THE JOHNS HOPKINS WHITING SCHOOL OF ENGINEERING MAGAZINE

JHU ENGINEERING

WINTER 2025

On the Ground in India

Students seek solutions to global health challenges.

Vision Envisioned

In the lab with Alan Yuille.

The Candy Man Can

An alum's sweet life in making treats more sustainably.

Road Warriors

Air pollutants have met their match in Peter DeCarlo and his lab on wheels.

FROM THE DEAN

Dear WSE community,

THE "HOMEWORK APOCALYPSE," A TERM COINED BY ETHAN MOLLICK, A WHARTON PROFESSOR WHO studies artificial intelligence and innovation, refers to the idea that AI soon will be able to complete most traditional homework assignments, "rendering them ineffective as learning tools and assessment measures." A study he cites reveals that even as students' homework scores increased with access to AI and the internet, their overall test scores declined. Clearly, access to answers does not correlate with understanding.

As educators, we need to find ways to embrace these technologies and realize their potential to enhance learning while we also preserve—and improve—the qualities that define a Johns Hopkins education and for which there is no digital substitute, such as small classes and a learning environment that fosters the exchange of ideas.

The timing of this new imperative aligns with changes that are already underway here, resulting from the findings of CUE2, JHU's Second Commission on Undergraduate Education. We are reimagining how we educate our students and what core elements should count toward completing a major of study.

Starting this year, all incoming undergraduate engineering students will complete a small-group, discussion-based or design-based, first-year seminar. We have also greatly expanded our advising and mentoring program to pair students with faculty members to discuss early-career ideas, internships, and research opportunities; connect students with the academic community; and respond to nuanced questions about course-specific content. And students are still advised by academic professionals to help them successfully navigate the curriculum, ensuring completion of their engineering majors.

With these and other new programs whose success is dependent on interpersonal relationships, our charge now is to leverage AI-based technologies to further our mission to improve one-on-one learning, enhance mastery of concepts, and support students in charting their own academic paths.

AI has made information ubiquitous, and the way we educate our students is changing. There is no longer a direct transfer of knowledge from expert to pupil. Traditional lectures may become obsolete, replaced by more seminar-based discussions where students debate their own ideas about a concept. We can't outsmart AI or pretend it doesn't already have a seat at the table. Our challenge is to integrate it into education to make learning engaging, evidence-based, and equitable.

Best wishes,

ED SCHLESINGER
Benjamin T. Rome Dean

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Cover photography by Bloomberg Philanthropies

A Boost for Cancer Moonshot

A JOHNS HOPKINS ENGINEERING-LED TEAM HAS BEEN AWARDED $20.9 million over five years to enhance surgical capabilities to treat cancer.

The award is part of $150 million in funding announced in August by the Advanced Research Projects Agency for Health (ARPA-H) in support of the Biden administration's Cancer Moonshot initiative.

Led by Emad Boctor of the Laboratory for Computational Sensing and Robotics and the Malone Center for Engineering in Healthcare, the team includes collaborators from JHU's schools of Engineering and Medicine, the University of Texas Southwestern Medical Center, the National Institutes of Health Clinical Center, and industry partners.

They are developing a noncontact photoacoustic endoscope designed to give surgeons an enhanced view of the surgical field without disrupting workflows. When paired with a multicancer fluorescent contrast agent, this tool enables surgeons to identify and remove microscopic cancer remnants during tumor-removal procedures.

The project also explores using existing fluorescent dyes with the new endoscope to visualize critical anatomical structures, such as hidden blood vessels and nerves, to avoid accidental damage during surgery.

This effort is part of the ARPA-H Precision Surgical Interventions program, which seeks to improve surgical outcomes for cancer patients. By making surgeries more effective and reducing the need for repeat procedures, the program aims to extend and save lives.

"This project exemplifies our commitment to life-changing innovations that directly improve human health," says Ed Schlesinger, the Whiting School's Benjamin T. Rome Dean.

The team is working on a prototype and anticipates beginning human trials within five years. Other key contributors include Johns Hopkins researchers Jin U. Kang, the Jacob Suter Jammer Professor; Peter Kazanzides; and Russell H. Taylor, a John C. Malone Professor, alongside industry and institutional partners.

Additionally, Nicholas Durr of the Department of Biomedical Engineering has received ARPA-H funding to partner with collaborators at Dartmouth College to develop a novel laparoscope that could improve robotic cancer surgeries.

— JAIMIE PATTERSON

THIS PAGE: ILLUSTRATION BY CECILIA CASTELLI.

AWARDS AND HONORS

LAUREN GARDNER, the Alton and Sandra Cleveland Professor of civil and systems engineering and director of the Center for Systems Science and Engineering, received the Future Insight Prize from Merck, a global life sciences conglomerate based in Germany. The award recognizes her contributions to developing artificial intelligence systems capable of discovering and tracking future pandemics. Gardner led the creation of the COVID-19 dashboard, the pandemic's most comprehensive public dataset.

Gardner has created predictive models for diseases including Zika, dengue, and MERS-CoV with goals of enhancing outbreak detection, creating an open data repository, and integrating public health policies in the design of these systems.

YUN CHEN, associate professor of mechanical engineering, is one of five recipients of the National Science Foundation's inaugural Trailblazer Engineering Impact Award. The three-year grant supports her research using quantum mechanics to control cellular behavior. Chen aims to engineer synthetic proteins, called quantum-enabled dials, that can be modulated by magnetic fields to control biochemical reactions. Read more on p.5.

RUI NI, associate professor of mechanical engineering, received a Gordon and Betty Moore Foundation grant to study the impact of background turbulence in storms on lightning formation. By replicating electrified storms in his lab, Ni seeks to understand how turbulence segregates charged particles and how such particles influence geophysical events and industrial processes.

FACTS AND FIGURES

While numbers may not tell the whole story, these statistics and highlights offer some insights into just how talented, driven, inspiring, and accomplished the members of Johns Hopkins Engineering's class of '28 are.

GPA AND ACCEPTANCE RATE

GPA **3.96**

Admit Rate **6.5%**

HOW FAR FROM HOME?

Closest: Baltimore, MD

1.11 miles

from Gilman Hall

Farthest: Singapore

9,627.94 miles

from Gilman Hall

FIRST GENERATION TO ATTEND COLLEGE

20.6%

WHERE DO THEY CALL HOME?

35 U.S. states, the District of Columbia, Puerto Rico, and Guam

17 countries outside the U.S.

SPECIAL TALENTS AND ACCOMPLISHMENTS

Kathryn Prather, youngest delegate to the 2024 Democratic National Convention from West Virginia

Isaac Kim, first-place violinist at the U.S. International Open Music Competition and concertmaster for a Carnegie Hall showcase

Max Siauw, Guinness World Record for the fastest time solving the Square-1 cube—a type of Rubik's Cube

A New Energy Hub in Baltimore

JOHNS HOPKINS UNIVERSITY IS BUILDING A RENEWABLE ENERGY LAB IN BALTIMORE'S REMINGTON NEIGHBORHOOD THAT WILL FOCUS ON energy transition innovations, including carbon management, energy storage, wind power, and grid optimization.

The 12,000-square-foot facility, known as R.Labs, will include research laboratories and an advanced materials discovery and manufacturing process center, and is being constructed above the existing R. House food market.

The project is funded through a $1.25 million award from the Maryland Department of Commerce's Build Our Future Grant Pilot Program to Johns Hopkins' Ralph O'Connor Sustainable Energy Institute (ROSEI).

"It's a win for Baltimore because it will anchor a new energy hub in our city and build on Remington's reputation for entrepreneurship," says Ben Link, ROSEI's deputy director.

"It's a win for the state of Maryland as well because energy technology will be a major economic driver in the years ahead, making this a direct investment in stimulating the state-level economy."

The facility will accommodate research on portable electric battery design and the manufacturing of offshore wind projects, the modeling of increasing renewables and distributed energy resources, and the application of artificial intelligence and machine learning to clean energy challenges.

Local tech companies and startups will also have access to the new space upon completion, which is planned for late 2025.

The project fulfills the aspiration of Ben Schafer, the Willard and Lillian Hackerman Professor of Civil and Systems Engineering and ROSEI's founding director, who aimed to build the facility in response to faculty who expressed the need for an advanced-capabilities clean energy space. "R.Labs is the first step in meeting these needs," Schafer says.

— WICK EISENBERG

A Powerful Tool for Cancer Detection

JOHNS HOPKINS ENGINEERS HAVE CREATED A NEW OPTICAL TOOL THAT could improve cancer imaging. Their approach, called SPECTRA, uses tiny nanoprobes that light up when they attach to aggressive cancer cells, helping clinicians distinguish between localized cancers and those that are metastatic.

"Our findings show that SPECTRA has huge potential for cancer detection and imaging," says team leader Ishan Barman, professor of mechanical engineering. "We're giving clinicians a more powerful tool that can find cancer cells earlier and more precisely than ever before."

The research appeared in *Advanced Functional Materials.*

SPECTRA leverages a first-of-its-kind combination: Raman spectroscopy—which uses the scattering of laser light to provide detailed information about molecular vibrations—and DNA origami, which involves folding DNA into specific shapes. The researchers used the folded DNA as a scaffold to create precisely arranged plasmonic nanoparticles: Raman reporters (molecules that produce a strong signal when analyzed using Raman spectroscopy) and cancer-targeting DNA sequences. Then they tested these nanoprobes on cancer cells.

They found that SPECTRA effectively and consistently bound to metastatic prostate cancer cells and even differentiated between those and nonmetastatic cells—unlike CT or MRI scans, which can indicate the presence of a tumor but not the specific molecular signatures that can alert physicians to current or impending metastasis.

The researchers also identified a Raman reporter that results in an active and distinct signal in a range that made it stand out against the background of normal tissue, helping clinicians more precisely locate disease.

"It's a smart design that gives high enhancement to the Raman signal, and it's uniform," says team member Swati Tanwar, a mechanical engineering postdoctoral fellow. "It can distinguish aggressive cancer cells from nonaggressive based on the intensity of the signal. In a tumor, if 10% of the cells are aggressive and 90% are nonaggressive, the 10% will light up and give a very high signal."

