helluva engineer

FALL 2023

GEORGIA TECH COLLEGE OF ENGINEERING

The Health Issue

How Georgia Tech engineers are improving medicine today and designing a healthier tomorrow

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Engineers are improving cancer detection and treatment **PAGE 8**

FDA APPROVED

Medical tech making a real difference for patients **PAGE 18**

THINK BIG & BE BOLD

25 years of the Coulter Department of Biomedical Engineering **PAGE 28**

HARRY TUAZON

UNRAVELING WIGGLY WORM KNOTS

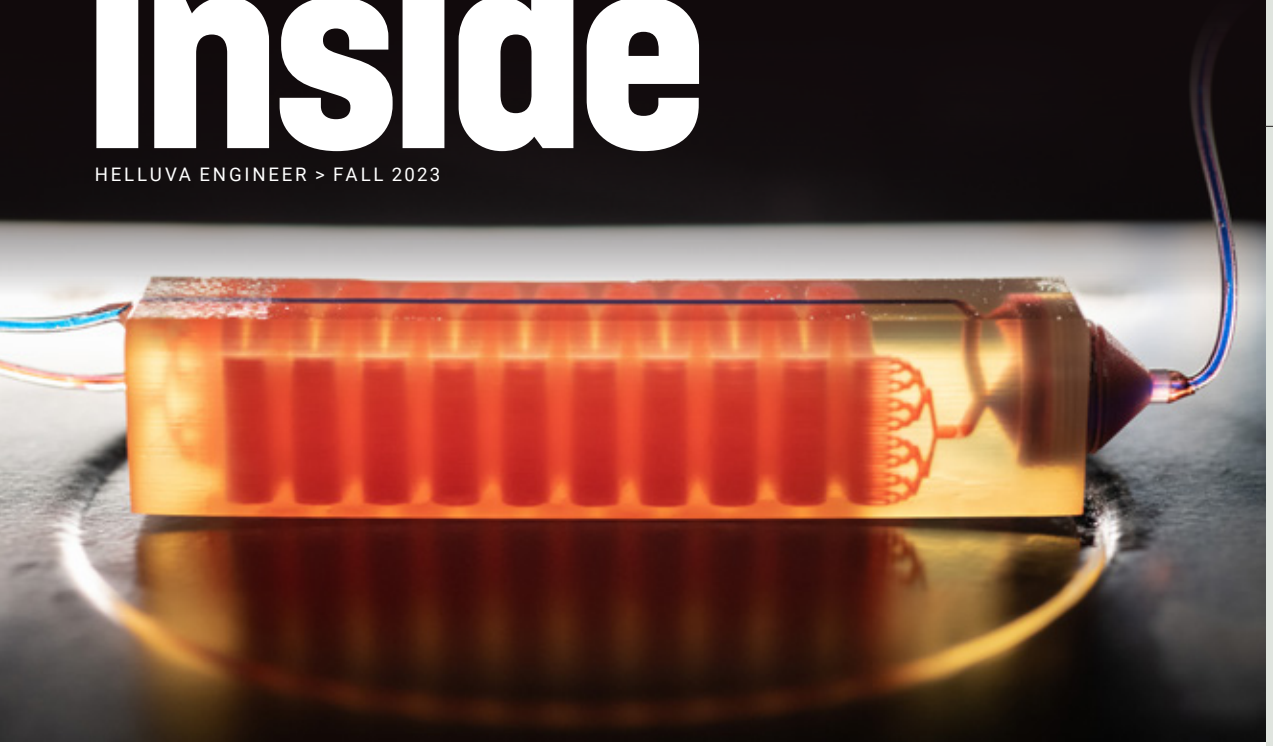
Tiny California blackworms intricately tangle themselves by the thousands to form ball-shaped blobs that allow them to execute a wide range of biological functions. Yet, while the worms tangle over several minutes, they can untangle in milliseconds, escaping at the first sign of a threat from a predator.

Saad Bhamla, assistant professor in the School of Chemical and Biomolecular Engineering, wanted to understand precisely how the blackworms tangle and untangle themselves. In the journal *Science*, he partnered with mathematicians at MIT to describe the worms' figure-eight movements and reveal how they facilitate knot-making and rapid untying. It's work that could influence the design of fiber-like, shapeshifting robotics that self-assemble and move in ways that are fast and reversible.

▶ **CATHERINE BARZLER**

READ THE STORY IN FULL AT **COE.GATECH.EDU/MAGAZINE/LINKS**

inside



FEATURES

Above: A 3D-printed cell trap. Blood samples flow through, and tumor cells are caught for study. (PHOTO: ALLISON CARTER)

WE ARE

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Dear Friends,

Much has changed in the three years since our College of Engineering magazine went on hiatus in the fall of 2020. For starters, I landed the best job on campus. I begin my fourth year as dean and Southern Company Chair this January.

It has been an amazing experience. I am inspired every day by our students, faculty, and staff, who drive engineering education forward with determination and creativity. The College continues to innovate in and out of the classroom, while also conducting research that improves lives around the world. In fact, the College set a record with more than $297 million in research awards in 2022-23 — nearly $30 million more than the previous year. All the while, Georgia Tech continues to rank among the top 20 universities in research and development spending — and is the only one on that list without a medical school.

Health has been at the forefront for my family the past two years. I was diagnosed with prostate cancer in December 2021, then underwent surgery to remove my prostate last summer. I've been cancer-free since August 2022 and am tremendously thankful for the support of the Georgia Tech community. The entire experience prompted me to go public with my story and encourage men to get tested — especially Black men, who are two times more likely to die from the disease.

Health is the theme of our "comeback issue," but for more reasons than my personal journey. The Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University begins its next 25 years atop the *U.S. News & World Report* Best Colleges national rankings. This is the first time the Department has simultaneously been No. 1 for undergraduate and graduate programs.

Coulter BME certainly does a significant share of health-related research in the College but doesn't exclusively own the space. In these pages, you'll read about some of the researchers across campus who are making discoveries to fight cancer, prostate and otherwise. You'll learn about devices and procedures developed by faculty and alumni that are making a real difference in people's lives after clearing the high bar set by the U.S. Food and Drug Administration. You'll also meet a few graduates who are helping transform health and medicine.

This year has a been a blessing for the College, and I know that the best is still to come. As we approach the holidays and a new year, I wish you and your loved ones the best of health and happiness.

Go Jackets!

Raheem A. Beyah

Raheem Beyah
Dean and Southern Company Chair

CANDLER HOBBS

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in the field

A Piece of the Moon

Fifty-one years ago, alumnus John Young, BSAE 1952, Ph.D. Hon 2003, walked and drove on the moon as commander of the Apollo 16 mission. He and his crew returned to Earth with 209 pounds of lunar samples in tow. Now a piece of one of those rocks has come to his alma mater.

On loan from the Young family and NASA, the lunar sample is on display in the Price Gilbert Library.

The sample is estimated to have been on the moon for at least 400 million years. Young and Charles M. Duke gathered it during Apollo 16's second extravehicular activity at the base of Stone Mountain, a codename Young gave to what NASA calls the Descartes site in the lunar highlands.

After arriving on Earth, the sample had been stored in a nitrogen-purged glove box at NASA's Johnson Space Center along with all of the other Apollo samples. Researchers carefully divided the sample into more than 250 subsamples, which have been used for numerous scientific studies to increase humanity's understanding of the moon and the formation of our solar system.

▶ KELSEY GULLEDGE

HELLUVA ENGINEER, HELLUVA ASTRONAUT

John Young is the first — and only — Georgia Tech graduate to walk on the moon. He's also the only astronaut to fly in NASA's Gemini, Apollo, and Space Shuttle programs, logging 835 hours over six space flights.

CANDLER HOBBS

2 More Silver Medals for Cassie Mitchell

Paralympian and Georgia Tech biomedical engineer Cassie Mitchell took another step toward a fourth trip to the Paralympic Games in 2024, winning silver medals in discus and club throw at the World Para Athletics Championships this summer in Paris.

"Obviously the goal is always gold, but I feel very blessed to have come here and won two silver medals," Mitchell told Team USA's website. "Paris 2024 is the big one, so everything is about taking that next step to 2024. I want that gold medal."

Mitchell is an assistant professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University. She's a three-time Paralympian, and currently holds the American club throw record in the F51 classification.

Mitchell's research focuses on harnessing the power of big data and machine learning to forecast disease, identify new therapeutics, and optimize treatments. She calls herself a "pathology forecaster" working at the intersection of engineering, data science, and pathophysiology.

▶ JOSHUA STEWART

PHOTO COURTESY: CASSIE MITCHELL; BYAGATHVALLI: CAMILLE CARPENTER HENRIQUEZ

Recent Grad Turns Research Into Biotech Startup

After finishing his bachelor's in industrial engineering in December 2022, Guarav Byagathvalli had a job waiting like many Tech students. The title was a bit different however: founding CEO of Piezo Therapeutics (PiezoTx), a biotechnology startup focused on affordable vaccine delivery.

PiezoTx launched this year with $2 million in seed funding from Open Philanthropy to improve delivery of therapies directly into cells and for far less money than current technology. The company's first device was developed from research at Georgia Tech that adapted the premise of a barbecue grill lighter: a phenomenon called piezoelectricity where each click creates a small pulse of electricity.

Byagathvalli with the PiezoTx electroporator.

MORE MICRONEEDLES

Find out more about Mark Prausnitz's FDA-approved microneedle technology on page 20.

Byagathvalli worked alongside School of Chemical and Biomolecular Engineering Assistant Professor Saad Bhamla to turn a lighter into a cheaper version of a medical device that uses electric pulses to allow DNA or RNA through a cell membrane, a process called electroporation. They brought in Regents' Professor Mark Prausnitz to incorporate microneedles.

"We realized that our novel electroporator, combined with microneedle technology, could deliver vaccines at an ultra-low cost and without a battery," Byagathvalli said. "We wanted to take it even further, to see how this technology could add value to society. Our mission is to make DNA and RNA vaccines safer, more accessible, and scalable for people all over the world."

Byagathvalli said their platform could close the financial and logistical gap between treatments and people who need them, particularly in middle- and low-income countries.

▶ EMMA RYAN

4

Interplanetary Owners

A piece of Georgia Tech property has ended up roughly 7 million miles from campus.

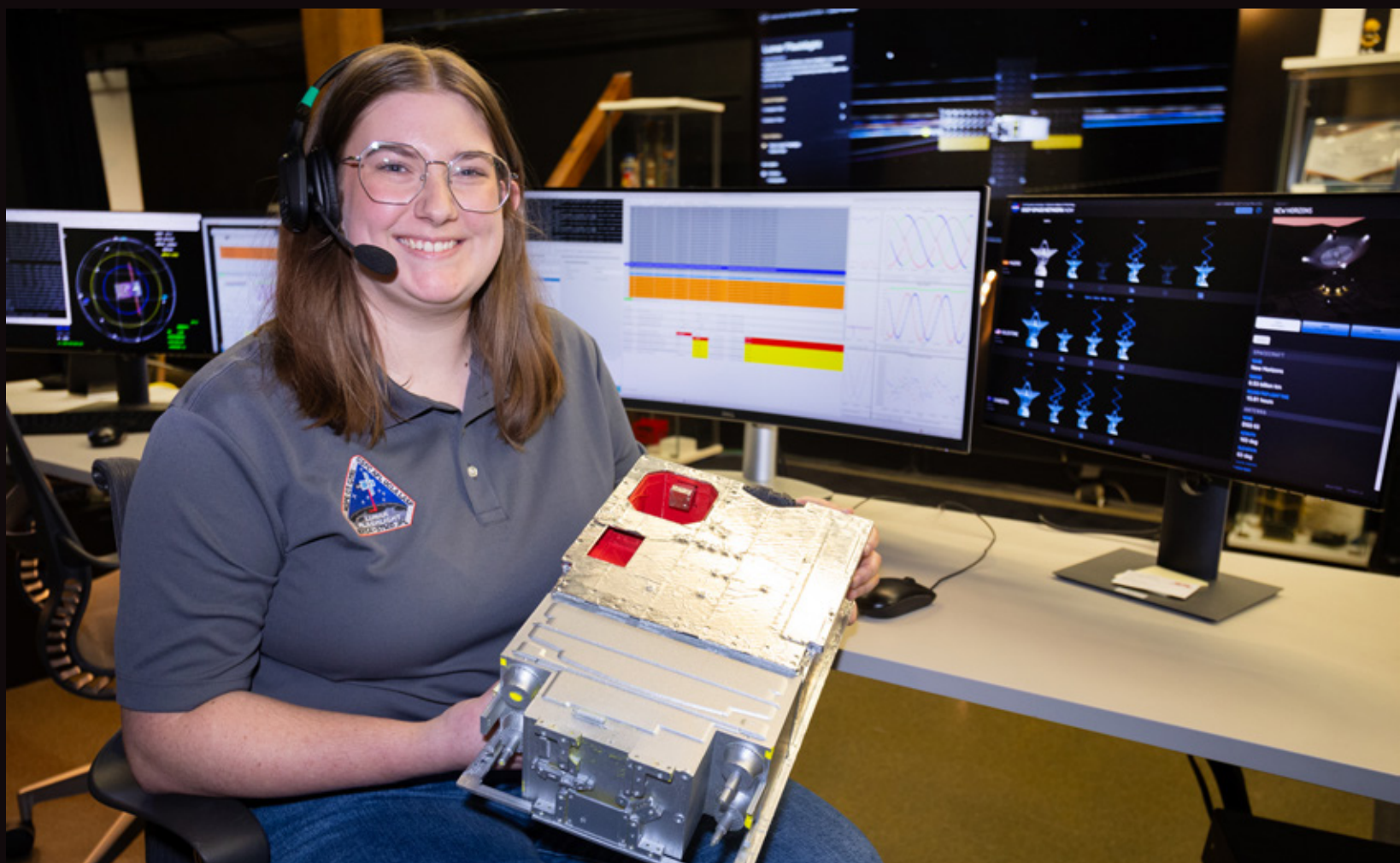
It's a satellite called Lunar Flashlight, and it was launched from Earth in December 2022. Aerospace engineering students served as mission control for what was then a NASA/Jet Propulsion Lab (JPL) mission to orbit the moon and fire lasers at its south pole in search of frozen water.

But problems with the CubeSat's propulsion system prevented the briefcase-sized machine from reaching lunar orbit. Students and JPL engineers spent months troubleshooting together before NASA ended the mission in May.

