The Sciences

at Georgia Institute of Technology

2023 Research & Community Review

Georgia Tech
College of Sciences

Year in Review

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Our Research

WELCOME FROM THE DEAN

The student course evaluations I received after teaching my first undergraduate course — now three decades ago — provided a hard lesson. One student's comment summed up feedback from the entire class: "Professor Lozier needs a new job." I was organized, punctual, and knew the material. I had that stuff down cold. But review after review told me the same thing, namely that I did not clearly communicate the material. (Or, to put it more bluntly, I failed to teach.)

To teach effectively I had to learn to communicate effectively, a skill that soon aided all other aspects of my academic career — and put me on the road to my current role. Today, my work hinges on the ability to effectively communicate with our community and stakeholders.

And yet, I am still learning. This past summer I had the immense pleasure of stepping onstage to share my work on the ocean's climate role at the TED Countdown Summit in Detroit. In preparing for that talk, I was coached to speak to the audience as if I was giving them "the gift of what I know." Communicating became about sharing.

That brings me to the publication you hold in your hands and what I hope to share through this annual letter. This magazine is an ongoing testament to our College's focus on progress and service. These pages illustrate our commitment to that work, whether we are in the classroom, the lab, the field, or scattered around the globe.

The arc of that work stretches from the smallest of worlds — where College of Sciences faculty are using yeast cells to uncover the origins of multicellular life — to the widest expanses of our universe — where researchers search for the arrival of neutrinos from distant galaxies using a detector in the frozen world of Antarctica.

Our researchers also bridge the worlds of discovery and solutions science, using studies of microorganisms and materials science to advance breakthroughs in sustainable technology, clean energy, and more.

Though some are focused on Mars, others on quarks, and still others on theorems, each of our faculty place a strong priority on another world — the classroom — where we teach and inspire the next generation. In our "Academics and Outreach" section, you can learn about several innovative new degree programs and initiatives, as well as how we are engaging future students and their families through community outreach like the Atlanta Science Festival.

As someone who likes to "fiddle" with words, I am also keenly aware that some stories are best told with numbers. And when it comes to the story of remarkable growth of the College of Sciences and Georgia Tech as a whole, the snapshot on the facing page of this letter says it all.

That growth is made possible by another set of numbers. Our College is a community of more than 3,000 students and 500 faculty and researchers across six internationally ranked schools, supported by the incredible staff members at the heart of our campus and this work.

We are also fortunate to include alumni and friends in these numbers — those who volunteer and generously support the mission and vision of the College. We are grateful for your support, enthusiasm, and encouragement — and are always looking to expand these friendships. Should these pages speak to you and spark an idea, please get in touch.

In closing, I am thankful that I did not take the advice of that student those many years ago. I stuck with my job, continued to learn and grow, and turned things around. Now I am rewarded with the opportunity to present this magazine — this gift — to you. Enjoy!

M. Susan Lozier

Dean and Betsy Middleton and John Clark Sutherland Chair
Professor in the School of Earth and Atmospheric Sciences
College of Sciences at Georgia Tech

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By the Numbers

Georgia Tech College of Sciences

6 SCHOOLS

- Biological Sciences
- Chemistry and Biochemistry
- Earth and Atmospheric Sciences
- Mathematics
- Physics
- Psychology

12 interdisciplinary programs

HOME TO **40+** student organizations

Neuroscience, Georgia Tech's fastest growing undergraduate program

EXPLORE LLC
Pre-health- and research-focused Living and Learning Community

$67.4M in state funding (FY24) and **$65.3M** in new research funding (FY23)

6 NSF-funded **Research Experiences for Undergraduates** (REU) programs

3,204 enrollments (FY23)

#1 in credit hours taught by colleges at Georgia Tech

121% majors growth from AY15

776 degrees awarded (AY22-23)
63% B.S.
21% M.S.
15% Ph.D.

51% of all degrees awarded to **women**

GEORGIA TECH 2023 FIRST-YEAR ADMISSIONS SNAPSHOT

#1 Public university in value for students
according to the Princeton Review

52,384 total applications

Of incoming first-year & transfer students:
- **15%** are first generation
- **43%** are women
- **13%** are from rural areas

113 Georgia counties

50 states + D.C. and P.R.

103 nations

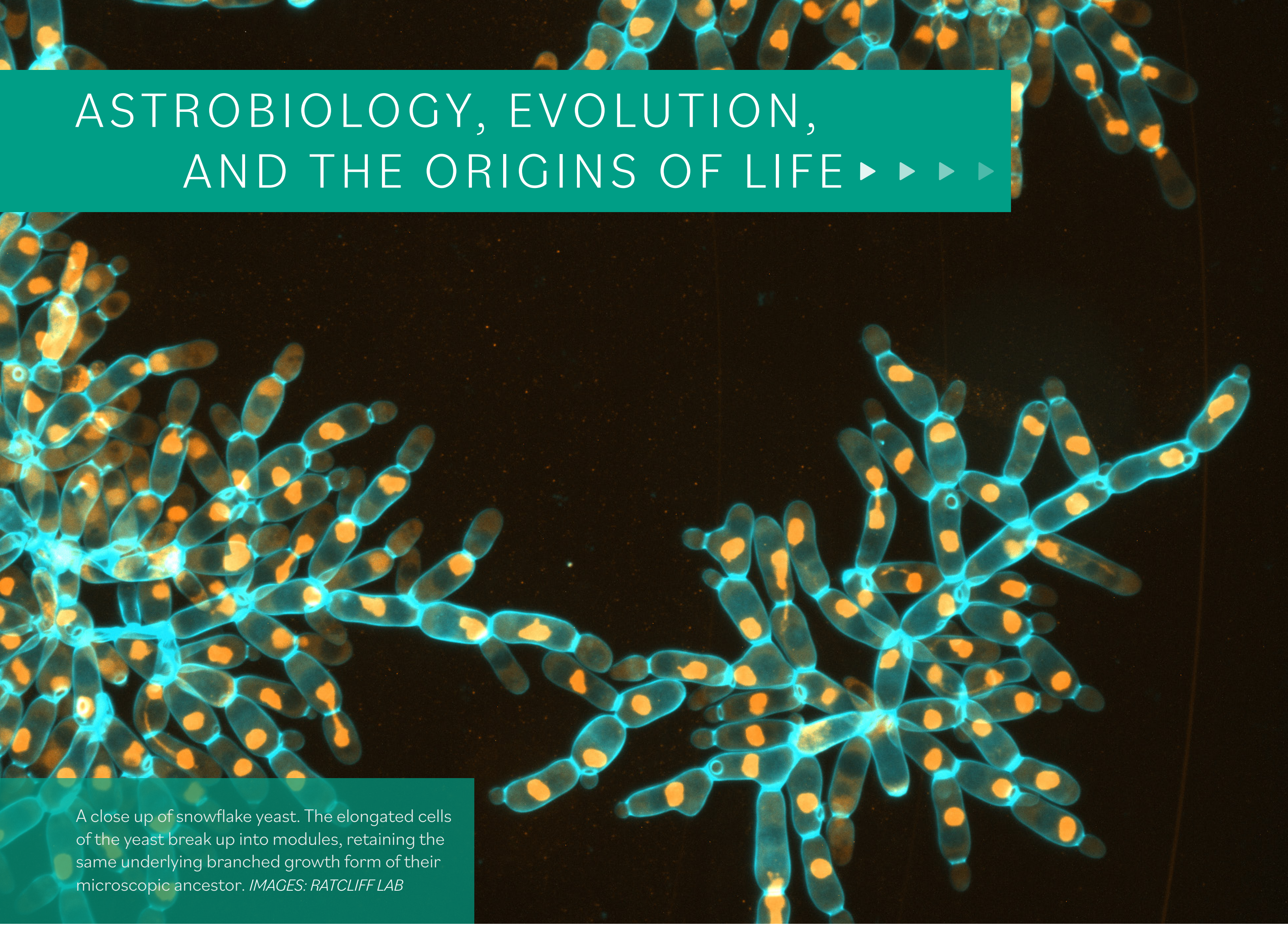
21% of total admitted students (FY23) are in the College of Sciences

22% **reduction in tuition and fees** for in-state students over 4 years when adjusted for inflation

Georgia Tech
College of Sciences

Learn more at **cos.gatech.edu**

ASTROBIOLOGY, EVOLUTION, AND THE ORIGINS OF LIFE



A close up of snowflake yeast. The elongated cells of the yeast break up into modules, retaining the same underlying branched growth form of their microscopic ancestor. *IMAGES: RATCLIFF LAB*

A Journey to the Origins of Multicellular Life

Long-term experimental evolution in the lab

Our world would look very different without multicellular organisms, but precisely how these organisms evolved from single-celled ancestors has previously been poorly understood. The transition happened hundreds of millions of years ago, and early multicellular species are largely lost to extinction.

Now a team of Georgia Tech researchers are taking evolution into their own hands. Led by **William Ratcliff**, associate professor in the School of Biological Sciences and director of the Interdisciplinary Graduate Program in Quantitative Biosciences, the team has developed an approach that allows them to create multicellular life from scratch — and examine thousands of generations of evolution in real time.

Their study, published recently in *Nature*, is the first major report on the ongoing Multicellularity Long-Term Evolution Experiment (MuLTEE), which the team hopes to run for decades.

Inside the MuLTEE

Ozan Bozdag, a research scientist and former postdoctoral researcher in Ratcliff's group and first author on the paper, initiated the MuLTEE in 2018, starting with single-celled snowflake yeast. Bozdag grew the yeast in shaking incubators and each day selected for both faster growth and larger group size.

The team selected on organism size because the ability to grow large, tough bodies is thought to play a role in increasing complexity, as it requires new biophysical innovations. However, this hypothesis had never been directly tested in the lab.

Over about 3,000 generations of evolution, their yeast evolved to form groups that were more than 20,000 times larger than their ancestor. And while the individual snowflake yeast started off weaker than gelatin, they evolved to be as strong and tough as wood.

New biophysical adaptations

In investigating how the snowflake yeast adapted to become larger, the researchers observed that the yeast cells themselves became elongated, reducing the density of cells packed into the group. This cell elongation slowed down the accumulation of cell-to-cell stress that would normally cause the clusters to fracture, allowing the groups to get larger. But this fact alone should have only resulted in small increases in size and multicellular toughness.

“We discovered that there was a totally new physical mechanism that allowed the groups to grow to this very, very large size,” Bozdag says. “The branches of the yeast had become entangled — the cluster cells evolved vine-like behavior, wrapping around each other and strengthening the entire structure.”

By simply selecting on organismal size, the researchers figured out how to leverage the biomechanical mechanism of entanglement, which ended up making the yeast about 10,000 times tougher as a material.

“Entanglement has previously been studied in totally different systems, mostly in polymers,” says **Peter Yunker**, associate professor in the School of Physics and a co-author on the paper. “But here we’re seeing entanglement through an entirely different mechanism — the growth of cells rather than just through their movement.”

Preliminary investigations of other multicellular fungi show that they also form highly entangled multicellular bodies, suggesting that entanglement is a widespread and important trait in this branch of multicellular life.

“By putting our finger on the scale of a single-celled organism’s evolution, we can figure out how they evolved into progressively more complex and integrated multicellular organisms, and can study that process along the way,” Ratcliff adds. “We hope that this is just the first chapter in a long story of multicellular discovery as we continue to evolve snowflake yeast in the MuLTEE.”

> “We discovered that there was a totally new physical mechanism that allowed the groups [of cells] to grow to this very, very large size.”
>
> — **Ozan Bozdag**, research scientist in the School of Biological Sciences

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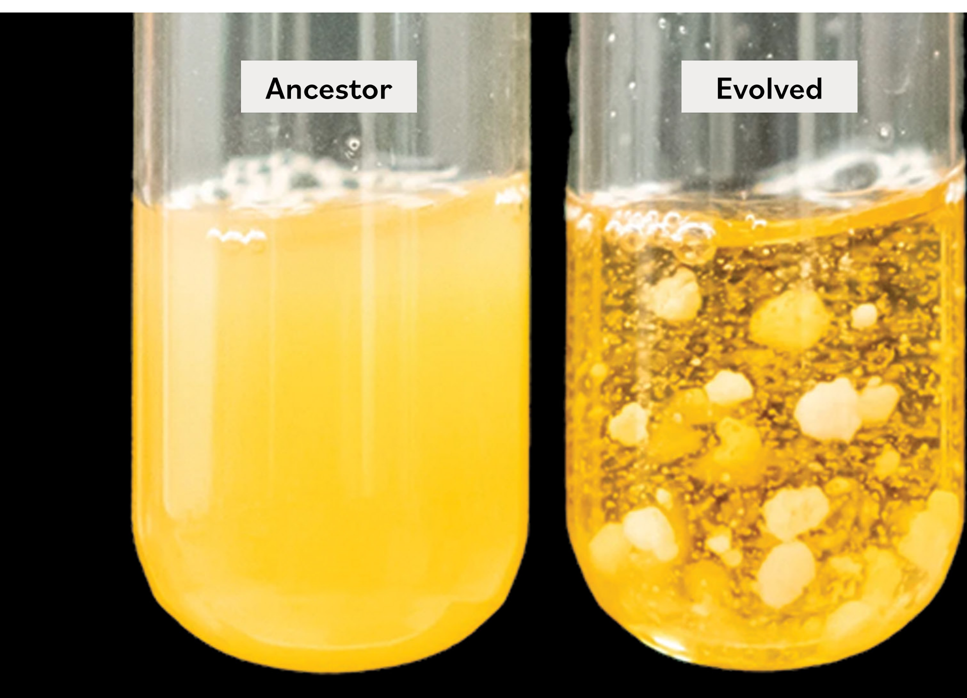
>
> — **William Ratcliff**, associate professor in the School of Biological Sciences

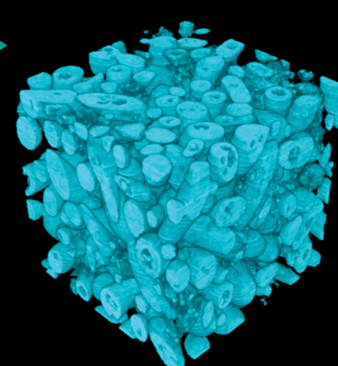
Story by Catherine Barzler • Supported by NIH, Human Frontiers in Science Grant, Packard Fellowship for Science and Engineering.



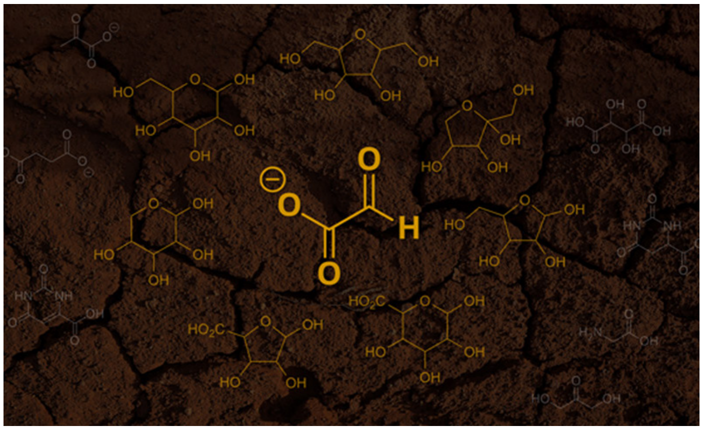
Getting a closer look

Snowflake yeast clusters evolved from clusters of 100 cells (left tube) to denser clusters of nearly half a million cells per cluster (right tube).

The internal structure of the yeast. The researchers imaged thousands of ultrathin slices of the yeast using a scanning electron microscope.



New Hypothesis for Early Earth's First Sugars



▲ Chemists hypothesize that the first sugars emerged from glyoxylate. *SCRIPPS RESEARCH/UNSPLASH*

Sugars are found throughout biology, including in the twisted backbone structure of DNA and RNA, but how the first sugars arose on early Earth is unclear. Chemists from Georgia Tech and Scripps Research have proposed that key sugars needed for making early life forms could have emerged from reactions involving glyoxylate (C_2HO_3–), a relatively simple chemical that plausibly existed on the Earth before life evolved.

Origin-of-life chemists seek to explain how the basic molecular building blocks and reactions necessary for life could have arisen from the simple chemicals that were likely present on the "prebiotic" Earth. Many scientists believe the first sugars (also called carbohydrates) came from reactions involving formaldehyde (CH_2O), but this theory has some drawbacks.

"The formaldehyde reactions proposed by this theory are quite messy — they have uncontrolled side reactions and other drawbacks due to formaldehyde's high reactivity under the envisioned early Earth conditions," says co-author **Charles Liotta**, Regents' Professor emeritus in the School of Chemistry and Biochemistry at Georgia Tech, with a joint appointment in the School of Chemical and Biomolecular Engineering.

The chemists' proposed alternative is a "glyoxylose reaction" scenario in which glyoxylate first reacts with itself, forming a close cousin of formaldehyde known as glycolaldehyde. The researchers suggest that glyoxylate, glycolaldehyde, their byproducts, and other simple compounds could have continued to react with one another, ultimately yielding simple sugars and other products, without the drawbacks of formaldehyde-based reactions.

"We show that our new hypothesis has key advantages over the more traditional view that early sugars arose from the chemical formaldehyde," says **Ramanarayanan Krishnamurthy**, an author of the study and a professor in the Department of Chemistry at Scripps Research.

The team is currently working to demonstrate in the laboratory that the glyoxylose reaction scenario could indeed have yielded the first sugars.

"Such a demonstration would expand the role of glyoxylate as a versatile molecule in prebiotic chemistry and further stimulate the search for its own origin on the prebiotic Earth," Krishnamurthy says.

The chemists are also looking into potential commercial applications of reactions that make glyoxylate, since these effectively consume CO_2 and thus can be used to reduce CO_2 levels, either locally in industrial settings or more widely to combat global warming.

Story by Scripps Research • Supported by NSF, NASA Exobiology, NASA Astrobiology under the Center for Chemical Evolution.

Rosenzweig Leads NASA Astrobiology Study

Billions of years ago, self-replicating systems of molecules became separated from one another by membranes, resulting in the first cells. Over time, evolving cells enriched the living world with an astonishing diversity of new shapes and biochemical innovations, all made possible by compartments.

▲ Frank Rosenzweig, professor in the School of Biological Sciences.

Compartmentalization is how all living systems are organized today — from proteins and small molecules sharing space in separate phases to dividing labor and specialized functions within and among cells.

Now, with $6 million in support from NASA, **Frank Rosenzweig** will lead a team of researchers studying the organizing principles of compartmentalization in a five-year project called "Engine of Innovation: How Compartmentalization Drives Evolution of Novelty and Efficiency Across Scales."

The new effort builds upon Georgia Tech's reputation in astrobiology, where a cluster of College of Sciences researchers including **Jennifer (Jen) Glass**, **Nicholas (Nick) Hud**, **Thomas (Thom) Orlando**, **Amanda Stockton**, and **Loren William**s are engaged in a diverse range of work supported by NASA and other agencies. Rosenzweig is also co-lead for a NASA Astrobiology Research Coordination Networks (RCN) launched in 2022, "LIFE: Early Cells to Multicellularity."

Story by Jerry Grillo • Supported by NASA Interdisciplinary Consortia for Astrobiology Research (ICAR) program.

Creative Destruction: Probing Protein Evolution

Applying an economics theory to the building blocks of evolution

Researchers in the lab of **Loren Williams** are using "creative destruction" as a model for protein fold evolution and innovation, and it might answer one of humanity's oldest questions: How did we become us?

Claudia Alvarez-Carreño, postdoctoral researcher and study lead author.

"We have protein structures that have evolved over almost four billion years, and we don't really understand where they came from or how they came to be what they are," said **Claudia Alvarez-Carreño**, a postdoctoral researcher in the Williams lab, which is called the Center for the Origin of Life, or COOL. "It's a very complex process forming these structures, and there are many hypotheses on how they could have emerged in early evolution."

"Creative destruction," an economic term coined in the 1940s, describes the deliberate dismantling of an established thing, like the wired telephone, to develop a new thing, like the smartphone.

In a new study published in the *Proceedings of the National Academy of Sciences*, Alvarez-Carreño joins co-authors Williams and Georgia Tech researchers **Rohan Gupta** and **Anton Petrov** to provide evidence supporting the common origins of some of the simplest, oldest, and most common protein folds. They discovered that once a protein can fold and achieve its 3D structure, when combined with another protein that has folded into a different 3D structure, the combination can easily become a new structure.

While the lab team is most interested in how their model helps them understand some of our deepest evolutionary questions, the creative destruction model also has applications in studying disease. "For example, we think this process is important in the biology of cancer — there are many, many proteins that have fused and, we believe, have refolded in cancers," says Williams, who also notes implications for diseases like Parkinson's or Alzheimer's.

"Creative destruction could help us understand where the proteins in our body came from," Williams adds, "and how we came to be what we are."

Story by Jerry Grillo • Supported by NASA and the NASA Postdoctoral Program, administered by Oak Ridge Associated Universities under contract with NASA.

> "Creative destruction could help us understand where the proteins in our body came from and how we came to be what we are."
>
> — **Loren Williams**, professor in the School of Chemistry and Biochemistry

Williams Named AAAS Fellow

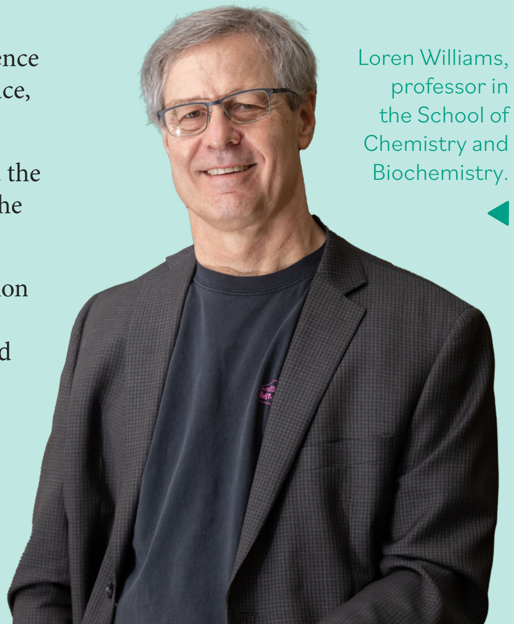
Loren Williams has been named an American Association for the Advancement of Science (AAAS) Fellow, a distinction awarded to the nation's most distinguished leaders in science, engineering, and innovation.

Williams was honored for his distinguished contributions to the fields of biophysics and the origins and evolution of life on Earth, particularly for advancing our understanding of the translation system's evolution.

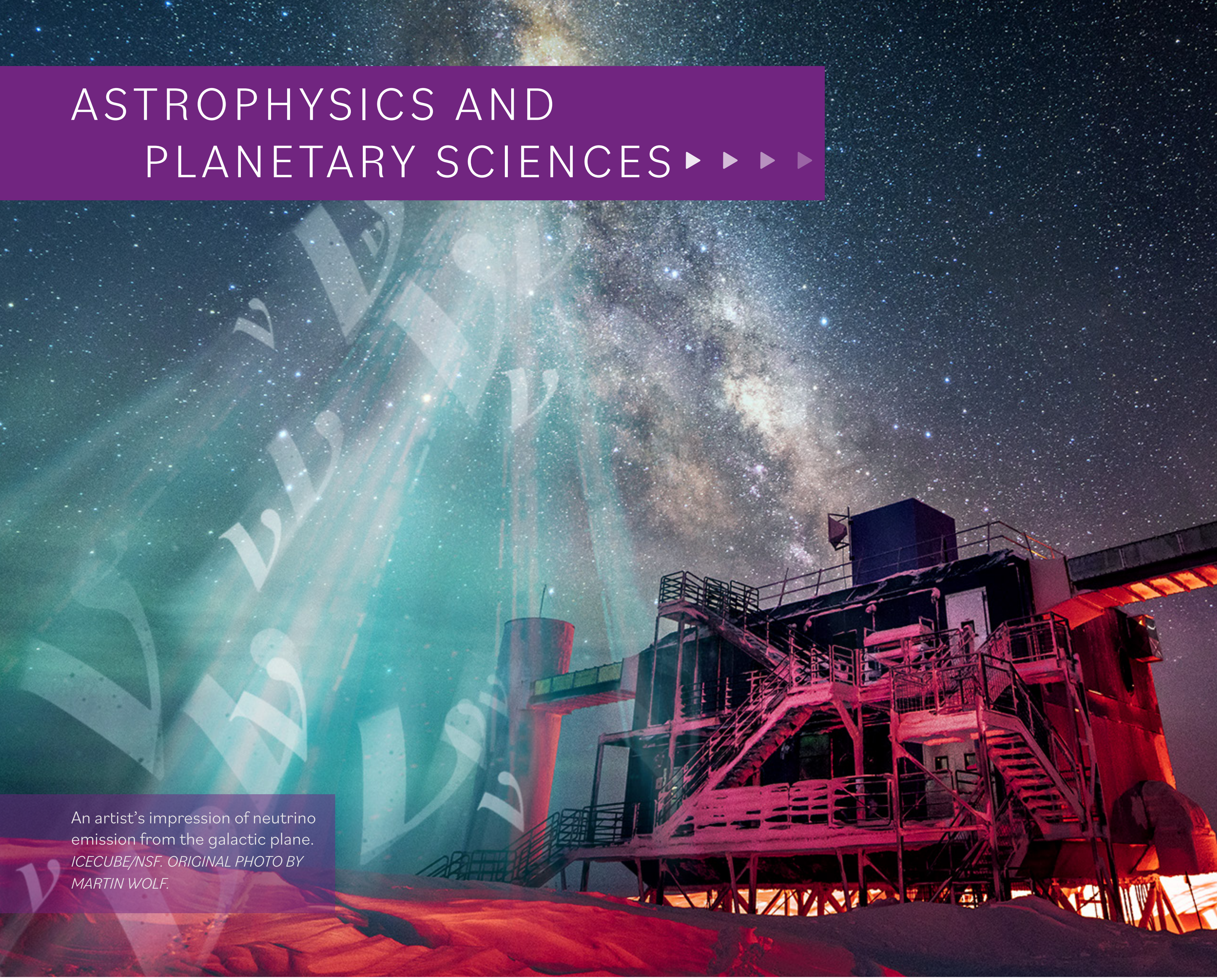
Williams began studying new ribosome structures at the turn of the century, found a passion for uncovering the origins of life on Earth, and continued his award-winning and NASA-funded research at Georgia Tech. He also serves as co-lead of the Prebiotic Chemistry and Early Earth Environment Consortium (PCE_3 a NASA Research Coordination Network).

Williams is joined by fellow Georgia Tech professors **Marion Usselman** and **Samuel Graham**, who were also named 2022 AAAS Fellows.

Story by Steven Gagliano.



Loren Williams, professor in the School of Chemistry and Biochemistry.



An artist's impression of neutrino emission from the galactic plane. *ICECUBE/NSF. ORIGINAL PHOTO BY MARTIN WOLF.*

IceCube Detects High-Energy Neutrino Emission From Milky Way

While the Milky Way is often viewable with the naked eye as a horizon-to-horizon, hazy band of stars, recently, for the first time, the IceCube Neutrino Observatory has produced an image of the Milky Way using neutrinos — tiny, ghostlike astronomical messengers.

In an article published in June 2023 in the journal *Science*, the IceCube Collaboration, an international group of over 350 scientists, presented evidence of high-energy neutrino emission from the Milky Way.

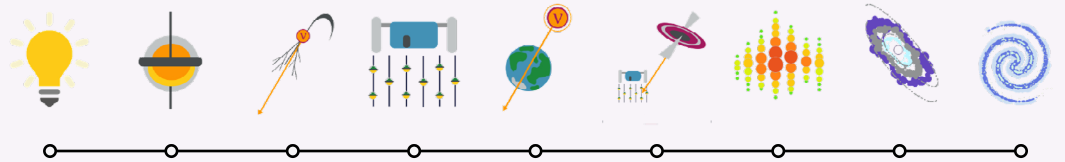
The detected neutrinos hold energies millions to billions of times higher than those produced by the fusion reactions that power stars.

"IceCube is truly unique," explains **Ignacio Taboada**, spokesperson for IceCube and a physics professor at Georgia Tech. "Built deep in Antarctic ice, its over 5,000 light sensors search for the flashes of blue light — Cherenkov radiation produced by neutrinos in the upper atmosphere, the Milky Way, and deep into the cosmos."

IceCube was built and is operated with National Science Foundation (NSF) funding and additional support from the 14 countries that host institutional members of the IceCube Collaboration. The cubic-kilometer neutrino detector operating at Amundsen-Scott South Pole Station searches for signs of high-energy neutrinos originating from our galaxy and beyond, out to the universe's farthest reaches.

A history of neutrino astronomy in Antarctica

The detection of the second source of high-energy neutrinos and cosmic rays is the result of over 30 years of scientific exploration, with continuous support from the National Science Foundation since the 1990s. *ICECUBE/NSF*



- **1988** Telescope in the Ice Envisioned
- **2000** AMANDA Completed
- **2001** Atmospheric Neutrinos Detected
- **2011** IceCube Completed
- **2013** Astrophysical Neutrinos Discovered
- **2018** First Source of 05606+056 Identified
- **2021** Glashow Resonance Neutrino Identified
- **2022** Second Source NGC 1068 Identified
- **2023** Third Source Milky Way Identified

Searching the southern sky

"As is so often the case, significant breakthroughs in science are enabled by advances in technology," says **Denise Caldwell**, director of NSF's Physics Division. "The capabilities provided by the highly sensitive IceCube detector, coupled with new data analysis tools, have given us an entirely new view of our galaxy — one that had only been hinted at before. As these capabilities continue to be refined, we can look forward to watching this picture emerge with ever-increasing resolution, potentially revealing hidden features of our galaxy never before seen by humanity."

Interactions between cosmic rays — high-energy protons and heavier nuclei, also produced in our galaxy — and galactic gas and dust inevitably produce both gamma rays and neutrinos. Given the observation of gamma rays from the galactic plane, the Milky Way was expected to be a source of high-energy neutrinos.

The search focused on the southern sky, where the bulk of neutrino emission from the galactic plane is expected near the center of our galaxy. However, until now, the background of muons and neutrinos produced by cosmic-ray interactions with the Earth's atmosphere posed significant challenges.

To overcome them, IceCube collaborators at Drexel University developed analyses that select for "cascade" events, or neutrino interactions in the ice that result in roughly spherical showers of light. Because the deposited energy from cascade events starts within the instrumented volume, contamination of atmospheric muons and neutrinos is reduced. Ultimately, the higher purity of the cascade events demonstrated a better sensitivity to astrophysical neutrinos from the southern sky.

Machine learning in the Milky Way

The final breakthrough came from implementing machine learning methods that improve the identification of cascades produced by neutrinos, as well as their direction and energy reconstruction.

"The improved methods allowed us to retain over an order of magnitude more neutrino events with better angular reconstruction, resulting in an analysis that is three times more sensitive than the previous search," says IceCube member, TU Dortmund physics Ph.D. student, and co-lead analyzer **Mirco Hünnefeld**.

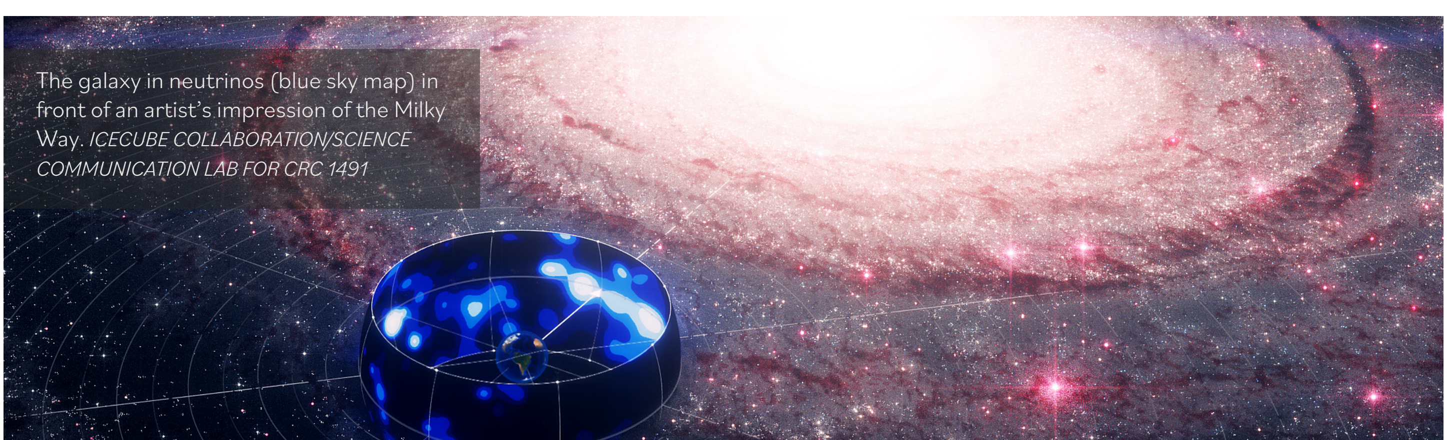
The dataset used in the study included 60,000 neutrinos spanning 10 years of IceCube data, 30 times as many events as the selection used in a previous analysis of the galactic plane using cascade events. These neutrinos were compared to previously published prediction maps of locations in the sky where the galaxy was expected to shine in neutrinos.