Tanwar explains that each strand of DNA in the origami scaffold has a unique sequence and occupies a specific position in the folded origami nanostructure. This meticulous arrangement facilitated the creation of the multifunctional SPECTRA nanoprobe.

"Raman spectroscopy is a molecular fingerprinting tool," adds team member Lintong Wu, a mechanical engineering PhD student. "Molecules can look similar at a distance, but using Raman spectroscopy, [we can] show different peaks and signals throughout the entire spectrum."

— JONATHAN DEUTSCHMAN

Ishan Barman

THIS PAGE PORTRAIT OF ISHAN BARMAN: WILL KIRK/HOMEWOODPHOTO.JHU.EDU; OPPOSITE PAGE: ILLUSTRATION GENERATED BY DALL-E3.

Powering Through the Freeze

RESEARCHERS AT THE WHITING SCHOOL AND JHU'S APPLIED PHYSICS LABORATORY (APL) ARE DEVELOPING LITHIUM-ION BATTERIES CAPABLE of operating in some of the world's coldest environments.

Traditional lithium-ion batteries fail in frigid temperatures because the liquid electrolyte that facilitates the electric charge freezes, rendering the battery inoperable. To address this, a team led by Jesse Ko, a senior staff scientist at APL, and Yayuan Liu, Russell Croft Faculty Scholar and assistant professor in the Whiting School's Department of Chemical and Biomolecular Engineering, is exploring solvent combinations that would create disorder—called "entropy"—in the electrolyte, lowering its freezing point and ensuring the battery's performance.

"As long as we increase entropy in a controlled manner, we can lower the electrolyte's freezing point," Ko says. "We'll be investigating various solvent combinations, but it's tricky because there are almost infinite possibilities."

Finding the right solvent combination through trial and error is extremely time-consuming. To accelerate the process, the team will use high-throughput experimentation, artificial intelligence robot-controlled electrochemistry, and machine learning (ML) to identify entropy-generating factors.

"We'll collect a lot of data with high-throughput experimentation, then feed it to an ML algorithm to help us find ideal conditions for creating entropy in the electrolyte," says Liu, an associate researcher in the Ralph O'Connor Sustainable Energy Institute.

The researchers also hope to achieve lab automation. "The idea is to conduct experiments with the robot, feed the results to the ML model, and have the model provide feedback on what combinations work better, creating a loop that accelerates materials discovery," says Liu.

Their work is timely and has far-reaching implications. "Climate change creates new challenges in the Arctic, where temperatures can reach -40° to -75°F," says Ko. "If you send a soldier or drone out there, you want the equipment to function as it should."

— **WICK EISENBERG**

3 Questions

Quantum Solutions

Interview conducted by Jonathan Deutschman

Yun Chen, associate professor of mechanical engineering, is one of six inaugural recipients of the National Science Foundation Trailblazer Engineering Impact Award. Her focus is on engineering a class of synthetic proteins that could be a game changer in cellular biology.

1 How is your approach trailblazing?

We are in the middle of the "second quantum revolution," with quantum technology promising unprecedented advances. This project is a first step toward realizing quantum mechanics' potential in biomedicine. "Are the laws of quantum physics important for life?" was a question raised by early quantum pioneers. This led to the emerging field of quantum biology, where quantum phenomena may regulate certain biological functions. The development of a new class of synthetic proteins, quantum-enabled dial (QED), could serve as a testbed for in vivo measurements that validate theoretical predictions in quantum biology.

2 What's the main objective of your project?

QEDs can control biochemical reactions, harnessing the power of quantum mechanics in engineered biomolecules to actuate biological functions. We're developing genetically encoded QEDs—recombinant proteins where the backbone is a spin-correlated radical pair that forms when excited by light. I'll use this magnetosensitivity to demonstrate that specific biochemical reactions can be actuated by QED. I'll also explore the possibility of exciting QEDs without light, enabling applications in thick tissues.

3 What transformative applications could this technology bring?

This will impact many fields because QED activity can be tuned on a continuous scale. It can be excited by light or by chemical energy. It is modular and can be designed to control numerous enzymatic activities, which can be spatially addressed by patterned magnetic fields. Lastly, QED has long-lived coherence time, the most desirable feature for quantum computing. Because of all these merits, QED can be used to solve grand challenges in synthetic biology, tissue engineering, medicine, and quantum computing.

Building Doctors' Trust in AI

WHILE ARTIFICIAL INTELLIGENCE-POWERED SYSTEMS CAN IMPROVE CLINICIANS' DIAGNOSTIC accuracy during telehealth visits, doctors still don't fully trust algorithms to screen patients. That's according to a recent study by Johns Hopkins researchers, which they say highlights the need to improve human-AI collaboration.

"Physicians do better with AI assistance, yet they still hesitate to alter their practices significantly as a result. For example, they will still frequently ask telehealth patients to visit the clinic for definitive testing," says Mathias Unberath, John C. Malone Associate Professor of Computer Science and a member of the team whose study appeared in *Nature Communications Medicine*.

Unberath and Therese Canares, a Johns Hopkins emergency medicine physician, used a smartphone-based AI system they developed (CurieDx) to examine "explainable" AI's potential to enhance clinicians' trust in AI-driven diagnostic tools. They specifically focused on how doctors use and perceive the system's explanations of strep throat diagnoses, which rely on analyzing smartphone images of users' throats.

The researchers created mockups featuring techniques the AI system might use to explain its diagnoses, including highlighting key visual features and providing examples of images it already analyzed and accurately diagnosed as either strep or not.

The team had clinicians review the mockups, measuring their agreement with CurieDx's resulting diagnostic recommendations, perceived trust in the system, and how the explanations influenced physicians' recommendations.

"We found that explaining by example was the most promising method," says lead author Catalina Gomez, a PhD student in computer science.

The researchers theorized that this type of explanation was the most successful because it most closely mirrors human clinical reasoning, which involves incorporating prior experience in the analysis of a patient's condition.

"This kind of explanation improved the accuracy of the clinicians' decisions. The providers also trusted the AI-generated predictions just as much as they trusted the diagnoses produced by their customary clinical prediction rule, which acted as our baseline," says Gomez.

Even so, the clinicians in the study often felt it was necessary to ask patients diagnosed remotely to visit the clinic for a follow-up. "This opens the dialogue to examine clinical workflows that incorporate AI screening tools," says Canares.

The team plans to continue exploring explainable AI methods to help users better understand how AI-powered systems work and further enhance user trust in those systems.

— JAIMIE PATTERSON

"When an environment gets tougher, you group together."

8/1/24 ***The New York Times***
Rui Ni, Mechanical Engineering, on a study that shows that when fish form a group in turbulent waters, they expend less energy than when traveling solo.

"Many bridges simply weren't built to withstand the pressures of today's maritime landscape."

5/31/24 Associated Press
Rachel Sangree, Civil and Systems Engineering, on vulnerabilities of structures such as Baltimore's Francis Scott Key Bridge, which collapsed in March 2024 when hit by a container ship.

"Knowing more about people—who they talk to, where they go, where they socialize—is a treasure trove for people who ultimately would want to do harm."

7/12/24 ***The New York Times***
Anton Dahbura, Computer Science, executive director of the Johns Hopkins Information Security Institute, on the data breach that affected AT&T customers.

"All of this information happens after you finish the surgery, so if this bad news happens later, then it's too late."

8/21/24 CBS News Baltimore
Emad Boctor, director of the Medical UltraSound Imaging and Intervention Collaboration Research Laboratory, about the issue of cancer cells being left behind following surgery. He and colleagues are developing a technology to solve this problem. (See story pg 2).

Alarming Trends in Opioid Deaths

In the early years of the COVID-19 pandemic, opioid-related deaths cut the nation's average life expectancy at birth by eight months, according to a new Johns Hopkins study. Overdose deaths nearly doubled for Black, Hispanic, and American Indian/Alaska Native communities.

The study, led by Alison Hill, assistant professor of biomedical engineering, and postdoctoral researcher Anne H. Hébert, examines how the opioid epidemic evolved since COVID-19's onset, which disrupted support systems, economic stability, and health care access.

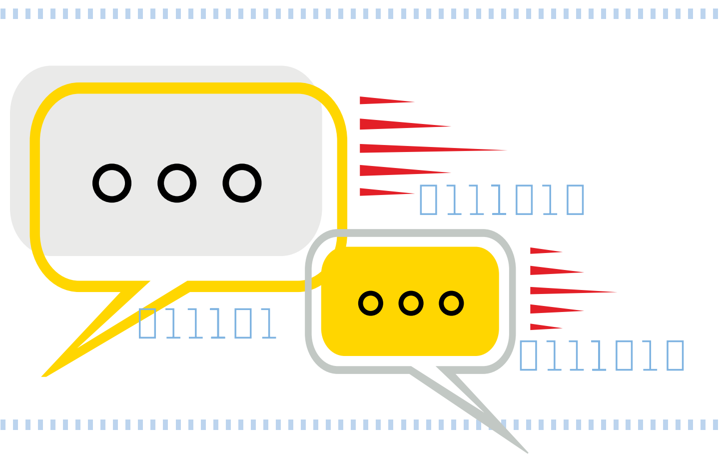
In 2022, over 80,000 of the 3.3 million U.S. deaths were caused by opioid-related overdoses. These deaths predominantly affected young adults, who lost an average of 38 years compared to U.S. life expectancy.

"Just the number of deaths alone hardly captures the enormous burden of the opioid crisis on this country," says Hill, senior author of the study in *The Lancet Regional Health–Americas*. "These are people in their 20s and 30s—it's taking away a huge number of potential years where they could have lived and contributed to society."

Using CDC mortality data, their analysis showed what was once viewed as a "rural white problem" was seeping into other racial and ethnic communities. Additionally, "polysubstance" overdoses involving multiple drugs made up about half of opioid-related deaths, with combinations of opioids and stimulants proving particularly fatal.

The researchers have made their analyses available through a public dashboard and plan regular updates.

— CATHERINE GRAHAM



'Jailbreaks' Threaten Low-Resource Languages

THE LARGE LANGUAGE MODELS (LLMS) THAT POWER MANY POPULAR TEXT-BASED ARTIFICIAL INTELLIGENCE APPLICATIONS ARE VULNERABLE TO jailbreaking attacks, during which a user enters a malicious prompt to bypass an application's guardrails to trick it into making inappropriate or harmful content.