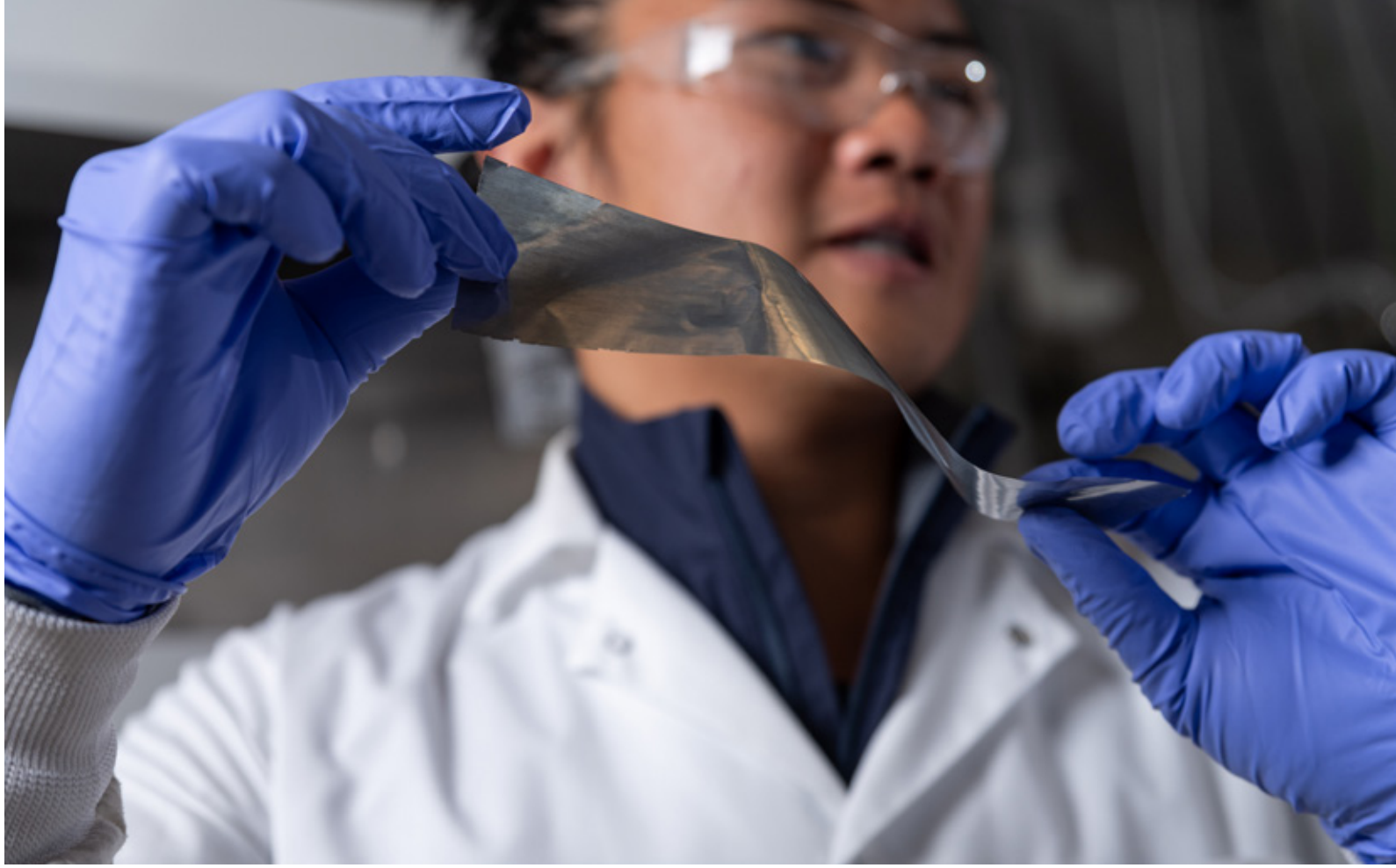
All was not lost, however. At the end of the summer, NASA transferred ownership of Lunar Flashlight to Georgia Tech, making it the only higher education institution in full control of an interplanetary spacecraft. That's typically something only NASA or foreign governments can claim.

Georgia Tech communicates with the CubeSat using NASA's Deep Space Network and will continue demonstrating operations of the satellite's lasers, detectors, radios, and imaging devices for as long as they continue to function.

▶ JASON MADERER



Aerospace undergrad student Micah Pledger serves as missions operations lead.

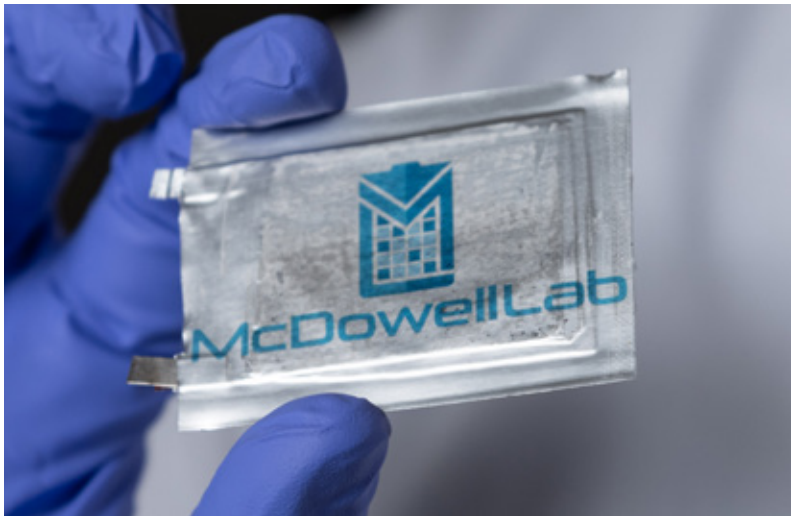


Cheaper and More Powerful Batteries — From Aluminum Foil

A team of researchers is using aluminum foil to create batteries with higher energy density and greater stability. Led by Matthew McDowell in the George W. Woodruff School of Mechanical Engineering and the School of Materials Science and Engineering, the team's work could enable electric vehicles to run longer on a single charge and would be cheaper to manufacture — all while having a positive impact on the environment.

"It's interesting that we can use aluminum as a battery material, because it's cost-effective, highly recyclable, and easy to work with," McDowell said.

The idea of making batteries with aluminum isn't new. Researchers investigated its potential in the 1970s, but it didn't work well. Still, McDowell's team knew that aluminum would have energy, cost, and manufacturing benefits when used in the battery's anode — the negatively charged side of the battery that stores lithium to create energy.



By mixing in small amounts of other materials with aluminum, they created foils with particular microstructures. After testing more than 100 formulas, they hit on a promising possibility.

"Our new aluminum foil anode demonstrated markedly improved performance and stability when implemented in solid-state batteries, as opposed to conventional lithium-ion batteries," said Yuhgene Liu, a Ph.D. student in McDowell's lab and first author of a *Nature Communications* paper describing their battery.

▶ **CATHERINE BARZLER**

Top: Graduate student researcher Yuhgene Liu holds an aluminum material for solid-state batteries.

Above: A solid-state battery built in McDowell's lab.

BATTERIES: ROB FELT; PLEDGER: CANDLER HOBBS; SATELLITE RENDERING: NASA/JPL

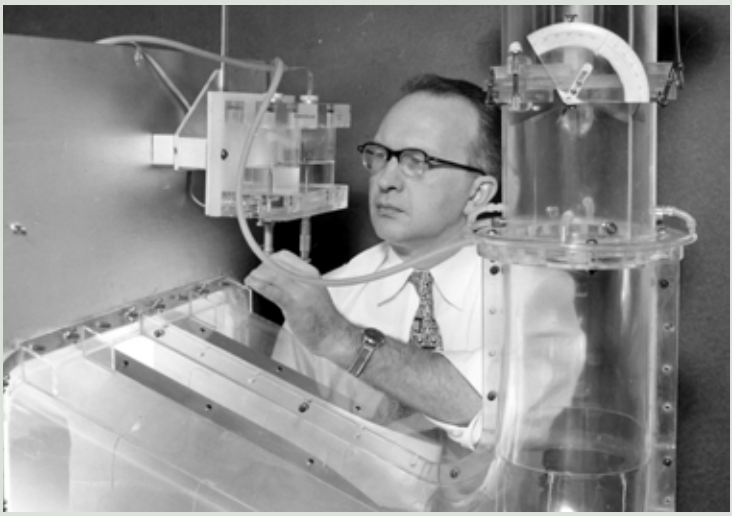
125 Years

OF CIVIL ENGINEERING AT GEORGIA TECH

Mechanical engineering was the only degree offered when the Georgia School of Technology opened its doors in 1888. Over the next decade, Georgia Tech's second president, Lyman Hall, worked to expand the school's offerings, including establishing a program in civil engineering.

What began with one instructor and a handful of students 125 years ago is now perennially one of the top programs in the nation. With a firm grounding in traditional civil engineering principles, the School of Civil and Environmental Engineering has expanded into an interdisciplinary powerhouse focused on addressing the grand challenges of the 21st century, preserving the planet, and improving the human condition.

MELISSA FRALICK

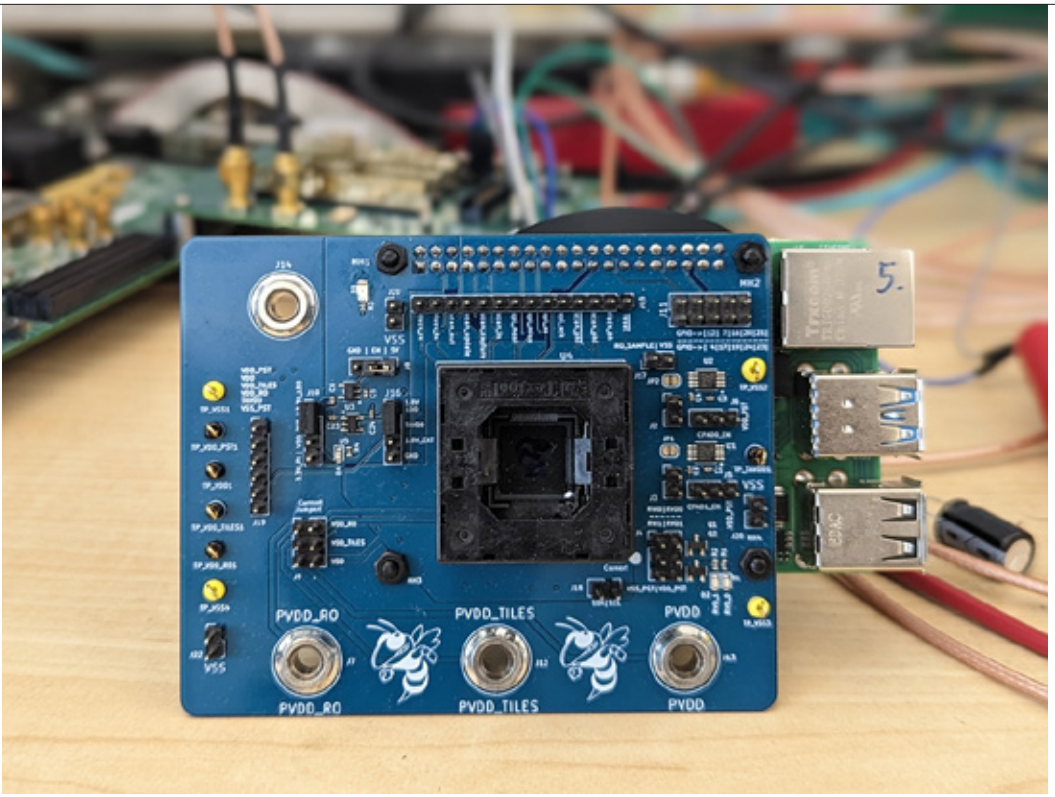


Top: Surveying in 1915.

Right: In the late 1940s, Carl Edward Kindsvater established a hydraulics laboratory that emphasized hydroelectric power, flood control, and the conservation and regulation of water supplies.

Civil engineering students and faculty gather for a photo in front of the Jesse W. Mason building in the early 1970s.

GEORGIA TECH ARCHIVES



Apple Collaboration Paves the Way for New Chip Development Courses

In the fast-paced world of Very Large-Scale Integrated (VLSI) design, the demand for engineers equipped with a comprehensive understanding of the entire chip manufacturing process is soaring. The School of Electrical and Computer Engineering (ECE) and Apple are working to meet that need, starting with an innovative undergraduate course that dives into the intricacies of the complete VLSI design cycle.

The academia-industry course is one of very few in the country that offers undergraduate students an opportunity to explore everything from system specification and architectural design to fabrication and testing. Designed and taught by Professor Visvesh Sathe, the course goes beyond mere industry training to directly address demand for expertise in real-world hardware design.

"By comprehending the complete picture, regardless of their specific role, students will be better equipped to excel and make meaningful contributions in various roles within the hardware industry," Sathe said.

The ECE team approached Fernando Mujica, a 1999 ECE Ph.D. graduate who is a director of engineering at Apple, to help. The timing coincided with Apple's New Silicon Initiative, a program designed to inspire and prepare students for careers in hardware engineering, computer architecture, and silicon chip design.

"The course equipped students with substantial knowledge, but also fostered essential teamwork skills, closely resembling the dynamic and problem-solving nature of real-world industry settings," Mujica said.

The course engages students for two semesters, starting with an introduction to VLSI design and expanding to fabrication of student-designed chips, testing, and measurement.

▶ DAN WATSON

Tim Lieuwen Named AE Interim Chair

Regents' Professor Tim Lieuwen has been appointed interim chair of the Daniel Guggenheim School of Aerospace Engineering following the August departure of Mark Costello at the conclusion of his five-year term.

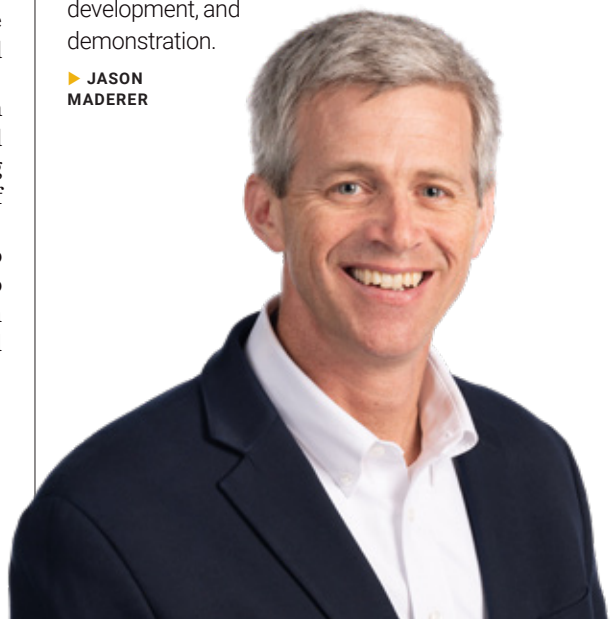
Lieuwen has been an AE School faculty member since 1999 and is a two-time Georgia Tech engineering graduate. He is an international authority on clean energy and propulsion. His research sits at the intersection of what makes energy systems work, focusing on fluid mechanics, combustion, and acoustics.

Lieuwen's work has contributed to a number of commercialized innovations in the energy and aerospace sectors. He's the founder and chief technology officer of Turbine Logic, an analytics firm working in the energy industry.

"Tim's leadership and research have had a tremendous impact on Georgia Tech and the nation," said Raheem Beyah, dean and Southern Company Chair. "His knowledge of our culture, students, faculty, and staff will be invaluable during this time of transition. I'm grateful for his willingness to lead the AE School as we search for a permanent chair."

Lieuwen also is the executive director of Tech's Strategic Energy Institute, managing overall strategy and external relations for more than 315 faculty members and 1,000 Georgia Tech researchers working in energy research, development, and demonstration.

▶ JASON MADERER



LIEUWEN: JOYA CHAPMAN; CHIP: NEALSON LI

CANCER FIGHT

From left: Engineers Ankur Singh, John Blazeck, Fatih Sarioglu, and Gabe Kwong. Not pictured: Susan Thomas (PHOTO: CANDLER HOBBS)

BY JOSHUA STEWART

By now, we were supposed to be able to treat just about every kind of cancer.

President Richard Nixon declared war on the disease in 1971 during his State of the Union speech, pledging to ask Congress for $100 million to find a cure for what was then the second-leading cause of death in America.

"It was thought that we would be able to solve it in about a decade; that was the goal. And we've learned over time, cancer is actually much more complex than we gave it credit for in the beginning," said Gabe Kwong, a Georgia Tech biomedical engineer working toward the goal Nixon laid out more than 50 years ago.

"There are many subtypes of cancer, and each requires a different strategy. And yet, as a population, we're living longer and longer. People are developing cancers because it's a disease of aging, basically. So, it's a big problem, it's very complex, and it requires new ways of thinking about it."