"The strong evidence for the Milky Way as a source of high-energy neutrinos has survived rigorous tests by the collaboration," says Taboada. "Now the next step is to identify specific sources within the galaxy."

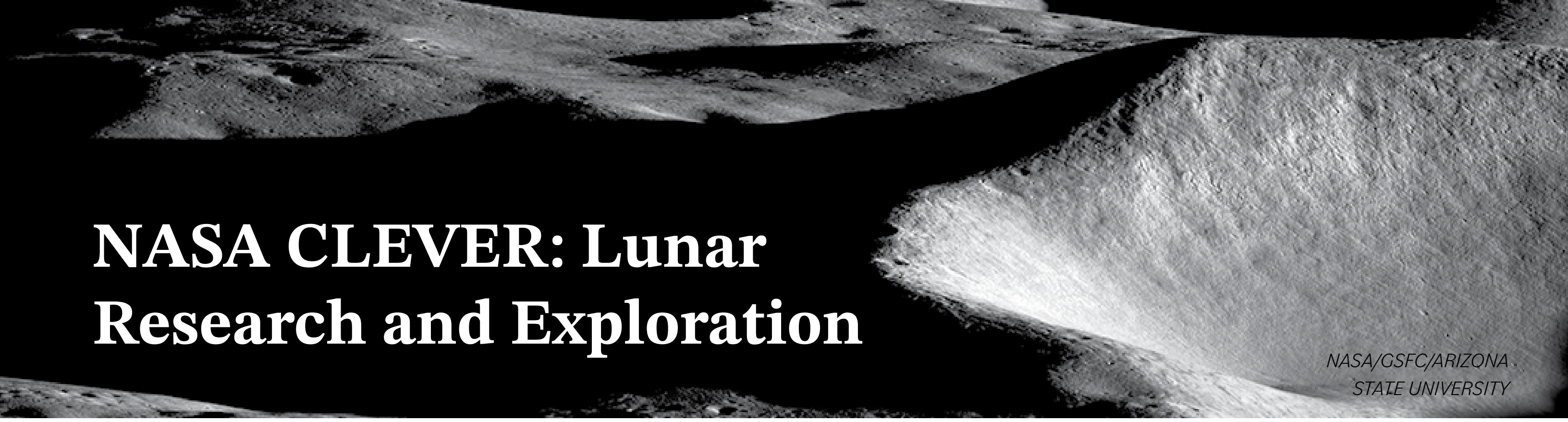
Story by NSF IceCube Collaboration • Supported by NSF.

"The strong evidence for the Milky Way as a source of high-energy neutrinos has survived rigorous tests by the collaboration. Now the next step is to identify specific sources within the galaxy."

— **Ignacio Taboada**, professor in the School of Physics and IceCube spokesperson



The galaxy in neutrinos (blue sky map) in front of an artist's impression of the Milky Way. *ICECUBE COLLABORATION/SCIENCE COMMUNICATION LAB FOR CRC 1491*



NASA CLEVER: Lunar Research and Exploration

NASA/GSFC/ARIZONA STATE UNIVERSITY

Thomas Orlando, Regents' Professor in the School of Chemistry and Biochemistry and the leader of the new center.

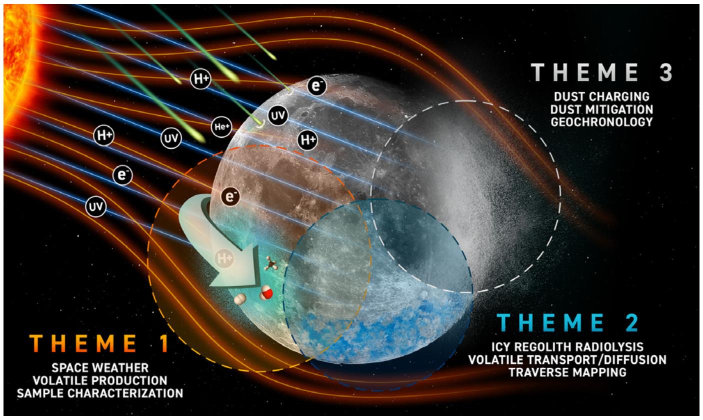
Georgia Tech researchers have been selected by NASA to lead the $7.5 million Center for Lunar Environment and Volatile Exploration Research (CLEVER).

Led by **Thomas (Thom) Orlando**, CLEVER looks ahead to the return of humans to the Moon for sustained periods — a key part of NASA's plan for space exploration in the coming decade. Volatiles such as water, molecular oxygen, methane, and hydrogen are crucial to supporting human activity on the Moon. Dust is also important, since the space-weathered particles can pose health risks to astronauts and hazards to the technology and hardware.

The interdisciplinary group of researchers supported by CLEVER will study how the solar wind and micrometeorites produce volatiles, research how ice and dust behave in the lunar environment, develop new materials to deal with potential dust buildup, and invent new analysis tools to support the upcoming crewed missions of the Artemis program.

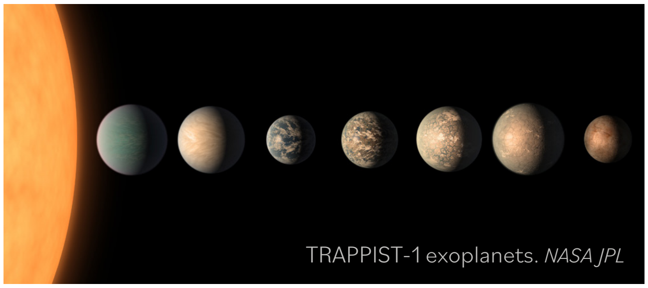
"The resources and knowledge that CLEVER will produce will be useful for the sustainable presence of humans on the Moon," Orlando says. "We have the correct mix of fundamental science and exploration — real, fundamental, ground-truth measurements; very good theory/modeling; and engineering — an easy mix with Georgia Tech and outside partners."

Story by M.G. Finn • Supported by NASA Solar System Exploration Research Virtual Institute (SSERVI).



Research themes of CLEVER. The team will characterize the lunar environment and volatile inventories required for near-term sustained human exploration of Earth's moon. *BRICE ZIMMERMAN*

Exploring Exoplanets



TRAPPIST-1 exoplanets. *NASA JPL*

The TRAPPIST-1 system of exoplanets hosts the most Earth-sized planets in the habitable zone of a single star found to date. Liquid water may also flow near — or on — the surface of some of these exoplanets.

Yet two recent studies from teams involving Georgia Tech School of Physics and School of Mathematics researchers show a few of these exoplanets could spin themselves into chaotic day-night cycles — ultimately becoming uninhabitable snowballs as a result.

The first study, led by Georgia Tech, developed new algorithms for computer simulations that account for gravitational pulls from these planets and their sun — along with tidal forces. The second study combined those algorithms with a 3D climate model.

"We found that the chaotic variations in the day-night cycles led to fast snowball transitions for TRAPPIST-1f [the fifth planet from the star that is the system's sun]," says **Gongjie Li**, assistant professor in the School of Physics and a co-author of both studies. "This can render the planet trapped in a permanent snowball state, and makes it less favorable to life."

Story by Renay San-Miguel • Supported by NASA.

A Sharper Look at the M87 Black Hole

The iconic Event Horizon Telescope image of the supermassive black hole at the center of M87 — sometimes referred to as the "fuzzy, orange donut" — has gotten its first official makeover with the help of a new machine learning technique. The high-fidelity image further exposes a central region that is larger and darker, surrounded by the bright accreting gas shaped like a "skinny donut."

The new machine learning technique enhances the fidelity and sharpness of radio interferometric images. Called PRIMO, which stands for "principal-component interferometric modeling," it was developed by researchers **Feryal Özel** and **Dimitrios Psaltis** (Georgia Tech), **Lia Medeiros** (Institute for Advanced Study), and **Tod Lauer** (NSF NOIRLab). Using data obtained by the Event Horizon Telescope collaboration in 2017, the team achieved the array's full resolution for the first time.

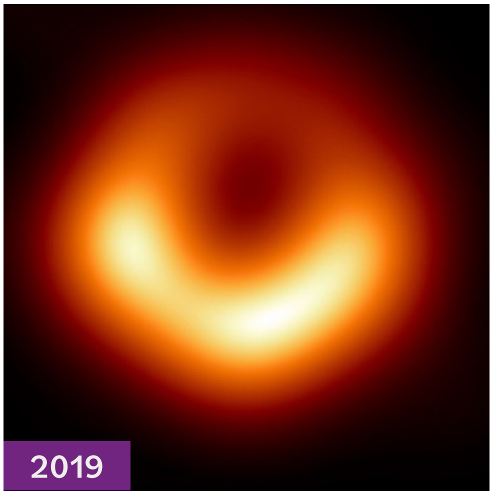
"The new image of the M87 black hole showcases the remarkable power of the highest-resolution telescope on Earth working in tandem with modern machine learning algorithms," says Özel. "It demonstrates how technology continues to push the boundaries of our understanding of the universe."

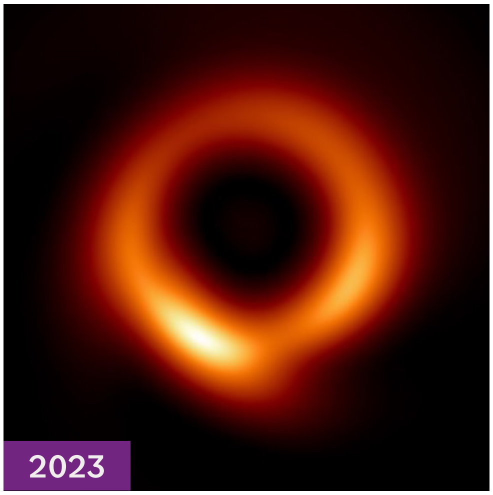
"[The new image of the M87 black hole] demonstrates how technology continues to push the boundaries of our understanding of the universe."

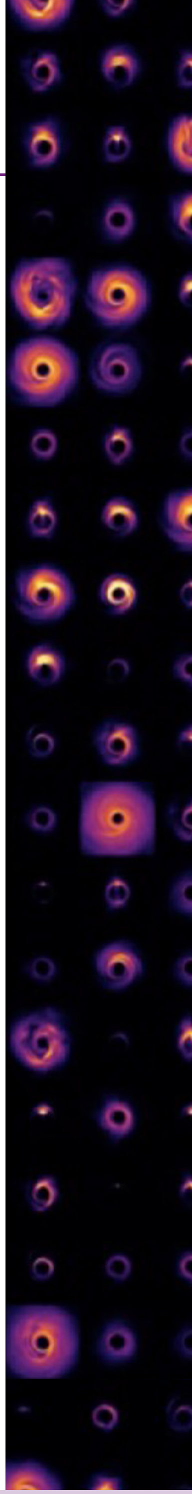
— **Feryal Özel**, professor and chair of the School of Physics

Story by Institute for Advanced Study • Supported by NASA Astronomy and Astrophysics Postdoctoral Fellowship.

Left: the original image of the black hole published in 2019. Right: PRIMO, the improved version using the researchers' machine learning algorithm. *EVENT HORIZON TELESCOPE*







Some of the simulations generated for the training set of the PRIMO algorithm. *EHT / MEDEIROS ET AL. 2023*

Qutob Receives Goldwater Scholarship

AS A LEDDY FAMILY DEAN'S SCHOLAR AT GEORGIA TECH, **Nadia Qutob** researches gravitational wave data analysis with the Laser Interferometer Gravitational-Wave Observatory (LIGO), specifically examining parameter estimation optimization for the high signal-to-noise ratio regime.

She is also among five Georgia Tech undergraduates awarded the prestigious Goldwater Scholarship for 2023. Qutob is joined by **Jim James**, **Maeve Janecka**, **Velin "Venny" Kojouharov**, and **Dawei Liu** in receiving the honor.

Qutob says that her mentors, Associate Dean for Research in the College of Sciences and Physics Professor **Laura Cadonati** and Postdoctoral Fellow **Meg Millhouse**, have been instrumental during her time at LIGO. "Their guidance and patience have cultivated an environment where I can thrive and reach my full research potential. I wouldn't be where I am today without them," she says, adding that "**Karen Mura** and **Shannon Dobranski** were instrumental in the success of my Goldwater application."

Story by Cory Hopkins • Supported the Goldwater Scholarship and Excellence in Education Foundation and the Leddy Family Dean's Scholar Program at Georgia Tech.

Supporting Multidisciplinary Science — and Dialog

Over the past school year, faculty across three College of Sciences schools have received new support from Research Corporation for Science Advancement (RCSA).

High risk, high reward

The foundation selected four researchers for its 2023 Cottrell Plus SEED Awards, including School of Physics' **Tamara Bogdanović** for her research, "Risk and Rewards: Pushing Boundaries with RMHD Simulations of Multimessenger Massive Black Hole Binaries." SEED is short for Singular Exceptional Endeavors of Discovery, and the award program offers Cottrell Scholars like Bogdanović the opportunity to start high-risk, high-reward new research and educational activities in chemistry, physics, and astronomy.

"These awards offer established teacher-scholars a chance to open up new lines of research," says RCSA Senior Program Director **Silvia Ronco**. "Their creative new projects have the potential to generate some high-impact science." Since 1994, the Cottrell Scholar program has honored and helped to develop outstanding teacher-scholars who are recognized by their scientific communities for the quality and innovation of their research programs and their potential for academic leadership.

Tamara Bogdanović, Dunn Family Professor in the School of Physics, also serves as associate director of the Center for Relativistic Astrophysics at Georgia Tech.

Early Earth aerosols

Amanda Stockton, associate professor in the School of Chemistry and Biochemistry.

This year, School of Chemistry's **Amanda Stockton** is studying "Irradiated Sea Spray Aerosol Generation and Analysis Under Early Earth Atmospheres" with **Tyler Robinson** (Lunar and Planetary Laboratory, University of Arizona). Stockton and Robinson are among eight teams selected for 2023 Scialog: Signatures of Life in the Universe program, now in its final year. The initiative is supported by RCSA, the Heising-Simons Foundation, the Kavli Foundation, and NASA.

Short for "science and dialog," the Scialog format supports research by stimulating intensive interdisciplinary conversation and community building around a globally important scientific theme. Small teams who have not previously collaborated compete for seed funding for novel research projects based on the ideas that emerge at an annual conference.

"Magic happens when people with different backgrounds, methodologies, and vocabularies work together," says RCSA President and CEO **Daniel Linzer**. "With decades of science in front of them, early career scientists at Scialog build new networks of people to bounce ideas off of and open up new avenues of research to make that as rich an experience as possible."

New Center for Relativistic Astrophysics Director

From the large-scale structure of the early universe to interactions between its smallest particles, researchers in Georgia Tech's Center for Relativistic Astrophysics (CRA) are working at the cutting edge of developments in astrophysics.

John Wise, the new director of the CRA, aims to lead the Center to new heights in machine learning and space sciences. Wise is a professor in the School of Physics and an award-winning creator of supercomputer-driven visualizations that depict the beginnings of galaxies.

In 2017, Wise's depiction of the creation of the universe's first galaxies won the Best Scientific Visualization Award at the Supercomputing Conference, one of the largest international conferences for high-performance computing.

Wise has also testified before Congress on the role supercomputing plays in research. He is the recipient of the Hesburgh Award Teaching Fellowship, the Eric R. Immel Award for Excellence in Teaching in the College of Sciences, and the Dunn Family Professorship at Georgia Tech.

John Wise, professor in the School of Physics.

Story by Renay San Miguel.

Martian environmental chemistry

School of Earth and Atmospheric Sciences' **Frances Rivera-Hernández** also recently earned Scialog support, named among eight multidisciplinary teams of researchers selected for 2022 funding. Partnering with **Laurie Barge**, a research scientist in the Planetary Sciences division of the NASA Jet Propulsion Laboratory, Rivera-Hernández will focus on "Mars Sample Return: Connecting Martian Environmental Geochemistry to Returned Samples," funded by NASA.

Frances Rivera-Hernández, assistant professor in the School of Earth and Atmospheric Sciences.

The pair hope to catalyze cutting-edge research with the potential to transform understanding of planetary habitability, of how the occurrence of life alters planets and leaves signatures, and of how to detect such signatures beyond Earth. "Fellows of this initiative have a great responsibility," notes RCSA's Linzer. "This research will help inform priorities and design the science for multibillion-dollar public investments in space missions in the years to come." Rivera-Hernández also co-leads a new $2.9 million NASA Planetary Science and Technology from Analog Research (PSTAR) grant.

Cottrell Collaborative: SMART training

Elisabetta Matsumoto, associate professor in the School of Physics.

Last fall, RCSA also awarded Cottrell Scholar Collaborative Awards to four new collaborative projects that emerged from discussions at the 2022 Cottrell Scholar Conference. Those awards support efforts to improve both undergraduate- and graduate-level science education.

School of Physics' **Elisabetta Matsumoto** is collaborating with faculty from Tufts University, University of Oregon, Williams College, and Stanford University on their selected project, "Supporting Making to Align Research and Teaching (SMART): A Cottrell Collaborative." The researchers note that "SMART builds off an existing Cottrell collaborative project aiming to increase awareness of making, an emerging instructional practice where students learn a discipline — and enjoy enhanced creativity and self-expression — by creating shared physical and digital artifacts."

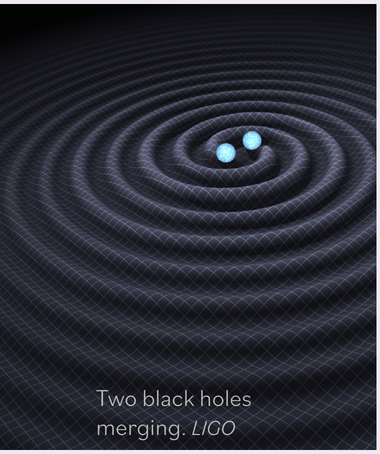
Their ultimate goal is to support and document faculty training and adoption of making methods, as well as generate examples of making activities in disciplines, such as chemistry and astronomy, that have not adopted this technique.

A rich history

At Georgia Tech, College of Sciences faculty across several disciplines have also been named Cottrell Scholars or joined the Scialog program, including **Jennifer (Jen) Glass**, **Chris Reinhard**, **Vinayak (Vinny) Agarwal**, **Gongjie Li**, **Chad Risko**, **Jean-Luc Brédas**, **Brian Hammer**, **David Collard**, and **Michael (Mike) Schatz**.

Story by Selena Langner • Supported by RCSA, the Heising-Simons Foundation, the Kavli Foundation, and NASA.

Physicists Predict Cosmic Collisions



Two black holes merging. *LIGO*

In 2017, the LIGO–Virgo gravitational-wave network alerted dozens of telescopes around the world that a fiery collision between two dead stars was taking place millions of light-years away. Thanks to the alert, approximately 70 telescopes observed the event.

LIGO–Virgo detectors have been undergoing a series of upgrades to make them even better at catching gravitational-wave events and thus neutron star mergers. One new feature to be employed is an early warning alert system. As neutron stars spiral around each other, they give off gravitational waves of increasingly higher frequencies. The LIGO early-warning software is designed to catch snippets of this last dance.

"In the next run, we might be able to catch one of the neutron star mergers 10 seconds ahead of time," says **Surabhi Sachdev**, an assistant professor in the School of Physics at Georgia Tech co-leading the development of early warning software. "By the fifth run, we believe we can catch one with a full minute of warning," she adds. That would give telescopes around the world more time to find and study the explosions.

Story by Caltech • Supported by NSF • Study published in The Astrophysical Journal Letters.

TO THE MOON, BACK, AND BEYOND

Half a century ago, Georgia Tech alumnus **John Young** (AE ‘52, Ph.D. Hon. ‘03) walked on the Moon. Now, the launch of Artemis 1 is NASA’s first step in returning astronauts to it. Georgia Tech experts discuss why we are returning to the lunar surface, what we might find there, what it might mean for international politics, and how it matters in the future of space exploration.

WHY ‘GO FORWARD’ TO THE MOON AND WHY NOW?

THE ARTEMIS I MISSION, an uncrewed Moon-orbiting mission part of NASA’s larger Artemis Program, is aimed toward establishing a sustainable human presence on the Moon. “It will also allow humans to probe the origin, and geophysical and geochemical, evolution of the Moon and Earth as well as the source of volatile molecules and Earth’s oceans,” says **Thom Orlando**, Regents’ Professor in the School of Chemistry and Biochemistry and an adjunct professor in the School of Physics.

Water will prove critical to the mission’s success, but “the source of water on Earth, on the Moon, or in any solar system is not really understood,” Orlando explains. “Returning humans to the Moon presents an opportunity to unravel this mystery, which may be tied to the mystery of the origin of life as we know it.”

But exploring the Moon does come with challenges. We “have to be careful since the pristine portions of the Moon — the permanently shadowed regions and the polar caps — likely contain history and preserved clues regarding the chemical inventory available during planetary accretion,” Orlando says. Keeping those portions of the Moon ‘clean’ must be a priority. Risks like solar wind and cosmic ray irradiation pose health risks to human explorers, and dust will also pose a challenge. “These risks are not just health risks,” adds Orlando. “Dust will interfere with the robots and technologies needed to operate on the Moon.”

Moon exploration will also bring unprecedented opportunities: for example, “access to the far side can allow a glimpse into the cosmic dark ages, which can help reveal the origin of the universe,” says Orlando. “Though the risks associated with going to the Moon are high, the rewards for humankind are far higher.”

> “Though the risks associated with going to the Moon are high, **the rewards for humankind are far higher**.”

Design: Brice Zimmerman & Darin Givens • Photos: Joya Chapman, Rob Felt, Candler Hobbs, Brice Zimmerman • Editor: Stacy Braukman

HOW WILL A PRESENCE ON THE MOON HELP US LEARN MORE ABOUT THE UNIVERSE?

"THE MOON AND ITS ENVIRONMENT SUPPORT THE EXPLORATION OF OUR UNIVERSE in two ways," says **Feryal Özel**, professor and chair of the School of Physics. "The first is using the Moon and orbits around it to place telescopes for exploring the far reaches of the cosmos."

Since the far side of the Moon is quiet with respect to radio waves, "a telescope on the far side of the Moon would help us listen to the faint signals from the early universe," Özel explains, and "a telescope orbiting around the Moon and working in tandem with ones on Earth could provide the highest resolution images of the universe ever obtained, bringing more galaxies, black holes, and their powerful jets into sharp focus.

"The second way is using the Moon as a launchpad to explore our solar system and experiment with the habitability of planets," especially those in the Milky Way. "Launching spacecraft from the surface of the Moon can help get larger payloads to Mars and carry out experiments on habitability," Özel says. "Our hope is that these experiments will shed further light on the question of what makes a planet habitable and help with our quest to look for life elsewhere in the universe."

> "Our hope is that these experiments will **help with our quest to look for life elsewhere in the universe**."

HOW WILL RETURNING TO THE MOON HELP US ANSWER ASTROBIOLOGICAL QUESTIONS AND PREPARE US FOR HUMAN EXPEDITIONS TO MARS?

"EXPLORATION OF THE MOON WILL BE A KEY STEP FORWARD in our understanding of how life emerged on Earth," says **Frances Rivera-Hernández**, assistant professor in the School of Earth and Atmospheric Sciences. While the Moon likely never hosted life, its surface can provide key information on the first billion years of the Earth and inner solar system — information not available from studying Earth itself.

For example, analyzing lunar samples could help unravel cratering rates on the Moon and Earth. Lunar samples might also record Earth meteorites, which could hold information regarding early life on Earth, including if organic molecules were delivered by impactors.

"The new age of exploration of the Moon will also help set the stage for future astrobiology activities on Mars," adds Rivera-Hernández. "The search for past evidence of microbial life on Mars is one of the main goals of Mars Sample Return and NASA's Mars Exploration Program. By assessing the rate of microbial contamination by human activities on the Moon, we will better understand the potential impacts of biological contamination in our search for life on Mars."

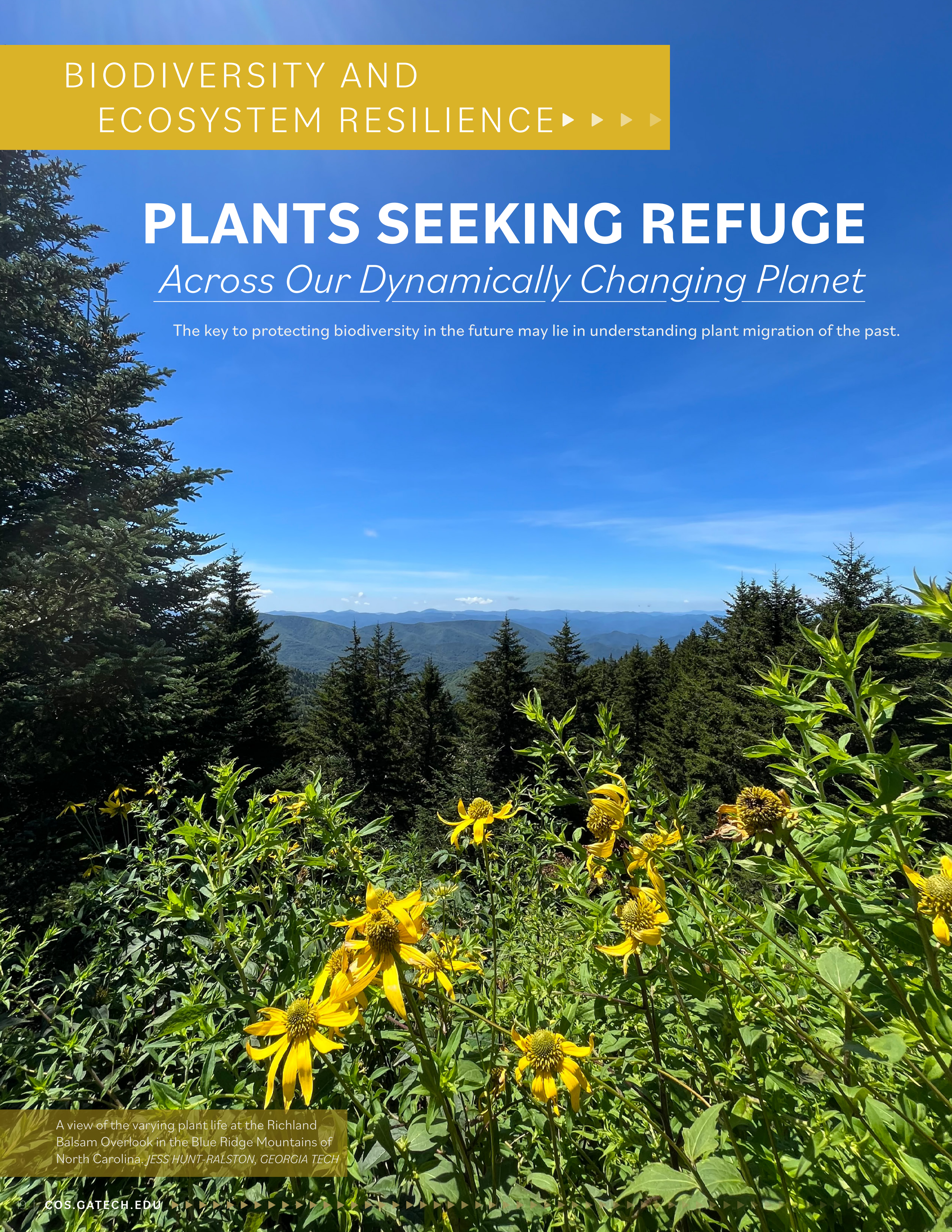
> "The new age of exploration of the Moon will also **help set the stage for future astrobiology activities on Mars**."

BIODIVERSITY AND ECOSYSTEM RESILIENCE

PLANTS SEEKING REFUGE

Across Our Dynamically Changing Planet

The key to protecting biodiversity in the future may lie in understanding plant migration of the past.



A view of the varying plant life at the Richland Balsam Overlook in the Blue Ridge Mountains of North Carolina. *JESS HUNT-RALSTON, GEORGIA TECH*

Plants, like animals and people, seek refuge from climate change. And when they move, they take entire ecosystems with them. To understand why and how plants have trekked across landscapes throughout time, researchers at the forefront of conservation are calling for a new framework.

Jenny McGuire, associate professor in the Schools of Biological Sciences and Earth and Atmospheric Sciences at Georgia Tech, spearheaded a special feature on the topic of biodiversity in the *Proceedings of the National Academy of Sciences*, along with colleagues in Texas, Norway, and Argentina. In the special feature, "The Past as a Lens for Biodiversity Conservation on a Dynamically Changing Planet," McGuire and her collaborators highlight the outstanding questions that must be addressed for successful future conservation efforts. The feature brings together conservation research that illuminates the complex and constant changes brought on by climate change and the ever-shifting ways humans use land. These factors, McGuire says, interact over time to create dynamic changes and illustrate the need to incorporate temporal perspectives into conservation strategies by looking deep into the past.

"Plants are shifting their geographic ranges, and this is happening whether we realize it or not," McGuire explains. "As seeds fall or are transported to distant places, the likelihood that the plant's seed can survive and grow is changing as climates are changing. Studying plants' niche dynamics over thousands of years can help us understand how species adapt to climate change and can teach us how to protect and maintain biodiversity in the face of rapid climate change to come."

McGuire's research about plants in North America investigates how and why they've moved across geography over time, where they're heading, and why this migration is important.

A new metric for understanding vulnerability

The first step to understand which type of plants exhibit what McGuire terms "climate fidelity," and which do not. If a plant has climate fidelity, it means the plant stays loyal to its preferred niche, often migrating across geographies over thousands of years to stay in its ideal habitat. Plants that don't exhibit climate fidelity tend to adapt locally in the face of climate change. Being loyal to one's climate doesn't necessarily mean being loyal to a particular place.

"Plants are shifting their geographic ranges, and this is happening whether we realize it or not."

— **Jenny McGuire**, associate professor in the School of Biological Sciences and the School of Earth and Atmospheric Sciences

McGuire and former Georgia Tech postdoctoral scholar **Yue Wang**, who is now an associate professor in the School of Ecology at Sun Yat-sen University in China, studied pollen data from the Neotoma Paleoecology Database, which contains pollen fossil data from sediment cores across North America. Each sediment core is sampled, layer by layer, producing a series of pollen data from different times throughout history. The data also indicates the relative abundance of different types of plants represented by pollen type — pine versus oak versus grass, for example — painting a picture of what types of plants were present in that location and when.

McGuire and Wang looked at data from 13,240 fossil pollen samples taken from 337 locations across the entirety of North America. "This process allowed us to see the climate fidelity of these different plant taxa, showing that certain plants maintain very consistent climatic niches, even when climate is changing rapidly," Wang says.

Their findings showed that when North American glaciers were retreating 18,000 years ago, spruce and alder trees moved northward to maintain the cool temperatures of their habitats.

Crucially, McGuire and Wang found that most plant species in North America have exhibited long-term climate fidelity over the past 18,000 years. They also found that plants that migrated farther did a better job of tracking climate during periods of change.

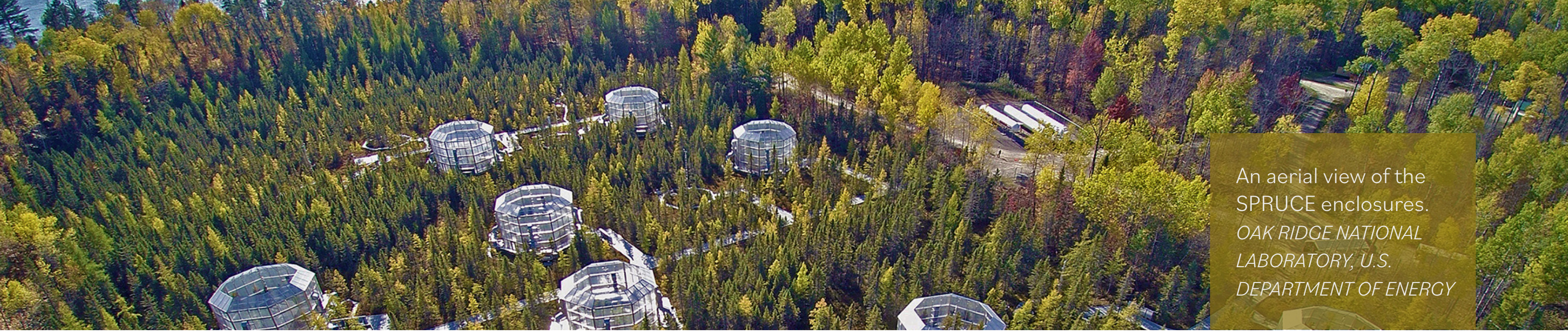
But some plants fared better than others. For example, the small seeds of willow trees can fly over long distances, enabling these trees to track their preferred climates very effectively. The large seeds of ash trees, however, can only be dispersed short distances. Habitat disruptions from humans could make it even more difficult for ash trees to be able to take hold in new regions.