New research by Johns Hopkins computer scientists has found that low-resource languages, such as Armenian and Māori, are more vulnerable to these attacks since there is limited text data available for AI model training.

The study, published in the proceedings of the 62nd Annual Meeting of the Association for Computational Linguistics, highlights a significant issue with serious implications for multilingual applications, the researchers say.

"The discrepancies stem from the initial training stage, when the LLMs are exposed to only a small amount of data in these languages with limited resources," says lead author Lingfeng Shen, MS '24, now a research scientist at ByteDance. "This means the root issue is that there simply isn't enough data available for less widely used languages during the model's first training process."

"Ensuring that LLMs can safely interact with users in various languages, including those with fewer resources, is critical for inclusivity and global applicability," says team member Daniel Khashabi, an assistant professor of computer science and a member of the Center for Language and Speech Processing. "If these systems are not safe and reliable across all languages, it could lead to misinformation, harmful content dissemination, and overall decreased trust in AI technologies."

The researchers encourage those training the next iterations of popular LLMs to include more data from low-resource languages such as Mongolian, Urdu, and Hausa. They also suggest developing new approaches for handling languages with limited data for training AI models.

"Our research advocates for more equitable AI development that considers the linguistic diversity of all users," says Khashabi.

— JP

OPPOSITE PAGE: WILL KIRK/HOMEWOODPHOTO.JHU.EDU.

TECH TOOLS

Cheaper Carbon Capture

Researchers at Johns Hopkins Engineering have developed a benchtop prototype device designed to capture carbon dioxide from the atmosphere by harnessing the unique interactions between electricity and indigo—the iconic, inexpensive, and readily available dye used in blue jeans. The team's innovative design, described in *Advanced Functional Materials*, presents a cost-efficient alternative to traditional carbon capture methods.

Working in a simulated environment resembling a factory's exhaust stream, the researchers showed promising results. "Our tests showed that this indigo-based system operates at 80% of the maximum theoretical efficiency," explains Krish Jayarapu, a third-year student in chemical and biomolecular engineering, who worked with Assistant Professor Yayuan Liu on the prototype. "Indigo's chemical properties allow it to latch onto carbon dioxide when electricity is applied and then release it when the current is reversed."

The new prototype device's electrical process achieves optimal carbon capture efficiency while using low-cost materials and a modular design, making it scalable for both small devices and large industrial applications.

— EMILY FLINCHUM


RAM

ROAD WARRIORS

Air pollutants have met their match in environmental scientist Peter DeCarlo and his lab on wheels.

BY Dale Keiger, A&S '11 (MLA)

PHOTOGRAPHY BY Will Kirk and Bloomberg Philanthropies

PETER DECARLO

steps back and watches as a colleague dressed in shorts and red, white, and blue sneakers climbs the front of a large white Dodge Ram 3500 ProMaster van. They have parked outside a coffee shop in Baltimore County, Maryland, because their GPS unit is not behaving. DeCarlo is an environmental engineer at the Whiting School, and the van is an instrument-crammed mobile laboratory called MOM+POP—Mobile Observatory Measuring Particles and Other Pollutants. Atop the van's roof is a long, horizontal tube. Benjamin Nault, the man now standing on the sloping hood, detaches from it a conical white component involved with location, wind direction, and temperature readings. Then he demonstrates that sometimes the only way to get optimal performance out of some very expensive lab equipment is to remove a piece and blow into it.

We climb back into the van and find that something—Nault's respiration, jiggling a few cables, divine intervention, who knows?—has restored the GPS to proper function. We pull back out onto the road and drive toward a natural gas pipeline and pumping station near a park called Oregon Ridge. DeCarlo is curious to measure how much, if any, methane might be escaping into the atmosphere.

He is an associate professor in the Whiting School's Department of Environmental Health and Engineering. For 20 years, he has used advanced instrumentation in airplanes, vans, and, on occasion, a backpack to sample and analyze the air, looking for substances that impact the environment and climate and do not belong in human lungs.

After securing funding from Bloomberg Philanthropies, he collaborated with Aerodyne Research, a private company, to build MOM+POP and begin making detailed air pollution measurements. His team took delivery of the van in late 2023 and has been road-testing it in New York, Delaware, and Maryland before they head south to the Gulf states later this year or early next year for a project funded by the Bloomberg Philanthropies' Beyond Petrochemicals initiative.

"There's a getting-to-know-it period," DeCarlo says of the lab. "We're doing a lot of stuff locally to really try to figure out what works and what we need to improve."

The DeCarlo team's mission is to figure out what chemicals and particles are in our air, how much of this stuff is out there, and where it's coming from. The EPA and others monitor air quality from fixed sites, but there are drawbacks to that method. Regulatory fixed sites are expensive, which limits how many can be deployed. Data from a fixed site has its uses, but it provides, at best, a limited picture. Driving the MOM+POP mobile lab, DeCarlo can find emissions hotspots, correlate their data with factors such as wind direction, and document how far pollutants travel in the atmosphere and who might be affected.

It's All in the Plumbing

Earlier in the day, DeCarlo and Nault had rolled out of a leased garage space near the Johns Hopkins Homewood campus. DeCarlo drove. Nault, an assistant research scientist in the DeCarlo Lab and a research scientist with Aerodyne Research, gingerly threaded his legs around cables and a gimbal that supports a large computer monitor to take the middle spot on the bench seat. In his lap he set a wireless keyboard, where he sifted through several data displays and instrument readouts, making sure everything seemed to be online and working. His job today would be to monitor the instruments and take detailed notes as the researchers drove about the city and county. A second Ben, assistant research scientist Benjamin Werden, stayed behind in the garage to work on an instrument that they eventually will install in MOM+POP.

Bolted into the van behind DeCarlo and Nault is a set of racked instruments and power units. Behind the passenger seat, there's an aerosol mass spectrometer. That one measures the size and chemical composition of particles

in the air samples. There's also a proton transfer mass spectrometer, which monitors volatile organic compounds. It's coupled to a gas chromatograph that performs additional analysis and toggles measurement back and forth between itself and the proton transfer mass spectrometer. To power all of this gear, there's a portable generator and a rack of batteries. Everything produces heat, so there's an additional air conditioner unit. Wires and cables snake everywhere, and there are a lot of tubes. (Plus DeCarlo's travel mug, which bears a sticker that reads "Best Dad Ever"—he has two sons.) The air intake on the roof juts over the van's nose, and the tubes route the air to the various instruments.

When asked about the multiple research disciplines his team applies to its fieldwork, DeCarlo first says, with a faint smile, "Plumbing. You think I'm joking, but I'm not. We draw air into instruments, and to do that, we need to put the tubes somewhere. Getting all that set up, splitting tubes from one instrument to another instrument, involves a lot of compression fittings and different materials, from copper to stainless steel to Teflon, and knowing how all those pieces fit together." He advises prospective students that if they come to his lab for a PhD, they will do fun science plus become handier around the house.

The major instruments have to combine extraordinary sensitivity with sufficient ruggedness to be useable in the field. They are housed in racks equipped with shock absorbers, but DeCarlo slows the van to ease it over railroad tracks and patches of torn-up pavement. Out on the road gathering data or back in the garage, he and the Bens routinely have to be scientists one minute, engineers the next, computer techs after that, and sometimes guys with hand tools. They seem to enjoy the challenge of being researchers adept at fixing things on the fly. If a spectrometer acts up in the field, they can't send it back to the vendor. Computer glitches need to be fixed in situ. And sometimes you just have to stop and blow into the GPS.

"It's not a road trip," DeCarlo says. "It's not getting onto the interstate and putting it in cruise control and listening to some tunes. There are a couple of million dollars' worth of instruments in the back of the van that you need to be concerned about."

Northbound on Interstate 83, known locally as the Jones Falls Expressway, Nault points at the monitor where a graph showing nitrogen oxides spikes every time a truck rolls past. Out in the county on a two-lane road, they pass a BBQ joint, and DeCarlo says, "That smells good." Atmospheric scientists supplement scientific instruments with their noses. DeCarlo cycles for fitness and often finds himself wondering what instruments might reveal about something he's picked up with his onboard olfactory sensor.

Around the Oregon Ridge natural gas pipeline and pumping station, the van picks up no alarming readings on methane levels. The natural

"Johns Hopkins MOM+POP van is giving researchers the data they need to hold polluters accountable and curb the production of petrochemicals,"

says Michael R. Bloomberg, the founder of Bloomberg L.P. and Bloomberg Philanthropies, and the UN Secretary-General's Special Envoy on Climate Ambition and Solutions. Bloomberg funded the project because he believes it has the potential to help save countless lives.

"

It's not a road trip. It's not getting onto the interstate and putting it in cruise control and listening to some tunes. There are a couple of million dollars' worth of instruments in the back of the van that you need to be concerned about.

PETER DECARLO

"

gas infrastructure in the U.S. is old and leaky, especially on the East Coast. DeCarlo recalls receiving a video from **Ellis Robinson**, a Whiting School research engineer. Robinson was doing a walking survey of a pipeline right of way in a county park outside of Pittsburgh when he came upon puddles bubbling with escaped natural gas. The pipeline beneath Oregon Ridge runs under a public park too, and one day DeCarlo was able to hike along a good bit of it wearing a sampling unit in a backpack. He detected two leaks. Data from that walk went into a paper that was under revision at press time. "Sometimes 'mobile' means using your feet," he says.

Sampling in 'Cancer Alley'

Ethylene oxide (EtO) is a chemical that has its uses, especially as a disinfectant. For example, hospitals use it to sterilize things that can't be run through an autoclave, like pacemakers. Plus, it is used to manufacture detergent, plastics, other chemicals, and solvents. But you do not want it in the air you breathe. EtO is mutagenic and carcinogenic. Online information from the Union of Concerned Scientists notes: "Chronic exposure to EtO through inhalation is associated with the development of cancers of the white blood cells, such as non-Hodgkin lymphoma, myeloma, and lymphocytic leukemia. Studies have also shown a relationship between EtO exposure and breast cancer in women. Also, because EtO is mutagenic—meaning it can change a cell's DNA—children may be especially susceptible to its cancer-causing effects."

