals, researchers, and scientists.

"Until you have real data to understand what's going on in health care in Africa, you can't provide real solutions," says Adegoke Olubusi MS '16, co-founder and CEO of the health care technology company Helium Health.

He notes that 90% of facilities have been relying on paper records. "You can't start to solve problems until insurance providers, pharmaceutical companies, and others have data visibility and access into the market, which right now is seen as a black box," he says.

Today, Helium Health operates in Nigeria, Ghana, Liberia, and Kenya, and it will be expanding into Morocco, Algeria, and Tunisia before the year is over. It has collected $12 million in funding from global investors to provide digital infrastructure to health care facilities. And it's become the largest health care technology provider in West Africa, serving thousands of doctors and moving into areas like telehealth and payment processing.

Helium Health has also been assisting with facilities' COVID-19 response by setting up virtual care platforms. As airports shut down in Africa, people who were accustomed to traveling to India, the United Kingdom, or the United States to meet their health care needs were grounded at home. They encountered shortages—ranging from cancer centers to MRI machines—in Africa.

"For the first time since the military rule in the 1990s, people couldn't just access health care outside the continent," Olubusi says. "We had to face the reality of what happens when you don't invest in the health care sector. And now everyone is open to conversation because they can see it's real."

After graduating from Johns Hopkins, Olubusi worked as a software and product engineer for companies including Goldman Sachs, eBay, and PayPal. His work as a founding board member of the social media company Yookos helped guide the thinking behind Helium Health, inspiring the creation of an intuitive experience that looks and feels like a social media platform. Olubusi also co-founded Magic Fund, a venture capital fund of startup company founders that backs transformative work.

In the near future, Olubusi intends to focus on making sure Helium Health spreads across Africa, adapting its vision of technology and data to fill the needs of diverse cultures. "It's really the process of establishing that same vision in Morocco or in Kenya," he says. "It's a big task for us."

— TRACY VOGEL

A New Coin of the Realm

IF MARK R. STOUDT HAS DONE HIS JOB WELL, YOU'LL NEVER NOTICE THE CHANGE.

Stoudt MS '92, PhD '00 is a materials scientist at the National Institute of Standards and Technology and a member of the small team responsible for a new alloy expected to be used for the U.S. nickel.

It'll look the same. It'll feel the same. "That was the whole point of it," Stoudt says. "[As a consumer], it's one of those things where you don't know what's going on behind the curtain and you don't care, as long as you put your coin in the vending machine and get the bag of chips."

Around 2006, the nickel started costing more to make—just over 7 cents per coin—than it was actually worth, triggering the hunt for a less expensive replacement alloy. That's a lot more challenging than it sounds; a striking variety of factors go into the makeup of the nickel. It has to have the right color. It needs to resist corrosion. It can't be too brittle so it cracks when it's struck, but it can't be soft enough to wear away easily. It has to have a consistent weight. It even has to have the same electrical conductivity, because that's how vending machines identify it.

The U.S. Mint turned to NIST's Materials Measurement Laboratory to investigate the solution. Over the course of three years, Stoudt, metallurgist Carelyn Campbell, and materials research engineer Eric Lass used a combination of computer modeling and measurements of material properties to come up with the best possible alloy while saving 25 to 40% on the current cost of the coin. Four patents arose from the work, and in December, the group was awarded the U.S. Department of Commerce Bronze Medal.

Stoudt has been with NIST since 1986, starting there shortly after earning an ASE in chemical engineering and a BSE in metallurgical engineering from Penn State. He would later attend Johns Hopkins to obtain both his MSE and PhD. "I wanted to be a chemical engineer back in eighth grade," he recalls. "It's one of those things where research gets into your blood and you're trained to attack a problem a certain way, and you start acquiring skills. I'm not doing anything directly related to my PhD research, but the skills I learned are applied on a daily basis."

Stoudt is currently working on projects involving additive manufacturing processes, or 3-D printing. The technology "has opened up areas of design space that were off-limits until a few years ago," he says.

But Stoudt looks back fondly on his days with the nickel. "It was fun to work on. I learned more about the interplay of these characteristics and how it relates to what I would be testing," he says. "You're always learning."

— TV

OPPOSITE PAGE: PHOTO COURTESY OF LINDA CURETON.

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Opening Doors

LINDA CURETON WAS DECIDING ON HER NEXT STEP. SHE'D JUST FINISHED NINE YEARS AT NASA, including more than four years as chief information officer for the entire agency, where she was responsible for the information technology decisions across all NASA centers.