Kwong is an associate professor in the Wallace H. Coulter Department of Biomedical Engineering, a joint program shared equally by Georgia Tech and Emory University. For all the reasons he outlined, cancer is a challenging problem.

And who is drawn to big, challenging problems more than engineers?

Kwong's efforts got a significant boost this fall when President Joe Biden's Cancer Moonshot Initiative awarded up to $50 million to support a project Kwong has been building to for more than a decade.

He's assembled a team to develop a new generation of tests capable of detecting multiple types of cancers earlier than ever, allowing doctors to start treatment when tumors are still small and most responsive.

The key is what Kwong calls the Cancer and Organ Degradome Atlas, or CODA platform, which will map the unique cellular profiles of cancer cells and leverage that knowledge to build new bioengineered sensors to detect those profiles.

Early detection is possible now, but only for a handful of cancers. Kwong's vision is to build a one-size-fits-all product that could do the work of those existing tests — mammograms, colonoscopies, and Pap smears, for example — plus detect cancer types currently without reliable tests for early detection.

ERS

ENGINEERS ARE REWIRING CELLS AND CREATING NEW TOOLS TO IMPROVE CANCER THERAPIES AND CATCH THE DISEASE EARLIER

"This is what researchers like to do — we dream about a different future; about the technologies we need to develop to get there," Kwong said. "I've been cultivating this vision for the last 10 years. Now there's a mechanism to implement it and go at light speed. That's pretty exciting."

It's hardly the only exciting work happening in the College of Engineering to make untreatable cancers treatable and improve the lives of patients.

Some researchers are using the body's own immune system to counteract and combat cancer, including significant efforts to leverage the capabilities of T cells — perhaps the body's most powerful cells. They're creating new ways to study, or change, the environment around tumors. And they're also building new tools to help demystify the "heterogeneity" of cancers, including why some cancers — like those of the prostate — take a far greater toll on Black and African Americans.

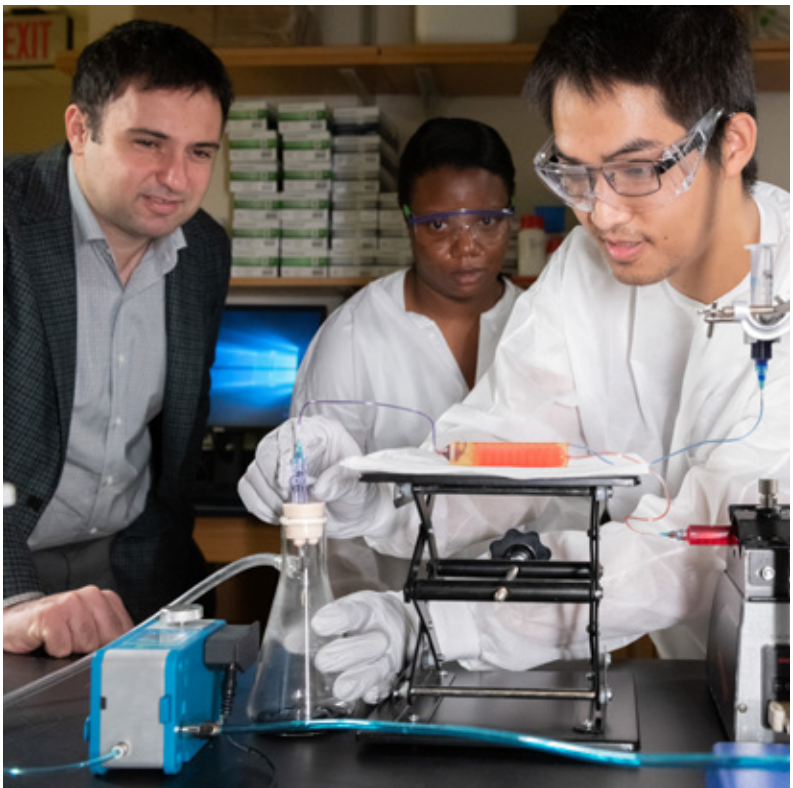
T CELLS

One of two main types of white blood cells called lymphocytes. They can attack the body's own cells that have been taken over by viruses or become cancerous.

Cancer 'Microchips'

Answering at least one part of that question is the subject of an ongoing multi-year study involving Georgia Tech electrical engineers and researchers at Emory University's Winship Cancer Institute.

Black men are twice as likely to die from prostate cancer and nearly twice as likely to be diagnosed in the first place, according to the American Cancer Society.



Fatih Sarioglu (left) and researchers work on a 3D-printed cell trap that captures tumor cells from diagnostic blood samples.

Fatih Sarioglu and his collaborators have been looking at tumor cells in blood samples from Black prostate cancer patients to isolate whether biological or physiological differences can account for those numbers.

It's a project made possible by technology Sarioglu's lab has developed that can pluck a single circulating tumor cell out of the 50 billion or so cells in a test tube of blood.

"It's still an evolving area, because the challenge has always been to reliably and robustly get these circulating tumor cells," said Sarioglu, associate professor in the School of Electrical and Computer Engineering. "Only when you have reliable technology, when you make them studiable, can the research and the clinical applications start."

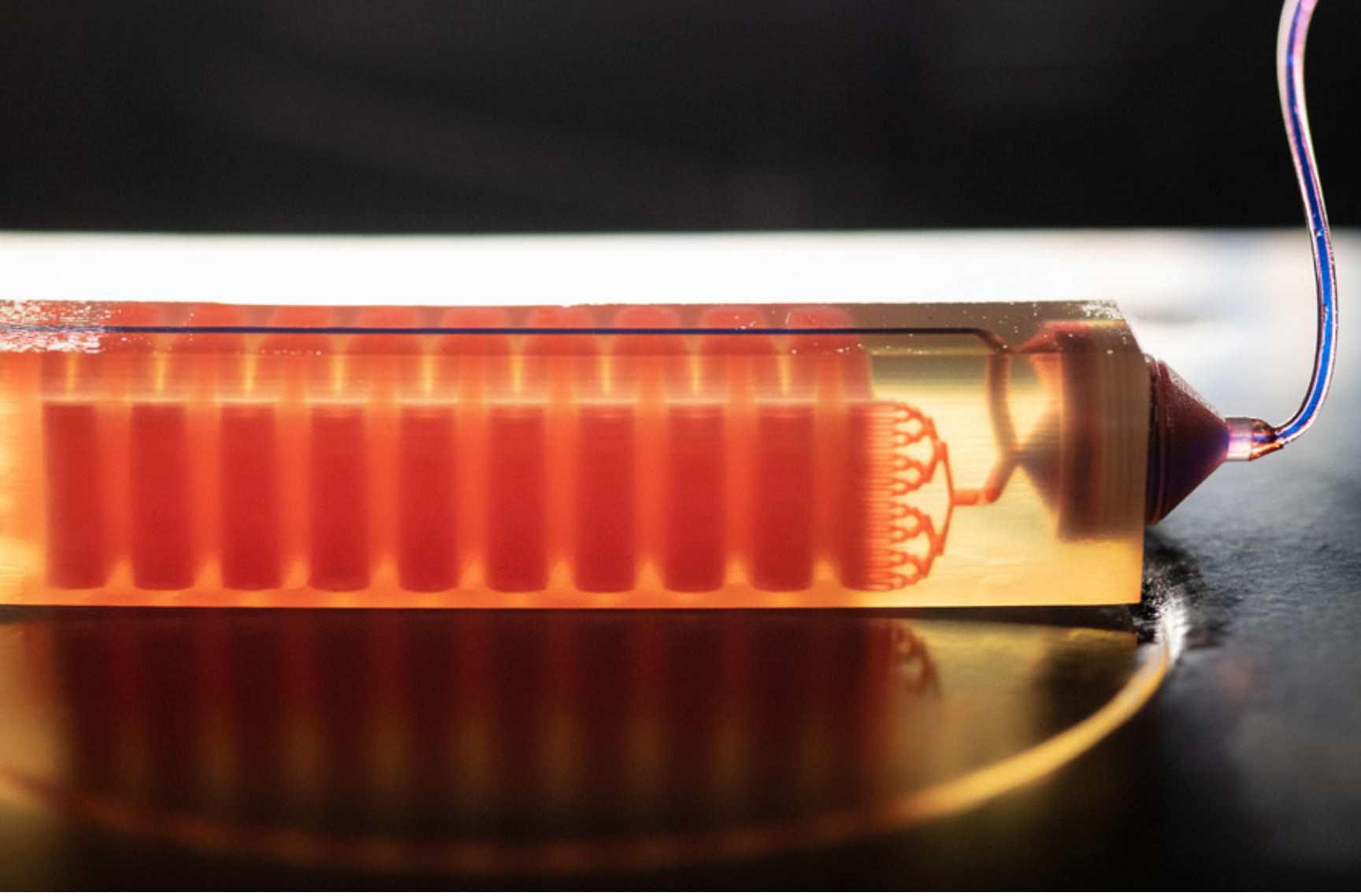
Using the same methods used to build computer chips, Sarioglu has developed microfluidic chips with tiny, cell-sized channels or pores that blood samples flow through. Along the way, tumor cells are caught for study.

In one version, his team used a 3D printer to create a two-step approach: The chip first captured large white blood cells using common proteins on their surface and then used a filter that allowed much smaller red blood cells and platelets through but stopped larger tumor cells. Another approach, called Cluster-Wells, filtered blood to capture tumor cells that have clustered together. They're more efficient at spreading cancer, Sarioglu said, but also have an interesting biophysical marker — the clumping — that allows him to find them in blood.

"We can design systems that will make sure every cell in that blood sample will go through the same testing. And then you can design a chip that will 'touch' essentially each of these cells, pick the ones that are tumor cells, and let the other cells go away," Sarioglu said. "That way you can actually find a needle in a haystack."

Other approaches exist to capture tumor cells in the blood, but they're typically too aggressive and damage the cells in the process or break up clusters. Sarioglu's techniques are both effective and sensitive, allowing clinicians to study tumor cell proteins or do full genome sequencing just like they would with tumors themselves.

Catching circulating cells sooner improves the chances of stopping the tumor's spread, a powerful tool



ALLISON CARTER

to fight metastatic cancer, which is responsible for most cancer deaths.

"Most of the time with a solid tumor, you have these cells circulating in the bloodstream. People have known this for more than 100 years," Sarioglu said. "People knew that the cells were killing the patient, but we didn't have a way of getting them."

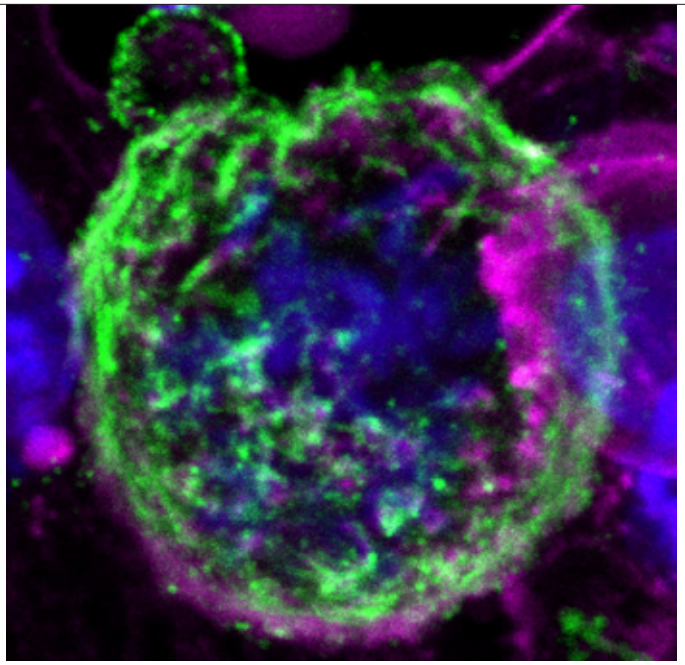
Now they do, and the chips his team is designing also can be used for other biofluids where cancer cells might be present. Blood is incredibly complex, but it's easy to acquire noninvasively, so it's the natural starting point.

One day, the screening tests could be part of everyone's annual checkup, Sarioglu said, just to check for early signs of cancer. His chips don't degrade the blood samples — they're not diluted and nothing is added — so the typical panel of blood tests could still happen after the sample passes through.

Most immediately, though, Sarioglu's team will continue processing blood samples in his collaboration with Emory in hopes of finding a thread that will begin to unravel why prostate cancer is so much more deadly for Black patients.

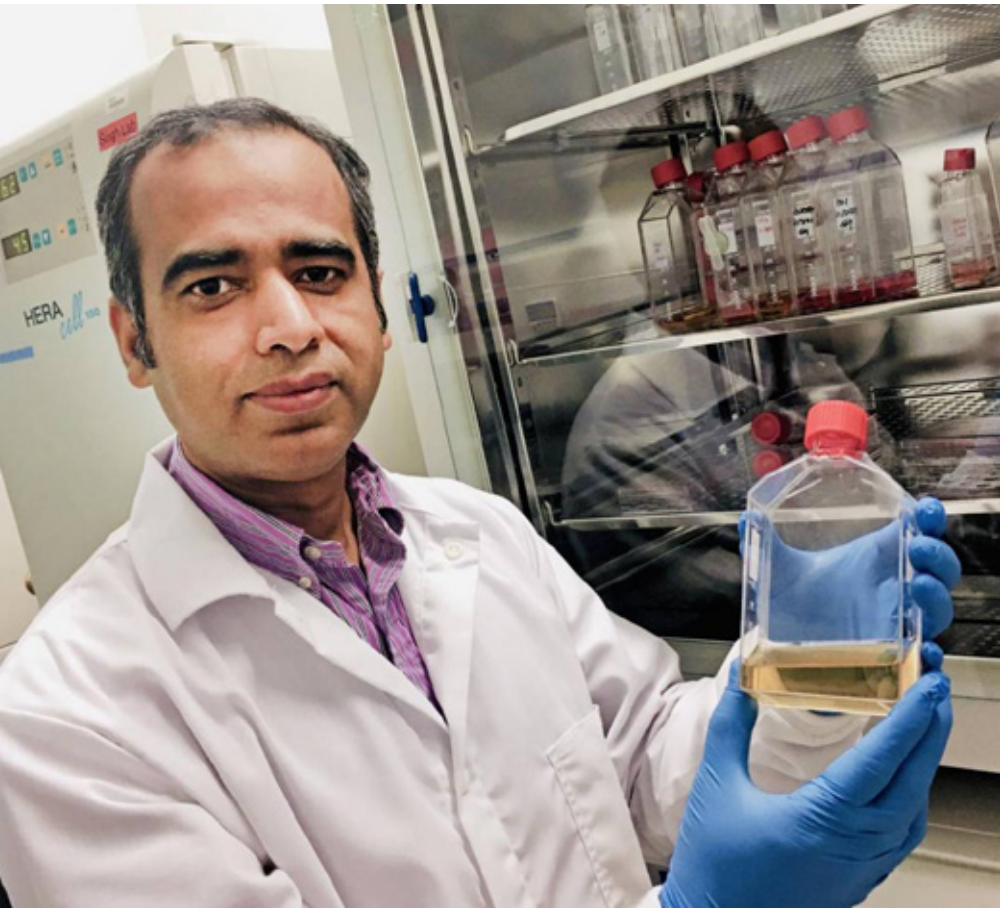
"This aggressive behavior of the disease has been known for a long time, but now we are really well positioned at Georgia Tech to do this research," he said. "We have excellent clinical collaborators at Emory, we have a large African American population in this area, and then we have these capabilities on campus — I think everything is coming together and this is the right time to go after this kind of problem."