Despite the recognized hazards, there has been little reliable monitoring of ambient atmospheric concentrations around the plants that produce or use EtO. The Environmental Protection Agency maintains some static air quality monitors, but for various reasons, they are not effective at measuring how much ethylene oxide is in the air at any given moment around or downwind of an emissions point source.

In February 2023, Bloomberg Philanthropies provided support for DeCarlo and other researchers to use an Aerodyne mobile lab and a second lab they put together themselves in a rented cargo van to sample the air in a section of southeast Louisiana that bears the unenviable nickname "Cancer Alley." They were looking for EtO in particular, and they found it. That didn't surprise them, but the quantities did.

By EPA standards, any EtO concentration of more than 11 parts per trillion constitutes a health hazard. The Johns Hopkins-led team found areas near chemical facilities that had concentrations of 40 parts per billion. That corresponds to exposure roughly 1,000 times higher than what is recommended, according to DeCarlo. Driving on surrounding roads, the researchers detected problematic EtO levels more than 10 kilometers downwind of the facilities.

Robinson, the study's lead author, says, "We know very little about EtO concentrations in the atmosphere—the accumulated literature on ethylene oxide is so scarce, while the societal focus on ethylene oxide is so intense—and so any reports of accurate EtO concentrations are very valuable right now." The study appeared on June 11 in the journal *Environmental Science & Technology*. The EPA recently tightened restrictions on EtO emissions from commercial sterilizing facilities and chemical facilities producing ethylene oxide.

Science with Social Purpose

When it came time to pick a field for graduate study, DeCarlo says, "I wanted to do something that involved chemistry and computation and data, and atmospheric science checked all those boxes." That started him on more than 20 years of sampling air around the world.

In 2003, he collaborated with a mobile lab while doing preliminary work for his doctoral research, which resulted three years later in him on a flight over Mexico City gathering data. He had already, in 2003 or 2004 (he's a bit fuzzy on the time), worked with grad school roommates to rig up their own van and drive it around Colorado. Postdoctoral work took him to Switzerland in 2008–10. Werden joined him in Nepal in 2015, working to better understand the sources of air pollution in the Kathmandu Valley. A major earthquake interrupted their work, which they resumed in late 2017 and early 2018, when they and Nepalese collaborators rented a van, took out several of its bench seats, filled it with instruments and 12 lead-acid batteries, and drove around for a month gathering data.

On the road in Baltimore County, we drive past McCormick & Company's spice facility, and Nault points to a section of the monitor that shows a spike in terpenes. Terpenes in the air are not a health hazard—they are what make the air around McCormick smell good. They occur naturally in spices and herbs, and the spice company uses them for various products. Detect something citrusy in the air? That would be limonene. Enjoy a deep breath. It won't hurt you.

As DeCarlo drives through a section of office parks, Nault says, "Random nitrogen oxide plume there." DeCarlo glances out the window: "Lawn care. Weed whacker." There's a landscape crew tending the grass beside the street. We pass a landfill, and he has a look at several visible vent pipes. "All of those are spinning, so something is coming out." Behind a familiar yellow vehicle, he asks, "Is that a clean school bus or a dirty school bus?" Nault, who has been typing notes throughout the morning, reads aloud from the data display: "Twenty. Thirty. Forty. Okay, not clean." A few minutes later, behind another public transport, Nault says, "Holy crap, 300 parts per million because of that bus!" He's not specific about 300 parts per million of what, but it's clearly nothing good.

After about three hours, DeCarlo steers to a city recreation center, where a group of high school kids in a summer science program get a tour of the van and an explanation of the lab instruments. Then it's back to base. Nearly home, DeCarlo looks at me and says, "So, would you want to do this six days a week for a month?" Days in the field are long, usually an hour or two of prep before moving out, then eight hours of gathering data, finished by a last hour or more checking out the instruments to make sure everything will be ready to go the next day.

Their curiosity as scientists meshes with a sense of social purpose. DeCarlo worked in the EPA's Office of the Science Advisor as an American Association for the Advancement of Science and Technology and Policy fellow in Washington in 2010 and 2011.

He says: "Ultimately, we try to work in areas in which the science we do can inform not just the scientific community but also be used in discussions about policy. The work we do with MOM+POP is helping to inform questions about disparate exposures for people who live at the fence line of industrial facilities and where there are opportunities to improve the assessment tools that exist from regulatory agencies like the EPA." He continues, "I've always had this idea that we can use the instrumentation we have to answer important questions that are of importance not just to the scientific community but more broadly to society."

The scientists also enjoy the detective work. Nault says that puzzling something out of a one-month dataset can take two years: "There are so many different things that can impact what we're observing."

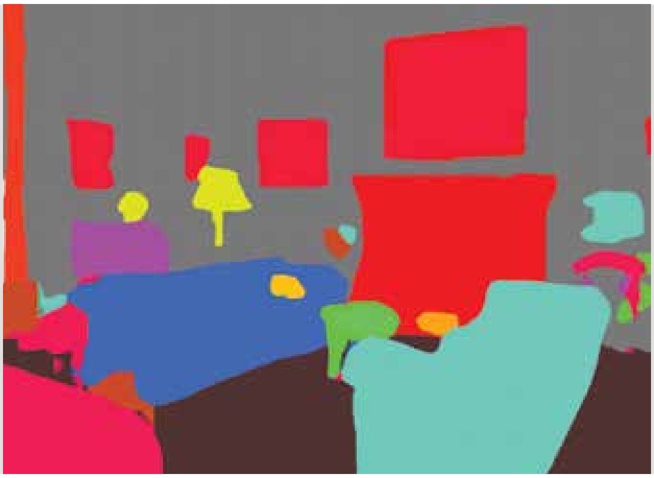
DeCarlo adds, "You see something interesting, and you don't know why. You're out driving, and you see one chemical go up. Where were we when we took that reading? What was nearby? What could be causing it? You try to backtrack through the data and figure out what's going on. It's like searching for a needle in a haystack. But it's a really cool needle." ■

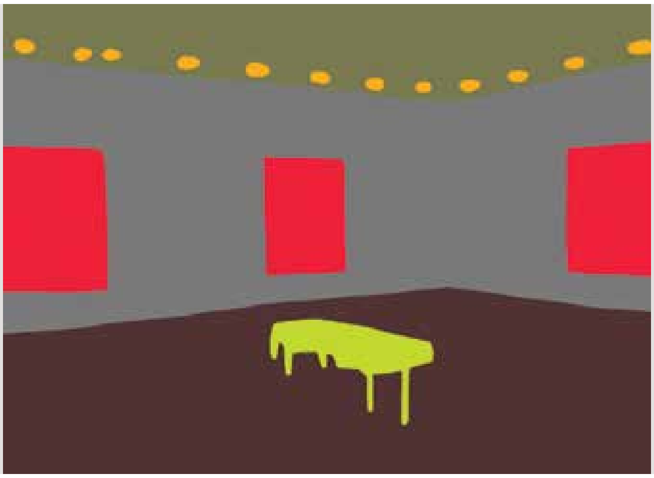
> I've always had this idea that we can use the instrumentation we have to answer questions that are of importance not just to the scientific community but more broadly to society.
>
> **PETER DECARLO**

VISION ENVISIONED

Bestowing machines with the ability to perceive the physical world as humans do has been a careerlong mission of Alan Yuille, a pioneer in the field of computer vision.

BY ADAM HADHAZY
PORTRAIT BY HOWARD KORN





The human brain is an absolute marvel of computing power. Estimates suggest the 3 pounds of tofulike tissue in our skulls can perform roughly 1 quintillion calculations per second—a feat only recently matched by the world's top supercomputers.

Yet that statistic, albeit impressive, fails to convey just how far the brain's remarkable capabilities go beyond those of machines. Consider our sense of vision. About half the neurons in our cerebral cortexes—the big, lobed, wrinkly outer layer of our brains—play a role in our visual system. That system near instantly handles visual tasks we humans find utterly mundane but that can flummox artificial intelligences. For example, a common cybersecurity tactic involves identifying which images in a set have, say, a bus or a bicycle in them—an easy "challenge" for humans that stumps online bots.

Although computer vision is not up to human snuff just yet, scientists have nevertheless made astonishing advancements since its inception in the 1960s. Nowadays, facial recognition apps on new smartphones have become de rigueur. Self-driving cars are on the cusp of wider adoption, having logged tens of millions of miles on public roads and compiling a safety record that some say surpasses that of human drivers. The medical profession is likewise getting closer to broadly adopting computer vision for clinic use to assist with detecting tumors and other abnormalities.

Over the last four decades, Johns Hopkins' **Alan Yuille** has made a significant impact on the overall development of computer vision and is also continuing to advance the field toward more humanlike abilities. Yuille has drawn inspiration from the human visual system—refined in our species over millions of years of evolution—for key insights into advancing computer vision capabilities.

"I want algorithms that will work in the real world and that will perform at the level of humans, probably ultimately better. And to do that, I think we need to get inspired by the brain," says Yuille, Bloomberg Distinguished Professor of computer science and cognitive science at the Whiting School of Engineering and Krieger School of Arts and Sciences.

Yuille's career has spanned multiple institutions and eras in computer vision, from the early conceptual days through the revolution of machine learning, where AI algorithms devour massive datasets of imagery and learn like humans. His contributions are tightly interwoven into the fabric of the field. Examples include semantic segmentation, where computers distinguish classes of objects and backgrounds at the level of individual pixels, to compositionality, where the whole of an object can be represented by the aggregate of its parts.

"What is so fascinating is that when you go to conferences, even the new young superstars, they know about Alan and are inspired by him," says Adam Kortylewski, a former postdoctoral researcher in Yuille's lab at Johns Hopkins and currently a group leader at the University of Freiburg and the Max Planck Institute for Informatics.

Kortylewski credits Yuille's career success to his enduring perspectives on vision and openness to innovation.

"Alan is convinced of certain ideas, but he's also flexible enough to then adapt to new insights and new technology. I think he's one of the very few figures who has this kind of capability," Kortylewski says. "So even today, the research and new papers coming from his lab are very well-cited and are pioneering work that other people catch up with."