By identifying which plants have historically been most sensitive to changing climates, McGuire and Wang's research can help conservation organizations prioritize where biodiversity is most vulnerable to climate change.

As a final step, McGuire and Wang identified "climate fidelity hotspots" — regions that have historically exhibited strong climate fidelity whose plants will most urgently need to move as their climates change. They compared these hotspots to climate-resilient regions identified by The Nature Conservancy that could serve as refuge areas for those plants. While plants in these resilient regions can initially adapt to impending climate change by shifting their distributions locally, the plants will likely face major challenges when a region's climate change capacity is exceeded due to lack of connectivity and habitat disruptions from humans. Refining these priorities helps stakeholders identify efficient strategies for allowing the fabric of life to thrive.

"I think understanding climate fidelity, while a new and different idea, will be very important going forward, especially when thinking about how to prioritize protecting different plants in the face of climate change," McGuire adds. "It is important to be able to see that some plants and animals are more vulnerable to climate change, and this information can help build stronger strategies for protecting the biodiversity on the planet."

Story by Catherine Barzler • Supported by NSF.



An aerial view of the SPRUCE enclosures. *OAK RIDGE NATIONAL LABORATORY, U.S. DEPARTMENT OF ENERGY*

Rising Temperatures Alter Microbial Processes in Peatlands

Peatlands cover just 3% of Earth's land area, but store over one-third of all soil carbon on the planet. This carbon storage is supported in large part by microbes. Two microbial processes in particular — nitrogen fixation and methane oxidation — strike a delicate balance, working together to give Sphagnum mosses access to critical nutrients in nutrient-depleted peatlands.

The coupling of these two processes is often referred to as the "missing link" of nutrient cycling in peatlands. Yet how these processes will respond to changing climates along northern latitudes is unclear.

Joel Kostka, Tom and Marie Patton Distinguished Professor and associate chair for Research in the School of Biological Sciences, and **Caitlin Petro**, a research scientist in Kostka's lab, recently led a collaborative study to investigate how peatlands (and the missing link of microbial processes that support them) may react to the increased temperature and carbon dioxide levels predicted to come with climate change. The team, which also includes researchers from the Oak Ridge National Laboratory (ORNL), Florida State University, and the University of Tennessee, Knoxville, recently published their work in the scientific journal *Global Change Biology*.

To see how northern peatlands will react to climate change, the team, which also included School of Earth and Atmospheric Sciences Associate Professor **Jennifer Glass**, turned to the ORNL Spruce and Peatland Responses Under Changing Environments (SPRUCE) experiment — a unique field lab in northern Minnesota where the team warms peat bogs and experimentally changes the amount of carbon dioxide in the atmosphere. The team exposed different parts of SPRUCE's experimental peatlands to a gradient of higher temperatures ranging from an increase of 0°C to 9°C. The moss's reaction was significant. Although nearly 100% of the bog's surface was covered in moss at the beginning of the experiment, moss coverage dropped with each increase in temperature, plummeting to less than 15% in the warmest conditions.

Critically, the two microbial processes that had previously been consistently linked fell out of sync at higher temperatures. Though unclear which of these changes — the moss dying or the altered microbial activity — is driving the other, it is clear that warmer temperatures and higher carbon dioxide levels bring a cascade of unpredictable outcomes for peat bogs.

Kostka and Petro hope their results will better equip computational models to predict the effects of climate change. "Down the road," Kostka says, "we hope the results can be used by environmental managers and governments to adaptively manage or geoengineer peatlands to thrive in a warmer world."

Story by Audra Davidson • Supported by NSF, U.S. Department of Energy's Office of Science, Biological, and Environmental Research Program (DOE BER), and the USDA Forest Service.

Joel Kostka takes soil samples at the SPRUCE facility in Minnesota.

Kostka Awarded $3.2 Million to Keep Digging Into How Soils and Plants Capture Carbon

A new Department of Energy (DOE) grant will help **Joel Kostka** build on research that has ranged from northern Minnesota peat bogs to coastal Georgia wetlands, all to learn how climate change impacts soils and plants that trap greenhouse gases — and whether some of those plants could end up as eco-friendly biofuels.

Kostka's studies will focus on the role of microbiomes — all the microorganisms living in a particular environment — in the biogeochemical cycling of carbon in terrestrial soils and wetlands by using genomics-based and systems biology. Kostka's funding is part of a wider $178 million dollar DOE effort to advance sustainable technology breakthroughs that can improve public health, help address climate change, improve food and agricultural production, and create more resilient supply chains.

Kostka will serve as principal investigator of the research team for the grant. The team includes Georgia Tech researchers **Caitlin Petro**, **Katherine Duchesneau**, **Kostas Konstantinidis**, as well as other university collaborators: **Rachel Wilson**, **Malak Tfaily**, and **Chris Schadt**.

Story by Renay San Miguel • Supported by DOE Genomic Sciences Program.

Machine Learning and Biodiversity in the Coral Triangle

Annalisa Bracco, professor in the School of Earth and Atmospheric Sciences, and **Lyuba Novi,** a postdoctoral researcher, have developed a new methodology that could revolutionize how conservationists monitor coral. The researchers applied machine learning tools to study how climate impacts connectivity and biodiversity in the Pacific Ocean's Coral Triangle — the most diverse and biologically complex marine ecosystem on the planet.

A school of planktivorous fish sheltering around a coral on a reef in the Solomon Islands in the Coral Triangle. *MARK HAY*

Years ago, Bracco and collaborators developed a tool, Delta Maps, that uses machine learning to identify regions within any kind of system that share the same dynamic. For this study, they used the tool to map out domains of connectivity in the Coral Triangle using 30 years of sea surface temperature data.

After applying a ranking system to the different regions, the researchers realized that while the El Niño-Southern Oscillation can cause coral bleaching, the alternation of El Niño and La Niña events has allowed for enormous genetic exchanges between the Indian and Pacific Oceans and enabled the ecosystems to survive a variety of different climate situations. It has also helped the Coral Triangle become rich in biodiversity. Because of this dynamic climate component, there is more possibility for rebuilding biodiversity in the Coral Triangle than anywhere else on the planet.

"As of now, coral monitoring often happens when groups have a limited amount of funding to apply to a specific localized region," Bracco says. "We hope our method can be used to create better monitoring over larger scales of time and space."

Story by Catherine Barzler • Supported by DOE Regional and Global Model Analysis (RGMA) Program.

Mycorrhizal Types Control Biodiversity Effects on Productivity

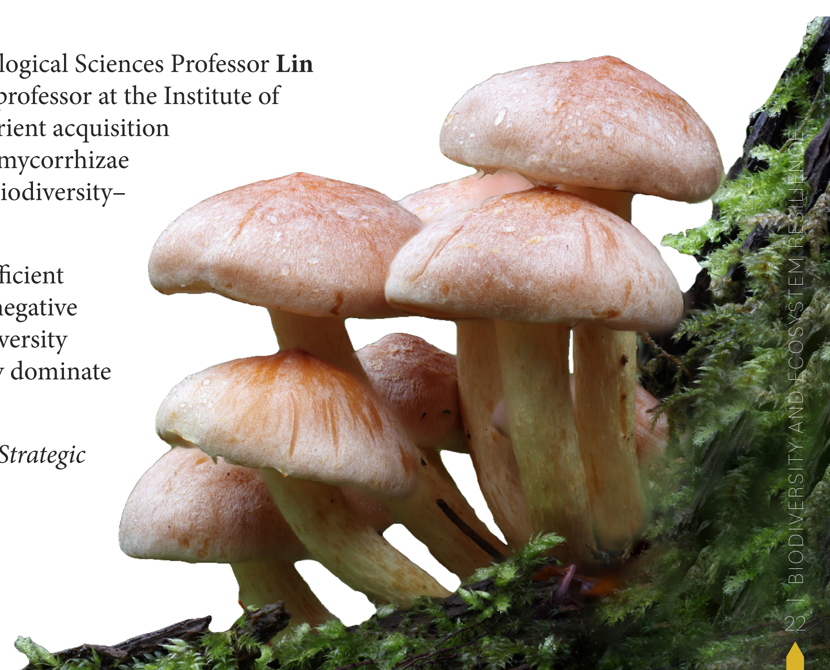
Mycorrhizal symbiosis — a symbiotic relationship that can exist between fungi and plant roots — helps plants expand their root surface area, giving plants greater access to nutrients and water. Although the first and foremost role of mycorrhizal symbiosis is to facilitate plant nutrition, scientists have not been clear how mycorrhizal types mediate the nutrient acquisition and interactions of coexisting trees in forests.

To investigate this crucial relationship, Georgia Tech School of Biological Sciences Professor **Lin Jiang** collaborated with an international team led by **Lingli Liu**, a professor at the Institute of Botany of the Chinese Academy of Sciences. The team studied nutrient acquisition strategies of two different mycorrhizal relationships — arbuscular mycorrhizae (AM) and ectomycorrhizal (ECM) — in the world's largest forest biodiversity–ecosystem functioning experiment.

Their findings, published in *Science Advances*, suggest that more efficient nutrient acquisition strategies — rather than microbial-mediated negative plant-soil feedback — drive the dominance of AM trees in high-diversity ecosystems, giving new insight into why and how AM trees usually dominate in high-diversity subtropical forests.

Story by the Chinese Academy of Sciences (CAS) • Supported by the Strategic Priority Research Program of CAS and the National Natural Science Foundation of China.

Fungi like these mushrooms can form symbiotic relationships with plants.



The marsh restoration site in historic Maryville, in Charleston, South Carolina. Volunteers can be seen planting grasses in the marsh. *SHELLFISH RESEARCH SECTION, SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES*

Community Collaborations

Researchers and alumni aid in $2.6 million effort to restore salt marshes in historic Charleston

For marine scientist, climate activist, and Tech alumnus **Albert George** (MS HSTS 2009), the fight against climate change is also a fight for home.

"I'm what you call Gullah Geechee," shares George, who works as the Carbon Neutral Program Manager at Apple and is also a co-founder of the Amazon Reforestation Project. The Gullah Geechee people are descended from Africans enslaved on rice, indigo, and cotton plantations on the lower Atlantic coast. "So, my family roots are inextricably tied to the coastal plains of Georgia and South Carolina."

Those efforts have culminated in a $2.6 million National Fish and Wildlife Foundation effort to restore degraded salt marshes in Charleston. The project will continue to build on previous work with the original project partners — including the South Carolina Aquarium, Georgia Tech researchers, Robinson Design Engineers, and South Carolina Department of Natural Resources (SCDNR) — and community volunteers through the South Carolina Oyster Recycling and Enhancement Program to study and restore seven acres of salt marsh in West Ashley, a historically important town of west Charleston formerly known as Maryville.

In addition to aiding in the restoration efforts, **Joel Kostka** and his team in the School of Biological Sciences at Georgia Tech will study the growth of marsh grasses, changes in sea level and land elevation, wildlife activity, and the chemistry of the marsh waters to improve adaptive management strategies.

Restoration and resilience

Kostka, who has a joint appointment in the School of Earth and Atmospheric Sciences, worked with SCDNR and Robinson Design Engineers, a local firm co-led by Tech alum **Joshua Robinson** (CE 2005), to develop engineering and design plans for the restoration of the salt marshes.

Using this information, over the next four years, community volunteers will work to plant marsh grasses, restore oyster reefs, and excavate the tidal creeks that supply the marsh with sea water. In addition to aiding in the restoration efforts, Kostka and his team will monitor the growth of marsh grasses, changes in sea level and land elevation, wildlife activity, and the chemistry of the marsh waters.

> “What excites me most is that this was a true collaboration… It was literally the community that stated the need. It was really us coming together to meet that need in a way that was going to be equitable.”
>
> — **Albert George** (MS HSTS 2009)

Joel Kostka (right, background) and Albert George (right, foreground) meet with collaborators in John Carr’s backyard (second from left) to discuss the project in 2021. Carr’s property now acts as one of the primary restoration sites for the project. *JOEL KOSTKA*

Community grown

With concerns that sea level rise and other climate change disturbances will disproportionately threaten underserved coastal communities, George founded the Resilience Initiative for Coastal Education (RICE) at the South Carolina Aquarium in 2015, in collaboration with the U.S. Department of Energy, the Medical University of South Carolina, South Carolina Educational Television, and Allen University.

As part of RICE, George collaborated with MDI Biological Laboratory researchers **Jane Disney**, an associate professor of environmental health, and **Cait Bailey**, a systems developer, to initiate a citizen science program encouraging community members to send photos of sea level changes and plastic pollution in the marshes surrounding Charleston.

It was through this initiative that **John Carr Jr.** brought the marsh die-off to George’s attention. “I affectionately call myself ‘Geechee,’” Carr says, sharing that his grandfather served as the last mayor of Maryville. In 2018, Carr showed George a photo of his family home in the 1980s — the current mud flats are a stark contrast to the lush marsh grass depicted in the photo.

George then rallied collaborators, including Kostka, to tackle the project.

“What excites me most is that this was a true collaboration,” George says. “It was not us coming in with a research project. It was literally the community that stated the need. It was really us coming together to meet that need in a way that was going to be equitable.

“What I tell people is, in a lot of ways, I’m fighting for home. That’s been my call,” he adds. “I take pride in the ‘Progress and Service’ motto I was steeped in when I was there at Georgia Tech. I’m just doing my best to leverage my talents to advocate for underserved communities, but also to move the needle.”

Story by Audra Davidson • Supported by the National Fish and Wildlife Foundation.

Former U.S. Secretary of Energy Gives Campus Climate Talk

In the spring semester, the School of Physics and College of Sciences welcomed Stanford University physicist **Steven Chu** to speak on climate change and innovative paths toward a more sustainable future. Chu is the 1997 co-recipient of the Nobel Prize in Physics, and in his former role as U.S. Secretary of Energy, became the first modern scientist to hold a U.S. Cabinet position.

LARRY DOWNING/REUTERS

The event, which was part of the School of Physics “Inquiring Minds” public lecture series, was held at the Ferst Center for the Arts. The campus and broader Atlanta community were invited.

Chu discussed the significant technical challenges and potential solutions that could provide better paths to a more sustainable future.

Story by Jess Hunt-Ralston.

Isaiah Bolden holds a freshly collected core from a coral in Curaçao.

Coral Helps Scientists Unravel Deeper History on St. Croix

On the U.S. Virgin Island of St. Croix, the ruins of a Danish sugar plantation built from harvested coral bricks could be the key to understanding how and why the area was decimated by the 18th century transatlantic slave trade.

With funding from the National Geographic Society, researchers from Georgia Tech and the University of California, Los Angeles (UCLA) are traveling to St. Croix to analyze this coral.

"We can survey these corals to try and reconstruct the climate around St. Croix before, during, and after the slave trade — particularly with regard to sea surface temperature and trade wind strength," explains **Isaiah Bolden**, a co-principal investigator and assistant professor in the School of Earth and Atmospheric Sciences at Georgia Tech. "This could give us an interesting, climatically informed perspective on the timing of the transatlantic slave trade and why and how St. Croix became a part of this history."

The coral codex

In the first stage of the project, **Justin Dunnavant**, a co-principal investigator, National Geographic Explorer, and assistant professor of archeology at UCLA, will use 3D photogrammetry — the process of combining photographs at different angles to create a 3D rendering — to determine which coral species were used in plantation construction. Then the researchers will collect live and historic coral samples with minimally invasive techniques so Bolden can analyze their composition.

Like trees, living coral grows in annual rings and can be dated by counting these rings. For the dating of ancient samples, the team is also applying uranium-thorium dating, a type of radiometric dating that relies on a natural "clock" that forms as radioactive uranium locked inside of coral skeletons naturally decays into thorium.

Determining the ages of the plantation structures will help reveal whether the coral was harvested alive from the sea floor, or if these buildings were constructed from preexisting coral rubble. Additional analyses can reveal how the ecosystem has responded to direct human impact from the 18th century to present.

The project will also sequence proteins trapped in the skeletons of fossilized and contemporary corals on St. Croix to investigate genetic differences.

Another clue comes from mineral "impurities" that can get substituted into the growth bands of a coral's skeleton, which can be measured and used to infer sea surface temperature, salinity, pH, runoff, and many other environmental conditions during a coral's lifetime.

"For example, the element strontium, which has a similar chemical behavior to calcium, is incorporated into the skeleton at a faster rate during cooler temperatures than warmer temperatures," Bolden says. "This means we can use the ratio of strontium-to-calcium across growth bands in the coral skeleton as a clue toward past temperatures.

"This is a really cool opportunity to study how local reefs have recorded and responded to climatic and anthropogenic changes during a definingly dark period of colonization and human civilization," Bolden adds. "How can we interface these new ecological and climate records with the written historical record to further detail the story of colonization and the slave trade in St. Croix?"

The St. Croix ecosystem — then and now

The researchers will also collect contemporary data to build a better understanding of St. Croix's existing modern coral reef ecosystems, and throughout the project, the researchers will collaborate with St. Croix universities and high schools, giving students research opportunities.

"I'm really interested in this opportunity to bring a climate context to the history often taught in schools to discover things we haven't learned," Bolden says. "We're talking about decolonizing geoscience and unearthing the stories that haven't been told."

Story by Tess Malone • Supported by National Geographic Society.

A healthy coral reef in St. Croix, U.S. Virgin Islands. *NOAA*

Earth and Atmospheric Sciences Assistant Professor Isaiah Bolden shakes hands with Vice President Kamala Harris. *ROB FELT, GEORGIA TECH*

Vice President's Visit Focuses on Climate Resilience

This year, Georgia Tech hosted **U.S. Vice President Kamala Harris** for a discussion about the climate crisis. The vice president spoke to students, faculty, staff, and community members with the message of creating an equitable clean energy economy.

Harris was joined by Georgia Tech's **Isaiah Bolden** and the University of Georgia's **Marshall Shepherd**, who described how their life experiences led to their respective career paths. Bolden's interest in climate science began when his hometown of Nashville, Tennessee, flooded.

"I had this passion burgeoning right then and there as someone who has this aptitude for science, this aptitude for math, but then seeing that the science is not reaching the public in a way that it should," Bolden said. "What can I then do with my career as an environmental scientist to generate data — and get that data into the hands of people who could do something with it?"

Joe Bozeman III, whose work as an industrial ecologist at Georgia Tech highlights the need for equitable climate adaptation and mitigation strategies, commented that "seeing the vice president speak so confidently and expansively about the issue of climate justice, equity, and the engineering side of things, I really found myself impressed ... I'm enthused to continue to do the work as a researcher here at Georgia Tech."

Story by Steven Gagliano.

Mangrove ecosystem restoration could be a novel path toward mitigating climate change. *GETTY IMAGES*

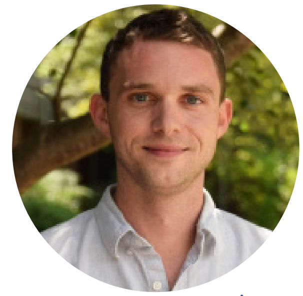
Mitigating Climate Change Through Restoration of Coastal Ecosystems

Researchers at Georgia Tech and Yale University have proposed a novel pathway through which coastal ecosystem restoration can permanently capture carbon dioxide from the atmosphere, all while benefiting local flora and fauna, helping to energize coastal economies, and combating increasing acidity in the ocean.

"Mangroves and seagrasses extract carbon dioxide from the atmosphere all day long and turn it into biomass," says **Chris Reinhard**, Georgia Power Chair, associate professor in the School of Earth and Atmospheric Sciences, and a senior author on the study. "Some of this biomass can get buried in sediments, and if it stays there, then you've basically just removed carbon dioxide from the atmosphere."

Led by **Mojtaba Fakhraee**, a former postdoctoral researcher at Georgia Tech, the team built a numerical model to represent the chemistry and physics of sedimentary systems — the complex mixture of solid particles, living organisms, and seawater that accumulates at the seafloor — to explore how effective restoring coastal ecosystems could be for inorganic carbon capture.

"This model comes up with representations for the rates of carbon transformation in the sediment based on how much mangrove is growing above the sediment," says **Noah Planavsky**, another senior author on the study. "We found that across an extremely large range of scenarios, restoration of blue carbon ecosystems leads to durable carbon dioxide removal as dissolved inorganic carbon."



Chris Reinhard, Georgia Power Chair and associate professor in the School of Earth and Atmospheric Sciences.

The team hopes this research can provide an impetus to protect current coastal ecosystems and economically incentivize restoration of degraded ecosystems.

"Companies trying to offset their own emissions could potentially purchase carbon removal through funding restoration of coastal ecosystems," Reinhard adds. "This could help rebuild these ecosystems and all the environmental benefits they provide, while leading to durable carbon dioxide removal from the atmosphere."

Story by Tess Malone • Supported by the David and Lucile Packard Foundation, the Yale Center for Natural Carbon Capture, and the Cullen-Peck Scholar Award from the Georgia Institute of Technology.

Lynch-Stieglitz Receives Jefferson Science Fellowship

Jean Lynch-Stieglitz, professor in the School of Earth and Atmospheric Sciences.

Jean Lynch-Stieglitz has earned a new fellowship with the National Academies of Sciences, Engineering, and Medicine to build STEM expertise in the State Department and the U.S. Agency for International Development. Lynch-Stieglitz, a professor in the School of Earth and Atmospheric Sciences, is one of nine fellows selected this year, and will be joined by **Olga Shemyakina**, associate professor in the School of Economics at Georgia Tech.

Lynch-Stieglitz researches the behavior of the Earth's oceans and climate over the last 100,000 years. Work in this area has helped scientists understand the full range of behavior possible for the ocean and climate system, and which parts of this system may be vulnerable to change in the future.

"I was very pleased to be named a Jefferson Fellow, and am particularly excited that I was matched to the Office of Global Change, which is responsible for implementing and managing U.S. international policy on climate change," Lynch-Stieglitz says. "I hope to apply some of my expertise in the oceanic carbon cycle and the role of the ocean in climate change to the work of the office."

Story by Renay San Miguel • Supported by the National Academies of Sciences, Engineering, and Medicine.

Supporting Collaborative Solutions for Healthy Oceans

A new international center — headquartered at the Georgia Aquarium, in partnership with Georgia Tech and Ocean Visions, and endorsed by the UN Decade of Ocean Science for Sustainable Development — will support versatile, collaborative solutions to improve the health of the world's oceans. The Center, called The Ocean Visions – UN Decade Collaborative Center for Ocean-Climate Solutions, is the first of its kind in the United States.

"This Center signals an urgent, strategic commitment to finding climate solutions," says **Susan Lozier,** dean of the College of Sciences, Betsy Middleton and John Clark Sutherland Chair, and professor in the School of Earth and Atmospheric Sciences. "Ocean health is also human health, and we must find effective ways to protect waters around the planet."

> "This Center signals an urgent, strategic commitment to finding climate solutions. Ocean health is also human health, and we must find effective ways to protect waters around the planet."
>
> — **Susan Lozier**, dean of the College of Sciences, Betsy Middleton and John Clark Sutherland Chair, and professor in the School of Earth and Atmospheric Sciences

The Center's primary focus is to help co-design, develop, test, fund, and deliver scalable and equitable ocean-based solutions to reduce the effects of climate change and build climate-resilient marine ecosystems and coastal communities. There are also tremendous opportunities to accelerate carbon clean-up and advance sustainable ocean economies.

"At this center, the best and brightest minds — including our researchers, staff, and students — will ensure that our ocean will remain vital for generations to come," adds **Tim Lieuwen**, Regents' Professor and executive director of the Strategic Energy Institute at Georgia Tech. "The solutions are there, and we look forward to working alongside Georgia Aquarium and Ocean Visions to find them, with the support of the Ocean Decade movement."

Story by Jess Hunt-Ralston • Supported by the Georgia Aquarium and the UN Decade of Ocean Science for Sustainable Development.

Talking Ocean Currents at TED Countdown Summit

What lessons are already available to us as we tackle climate change? At the TED Countdown Summit this past July, science, solutions, and the role of industry in addressing the climate emergency took center stage.

College of Sciences Dean **Susan Lozier** delivered a TED Talk at the Summit, which took place in Detroit, Michigan. She spoke alongside other climate researchers and industry leaders, including **Jonathan Foley**, **Emma Nehrenheim**, **Cedrik Neike**, **Morten Bo Christiansen**, **Bo Cerup-Simonsen**, **Mike Duggan**, and **Laprisha Berry Daniels**.

During her talk, Lozier dove into the importance of the ocean's natural circulation, which overturns water in a way that naturally captures carbon and regulates global temperatures, and shared the international research tracking changes in this overturn. Lozier also warned of the dangers facing future generations if we don't change course now, calling for climate action to lower temperatures within the next 10 years.

Story by Brian Greene/TED • Supported by TED.

Dean Susan Lozier presents her TED Talk at the TED Countdown Summit, held July 2023. *NICK HAGEN, TED*

Gauging Glaciers With Alex Robel

Ice is a critical part of our Earth system, but the world's coastal glaciers are melting faster than ever. Georgia Tech's **Alex Robel** is working to understand how and why these ice sheets change by leveraging computer science, mathematics, high-performance computing, and data to create models that explain observations and predict what might happen in the future.

Alex Robel, assistant professor in the School of Earth and Atmospheric Sciences, with an ice experiment in his lab. *ALLISON CARTER*

Linking coastal glacier retreat to climate change

Robel, alongside other Georgia Tech researchers and researchers at the University of Texas Institute for Geophysics (UTIG), has developed a methodology to determine why coastal glaciers are retreating, and in turn, how much can be attributed to human-caused climate change.

"This study gives us a toolbox to determine the role of humans in the loss of ice from Greenland and Antarctica, to say with confidence that it's not just coincidence," says Robel.

The methodology is unique because it treats rapid glacier retreat as an individual probabilistic event, like a wildfire or tropical storm. When testing the approach with computer models using simplified glaciers, they found that even modest global warming caused most glaciers to melt, or retreat.

"The methodology we're proposing is a road map toward making confident statements about the human role [in glacial retreats]," says glaciologist **John Christian**, assistant professor at the University of Oregon and a former postdoctoral researcher at Georgia Tech. "Those statements can then be communicated to the public and policymakers and help in their decision making."

Thinning ice sheets may drive sharp rise in subglacial waters

Robel is also looking to improve methods of understanding subglacial flow, which traditionally have involved time-consuming computations. In collaboration with **Shi Joyce Sim**, he developed a simple equation for predicting exfiltration rates using satellite measurements of Antarctica from the last two decades.

They hope the predictions made possible by this theory can be incorporated into ice sheet models that scientists use to predict future ice sheet change and sea level rise.

"This is, to our knowledge, the first mathematically simple theory describing the exfiltration and infiltration underneath ice sheets," Robel says. "The entirety of our prediction can be done in a fraction of a second on a laptop."

"It's really nice whenever you can get a very simple model to describe a process, and then be able to predict what might happen, especially using the rich data that we have today," adds Sim. "Seeing the results was pretty surprising."

One of the team's main arguments underscores the potentially large source of subglacial water — possibly up to double the amount previously thought — that could be affecting how quickly glacial ice flows and how quickly the ice melts at its base, while potentially increasing glacial melt, sea level rise, and biological disturbances.

Continuing research with NSF CAREER grant

Robel has now turned his attention to improving how models of melting ice sheets incorporate data from field expeditions and satellites. Supported by a $780,000 NSF CAREER grant, he is developing an open-access software package including state-of-the-art tools and paired with ice sheet models that anyone can use, even on a laptop or home computer.

Robel's team plans to use a set of techniques called data assimilation to adjust — or "nudge" models — then incorporate this data assimilation capability into a cloud-based computational ice sheet model. "We are planning to build an open-source software package in Python that can use this sort of data assimilation method with any kind of ice sheet model," Robel explains.

Robel's team will then apply their software package to a widely used model, which now has an online, browser-based version. Researchers collecting data will be able to upload their data to the repository and immediately see the impact of their observations on future ice sheet melt simulations. Field researchers could use the model to optimize their long-term research plans by seeing where collecting new data might be most critical for refining predictions.

"Ultimately," Robel adds, "this project will empower more people in the community to use these models — and to use these models together with the observations that they're taking."

Story by Selena Langner • Supported by NSF, NASA, and the Georgia Tech Research Corporation.

New Director of Ocean Science and Engineering

Joseph Montoya, professor in the School of Biological Sciences.

Joseph Montoya has been named director of the Interdisciplinary Ph.D. Program in Ocean Science and Engineering (OSE) at Georgia Tech.

Montoya is a biological oceanographer with research interests at the interface of biology and geochemistry. His group's research program is highly interdisciplinary, incorporating work in plankton biology, marine chemistry, and isotope biogeochemistry both at sea and in the lab.

Montoya has previously served as associate chair for Undergraduate Affairs in Biology, and has additional leadership experience with the ECOGIG (Ecosystem Impacts of Oil and Gas Inputs to the Gulf) Consortium. He is also a founding member of the Georgia Tech Diversity, Equity, and Inclusion Council, as well as a member of the College of Sciences Faculty Diversity Council.

California Academy of Sciences Fellow

Montoya is also one of 11 new Academy Fellows in the California Academy of Sciences (CAS), based in San Francisco.

The Fellows are a governing group of more than 450 distinguished scientists and other leaders who have made notable contributions to scientific research, education, and communication. Nominated by their colleagues and selected by the CAS Board of Trustees, the Academy Fellows are partners and collaborators in the pursuit of the Academy's mission to regenerate the natural world through science, learning, and collaboration.

"I'm excited at the chance to interact with old and new colleagues studying the marine nitrogen cycle who are also CAS Fellows," Montoya says. "The CAS will give us new opportunities for developing collaborations and sharing our work with the public, as well as with other scientists."

Story by Jess Hunt-Ralston • Supported by Ocean Science and Engineering at Georgia Tech and the California Academy of Sciences.

Undergrad Education Incorporates UN SDGs

The Georgia Tech group Sustainability Next has developed a plan to integrate and expand the United Nations Sustainable Development Goals (UN SDGs) concepts and skills integration across the undergraduate curriculum. In support of the plan, 21 projects representing the Institute's six colleges and 15 of the 29 schools were presented at the Undergraduate Sustainability Education Jamboree, held on April 26 in the Kendeda Building auditorium. With many winning projects featuring high-enrollment classes and core courses, this first round of sustainability education "seed grants" will significantly expand the reach of Georgia Tech's sustainability-across-the-curriculum initiatives.

Story by Rebecca Watts Hull.

The Kendeda Building for Innovative Sustainable Design. *GEORGIA TECH*

SDG Week Highlights UN Sustainable Development Goals

This March, the Georgia Tech community celebrated SDG Action and Awareness Week, focusing on UN SDG13: Climate Action and intersecting SDG. Georgia Tech President **Ángel Cabrera** convened a panel of faculty to discuss climate action, including **Marilyn Brown**, **Andre Calmon**, **Tim Lieuwen**, and **Brian Stone**.

Other events included a green cleaning DIY workshop, a social impact careers alumni panel, a community market, a session on how to afford study abroad, SDG interactive art hours, a seminar on race and gender, two micro-workshops on aligning course objectives with the SDGs, a corporate carbon accounting panel, an information session and ice cream social through the EcoCAR Vertically Integrated Project team, and a Climate Action Plan Stakeholder Engagement Session.

SDG Action and Awareness Week is part of a larger global effort through the University Global Coalition (UGC), which President Cabrera chairs and helped found. The UGC comprises higher-education leaders from around the world who work to advance the SDGs through education, research, service, and campus operations.

Story by Victor Rogers.