Using the same methods used to build computer chips, Sarioglu has developed microfluidic chips with tiny, cell-sized channels or pores that blood samples flow through. Along the way, tumor cells are caught for study.



At left, a tumor cell in an lab-created lymphoma organoid. Ankur Singh uses organoids to model tumors and study the complex interactions between cancerous growths and the cells nearby. The green portions are protein markers for tumor cells, and the magenta areas are protein markers for supporting connective tissue cells.

Below, Singh in his lab with a synthetic hydrogel his team developed to grow organoids to study prostate cancer.



A Question of Environment

Ankur Singh's immunoengineering lab is tackling disease disparities for a different cancer. Lymphoma — cancer of the lymphatic system — affects people of all races and ethnicities but occurs in Black patients at a younger age than other groups, and the disease is often more advanced. Black patients also don't respond to treatment as well as white patients.

Working with Emory University oncologist Jean Koff, Singh hopes to unravel how the area around tumors in the body — the tumor microenvironment — plays a role.

"There is evidence that the mutational landscape is different for those patients across demographics in terms of the tumor cells, but what about the tumor microenvironment? There is absolutely no solid information out there," said Singh, professor in the Coulter Department and the George W. Woodruff School of Mechanical Engineering.

"There's reason to believe all of this is happening because of a combination effect of mutation and microenvironment. We understand the mutation through genetic studies; we do not understand the impact of microenvironment. And that's where my lab is leading."

Singh is fascinated by the complex interplay of cancerous growths and other cells nearby. Those interactions impact how the cancer progresses, or doesn't, and why treatments work for some patients yet fail for others.

To understand those interactions, Singh's research group creates models of tumors and lymph tissues in the lab using materials called hydrogels and uses chip-based models to study the intricate movement of fluid in tissues.

Earlier this year, his team published details of a new synthetic hydrogel-based model of the lymphoma microenvironment. They used data from more than 1,100 patients with a specific kind of lymphoma to create their platform, and they were able to grow tumors from patient samples. Singh's team discovered how the tumors were hijacking the immune system to resist a new kind of inhibitor drug, even at high doses.

"We demonstrated that there is a massive dampening of therapeutic response when you have certain kinds of immune cells present in the tumor microenvironment," he said. "It is only by using a precision approach of combination therapy that you can overcome those tumors."

That, he said, is the power of seeing the whole picture: tumor plus its environment. Ultimately, he's working toward models that could be adjusted to fit every specific tumor and patient to help doctors try treatments before they give them to patients.

> "What we're doing is fundamentally different. We're trying to get the drug to the immune cell wherever it is, and we think a good place to look is where they naturally congregate — lymph nodes."
>
> Susan Thomas

"Our approach is that every patient's tumor is different. Every patient is different. Black patients versus white patients, male versus female, young versus old, obese versus lean, all of those factors are tied into it," Singh said. "We're working to make a technology where you can plug-and-play and change the components to meet the needs of that particular patient's tumor."

Therapeutic Superhighway

Immunoengineer Susan Thomas also spends her days thinking about lymph nodes.

Thomas specializes in drug delivery — getting therapies to exactly the place they're needed. And she sees the lymphatic system as the superhighway those therapies can travel.

"When you get vaccinated or have a sore throat, your lymph nodes swell. They're essentially tissues where tons of immune cells in your body gather. Our thought is to help the magic happen where all the cells are," said Thomas, professor in the Woodruff School.

Her lab creates biomaterial drug delivery technologies that capitalize on those gatherings. Getting drugs into the lymphatic system means they can reach niches where immune cells gather in high numbers before they distribute elsewhere to fight disease.

"The idea is you want to activate the immune system to go and survey your entire body looking for cancers and then try to kill it," Thomas said. "And that works for many types of cancer."

One powerful cancer therapy is a relatively new type of drug called an immune checkpoint inhibitor, which counteracts a trick that tumors play on the body's immune system. Normally T cells would identify the foreign tumor cells and destroy them. But some tumors produce immune checkpoint proteins, so the T cells think the tumor cells are part of the body and leave them alone.

Immune checkpoint inhibitors essentially block these checkpoint proteins, preventing the tumor from turning off the T cells. Often, though, these therapies work only for a portion of patients. Thomas' work aims to help those immune checkpoint blockade drugs work better and at a lower overall dose.

"By micro-dosing lymph nodes with those immune checkpoint blockade drugs, you're getting some of that drug to many cells in one spot. Those cells then leave that lymph node and travel elsewhere in the body. They are now more capable of killing cancer cells, and this was achieved using the drug at a very low dose systemically," she said.

Traditionally, the approach has been to try to deliver cancer drugs throughout the body or directly to the tumor, she said. "What we're doing is fundamentally different. We're trying to get the drug to the immune cell wherever it is, and we think a good place to look is

THOMAS: ALLISON CARTER; SINGH: JERRY GRILLO; CELL: ANKUR SINGH

John Blazeck

where they naturally congregate — lymph nodes. After interacting with the drug, the immune cell is changed and behaves differently once it is in the tumor. We don't need the drug to be in the tumor to still have the effects. And we think that is part of the reason why our systems are working so well, because it's getting more cells to behave in that beneficial, different way."

Another project is a collaboration with the Woodruff School's Brandon Dixon to improve the quality of life for patients after cancer treatment.

About a fourth of breast cancer patients experience swollen limbs after a mastectomy or lumpectomy that also removes lymph nodes. This prevents fluid from draining out of tissues properly, and the resulting lymphedema is uncomfortable and irreversible. Thomas and Dixon created a nanoparticle that delivers a drug directly to failing lymph vessels, restoring their ability to pump fluid and drain tissues.

Since they published a study on their nanoparticle, Thomas has received emails and phone calls almost every day from patients with lymphedema looking for relief and hoping the team's work will lead to a trial they can participate in.

"They've survived their cancer, but they don't know what to do about the lymphedema," Thomas said. "We always think about trying to save patients. We need to also start thinking more about quality of life for patients in the wake of their treatment."

Metabolic Machinery

The immune system's T cells are the focus for chemical engineer John Blazeck, too. And like Singh, he's looking less at tumors themselves and more at their environment.

Blazeck studies changes in metabolism that occur in and around solid tumors, a hallmark of many types of cancer. He's thinking about ways to make that environment less favorable so cutting-edge immunotherapies are more effective for more people. He's particularly interested in lung and breast cancers.

"Those are the ones that we study the most, in part, because the metabolic changes that occur seem to really impact the efficacy of current frontline immunotherapies," said Blazeck, assistant professor in the School of Chemical and Biomolecular Engineering. "This is where our contributions could have direct relevance in helping the current best-in-class treatments."

Blazeck has received significant funding from the National Institutes of Health (NIH) to explore two parallel approaches to make the tumor's environment less hospitable.

Often tumors use up the nutrients around them faster than they can be replenished — think energy molecules like glucose and protein building blocks like amino acids. The tumors might be growing faster than other cells and have less blood supply, so they vacuum up nearby nutrients, simultaneously depriving the body's immune cells of tools they need to grow fast and kill the tumor cells.

"We want to rewire the metabolism of T cells, enhancing it so that they can outcompete tumor cells for some of these limited nutrients in the tumor environment and resist this nutrient depletion," Blazeck said.

That's just part of the one-two punch tumors deliver to the body's metabolism. They also overproduce metabolites, leftovers or byproducts of metabolism. The accumulation of these molecules interferes with T cells, basically turning them off.

Blazeck is working to engineer enzymes to degrade these immunosuppressive metabolites, freeing the T cells to attack the growing tumor.

Right now, he's exploring both paths in parallel. But the hope is they could eventually converge into a combination approach.

BLAZECK: CANDLER HOBBS; KWONG: JERRY GRILLO

"Our idea to use cells to remodel their metabolic environment hasn't really been attempted," Blazeck said. "If we succeed, it would be the first potential way to use an engineered cell therapy to change the extracellular metabolic environment of the cell itself."

Living Sensors

Blazeck also is part of the multi-institutional research team Gabe Kwong has assembled for his $50 million Cancer Moonshot effort to build an atlas of cancer cell biomarkers and create tests that can detect multiple cancers early in their development.

Kwong has long used cell engineering techniques to create cell therapies or diagnostics. He's co-founded two biotech companies working to commercialize some of the innovations his team has built in the lab.

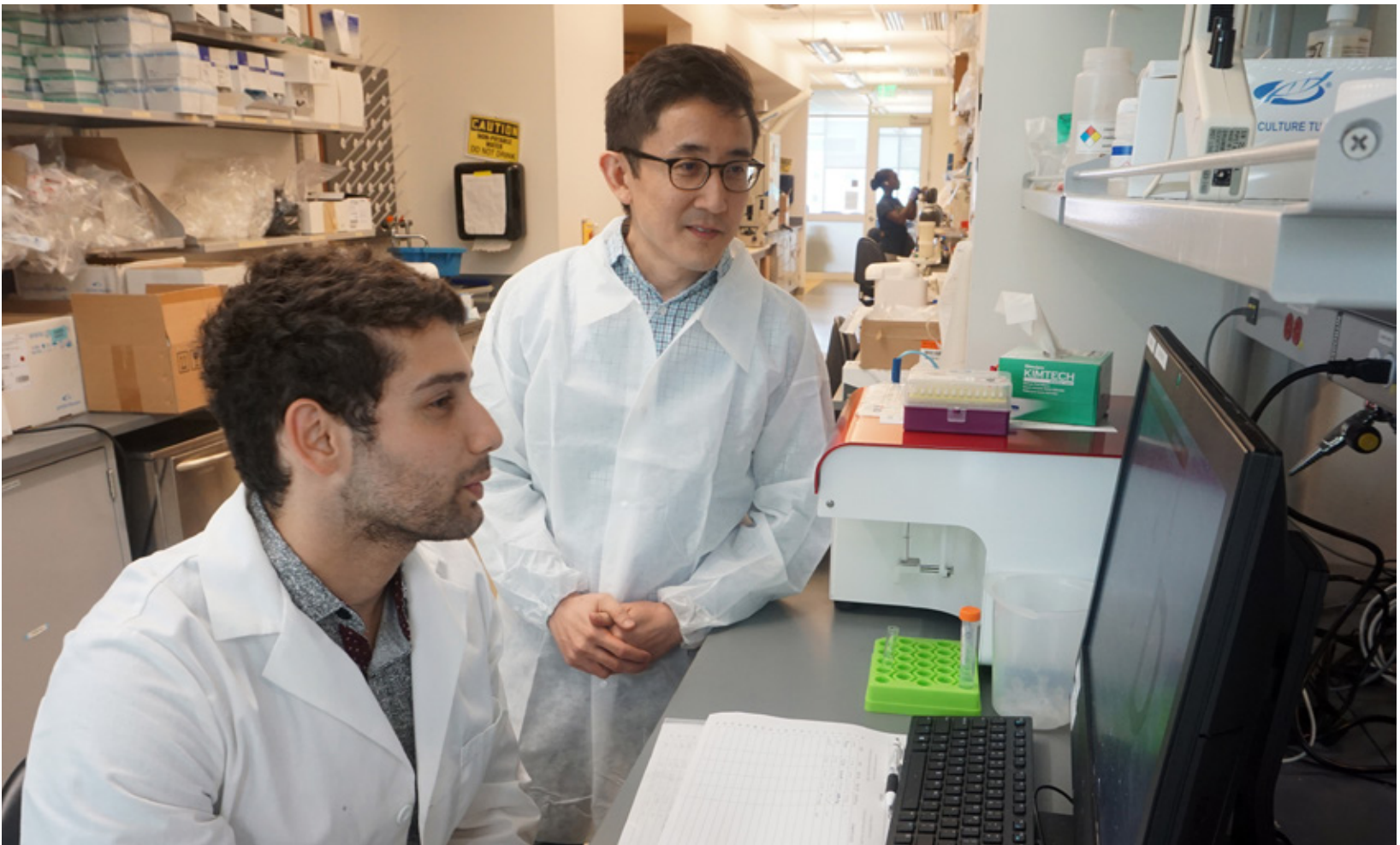
In one line of inquiry, Kwong is turning the immune system's T cells into mini drug factories right at the tumor site.

It's an extension of chimeric antigen receptor (CAR) T cell therapy. The idea is to engineer the T cells to produce powerful but toxic drugs, and then activate them with a focused ultrasound beam.

"We're using that technology to give us spatial precision so we can turn on these T cells and locally produce a drug that you would not dare to use systemically," Kwong said.

Over the last year or so, he's also been working on a different project to turn immune cells into roving sentinels watching for tumor growth.

For more than a decade, Kwong has developed synthetic biosensors that can tell doctors if a patient is responding to immune checkpoint blockade therapies or watch for metastasizing cancers. Those sensors are like inorganic chemical probes that produce a signal in urine or blood. Kwong said engineers can do a lot of things with those systems, but the limitations are real.



Gabe Kwong (standing) and Ph.D. student Ali Zamat added a genetic on-off switch to CAR T cells and developed a heat-activation system to enhance how the cells attack tumors.

"We could imagine a future where this is safe and inexpensive enough that you do this in healthy individuals. You pre-engineer a small subset of their immune cells to report on the cancer that they're susceptible to. That's where we're trying to go."

Gabe Kwong

They don't proliferate and they don't have memory, for example.

Some immune cells do; they patrol the whole body, they can destroy target cells, and some remember once they've seen a molecule or antigen. That makes them an exciting potential tool to watch for, produce an alert, and even eradicate cancer lesions early, he said.

"Immune cells have already evolved all these functions. We, as engineers, just need to know how to harness them and redirect — and in some cases, rewire — these functions to do the things that we want the cell to do."

Kwong's team has created the initial proof of concept of that rewiring in the lab, engineering immune cells with tumor-sensing receptors and programming them to secrete a molecule that can be detected when they find tumor cells.

Kwong said the idea of engineering immune cells as sensors will help lead us to a new era of preventative oncology. He could see his engineered cells even being used to monitor patients who are high risk but don't have cancer.

"We could imagine a future where this is safe and inexpensive enough that you do this in healthy individuals. You pre-engineer a small subset of their immune cells to report on the cancer that they're susceptible to," Kwong said. "That's where we're trying to go. That vision will take maybe 10 or even 15 years, but that's a real possibility in my view."

INTEGRATED CANCER RESEARCH CENTER

Cancer researchers at Georgia Tech created a research consortium focused on harnessing expertise across disciplines to develop new diagnostics and therapeutic approaches for cancer. The Integrated Cancer Research Center aims to build on Tech's history of collaboration in those areas, coordinating efforts across campus and with Tech's partner institutions.

Helping Families Keep a Watchful Eye

Living biosensors constantly patrolling for cancers would be a game-changer for families who are genetically predisposed to get certain types of the disease. In the meantime, researchers at Georgia Tech, Emory, and the Georgia Clinical & Translational Science Alliance (Georgia CTSA) are working to help these families with a very practical need: keeping track of their intense schedule of tests and doctor appointments.

Roughly 5% to 10% of cancer malignancies occur in patients with cancer predispositions. For these patients and their families, continual surveillance is a fact of life to catch cancer early, when it is most treatable. That means regular blood work, MRIs or other imaging scans, and other procedures.

It can quickly become overwhelming: Because the predisposition is genetic, that usually means everyone in the family is on some kind of testing regimen.