'ADVENTUROUS' AI

Yuille's path to collectively studying natural cognition, artificial intelligence, and computer vision was far from linear. He grew up in North London in an area known as Highgate, bordering a cemetery. ("Karl Marx was buried over behind our backyard wall," Yuille relates.) His parents, from Australia originally, were into the liberal arts—his mother in English literature, his father in architecture. Yuille remembers there being thousands of books about visual art in his home. Along with frequent trips to art museums, he thinks the exposure must have made an impression, despite his lackluster interest. "I think at the time, I rather reacted against it," Yuille jokes.

What did rivet Yuille, though, was sports, and as an adult, Yuille continues to find active outlets. "I hike up mountains, I ski down mountains. I've done hang gliding. I've flown a small airplane," he says. He chalks up his adventure-seeking to "too many Bond films when I was a boy."

In college, Yuille first became fascinated by mathematics and Albert Einstein's general theory of relativity, the prevailing, century-old explanation for gravity. That pursuit led to a PhD in theoretical physics from the University of Cambridge in 1981, supervised by one of the most famous physicists of all time, the late Stephen Hawking, whom Yuille fondly recalls.

Stephen Hawking, (foreground right) meets with a group of his doctoral students at Cambridge University during the late 1970s. Alan Yuille is highlighted. [Photo courtesy of Alan Yuille]

"Stephen didn't take things too seriously," he says, recounting one afternoon when Hawking, having already developed severe symptoms from amyotrophic lateral sclerosis, had Yuille handle the computer interface for a Dungeons and Dragons game Hawking wanted to play.

However, Yuille's research—involving the fiendishly still-unresolved quandary of quantum gravity—foundered, leaving him looking for something new but similarly profound. "I thought, 'Well, AI was sort of something as fundamental as understanding the basic physical laws of the universe.' Because AI is really understanding human intelligence, and that's equally fundamental," says Yuille.

Compared to physics, the field of AI was also attractively far less developed, plus more practical.

"I liked the fact that AI would have real-world consequences," says Yuille. "So that got me into leaving physics and doing AI—because it was new, it was somewhat adventurous."

VISUAL RUDIMENTS

Pursuing this newly embraced academic space, Yuille joined the Artificial Intelligence Laboratory at MIT in the early 1980s. Perhaps hearkening back to his childhood exposure to the visual arts, he focused his research on computer vision—a fledgling field begun at MIT barely 15 years prior.

"In the 1980s, it was almost like the Wild West," says Yuille. "We had to start making sense of the whole enormous complexity of vision."

Phenomenologically, vision involves particles of light, called photons, being emitted or reflected by matter and then striking the retinal cells at the back of our eyeballs. Generated nerve impulses subsequently travel to our brain's visual cortex. There, vast networks of neurons process the streamed-in information and construct our richly perceived world of color, shape, textures, and distances.

Seeking a way into this morass, Yuille teamed up with Tomaso Poggio, who had also just joined the faculty at MIT. "We hit it off almost immediately and started working together, maybe because both of us were physicists originally and not computer scientists," recalls Poggio, who stayed on at MIT and is now the Eugene McDermott Professor in the Department of Brain and Cognitive Sciences.

In focusing on intrinsic elements of human visual perception and cognition, Yuille and "Tommy," as he affectionately calls Poggio, studied how computers might perceive the basic lines and edges of objects to make broad inferences about the contents of a visual field. "Finding reliable contours of objects and edges in images at the time was one of the early problems in computer vision," says Poggio.

During this early phase, much of the work was conceptual and could not be deeply demonstrated, owing to the lack of computing power and massive datasets that would later transform the field. Yet being restrained in this way meant that Yuille and colleagues had to proceed from a more theoretical basis, getting at the conceptual underpinnings of vision rather than worrying about go-to-market applications. "I think a lot of the ideas we had were actually pretty good," says Yuille, "but we didn't have the models that could take advantage of the big data that we now have."

> "*I liked the fact that AI would have real-world consequences. So that got me into leaving physics and doing AI—because it was new, it was somewhat adventurous.*"
>
> **ALAN YUILLE**

MENTAL MODELS FOR VISION

Building on his research progress in computer vision, Yuille moved to Harvard University in the mid '80s and became a professor. From there, in 1995, he went to the Smith-Kettlewell Eye Research Institute, a nonprofit research organization in San Francisco. Seven years later, he returned to academia at UCLA as a professor with joint appointments in statistics, computer science, psychiatry, and psychology, an indication of how his research had become highly multidisciplinary.

Some of the areas where Yuille broke ground along the way include the aforementioned semantic segmentation, which is a core task for self-driving cars as they find where the road is, where boundaries are, and discern other cars. Another related area where Yuille introduced key ideas—also tying into the combining-parts-to-make-the-whole concepts of compositionality—is termed "analysis by synthesis."

The essential notion of analysis by synthesis is that, through experience of the world, humans build up a vast mental library of possible objects. During moment-to-moment vision, we constantly and rapidly form hypotheses about the identity of the objects we are likely seeing. Based on that mental library, we then cognitively synthesize the hypothesized object, forming a manipulable, virtual version of it. As the milliseconds pass, we continue comparing the observed object to the synthesized object, filling in details and ultimately determining what the object is.

"It's like you're saying, 'OK, we're pretty sure this is a face at this angle, and now let's check and get the details correct exactly about whose face it is, where the eyes are if they're looking at you,' things like that," says Yuille.

APPREHENDING CANCER

On account of Yuille's reputation, based on these and other breakthroughs in computer vision, he was recruited by Johns Hopkins in 2016 to be a Bloomberg Distinguished Professor. A $350 million endowment from **Michael R. Bloomberg '64** established these influential positions at the university in 2013 to foster innovatively interdisciplinary collaborations aimed at tackling particularly complex problems.

"I was attracted to Hopkins because of the idea of trying to relate the study of biology or cognitive science to the study of AI," says Yuille.

A fruit of this labor has been Yuille's trailblazing research into using computer vision to detect tumors in CT scans. A project dedicated to this approach for pancreatic cancer, one of the deadliest malignancies, is known as FELIX, named after a magical potion, Felix Felicis or "Liquid Luck," from the *Harry Potter* series.

The FELIX project has brought together Yuille's expertise in computer vision and deep neural networks—"deep nets," in the jargon—with that of Elliot Fishman, a professor of radiology and oncology at the

Johns Hopkins University School of Medicine. Clinicians have sought to boost rates of detecting pancreatic cancer early, when a cure is still possible. Human radiologists fail to detect tumors in about 40% of CT scans of patients whose tumors are still small (less than 2 centimeters) and surgically removable. The hope is that machine learning algorithms can act as a second pair of expert eyes to review scans and alert radiologists to tumors that they might have otherwise missed.

"The goal is to bring this technology to the clinic so one day, whenever anyone gets a CT scan, they will have the help of this AI friend," says Bert Vogelstein, MED '74 (MD), the Clayton Professor of Oncology at the School of Medicine and a participant in the FELIX project.

Yuille recognized that semantic segmentation and other computer vision techniques could accelerate the project, along with efforts to simulate rare, early tumors for more effective training of the algorithms. "Alan has tremendous insights into the underlying principles of deep networks and other machine learning algorithms," says Vogelstein.

The FELIX project overall has achieved excellent performance, closely matching human skill at detecting larger tumors, while also revealing dangerously tiny ones. In total, about one-quarter of the pancreatic cancers FELIX has picked up had not been previously diagnosed, illustrating the approach's immense promise.

Ongoing work continues to validate FELIX for innovative clinical use and extend its value to detecting cancer in other abdominal organs. "These forms of automatic diagnosis could obviously be huge," says Yuille.

THE FUTURE OF COMPUTER VISION

As he has expanded the frontier of what's possible in computer vision over decades, Yuille has also educated hundreds of students, many of whom have gone on to build upon their former teacher's results.

"Alan is a great mentor," says computer vision researcher Cihang Xie, who first took a machine learning course of Yuille's during his master's degree studies at UCLA, then later joined Yuille's lab at Johns Hopkins to obtain his PhD in 2020. He is now an assistant professor of computer science and engineering at the University of California, Santa Cruz.

"Alan is quite open to new directions, and he respects your ideas," Xie adds. "He is always very patient in completely understanding what you're trying to do and help you in building a more mature research case, even when it's something he also needs to learn."

Xie worked on compositional models with Yuille, among other topics, and has seen how combining them with deep nets is growing the technology. "Alan started these deep compositional models that are more powerful and pretty robust to [object] occlusion or other harder scenarios that cannot be solved by regular deep learning models," says Xie.

The advancements keep on coming. In work presented at an international conference in July 2024, for instance, Xie, Yuille, and their students demonstrated an enhanced version of image-GPT, a visual equivalent to the celebrated chatbot ChatGPT. Just as these large language models can predict the next words in a sentence to form (usually) coherent statements, image-GPT predicts next pixels, generating images—for instance, of people, animals, cars, buildings, and so on. By incorporating more contextually semantic predictive approaches, the researchers achieved 90% classification accuracy on a benchmark dataset—the best performance shown in academia and on par with big tech companies such as Google and Meta. "We constructed a state-of-the-art image recognition model, and we're pretty excited about it," says Xie.

'THE HUMAN ELEMENT'

Amid successes in the dramatic rise of computer vision, Yuille emphasizes that for the field to evolve further, it must embrace the human visuocognitive experience of lived-in environments.

"Human vision is developed by interacting with the world as infants; I see it with my son," Yuille explains. Rather than just looking at tons of images, "you explore, you touch objects with your hand, you build up a knowledge model."

"I think if we want to take computer vision algorithms up to the next level," Yuille concludes, "we'll need to get that human element back in." ■

> *I was attracted to Hopkins because of the idea of trying to relate the study of biology or cognitive science to the study of AI.*
>
> **ALAN YUILLE**

Getting

Improving global health care requires engaging with patients and health care providers on the ground. Last summer, students from JHU's Center for Bioengineering Innovation and Design (CBID) traveled to India to gain an immersive knowledge of the challenges facing India's rural and urban clinicians and community health workers.