EARTHQUAKES AND EXTREME WEATHER

Paola Vargas (left), a graduate student in civil and environmental engineering at Georgia Tech, and Stephen Hughes of the University of Puerto Rico, Mayaguez calibrate an instrument in front of a landslide in Puerto Rico. *ALL PHOTOS: FRANCES RIVERA-HERNÁNDEZ*

In Puerto Rico, Georgia Tech Researchers Team Up to Build Landslide Ready Communities

Last October, **Frances Rivera-Hernández**, an assistant professor in the School of Earth and Atmospheric Sciences, headed to Puerto Rico, joined by research partners **Karl Lang**, a fellow assistant professor in the School of Earth and Atmospheric Sciences, and **Rafael Bras**, also of Georgia Tech.

Supported by NSF funding, the researchers' ultimate goal is to one day create a national center for the study of geohazards, "with Georgia Tech as the lead institution," Bras says. "We surmise there will be several 'hubs', one of which would be Puerto Rico."

Bras is the K. Harrison Brown Family Chair and Regents' Professor in the School of Civil and Environmental Engineering (CEE) with a joint appointment in Earth and Atmospheric Sciences — and like Rivera-Hernández, a native of Puerto Rico. For a decade, he served as provost and executive vice president for Academic Affairs at Georgia Tech, and today he continues to research ways to protect communities from disasters.

A month previously, in September 2022, Category 4 Hurricane Fiona had hit the island, and the research team's mission was to learn how the storm had devastated the island's landscape. They also investigated whether it potentially created other long-term geohazards like unstable hill slopes, debris and rock falls, and landslides.

While less damaging than Hurricane Maria — a 2017 storm that was one of the worst to strike Puerto Rico — Fiona gave the researchers a chance to gather more data on surface hazards in the wake of a natural disaster. "We can use that information to better prepare communities," Rivera-Hernández explains, citing the team's goal of creating a "landslide ready" program to help with emergency preparedness. "But before that, we need to know: Where are they more frequently occurring? What's the cause? How much rain is needed to induce a landslide? We need science so we can better educate communities."

'A no-brainer'

Both Rivera-Hernández and Bras lived through hurricanes as they were growing up on the island, and both have seen the wide-reaching impact of major storms. When Hurricane Maria hit the island, Bras' niece, who runs a farm growing culinary mushrooms, dealt with a months-long power outage that affected refrigeration and distribution.

Basic communications are also a problem during hurricanes, especially Maria, Rivera-Hernández remembers. "People didn't have power for six months to a year.

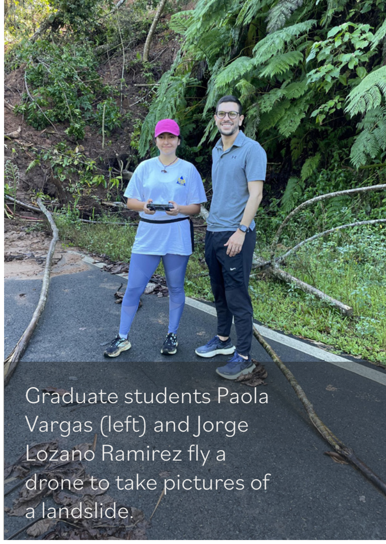
"I think it took like a week or two just to communicate to people in Puerto Rico because the whole power system was out, which means the cell networks were completely out," she continues.

As a planetary geologist, Rivera-Hernández's primary research interests are astrobiology and planetary science. Before this effort with Bras and Lang, she had never studied landslides. "Most of my work is focused on trying to better understand other planetary bodies," she says. "But when Rafael and I started talking about this, we decided this is something that's really important to us. It was a no-brainer."

The future of research

The effort to study Hurricane Maria's geohazards has already earned the wider team a National Science Foundation Track One Center Catalyst grant for their proposal: "Collaborative Center for Landslides and Ground Failure Geohazards."

From left to right, Earth and Atmospheric Sciences graduate students Sharissa Thompson, Tatiana Gibson, and Dru-Ann Harris sample water in Puerto Rico.



Graduate students Paola Vargas (left) and Jorge Lozano Ramirez fly a drone to take pictures of a landslide.

More recently, a GEER (Geotechnical Extreme Events Reconnaissance) expedition associated with Hurricane Fiona has helped Bras, Lang, and two CEE students, **Paola Vargas** and **Jorge Lozano Ramirez**, continue their research on the island, studying evidence left by the storms.

After Fiona, the trio of researchers were able to quickly apply for two more grants, one from the Heising-Simons Foundation and an NSF Rapid Response Research (RAPID) Award. That allowed them to revisit the island to gather more data. And Bras is currently working on an NSF Track II funding grant that would help establish the geohazards center.

Story by Renay San Miguel • Supported by NSF.

"Most of my work is focused on trying to better understand other planetary bodies. But when Rafael and I started talking about this, we decided this is something that's really important to us. It was a no-brainer."

— **Frances Rivera-Hernández**, assistant professor in the School of Earth and Atmospheric Sciences

From left to right, Sharissa Thompson, Dru-Ann Harris, Tatiana Gibson, Frances Rivera-Hernández, and Karl Lang during a November 2022 Puerto Rico research trip.

NSF RAPID Response to Earthquakes in Turkey

In February, a major earthquake event devastated the south-central region of the Republic of Türkiye (Turkey) and northwestern Syria. The president of Turkey has called it the “disaster of the century,” and the threat is not over — aftershocks could still affect the region.

Now School of Earth and Atmospheric Sciences Professor **Zhigang Peng** and graduate students **Phuc Mach** and **Chang Ding** are using small seismic sensors to better understand just how, why, and when these earthquakes are occurring.

Supported by an NSF RAPID grant, the team placed approximately 120 small sensors, called nodes, in the East Anatolian fault region this past May. Sensor deployment continued through the summer, in an effort to better map the aftershocks of the earthquake event — which can occur weeks or months after the main event.

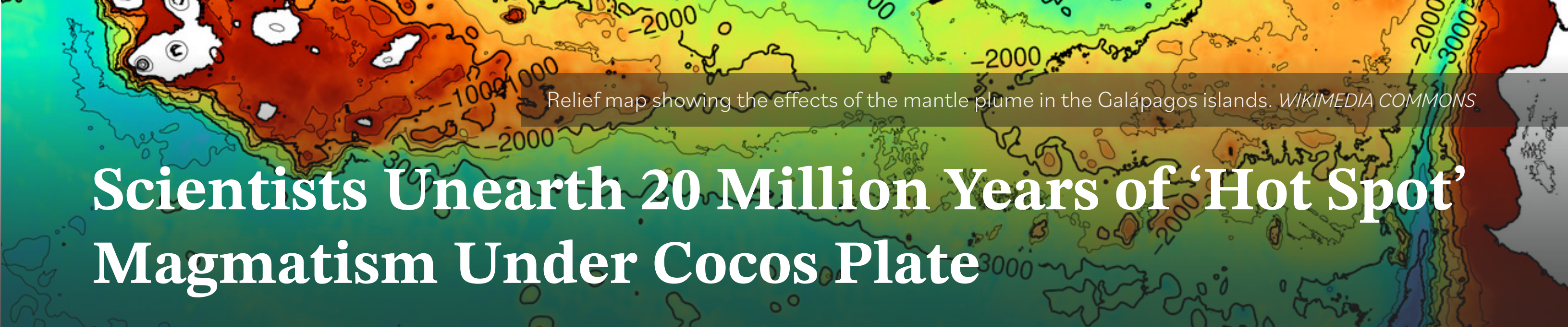
It’s the first time sensors like this have been deployed in Turkey, says Peng. “The primary reason we’re deploying these sensors quickly following the two mainshocks is to study the physical mechanisms of how earthquakes trigger each.” Mainshocks are the largest earthquake in a sequence. “We’ll use advanced techniques such as machine learning to detect and locate thousands of small aftershocks recorded by this network. These newly identified events can provide new important clues on how aftershocks evolve in space and time, and what drives foreshocks that occur before large events.”

Story by Selena Langner • Supported by NSF.

Graduate student Phuc Mach places a node.

Graduate student Chang Ding posing with a local villager at a seismic site in Southern Turkey.

Researchers from Georgia Tech, Univ. of Missouri and TUBITAK before heading to the field in May 2023.



Relief map showing the effects of the mantle plume in the Galápagos islands. *WIKIMEDIA COMMONS*

Scientists Unearth 20 Million Years of 'Hot Spot' Magmatism Under Cocos Plate

Ten years ago, **Samer Naif** made an unexpected discovery in Earth's mantle: a narrow pocket, proposed to be filled with magma, hidden some 60 kilometers beneath the seafloor of the Cocos Plate.

Then, the observation provided an explanation for how tectonic plates can gradually slide, lubricated by partial melting. The study also "raised several questions about why magma is stored in a thin channel, and where the magma originated from," says Naif, a School of Earth and Atmospheric Sciences assistant professor.

Then, "I basically went on a multiyear hunt, akin to a Sherlock Holmes detective story, looking for clues of mantle magmas that we first observed in the 2013 *Nature* study," he says.

The team combined geophysical, geochemical, and seafloor drilling results with seismic reflection data, a technique used to image layers of sediments and rocks below the surface. Now, the results of that search are detailed in a new *Science Advances* article.

The team's identified source of the magma, the Galápagos Plume, "is more than 1,000 kilometers away from where we detected this volcanism. It is not clear how magma can stay around in the mantle for such a long time, only to leak out episodically."

Importantly, the new study also suggests that these plume-fed melt channels may be widespread and long-lived sources for intraplate magmatism itself — as well as for mantle metasomatism, which happens when Earth's mantle reacts with fluids to form a suite of minerals from the original rocks.

The work also provides compelling supporting evidence that magma could still be stored in the channel.

"We learned that the magma channel has been around for at least 20 million years, and on occasion some of that magma leaks to the seafloor where it erupts volcanically," Naif adds.

Story by Jess Hunt-Ralston • Supported by the NSF Science Support Program.

Bringing Seismic Imaging Studies to Climate Action and Beyond

Felix Herrmann, GRA Eminent Scholar Chair in Energy and professor in Earth and Atmospheric Sciences with joint appointments in Computational Science and Engineering, and Electrical and Computer Engineering.

A Georgia Tech research group spent last summer preparing studies that could help reduce greenhouse gas levels through machine learning and high-performance computing methods.

The School of Computational Science and Engineering's (CSE) Seismic Laboratory for Imaging and Modeling (SLIM) is a research group that specializes in providing industry partners with computational models that advance seismic imaging. Led by School of Earth and Atmospheric Sciences and CSE Professor **Felix J. Herrmann**, one area where SLIM concentrates their imaging research toward is Geological Carbon Storage (GCS), an emerging solution to help combat climate change.

GCS is a process of removing carbon dioxide from the atmosphere and storing it in deep, underground reservoirs.

SLIM's research in seismic imaging helps engineers monitor carbon dioxide dynamics stored in the Earth's subsurface. This includes detecting potential leaks in underground reservoirs, which minimizes risks in GCS projects.

While GCS is currently one of the few truly scalable solutions to help combat climate change, there are challenges to increasing the number of injection sites while reducing risks and cost. These challenges make SLIM's studies even more important for areas that stand to benefit from time-lapse seismic imaging, like GCS.

"By gradually shifting to carbon storage monitoring with seismic techniques, SLIM aims to be part of the solution to climate change," says CSE Ph.D. student **Ziyi (Francis) Yin**. "With the recent innovations in the group, we want to lower the risk of carbon storage projects.

"SLIM has been involved with Society of Exploration Geophysics conferences for many years. Every year, we bring our latest developments to the IMAGE conference," Yin continues. "With the talent in our group, we can tackle large-scale geophysical problems with our cutting-edge computational methods."

Story by Bryant Wine • Supported by the Center for Machine Learning for Seismic Industry Partners Program (ML4Seismic).

Assessing Storm Seasons

Behind the 2023 hurricane season projections was a balancing act of rising oceanic temperatures, explains **Susan Lozier**, dean of the College of Sciences, Betsy Middleton and John Clark Sutherland Chair, and professor in Earth and Atmospheric Sciences (EAS). “As climate change progresses, we are interested in understanding how weather patterns will be disrupted, including those related to hurricane formation and pathways,” she says.

Understanding our role in mitigating climate change could be a key factor in our ability to accurately assess the threat of developing storms. Georgia Tech researchers are at the forefront of this effort.

Georgia Power Chair and EAS Associate Professor **Chris Reinhard** is exploring how coastal ecosystem restoration can permanently capture carbon dioxide from the atmosphere as it becomes buried in sediment on the seafloor. A team of researchers in the School of Chemical and Biomolecular Engineering is developing a traditional direct air capture system that is more efficient at carbon capture. And **Marilyn Brown**, Regents’ and Brook Byers Professor of Sustainable Systems in Public Policy, serves on the leadership council of Drawdown Georgia.

“The private and public sectors are increasingly looking at actively removing carbon from the atmosphere because we are unlikely to limit global warming simply by curtailing emissions. Active carbon drawdown from the atmosphere and the ocean are active areas of research right now,” Lozier notes.

Story by Steven Gagliano.

Research Aircraft Investigate Monsoon-Climate Connections

Greg Huey, professor and chair of the School of Earth and Atmospheric Sciences at Georgia Tech.

In August 2022, two research aircraft enabled a team of international scientists, including principal investigator **Greg Huey**, to study how the Asian summer monsoon — one of the largest and most important meteorological patterns in the world — affects atmospheric chemistry and global climate.

The Asian Monsoon Chemical and Climate Impact Project’s (ACCLIP) scientific objectives include improving our understanding of how the Asian summer monsoon transports air from the ground to the top of the troposphere and the bottom of the stratosphere miles above Earth’s surface, as well as what chemicals are contained in that air.

The researchers also wanted to understand how those chemicals react once they are lofted up, as some chemical species can transform into aerosols and reflect the sun’s light back into space, cooling the Earth. Other aerosols originate from combustion at the surface and can produce a heating effect. Aerosols, as well as water vapor sucked up by the monsoon, can affect cloud formation and brightness, and the monsoon may also redistribute relatively short-lived greenhouse gases, such as methane, and ozone-depleting substances, such as chlorinated solvents.

ACCLIP researchers were also interested in studying how the pollutants pulled up by the monsoon may affect ozone chemistry in the region of the atmosphere where the protective ozone layer forms.

The broad participation in ACCLIP — globally, more than 30 institutions were involved in the month-long project — speaks to its strong scientific appeal. In fact, researchers worked for more than a decade to get a field campaign focused on the Asian summer monsoon up and running. After a number of logistical challenges slowed the effort, including the Covid-19 pandemic, the mission was cleared to move forward at a U.S. Air Force Base in South Korea.

Story first published in the NCAR & UCAR newsroom • Supported by NSF, NASA, NOAA, and the Office of Naval Research.

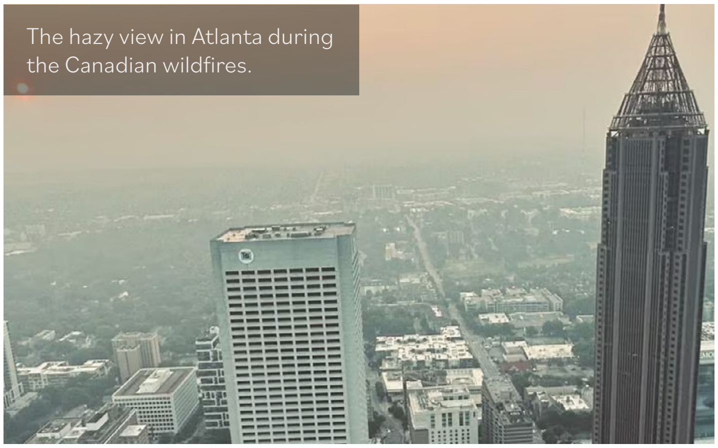
Canadian Wildfire Smoke Affects Atlanta

Wildfires blazing in Canada created smoke and dust particles carried by the jet stream all the way down to the Deep South this year.

Zachary Handlos, meteorologist and senior academic professional in the School of Earth and Atmospheric Sciences, says that "it is unusual to experience high concentrations of smoke aerosols within the contiguous U.S. such as what we have been observing recently," adding that a specific weather pattern has contributed to the conditions necessary for the smoke to travel such far distances. Summer heat and climate change are amplifying this atmospheric environment.

Talat Odman, Regents' Researcher, principal research engineer, and air quality expert from the Georgia Tech School of Civil and Environmental Engineering, adds that "we should expect more events like this when smoke from fires in the western U.S. and Canada pollute the air in Atlanta."

But can anything be done to make the situation better? The answer is complicated. Georgia Tech researchers have been working on ways to capture and clean air pollutants and to determine days to adjust power plant operations in an effort to control emissions.


The hazy view in Atlanta during the Canadian wildfires.

Valerie Thomas, the Anderson-Interface Chair of Natural Systems and professor in the H. Milton Stewart School of Industrial and Systems Engineering at Tech, says there's also something that can be done on an individual level: "Staying inside and not driving on days with poor air quality will reduce exposure to air pollution and reduce emissions."

Story by Steven Norris.

Study Finds Unexpected Interactions in Formation of Secondary Organic Aerosol in Atmosphere

Secondary organic aerosol (SOA) consists of extremely small particles generated in the atmosphere from natural and human-made emissions. It is a major constituent of $PM_{2.5}$ (particulate matter with a diameter smaller than 2.5 micrometers) worldwide, which is known to affect climate and human health.

Nga Lee (Sally) Ng, Love Family Professor in Earth and Atmospheric Sciences with a joint appointment in Chemical and Biomolecular Engineering, recently led a study published in the journal *Nature Communications* investigating the formation and properties of SOA from the nitrate radical oxidation of two common monoterpenes, a class of volatile organic compounds (VOCs) found in many plants. Specifically, her research team examined the monoterpenes α-pinene and limonene, which are both emitted in large quantities from trees.

Ng's team found that oxidizing mixtures of monoterpenes simultaneously produced different results than observed through oxidizing them separately in laboratory chamber experiments.

"Our results highlight that unlike what is currently assumed in atmospheric models, the interaction of products formed from individual VOCs should be accounted for accurately to describe SOA formation and its climate and health impacts," Ng says.

Story by Brad Dixon • Supported by NSF, NOAA, and the Eckert Postdoctoral Fellowship.


Sally Ng and graduate student Masayuki Takeuchi conducting research using an advanced mass spectrometer.

HUMAN HEALTH, MICROBIAL DYNAMICS, AND INFECTION

The world at night. *NASA*

Ethnicity, Life Expectancy Data Can Aid in Health Equity Efforts

Across the planet, many people are living better and longer, as humans continue to experience substantial increases in life expectancy and quality of life.

Unfortunately, that positive trend is not evenly distributed across communities.

Despite the progress in healthcare over the last century, resulting in longer life expectancy and better disease survival outcomes, significant disparities between various population groups remain a major global health issue.

A new study by Georgia Tech researchers in the open-access journal *PLOS Global Public Health* probes ethnic health disparities and mortality risk factors in the United Kingdom. Their work points to mortality risk factors that are group-specific, but modifiable, supporting the notion of targeted interventions that could lead to greater health equity.

"Different ethnic groups show very different levels of disease-specific mortality along with distinct mortality risk factors," says **I. King Jordan**, professor in the School of Biological Sciences and principal investigator on the study. "Unfortunately, when it comes to health, ethnicity still matters."

Both environmental and genetic factors, and the interaction between them over time, have been cited as main contributors of health disparities. Closing the gap will require a long-term, complex series of solutions.

"Taking a one-size-fits-all approach to healthcare will only exacerbate the health disparities that already disproportionately burden ethnic minorities," explains Jordan, whose collaborators on the study were lead author **Kara Keun Lee**, as well as **Emily Norris**, **Lavanya Rishishwar**, **Andrew Conley**, and **John McDonald**, emeritus professor in the School of Biological Sciences and founding director of Georgia Tech's Integrated Cancer Research Center.

The work was done in collaboration with and with support from the NIH's National Institute on Minority Health and Health Disparities (NIMHD) and **Leonardo Mariño-Ramírez**, an Earl Stadtman Investigator on epidemiology and genetics research at NIMHD's Division of Intramural Research (DIR).

The U.K. example

The research team analyzed data on 490,610 Asian, Black, and white participants from the U.K. Biobank, a study that enrolled 500,000 people in the U.K. aged 40-69. The U.K. Biobank includes data spanning physical measures, lifestyle, blood and urine biomarkers, imaging, genetic, and linked medical and death registry records.

Certain causes of mortality were more common among the different ethnic groups: Asian individuals had the highest mortality from ischemic heart disease, while individuals in the Black community had the highest mortality from Covid-19, and white individuals had the highest mortality from cancers of respiratory/intrathoracic organs.

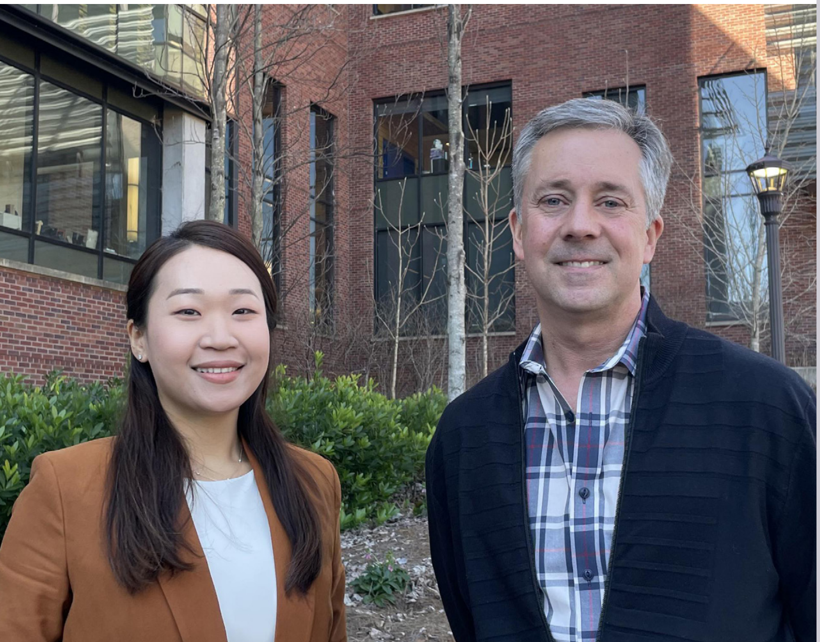
In addition, some preexisting medical conditions and biomarkers showed specific associations with ethnicity and mortality. Mental health diagnoses, for instance, were a major risk factor for mortality in the Asian group, whereas parasitic diseases and C-reactive protein serum levels were associated with higher mortality in the Black group.

"These results underscore the importance of population-specific studies that can help decompose health disparities and inform targeted interventions toward shrinking the health disparity gap," says Jordan, who praised Lee's approach to the study, "which highlights the importance of considering individuals' self-reported identity as it relates to their health outcomes, disease risks, and exposures."

For future work, the team plans to look at racial and ethnic health disparities in the U.S., in collaboration with the NIMHD.

Story by Jerry Grillo • Supported by NIH's Distinguished Scholars Program, the Division of Intramural Research of the National Institute on Minority Health and Health Disparities at NIH, the IHRC-Georgia Tech Applied Bioinformatics Laboratory, the Ovarian Cancer Institute (Atlanta), the Deborah Nash Endowment, and the Northside Hospital Research Foundation.

▼ Kara Keun Lee (left), a former Ph.D. student in bioinformatics at Georgia Tech, and I. King Jordan.



VIA CDC

Rapidly Diagnosing Sepsis, Respiratory Infections With Nucleic Acid-Based Devices

A multidisciplinary team of Georgia Tech researchers has received $14.7 million in funding from the Defense Advanced Research Projects Agency (DARPA) to develop novel diagnostic devices able to rapidly identify the bacteria causing sepsis, as well as and viruses that cause respiratory infections such as RSV, SARS-CoV-2, and influenza.

Funded by DARPA's Detect It with Gene Editing Technologies (DIGET) program, the novel nucleic acid detection devices will use the CRISPR Cas13a enzyme to initiate a synthetic biology workflow being developed by Georgia Tech researcher **Mark Styczynski**. This produces a visible signal if a targeted infectious agent is present in a blood sample or fluid from a nasal or throat swab. The devices will be simple to use, similar to the lateral-flow technology in home pregnancy tests.

"This new technology will make it much faster and more cost-effective to diagnose these infections," says **Mike Farrell**, a Georgia Tech Research Institute (GTRI) principal research scientist who leads the project, known as Tactical Rapid Pathogen Identification and Diagnostic Ensemble (TRIAgE). "This could be a huge leap forward in rapidly diagnosing these diseases where sophisticated laboratory testing isn't available."

Georgia Tech researcher **I. King Jordan**, professor and director of the Bioinformatics Graduate Program in the School of Biological Sciences, will mine the genomes of the targeted pathogens for optimal Cas13a target sequences as, well as the corresponding Cas13a RNA guide sequences.

Story by John Toon • Supported by DARPA.

"This could be a huge leap forward in rapidly diagnosing these diseases where sophisticated laboratory testing isn't available."

— **Mike Farrell**, Georgia Tech Research Institute principal research scientist

Pseudomonas aeruginosa clumps grown in synthetic cystic fibrosis sputum.

Scientists Discover Small RNA That Regulates Bacterial Infection

Pseudomonas aeruginosa, a common environmental bacterium, can colonize different body parts, such as the lungs, leading to persistent, chronic infections that can last a lifetime — a common occurrence in people with cystic fibrosis.

The bacteria can also sometimes change their behavior and enter the bloodstream, causing chronic localized infections to become acute and potentially fatal. Despite decades of studying this transition in lab environments, how and why the switch happens in humans has remained unknown.

However, Georgia Tech researchers have recently identified the major mechanism behind the transition between chronic and acute *P. aeruginosa* infections. **Marvin Whiteley**, Georgia Research Alliance Eminent Scholar professor in the School of Biological Sciences and Bennie H. and Nelson D. Abell Chair in Molecular and Cellular Biology, and **Pengbo Cao**, a postdoctoral researcher in Whiteley's lab, discovered a gene that drives the switch. By measuring bacterial gene expression in human tissue samples, the researchers identified a biomarker for the transition. Their research findings, published in *Nature*, can inform the development of future treatments for life-threatening acute infections.

Story by Catherine Barzler • Supported by NIH, the Cystic Fibrosis Foundation, the Cystic Fibrosis Trust Foundation, and Cystic Fibrosis Postdoctoral Fellowships.

Marvin Whiteley, Georgia Research Alliance Eminent Scholar professor in the School of Biological Sciences, and Bennie H. and Nelson D. Abell Chair in Molecular and Cellular Biology.

Making Medicines: Agarwal Awarded NSF CAREER Grant for Peptide Research

Vinayak Agarwal, associate professor in the School of Chemistry and Biochemistry.

In the race to develop new pharmaceuticals, an increasing number of biochemists are looking to discover new natural products — and uncover the mechanisms that produce and influence them. And **Vinayak Agarwal**, an associate professor in the School of Chemistry and Biochemistry, is helping lead that charge.

Now, a $700,000 NSF CAREER grant will support his research efforts. Known as CAREER awards, the grants are NSF's most prestigious funding for untenured assistant professors. Agarwal is also one of 18 researchers around the U.S. chosen as a 2023 Camille Dreyfus Teacher-Scholar. The award recognizes his work in the lab and classroom, and how he combines the two in working with undergraduate researchers.

Agarwal's CAREER award specifically focuses on his research into peptides, short strings of amino acids comprising proteins. Over 100 peptide-based drugs are currently available in the U.S., where they're used to treat conditions ranging from Type 2 diabetes to MS.

Agarwal's first goal is to discover new chemical reactions between peptides and enzymes by leveraging in vivo synthetic biology (inside living organisms) and in vitro biochemistry experiments (outside of living organisms). Agarwal also hopes to better understand how peptides and proteins interact, and why so many chemical reactions depend on them.

What does this research look like? Petri dishes. A lot of petri dishes. And many opportunities for students. "One of our key goals is to use our interdisciplinary training to engage underserved students in research and lab experience. We want to educate, train, and diversify the next generation of scientists," Agarwal says.

Some of these opportunities are already bearing fruit: Agarwal recently collaborated with a team of undergraduates during a semester-long lab course, which included conducting laboratory research and publishing their findings.

"For me, the biggest thing is student progress, as well as curriculum development and training," Agarwal says. "That's my driving force."

Story by Selena Langner • Supported by NSF.

Healing Breath

Researchers Dramatically Improve Inhalable mRNA Therapy

Messenger RNA, or mRNA, has been used to immunize millions of people, leading the world out of a pandemic, and allowing researchers to consider other therapeutic targets for these flexible, effective drugs.

A team of multidisciplinary investigators led by Georgia Tech researchers has described polymeric nanoparticle formulations designed specifically for inhalable mRNA delivery, via an easy-to-use nebulizer, in a recent paper published in *Nature Materials*.

The researchers focused on synthetic, biodegradable polymers called poly(beta-amino-ester)s, or PBAEs. In a groundbreaking study released last year, the team demonstrated the strength of PBAE formulations in delivering mRNA that can express the CRISPR Cas13a protein in lung tissue, where it effectively stopped SARS-CoV-2.

After screening 166 different PBAE formulations, one of these — P76 — emerged as the best candidate for delivering therapeutic goods into the lungs of animals, from mice to non-human primates. The polymer is also compatible with a variety and combination of cargos, which is not typically the case with the delivery of RNAs.

The study was led by **Phil Santangelo**, professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University. In addition to other university collaborators, the study included two Georgia Tech faculty members from the School of Chemistry and Biochemistry: School Chair and James A. Carlos Family Chair for Pediatric Technology **M.G. Finn** and Associate Professor **James Gumbart**, who also is a member of the School of Physics.

"With this new polymer, compared to the old one from our previous work, we get much better protein expression," Santangelo says. "We can actually decrease dosage by a factor of four, or 400%, and have the same therapeutic effectiveness. That is significant. It's a striking improvement."

Story by Jerry Grillo • Supported by NSF and DARPA.

Researchers Target TANGO2 to Study Iron-Rich Blood Molecule

Heme, the iron-holding molecule that gives blood its red color, is essential for life. While the way heme is biosynthesized and degraded has been known for decades, how it is mobilized from sites of synthesis and storage for use in cells has not been clear. Georgia Tech researchers — co-led by School of Chemistry and Biochemistry Associate Professor **Amit Reddi** — have developed new tools and approaches to image, monitor, and probe heme in biological systems to study how organisms handle this essential but potentially cytotoxic metabolite. Their findings have been published in *Nature*.

In a collaboration with China's Zhejiang University and the University of Maryland School of Medicine, the team discovered a previously uncharacterized protein, HRG-9 (also called TANGO2), that helps mobilize heme from sites of synthesis or storage for metabolic use. The discovery of a new protein that ensures heme is made bio-available may serve as a new therapeutic target in many disease contexts.

Story by Renay San Miguel • Supported by NSF, NIH, the National Natural Science Foundation of China, and the National Key Research and Development Program of China.

Amit Reddi, associate professor in the School of Chemistry and Biochemistry.

M.G. Finn — chemistry professor and chair of the School of Chemistry and Biochemistry and James A. Carlos Family Chair for Pediatric Technology at Georgia Tech — on the principles of what click chemistry is about: "The whole point of click chemistry is to democratize chemistry," he says.

The Nobel Whisperer: M.G. Finn on Click Chemistry and Collaboration

On Dec. 10, 2022, Georgia Tech chemist **M.G. Finn** found himself attending the Nobel Prize awards ceremony with **K. Barry Sharpless**, winner of the 2022 Nobel Prize in Chemistry for the creation of "click" chemistry. Sharpless shared the prize with **Carolyn Bertozzi** and **Morten Meldal**.

In 2001, Finn, Sharpless, and **Hartmuth C. Kolb** published the paper that introduced click chemistry to the world, which was also one of the papers cited for the 2022 Nobel Prize.

As for Finn's contributions, he articulated the concept and illustrated the utility of click chemistry early on. His lab was among the first to implement click chemistry reactions, showing how to make connections to biological molecules and other materials.

"I think M.G. is the most collaborative person I've ever met," says George W. Woodruff School of Mechanical Engineering Professor **Susan Thomas**, who describes her ongoing, 10-year collaboration with Finn as one of the most fulfilling and satisfying scientific journeys of her career.

Today, click chemistry is used in thousands of labs worldwide. Its applications have been wide-ranging, transforming entire areas of materials science, surfaces, biology, and medicine, among others.

Story by Catherine Barzler.

Fernández Elected to Metabolomics Association of North America Board (MANA)

With the mission of advancing the field of metabolomics, or "the systems-scale study of biochemical intermediates in biological systems," MANA has created a prestigious network of North American scientists seeking to advance our understanding of the metabolism of microbes, plants, animals, and humans. Now, **Facundo Fernández** has been elected to the board of MANA, joining School of Chemical and Biomolecular Engineering Professor **Mark Styczynski** on the board of directors.