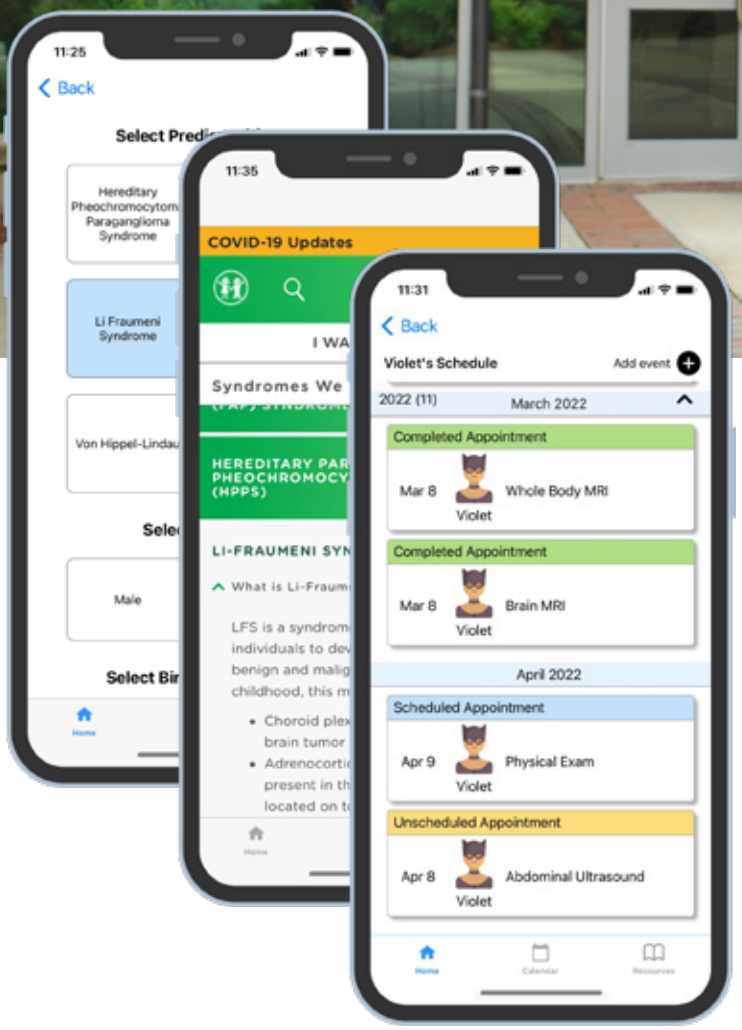
"Keeping track of these appointments is important. We know patients who miss their surveillance studies are worse off from a clinical perspective, and they have a worse prognosis," said Wilbur Lam, professor in the Coulter Department of Biomedical Engineering and in the Emory University Department of Pediatrics.

Lam leads the innovation catalyst at Georgia CTSA, including AppHatchery, which pulled together clinicians, engineers, and software developers to create a mobile app to help these families avoid the health impacts of missing their regular scans. Called HomeTown, their app is "a simple but elegant solution to addressing a very important clinical problem for these patients," Lam said.

Based on conversations with families, the app includes a calendar to track appointments and recommended tests for each family member along with reminders to schedule those tests. Users can store test results and notes from doctor's appointments and research recommended surveillance protocols. In its initial form, the app includes guidelines for six of the most common cancer predispositions.

"HomeTown can help streamline complex care for patients and families who have a cancer predisposition syndrome. For example, the reminder feature helps them keep track of scheduling various cancer surveillance interventions. This can be extremely cumbersome, especially when one caregiver is coordinating surveillance for a number of family members or children," said Sarah Mitchell, a physician at Children's Healthcare of Atlanta who collaborated on the app.

Wilbur Lam



The HomeTown app helps families with cancer predispositions track their regimen of preventative tests and doctor visits.

LAM: JERRY GRILLO

Beyond keeping up with critical monitoring regimes, the development team also found the app helped reduce the "mental load" that comes with the constant worry about what test results will show, according to lead developer Santiago Arconada Alvarez.

"The period between the scan and the result is really stressful," said Arconada Alvarez, scientific director of the Georgia CTSA AppHatchery. "Anything we can do to offload what's going on in their head, to help them trust that it's in the app and they don't also have to carry it as part of their daily lives, we found to be helpful to these caregivers and families."

In the initial testing, more than 150 families around the country downloaded and used the app. The team is hoping for continued growth.

"I can definitely see an app like this being incorporated into patients' lives," Mitchell said. "Everyone seems to have a smartphone, and a mobile app like this could be an incredible resource for patients, families, and healthcare providers."

When Nixon declared war on cancer back in '71, it may well have been wishful thinking that scientists would find a cure at all, let alone in a decade.

Susan Thomas argued "cure" isn't really the goal anyway. She suggested the word "manage" would be more apt — and the tools Georgia Tech engineers are developing will help in that quest.

"In an aging society, you're going to have a higher prevalence of cancer, not a lower prevalence. What we need to get to is something more like a hip implant: We have tools and we understand how to use them to prolong a healthy and rewarding life for patients." ◂

BY JASON MADERER

FDA APPROVED

Several alumni and faculty members have received FDA approval for devices and procedures in recent years — and are preparing to do it again.

The flight from Atlanta to Los Angeles is full. As luggage feeds into the plane's belly and passengers take their seats, the captain claims her own. She's flown the ATL-LAX route countless times and is ready for another. As she sits and looks at the control panel, preflight checklist finished, there's nothing more to do but start the engines.

That's because the captain is about to fly cross-country without a flight plan. The 777 is unequipped with communication devices, so there will be no contact with air traffic control. Nor is there radar, which means no warning signs of bad weather. The captain will rely solely on what she sees out her window, guided by landmarks and compass direction.

This, of course, isn't how pilots fly planes. But it is how doctors implant cardiovascular devices surgically or with catheters. Surgeons go into a procedure without knowing how well the device will perform or if the patient will experience complications, much like an airline captain guided solely by their skill and eyesight.

Unless, that is, a surgeon uses a tool created by a Georgia Tech faculty member to improve health outcomes for patients with heart disease. Lakshmi Dasi has developed software that uses artificial intelligence (AI) to predict what will happen on the operating table — before doctors even touch their patients.

The software is one of many tools, devices, and procedures created in recent years by College of Engineering researchers and alumni that have received clearance from the Food and Drug Administration (FDA) and are making a real difference in people's lives.

The trek from an idea to the lab to FDA approval is often long and full of twists and turns. But these Georgia Tech community members have done it at least once — and they all plan to try again. ▸

> FDA Approved

The Eye of the Needle

Sticking needles into eyes isn't as rare as it might seem. And doing so can be good for you.

Doctors routinely inject steroids into the eye to treat conditions such as macular degeneration and retinal vein occlusion. The needles are up to 16 millimeters (more than a half-inch) in length.

However, medicine administered into the eye via needles can't be easily targeted. Injected steroids flood the entire organ, which can cause cataracts and glaucoma.

Regents' Professor Mark Prausnitz and his research team found a more effective way of injecting medicine almost by accident in 2006. They were using very small needles to insert a depot of drugs into the sclera, the white part of the eye that is firm and difficult to penetrate. Then one day a newer student tried. He found it very easy.

"He knew he did something wrong," said Prausnitz, the J. Erskine Love Jr. Chair in the School of Chemical and Biomolecular Engineering. "It turns out that the student pressed the needle *across* the sclera and into the area — the suprachoroidal space — behind it. When a needle is pressed in that space, the injected fluid fills a pocket behind the sclera that keeps the medicine in place and away from other parts of the eye that can cause side effects."

The "mistake" led the team to create hollow microneedles that are just a millimeter long. They're tailored to penetrate the eye only as far as needed to deliver the drugs to targeted internal spaces. Prausnitz and his collaborators at Clearside Biomedical received FDA approval in 2021 and launched the first microneedle product for ocular injections in 2022.

In addition to hollow microneedles for the eye, Prausnitz's work has led to solid microneedle patches for long-acting contraception, microneedle particles to treat dermatological disease, and microneedle electrodes for mRNA vaccination.

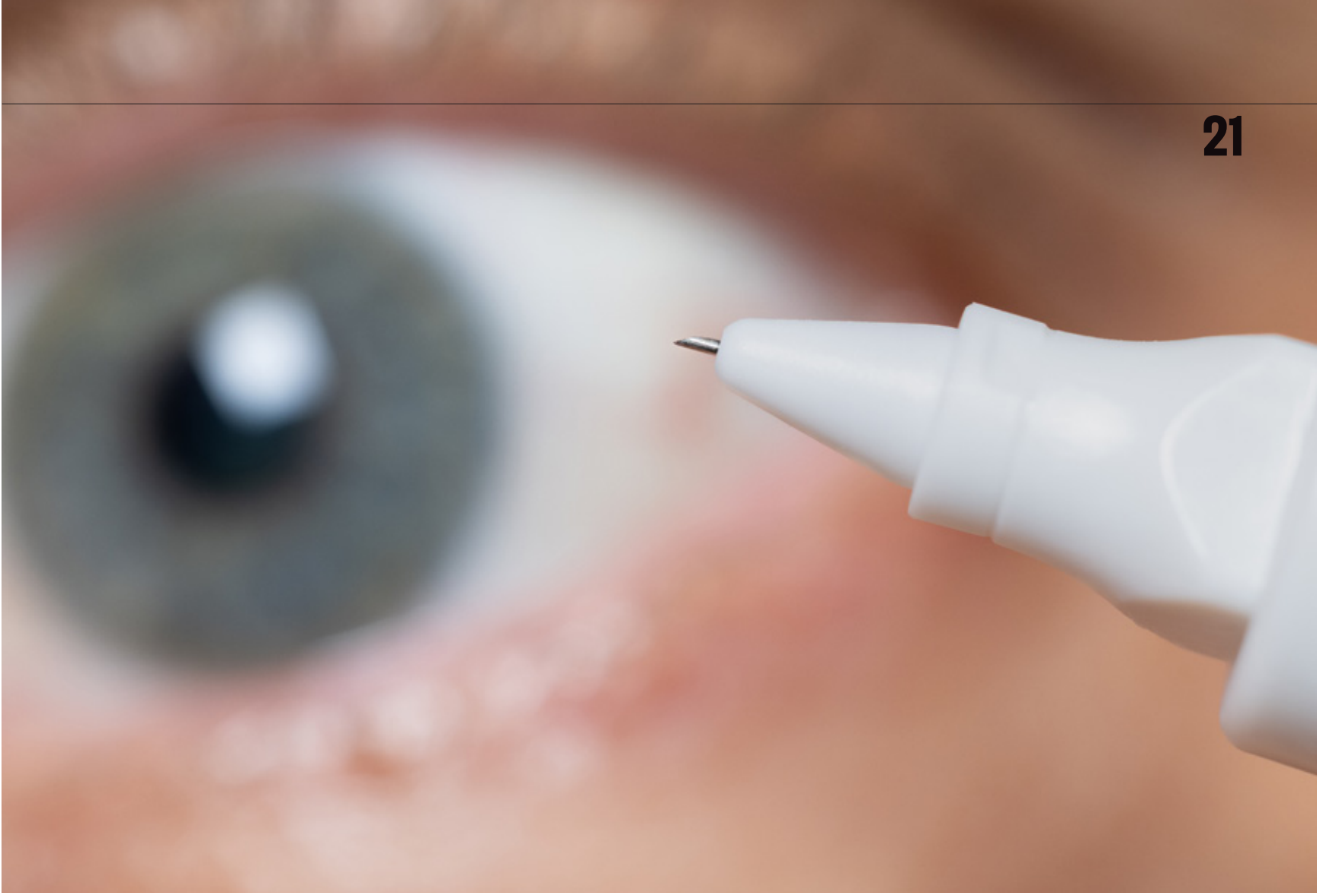
"One of my goals as a Georgia Tech faculty member is training students in the lab and classroom to allow them to launch successful careers. Another goal is doing innovative research that can be published to advance science and engineering," Prausnitz said. "But I won't be satisfied if those are my only contributions. I want my research to go beyond Georgia Tech and into the medical community in order to make a difference in healthcare."

Opposite page: The hollow microneedle is just a millimeter long. Below: Prausnitz's work has also led to microneedle patches for drug delivery.

"I want my research to go beyond Georgia Tech and into the medical community in order to make a difference in healthcare."

Mark Prausnitz

MICRONEEDLE PATCH: CHRISTOPHER MOORE

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The AnemoCheck point-of-care kit.

Below left: Georgia Tech's InVenture Prize competition was one step on the way to commercialization for Erika Tyburski and AnemoCheck.

Below right: The app makes it easy for users to manage anemia at home.

INVENTURE PRIZE: ROB FELT; ANEMOCHECK COURTESY: ERIKA TYBURSKI

> FDA Approved

A New Checkpoint for Anemia

Erika Tyburski made a career-defining decision after her senior design project wrapped up in 2012. The biomedical engineering major had created an instant anemia test and was thinking about potential commercialization.

"I had two options: Go into industry for a cushy job, make lots of money, and pay off my student loans," Tyburski said. "Or I could go on a different path and see where the project, AnemoCheck, would take me."

Tyburski walked that second route, and it's worked. She's now the chief executive officer of Sanguina, a company with a digital platform and physical products that include AnemoCheck. The company has 14 employees spread across the country and is headquartered in Peachtree Corners, just a few miles northeast of Georgia Tech's campus.

"If we can get our technology into the hands of those who need it, people will become more empowered to take greater control of their own health."

Erika Tyburski

People suffering from anemia lack enough healthy red blood cells or hemoglobin, a protein that carries oxygen from the lungs to the body's organs. Having anemia can cause fatigue and weakness. The AnemoCheck test measures hemoglobin levels with a single drop of blood. The technology, which finished second at the 2013 Georgia Tech InVenture Prize, was cleared as an in vitro diagnostic by the FDA in 2017 to allow clinicians to diagnose anemia.

Tyburski, who is herself anemic, said she's a different person than the one who stood on the InVenture Prize stage 10 years ago.

"I was once afraid to ask questions," she said. "I've learned not to be afraid. I ask questions and learn. I have the right team around me, and I know I'm the right person to run this company."

Sanguina also has created a digital platform and smartphone app for anemia management. The company's current goal, shaped by the increased availability and acceptance of remote healthcare after the pandemic, is to expand the AnemoCheck test offerings so people can test themselves and monitor anemia at home.

"Telehealth used to be a novelty. It isn't anymore," Tyburski said. "For anemia and other chronic diseases, remote management is ideal. Nearly a fourth of the world's population is anemic, and many live in rural areas or low-resource settings. Sanguina's mission comes down to access — providing access to our tools. If we can get our technology into the hands of those who need it, people will become more empowered to take greater control of their own health."

> FDA Approved

Safer Surgery Through Simulation

The most recently FDA-cleared technology born from Georgia Tech research comes from Lakshmi "Prasad" Dasi's lab.

His company, DASI Simulations, received the go-ahead in summer 2023 for its first product, called Precision TAVI. The software tool uses CT scan angiograms to build 3D models and an interactive platform for cardiologists to simulate heart-valve surgery before they even step foot in the operating room.

"The surgeon uses the software to interact with a digital twin of the patient and make predictions about how the surgery might go," said Dasi, the Rozelle Vanda Wesley Professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University. "This is the first tool available to physicians to visualize the interaction between various devices and each patient's unique anatomy before surgery."

Dasi said nearly every device-related complication in heart valve surgeries is due to an imperfect interaction between the patient's organs and the implant. Heart tissues can be stressed during some surgeries. In others, abnormal blood flow can prove fatal. With Precision TAVI, doctors can see possible ruptures before they happen.

"Hindsight is always 20/20 when it comes to complications during or after heart valve surgery," Dasi said. "One surgery at a time, our technology helps avoid complications and repeated interventions, helps with lifelong planning for optimal structural heart care, and has the potential to save billions in unnecessary costs from preventable complications."