Art by Franziska Barczyk | **Compiled by** Sarah Achenbach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Jamshedpur
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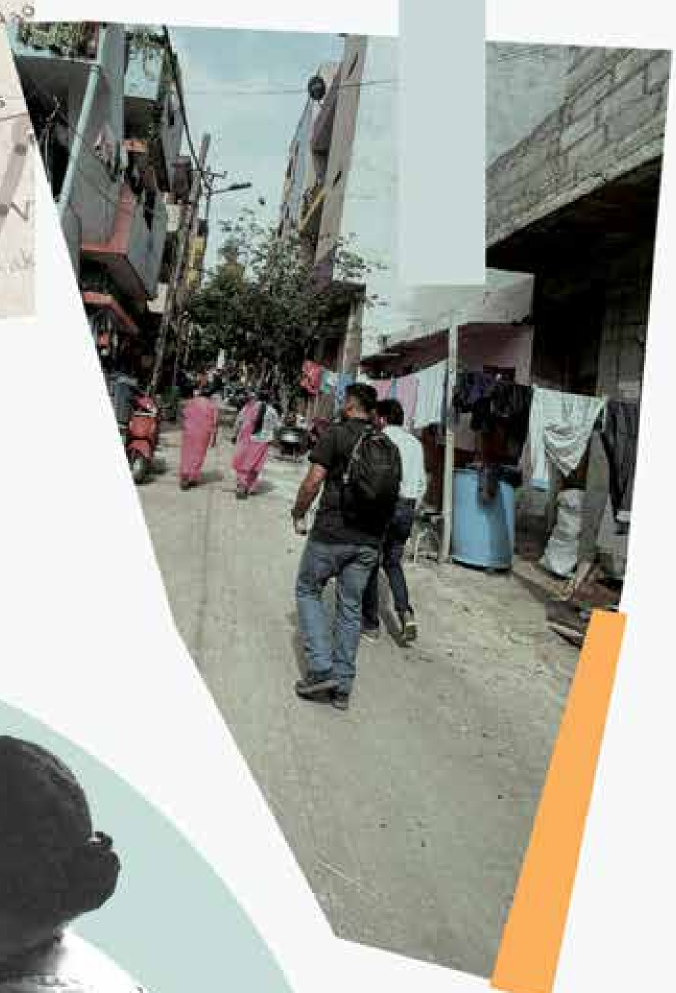
Bhopal
Indore
Ahmadabad
Raipur
Nagpur
Surat
Amravati
Chandrapur
Jalna
Aurangabad



Real

Students in CBID develop and create solutions for major challenges to human health, with a focus on real-world impact. The program includes clinical immersion both at Johns Hopkins Medicine and in low-resource regions of the world.

What they learned, as engineers and as global citizens, is informing and inspiring their CBID research projects.

Tuberculosis in Urban and Rural Settings

August 2–21

Research Project Overview: Six CBID fellows traveled to India to gain a deeper understanding of how tuberculosis (TB) is screened, diagnosed, treated, and managed in rural and urban settings. Sponsored by the Gupta-Klinsky India Institute (GKII) at Johns Hopkins, the team attended research presentations and met with clinicians, researchers, government health care workers, and adult and pediatric TB survivors for in-person observations.

Reflections from Ishir Sharma

"India, the largest country in the world, with 1.4 billion people, has the highest burden of TB for any single country. Our conversations with stakeholders revealed to us the power of community and family in delivering care at the grassroots of the Indian health care system. In rural Uttar Pradesh, we had a unique opportunity to interact with a TB survivor. His remarkable story exemplified the success of the Indian government's National Tuberculosis Elimination Program. As a daily-wage laborer from a different part of the country, he returned home for a six-month-long TB treatment paid for by the national program. However, he was the only family member who worked and could not earn for his family during treatment. We also spoke with rural health care providers responsible for treatment adherence.

"As engineers and engineering innovators, we often find ourselves interested in solving health care challenges that are most apparent to us. This trip took us one level deeper. One of the most important lessons we learned was to engage stakeholders effectively and become better listeners [by focusing on] the soft skills needed for conducting effective informational and ethnographic interviews. I found myself leveraging my knowledge of the Hindi language to gain insights from local stakeholders in the most effective way possible for our team. In this way, the language barrier was not a major communication problem, even in remote or rural sites visited.

"An 'a-ha' moment occurred at the Delek Hospital in Dharamshala, where we saw the Zero TB Kids program. This is a Johns Hopkins collaborative initiative used with the Tibetan refugee population to eliminate pediatric TB. We witnessed the ZTB team in action at the Gyuto Tantric Monastery at a functioning screening protocol event for the monks. This got us thinking about ways to scale up the success of this program to other communities and sites in India,

Tuberculosis team (left to right): Sabrina Zhou, Amanda Cheung, Mark Schuweiler, Emma Turner, Mads Bundgaard Nørløv, and Ishir Sharma and the role that technology could play in that process. We also had the opportunity to see how screening is performed in schools at the Tibetan Children's Village School and interviewed schoolchildren about the pediatric patient experience.

"Being from India, I was keen to show my team a *real* Indian cultural experience. I took our team to the middle of one of the busiest markets in the city of Pune. The marketplaces were hustling and bustling with life: street vendors, food carts, fragrant flowers, colorful garments, bright jewelry, sweet delicacies, traffic honking, and masses of people! It was quite a push out of the comfort zones of our quiet hotel building, but there was still a calmness about where we were. We decided to embrace this new environment by engaging with the local people and cultures. We visited temples, ate local street food, and even rode auto rickshaw taxis. This day turned out to be one of the most meaningful cultural experiences we had together."

NEXT STEPS: The team identified opportunities to improve India's TB care pathway, focusing on technical solutions that address clinical- or systems-level challenges related to diagnostic and treatment workflow for India's screening program, the GKII's TB-Free Schools Initiative.

Streamlining AI/ Intelehealth

July 28–August 18

Research Project Overview: Five CBID students and a CBID fellow traveled across three states in India to observe telehealth consultations and workflow at health care centers across the Indian health care system. The goal: to create a more streamlined, culturally sensitive artificial intelligence/Intelehealth experience for patients and providers and to ensure patients have access to high-quality care.

Reflections from Lindsay Lamberti, Mitch Lipke, and Selena Shirkin

"We shadowed a community health worker in a tribal village. She travels house to house collecting patient vitals, facilitating telemedicine consultations, and providing prescriptions to people unable to reach a pharmacy. During the consultation, the patient's whole family and other patients from the village also observe. It was such a dichotomy to be in a crowded room with a tin roof, open doorways with curtain doors, and flickering lights and to be on a telehealth video call with one of the most prominent physicians in the state." —*Lindsay Lamberti*

"The doctors care deeply about their patients and want to provide the best care possible, but they are constrained by the immense workload. Each consultation lasts about two minutes, during which the doctor collects the patient's history, provides a diagnosis, and prescribes a medication treatment plan, further testing, lifestyle modifications, or a referral to a specialist. In such a short period of time, it can be difficult to provide a complete and high-quality consultation, but unfortunately, the doctors do not have any additional time to spare. Due to the high patient demand and shortage of health care providers, consultations must be kept this short or else some patients will be left without treatment. When we asked one doctor why she cares so much, her response was, 'The world is your family.' She treats every patient with the same care that she would give to her own family. Many shared how grateful they were that we had come to learn from them and try to make an impact in their lives with our work."

—*Lindsay Lamberti*

Telemedicine team (left to right): Selena Shirkin, Lindsay Lamberti, Santiago Sánchez Rentería, Mitch Lipke, and Jay Tailor

"While conducting interviews with doctors at District Hospital in Cuttack, Odisha, I was taken aback by the number of people. The entrance overflowed with patients waiting to receive their medication or be seen by a doctor. We were ushered past huge lines of patients into a cramped room with two doctors conducting telemedicine consultations. We split into two groups, one interviewing a doctor and another observing the other doctor's telemedicine consultations. My interview was interrupted by a patient walking into the room and asking for his family member to be seen. This unexpected interruption and hospital crowding highlighted the intense demand for medical services and the challenges faced by health care providers working in these densely populated areas. Although I was outside my comfort zone, I politely paused the interview to allow this doctor to address her patient's concerns. This taught me the importance of adaptability and composure in high-pressure environments. It also deepened my empathy for both health care providers and patients, reinforcing the need for health care innovations in resource-limited settings." *—Selena Shirkin*

"India's rural health and wellness centers staffed with a community health officer (CHO) serve as one of the first contact points for many. The CHO's role is critical to the Indian health care system, as the CHO determines where the patient goes next: Send them home or refer them to more advanced care. The CHO [we observed] knew these patients well and took the time to address each patient's needs. The patients took to her advice much better than if she had been rushing. In developing new technologies in this space, it's important that we don't lose the human touch, but rather enable it. When we were in Nashik, we learned how resource-constrained India's rural population is. This made us question bringing AI technology to some places. It seemed a little tone deaf, so focusing more on the needs and what technologies can service those needs will be our main goal this fall."

—Mitch Lipke

"India's Ministry of Health and Family Welfare accredited social health activist workers—members of the villages who advocate for patient health and facilitate initiatives within the community, including vaccination camps and prenatal care—receive a fraction of their promised salaries. They are overworked and undercompensated. It's no wonder their numbers are declining. We learned that the corruption extends to the public sector of health care, which is supposed to be free and accessible to all patients. One village's leader told us of a woman who had hepatitis and delayed treatment/seeing a doctor because her husband was an alcoholic and would not allow her to go. She just kept working on

Telemedicine team (left to right): Lindsay Lamberti, Selena Shirkin, Santiago Sánchez Rentería, Sandhya Tiku, and Dr. Gupta

her farm, and her condition got worse. She went to a rural hospital, but she was turned away until the tribe leader insisted she be treated. She was treated for one night and then sent away again. Next, she tried the 'free' public hospital and was told treatment would cost 40,000 rupees. (They live on 20,000 rupees per year.) She got no treatment, was sent home, and passed away that night. The village was still in the process of their grieving rituals when we were there. This was my 'a-ha' moment. It was raw and real. We were able to see the true impact of the injustices of the health care system and exactly where it falls short. From this point on, my project became about more than just improving access to quality health care in India. It became about the individual lives that can and will be changed because of the implementation of telemedicine services throughout India."

