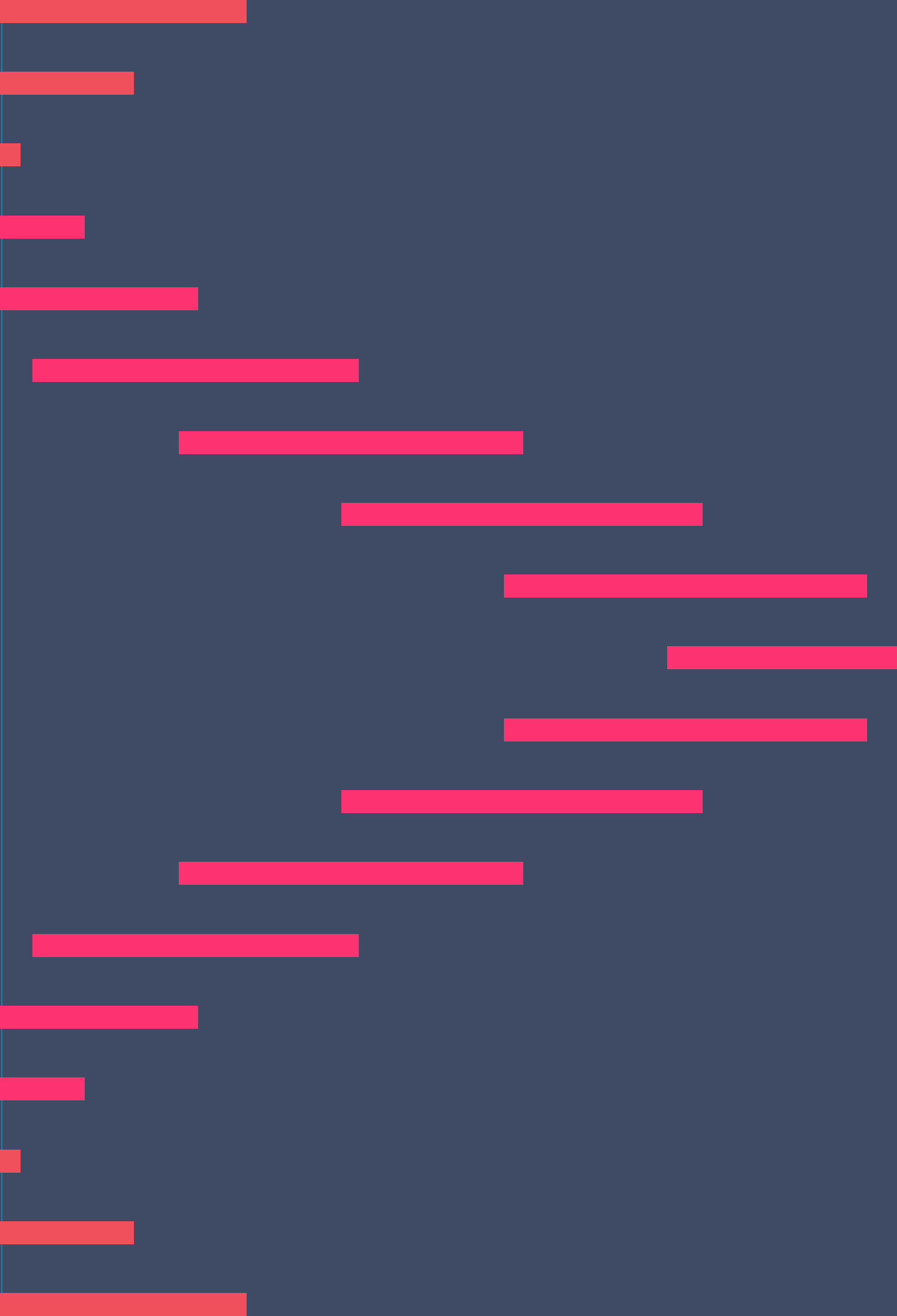
Hey Science,

we're glad you're here

2024 IGB ANNUAL REPORT



Abbreviations

RESEARCH THEMES

ACPP	Anticancer Discovery from Pets to People
BSD	Biosystems Design
CABBI	Center for Advanced Bioenergy and Bioproducts Innovation
CAIM	Center for Artificial Intelligence and Modeling
CGD	Center for Genomic Diagnostics
CIS	Center for Indigenous Science
EIRH	Environmental Impact on Reproductive Health
GEGC	Genomic Ecology of Global Change
GNDP	Gene Networks in Neural and Developmental Plasticity
GSP	Genomic Security and Privacy
IGOH	Infection Genomics for One Health
MME	Microbiome Metabolic Engineering
MMG	Mining for anti-infectious Molecules from Genomes
M-CELS	Multi-Cellular Engineered Living Systems
RBTE	Regenerative Biology and Tissue Engineering

Acronyms

Beckman	Beckman Institute for Advanced Science and Technology
DOE	Department of Energy
NASA	National Aeronautics and Space Administration
NCSA	National Center for Supercomputing Applications
NIH	National Institutes of Health
NSF	National Science Foundation