Fernández's research interests lie in the field of metabolomics and the development of new ionization, imaging, machine learning, and ion mobility spectrometry tools for probing composition and structure in complex molecular mixtures.

"It is an honor to be elected to the board of MANA and have a chance to engage with top scientists in the field to shape the future of metabolomics in North America," Fernández says.

Story by Audra Davidson.

Facundo Fernández, Regents' Professor, Vasser-Wooley Chair in Bioanalytical Chemistry, and associate chair for Research and Graduate Training in the School of Chemistry and Biochemistry.

M.G. Finn, chair in the School of Chemistry and Biochemistry and James A. Carlos Family Chair for Pediatric Technology (left), with the OZ-Link leadership team (from left to right): Wenting Shi, lead scientist; Kasie Collins, CEO and co-founder; Jasmine Hwang, chief scientific officer; and Steve Seo, chief operating officer.

OZ-Link Technologies Aims to Improve Controlled Drug Delivery

For many patients battling a disease or trying to prevent one, the best treatment option is controlled drug delivery. In those cases, a delivery system must bind with the drug and then release it precisely where and when it will be most effective. That's where OZ-Link hopes to make a significant impact.

The early stage company, growing in the lab of Georgia Tech researcher **M.G. Finn**, is working to demonstrate its system can provide sustained, extended release in ways that can be varied from days to weeks. Small-molecule drugs (the most common drugs on the market) and biologics (the fastest emerging class of drugs) can both benefit from this type of delivery, but in different ways and over different time frames, depending on the target.

Currently, nothing on the market is capable of doing that effectively, and drug manufacturers large and small are intrigued by the notion of such precise biocompatible delivery. Based on the feedback OZ-Link has received from its potential client base, the company is at work now on its next phase of research and development.

"What's unique about our technology is whether the carrier system is an antibody, nanoparticle, polymer, or hydrogel, it connects to whatever the drug is," said **Kasie Collins**, CEO and co-founder of OZ-Link. "Our technology is designed to be compatible with both small molecules and biologics."

In addition to Collins, OZ-Link's founding leadership team includes **Steve Seo**, **Jasmine Hwang**, and **Wenting Shi**. All are members or affiliates of the Finn lab.

Story by Jerry Grillo • Supported by the Biolocity Fund.

McDonald Honored by Georgia Center for Oncology Research and Education (CORE)

John McDonald has been named one of "Today's Innovators" in cancer care by the Georgia Center for Oncology Research and Education. McDonald is the founding director of Georgia Tech's Integrated Cancer Research Center and has served as the chief scientific officer of the Ovarian Cancer Institute.

Also chosen as a "Today's Innovator" this year is **Lynn Durham**, who previously served as vice president for Institute Relations at Georgia Tech and is now CORE's president and CEO. Across 25 years on campus, Durham also worked as chief of staff and led the Institute's legislative advocacy program.

Story by Renay San Miguel.

John McDonald (left), emeritus professor in the School of Biological Sciences and founding director of Georgia Tech's Integrated Cancer Research Center, and Lynn Durham, CORE's president and CEO.

Georgia Tech Welcomes First GRA Distinguished Investigator, New Eminent Scholar

Jason Azoulay has been appointed as Georgia Tech's first Georgia Research Alliance (GRA) Distinguished Investigator. He is joined by GRA Eminent Scholar **Lynn Kamerlin** — bringing the Institute's total of GRA Eminent Scholars to 27. GRA is a public-private partnership that supports the recruitment of top scientists to Georgia universities.

Azoulay and Kamerlin join the School of Chemistry and Biochemistry, with Azoulay also holding a joint appointment in the School of Materials Science and Engineering.

"Lynn Kamerlin's exploration of enzymes and proteins is nothing short of astounding," says former GRA President **Susan Shows**, who recently retired after 20 years of service with GRA. "The research she is doing opens up paths to all kinds of exciting outcomes, from major advances in biomedicine to new ways of breaking down toxic materials. And her passion for educating the next generation of scientists will be a great asset to Georgia Tech."

"We are also very fortunate to have recruited a scientist of the caliber of Jason Azoulay as Georgia Tech's first GRA Distinguished Investigator," Shows adds. "Not only has he built a world-class research program in polymer science and electronic materials, he also has the vision and drive to bring inventions to the marketplace. He is the kind of enterprising scientist GRA aims to bring to Georgia."

Story by Jess Hunt-Ralston • Supported by the Georgia Research Alliance.

Jason Azoulay and Lynn Kamerlin.

American Chemical Society Presents 2023 Herty Medal to 'Chemist's Chemist' David Sherrill

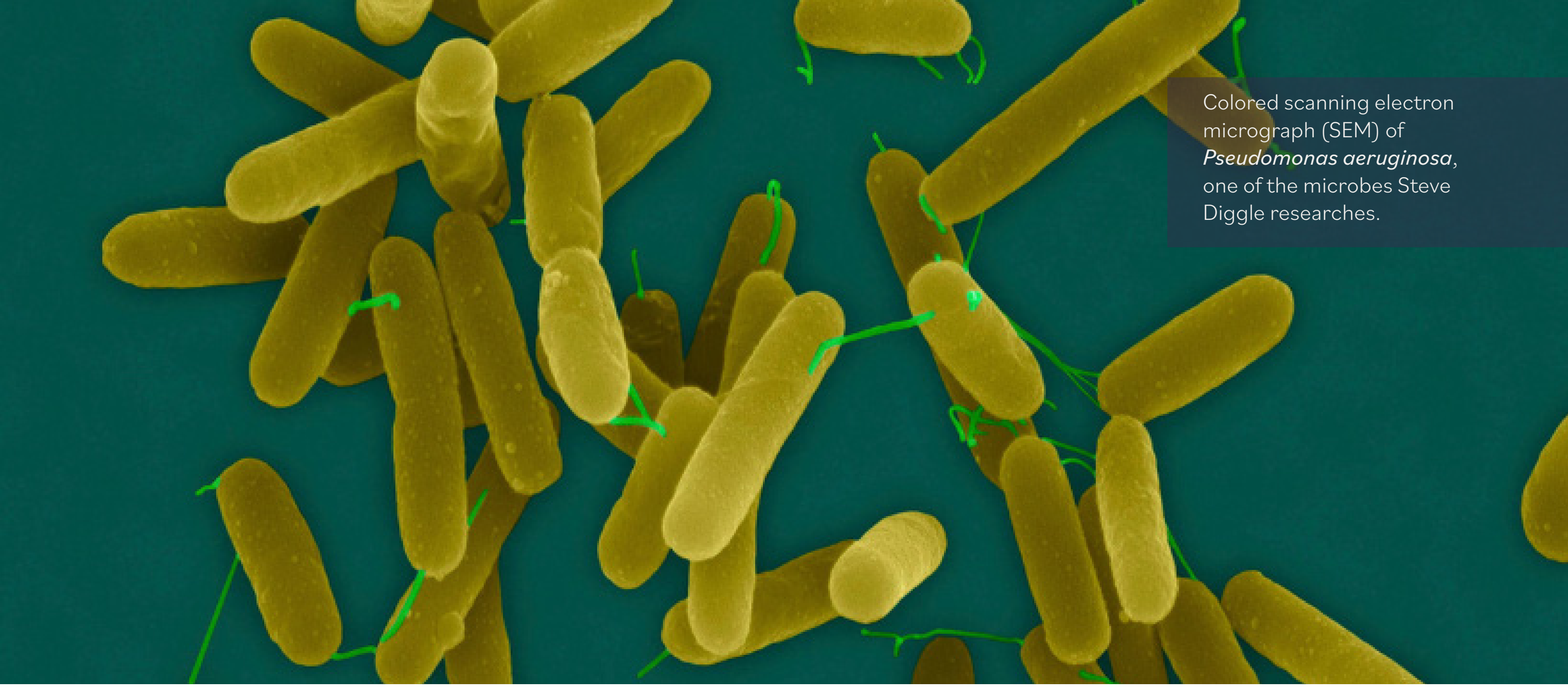
David Sherrill is the recipient of the 2023 Charles H. Herty Award, given by the Georgia Section of the American Chemical Society (ACS).

Presented annually for more than 75 years, the Herty Award honors outstanding research, education, and service by a chemist in the Southeast.

Sherrill has long been an active member of the ACS, both nationally and in the Georgia Section. In 2017, he received the ACS Outreach Volunteer of the Year Award for his work with K-12 teachers during National Chemistry Week. Sherrill's recent research continues his career-long investigation into how molecules interact with each other, but it now involves computational techniques such as machine learning. Sherrill is a Fellow of the American Association for the Advancement of Science, the American Physical Society, and ACS. He serves as an associate editor of the *Journal of Chemical Physics* and was recently elected to the board of the World Association of Theoretical and Computational Chemists.

Story by Renay San Miguel • Supported by the American Chemical Society.

David Sherrill, Regents' Professor in the School of Chemistry and Biochemistry and School of Computational Science and Engineering and associate director of the Georgia Tech Institute for Data Engineering and Science. *ROB FELT*



Colored scanning electron micrograph (SEM) of *Pseudomonas aeruginosa*, one of the microbes Steve Diggle researches.

Center for Microbial Dynamics and Infection Appoints New Director

Steve Diggle's research interests focus on cooperation and communication in microbes and how these are related to virulence, biofilms, and antimicrobial resistance, with special interest on how *Pseudomonas aeruginosa* evolves during chronic infections such as those found in cystic fibrosis patients and chronic wounds.

Steve Diggle, professor in the School of Biological Sciences.

Now a new role and new recognition will help him broaden his impact even further.

As the recently appointed director of the Center for Microbial Dynamics and Infection (CMDI), Diggle hopes to continue attracting the world's top microbiology researchers to join the CMDI faculty while seeking out more external funding. "The ultimate goal is to make Georgia Tech one of the best places to come and do microbiology research in the U.S.," Diggle says. "Given what we've accomplished so far, I think that's a reasonable goal."

Founded in 2018, CMDI seeks to understand the chemical, physical, and biological connections that together underpin microbial dynamics. The Center's science research includes a wide variety of disciplines: microbial ecology, microbiome dynamics, biogeochemistry, microbial biophysics, socio-microbiology, infection dynamics, host-pathogen interactions, marine and aquatic microbiology, microbial evolution, viral ecology, spatial imaging, and math/computational modeling.

"It's an honor to be chosen for this," Diggle said. "What's really exciting is that when I joined Georgia Tech in 2017, we were only just developing microbiology here. What's happened since is that microbiology has taken on a much bigger profile at Georgia Tech. We're now at the point where we are attracting really strong graduate students specifically to do microbiology, which is great. CMDI is more visible now, and I think that's one reason graduate students are applying."

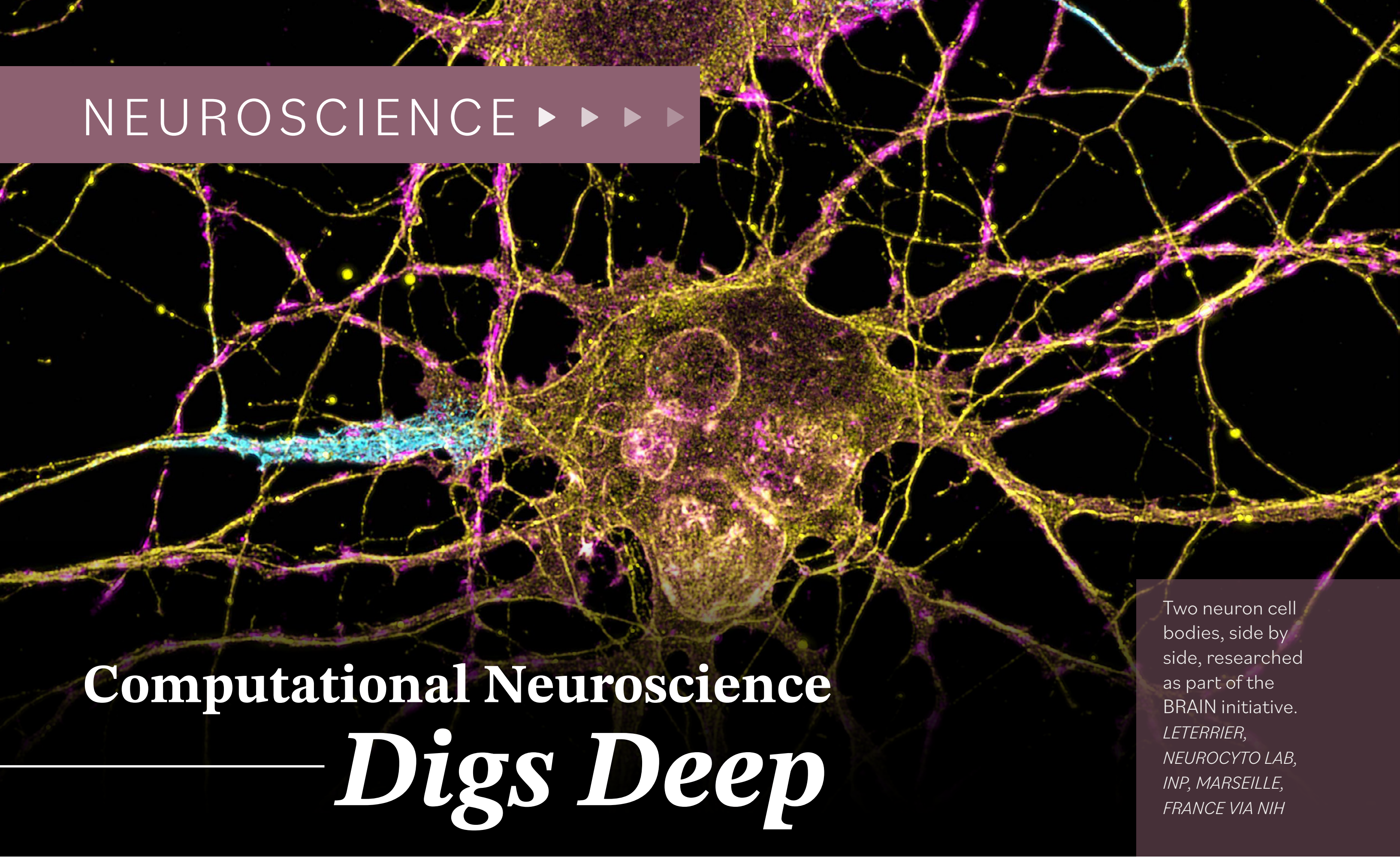
Diggle is also one of 65 new 2023 Fellows of the American Academy of Microbiology (AAM).

The AAM is an honorific leadership group and think tank within the American Society of Microbiology (ASM). Fellows are elected annually through a highly selective, peer-review process, based on their records of scientific achievement and original contributions that have advanced microbiology. The Academy received 148 nominations this year.

More than 2,600 Academy Fellows represent all subspecialties of the microbial sciences. They are involved in basic and applied research, teaching, public health, industry, and government service.

In 2020, Diggle received the Cullen-Peck Scholar Award, which recognizes research accomplishments led by Georgia Tech College of Sciences faculty at the associate professor or advanced assistant professor level. Diggle was selected as an American Society for Microbiology Distinguished Lecturer in 2021.

Story by Renay San Miguel • Supported by Georgia Tech's Center for Microbial Dynamics and Infection and the American Academy of Microbiology.



Two neuron cell bodies, side by side, researched as part of the BRAIN initiative. *LETERRIER, NEUROCYTO LAB, INP, MARSEILLE, FRANCE VIA NIH*

Computational Neuroscience *Digs Deep*

A community of multidisciplinary researchers at Georgia Tech is decrypting neuronal chatter, which may hold the key to advanced robotics and artificial intelligence (AI), global energy efficiency, and better treatments for disease and addiction.

Chethan Pandarinath, assistant professor in the Wallace H. Coulter Department of Biomedical Engineering.

These researchers work on computational neuroscience, a branch of neuroscience that uses mathematical models, computer simulations, and theoretical analysis of the brain to gain a deeper understanding of the nervous system.

"There has been an explosion of technology over the past five or 10 years," says **Chethan Pandarinath**, assistant professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University. "So, we're moving into a different space in the ways we approach the brain, and the ways we think about it."

Much of that explosion has manifested at Georgia Tech in the form of additional academic offerings as well as research interest, where it was fueled by the BRAIN Initiative. Launched by President Barack Obama in 2014, the Initiative identified computational neuroscience as an area where progress was critical, citing the need for improvements in machine learning, AI, and crowdsourcing approaches to translating the massive volume of data being gathered from human brains. And Georgia Tech researchers have their hands in every area.

"This field is multidisciplinary and collaborative by nature and necessity," says **Tansu Celikel**, chair of Georgia Tech's School of Psychology, who wants to understand complex behaviors controlled by the brain in order to make smarter, more intuitive robots.

Tansu Celikel, professor and chair in the School of Psychology.

"It begs for biologists, psychologists, mathematicians, physicists, data scientists — people from the machine learning and AI worlds — to come together and advance the state of computation and brain research," Celikel adds. "With that in mind, Georgia Tech is in an excellent position to make a significant impact and become a global center for this kind of research."

Celikel and Pandarinath are just two of the researchers at Georgia Tech in computational neuroscience, a wide-ranging field that relies on collaborations between data scientists, experimentalists, and clinicians. A small sampling of the people connecting the brain's neural dots and expanding this body of research in the College of Sciences include:

Hannah Choi, *Assistant Professor, School of Mathematics*

While working toward her Ph.D. in applied mathematics, Choi "got really interested in nonlinear dynamical systems, a big topic in applied mathematics," she remembers. "I soon realized the brain is the most exciting nonlinear dynamical system, and that I could apply my mathematical tools and develop computational theories to better understand the brain."

Choi's work in applying math to neuroscience earned her a prestigious 2022 Sloan Research Fellowship, which goes to the nation's most promising young scientific researchers. Since launching her lab at Georgia Tech in January 2021, Choi has continued her collaboration with the Allen Institute, while starting partnerships with several Georgia Tech and Emory researchers.

Choi also wants to improve computation and AI. "The idea is to apply what we have learned about our very energy-efficient brains to the development of better, more efficient, artificial neural networks," she says.

"I soon realized the brain is the most exciting nonlinear dynamical system, and that I could apply my mathematical tools and develop computational theories to better understand the brain."

— Hannah Choi

Dobromir Rahnev, *Associate Professor, School of Psychology*

Rahnev uses a combination of neuroimaging and computational modeling to reveal the mechanisms of perception and decision making in humans.

A recipient of both the American Psychological Association Distinguished Scientific Award for an Early Career Contribution to Psychology and the Elsevier/Vision Science Society Young Investigator Award, Rahnev has already made important contributions to our understanding of how people perceive the world and make decisions. He has recently begun investigating how deep neural networks — which have established themselves as state-of-the-art computer vision algorithms — can serve as excellent models for the perceptual and decisional processes in the human brain.

"One of my strongest passions is to make science more open in every sense of the word," says Rahnev, who organized the Confidence Database, the largest field-specific database of open data in the behavioral sciences. "It's important for me to be involved in efforts to attract and retain people from underrepresented groups in cognitive and computational neuroscience."

"One of my strongest passions is to make science more open in every sense of the word."

— Dobromir Rahnev

Lewis Wheaton, *Professor, School of Biological Sciences*

When he isn't helping to lead the new Center for Promoting Inclusion and Equity in the Sciences at Georgia Tech, Wheaton helms a research effort that could lead to user-friendly prosthetic devices and improved motor rehabilitation training, particularly for people with upper limb amputation.

"There are a lot of beautifully developed upper limb prostheses available right now, but one of the big challenges is they're just not heavily used by individuals — partly because they're really, really expensive, but also because they're such an easy thing to not use," said Wheaton. "It's very easy to just take it off and never wear it at all."

That's why much of Wheaton's research is focused on acquiring and studying data that shows what upper limb amputees are thinking or feeling while using, or trying to use, a prosthesis. By integrating a patient's neural activity with observations of behavior and gaze patterns, the team is "gathering data that's never really been acquired before," Wheaton says. "This will help us gather more information that is helpful in developing new rehabilitation protocols for persons learning how to use prostheses. A better understanding of how rehabilitation efforts are influenced by different types of prostheses can also inform engineers and the marketplace on the type of prostheses we should be developing.

Story by Jerry Grillo.

"[Our work] will help us gather more information that is helpful in developing new rehabilitation protocols for persons learning how to use prostheses."

— Lewis Wheaton

Undergraduate Research in the Spotlight

Psychology, economics team up to explore spatial navigation and learning

A recent paper by an interdisciplinary team of authors from the School of Psychology and the School of Economics at Georgia Tech discovered what makes people good navigators — and what strategies may help people navigate more efficiently.

The team found that good navigators often use a bird's-eye view perspective to organize and remember different places in the environment, and have a map-like representation of the environment in their mind. Bad navigators on the other hand, often use a route-based or turn-by-turn strategy to learn the environment.

By combining psychology, computer science, and data science, the team was able to explore reinforcement learning (RL), a popular type of machine learning algorithm which the famous AlphaGo is built on, to further investigate these individual differences in spatial navigation.

"The critical thing RL brings to the table for human navigation research is it helps us interpret how 'adaptive' a person's strategy is," notes Assistant Professor of Psychology **Thackery Brown**. "For example, sometimes navigating a well-learned route is just as efficient as any other path we might come up with to reach a goal — in this case, the person navigating that route isn't necessarily a bad navigator, but may actually be allocating their brain's resources in the most efficient way."

Brown adds that in the study, RL was used to characterize how someone's current navigational choices relate to the quickest option to reach a goal and how this option seems to build on their past experiences.

Elizabeth H. Beveridge (left), Lou Eschapasse (center), and Jancy Ling Liu.

Two undergraduate students, **Lou Eschapasse** and **Elizabeth H. Beveridge**, along with then-graduate student **Jancy Ling Liu**, are also co-authors on the paper. The students "contributed significantly to the research," says **Tansu Celikel**, professor and chair of the School of Psychology. "This is a great example of the research ecosystem available to undergraduates at Tech."

"Elizabeth and Lou are perfect examples of how brilliant, motivated, and well-trained our students are in neuroscience, psychology, and the related disciplines," Brown adds.

"The insights from the study could inform interventions to teach people to be better at navigating challenging situations and can even inform efforts in computer science and robotics to develop artificial agents that can learn to solve navigational problems in the ways people do."

Story by Laurie E. Smith • Supported by NIH and the Warren Alpert Foundation.

Education Intervention Doesn't Live Up to Promise

New research suggests the "growth mindset" strategy favored by some educators to improve student performance hasn't lived up to its promise. The resulting time and effort spent on growth mindsets in the classroom has not yet yielded meaningful gains in grades or test scores.

More than 30 years ago, noted psychologist **Carol Dweck** proposed that students with a growth mindset — those who believe their intelligence can "grow" with effort — focus more on learning, work hard, seek challenges, and are resilient to setbacks.

But recent research by **Alexander Burgoyne**, a research scientist in the School of Psychology at Georgia Tech, and **Brooke Macnamara**, associate professor of cognitive psychology at Case Western Reserve University, that examined all relevant studies on the topic, found little to no positive effect of growth mindset interventions on student performance.

Despite growth mindset's popularity in schools and other settings, the interventions may be largely ineffective and may even be harmful by pulling resources away from more promising efforts, the researchers say.

"The concept of growth mindset is appealing; it's a feel-good idea," Macnamara says. "But the claims of growth mindset interventions do not stand up to rigorous scientific inquiry."

Story by Mike Scott.

School of Psychology Research Scientist II Alexander Burgoyne.

Neuroscience, Mental Health, and Motherhood

Christina Ragan and her husband Zachary Grieb have studied the neuroscience of mental health and parenthood for years — and recently became parents. *CHRISTINA RAGAN*

Christina Ragan is studying how the events of pregnancy and early parenthood may affect mental health.

"Mental health is one of those things that's not always as obvious as other physical ailments," explains Ragan, a faculty member and academic professional in the School of Biological Sciences and the director of Outreach for the Undergraduate Program in Neuroscience at Georgia Tech. "We need better markers of mental health — if we can find some of those neurobiological markers, maybe that can help identify who's at risk."

One of her big interests is postpartum anxiety. Throughout her career, Ragan has examined how factors such as exposure to certain medications or skin-to-skin contact impacts behavioral and neurobiological markers of anxiety in both maternal and postnatal animals.

For the past year, **Harika Kosaraju**, an undergraduate at Georgia Tech, followed on Ragan's behavioral research. Kosaraju is diving deeper into this work this fall, looking at how those conditions impact serotonin in decision-making areas of the brain, as well as how the molecular machinery cells use to produce serotonin are affected.

"I was initially really attracted to Dr. Ragan's projects because of this population that they were addressing, that I hadn't seen addressed in a lot of research," says Kosaraju. "Focusing on a population that doesn't have a lot of research is so important, especially because of the stresses and risks of pregnancy, childbirth, and the postpartum period." • *Story by Audra Davidson.*

Research Teams Awarded $15M by Department of Defense for Multidisciplinary Research

Two teams from Georgia Tech have been awarded a combined $15 million from the U.S. Department of Defense (DoD) for research projects as part of the Multidisciplinary University Research Initiative (MURI) program.

Randy Engle, professor in the School of Psychology, was awarded $7.5 million for his project, "Understanding and Building Overall Cognitive Capability Through Attention Control." **Alper Erturk**, Carl Ring Family Chair and professor in the George W. Woodruff School of Mechanical Engineering, and **Yuhang Hu**, associate professor and Woodruff Faculty Fellow in the Woodruff School and the School of Chemical and Biomolecular Engineering, were awarded the same amount for their project, "Bio-Inspired Material Architectures for Deep Sea."

In collaboration with Georgia Tech co-investigator **Alexander Burgoyne**, Engle will explore the brain's mechanisms of attention control and investigate methods to potentially improve it or reduce its decline. Engle's work with air traffic control trainees showed that current evaluations used to select candidates for training only predict a small percentage of success. Engle found that by using his measures of ability to control attention in evaluations, the Navy could more than double predictive success in candidate training.

Randy Engle, professor in the School of Psychology.

Erturk and Hu's interdisciplinary project will explore the fundamental science behind the biological characteristics that allow deep sea fish to adapt and survive in high-pressure ocean environments. They will then translate those findings to engineer bioinspired materials needed to realize the Navy's advanced capabilities in deep sea environments.

Story by Catherine Barzler • Supported by the Department of Defense.

Mudskippers and the Key to the Evolution of Blinking

A mudskipper, an amphibious fish that spends most of its time on land. *GEORGIA TECH*

Blinking is crucial. It's how animals clean their eyes, protect them, and even communicate. Mudskippers — amphibious fish that spend most of their time on land — might hold the key to understanding blinking, and why it's such a fundamental behavior for life on land. Georgia Tech researchers, alongside researchers at Seton Hill University, University of Chicago, and Pennsylvania State University, are uncovering these connections.

"We all blink without thinking, and understanding why we blink is such a beautiful puzzle right in front of our eyes," explains **Saad Bhamla**, an assistant professor in Georgia Tech's School of Chemical and Biomolecular Engineering. "Through our research on mudskippers, and by conducting biophysical and morphological analyses, we expose how blinking serves a multitude of functions for adapting to life out of water."

"Blinking is a reflection of a bigger question," adds **Simon Sponberg**, Dunn Family Associate Professor in the School of Physics and School Biological Sciences at Georgia Tech, whose lab led the research. "How did major evolutionary transitions occur that enabled organisms to inhabit basically every environment on this planet?

"What we learned is you don't need the evolution of a lot of specialized musculature or glands; evolution can tinker with the structures that are already there, allowing them to be used in a new way and for a new behavior."

Breaking down blinking

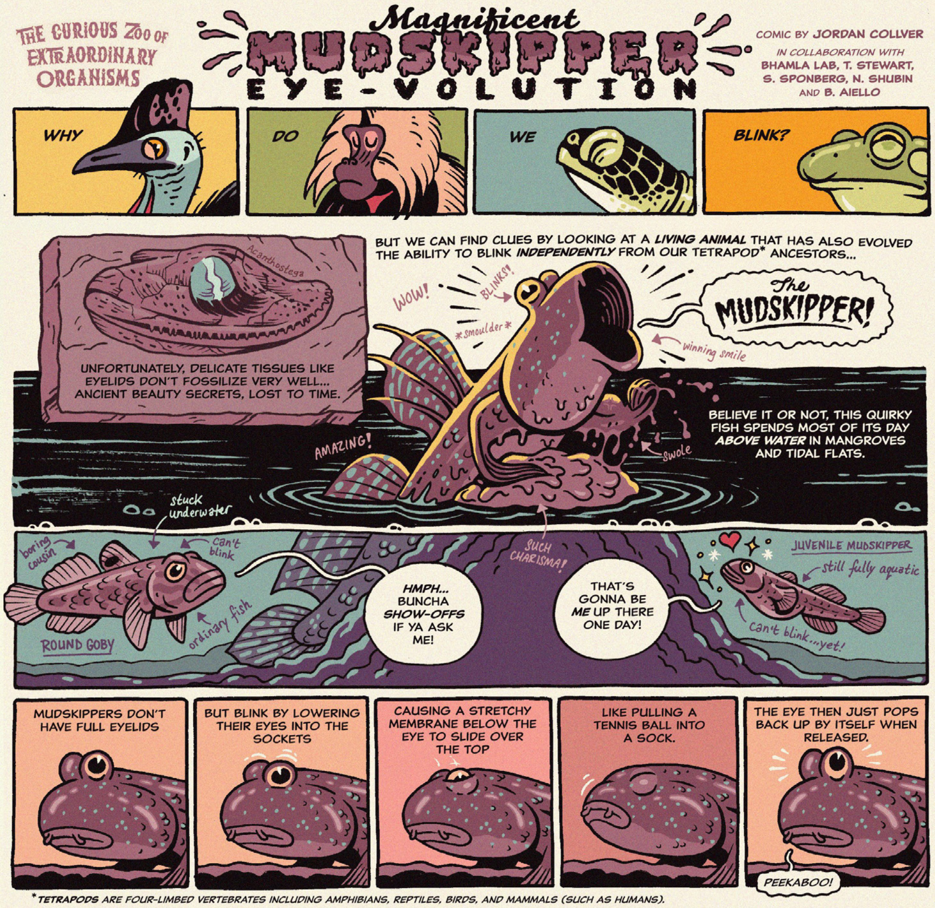
"By comparing the anatomy and behavior of mudskippers to the fossil record of early tetrapods, we argue that blinking emerged in both groups as an adaptation to life on land," says **Tom Stewart**, a senior author on the paper and an assistant professor at Penn State. "These results help us understand our own biology and raise a whole set of new questions about the variety of blinking behaviors we see in living species."

Mudskippers blink by sucking their eye downward into their eye socket, using their existing set of eye muscles in a new way rather than evolving to have new parts, like new muscles or special glands.

"This is a very exciting result because it demonstrates that the evolution of a new, complex behavior can be achieved using a relatively rudimentary set of structures," explains **Brett Aiello**, the lead author as a postdoctoral fellow at Georgia Tech, who is now an assistant professor at Seton Hill.

The team found that mudskippers blink for three main functions: to wet, clean, and protect the eye. These functions are also why humans and other land-dwelling vertebrates blink.

"We find that a single behavior can be deployed to accomplish three complex, distinct functions," says Aiello. "These results not only help humans understand our own history, but also help us reevaluate the adaptations necessary for major transitions in the evolutionary history of vertebrates, like moving from water to land."



The project also involved digital outreach, including this comic explaining the study. See the full comic at bhamla.gatech.edu.

Engaging undergraduates

Aiello and Sponberg also engaged the Vertically Integrated Projects (VIP) program, which allows undergraduates to participate in long-term, large-scale research projects as part of their coursework at Georgia Tech.

"VIP drew me closer to the programming and device areas of my biomedical engineering major and solidified why I chose a computer science minor," **Kendra Washington** says. "I continued to pursue that fusion through later internships and research and now work with hemodynamic monitoring. But in a sense, I still help characterize physiology through programming."

"I used my computer science skills to gather raw data and analyze and plot them using programs like MATLAB or Python," notes **Manognya Sripathi**, a biomedical engineering graduate who minored in computer science. "I also used engineering skills to help build the experimental equipment, allowing us to apply engineering methods to study a biological problem in a unique way."

Hajime Minoguchi, a biomedical engineering graduate, now works as a systems integration research and development engineer, thanks to his experience in the class. "Working in an interdisciplinary team like this has allowed me to learn how to understand and communicate ideas between disciplines, which helped me to be a more well-rounded engineer," he says.

"My work requires a thorough understanding of biology, electrical circuitry, software, firmware, mechanical interactions, and physics. This VIP experience was instrumental for me in being successful at my current job."