She had another CIO job locked down. But as she talked with the person offering her the position, she told him that she had decided to focus on her own company.

"When I started thinking about what really mattered to me, what was important were three things: I want to do what I love, work with people that I love, and help them enjoy and love what they do. Owning my own company was how I could do that," she says today. "I closed a door behind me and opened a door in front of me, and that's the world I'm in now."

Cureton MS '98, post-masters's certificate '99, began Muse Technologies in 2013. Muse assists businesses with technology and management planning and training, organizational planning and training, and administrative support. "We're the company that I wish I'd had to help me do the things I had to do as a CIO and as an executive," Cureton says. "A company that's well-rounded, flexible, and nimble, and helps executives be successful."

Before joining NASA's Goddard Space Flight Center in Maryland as CIO, and eventually moving up to become NASA CIO, Cureton had successfully advanced technology efforts at the Department of Justice, the Department of Energy, and the Bureau of Alcohol, Tobacco, and Firearms. During her time at NASA, she worked through an IT infrastructure consolidation of contracts worth more than $4 billion, with savings of $120 million annually.

Today, Muse Technology is assisting clients with pandemic-related organizational changes, including transitioning to and managing off-site workforces. Cureton is also finishing up her PhD, with her research focusing on the leadership of complex organizations. She offers a music analogy to describe the complexity: "It's like a jazz ensemble—a lot of improvisation, changes, taking advantage of opportunities, people jumping in and taking charge and other people stepping back."

She's also focusing efforts on what she calls "pink architecture," which began as an exploration of how women and women of color can navigate and work in technology-based environments. It has developed into a support community for women and men that holds events ranging from lunchtime Zoom meetings to leadership conferences.

"I love that," she says. "If I retire, I'll be on the beach and in my spare time working on pink architecture. I want to reach and help as many people as I can, and as many people that's practical."

— TV

Aerial Artistry

“This gives me a sense of artistic and spiritual accomplishment—something like a sculptor must feel.”

— SATHAPPAN RAMESH

Sathappan Ramesh has trained at the New England Center for Circus Arts and with teachers locally to become an accomplished aerial silk performer. Before the pandemic, he often performed at Mobtown Ballroom in Baltimore.

MOST PEOPLE SCARED OF HEIGHTS SIMPLY AVOID THEM. Not Sathappan Ramesh. Instead, he regularly performs feats of acrobatic skill suspended 26 feet above the ground on a long strip of fabric.

Ramesh is a practitioner of aerial silks, an artform that blends dance, yoga, circus skills, and choreography to create something entirely new. Clad in compression tights custom-painted in ethereal designs, he performs climbs, wraps, and drops in routines set to music ranging from Carl Orff’s “Carmina Burana” to Yanni’s “On Sacred Ground,” while audiences stare from below, transfixed.

“This gives me a sense of artistic and spiritual accomplishment—something like a sculptor must feel,” says Ramesh, senior laboratory coordinator in the Department of Electrical and Computer Engineering. “I consider the aerial apparatus like a deity, because it protects me and keeps me safe.”

Ramesh learned about this art form in 2009, when friends invited him to a workshop. Initially reluctant due to his fear of heights, he was surprised to fall in love with the experience. He began to take classes, even training at Vermont’s New England Center for Circus Arts. In nonpandemic times, he performs regularly at Mobtown Ballroom and at other local studios.

Though aerial silks is definitely an art, his background in physics helps him appreciate the science involved. “I use physics to do things like spinning, rotating, mounting, and balancing,” he says. “But you don’t need to know advanced physics or equations to do aerials. You just learn the techniques, be strong and flexible. And practice—a lot!”

— LISA DENIKE ERCOLANO

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Breathing Easier During COVID-19

Six third-year students at Johns Hopkins are on a mission to help combat the COVID-19 pandemic by designing leak-proof masks that can be used with ordinary CPAP machines to deliver breathing relief to hospitalized COVID-19 patients.

The students—Varahunan Mathiyalakan, Min Jae Kim, Ankur Govil, Joshua Ni, Adam Kenet, and Noah Sobel, who collectively represent the departments of Biomedical Engineering, Chemical and Biomolecular Engineering, and Biophysics—formed their team earlier this year when the United States faced a national shortage of ventilators to treat COVID-19 patients, and they've been hard at work ever since.

"The problem is that the masks often leak, so they have the potential to spread virus particles," says Mathiyalakan.

So far, "Team AirTight" has designed more than 10 functional prototypes and developed unique testing protocols to verify mask efficacy. The students plan to begin clinical testing at the Johns Hopkins Hospital soon.

— SARAH TARNEY