—Lindsay Lamberti

"Connectivity challenges affect how telemedicine is practiced in India. It was very interesting to see how quickly health care providers switched to unofficial channels like WhatsApp or phone calls when their government-run telemedicine platform (eSanjeevani) was experiencing connectivity issues. This made us understand how important it would be to incorporate a low-bandwidth component into any solution that we designed." *—Lindsay Lamberti*

Next Steps: Using information gathered through interviews, observations, and doctors' logbooks, the team identified several potential areas for innovation and plan to focus their project on one of the following challenges: improving patient history collection and transfer across India's entire health care system, incorporating diagnostic support tools into telemedicine platforms to help doctors interpret patient histories and improve diagnoses, and improving patient compliance to treatment plans and medications prescribed via telemedicine consultation through enhanced health education.

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Sreyas Chintapalli

Helping Maryland Reach Its Climate Goals

THE ROAD TO DECARBONIZATION WILL BE PAVED WITH MANY TRADEOFFS. Sreyas Chintapalli, a PhD candidate, is helping Maryland make the right ones as state leaders implement some of the country's most ambitious climate initiatives.

To achieve a net-zero carbon economy by 2045, the state has mandated that by 2028, at least 14.5% of electricity sold in Maryland must be derived from solar resources. Chintapalli is lending his technical expertise to the state's Solar Photovoltaic Systems Recovery, Reuse, and Recycling Working Group as they seek to understand the challenges related to the increased adoption of solar photovoltaics.

Using computer modeling and tools from the National Renewable Energy Lab in Colorado, he is answering a host of questions, including what waste solar panels might generate as they near the end of life.

"Even if solar is more efficient from a greenhouse gas perspective, you still have tons of glass and aluminum and silicon that are going to have to be recycled, and there are very few commercial programs that recover trace metals," Chintapalli says. The issue is just one of many complexities that Chintapalli, together with researchers from the University of Maryland, is advising on.

After completing an undergraduate degree in chemical engineering at Washington University in St. Louis in 2016, Chintapalli worked at semiconductor manufacturer GlobalFoundries for two years before joining the lab of Susanna Thon, an associate professor of electrical and computer engineering and Marshal Salant Faculty Scholar.

For his thesis, "Structural Control of Absorption in Photonic Systems," Chintapalli is researching efficiency improvements of quantum dot-based solar cells—tiny spheres of semiconductor material measuring 2–10 billionths of a meter in diameter. Quantum dots have the capacity to increase solar panels' efficiency because they can extract more energy out of every incoming sunlight photon. They have enjoyed renewed momentum since the scientists who discovered them were honored with the Nobel Prize for Chemistry in 2023.

Chintapalli is keen on borrowing the best from both industry and academia by exploring practical applications to research and modeling. "It's ideally where I would like to end up, as someone who understands both the theory and applications of science," he says.

— POORNIMA APTE

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Jocelyn Freed

Flying High in Aerospace Materials Research

WHEN JOCELYN FREED LAST VISITED THE NATIONAL AIR AND SPACE MUSEUM IN WASHINGTON, D.C., the fourth-year materials science and engineering major was drawn to a video showcasing Amy Ross, an engineer who designs space suits for NASA. It would turn out to be a defining moment for Freed. Soon after, she decided she would pursue a materials engineering career related to aerospace.

"Up until then, I didn't think that a job so specific like making spacesuits could be available to me," Freed says. "After that, I got interested in not just spacesuits, but also coatings and all things aerospace."

Last summer, she landed an internship at the aerospace startup Ursa Major, funded by the Brooke Owens Fellowship, which encourages women's participation in the field. There, she tested the hardness, tensile, and fatigue strength of nickel "superalloys" strengthened with elements like cobalt or carbon. (Nickel alloys are ideal for aerospace applications because of their high strength to weight and resistance to extreme temperatures.) The tests involved evaluating the forces at which the alloys fracture or break apart. Freed also studied the structure of the alloys using optical and scanning electron microscopy, and jumped in to write a simpler manual for the startup's optical microscope, complete with illustrations, after noting the group's existing manual was long and difficult to understand.

This academic year, Freed gets to work on space suits as part of her senior design project. In the lab of Michael Bevan, a professor of chemical and biomolecular engineering, she is evaluating the effects of electrical fields on microscopic colloidal particles, which are tiny particles suspended in fluid. A space suit coated with such materials would more effectively repel "space junk," materials that can pierce the suit, causing air to leak out.

Freed says she especially loves the intersection of materials science and aerospace because it opens so many opportunities and topics to explore. "The field of aerospace materials sounds so specific, but at the same time, it's so broad; you can work on metals, on polymers, on ceramics. It's a lot of fun," she says.

No matter what she pursues after her undergraduate studies, Freed knows there will be room for art, which she is pursuing through a minor at JHU. "I've always been a creative person," she says. "Art exercises a different part of my brain."

—PA

Jooyoung Ryu

“What really stands out to me is the importance of staying calm under pressure and working closely with the other paramedics on the scene to provide the best care possible.”

—JOOYOUNG RYU

The Heart of the Matter

SUDDEN CHEST PAIN MIGHT BE A SIGN OF A HEART ATTACK, A PANIC ATTACK, or even broken heart syndrome—a type of cardiac dysfunction known as stress cardiomyopathy caused by sudden physical or psychological stress, such as a car accident or a family member dying.

But stress cardiomyopathy is not always easy to identify. That's why Jooyoung Ryu, a third-year student majoring in computer science, is using his Provost's Undergraduate Research Award to train a machine learning model to better distinguish between stress cardiomyopathy and other acute cardiac syndromes, such as myocardial infarction—the technical term for a heart attack.

While the effects of a heart attack can be irreversible, the heart generally returns to normal after stress cardiomyopathy, notes Ryu. As a result, the conditions require different treatments. “But right now, there's no pragmatic clinical tool to differentiate early on if the patient has stress cardiomyopathy or myocardial infarction,” he says.

Enter machine learning. Advised by Robert Stevens, an associate professor of anesthesiology and critical care medicine at the School of Medicine, Ryu and other members of the Laboratory of Computational Intensive Care Medicine are training an artificial intelligence model to look at electrocardiograms (ECGs) for signatures that can help physicians better distinguish between different types of acute cardiac dysfunction shortly after their onset.

Making this distinction could significantly increase precision in directing additional tests and treatments—especially ones that are higher-risk and resource-intensive, such as coronary angiography, a procedure using special dye and X-rays to see how blood flows through the arteries in the heart.

So far, the team has trained its model using ECG waveforms and other clinical features as input data. “Currently, we have a very strongly functioning model,” Ryu reports. “Now we're focusing on making it perform better, moving on to hyperparameter tuning.”

A premed student, Ryu has volunteered as an EMT for the past year with the Rosedale Volunteer Fire Company in Baltimore. “Caring for patients as an EMT is both challenging and rewarding,” Ryu says. “What really stands out to me is the importance of staying calm under pressure and working closely with the other paramedics on the scene to provide the best care possible.”

—JAIMIE PATTERSON

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Testing the Water

WHEN NOOR HAMDAN WAS A CHILD, SHE NOT ONLY COLLECTED WILDFLOWER BOUQUETS to present to her mother, but she also researched their scientific names and cataloged the specimens in a book that still sits on her bookshelf today.

"Being in nature is my favorite thing in the world," says Hamdan, a PhD candidate in the lab of Carsten Prasse, assistant professor in the Department of Environmental Health and Engineering.

So she jumped at the opportunity to collaborate on a study Prasse proposed, which was aimed at exploring the impact that recreational activities, specifically floating down a river on an inner tube, might have on water quality.

"We really were interested in what the tubers themselves were bringing into the streams compared to what was already naturally present," says Hamdan. Such questions are timely, given concerns around climate change, hotter summers, and dropping water levels.

Working with researchers at the Colorado School of Mines, the team examined water samples collected from Clear Creek, in Colorado, over a busy Labor Day weekend, and then several days later, when river traffic was slow. The team also collected samples upstream of the main "put-in" point for tubers. Sampling varied by time and location so the researchers could isolate the effects of the heavy activity in that popular spot.

The researchers analyzed the samples using a mass spectrometer, which measures the masses of carbon-containing molecules with very high precision, creating "chemical fingerprints" that can be matched to a library of known substances.

Hamdan says many of the chemicals they found in samples from the put-in spot during high-traffic times are assumed to have washed off human skin or been excreted in urine: chemical sunscreens, prescription and over-the-counter medications, DEET bug repellant, and personal hygiene products—even traces of cocaine. The control samples had little or no traces of these substances.

"We now know that these compounds are in the river," says Hamdan. Their results appeared in *ACS ES&T Water*. "[While] we don't know their concentrations or how they impact the fish or other species in the environment, this kind of work is mostly used to bring to light gaps in research knowledge related to recreational activities in freshwater systems with frequent use [by humans]."

Now that she knows what's floating around in popular recreational waterways, Hamdan said she's not going tubing anytime soon.

"This research has definitely opened my eyes to a lot of different chemicals that I use in my day-to-day life," she says, "and which products I'm more likely to use," such as mineral sunscreens, which are less toxic for the environment.

—DANIELLE UNDERFERTH

Noor Hamdan

Benjamin Urmston

Antarctic Adventurer —and More

WHAT DO YOU DO IF YOU HAVE DIVERSE INTERESTS? YOU EXPLORE THEM ALL.

It's a philosophy that has inspired Benjamin Urmston, MS '19, to study aerospace engineering at the University of Colorado, sail the Atlantic (he has a Coast Guard captain's license), teach American Sign Language at a school for the deaf, help astronauts hone team-building skills as a longtime instructor for the National Outdoor Leadership School, play the cello as part of a band, and even rig an automatic door opener for his parents' chicken coop.

But reading *Endurance*, an account of Ernest Shackleton's ill-fated voyage to Antarctica that began in 1914 and left the explorer and his crew stranded on the ice in 1915, rebooted everything and seeded a lifelong love affair with the continent.

Since 2006, Urmston has deployed to Antarctica's McMurdo Station 10 times through the National Science Foundation's United States Antarctic program. On his first deployment, he served as a general assistant. "We were just grunt workers … shoveling snow, cleaning dishes, working in the wastewater treatment plant," Urmston remembers.