Story by Tess Malone • Supported by NIH, NSF, and the Brinson Foundation.

On the Edge

Georgia Tech professors awarded Curci grants for emerging bio research

Simon Sponberg, Dunn Family Associate Professor in the School of Physics and the School of Biological Sciences, and **Lily Cheung**, assistant professor in the School of Chemical and Biomolecular Engineering, have been awarded prestigious Curci grants, which will fund cutting-edge research in their fields. The Shurl and Kay Curci Foundation supports science-based research striving for the advancement of a healthy and sustainable future for humans.

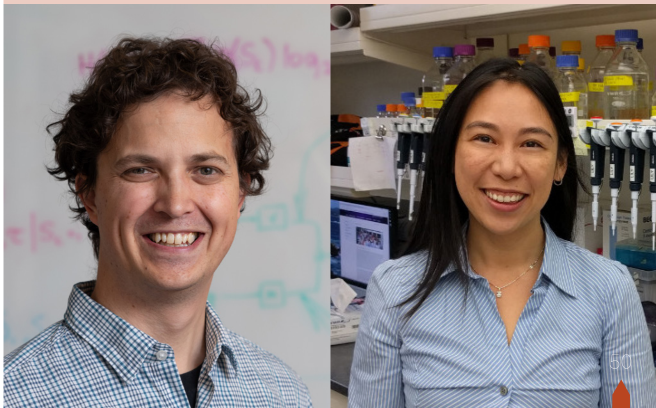
Sponberg's research into agile movement has the potential to change the way we approach physical therapy for degenerative diseases, as well as a number of other applications, including building better robots.

"The Curci Foundation funds research that's just emerging, that's on the edge," Sponberg says. "Part of the goal is to develop fundamental knowledge that will seed all sorts of future research."

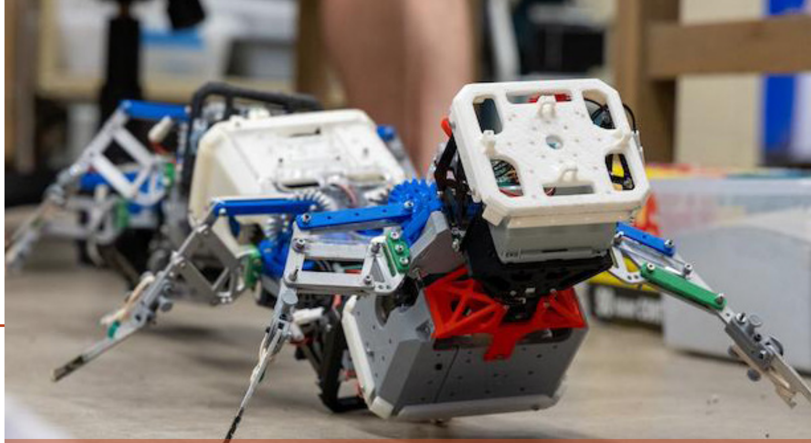
Cheung's research has medical applications, with the potential to improve medical treatments, including for cancer — and also to help create plants that are more resilient to climate change, which could help feed communities of the future.

Story by Selena Langner • Supported by The Shurl and Kay Curci Foundation.

Simon Sponberg (left), Dunn Family Associate Professor in the School of Physics and School of Biological Sciences, and Lily Cheung, assistant professor in the School of Chemical and Biomolecular Engineering.



Centipede-Inspired Robots May Help With Weed-Free Farming



The robot created by the team is designed to mimic a centipede's wiggly walk to better traverse terrain without stopping. *GEORGIA TECH*

Inspired by the many legs of a centipede, a team of Georgia Tech physicists, engineers, and mathematicians developed a new theory of multilegged locomotion and created many-legged robotic models, discovering that a robot with redundant legs could move across uneven surfaces without any additional sensing or control technology — just as the theory predicted.

"When you see a scurrying centipede, you're basically seeing an animal that inhabits a world very different from our world of movement," says **Daniel Goldman**, Dunn Family Professor in the School of Physics. "Our movement is largely dominated by inertia. If I swing my leg, I land on my foot and I move forward. But in the world of centipedes, if they stop wiggling their body parts and limbs, they basically stop moving instantly."

These robots can move over complex, bumpy terrain — and there is potential to use them for agriculture, space exploration, and even search and rescue.

"They're kind of like a Roomba but outside for complex ground," Goldman explains. "A Roomba works because it has wheels that function well on flat ground. Until the development of our framework, we couldn't confidently predict locomotor reliability on bumpy, rocky, debris-ridden terrain. We now have the beginnings of such a scheme, which could be used to ensure that our robots traverse a crop field in a certain amount of time."

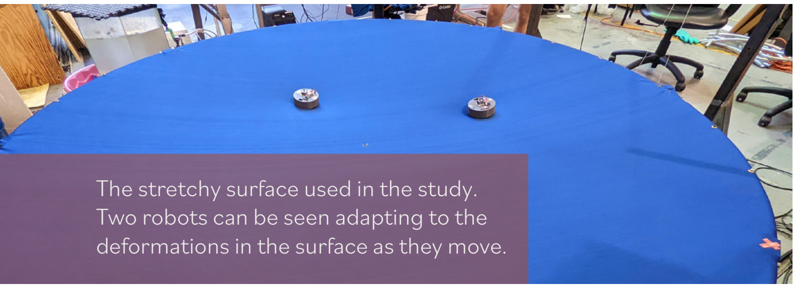
The researchers are already applying their discoveries to farming. Goldman has co-founded a company that hopes to use these robots to weed farmland, instead of using chemical weed killers.

Story by Tess Malone • Supported by NSF, Georgia Research Alliance, Army Research Office, and the Dunn Family Professorship.

Mini Robots Learn to Drive on Stretchy Surfaces

When self-propelling objects interact with each other, interesting phenomena can occur, like people at a concert spontaneously creating vortices when they nudge and bump into each other. While many of these interactions happen through direct contact, some interactions can transmit through the material the objects are on or in. These are known as indirect interactions. Physicists are using small, wheeled robots to better understand these indirect mechanical interactions, how they play a role in active matter, and how we can control them.

In a recent paper led by **Shengkai Li**, a former Ph.D. student in the School of Physics at Georgia Tech, researchers illustrated that active matter on deformable surfaces can interact with others through non-contact force — then created a model to allow control of the moving objects' collective behavior on deformable surfaces through simple changes in the robots' engineering. Co-authors include Georgia Tech's **Daniel Goldman**, **Gongjie Li**, and graduate student **Hussain Gynai**.



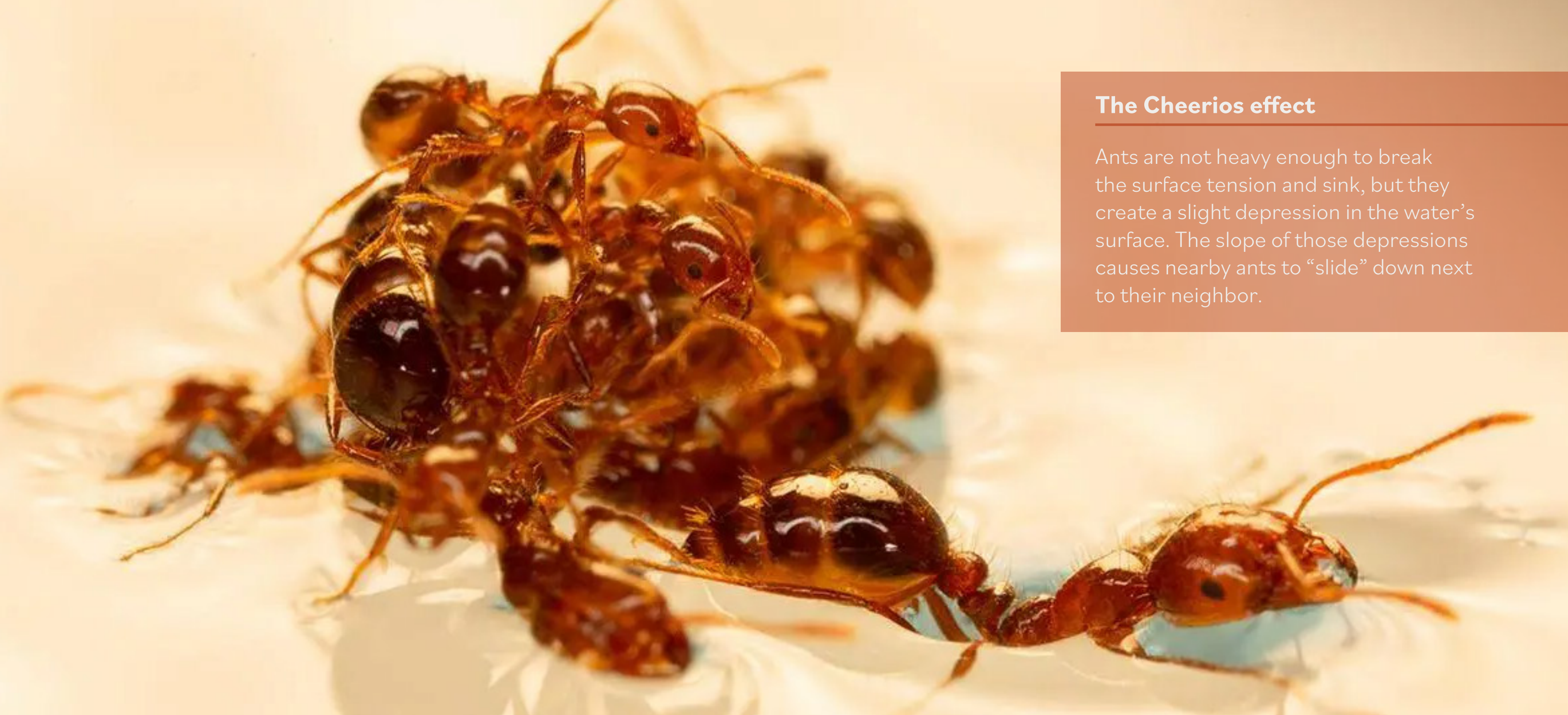
The stretchy surface used in the study. Two robots can be seen adapting to the deformations in the surface as they move.

The researchers built robots that drove at a constant speed over flat, level ground. When encountering a surface with dips and curves, these robots maintained that constant speed while reorienting themselves to align with the slope. The amount the robot turned was a result of the slope's steepness. When these robots were placed on a circular, trampoline-like surface, the researchers could monitor how the robots turned in response to the changing surface as the robots created new dips in the surface with their weight.

The significance of this research spans from biology to general relativity. For researchers using biomimicry to build robots, the team's work could help inform robotic designs that avoid or utilize aggregation. The work could also advance the understanding of general relativity.

"Since our model can create steady-state orbits," explains Li, "it can also overcome common issues in previous studies. With this new model, researchers have the ability to map to exact general relativity systems, including phenomena like a static black hole."

Story by Selena Langner • Supported by NSF, NASA, Army Research Office, and the Dunn Family Professorship.



The Cheerios effect

Ants are not heavy enough to break the surface tension and sink, but they create a slight depression in the water's surface. The slope of those depressions causes nearby ants to "slide" down next to their neighbor.

Fire Ant Rafts Form Thanks to a Force Known as the 'Cheerios Effect'

Ever stare at your bowl of breakfast cereal and watch pieces clump together or cling to the side of the dish?

Scientists have dubbed the combination of forces causing those clumps the "Cheerios effect," and researchers at Georgia Tech have discovered those same forces draw small numbers of ants together to begin to form water-repellent ant rafts — even though the ants seem to be uninterested in collaborating with their neighbors for survival.

Described in the journal *Physical Review Fluids*, the study explains for the first time the underlying forces at play in attracting ants to each other. Ants clump together into rafts to survive during flooding, and the team determined it takes exactly 10 ants to form a stable raft.

"The motivation here was to understand how these individual parts come together," said **Hungtang Ko**, a mechanical engineering Ph.D. student in Professor **David Hu**'s lab and first author of the study. "We looked at how a pair of ants interact, and we were surprised to find that they don't actually actively swim toward each other. Even when they do, they tend to repel or ignore the other ant."

Studying small groups of ants — down to just a pair of individuals — the team found they flail their legs when placed in water and bounce off each other. Yet, inexorably, the Cheerios effect draws them together.

Hu and his lab have long studied how fire ants weave themselves into tight, water-resistant rafts for survival. They can float atop water for weeks at a time — like the huge colonies in Houston after Hurricane Harvey that drew national attention. Hu has documented that ants in these rafts create connections with an average of 14 others to form their water-repelling seal. Groups also can build towers to escape rising water.

Usually, studies of rafts involve 1,000 or more ants. This time, the team scaled down to as few as two ants to understand the mechanism behind raft formation.

"I think the surprising thing here is that ants prioritize exploration, actively avoiding each other on the water surface. They instead rely on physical forces to bring them together — the Cheerios effect," said Hu, professor in the George W. Woodruff School of Mechanical Engineering and the School of Biological Sciences. "Previously, we only studied the change in the shape of the raft, once formed; we never asked how ants find each other on the water surface."

Birds, fish, and other organisms exhibit this kind of grouping behavior, but little is known about how they do amazing things as a group that the individuals don't do, Hu says. "This study is about their coherence — the ability of the members to stay together."

Ko said that's what makes collective behavior so fascinating: The collective is usually greater than the sum of its parts.

"An individual fish or bird has limited abilities to escape predators, but when they come together in groups, they can perform evasive tactics as a team, plus many more fascinating tasks," Ko said. "And this extends beyond animals. Air molecules individually only obey so many laws, but when they come together, they can flow like a fluid. There are all kinds of complex weather phenomena that arise from the individual interactions."

Story by Joshua Stewart • Supported by Army Research Office and Georgia Tech President's Undergraduate Research Award.

Robotic Motion in Curved Space Defies Standard Laws of Physics

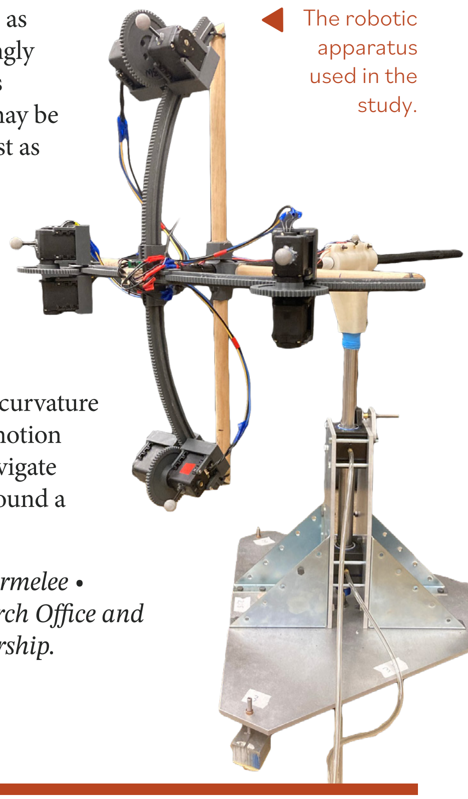
When humans, animals, and machines move throughout the world, they push against something, whether it's the ground, air, or water. Until recently, physicists believed this to be universal, following from the law of conservation of momentum. Now, Georgia Tech researchers have proven the opposite — when bodies exist in curved spaces, they can in fact move without pushing against something.

A team of researchers led by **Zeb Rocklin** created a robot confined to a spherical surface with unprecedented levels of isolation from its environment, so that these curvature-induced effects would predominate.

"We let our shape-changing object move on the simplest curved space, a sphere, to systematically study the motion in curved space," says Rocklin, assistant professor in the School of Physics. "We learned that the predicted effect, which was so counterintuitive it was dismissed by some physicists, indeed occurred: As the robot changed its shape, it inched forward around the sphere in a way that could not be attributed to environmental interactions."

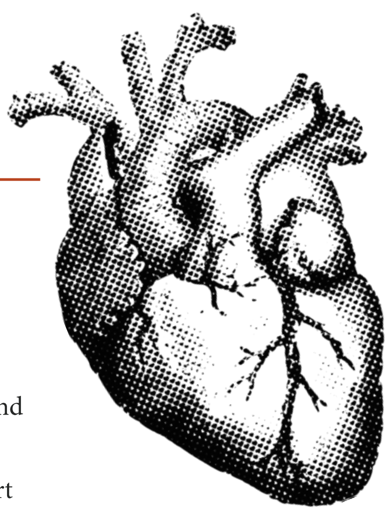
While the effects are small, as robotics becomes increasingly precise, understanding this curvature-induced effect may be of practical importance, just as the slight frequency shift induced by gravity became crucial to allow GPS systems to accurately convey their positions to orbital satellites. Ultimately, the principles of how a space's curvature can be harnessed for locomotion may allow spacecraft to navigate the highly curved space around a black hole.

Story by Georgia Robert Parmelee • Supported by Army Research Office and the Dunn Family Professorship.



The robotic apparatus used in the study.

Researchers Map Rotating Spiral Waves in Live Human Hearts



The findings could help treat deadly arrhythmias

Electrical signals tell the heart to contract, but when the signals form spiral waves, they can lead to dangerous cardiac events like tachycardia and fibrillation. As part of a decade-long collaboration between the Georgia Tech School of Physics and the Emory School of Medicine, researchers are bringing a new understanding to complicated cardiac conditions with the first high-resolution visualizations of stable spiral waves in human ventricles.

"Clinicians have known for decades that spiral waves of electrical activity can occur in the heart, and researchers have done experiments in animal and human hearts before," says School of Physics Professor **Flavio Fenton**. "However, this is the first time the evolution of relatively stable, spiral waves of voltage and calcium in the ventricles of human hearts have been mapped at very high spatial and temporal resolution."

Flavio Fenton, professor in the School of Physics.

Studying live hearts from heart transplant patients gives a rare window into the detailed behavior of the heart during conditions that are difficult to treat like fibrillation. As a result, doctors can better understand how spiral waves begin and are sustained, which can lead to new therapies.

"We're very fortunate to have this strong collaboration between Emory and Georgia Tech to perform these experiments," Fenton notes. "There are very few physicians who, in addition to treating patients, want to partner with physicists to investigate arrhythmias."

Story by Tess Malone • Supported by NIH and NSF.

To Help Recover Balance, Robotic Exoskeletons Have to be Faster Than Human Reflexes

Even the most advanced robots and wearables, like robotic exoskeletons, have trouble replicating how our brains and bodies work together to keep us balanced. A new study from researchers at Georgia Tech and Emory University is taking the first step toward addressing this balance problem.

In a paper published in *Science Robotics*, the group showed that an ankle exoskeleton must react faster than our bodies to improve balance. The findings “flip the narrative a bit” for these kinds of robotic tools, as co-author and associate professor in the George W. Woodruff School of Mechanical Engineering and the School of Biological Sciences **Greg Sawicki** put it.

“One thing that’s really special about this is we were able to ask a very specific question about the interaction between the exoskeleton and the human and understand a bit more about how exoskeleton either helps or disrupts human physiological responses,” says **Max Shepherd**, a postdoctoral fellow at Georgia Tech during the study and now an assistant professor at Northeastern University. “This study is a very clean way to offer insight into improving balance, which could become a very, very big subfield within exoskeletons.”

Story by Joshua Stewart • Supported by NIH and the McCamish Parkinson’s Disease Innovation Program.

The ankle exoskeleton used in the study. *CANDLER HOBBS*

A New Framework for Measuring Stability During Walking

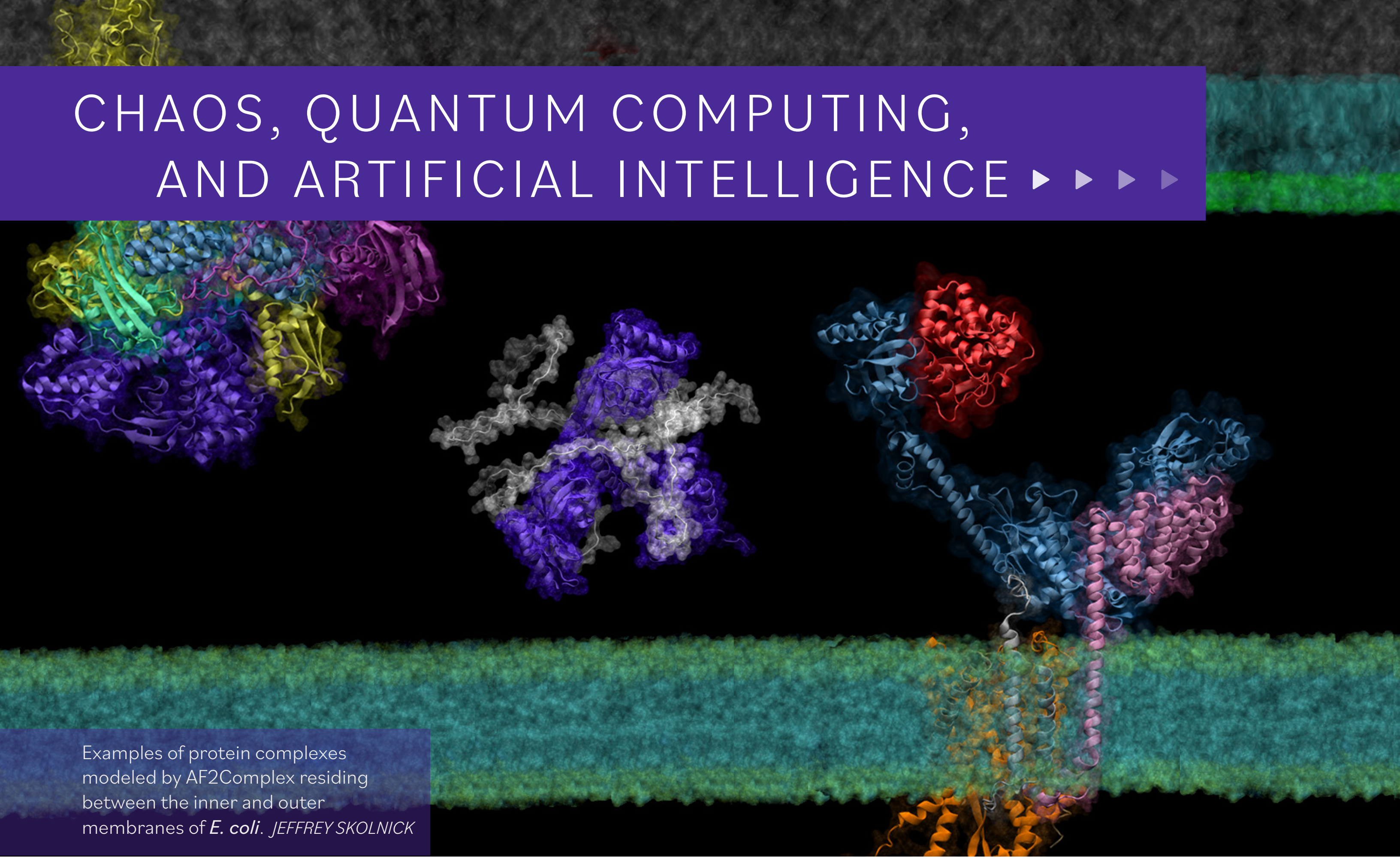
Greg Sawicki (left) and Pawel Golyski on the instrumented treadmill and immersive virtual reality system used to conduct the study.

While there has been extensive research into the biomechanics of falls, most current approaches study how the legs, joints, and muscles act separately — rather than as a system — to respond. The ability to measure how these different levels relate to each other could paint a much clearer picture of why someone falls and precisely how their body compensates. Until recently, however, an integrated measuring approach has been elusive.

In newly published research, **Greg Sawicki**, associate professor in the George W. Woodruff School of Mechanical Engineering and the School of Biological Sciences, and **Pawel Golyski**, a graduating member of Sawicki’s Physiology of Wearable Robotics (PoWeR) Lab, investigated whether mechanical energy can be used as a “common currency” to measure how humans use lower limbs for stability while walking. Their research lays the groundwork for using mechanical energetics to understand the roles of joints and muscles during unsteady locomotion. The paper also contributed to Golyski’s selection as this year’s recipient of the American Society of Biomechanics’ (ASB) Pre-Doctoral Achievement Award, a prestigious honor that considers a candidate’s entire portfolio of publications.

Their new framework could assist in determining which part of a person’s body manages responses to destabilizing energy, pointing to specific muscles or joints to target with rehabilitation therapy. It could also open doors to advanced exoskeletons and prostheses that target specific joints to restore stabilizing responses in individuals with impaired balance.

Story by Catherine Barzler • Supported by NSF and the U.S. Army Natick Soldier Research, Development, and Engineering Center.



Examples of protein complexes modeled by AF2Complex residing between the inner and outer membranes of *E. coli*. *JEFFREY SKOLNICK*

AF2Complex 'Computational Microscope' Predicts Protein Interactions, Potential Paths to New Antibiotics

Though a cornerstone of virtually every process that occurs in living organisms, the proper folding and transport of biological proteins is a notoriously difficult and time-consuming process to experimentally study.

In a new paper published in *eLife*, researchers in the School of Biological Sciences and the School of Computer Science have shown that AF2Complex may be able to lend a hand.

AF2Complex — short for AlphaFold 2 Complex — is a deep learning tool designed to predict the physical interactions of multiple proteins. With these predictions, AF2Complex is able to calculate which proteins are likely to interact with each other to form functional complexes in unprecedented detail.

With AF2Complex, it's "like using a computational microscope powered by deep learning and supercomputing," explains **Jeffrey Skolnick**, Georgia Research Alliance Eminent Scholar in Computational Systems Biology and one of the corresponding authors of the study. Skolnick is also a Regents' Professor and the Mary and Maisie Gibson Chair in the School of Biological Sciences.

In their latest study, the researchers used this "computational microscope" to examine a complicated protein synthesis and transport pathway. They sought to clarify how proteins in the pathway interact and ultimately transport a newly synthesized protein from the interior to the outer membrane of the bacteria, and additionally identify players previous experiments might have missed. Insights into this pathway may find new targets for antibiotic and therapeutic design. They could also provide a foundation for using AF2Complex to computationally expedite this type of biology research as a whole.

Computing complexes

AF2Complex builds upon AlphaFold 2, a deep learning tool created by London-based artificial intelligence lab DeepMind. This tool is able to generate accurate predictions about the three-dimensional structure of single proteins using just their building blocks: amino acids. Taking things a step further, AF2Complex uses these structures to predict the likelihood that proteins are able to interact to form a functional complex, where the likely interaction sites are, and even which protein complexes are expected pair up to create even larger functional groups called supercomplexes.

"The successful development of AF2Complex makes us believe that this approach has tremendous potential in identifying and characterizing the set of protein-protein interactions important to life," says **Mu Gao**, a senior research scientist at Georgia Tech. "To further convince the broad molecular biology community, we [had to] demonstrate it with a more convincing, high impact application."

To showcase the tool's power, the researchers chose to apply AF2Complex to a pathway in *Escherichia coli* (*E. coli*) in order to examine the synthesis and transport of proteins essential for exchanging nutrients and responding to environmental stressors: outer membrane proteins, or OMP for short.

Using the Summit supercomputer at the Oak Ridge National Laboratory, the team, which also included computer science undergraduate **Davi Nakajima An**, put AF2Complex to the test. They compared a few proteins known to be important in the synthesis and transport of OMP to roughly 1,500 other proteins — all of the known proteins in *E. coli*'s cell envelope — to see which pairs the tool computed as most likely to interact, and which of those pairs were likely to form supercomplexes.

"Encouragingly," says Skolnick, "among the top hits from computational screening, we found previously known interacting partners." Even within those protein pairs known to interact, AF2Complex was able to highlight structural details of those interactions that explain data from previous experiments, lending confidence to the tool's accuracy.

In addition to known interactions, AF2Complex predicted several unknown pairs. Digging further into these unexpected partners revealed details on what aspects of the pairs might interact to form larger groups of functional proteins, likely active configurations of complexes that have previously eluded experimentalists, and new potential mechanisms for how OMP are synthesized and transported.

"Since the outer membrane pathway is both vital and unique to gram-negative bacteria, the key proteins involved in this pathway could be novel targets for new antibiotics," says Skolnick. "As such, our work that provides molecular insights about these new drug targets might be valuable to new therapeutic design."

The tool's accuracy is currently being put to the test by biologists. "Indeed," Gao notes, "the computational predictions of these protein complexes are being confirmed by new experimental studies."

Story by Audra Davidson • Supported by the Department of Energy, National Institute of General Medical Sciences, Advanced Scientific Computing Research, and Partnership for an Advanced Computing Environment (PACE) at Georgia Tech.

School of Biological Sciences faculty members Jeffrey Skolnick, Georgia Research Alliance Eminent Scholar in Computational Systems Biology, Regents' Professor, and Mary and Maisie Gibson Chair (left); and Mu Gao, senior research scientist. *JESS HUNT-RALSTON*

Brook trout, a species of freshwater fish students are modeling using VERA.

AI-ALOE Brings AI-Based Ecological Research Power to Local Technical College

During the summer of 2022, **Duncan Hughes**, an instructor at North Georgia Technical College, introduced his students to the web application Virtual Ecological Research Assistant, better known as VERA. It allowed students to construct conceptual models and ecological systems, as well as run interactive model simulations on the brook trout, a species of freshwater fish.

VERA was developed by the Design & Intelligence Lab at Georgia Tech in collaboration with Encyclopedia of Life. The technology is being used by students as an assistive tool and is publicly accessible. The data being collected from the students' usage is part of the research conducted at the NSF AI Institute for Adult Learning and Online Education (AI-ALOE).

"This is our way of providing an accessible and informal learning tool," says **Ashok Goel**, director and co-principal investigator of AI-ALOE and computer science professor at Georgia Tech. "Using VERA as an assessment tool is excellent. These students are using VERA in a way we are not."

The technical college has plans to introduce VERA to another classroom, held by Natural Resource Management instructor **Kevin Peyton**.

Story by Breon Martin • Supported by NSF.

Quantum CAREERs

Learn about three College of Sciences researchers who received grants from the National Science Foundation's Faculty Early Career Development (CAREER) Program to continue their work on quantum methods, chaos, and more.

Stories by Selena Langner • Supported by NSF CAREER.

The Fundamental Questions: Predicting Chemical Reaction Rates

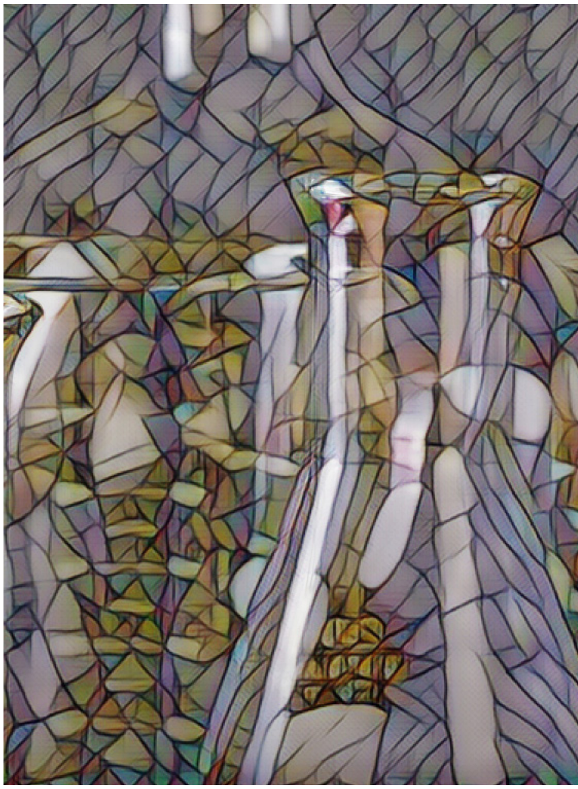
Jesse McDaniel, assistant professor in the School of Chemistry and Biochemistry.

Chemists currently use quantum chemistry techniques to predict the rates and energies of chemical reactions, but the method is limited: Predictions can usually only be made for up to a few hundred atoms. In order to scale the predictions to larger systems, and predict the environmental effects of reactions, a new framework needs to be developed.

Jesse McDaniel is creating that framework by leveraging computer modeling techniques with support from a new NSF CAREER grant.

"Chemical reactions are inherently quantum mechanical in nature," explains McDaniel, who is an assistant professor in the School of Chemistry and Biochemistry. "Electrons that rearrange as chemical bonds are broken and formed." McDaniel's team is developing modeling techniques based on quantum chemistry that could function over multiple scales, using computer models to scale the predictions. They hope this will help predict environmental effects on chemical reaction rates.

"Our goal is to understand the microscopic mechanisms and intermolecular interactions through which chemical reactions are accelerated within unique solvation environments, such as microdroplets, thin films, and heterogeneous interfaces," McDaniel says, adding that he hopes it will allow for computational modeling of chemical reactions in much larger systems. "I am excited about the CAREER research because we are really focusing on fundamental questions that are central to all of chemistry."