The early prototypes of the AI interface were made from commercial software. However, Dasi said such a setup can't be scaled and personalized. That's not ideal when doctors replace 100,000 heart valves every year. Dasi and his team developed a second-generation approach that added the ability to personalize the simulations, then tested it with patients at Piedmont Hospital in Atlanta.

"When Georgia Tech makes it possible for engineers like me to collaborate with doctors and have the resources and freedom to pursue high-risk tech, that's when innovation happens," Dasi said. "We were blessed to have such a free environment to develop our ideas and bring them to reality."

The software tool Precision TAVI uses CT scan angiograms to build 3D models and an interactive platform for doctors to simulate surgery before they insert heart valves into patients.

SIMULATION IMAGES COURTESY: DASI SIMULATIONS

"When Georgia Tech makes it possible for engineers like me to collaborate with doctors and have the resources and freedom to pursue high-risk tech, that's when innovation happens."

Lakshmi "Prasad" Dasi


DASI
Simulations

"Once you become an engineer, you never stop being an engineer. You're always looking to make things better and solve problems."

Greg Kolovich

> FDA Approved

X-Rays to Go

Greg Kolovich earned his electrical engineering degree in 2004, then went to medical school at Ohio State and Harvard and became a hand surgeon in Boston.

Day after day, he looked at X-rays of traumatic hand injuries. The more he saw, the more he recalled his Georgia Tech experience.

"Once you become an engineer, you never stop being an engineer," Kolovich said. "You're always looking to make things better and solve problems."

As a hand and orthopedic surgeon, he became frustrated about how difficult it was to get X-rays for his patients. They would frequently have to wait several days for an appointment, then drive to his office, often from long distances.

"If technology could shrink a computer into a phone that could be taken anywhere, surely we could miniaturize an X-ray machine to make it more widely available," Kolovich said.

That's when he called his former Tech classmate Evan Ruff. Within five years, the duo had started OXOS Medical and created the world's first handheld, dynamic X-ray system. Ruff said the device, which is in use in 50 facilities nationwide, is much more than a smaller machine. It's the start of an effort to redefine the future of radiology and make healthcare accessible to more people.

"X-ray machines shouldn't be limited to hospitals and doctors' offices," said Ruff, OXOS's CEO, who finished his computer engineering bachelor's in 2003 and earned his Tech MBA four years later. "We want to put them in retirement homes, schools, at sports fields, and in developing nations. Our cloud-based technology can streamline the entire process, with images sent to doctors working remotely, allowing them to see and diagnose within minutes rather than waiting days to see patients."

The OXOS machine also uses less radiation than typical X-ray machines, the founders said.

"I never lost that engineering curiosity, even while working with X-ray technology that has been around for more than 130 years," said Kolovich, OXOS's chief medical officer. "The real value of Georgia Tech was learning about perseverance and not taking things at face value. It's exciting to help redefine this field and make it safer and more accessible to society." ◂

Former classmates Evan Ruff (top, left) and Greg Kolovich invented a handheld x-ray device to shorten the diagnosis time for patients.

IMAGES COURTESY: OXOS MEDICAL

BY JOSHUA STEWART
ILLUSTRATIONS BY CHARLIE LAYTON

THINK BIG AND BE BOLD

25 years after creating a powerhouse program between a public and private university, Georgia Tech and Emory's biomedical engineering department looks ahead to its next chapter.

30

Millicent Warner wants to be a doctor. So when the time came to consider colleges, Warner knew she wanted to get the best possible preparation for medical school.

Engineering wasn't on her radar — until she bumped into a parent at her sister's high school graduation who worked in drug development at Emory University. He told her point-blank: "If you want to go to med school, get a biomedical engineering bachelor's degree in the joint Georgia Tech-Emory program." Then, he said, "You're set."

That was all the convincing she needed; the path now seemed clear. And three years into her studies, Warner said she found in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University just what she was looking for.

It was a rough start to be sure. Warner was among the students who started college in the depths of the coronavirus pandemic. She spent that first year mostly at home 40 minutes north of campus and not feeling engaged. She decided to change all that in her second year. She studied at Georgia Tech-Europe. She found work in a research lab. She started to volunteer at Emory Hospital Midtown. This fall, she's worked on a Capstone Design project with physicians at Mayo Clinic.

"I had no clue what to expect when I started BME at Tech," Warner said. "I'm glad I took that blind leap of faith. I feel like engineering, for a lot of people, is this far-off, what-is-it thing. It's a widespread field, and you can take it in a lot of directions, which can lead to confusion. But once I got into BME at Tech, two things really stuck out to me: It was very process-based, and it was a very creative atmosphere."

For someone who hadn't thought much about engineering, it turned out to be something Warner loved. She's always been a hands-on person, someone who enjoyed stepping in and fixing or tinkering with things. In other words, she loved the process. And she loved that it was baked into the BME curriculum from her very first semester, when she took BMED 1000, Introduction to Biomedical Engineering.

"Our instructors have a very clear — and very cohesive between classes — focus on not caring about the product that you're making but caring about the problem that you're trying to solve," Warner said. "I felt my way of thinking change. It became more than, will it work or not; it became more creative, more about, what are we really trying to solve here."

Warner's experience is just what the architects of the Coulter Department had in mind. They were innovating from the beginning — first, by formally uniting a private medical school and a public engineering college in a joint department, and then by adapting the problem-based learning used in medical schools to engineering education.

Problem-based learning isn't about taking in information and being tested on it. Instead, students get real-world problems — complex, undefined, messy — and have to figure out solutions. They don't know everything they need to, and they learn as they go. As Warner has

COULTER BME BY THE NUMBERS

1
department across two campuses

25
years since the founding of the department

$40M+
in research awards annually

experienced, grades are not about the end product; they're about the process.

And just like the methodical way faculty members in Coulter BME reimagined engineering curriculum, they've also built a powerhouse research program with more than $40 million in research awards annually. Graduate students flock to the Department because they can find mentors to help them pursue virtually any direction they wish, drawing from two campuses of resources to create their own unique experience.

Twenty-five years after its founding, the Coulter Department is perennially one of the nation's highest-ranked programs — currently the top BME undergraduate and graduate program on the widely watched *U.S. News & World Report* Best Colleges lists.

Coulter BME also has become the largest and most diverse program of its kind in the nation, boasting 1,500 students and more than 70 tenured and tenure-track faculty members. The Department annually graduates more women and underrepresented minorities than any other BME program in the country.

It's a remarkable run in 25 years. And it's just the beginning, if you ask Wallace H. Coulter Department Chair Alyssa Panitch.

"There's such a great foundation in education, a great culture, and so many really talented researchers that it gives me the opportunity to think big and be bold," said Panitch, who became the fifth permanent department chair in 2022. "We can start to take things to the next level: How do we double our research dollars? How do we start thinking about solving the world's next problems? We're bringing the faculty, staff, and students together and saying, 'OK, what do we think the really impactful things are to go after and how do we get there?'"

Answers to those questions and more will shape the next quarter century for the Coulter Department.

It's a future where maturing technology in artificial intelligence and synthetic biology will unlock new approaches to health and medicine. Where a greater understanding of the individual differences that lead to the success or failure of therapies for intractable diseases

> "We can start to take things to the next level … We're bringing the faculty, staff, and students together and saying, 'OK, what do we think the really impactful things are to go after and how do we get there?'"
>
> Alyssa Panitch

CANDLER HOBBS

No. 1
graduate and undergraduate programs in the nation
U.S. News & World Report

No. 1
nationally in degrees awarded to women and underrepresented minorities

70+
tenured and tenure-track faculty members

1500+
students

will open pathways to truly personalized medicine. Where, from Panitch's perspective, the pace of impact and discovery in Coulter BME will only accelerate.

Foundations

Georgia Tech and Emory are very different places. One, a public university and engineering powerhouse. The other, a well-respected private university with a top liberal arts program and one of the nation's most comprehensive academic healthcare systems.

But both share a mission centered on people: at Emory, to "create, preserve, teach, and apply knowledge in the service of humanity," and at Georgia Tech, "developing leaders who advance technology and improve the human condition."

Back in the late 1980s, leaders at both institutions saw an opportunity in the other campus to complement their strengths and have real impact. That led to the first formal relationship, a Biomedical Technology Research Center with a seed grant program designed to nurture research across the Downtown Connector.

As Regents' Professor Emeritus Ajit Yoganathan put it some years later: "That was our venture into the first phase of the Georgia Tech-Emory relationship on a formal basis. And I'm not even sure if 'venture' is the right word. Maybe 'adventure' is correct, because we were really trying out something new."

The research center and seed grants led to more funding from the Whitaker Foundation and the formation of an interdisciplinary bioengineering Ph.D. program, which quickly became one of the best in the country under Yoganathan's guidance. By the mid 1990s, Emory and Georgia Tech leaders saw BME departments sprouting up across the country and started talking about a new collaboration: a joint academic department. They recruited Johns Hopkins University engineering dean Don Giddens back to Georgia Tech to lead the effort.

In September 1997, the Emory Board of Trustees signed off, followed quickly by the University System of Georgia Board of Regents. The first students enrolled in 2000, and the following year, the Department was named for Wallace H. Coulter, a pioneer in automated cell analysis and hematology, after his namesake foundation committed $25 million to support the burgeoning program.

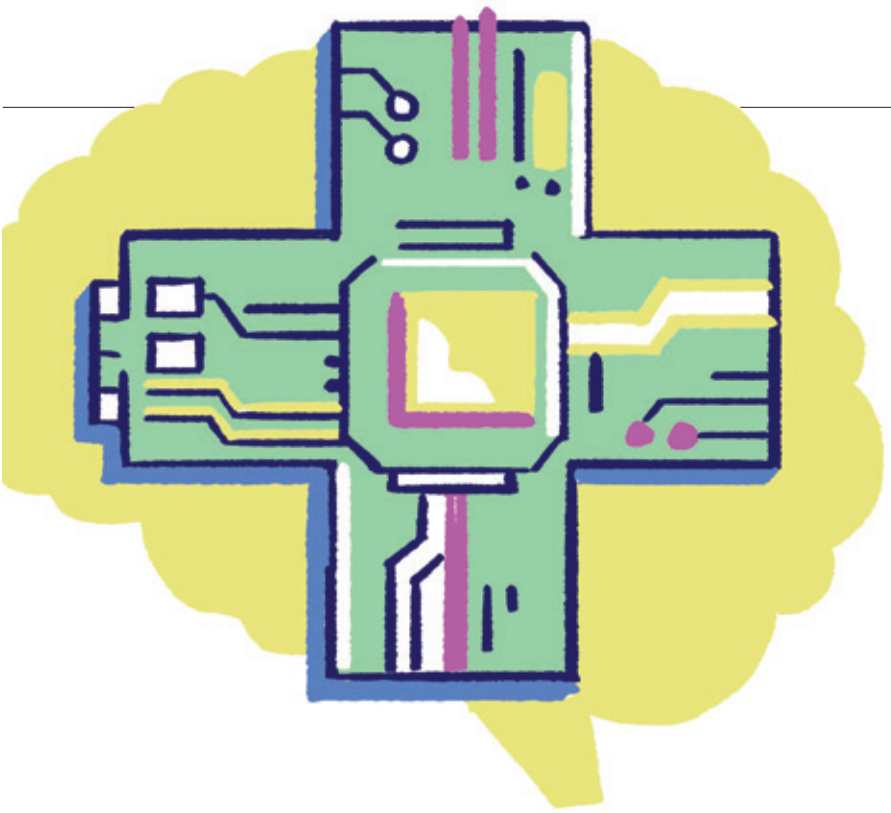
Panitch credited the visionaries at both institutions for establishing a culture of innovation from the very beginning that has allowed the Department to grow into a national powerhouse.

"The strength of the Emory School of Medicine, the strength of Georgia Tech, the drive for people to become biomedical engineers, and the pull from society for improved healthcare — all of that has allowed us to grow," Panitch said. "Along with a lot of forward thinking from previous leaders."

Now it's Panitch's turn to leverage the collective power of the Department's students, faculty, and staff and focus the resources of two campuses to set the stage for what comes next.

Solving the World's Next Problems

AI seemingly has started to disrupt every industry with powerful new ways to interpret and extract meaning from data. Synthetic biology approaches are enabling scientists to engineer new biological systems and redesign and harness natural systems to fight and monitor disease or model human physiology. Both are areas where technologies have been maturing for



decades — and areas where Panitch and her faculty colleagues think the Coulter Department is poised to lead.

One of Coulter BME's strengths, Panitch said, is the breadth of research happening in the Department's labs. From cardiovascular engineering to bioinformatics, immunoengineering to biomedical imaging and instrumentation, the Department has built a stable of expertise across a wide area.

Panitch wants to draw from that strength to lay down a marker in AI for health and synthetic biology, areas she called the "next frontiers" in BME.

"I don't want to upend the balance of being good in multiple areas. We know that diverse ideas and tools come together in ways that we don't anticipate. It's critical to continue to have that," Panitch said. "My goal is to maintain our strength in the research we're doing and also really take off in these areas that we think are the future needs for biomedical engineering, healthcare, and society."

Melissa Kemp is helping lead the exploration of how Coulter BME can build its reputation in synthetic biology. She said Panitch is savvy for seeing that the area and the Department are at a precipice where the right push can be transformational.

"As a Department, we haven't really branded ourselves as a hotbed of synthetic biology research. But when we start looking at the various activities people are involved in, there is quite significant research in related areas," said Kemp, Carol Ann and David D. Flanagan Professor.

Kemp pointed to work developing tissues in the lab that mimic a specific patient's physiology, allowing researchers to screen the effectiveness of drugs to find the right therapy for that patient. Other work is reengineering the body's T cells with chimeric antigen receptors (an approach called CAR T cell therapy) to bypass normal signaling mechanisms so they can identify and kill cancer cells more easily. (Read more about this and other efforts to treat cancer on page 8.)

In her own lab, Kemp is looking at a kind of computer-aided design for tissues created from stem cells. The idea is to create multicellular simulations of the tissues that would offer instructions to synthetic biologists of the kinds of biological circuits they need to build to get specific tissue properties. It's an idea that grew from years of collaborations with tissue engineers across Atlanta institutions.

"Our Department historically has been very good at creating research communities, and once you have people actively engaged with each other, great things happen," Kemp said.

Those collaborations are happening in AI too — an area where Emory has invested heavily to create its AI.Humanity Initiative and where Georgia Tech has created a new AI Hub to take "Research to the Power of AI."

"Our Department historically has been very good at creating research communities, and once you have people actively engaged with each other, great things happen."

Melissa Kemp

That kind of focused community-building to foster unique ideas is just the kind of thing Anant Madabhushi has in mind. He's helping lead efforts to position the Coulter Department as a leader in leveraging AI to advance healthcare.

"People are doing pockets of great research in this space, but they haven't really coalesced," said Madabhushi, Robert W. Woodruff professor in Coulter BME and research career scientist at the Atlanta Veterans Administration Medical Center. "It's not going to magically happen; we have to be intentional about it and create the opportunity for people to talk, band together, and become a creative community."

AI techniques can process mountains of data to help researchers uncover patterns or find new avenues of inquiry for diseases from cancer to Alzheimer's. Researchers are using artificial neural networks to study the brain and other AI tools to help reconnect the brain and body for patients with spinal cord injuries.

Madabhushi's team has been working on AI models that are tuned for specific populations. A few years ago, they demonstrated an AI approach that predicted prostate cancer risk for Black men better than models that weren't specific to any population. The work demonstrates the power of AI to tackle big problems and create a future of precision medicine.