About a decade later, intent on getting a stronger background in electronics and electrical engineering, Urmston turned to the Whiting School's Engineering for Professionals (EP) program to earn his master's degree in electrical and computer engineering.

He moved on to work at McMurdo as an electronics and solar power technician. In September, he embarked on another five-month rotation, this time as the field training supervisor, managing a group of six field safety coordinators who support and train scientists on base. During limited spare time while deployed, he skate skis and is a member of a rock band, IcePatch, a cover of his brother's well-known indie/roots band, Dispatch.

Urmston enjoys building solutions, the scrappier the better. For an EP course led by oceanographer David Porter, who teaches in the Applied Physics program, Urmston built a remote temperature monitoring array for a skating pond. And on one of the Antarctic program's research ships, he rigged a display for a depth meter using 3D printing and assorted parts. "It's the creative activity of electronics I like so much," he says.

Engineering has taught him problem-solving for mistakes—which inevitably happen. "I try to incorporate that philosophy in my life; if something is broken, let's fix it," he says.

Urmston's wanderlust is striking again. The destination this time: outer space. Is being a NASA astronaut next on his career bingo card? "We'll see," he laughs. "My application is in."

— POORNIMA APTE

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President Biden honored Bloomberg for revolutionizing the financial information industry and for transforming the state of education, the environment, public health, and the arts in New York City as its mayor from January 2002 to December 2013.

Michael Bloomberg Receives Presidential Medal of Freedom

PHILANTHROPIST, BUSINESS LEADER, AND THREE-TERM NEW YORK CITY mayor Michael R. Bloomberg ’64 was presented with the Presidential Medal of Freedom by President Joe Biden during a ceremony at the White House in May. He was one of 19 honored that day.

The nation’s highest civilian honor, the Medal of Freedom is presented to those who have made exemplary contributions to the prosperity, values, or security of the United States, world peace, or other significant societal, public, or private endeavors, according to a White House news release.

President Biden honored Bloomberg for revolutionizing the financial information industry and for transforming the state of education, the environment, public health, and the arts in New York City as its mayor from January 2002 to December 2013.

He joins an esteemed class of honorees this year, including former Vice President and U.S. Senator and Congressman Al Gore, former Secretary of State John Kerry, Olympic swimmer Katie Ledecky, astronaut Ellen Ochoa, former Speaker of the House Nancy Pelosi, and Academy Award-winning actress Michelle Yeoh.

Bloomberg is the latest of several Hopkins affiliates to receive the honor.

— **STAFF REPORT**

On a Mission to Cure Cancer

Adrian Johnston

SHORTLY AFTER ADRIAN JOHNSTON, PHD '24, FINISHED HIS FRESHMAN year of high school, his father lost his battle with cancer. Unmoored for a while, Johnston eventually found his footing in the sciences as an undergraduate at the University of Maryland. He decided then that he'd work to fight the often deadly disease.

Last April, Johnston founded DUA, an early-stage startup that continues the work he pursued at Johns Hopkins during his doctoral studies in chemical and biomolecular engineering. His PhD thesis reported that novel CAR T-cell immunotherapy shows early promise for treating solid tumors like breast, lung, and stomach cancers, among others. That's notable because solid tumors, unlike blood cancers, have until now been highly resistant to immunotherapy.

The effectiveness of this approach stems from his invention, velocity receptors, which are special protein molecules that can move therapeutic cells to a targeted tumor. "If you imagine us as the therapy cell, the velocity receptors are like our feet. They help us get to where we need to go," Johnston explains.

Johnston's father was Ghanaian and settled in Sierra Leone before emigrating to the United States. The name DUA, or "tree" in Ghanaian, is often associated with "grow." "My goal with DUA is to grow hope and peace, both of which my father had in short supply in his final days," Johnston says.

His father's passing has made Johnston more attuned to the importance of people and community. "It's the people I get to help, the people I've been blessed to have been mentored by, the people I work with, that have made me the person I am today," he says.

At Johns Hopkins, the opportunity to develop such bonds was born through Explore Hopkins, a weekendlong program that encourages prospective students from underserved communities to explore doctoral studies at Johns Hopkins. Johnston remembers visiting the research lab of K.T. Ramesh, the Alonzo G. Decker Jr. Professor of Science and Engineering.

"Unplanned, he took us on a tour of his labs. Walking through the campus in the evening, then through the old historic architecture of Latrobe Hall felt like a movie, something like *The Social Network*," Johnston says. "When he showed us around his labs and the work he was conducting, it felt real—like serious work was being done that directly impacts our everyday lives."

— PA

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Event Planning Made Easy

Amy Sun Yan (right) and her sister Anna (left)

FROM CHESS AND SUDOKU TO THE SPORT OF BOULDERING, AMY SUN YAN '16 HAS ALWAYS loved to solve a puzzle.

Today, as COO and co-founder of Nowadays, she's taking on the notoriously difficult problems inherent in event planning—a field that, until now, required gathering and evaluating hundreds of details and documents individually. Nowadays uses artificial intelligence to automate that process and present options in a clean, modern interface for easier decision-making.

Founding a company wasn't always in the plan for Yan, who double majored in mechanical engineering and biomedical engineering at the Whiting School and began her career as a banking consultant at McKinsey before moving into strategy and operations roles at Groupon, Meta, and Google. After eight-and-a-half years in corporate work, she was looking to make a greater impact—and in 2023, her younger sister Anna proposed that they start something of their own.

Both women knew the challenges of event planning firsthand, having served as class presidents at their respective universities (Amy at Johns Hopkins, Anna at MIT).

"It's a sea of emails, spreadsheets, and phone calls," says Yan. "It takes so many callbacks to get vendors to respond to you, only to find out they're unavailable on your dates, and you need to start over. We wanted to put the joy back in event planning."

Although Amy classifies herself as risk-averse, Anna convinced her to take the leap. The sisters were accepted into the elite Y Combinator program, which helps early-stage startups with funding, mentorship, and community. To date, it's launched more than 4,000 companies, including Airbnb and Stripe.

Their vision for Nowadays is to handle end-to-end planning for any type of occasion. It already offers a streamlined selection for venues and travel. The bigger engineering challenge, currently in progress, is to cover every type of vendor, from UV face painters to dune buggy rentals and beyond.

Such custom events are dear to Yan's heart. A prime example is a project now underway for Grant Delpit of the Cleveland Browns. Delpit's event will pair 120 children with 20 NFL players for flag football and mentoring. In addition to the satisfaction of supporting a worthy cause, the experience also earned the sisters a chance to attend their first Super Bowl.

One year into the company's launch, the response has been extremely promising. Nowadays operates in 26 countries and has booked $3.4 million in revenue, with clients including Google, Supabase, and Notion. The growth has come exclusively through word of mouth, with no marketing required.

Yan says she's all in on the entrepreneurial life. "If you have an idea, follow it," she advises. "The earlier you start, the earlier you're going to see traction."

— HEATHER LOWE

Garett Clark

The Candy Man Can

HOW MUCH ENERGY GOES INTO MAKING A SKITTLE?

That's one question occupying the mind of Garrett Clark '07. As a Chicago-based senior R&D engineer with Mars Wrigley, the chemical and biomolecular engineering graduate is using his talents to make the world taste good.

Which brings us back to those Skittles. As the world's leading manufacturer of chocolate, chewing gum, mints, and fruity confections, Mars has pledged to cut greenhouse gas emissions by 50% by 2030, and every process is up for reinvention.

Clark is part of a team identifying how to make Mars' iconic candies in more sustainable ways. "If we can't change the Skittle itself, can we redesign the process of making them?" he says. "It's a significant engineering challenge and deeply rewarding."

His work has taken him all the way to China, where he helped add a line to manufacture sugar-free gum, and to Kenya, to construct a new candy factory. Back home in Chicago, Clark's laboratory is the innovation center—an industrial kitchen where he and his colleagues get to play candymaker. If initial feedback is good, the prototype proceeds to the consumer center for taste testing.

"All my friends ask for an invite," he laughs.

When a winning product is identified, the question becomes how to industrialize it. Sometimes, delivering a new treat requires designing the equipment and processes from scratch. "Candy making is really just cooking at an industrial scale," says Clark. It makes sense, then, that his team's motto is "scaling moments of happiness."

The mission includes creating healthier choices for snacking that still taste indulgent and fun. Clark is part of a team behind Starburst Goodies, a plant-based gummy with 70% less sugar. The product began rolling out on shelves this past summer.

He doesn't take his sweet job for granted. "Never in a million years did I dream I'd be making candy for a living," he says. "I hope this shows that engineering can be so many things. It's not just calculus and spreadsheets; there is plenty of room for emotion, creativity, and fun."

— HL

THIS PAGE: NATHANIEL SMITH; BACK COVER: PHIL LAUBNER.

HOPKINSAT HOME

JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

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SAN MARTIN CENTER
BALTIMORE, MD 21218

Igniting Passion for STEM

For 20 years, the Whiting School's Center for Educational Outreach (CEO) has focused on igniting and deepening a passion for STEM in pre-K–12 students and teachers, while strengthening Johns Hopkins Engineering's connections in the Baltimore community.

With programs ranging from after-school activities and engineering-based academic offerings for city school students to educator training, the center has reached over 100,000 individuals since it launched.

Programs include the Barclay Hopkins STEM Partnership, a far-reaching effort encompassing everything from teachers' professional development to curricula and after-school activities for pre-K–8 students, and the Robotics Outreach program, through which Johns Hopkins students mentor local teams, preparing them for competitions.

STEM Achievement in Baltimore City Schools, originally a CEO effort to enhance elementary science and engineering instruction and provide community-based experiences to students at a few city schools, is now available districtwide, reaching nearly 35,000 students annually.

"Our initiatives provide students with a strong foundation of knowledge, collaboration, and problem-solving skills. And by focusing on underrepresented groups, we're helping shape a more diverse future in STEM," says Alisha Sparks, executive director of the Center for Educational Outreach. She adds, "CEO's 20th anniversary lets us reflect on our accomplishments and provides a chance to consider how we inspire new generations of innovators and problem-solvers."

— LISA ERCOLANO