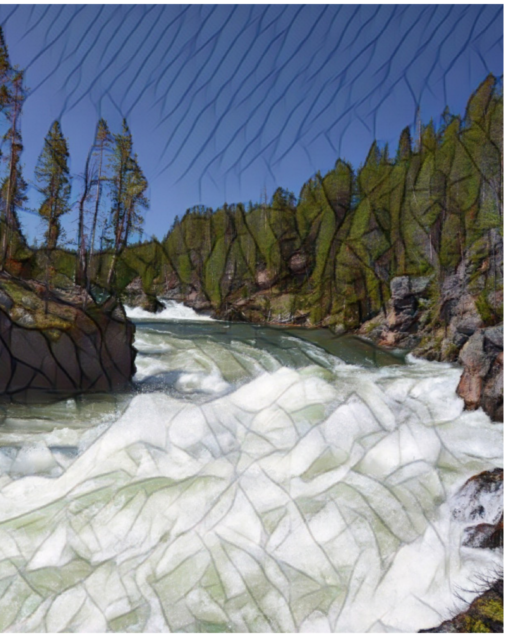
"I am excited about the CAREER research because we are really focusing on fundamental questions that are central to all of chemistry."

— **Jesse McDaniel**

"This relationship is going to benefit both areas tremendously. It significantly increases the number of tools we can use."

— **Anton Bernshteyn**

Chasing Chaos and Fluid Dynamics



Imagine predicting the exact motion of particles in a patch of whitewater, or recreating the exact way frothy water pours from a faucet into a full sink. **Alex Blumenthal**, assistant professor in the School of Mathematics, has been awarded an NSF CAREER grant to work toward just that.

Alex Blumenthal, assistant professor in the School of Mathematics.

The award will help Blumenthal continue tackling some of the most difficult questions in his field – those of chaotic fluid dynamics. Because Blumenthal's work with fluid dynamics intersects with chaos and disorder, the impacts of his work range from weather prediction to how we model economics.

Another key application of the research? The development of a new problem-solving framework based on probability theory, which Blumenthal plans to investigate with the CAREER grant as a key for unlocking new research into broader turbulence and chaos problems.

The grant also includes funding to bring students to the forefront of the field. "One cool thing about these systems is that they lend themselves to a lot of computational projects that are accessible to undergraduates," Blumenthal says. He expects the intersection with data science will be particularly interesting to undergraduates.

Solving Infinite Problems: A New, Unified Theory of Descriptive Combinatorics and Distributed Algorithms

Anton Bernshteyn, assistant professor in the School of Mathematics.

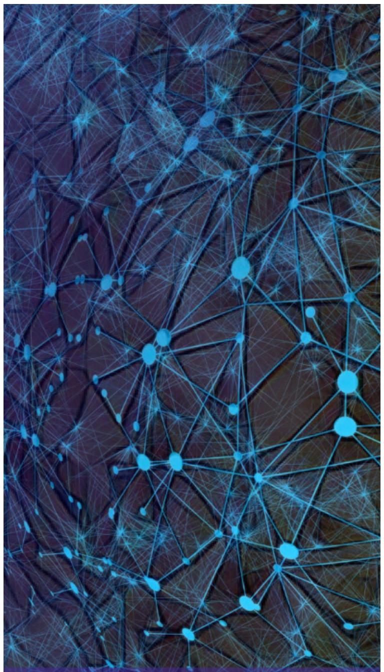
Anton Bernshteyn is forging connections and creating a language to help computer scientists and mathematicians collaborate on new problems — in particular, bridging the gap between solvable, finite problems and more challenging, infinite problems.

Bernshteyn, an assistant professor in the School of Mathematics, will focus on "developing a unified theory of descriptive combinatorics and local algorithms" — connecting concepts and work being done in two previously separate mathematical and computer science fields.

By pioneering this connection, Bernshteyn hopes to connect techniques mathematicians use to study infinite structures with the algorithms computer scientists use to model large — but still limited — interconnected networks and systems.

"The final goal, for certain types of problems," Bernshteyn explains, "is to take all these questions about complicated infinite objects and translate them into questions about finite structures, which are much easier to work with and have applications in practical, large-scale computing.

"This relationship is going to benefit both areas tremendously. It significantly increases the number of tools we can use."



ILLUSTRATIONS BY SELENA LANGNER

Mathematicians Discover Highly Efficient Method for Solving 'Hard Minimal Problems'

A team led by School of Mathematics Professor **Anton Leykin** has developed a powerful new technique for solving problems related to 3D reconstruction, and implications of the new research span from math to helping autonomous vehicles use 2D camera images to "see" in three dimensions.


Anton Leykin, professor in the School of Mathematics.

The research team's open-access paper, "Learning to Solve Hard Minimal Problems," has also won the prestigious best paper award at CVPR 2022 — selected from a pool of over 8,000 papers submitted last year.

The team's research idea revolved around developing a new way to solve a family of problems known as "hard minimal problems," which are essential for 3D reconstruction. "A minimal problem is the smallest geometric problem one can consider in the 3D reconstruction context," Leykin explains. "For example, recovering a 3D scene consisting of five points from two views (two-dimensional images of five points in the plane) without knowing the relative position and orientation of the second camera with respect to the first."

Since the technique the researchers developed is general, Leykin said it can be applied to many other situations with similar mathematical problems. In addition, the software pieces derived from the researchers' findings are in the public domain, and can be used by a broad computer vision community.

Story by Selena Langner • Supported by NSF.

Jen Hom Named 2023 American Mathematical Society Fellow


Jen Hom, professor in the School of Mathematics.

Jen Hom, professor in the School of Mathematics, has been named to the 2023 Class of Fellows of the American Mathematical Society for her "contributions to low-dimensional topology, Heegaard Floer homology, and service to the mathematical community."

The Fellows of the American Mathematical Society program recognizes members who have made outstanding contributions to the creation, exposition, advancement, communication, and use of mathematics.

Hom's research focuses on "knots, surfaces, and their higher dimensional analogs," referring to certain mathematical structures embedded in three-dimensional space. Rather than the kinds of knots used in ropes and shoelaces, for example, the ends of strings in mathematical knots are joined together. "Surfaces," meanwhile, refer to the outsides of malleable geometric shapes.

Story by Renay San Miguel • Supported by the American Mathematical Society.

Machine Learning Maestros

GEORGIA TECH'S MACHINE LEARNING EXPERTS, including **Wenjing Liao**, an associate professor in the School of Mathematics, shared their knowledge at the International Conference on Machine Learning this July, investing in a future where artificial intelligence solutions can benefit individuals and communities across our planet. Highlights of the event, which took place in Honolulu, Hawaii, included talks, workshops, and a student video series.

Mathematicians at the Forefront of Research with ICERM at Brown

School of Mathematics Professor **Rachel Kuske** has been named board chair for the Institute for Computational and Experimental Research in Mathematics (ICERM) at Brown University, strengthening a long-standing partnership between Georgia Tech and a top mathematics lab for numbers-crunching researchers.

Kuske's new role with ICERM is just one Georgia Tech connection to the Center: More than 20 School of Mathematics faculty members and graduate students have participated in recent ICERM programs, including a series of seminars during the Fall 2022 semester on harmonic analysis and convexity, mathematical processes that help researchers navigate large collections of data. "Georgia Tech's multifaceted involvement in ICERM benefits our research groups and advances both research and development of talent in the wider research community," says Kuske.

Story by Renay San Miguel.

Rachel Kuske, professor in the School of Mathematics.

Vempala, Baker Recognized by the Simons Foundation

Santosh Vempala Named Simons Investigator

Santosh Vempala, Frederick Storey II Chair of Computing and Distinguished Professor in the School of Computer Science with courtesy appointments in the School of Mathematics and H. Milton Stewart School of Industrial and Systems Engineering.

Santosh Vempala has been named a 2023 Simons Investigator in theoretical computer science by the Simons Foundation. The Simons Investigator award supports "outstanding theoretical scientists in their most productive years."

Vempala holds courtesy appointments in the School of Mathematics and the H. Milton Stewart School of Industrial and Systems Engineering, and serves as the Frederick Storey II Chair of Computing and Distinguished Professor in the School of Computer Science at Georgia Tech.

Vempala will receive $150,000 per year for five years, which could be renewed for another five years. Not constrained to any one project, the funding is meant to empower award recipients to push forward on foundational challenges to computer science that are related to their interests.

"This is a great recognition for Santosh that is not only a testament to his accomplishments but also a positive reflection on Georgia Tech," says **Vivek Sarkar**, the chair of the School of Computer Science and the Stephen Fleming Chair for Telecommunications in the College of Computing. "Simons Investigators include world-class leaders in astrophysics, computer science, mathematics, biology, and physics, placing Santosh in excellent company."

Matt Baker Elected Simons Foundation Fellow

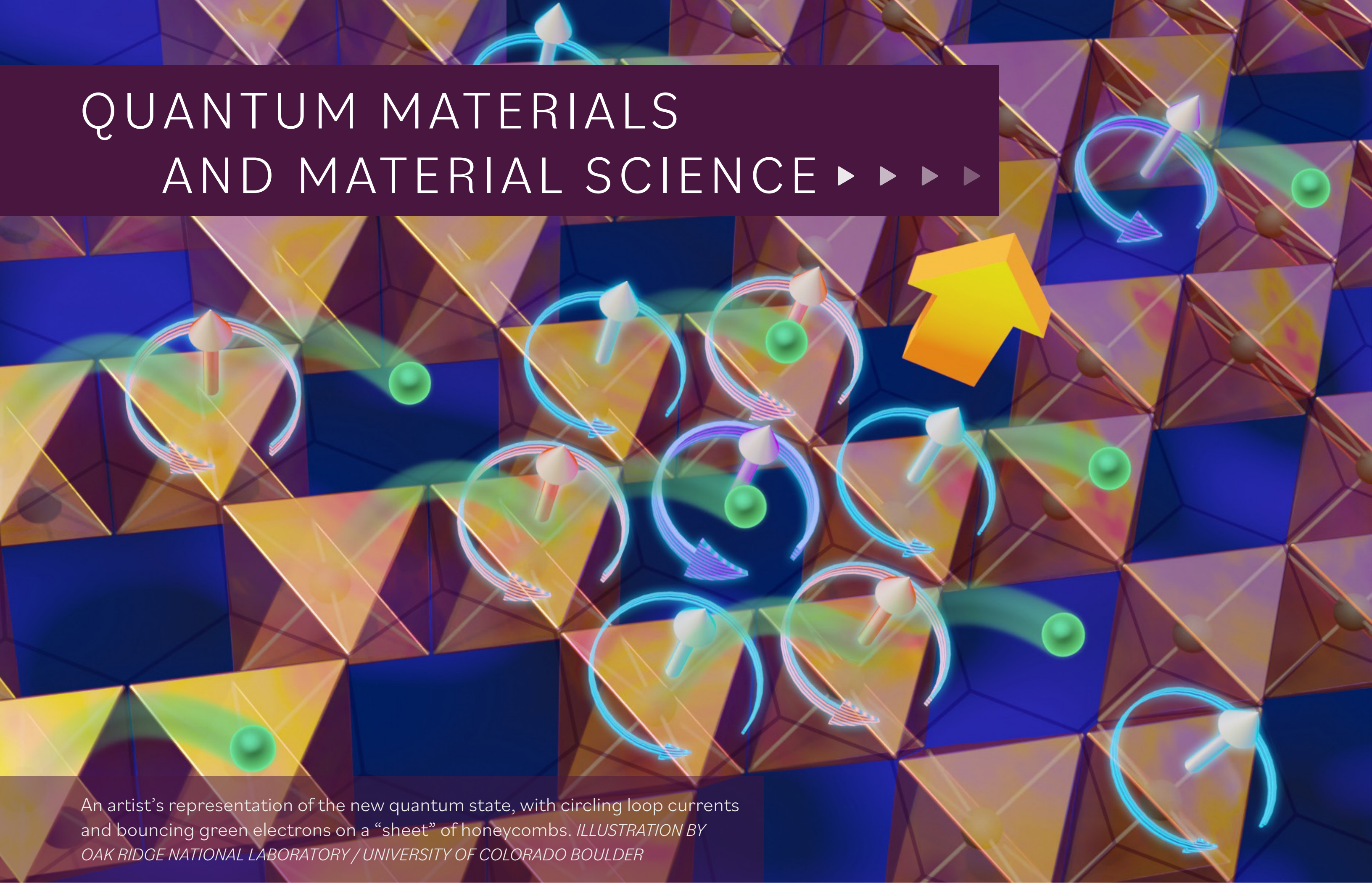
Matt Baker is one of 39 researchers named to the 2023 Class of Simons Fellows. The Simons Fellows are part of the Simons Foundation's mission to support discovery-driven scientific research undertaken in pursuit of understanding the phenomena of our world. It provides funds to faculty for up to a semester-long research leave from classroom teaching and administrative obligations.

Matt Baker, professor in the School of Mathematics.

"I'm really excited to have the opportunity to pursue some intellectual projects that I haven't had time for in the recent past," says Baker, a professor in the School of Mathematics. "And I'm grateful to the School of Mathematics, the College of Sciences, and the Simons Foundation for their support."

"The Simons Fellowships have become a principal distinction for senior mathematicians," explains **Michael Wolf**, professor and chair of the School of Mathematics. Annually, "only about 40 mathematicians in the U.S. and Canada receive these awards, and they go to the mathematical scientists with the best research records in the previous five years, whose potential to use a semester to think promises the greatest possibilities. The awardees are the household names of the mathematicians doing the best current work nationally, and while it is natural to see Matt included, it is still a wonderful statement of how his impact is appreciated by his colleagues in this country."

Story by Renay San Miguel and Morgan Usry • Supported by the Simons Foundation.



An artist's representation of the new quantum state, with circling loop currents and bouncing green electrons on a "sheet" of honeycombs. *ILLUSTRATION BY OAK RIDGE NATIONAL LABORATORY / UNIVERSITY OF COLORADO BOULDER*

New Quantum State Discovered in Trimer-Honeycomb Material

A group of physicists that includes two Georgia Tech researchers have discovered a new quantum state. The study, published in the journal *Nature*, uncovered novel looping currents flowing along the edges of octahedral cells in a crystal of $Mn_3Si_2Te_6$, which allowed for a billion-percent increase in the material's electric conductivity. The findings could lead to a new paradigm for quantum devices and superconductors.

The team consists of Georgia Tech theoretical physicists **Sami Hakani** and **Itamar Kimchi**, along with experimental physicists **Feng Ye** (Oak Ridge National Lab), **Lance DeLong** (University of Kentucky), and **Gang Cao**, **Yifei Ni**, **Yu Zhang**, and **Hengdi Zhao** from the University of Colorado at Boulder. The group was drawn to the research after their previous study investigated the same material.

"Because this material did not fit any preexisting models, we had to develop new ideas to understand it," says Hakani, who played a key role in developing the theory. "These new ideas will help us study related materials that could be used for next-generation magnetic field devices."

An exception to the rule

The physicists first became interested in the material due to its unique electrical properties — in particular, a property called "colossal magnetoresistance," an extreme enhancement in a material's electrical conductivity when a magnetic field is applied.

In instances of colossal magnetoresistance, a material can change from behaving like an insulator — like Styrofoam — to being as conductive as a metal wire.

Materials displaying giant magnetoresistance are not uncommon and are often used in computers; however, in all of these known materials, the material does not change its behavior in a way that significantly depends on the direction of the applied magnetic field. This new trimer-honeycomb material does.

"The phenomenon defies all existing theoretical models and experimental precedents," says Kimchi, an assistant professor in the School of Physics. And that's where he and Hakani come in.

School of Physics graduate student Sami Hakani (left) and Assistant Professor Itamar Kimchi. *JESS HUNT-RALSTON*

Uncovering looping currents

Using the information uncovered by experimental physicists, Hakani and Kimchi set out to understand why the extreme change in conductivity only happens when the magnetic field is applied perpendicularly to the honeycomb-like surface of the material.

They found that, viewed from above, the material looks like a series of two-dimensional honeycombs. From the side, however, the material is composed of "sheets," like a layer cake. Within each sheet of honeycomb, electrons can move in circular paths around each octahedral cell. These looping, circular-moving currents within the material are responsible for the material's unique behavior.

On its own, without a magnetic field present, electrons move around the honeycomb cells, like cars going in both directions around a roundabout. Just like in uncontrolled traffic, this makes it difficult for electrons to move quickly throughout the material. Without a way to streamline traffic, the material acts more like an insulator.

However, if a magnetic field is applied perpendicularly to the honeycomb-like surface, a "flow of traffic" is established, and electrons navigate the loops more quickly. The material then acts as a conductor, showing a seven-magnitude increase in conductivity — equivalent to an increase of a billion percent.

A new paradigm

The transformation from insulator to conductor can also be driven by applying electrical currents in the material, but in that case, it doesn't happen instantaneously. It can take seconds or even minutes for the material to switch from insulator to conductor.

The team believes that this slower type of switching, coupled with the material's sensitivity to currents, could lead to new applications and discoveries in current-controlled quantum devices, a field of devices that range from sensors to computers to secure communication.

The next step? Working to better understand the newly discovered quantum state, and finding other materials where the quantum state might exist.

Story by Selena Langner • Supported by NSF and the Department of Energy.

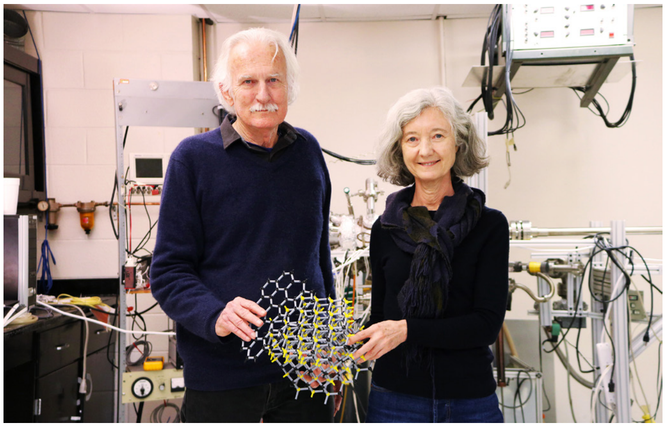
> "These new ideas will help us study related materials that could be used for next-generation magnetic field devices."
>
> — **Sami Hakani**, Ph.D. student in the School of Physics

At the Edge of Graphene-Based Electronics

With silicon nearly maxed out in its ability to accommodate faster computing, the next big nanoelectronics platform is needed now more than ever.

Walter de Heer, **Claire Berger**, and their collaborators have now developed a new nanoelectronics platform based on graphene — a single sheet of carbon atoms. The technology is compatible with conventional microelectronics manufacturing, a necessity for any viable alternative to silicon. In the course of their research, the team may have also discovered a new quasiparticle. Their discovery could lead to manufacturing smaller, faster, more efficient, and more sustainable computer chips, with potential implications for quantum and high-performance computing.

It will likely be another five to 10 years before we have the first graphene-based electronics, according to de Heer. But thanks to the team's new epitaxial graphene platform, technology is closer than ever to crowning graphene as a successor to silicon.



▲ School of Physics faculty members Walter de Heer, Regents' Professor (left), and Claire Berger, professor of the practice, holding an atomic model of graphene (black atoms) on crystalline silicon carbide (yellow atoms) in the Epitaxial Graphene Lab at Georgia Tech. *JESS HUNT-RALSTON*

Story by Catherine Barzler • Supported by NSF, Department of Energy, Agence Nationale de la Recherche, National Natural Science Foundation of China, and the Department of Education in China.

Going Back to Basics Yields a Printable, Transparent Plastic That's Highly Conductive

James Ponder and a team of Georgia Tech chemists and engineers have designed a transparent polymer film that could conduct electricity as effectively as other commonly used materials, while also being flexible and easy to use at an industrial scale.

The resulting process could yield new kinds of flexible, transparent electronic devices — items like wearable biosensors, organic photovoltaic cells, and virtual or augmented reality displays and glasses.

"We had this initial idea that we have a conductive element that we're covering with a nonconductive material for processing. So what if we just get rid of that? We should improve performance," explains Ponder, who earned a Ph.D. in chemistry at Georgia Tech and returned as a research scientist in mechanical engineering. "It's a simple idea, and there were so many points where it could have failed for different reasons. But it does work, and it works better than we expected."

The team already is attracting attention for their material, which they call PEDOT(OH). They have a patent application in process and are meeting with industry collaborators interested in licensing the technology because of a few key advantages of the films.

Story by Joshua Stewart • Supported by the Office of Naval Research, NSF, Department of Education Graduate Assistance in Areas of National Need, Link Energy Foundation, the Center for the Science and Technology of Advanced Materials and Interfaces (STAMI) , and Department of Energy.

The polymer created by Georgia Tech researchers is initially a reflective bluish color when it's cast as a film and not transparent. Further processing results in a flexible, highly conductive, transparent plastic. *JAMES PONDER*

Directed by Henry (Pete) La Pierre, associate professor in the School of Chemistry and Biochemistry (left), the Transuranic Chemistry Center of Excellence also includes Georgia Tech collaborators Anna Erickson, Woodruff Professor and associate chair for Research in the George W. Woodruff School of Mechanical Engineering (center); and Martha Grover, professor and associate chair for Graduate Studies in the School of Chemical and Biomolecular Engineering. *JESS HUNT-RALSTON*

Georgia Tech Researchers Receive $11.6 Million to Establish the Transuranic Chemistry Center of Excellence

Safeguarding and maintaining nuclear defense materials using modern techniques is a critical mission of the U.S. Department of Energy's National Nuclear Security Administration (NNSA), driving renewed investments into nuclear science and engineering.

Georgia Tech researchers were recently awarded $11.6 million from the NNSA to address this growing need — and to study and expand on existing models of transuranic chemistry, a branch of chemistry dedicated to studying elements with atomic numbers greater than that of uranium.

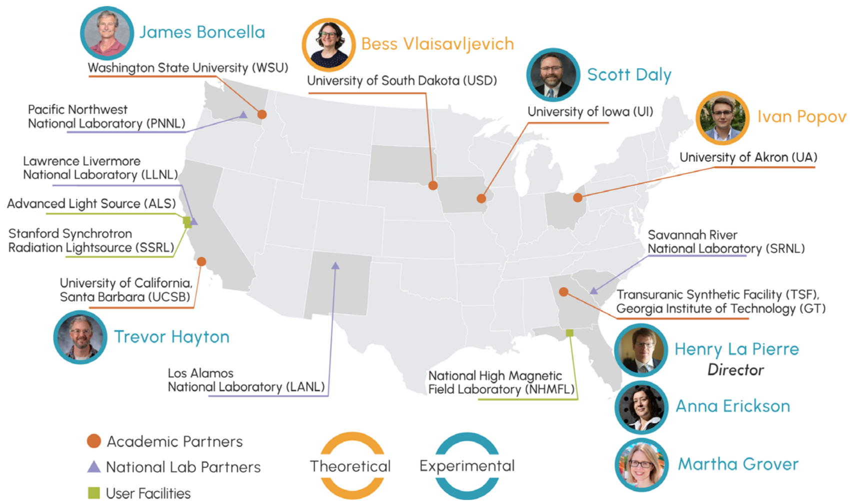
Led by Georgia Tech's **Henry (Pete) La Pierre**, the funding will serve to establish the Transuranic Chemistry Center of Excellence, which will house a collaborative network of universities and national laboratories across the United States conducting both theoretical and applied research.

"Scientifically, actinides and transuranic elements present unique challenges to existing models of chemical bonding," explains La Pierre. These elements are human-made radioactive metals, many of which are not available in large quantities. "There are amazing open-ended questions fundamental to our understanding of chemical bonding and activities that transform our knowledge of how the elements form bonds across the periodic table."

This funding comes to Georgia Tech as part of NNSA's $100 million program establishing Stewardship Science Academic Alliances Centers of Excellence, which aims to recruit, train, and educate the next generation of researchers in nuclear science and engineering.

"The science and engineering collaboration of this center is a true synergy," says Georgia Tech's **Martha Grover**, who will be part of the Center. Fellow Georgia Tech collaborator **Anna Erickson** adds that the Center "provides a new example of the growing prominence of Georgia Tech in the nuclear field."

Story by Audra Davidson • Supported by Department of Energy's National Nuclear Security Administration.



▲ Led by Georgia Tech, the Center will include six universities, four national laboratories, and two user facilities. *JULIE NIKLAS*

Climate author Zahra Biabani signs a copy of her book as part of the launch event for the new undergraduate degree in environmental science. *ALL PHOTOS ROB FELT*

New Environmental Science Degree Launches at Georgia Tech

Georgia Tech's newest interdisciplinary degree program, the Environmental Science B.S. degree (ENVS), has launched and is now enrolling students.

Developed jointly by faculty of the School of Earth and Atmospheric Sciences and the School of Biological Sciences, the ENVS degree provides a strong foundation in the basic sciences, requiring core content in mathematics, physics, chemistry, biology, earth sciences, and environmental policy. Flexible electives in upper-level coursework will allow students to customize their studies to their interests and career goals.

"The new degree will prepare students to be future leaders who are well-versed on how the Earth's systems can be influenced by human activity and contribute to human well-being," says **Greg Huey**, professor and chair of the School of Earth and Atmospheric Sciences. "Graduates will be positioned to be leaders in industry, academia, education, and communications to create innovative solutions to the most significant environmental challenges of our time."

Two faculty members in Earth and Atmospheric Sciences and a faculty member in the School of Biological Sciences serve as inaugural leadership: **Jennifer Glass**, associate professor, is program director; **Samantha Wilson**, senior academic professional, is director of Undergraduate Studies; and **Linda Green**, senior academic professional in Biological Sciences, is director of Experiential Learning.

The foundational science classes in this new degree are joined by courses in public policy and city planning, including geographical information systems and environmental policy and politics, as well as options that provide students with flexibility in course options to better fit their career paths and interests.

“Past students have been interested in careers related to environmental consulting, environmental law, and continuing their studies in graduate school,” Wilson says. “The variety of environmental career paths was the driver behind allowing students to diversify their options within the degree.”

“This degree gives Georgia Tech students a unique opportunity to customize their program of study to their interests and career goals in science, policy, public service, nonprofits, government, industry, academia, or beyond,” adds Glass. “We are committed to building an academic community in ENVS that values student leadership, diversity, inclusion, equity, accessibility, and belonging.”

Hands-on learning opportunities will include field station experiences and field trip excursions, study abroad programs, and internships, Green says. “This major sustains the Institute’s strategic plan to lead by example, champion innovation, and connect globally — particularly in an area so critical as addressing Earth’s environmental issues.”

Glass notes that the schools of Chemistry and Biochemistry, Biological Sciences, and Earth and Atmospheric Sciences are currently revamping several classes to incorporate the United Nations Sustainable Development Goals (SDGs). Students will advance to be global leaders of environmental solutions that draw upon the SDGs and incorporate awareness of environmental justice issues.

A degree launch event in August welcomed 100 students, faculty, and staff to celebrate the new program. Held in The Kendeda Building for Innovative Sustainable Design in the heart of Georgia Tech's Atlanta campus, the kickoff featured remarks by Georgia Tech President **Ángel Cabrera**, College of Sciences Dean **Susan Lozier**, program directors, and a keynote by **Zahra Biabani**, author of *Climate Optimism: Celebrating Systemic Change Around the World*.

Story by Renay San Miguel.

College of Sciences Honors Faculty and Staff at Spring Sciences Celebration

Joined by alumni and friends, the College of Sciences community gathered in Harrison Square on April 18 to honor faculty and staff with awards for the 2022-23 school year during the Spring Sciences Celebration.

“It is nothing short of a pleasure to recognize outstanding faculty who excel in teaching and research,” says **Susan Lozier**, College of Sciences Dean and Betsy Middleton and John Clark Sutherland Chair, “and to celebrate the leadership and commitment to excellence of our remarkable staff members across the College.”

At the annual celebration, Lozier and the College recognized 18 faculty and staff members for excellence in mentorship, teaching, research, and leadership, while also welcoming 25 new faculty members who joined the College of Sciences for the 2022-23 academic year.

Story by Renay San Miguel • Supported by generous alumni.

Psychology Launches New Minor in the Science of Mental Health and Well-Being

Tansu Celikel, professor and chair in the School of Psychology (left), and Tiffiny Hughes-Troutman, who serves as director of the program. *JESS HUNT-RALSTON*

Whether it's diagnosing an ailment, preventing it, or alleviating its symptoms, conversations about health often center around illness. The same can be said about mental health.

With a new minor in the science of mental health and well-being in the School of Psychology, **Tiffiny Hughes-Troutman** is hoping to balance the conversation. The minor gives students practical tools to build mental wellness and conceptualize mental health, well-being, and other constructs in neuroscience.

"I view this as a really great opportunity not only to infuse content about health and well-being into the curriculum for students, but also as a pivotal step that students can take to foster a greater sense of health and well-being for themselves," says Hughes-Troutman, a professor of the practice in the School of Psychology and a licensed psychologist. "Through this minor, we aim to help students cope with pressures and stress, and ensure that they understand the relation between increased well-being, higher productivity, enhanced learning, and a stronger sense of connectedness and purpose."

Cultivating well-being is a key component of Georgia Tech's strategic plan, and bringing wellness into the curriculum has been a vital step toward that goal across the Institute.

"As we aim to instill students with a wide range of fundamental knowledge and skills that can benefit them throughout their lives," says **Tansu Celikel**, professor and chair of the School of Psychology, "this minor will be of interest to all students across the Institute."

Launched in the Fall 2023 semester, the minor includes a new course co-taught by Celikel and Hughes-Troutman called Neuroscience of Mental Health: Research and Practice. In the class, Hughes-Troutman says, "We're taking a deep dive into what happens in the brain, practical applications to enhance well-being, and other ways that students can increase positive affective states such as joy and happiness — while minimizing stress."

That course is linked with a Vertically Integrated Project (VIP) team that gives students hands-on experience assessing and building mental health and wellness. "Well-Being VIP students will work with students in the class using survey and biosensing data to give them accurate data and monitoring for their mental health," explains Hughes-Troutman. "They'll use apps and other e-tools to measure their levels of mindfulness, help them meditate, and reach their goals related to focus, attention, and relaxation. By the end of the class, students will have developed a portfolio that allows them to reflect upon and document a cadre of skills and experiences."

Students will also choose 12 credits of other courses offered as part of the program, including science of stress, anxiety, and happiness; mindfulness: science and practice; health psychology; and related class options exploring the neuroscience and psychology of mental health.

"The science of mental health and well-being curriculum highlights the importance of a comprehensive approach that considers both psychological and neurological factors maintaining mental well-being," says Celikel. "A deeper appreciation for the complexities of mental health conditions and their underlying mechanisms will help to reduce stigma and drive research and innovation in the field."

"The degree to which we can provide education about health and well-being," Hughes-Troutman adds, "that we can get students excited about those concepts, and that we can contribute to the greater good of our community at Georgia Tech so students are equipped with the skills to help themselves and others — it's just fantastic."

Story by Audra Davidson.

"I view this as a really great opportunity not only to infuse content about health and well-being into the curriculum for students, but also as a pivotal step that students can take to foster a greater sense of health and well-being for themselves."

— **Tiffiny Hughes-Troutman**, program director, professor of the practice in the School of Psychology, and licensed psychologist

Reimagining High School Math Day — and Multiplying the Fun

Ghenerune Ekuerhar, a ninth-grade student at Kennesaw Mountain High School, is focused intently on a puzzle at Georgia Tech's High School Math Day, held April 22 at Clough Undergraduate Learning Commons.

"It's pretty fun," she says, looking up from the logic challenge she's working to solve. "The first test, I was racking my brain trying to think of answers. But I really like these activities, because I have to think outside the box for a lot of them."

This year, organizers with the School of Mathematics reimagined the event — the first one held in person since Covid hit in 2020. Formerly called High School Math Competition Day, a tradition at Georgia Tech since 1958, the annual event is now simply known as High School Math Day.

It's an effort to get more students, including those from historically marginalized and underrepresented communities, thinking about math in a different way, and to have some fun and meet new friends and mentors along the way. With that in mind, the School reimagined the day around a variety of math activities, from group sessions and an algebra exam to logic-based games and puzzles.

"With the pandemic forcing a pivot in style for the competition, it made sense to relaunch the event in person with different foci and ambitions," says **Michael Wolf**, professor and chair of the School of Mathematics. "Part of the day still revolves around a competition by talented high school students who have learned a lot of math in their schools, competing as individuals, but there is plenty of fun and challenging mathematics that does not require a lot of background and can also be done productively in groups."