"It's not just going to be using these tools from a diagnostic perspective, but really identifying the treatment response for a given patient with a given disease," Madabhushi said.

"It's an extremely exciting area, and I think that we have an opportunity to really carpe diem this, to really seize the day here."

Evolving Graduate Education

From the beginning, Coulter BME created new approaches to teaching and learning in the undergraduate curriculum. And that's been true for graduate education too. Mike Davis remembers how rigid the curriculum was when he joined the faculty almost two decades ago — highly structured in the way most undergraduate engineering programs are.

Faculty members changed it when they saw that wasn't meeting the needs of their students. They created integrative cores and advanced seminar courses, building a more open-ended approach for students.

"Not every student interested in cardiovascular wants to learn the same thing," said Davis, who now leads the Department's graduate programs. "We care more that our students learn how to solve problems, how to work as teams, how to write grants and papers, rather than whether they can recite some equation from memory."

Now Davis and Director of Faculty and Student Training Rachael Pitts Hall are listening to students again and shaping the curriculum to meet the needs of a new generation. Davis said more graduate students are interested in industry jobs rather

"Our students are interested in the tools and the knowledge that will prepare them for the next 25 years of growth, and it's not always just about whether you know how the cell responds in cell culture."

Mike Davis

than academia and building skills that match what those positions require. Which means it's not always just about writing grants and papers.

"What our students have said to us is, they want better presentation skills, better writing skills, they want the ability to communicate more effectively, they want to tackle problem-solving using cutting edge approaches like machine learning and AI because that's where industries are going," he explained. "Our students are interested in the tools and the knowledge that will prepare them for the next 25 years of growth, and it's not always just about whether you know how the cell responds in cell culture."

Pitts Hall called it "backwards design." They've asked students about gaps, and now they're working with the faculty to fill them, with new classes in some cases but also adding modules to existing courses or creating workshops around other areas.

"Students are more interested in social justice, and we're also talking about how to incorporate things like health disparities and aspects of equity that are related to the research and science itself," Pitts Hall said.

The point is to meet Gen Z students where they are, "helping them be better versions of themselves, instead of a smaller version of their advisor or their mentor.

"BME has a history of figuring out what works in education and trying it, iteratively changing, and adapting," Pitts Hall said. "We have a great history of that with our undergraduate program, and I'm happy that we are taking on that mantle in the graduate program to really apply some of these research-based methods to meet our students' needs."

New Space, New Programs

Meanwhile, a physical manifestation of the future of biomedical engineering education and research has taken shape on the edge of Emory's campus with construction of the new Health Sciences Research Building II. Designed to be a hub of cross-pollination, the building has significant space for Coulter BME alongside pediatrics, brain health, cardiovascular medicine, and more.

The building was designed to create opportunities for collaborative conversations and encourage new thinking. It also is home to an incubator area to help researchers work with industry to translate their work from the lab to the patient bedside.

The building will be home to a new Coulter BME master's degree program under development. The Department leads the National Science Foundation Engineering Research Center for Cell Manufacturing Technologies (CMaT) and the Marcus Center for Therapeutic Cell Characterization and Manufacturing at Georgia Tech. The M.S. in Biomedical Innovation and Development – Advanced Therapeutics will leverage that expertise in an industry-focused program to train the next generation of leaders in cell therapy, gene therapy, tissue engineering, and regenerative medicine.

"There are lots of master's programs around medical devices. There aren't very many training students to be experts for gene and cell engineered products," Panitch said. "Couter BME at Emory is the perfect place to launch this innovative program, and with CMaT and the Marcus Center, we can be a leader."

The new program will be the first Coulter Department master's based exclusively at Emory, complementing the successful Master of Biomedical Innovation and Development at Georgia Tech that focuses on engineering devices and technology.

Like the Department's plans for research and education, it will help weave more and tighter connections between two campuses on opposite sides of town but very much aligned in serving Atlanta, the state, the nation, and people around the world.

"We've been really intentional about making sure that this is a partnership — one department on two campuses," Panitch said. "We value both: it's a great medical school and it's a great engineering school. We bring the power of both institutions together. We do unbelievable things together." ◂

Keeping People First

Alumna Parika "Pinky" Petaipimol is inspired to persevere by people she'll never meet

It's an April night in Paris, and Parika "Pinky" Petaipimol is late for a meeting. She's just stepped out of a train station in the City of Lights after taking the Chunnel from London. The taxi line is long, and the vehicles are slow to arrive.

After 20 minutes, Pinky is only halfway through the queue. Then a motorcycle pulls up and its driver asks for a single passenger. At least that's what she infers, as no one is speaking English.

There are no takers, as the line is visibly uncomfortable about the possibility of riding with a stranger on the two-wheeled machine. A few minutes pass and the male motorcyclist asks again, "Taxi moto?"

Pinky evaluates the situation: The line snakes around the train station. The hour is growing late. She eyes the motorcycle and her bags and throws caution to the evening wind. She doesn't know the language and will have to cut through the labyrinth of people before jumping onto the bike after strapping her luggage to the back. But she's already hours late for a meeting and this is the best option. Plus, the Georgia Tech biomedical engineering graduate has learned a thing or two about problem solving and taking risks.

As those waiting watch in wonder and amusement, Pinky takes a selfie, then plays the equivalent of charades to ask if the French motorcyclist takes credit cards. He doesn't understand, until she pulls out her wallet and shows a card. "Oh, oui!" he says, and they zoom off through the streets of Paris.

"You never know, right?" Pinky remembered a few months after the trip. "You never know where something unexpected will lead you."

That night, it led her safely to a nearby hotel and her meeting. Other times, though, Pinky has been pleasantly surprised at where chance encounters with people have taken her, especially in the medical field. It's also helped develop a mindset that those she'll never meet have inspired her to persevere in the field.

Competitive to Collaborative

Pinky's outgoing personality was a necessary part of her childhood. After attending elementary school in Duluth, Georgia, she moved overseas to Thailand for middle and high school. She had to make new friends in a new world, while adjusting to her new life.

Her family kept the Georgia house, allowing her to apply for in-state college tuition despite living 9,000 miles away from Atlanta.

"I qualified for the HOPE Scholarship because my parents paid Georgia taxes," she said. "I was responsible for paying my own way, so I only applied to state universities."

Pinky returned to Georgia in 1999 and enrolled at Tech as a biology student. She changed her major a year later when a new biomedical engineering department started enrolling undergraduates. (That Department is now a national leader. Read about the faculty's plans for the future on page 28.)

"Only 40 people were chosen, so we were all a little cocky. And competitive. That first semester was very cutthroat," Pinky said. "Google wasn't really a thing yet, so we really had to think hard to work out solutions for problems by utilizing all our resources, like going to the library and actually checking out a book. Our solution was presented and compared to other groups. All the teams were critiqued by the professors."

Pinky and her peers soon decided competition was pointless, and the class bonded and built strong bridges of collaboration as the first BME undergraduate class.

"I do appreciate the grittiness the program instilled in us. Things aren't going to be perfect the first time, so you just need to learn from what happened and try again," she said.

Pinky used that team-first mentality for her senior design project in 2004. She and her partner modeled a retroviral vector manufacturing process for gene therapy commercialization. The senior design project helped her get in the door with Biogen, a biotechnology

Pinky with her husband, Chris, her mom, Add, and her children, Izzy and Greyson.

company where she spent 14 years. She worked across the company, including in manufacturing sciences, technical business development, and new product commercialization.

"I seized the opportunity as a training ground and went from one department to another to get as many skills as possible," Pinky said.

She used tuition reimbursement to earn her MBA and a master's degree in manufacturing engineering at Boston University. While pursuing her MBA, she was assigned to a team spinning out a company from the university. "I was surprised how much fun I had putting together a business plan and just talking to potential investors. The experience eventually led me to where I am now: working with a small company."

Going Small

In 2018, Pinky had the opportunity to work at an early stage biotech startup called Pandion Therapeutics, overseeing the development and manufacture of a drug candidate to get it to its first clinical trial. She was the company's 14th employee.

Pandion grew to 58 employees by 2021, had completed its first clinical trial, and was well on the way to starting another while advancing several other drug candidates in its pipeline.

Then in February 2021, Merck agreed to acquire Pandion Therapeutics for $1.85 billion. After her Pandion experience, Pinky was more interested in working for a smaller company instead of one as large as Merck.

One late summer day in 2021, one of Pinky's mentors contacted her about an opportunity to join the startup the mentor was leading. Pinky would be employee No. 3. She's now in her third year as head of technical operations with that company, Upstream Bio. She oversees a team of three employees as Upstream establishes the manufacturing, development, and supply chain processes for biologics used in inflammatory disease medicines.

"Being part of the founding team of a company is a once in a lifetime experience. It was crazy the first few months, because there were fewer than 10 of us and we were all chipping in — doing things like putting desks together and painting walls in the office."

Patients First

What Pinky loves most about being at a small company, she said, is that she can help create its culture. One of Upstream's core values is "Patient Focus," which means putting the patient at the center of everything. It's something she always keeps top of mind — a mindset she can track to her time at Georgia Tech.

As a student, one of Pinky's classmates had a chronic condition that required weekly injections at the student health center to prevent the disease from spreading. Her friend praised the medicine and its benefits. She and Pinky connected about six months after graduation. That's when Pinky learned that she was working at the same company that made the friend's medication.

"It was my first project out of Georgia Tech," Pinky said. "That conversation had such a profound effect on me. It personalized not just what I was doing every day but *why* I was doing it. Your actions can help a friend or even complete strangers. A lot of the time, it's hard to keep that in mind when you're in the lab, feeling like everything you do keeps on failing... or when you're chasing funding that seems elusive. But you must remember that you can help people if you persevere. It's that grittiness that will help you push through."

Pinky recently joined the College of Engineering's Advisory Board and is finding new ways to give back to Georgia Tech students. One of those ways is repeating to students again and again her message of keeping people first, even those you've yet to meet.

"I hope my example can inspire students, and even professors, to pursue their field of study with the goal of changing people's lives for the better," Pinky said. "People aren't just patients. They're fathers and mothers and siblings. They are somebody to someone. We can help them. Because everyone has a right to healthcare. Everyone needs healthcare."

▶ JASON MADERER

Bulletin Board Material

A scrap of paper changed the life of two-time cancer survivor Josh Vose, leading him away from the operating room and into the field of medical devices

Josh Vose's career in medical devices began in front of a bulletin board in the basement of the Gilbert Hillhouse Boggs Building. It was 1999. Vose was in his third year. He was focused on getting through a summer of biochemistry, planning for medical school, and becoming a surgeon after Georgia Tech — until he saw that bulletin board and a flyer with tear-off tabs.

A startup company called SaluMedica was looking to hire undergraduate students. Vose pulled the last tab.

"It was a real *Sliding Doors* moment for me. If the tab wasn't there or if I hadn't grabbed it, everything in my life would have been different," Vose remembered recently.

Vose got the job and became SaluMedica's first intern, working on a new hydrogel for two years until graduation. There, he met Georgia Tech Professor David Ku, one of the company's co-founders and its CEO. Ku's mantra would stick with Vose through the years: Medical doctors can make a much greater difference in health by merging engineering and medical knowledge with business than they can through practice alone.

That $10-an-hour job and the experience Vose accumulated changed his entire perspective, eventually leading him out of a career in surgery. It's a path that culminated last year when the 2001 chemical engineering graduate led a medical technology company through a $140 million acquisition.

Yet it's far from the most impressive thing he's accomplished since leaving campus: Vose beat cancer once. Then he did it again. All before the age of 45.

> **"Surviving cancer, for me at least, has been a catalyst to greater professional meaning and a clarifying exercise on my priorities in life. My goals beyond family are to work with people I admire and trust on endeavors that can scale to meaningful improvements in healthcare."**
>
> Josh Vose

A Nightmare Come True

Vose fulfilled his post-Georgia Tech goal of earning his M.D. at the Medical College of Georgia. After a year as an intern at a teaching hospital of Harvard Medical School, he realized the thing he loved most wasn't surgery. It was what he did at Tech: developing novel medical devices that could scale to improve health.

Vose quit surgery and started working as medical director for PEAK Surgical, overseeing the company's human and animal research trials and working with surgeons to improve the company's products. He helped grow PEAK's revenues to $20 million a year before Medtronic purchased the company in 2011.

Medtronic asked him to come back a few years later, and in 2013 he joined the business unit that had acquired PEAK. Vose's life took a new turn shortly after starting with the company. He was 37 and newly married when he woke from a nightmare about having leukemia.

"I'm not sure why, but I had a deeper feeling that something wasn't right. Looking back, it was a premonition," Vose said. "Two weeks later, I reached up and felt something behind my collarbone. I was supposed to fly to Europe that day; instead, I canceled my plans and went to Stanford Medicine's emergency room."

Doctors found a golf ball-sized lymph node and ultimately diagnosed him with stage 2A Hodgkin lymphoma, a cancer of the lymphatic system. As he discussed treatment options with his doctors, Vose found himself leaning on his time in Georgia Tech classrooms, where he learned the importance of tradeoff analyses.

"I had a choice in chemotherapy: two drugs twice a month for six months, or a more difficult regimen. I chose the hard and fast option: seven drugs, twice a week, for eight straight weeks," Vose said. "And it *was* hard. But it worked."

Vose fought through the side effects of treatment while continuing to work full-time as Medtronic's medical officer. He wrapped up the treatment, took a one-week break, then began orientation for business school at the Massachusetts Institute of Technology.

"I was hairless, fatigued, and down 15 pounds, but also incredibly energized to be

Vose and his wife, Madelyn Lodge, with their children, Everett and Eleanor, on a recent visit to Georgia Tech.

ALLISON CARTER

back with the rest of the living world doing something that really mattered to me," Vose said.

A Second Fight

Vose had rowed for an intramural national championship while at Georgia Tech; after college, he transitioned from rowing to cycling. He joined a Seattle cycling club in the summer of 2020 and enjoyed the first group ride.

The second meet-up changed his life, again.

"I began passing a massive amount of blood after the second ride," Vose said. "I had a colonoscopy as soon as possible and learned the effort from the challenging group ride had ruptured a vessel in a tumor in my colon."

The mass was 5 centimeters in size. Doctors diagnosed stage 3 colon cancer, and once again, he was facing another treatment regimen, this time at just 43 years old. And as if to rub salt in the wound, he learned the diagnosis on the five-year anniversary of being declared free from Hodgkin's.

"It was incredibly challenging, just simply from a mental perspective. The questions it raised about life, career, how you spend your time, and day-to-day priorities were profound. Getting through treatment is a grind, but it's predictable; how you come to peace with your life and what comes next is the real challenge."

Three years after surgery and chemo, Vose is once again in the clear. His doctors tell him the colon cancer is not expected to recur.

"Surviving cancer, for me at least, has been a catalyst to greater professional meaning and a clarifying exercise on my priorities in life," said Vose, a father of two young children. "My goals beyond family are to work with people I admire and trust on endeavors that can scale to meaningful improvements in healthcare."

Those goals were fulfilled leading Surgical Innovation Association (SIA) as CEO, a role he took in early 2021 in the aftermath of treatment. The medical device company's flagship product was a resorbable polymer mesh used in breast reconstruction after mastectomy. During the reconstruction procedure, SIA's mesh is placed underneath the permanent implant as a support, allowing new tissue to grow through and around the material. Vose led the company through its most recent financing and commercial growth, and he oversaw the acquisition process when SIA was purchased for $140 million by Integra Lifesciences in December 2022.