Some 250 students, parents, and teachers attended this year's event. The attendees came from 42 schools around the state.


About 250 students, parents, and teachers attended this year's Georgia Tech High School Math Day at Clough Undergraduate Learning Commons. *RENAY SAN MIGUEL*

"We wanted to broaden the appeal and make this a more inclusive event," says **Trevor Gunn**, Ph.D. student in the School of Mathematics and Math Day co-organizer, along with **Evelyne Smith-Roberge** and **Wade Bloomquist**, both visiting assistant professors. "We advertised to majority-minority counties in the area. And Atlanta is a very diverse region."

Wolf adds that the High School Math Day rebranding also resulted in some attendance growth, "and a lot of fun — for a lot of students. Going forward, we hope the word gets out and we are able to grow the participation to as many high schools as we can, with activities that are accessible and inspiring to high school students of any age, and with any mathematical background."

Story by Renay San Miguel.

Georgia Tech Hosts American Mathematical Society Spring Southeastern Sectional Meeting

This past spring, Georgia Tech hosted one of the largest regional meetings of mathematicians in the country. The 2023 Spring Southeastern Sectional Meeting of the American Mathematical Society (AMS) brought 800 mathematicians to campus for a theorem-filled weekend of sessions and lectures.

"Mathematics advances through sustained conversation, and one can see the hunger for personal connection that built up over the pandemic reflected in the large number of special sessions and the robust attendance," says **Michael Wolf**, professor and chair of the School of Mathematics.

Forty-one special sessions for the meeting focused on topics spanning combinatorics, the intersection of math and biology, geometric group theory, quantum systems, disease transmission, big data, and new methods for teaching math to undergraduates.

Story by Renay San Miguel.


Michael Wolf, professor and chair in the School of Mathematics.

Sciences Lands Howard Hughes Medical Institute Inclusive Excellence Grant

Four faculty in the College of Sciences have received new funding to help foster student belonging at Georgia Tech. The team's six-year grant is part of the Howard Hughes Medical Institute's (HHMI) Inclusive Excellence 3 initiative, and is one of 104 new grants funded through an overall initiative that's allocating $60 million over six years and several phases.

"HHMI's challenge to us addresses a critical need in U.S. higher education, and it is aligned with Georgia Tech's strategic plan," says **David Collard**, senior associate dean in the College and lead researcher for the effort at Tech. "The grant will support a team effort in pursuing a number of complementary projects."

Collard is joined by College of Sciences co-investigators **Jennifer Leavey**, assistant dean for Faculty Mentoring; **Carrie Shepler**, assistant dean for Teaching Effectiveness; and **Lewis Wheaton**, inaugural director of the Center for Promoting Inclusion and Equity in the Sciences at Georgia Tech. Collard and Shepler also serve as faculty members in the School of Chemistry and Biochemistry, and Leavey and Wheaton in the School of Biological Sciences.

Inclusive Excellence 3

As the third phase of the HHMI program, Inclusive Excellence 3, known as IE3, challenges U.S. colleges and universities to "substantially and sustainably build their capacity for student belonging, especially for those who have been historically excluded from the sciences."

IE3 is also distinct from previous HHMI science education initiatives because it begins with a learning phase where learning communities envision how to move cooperatively into an implementation phase.

The grant uniquely challenges groups to work collaboratively to address one of three broad efforts. At Georgia Tech, the College of Sciences is working with institutions across the country to help empower colleges and universities to develop and support systems that cultivate teaching and learning in tandem with key concepts in inclusion and equity.

At Georgia Tech, each IE3 team member is concentrated on a distinct area of work.

Inclusive teaching

Leavey is focusing on "working with collaborators from other institutions to share faculty development strategies focused on inclusive teaching, such as the Inclusive STEM Teaching Fellows program," she explains, "which the College of Sciences piloted last spring along with the Center for Teaching and Learning, the College of Engineering, the College of Computing, and the Office of Institute Diversity, Equity, and Inclusion."

Leavey adds that a semester after its launch, the Fellows program is already generating interest across campus and at collaborating institutions.

Jennifer Leavey, principal academic professional in the School of Biological Sciences and assistant dean for Faculty Mentoring.

Inclusive impact

Shepler is helping faculty assess the impact of their inclusive teaching efforts, working with collaborators to develop an iterative process to help institutions create formative assessment methodologies for teaching and learning that both facilitate and prioritize inclusion and equity in a manner that is consistent with institutional values and missions.

"Throughout the project, our aim is to make sure that students have a voice in defining what it means for them to experience teaching that centers" on these concepts, Shepler says.

The work coincides with a goal of the College of Sciences' new Teaching Effectiveness, Advocacy, and Mentoring (TEAM) committee, which Shepler leads, to "develop and adapt new processes for the evaluation of teaching that are inclusive and equitable for all faculty."

"Throughout the project, our aim is to make sure that students have a voice in defining what it means for them to experience teaching that centers" on these concepts.

— **Carrie Shepler**, principal academic professional in the School of Chemistry and Biochemistry and assistant dean for Teaching Effectiveness

Lewis Wheaton, professor in the School of Biological Sciences and director of the Center for Inclusion and Equity in the Sciences (C-PIES).

Inclusion and equity

Meanwhile, Wheaton's work as the director of the Center for Promoting Inclusion and Equity in the Sciences (C-PIES) informs and amplifies Leavey and Shepler's goals for the grant.

Wheaton is also leading a competitive C-PIES Faculty Fellows program that focuses on innovative teaching and research ideas that can transform student learning using key principles.

"The Center is sponsoring several C-PIES Inclusive Excellence Faculty Fellows in this effort," he says. "This is an exciting direction that will provide the tools to develop assessments in our curriculum, leading to a culture that emphasizes and facilitates a growth mindset of continued development."

Transforming the future

Ultimately, the researchers hope to leverage the Inclusive Excellence Grant to transform teaching and learning for faculty and students of today — and of tomorrow.

"Though much of the HHMI work will focus on faculty, particularly those in instructional roles, the potential impact of these efforts is on the learning experiences of future generations of students," adds Collard. "I look forward to seeing how the project develops — and how it fosters changes that support student and faculty success."

Story by Jess Hunt-Ralston • Supported by the Howard Hughes Medical Institute.

"I look forward to seeing how the project develops — and how it fosters changes that support student and faculty success."

— **David Collard**, professor in the School of Chemistry and Biochemistry, senior associate dean

Biology Researchers Awarded HHMI Gilliam Fellowship

For the second consecutive year, a Georgia Tech student and their advisor have been awarded a Howard Hughes Medical Institute (HHMI) Gilliam Fellowship for Advanced Study. **Autumn Peterson**, a Ph.D. student in biology, will receive $53,000 per year for up to three years for dissertation research. Peterson's advisor, **William Ratcliff**, will participate in activities that address challenges of fostering diversity and inclusion at the graduate level.

"Receiving the HHMI Gilliam award will allow me to conduct innovative research while building leadership and mentorship skills — all attributes that are necessary to become a better scientist," says Peterson. "Ultimately, this will help me prepare for a career in academia as a professor."

HHMI awards student-advisor pairs based on the student's potential for scientific leadership and the advisor's commitment to a culture of inclusion in academia. The program awards grants to dissertation advisors and encourages the grantee institution and the advisor to facilitate institutional changes to create environments that advance those efforts.

"As an advisor, I'm delighted to see Autumn's work and leadership recognized this way," says Ratcliff, an associate professor in the School of Biological Sciences and director of the Interdisciplinary Ph.D. in Quantitative Biosciences at Georgia Tech. "This fellowship is also a huge opportunity for us to do cool science, become better scientists and mentors, and work to improve diversity and inclusion at Georgia Tech. I cannot wait to get to know the broader community of Gilliam Fellows and mentors."

Story by Sara Franc • Supported by the Howard Hughes Medical Institute.

Autumn Peterson (left), a Ph.D. student in Biology, with her advisor William Ratcliff, an associate professor in the School of Biological Sciences.

Meet the Center for Promoting Inclusion and Equity in the Sciences (C-PIES)

Launched in August 2022, the Center for Promoting Inclusion and Equity in the Sciences (C-PIES) is a new milestone in the College's long-standing efforts to foster belonging, as well as a key pillar of its 10-year strategic plan.

With a mission "to recruit, support, and retain a diverse population for all sectors of our community — staff, faculty, and students — and build an inclusive community that broadens access to science and mathematics and creates opportunities for advancement," C-PIES is expanding programming across the College of Sciences community.

"I am excited about this new direction and its potential for making significant progress toward our goal of creating a diverse and inclusive community," says College of Sciences Dean and Betsy Middleton and John Clark Sutherland Chair **Susan Lozier**.

Lewis Wheaton, professor in the School of Biological Sciences, serves as director for the Center. Working with Dean Lozier, ADVANCE Professor **Jennifer Curtis**, and the College's associate and assistant deans, Wheaton is implementing recommendations from the College's Task Force on Racial Equity, coalescing collaborative work across the College's six schools, and ongoing efforts in student and community belonging.

"I love science," says Wheaton. "I'm really, really passionate about what I do, and I'm passionate to the point of wanting to make sure that everyone gets the opportunity to at least be exposed to the possibility of doing science — and specifically doing it here at Georgia Tech. That means a lot to me."

Together with C-PIES Program Operations Director **Lea Marzo**, Wheaton shares that in the Center's first year, "We have been able to create community-building events, fund student initiatives, support a variety of faculty needs, enable improved underrepresented student recruitment, and engage in meaningful conversations with student, staff, and faculty groups in the College.

Lea Marzo, director of program operations for C-PIES.

"I hope that the Center, as it evolves, turns into a real catalyst for change," says Wheaton. "Change not just in building a better community, diversifying our community, and promoting better inclusion, but also creating a catalyst for new questions and new horizons to address the needs of the community."

Story by Audra Davidson.

"I'm passionate to the point of wanting to make sure that everyone gets the opportunity to at least be exposed to the possibility of doing science — and specifically doing it here at Georgia Tech."

— **Lewis Wheaton**, professor in the School of Biological Sciences and inaugural director of C-PIES

Leading in the Sciences

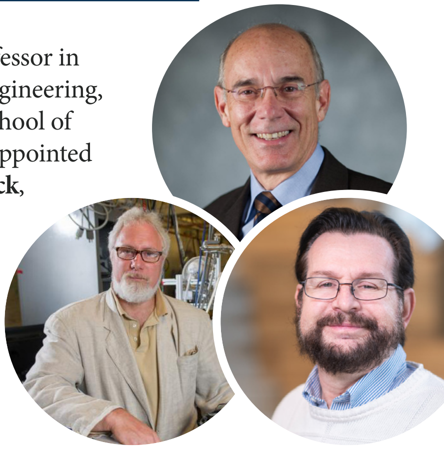
Sciences Faculty Receive 2023 Regents' Distinctions

The University System of Georgia (USG) Board of Regents (BOR) announced 12 first-time Georgia Tech appointments to Regents' distinctions for 2023 and affirmed the renewal of existing distinctions for four esteemed faculty members.

These distinctions are given to those who make outstanding contributions to their respective institutions, and are granted for a period of three years to outstanding faculty members from select USG institutions. A Regents' distinction is awarded only after unanimous recommendation from several leaders of the recipient's university and approval by BOR officials.

Newly appointed Regents' Professors in the College of Sciences include **Rafael L. Bras**, a professor in the School of Earth and Atmospheric Sciences who also serves as K. Harrison Brown Family Chair and professor in the School of Civil and Environmental Engineering, and **Thomas Orlando**, professor in the School of Chemistry and Biochemistry. Originally appointed Regents' Professor in 2020, **Jeffrey Skolnick**, who serves as professor and Mary and Maisie Gibson Chair in the School of Biological Sciences, and as Georgia Research Alliance Eminent Scholar in Computational Systems Biology, received an appointment renewal.

Story by Brittany Aiello • Supported by USG BOR.



Rafael L. Bras (top), Thomas Orlando (left), and Jeffrey Skolnick.

Iramofu Dominic Wins Merck Research Award

Iramofu (Mofu) Dominic, a Ph.D. candidate and graduate research assistant in the School of Chemistry and Biochemistry, is one of 16 national winners of the 2023 Merck Research Award for Underrepresented Chemists of Color. In addition to working with mentors, the Merck Award researchers presented their work at an award symposium this fall.

The award recognizes graduate students and postdoctoral scholars for their chemical science research across a range of subdisciplines — computational, analytical, medicinal, biological, and synthetic chemistry.

"As someone who is interested in an industry career within the pharma and biotech spaces," Dominic says, "the award offers an invaluable opportunity to get help and support for my professional aspirations, especially from underrepresented minorities like me who are building successful industry careers."

Story by Renay San Miguel • Supported by Merck.

Iramofu (Mofu) Dominic, Ph.D. candidate in the School of Chemistry and Biochemistry.

Breanna Shi Awarded Advanced Graduate Ambassadorship

Breanna Shi, Ph.D. student in bioinformatics.

Breanna Shi, a Ph.D. student in bioinformatics, was recently named an Advanced Graduate Ambassador by the Institute for Advanced Study's (IAS) Women and Mathematics program. The award is funding a workshop hosted by Shi, where she will use her math background to engage with and mentor other underrepresented graduate students across the College of Sciences.

In addition to holding a Department of Education Graduate Assistance in Areas of National Need award, Shi has been awarded the Graduate Fellowship for STEM Diversity and the Graduate Retaining Inspirational Scholars in Technology and Engineering (Grad RISE) from Georgia Tech's Center for Engineering Education and Diversity.

During her workshop, Shi hopes to employ a few nontraditional techniques that will allow students to feel less resistant and more understanding of the subjects. "Our hope is to get graduate students interested in using mathematics and computer science in their research."

Story by Laurie E. Smith• Supported by Institute for Advanced Study.

A Decade of the Atlanta Science Festival

Georgia Tech and the College of Sciences celebrate 10 years of science outreach in partnership with the Atlanta Science Festival

There's only one place in Atlanta where you can touch a brain, see a science fashion show, watch scientists give improv performances, and learn about biomechanical robots at the zoo — and that's at the Atlanta Science Festival.

Ten years ago, Georgia Tech, Emory University, and Metro Atlanta Chamber founded the Festival with a goal to bring science to the Atlanta community and reduce barriers to learning about STEM.

In spring 2023, 47,000 people attended the festival, which had an estimated digital reach of over 40 million. "We want to cultivate an equitable community of lifelong learners across metro Atlanta who are connected to and inspired by the wonder of science," say Science ATL co-executive directors and Festival co-founders **Jordan Rose** and **Meisa Salaita**.

Top: A Georgia Tech student works with an Atlanta Science Festival attendee on a math puzzle. JESS HUNT-RALSTON. **Left:** Festival co-founder Meisa Salaita on stage at the 2023 kickoff event, Destination Science, where three scientists shared their experiences conducting field work around the world. SCIENCE ATL **Right:** Festival attendees investigate aerodynamics at the Exploration Expo. SCIENCE ATL

CELEBRATING THE TENTH ITERATION OF THE FESTIVAL, the 2023 theme used imagery inspired by vintage postcards to "explore all of the places science can take you." Attendees were encouraged to design their own postcard describing their "dream destination to do science" for a chance to win a trip to a National Park of their choosing.

STEMcomm

In 2017, **Jennifer Leavey**, who co-leads STEMcomm, a Georgia Tech Vertically Integrated Project (VIP) course, started challenging her students to host Festival events. "The events really pushed it over the top," Leavey says. "I just love to think back and look back through the pictures of all of the events we've done for the Atlanta Science Festival through the years."

Open to students across Georgia Tech, STEMcomm focuses on honing communications skills in science, technology, engineering, and math. Past class events have included science-themed escape rooms, a food festival, and a sober science speakeasy. During Covid-19, STEMcomm devised online cooking demonstrations focusing on the chemistry of food preparation.

Mudra Nagda, a master's student in human-computer interaction, models wearable computing technology. SCIENCE ATL

THE DEVIL WEARS SCIENCE

The students and faculty of STEMcomm gather after their event, "The Devil Wears Science." JALEN BORNE.

For 2023, STEMcomm students put on a science-themed fashion show highlighting sustainable fashion, wearable technology, and more.

"I didn't realize just how much I enjoyed science communication before this," says STEMcomm student **Carrera Ortiz**, now a School of Physics alum. "As I'm graduating, I find myself most excited for opportunities that seem to include some aspects of science communication."

Jalen Borne (CHEM '22), a graduate student in the School of Materials Science and Engineering at Georgia Tech, has been part of STEMcomm since 2019. "In my career, no matter what I end up doing," he says, "I know I want to do some type of outreach and development."

K.I.D.S. CLUB

Hands-on, interactive STEM activities are a hallmark of the K.I.D.S. Club sessions, which are hosted by the Center for Education Integrating Science, Mathematics, and Computing (CEISMC) at Georgia Tech in conjunction with the Atlanta Science Festival. These Saturday campus sessions are offered every fall and spring for elementary and middle school students.

This spring, fourth and fifth graders discovered how the circulatory system works, including how blood flows through the heart and how the brain communicates with the heart, thanks to the help of students in the Wallace H. Coulter Department of Biomedical Engineering.

INSPIRING YOUNG INNOVATORS

As part of the 2023 Festival, more than 1,500 children and parents attended the second-annual Georgia Tech Science and Engineering Day. Students, staff, and faculty volunteers hosted more than 40 demonstrations, hands-on STEAM activities, tours, and learning opportunities designed to engage and educate participants.

Participants learned about battery fuel cells, nanotechnology, DNA, immunoengineering, chemistry, engineering, superconductivity levitation, wastewater treatment, aerospace, space outreach, virtual reality, biology, robotics, computing, paper making, and more.

Demonstrations ranged across how to extract DNA, seeing LIDAR in action, experiencing heat sensing sensors, how X-rays are used, viewing scanning electron microscopes, playing a virtual reality game, and 3D printing to experiencing chemical reactions, making slime, showing atom-level nano materials in synthesized materials, neuroscience demos, and liquid nitrogen experiments.

"I had several Georgia school systems reach out to me that were interested in attending this event," said **Leslie O'Neill**, education outreach manager with the Southeastern Nanotechnology Infrastructure Corridor (SENIC) at Georgia Tech. "Georgia Tech plays a vital part in its community. We wanted to showcase the campus, the research, and the amazing science and engineering being done. We've had a fantastic turnout this year for this event."

Top: Visitors gather for Georgia Tech Science and Engineering Day, held in 2023 across five campus buildings, including the Marcus Nanotechnology Building. **Left:** An attendee looking at the scales of a butterfly wing under a powerful microscope. **Right:** Young author Soleil A. Cross holds her book, ***Pluto, Special, Just the Same Dwarf Planet***, as she explores the Brain Games exhibit with her mom. PHOTOS JESS HUNT-RALSTON

WALK LIKE THE ANIMALS

Venny Kojouharov (above, to right) explains the biomechanics of snake movement with bio-inspired robots. AUDRA DAVIDSON

Biology undergrads Charlie Hammer (above, center in photo) and Skylar Taylor (above, to right) explain the mechanics of flamingos standing on one leg, challenging attendees to test how long they could stand in the same fashion. RENAY SAN MIGUEL

Scientists and engineers study animal movements for clues to improve life for humans, such as designing better prosthetics or terrain-conquering robots. But that doesn't mean fun can't be a part of the research as well — as in asking kids to see how long they can stand on one leg, à la flamingos. That was one of many events on display at Animals in Motion: Biomechanics Day at the Zoo.

Biomechanics researchers from Georgia Tech, Clemson University, and the University of Akron hosted more than 8,000 visitors gathered to learn more about wildlife and work exploring biomechanics — from using ultrasound imaging to give an "under the skin" look at how animal and human muscles work together with tendons to move the body, to exploring different insect wing shapes and understanding how snakes slither, to balancing just like flamingos (and learning how they manage to do it so well).

"They have to deal with the same physical challenges to stand in a stable way," explains **Young-Hui Chang**, professor in the School of Biological Sciences and associate dean of Faculty in the College of Sciences. "Biology tells us that as vertebrates, flamingos are starting with many of the same muscles and bones of the leg that humans have. But flamingos have evolved a way to use their limbs such that they can sleep standing on one leg with minimal involvement of the muscles, which would be impossible for us humans to do."

THE EXPLORATION EXPO

HELD AT PIEDMONT PARK IN THE HEART OF MIDTOWN ATLANTA, the Exploration Expo is the finale of each year's Festival. The 2023 Expo featured over 91 exhibits that reached over 20,000 people — more than a 30% increase over the previous year.

"Each spring, the Atlanta Science Festival electrifies campus and reaches across our city with fun and accessible activities for all ages," shares **Jess Hunt-Ralston**, director of Communications for the College of Sciences at Georgia Tech, who also represents the Institute on the Science ATL Board of Directors.

"Whether you're about to start preschool or volunteering with your grandkids, you're here because you also believe that Atlanta is a science city — that we're here to learn, teach one another, and improve our world through shared inquiry," she says. "And there's nothing quite like seeing the scales of a butterfly wing for the first time, playing brain games with new friends, or peering through a telescope together to help spark and sustain that spirit of curiosity."

Two Expo attendees learn about the human brain. SCIENCE ATL

"It never ceases to amaze me the positive energy that exists when attending the Atlanta Science Festival Expo. It really is an experience that everyone needs to check out once if living in Atlanta."

— **Zachary Handlos**, Expo volunteer and senior academic professional in the School of Earth and Atmospheric Sciences at Georgia Tech

Microbiology Ph.D. student Iris Irby shows attendees glowing bacteria at a booth hosted by the Center for Microbial Dynamics and Infection. JESS HUNT-RALSTON

Creating a Buzz Near and Far

This year, four College of Sciences alumni landed on the Georgia Tech Alumni Association's 40 Under 40 list, which annually recognizes 40 alumni under the age of 40 who innovate their fields and positively impact the world — whether that's furthering space exploration or revolutionizing healthcare.

Stephen Crooke, Ph.D. Chem '18

Lead Microbiologist, Vaccine Immunology, Centers for Disease Control and Prevention (CDC)

Stephen Crooke leads the Vaccine Immunology Team in the Viral Vaccine Preventable Diseases Branch at the CDC, where his team supports global and international disease surveillance and researches the development of new vaccines and diagnostics. He is a recipient of the Maurice R. Hilleman Early-Stage Career Investigator Award from the National Foundation for Infectious Diseases, and he is also an investigator in the Center for Childhood Immunizations and Vaccines at Children's Healthcare of Atlanta.

Jasreet Hundal, M.S. BI '09

Scientific Operations Manager, Data Insights (Oncology), Natera

Jasreet Hundal has revolutionized personalized medicine through her innovative work in computational genomics. After completing her master's in bioinformatics at Georgia Tech, she joined the Genome Institute at Washington University, focusing on cancer genomics and researching neoantigens. Hundal developed pVACtools, a computational suite that revolutionizes cancer treatment by predicting individualized neoantigens. Clinical trials across various tumor types now utilize pVACtools to design personalized cancer vaccines.

Lujendra Ojha, Ph.D. EAS '16

Assistant Professor, Rutgers University

Lujendra Ojha is a planetary scientist and assistant professor of planetary sciences at Rutgers University. He gained widespread recognition for his discovery of Recurring Slope Lineae (RSL) on Mars, which are seasonal features that may indicate the presence of liquid water on the planet. Ojha's groundbreaking discovery led to numerous media appearances, including interviews with major news networks and an article in *Rolling Stone* magazine. Ojha is committed to advancing our understanding of planetary evolution and the potential for habitability beyond Earth.

Lavanya Rishishwar, M.S. BI '12, Ph.D. BI '16

Senior Technical Manager, Pillar Biosciences

Lavanya Rishishwar extracts meaningful and actionable insights from vast genomic datasets. Collaborating with federal and state government partners, he has contributed to outbreak investigations, developed infrastructure for laboratory preparedness, and pioneered scalable computational tools for the future. Through mentoring and training, he nurtures the next generation of scientists. His work exemplifies the tremendous potential bioinformatics holds in advancing our understanding of the biological world.

Nominees who completed at least one semester at Georgia Tech and were under the age of 40 as of June 30, 2023 were scored using a 25-point rubric by a committee of 24 faculty, staff, and volunteers who collectively represented all Georgia Tech colleges.

FORTY UNDER FORTY

2024 Class of 40 Under 40

Are you a Georgia Tech College of Sciences alum who would like to be nominated for next year's class, or would like to nominate a classmate, friend, or family member?

Email development@cos.gatech.edu to learn more and get involved.

External Advisory Board

The College of Sciences External Advisory Board provides advice to the Dean regarding priorities and directions for sciences education and research. Board members are from the private and public sectors and academia, and include alumni who are interested in the success of the College and Georgia Tech.

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Heidi Schindler

B.S. Applied Biology 1997
Head of Commercial Coaching and Project Management, MilliporeSigma

VICE-CHAIR

Jeffrey S. Hurley, Ph.D.

Ph.D. Chemistry 1992; M.S. Chemistry 1990
President, Tazza Brands

RETURNING BOARD MEMBERS

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B.S. Chemistry 1993
Senior Vice President of Research, Aileron Therapeutics, Inc.

Mercedes Dullum, M.D.

B.S. Biology 1975
Consultant, Healthcare and International Services

Belma Erdogan-Haug, Ph.D., M.B.A.

Ph.D. Chemistry 2003
Head of Product Development, Henkel of America, Inc.

Alexis E. Gallardo

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Vice President, Proluxa, S.A.

Karla Haack, Ph.D.

Ph.D. Biology 2009
Associate Medical Writer, Merck

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B.S. Applied Biology 1972
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Founder, CMG Petroleum Consulting, Ltd.

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Ph.D. Organic Chemistry 1988
Chief Executive Officer, Jadex Inc.

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M.S. Industrial Systems Engineering 1976;
B.S. Mathematics 1975
Mathematical Analyst (Retired), The Coca-Cola Company

Kelly Sepcic Pfeil, Ph.D.

Ph.D. Chemistry 2003;
M.S. Chemistry 1992
President, ArrowInno

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B.S. Applied Biology 1986
Professor of Genetics and Biochemistry and Director, Eukaryotic Pathogens Innovations Center (EPIC), Clemson University

Christa Sobon

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Director of Digital Business Operations, Manheim

Gerald W. Staton Jr., M.D.

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John Sutherland, Ph.D.

Ph.D. Physics 1967; M.S. Physics 1964;
B.S. Physics 1962
Dean of the College of Science and Mathematics, Augusta University

Nsé Ufot

B.S. Psychology 2002
Activist and Community Organizer

G. David "Dave" Williamson, Ph.D.

B.S. Applied Biology 1973
Associate Director for Science, Centers for Disease Control and Prevention

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B.S. Earth and Atmospheric Sciences 2007
Head of Weather, Engelhart Commodities Trading Partners

Angela Clark

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Vice President, Federal Market, HDR Engineering

Tracy Giest, Ph.D.

Ph.D. Applied Physiology 2015
Sr. Staff Research Scientist, Fitbit, Inc.

Eva Heintz, Ph.D.

Ph.D. Chemistry 2004
Manager, Strategic Key Accounts, Solvay Specialty Polymers

Stewart W. Long

B.S. Physics 1975
Managing Director, Patriots for Reliable Electric Power

Jack McCallum, M.D., Ph.D.

B.S. Applied Biology 1972
Chairman and Chief Executive Officer, IntegerHealth

Jessica McDermott, M.D.

B.S. Applied Biology 2004
Assistant Professor of Medicine, Division of Medical Oncology, Rocky Mountain Regional Medical Center

Tia Williams

B.S. Earth and Atmospheric Sciences 1996
GVP Product Design, New Relic

Transforming Tomorrow
The Campaign for Georgia Tech

Across six internationally ranked schools, the College of Sciences is developing leaders and exploring solutions to improve the human condition and create a better world. Your philanthropic support helps us cultivate the next generation of leaders in science and society who will develop the scientific solutions of tomorrow.

> We're focused on that arc from discovery to solution, and in the College of Sciences, we are developing leaders who will use their knowledge to improve the health of the planet and its people.
>
> — **Susan Lozier**, dean and Betsy Middleton and John Clark Sutherland Chair, College of Sciences

We inspire faculty and students to solve some of the most significant challenges facing our modern world. Our research and education priorities focus on collaboration and team science, interdisciplinary inquiry, equity and inclusion, and leadership in rapidly changing fields such as artificial intelligence, bioengineering, and climate adaptation and mitigation.

We leverage the power of science to fuel discovery and find solutions for a healthier planet and people — and develop the next generation of global leaders in STEM. Your investment ensures these bright minds have the resources, facilities, and mentors to excel at Georgia Tech and beyond.

OUR CAMPAIGN PRIORITIES

1 Endowed Faculty Funding

We believe in investing in leaders who catalyze discovery and scientific solutions. The success of our research hinges on supporting, retaining, and mentoring faculty, especially mid-career faculty whose research growth and productivity are particularly critical to Georgia Tech.

2 Graduate Student Fellowships

We provide transformative educational experiences for students and trainees by fostering a creative, inclusive, and equitable learning environment. To cultivate the next generation of global leaders and amplify the College's impact, we must recruit top doctoral candidates with a particular emphasis on those students traditionally underrepresented in the sciences and mathematics.

3 Undergraduate Scholarships and Support

We believe in supporting students throughout their educational journey by providing the financial resources, mentoring, and programs to ensure they will be prepared to answer the questions of tomorrow.

4 Innovative Teaching and Equitable Experiential Learning

We believe progress in our quest to find solutions for a healthier planet and people requires expanding partnerships within — and beyond — our scientific community.

> One of the good things about being a STEM scholar is that there's an emphasis on what you're doing with your scholarship and how you are impacting and investing in the community. That's one thing that I've learned — that being a leader is about what you're giving back.

—**Zizi Ohamadike**, BIO 2023

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Tomorrow starts at Georgia Tech.

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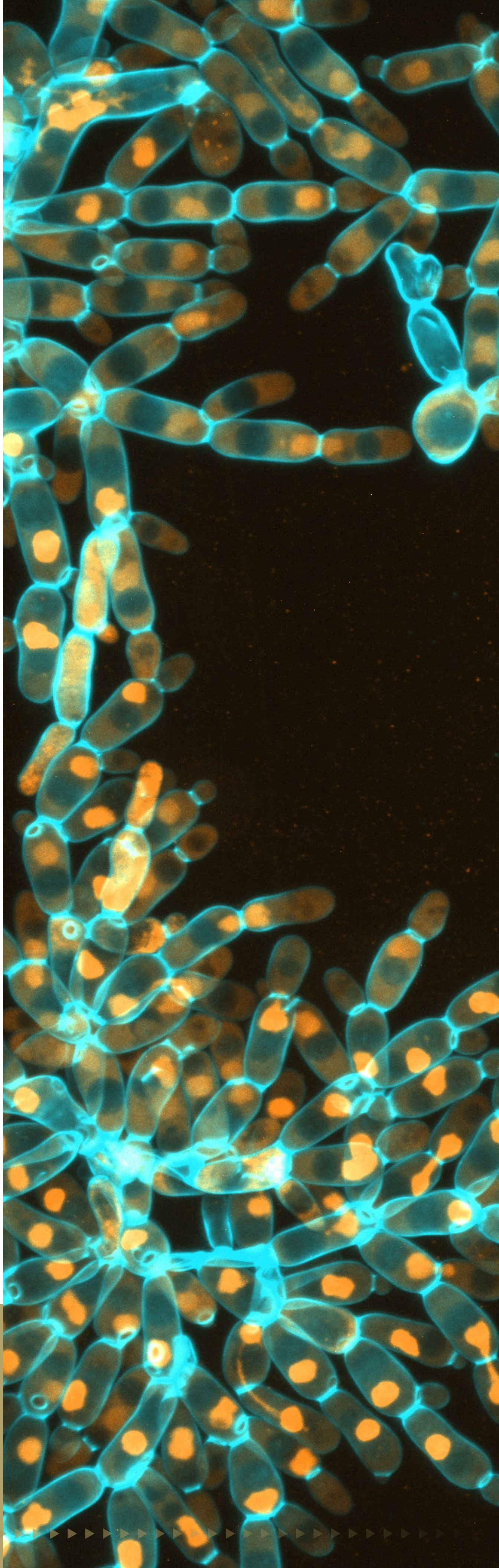
Inside the Sciences

The origins of multicellular life

To investigate how multicellular life evolves from scratch, a team of researchers decided to take evolution into their own hands. Led by William Ratcliff, associate professor in the School of Biological Sciences, the scientists have initiated the first long-term experiment aimed at evolving new kinds of multicellular organisms from single-celled ancestors in the lab.

More on page 7



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