"Josh is so successful in the medical device profession because of his experience and genuine personality," said Ku, a professor in the George W. Woodruff School of Mechanical Engineering who continues to stay in touch with Vose. "Most medical doctors understand the clinical reasoning of a new device but don't know how the technology works. As a chemical engineer, Josh understands both."

Now that the acquisition is wrapped up, Vose is engaging with Georgia Tech more than ever. He's met with leaders at three entrepreneurial and research programs: CREATE-X, the Vertically Integrated Projects program, and VentureLab. He's also exploring new startup possibilities and providing advice to a few faculty members.

"I could never have imagined as an undergrad standing in front of that bulletin board that my life would turn out this way," Vose said. "But I am so thankful that it has. My Georgia Tech mentors invested so much in me, personally and professionally, that I will always be indebted to them and the Institute. Now it's my turn to give back."

▶ JASON MADERER

CANDLER HOBBS

Ph.D. student Richard Agbeyibor, left, and Professor Karen Feigh prepare for a round of tests in their custom-designed medevac simulator.

Air Autonomy

AE Professor Karen Feigh is looking to the skies for the future of AI and health

A doctor is flying in the back of a helicopter for a daytrip from Atlanta to a rural Georgia county. With more than a third of the state's counties lacking a pediatrician, according to the Georgia Public Policy Foundation, that doctor's visit would fill an important void.

The physician takes that trip alone. There is no pilot. She's ferried back and forth by an autonomously flying rotorcraft vehicle.

It sounds like science fiction, but Karen Feigh can see it happening in the not-so-distant future.

"We're seeing more automated systems on the road. The next evolution is in the air," said Feigh, professor in the Daniel Guggenheim School of Aerospace Engineering.

But for a passenger to fly solo with an AI pilot sometime in the next 15 years or so, Feigh and her peers must first understand how people can interact with autonomous machines. And vice versa.

Feigh is working on a three-year study that brings metro Atlanta emergency medical technicians (EMTs) to campus to interact with automated flying systems during simulated medevac situations.

The EMTs climb into a makeshift aircraft cabin in one of Feigh's lab spaces, complete with windows that allow them to look outside at a simulated landscape. The machines ask the humans simple questions, such as if they're ready to take off or if everyone is buckled in before the simulator "flies." In turn, the people provide feedback to the AI pilot about their hypothetical patient's health or perhaps the need to change landing spots based on the patient's vital signs.

"We're trying a variety of communication methods, such as touchscreens and natural language processing, then watching how each side responds," Feigh said. "We have seen a huge increase in automated systems — whether they be AI, machine learning, or regular automation — and we've seen demonstrations of automated piloting of vehicles, particularly rotorcraft. We just have to better understand how people and machines can work together."

The initial series of experiments created a very simple system with a touchscreen for the EMTs to interact with the AI systems. It worked pretty well, Feigh said, but participants quickly found it was cumbersome to have to focus on the touchscreen while caring for their patient. A common request was to be able to talk to the AI instead.

Feigh's next step may be to incorporate natural language processing — the kind of technology that allows us to talk to Alexa, Google, and Siri — but that's quite a bit more complicated. And it presents other questions: Should passengers be able to ask anything? Or would a "closed" system work better, something not unlike the limited things drivers can say to their car when asking for songs or temperature changes.

And that's the point: to learn enough so that when manufacturers are ready to implement AI systems into aircraft, her findings will serve as a guide for what works and what isn't practical.

The project is funded by the Office of Naval Research, with an emphasis on search-and-rescue and disaster relief missions. Feigh sees applications beyond transporting soldiers or cargo into dangerous or uncertain areas, including the idea of a doctor flying to remote areas to fill gaps in access to healthcare.

"We have seen a huge increase in automated systems — whether they be AI, machine learning, or regular automation — and we've seen demonstrations of automated piloting of vehicles, particularly rotorcraft. We just have to better understand how people and machines can work together."

Karen Feigh

"There's an active, national interest in trying to alleviate a pilot shortage by creating systems that could fly autonomously. And there are several great reasons for that," Feigh said. "Having a helicopter pilot on standby is very expensive. If you could get an automated system in place, you could have aircraft on reserve to take off at a moment's notice. Hospitals also could share in the cost, allowing for greater flexibility in cities and surrounding areas."

In the near future, Feigh thinks autonomous systems will be added to current rotorcraft along with actuators and other equipment to help those systems operate in their environment. Much like the self-driven car concepts of today, humans still will sit in the cockpit.

Once that happens, and people get more comfortable with the aircraft flying itself, the next step will be fully autonomous aircraft designed and built from scratch — without the controls for a human pilot.

"Before any of that happens, we have to map out what works and what doesn't. We have to outline an initial, definitive guidance," said Feigh, who is currently recruiting EMTs for the next phase of the project in spring 2024. "If we can create interfaces to support future technology, we can help define the future of healthcare and autonomous systems."

▶ JASON MADERER

There's No Stopping Savi Agarwal

In fact, "no" isn't a word the 17-year-old second-year BME student uses very much at all

Savi Agarwal is a master of time management.

When she graduates in Fall 2023, she'll have earned a bachelor's degree in biomedical engineering and minors in international business, language, and culture and health and medical sciences — and she'll have done so in only 2.5 years.

Between classes, she's been involved with several pre-medical student organizations, volunteered at local clinics and hospitals, and done medical research. And as if there wasn't enough on her plate, Agarwal is the founder of Medical Brigades, a Georgia Tech student organization dedicated to providing medical care to underserved communities.

Oh, and Agarwal is just 17.

"I haven't said 'no' to anything, and I've never felt that being the youngest person in the room was an obstacle," she said. "I think my age gives me a different perspective, and that helps me to be more understanding of people who also have different outlooks. Learning to have a multi-faceted perspective through all these experiences at Tech has been very meaningful to me, and keeps me motivated for medical school, residency, and beyond."

Mission Abroad

In May, Agarwal led a 30-person Medical Brigades team to Honduras, where they served three communities and approximately 600 people. Over the course of a week, the team of 26 student volunteers, two doctors, a dentist, and a pharmacist set up a free medical clinic to provide OB-GYN services, prostate exams, general checkups, low-cost medications, personal hygiene supplies, and dental care.

> **"... I've never felt that being the youngest person in the room was an obstacle. I think my age gives me a different perspective, and that helps me to be more understanding of people who also have different outlooks."**
>
> Savi Agarwal

They offered healthcare workshops on topics like anxiety, malnutrition, dental care, and adapting medical topics to one's sociocultural environments.

The team also built 18 "eco-stoves," enclosed cooking stoves for homes that lessen exposure to smoke and help prevent pulmonary diseases, particularly for women.

"We were immersed in the community; we lived with the people we were serving," Agarwal said. "We didn't have access to running water, consistent electricity, Wi-Fi, or cell service. Having personal relationships made our work that much more meaningful and helped me to understand the financial and medical toll of the healthcare system in Honduras."

Agarwal grew up in India and the United States, and she said the trip to Honduras brought up many parallels in lifestyle and lack of resources from her years in India. But she also saw a similar appreciation of life.

"People [in both countries] celebrate the fact that they're alive and can support their families," she said. "They recognize that the true gifts of the world are not

HEADSHOT: CANDLER HOBBS; GROUP PHOTO: SAVI AGARWAL

materialistic, but about being in community together. The smallest and humblest homes have the brightest celebrations.

"It was a reminder to me that I want to support the people who represent where I'm from by sharing this attitude."

Driven to Serve

Agarwal said she knows the importance of a well-rounded education. In high school, she doubled up on Advanced Placement classes, qualified three times for the American Invitational Mathematics Exam, and led her Science Bowl team to a top-16 finish nationally, gaining a love for interdisciplinary science along the way.

She enrolled at Tech when she was just 15, decided on biomedical engineering for her studies, and took 21-credit semesters, motivated by her desire to learn from as many perspectives as possible.

Agarwal sprinkled in research on organ-on-chip devices; clinical rotations and volunteering; assisting with cancer care at Northside Hospital; and building collaborations between student clubs focused on social justice, medicine, and innovation.

A pivotal experience came when she began volunteering at the Clarkston Community Health Center just outside Atlanta. The free clinic serves a diverse community where many people lack insurance and live in poverty. There, she saw doctors and medical students helping people navigate barriers to healthcare that she said she encountered again and again as she shadowed at other hospitals.

"There are barriers beyond just financial stability, like housing, literacy, or even stigma due to a lack of education or experience," Agarwal said. "Being able to directly help patients move past those blockages and

Savi Agarwal and Medical Brigades volunteers brought a medical and dental clinic to a Honduran village in May 2023, serving 600 people over the course of a week.

reach a level of autonomy and well-being where they don't have to come back is very dear to my heart."

That passion for serving disadvantaged patients led Agarwal to start Medical Brigades. In addition to international trips, the organization partners with local clinics like the Clarkston Center to assist with medical services. With graduation looming, Agarwal plans to expand the organization beyond Georgia Tech to stay involved in the community.

Finding Balance to Stay Motivated

With the goal of continuing to serve needy communities, Agarwal hopes to get into medical school and has her sights set on Emory University. She hopes to learn to serve patients holistically, with empathy, global perspective, and emotional intelligence.

"In the long run, I'd like to combine my medical work with my passions for leadership and culture," she said. "Maybe I'll work in a rural hospital, or even just be involved with an administrative campaign for a region. But my goal right now is to gain the medical knowledge I need; the first step is to become a respectable physician who can really support her patients."

Between graduation and starting medical school in Fall 2024, Agarwal is planning the next Medical Brigades trip — this time to the Dominican Republic, with a focus on providing clean water to the communities they visit.

Agarwal admits her schedule is packed, calling her time at Tech an "avalanche of experiences." But she said she's learned habits along the way that help her find balance.

She makes time away from work a priority, playing tennis, swimming, and skating (she's vice president of the Georgia Tech figure skating club). She sings Indian classical music, plays the piano and the flute, and loves listening to K-pop.

She's also a big fan of the Marvel Cinematic Universe: "Give me a line, and I'll quote you the whole scene," she said. She watches a movie almost every day, saying that it gives her time to "not think about what happens next." She prioritizes spending time in nature and with her family, which helps her to stay grounded and in the moment.

Agarwal said she recognizes her journey so far has been unconventional, but she also knows it's true to who she is.

"I'm not trying to tell anyone that they should do what I've done," she said. "But I want people to know that if there's something you want to do, and you're hesitant because it's unconventional, then just go for it."

▶ **EMMA RYAN**

Top: Agarwal and fellow volunteers during their weeklong medical mission to Honduras.

Right: Figure skating is one of the ways Agarwal balances her demanding academic and extracurricular pursuits.

10 TO END

ALLISON CARTER

10 Questions with Manu Platt

Manu Platt, Ph.D. BME 2006, was a member of the second class of Ph.D. students in the Wallace H. Coulter Department of Biomedical Engineering and eventually returned to the faculty for more than a decade. In 2023, Platt was named founding director of the new Center for Biomedical Engineering Technology Acceleration (BETA) at the National Institutes of Health (NIH).

1 ▸ What is the new BETA Center? The BETA Center is an NIH-wide resource housed by the National Institute for Biomedical Imaging and Bioengineering that will serve as a new NIH model for accelerating technology-driven interdisciplinary research and clinical translation. The BETA Center will bring together researchers with expertise including biomedical imaging, biosensing, biomechanics, engineered/synthetic biology, nano/biomaterials, artificial intelligence, modeling, computation, and informatics.

2 ▸ What are your biggest dreams for the center? There is so much potential for innovation due to the nature and flexibility of the NIH's intramural program, the quality of investigators across NIH, and access to patients and clinical trials. I want to bring more researchers from the outside to the NIH campus. Diversifying and supporting investigators across NIH would also be an important achievement. The possibility of America is that we are able to pull from individuals from so many backgrounds, countries, cultural insights, and challenging upbringings. When we capitalize and value that grit and experience, we can be truly disruptive in our approaches to health, disease, and treatment.

3 ▸ How are you shaping your own research at NIH? Up to 10% of NIH's budget goes toward research done on NIH's campus — what we call the intramural research program. This opens the opportunity to develop new ideas at the fringes of multiple established areas. My research questions have always been at the edge of one field and touching another. For example, even though I study sickle cell disease, which is a mutation in red blood cells, I study the tubes and cardiovascular aspects, not the hematological aspects. I also love cathepsins, a group of enzymes that are involved in a number of tissue-destructive diseases that are a bit difficult to study because of their structure and location inside of cells. That's biochemistry and cell biology, but I

"There were programs and opportunities that others spent time to run so that I could be exposed to experiences beyond what I could imagine. If you don't know what you don't know, then how are you to access it?"

Manu Platt

look at them from a systems biology perspective using mathematical modeling and experimental tools.

4 ▸ How did sickle cell disease become a key focus area for you? My mother used to talk about it, because she was in high school when they started testing everyone for sickle cell under a program President Nixon started. Plus, it predominantly affects African Americans in the U.S. I had been studying mechanisms of stroke during my Ph.D., but for people in their 60s, 70s, or 80s. When I learned that young children with sickle cell disease were having strokes, I was shocked. So, we began to investigate.

5 ▸ What's the next big advance in treating people with sickle cell disease? There's major movement in gene therapy to change the DNA of people with this genetic mutation to provide a functional cure. Big challenges remain, though, in making sure the corrected hematopoietic stem cells go to the bone marrow, make a home for themselves, and are able to produce enough blood cells.

6 ▸ Why did you choose the Georgia Tech-Emory partnership for your Ph.D. studies? My senior year at Morehouse College I began working with Robert Nerem, founder of the Petit Institute for Bioengineering and Biosciences (IBB). The environment in IBB, the new BME department, the buzzing interdisciplinary nature of the research questions, and collaborations with Emory doctors all created an exciting atmosphere. This was also one of the first programs to accept life science students into a Ph.D. program alongside engineering students. I was into it!

7 ▸ We hear you originally wanted to work at NASA. What changed? Physical forces controlling biology fascinated me, and changes our bodies would undergo in microgravity would need to be figured out for long-term space travel. I had NASA scholarships and internships during my undergrad. During my Ph.D., I received a NASA fellowship that came with more internship opportunities, and in summer 2005, I went back to Johnson Space Center in Houston. It was after the Columbia shuttle disaster. NASA had grounded the shuttles, and the life science budget had been largely redirected. What has always driven me about scientific research is the choice to pursue subjects I found interesting. That summer, I learned that NASA researchers had to wait for new research priorities from the government, which was devastating to the team I joined, and I knew that I would feel the same way. So, I decided it was not the right environment for me.

8 ▸ How has your own life and career influenced your efforts to expand access in STEM? I am the first person in my family to earn degrees in science or engineering. Of course, there were family members who used science and engineering for generations, but navigating the formal pathway is different. There were programs and opportunities that others spent time to run so that I could be exposed to experiences beyond what I could imagine. If you don't know what you don't know, then how are you to access it? I am thankful to those who opened side doors, put me on conveyer belts, and shot me over rainbows to reach new heights, and it is only right to spend time and effort to do it for others.

9 ▸ What's been your proudest accomplishment so far in your career? The obvious, though corny, answer is my students. Watching them grow, develop, train their own students, and reach their goals is more rewarding than I would have imagined.

10 ▸ You lived in Atlanta for a long time. What do you miss most? Direct flights to anywhere from Hartsfield-Jackson airport!

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parting shot

A model of a lymphoma tumor called an organoid that allows Ankur Singh to study the complex interactions between cancerous growths and the cells nearby. Green represents protein markers for tumor cells, and magenta areas are protein markers for supporting connective tissue cells. (IMAGES COURTESY: ANKUR SINGH)

▶ MORE ON CANCER FIGHTERS, PAGE 8