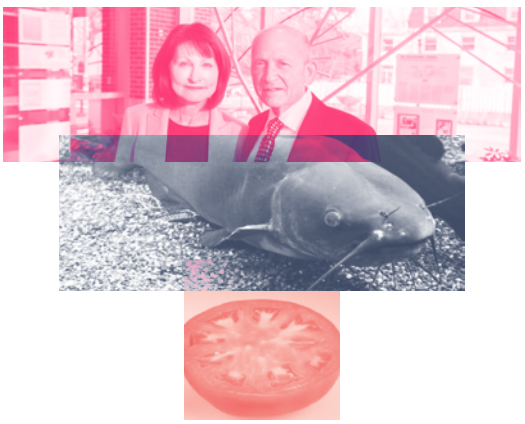
Table of Contents

Hey Science,

You've put in a lot of work this year. When it was time to be curious, check some facts, make a plan, you were there. You asked big questions and then looked for the answers. How did it go?

It is my pleasure to introduce this year's Annual Report, which celebrates science and the people propelling it. Wrapped in these pages is our reflection on the remarkable research and innovations emerging from the Carl R. Woese Institute for Genomic Biology's 15 research themes in 2024.

In science, there is often an inclination to let the research speak for itself: show the work, show the data, and build consensus through the independent judgement of each person who considers the results. Yet science is a human pursuit, and humans need connection. Through our institutional communications we aim to highlight the humanity of our research community, and this year we have done so not only by sharing the individual voices of our members, but by giving science a collective voice, the one that welcomed you to this publication. We hope the whimsy of this makes you smile, and also that a feeling of affirmation stays with you.



As you read on, you will revisit highlights of the past year in science at the IGB. Each section features a different set of accomplishments. *New Beginnings*[1] introduces some of the most recent funded projects and centers, including several that expand the boundaries of interdisciplinary inquiry. For example, the Bill and Julie Kellner Center for Neurogenomics, Behavior and Society[2] was established this year by a generous gift to strengthen collaborative work among genomicists, neuroscientists, and social scientists. Noteworthy outcomes of ongoing efforts can be found

[1] New beginnings: p10-27 [2] Center established to address mental illness: p12-14

in *Remarkable Research*[3], including a reminder of how organisms—from catfish[4] to tomatoes[5] to people—are impacted by the interplay of hereditary and environmental influences on the genome.

Even tomatoes, we have learned, live in constant and supportive communication with their neighbors. The IGB and its mission are inextricable from the broader community, with whom we are in continuous contact. In *Connected Communities*[6] we look back on a year of public engagement, culminating in the long-anticipated return of our flagship public event, the World of Genomics[7], offered in 2024 in partnership with the Griffin Museum of Science and Industry in Chicago. We say *Congrats*[8] to members whose scientific work received formal recognition this year, and close with a glimpse at what new solutions and innovations our ongoing research promises in pursuit of building a better world.[9]

As the scientific research enterprise is thrust into broader public conversation and faces new challenges, the IGB reaffirms our mission to advance life sciences to address societal issues.

Now, more than ever before, it is also imperative that we continue to lead with our humanity. We will continue to foster greater scientific understanding and share the importance and relevance of genomics research in everyday life. We will continue to place our confidence in our next generation of scientists who are here every day, shaping our future.

GENE E. ROBINSON
DIRECTOR,
CARL R. WOESE INSTITUTE FOR GENOMIC BIOLOGY

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[3]Remarkable Research: p28-49 [4]PFAS found in nearly all fish tested from four northern Illinois rivers: p46-48 [5]Talking tomatoes: How their communication is influenced by enemies and friends: p30-33 [6]Connected Communities: p50-71 [7]World of Genomics: p53-56 [8]Congrats: p72-87 [9]Futureproofing: p88-105

Let’s travel back in time
together and revisit
what Science has been
up to in 2024.

You had 15 research themes in 2024

That’s a lot of areas to cover.
How do you do it all?

Anticancer Discovery from Pets to People (ACPP) develops cancer treatments in pet animals that translate to human disease.

Biosystems Design (BSD) applies engineering principles to real and artificial biological systems.

Center for Advanced Bioenergy and Bioproducts Innovation (CABBI) develops ways to grow bioenergy crops and transform biomass into valuable biofuels and bioproducts.

Center for Artificial Intelligence and Modeling (CAIM) uses computational science and modeling to address complex biological questions.

Center for Genomic Diagnostics (CGD) identifies reliable biomarkers of disease and develops technologies to detect those biomarkers.

Center for Indigenous Science (CIS) addresses societal and environmental issues using Indigenous Science frameworks.

Environmental Impact on Reproductive Health (EIRH) studies reproductive function and fertility disorders and develops therapeutic tools.

Genomic Ecology of Global Change (GEGC) studies the intersection of plant genomics and global climate change.

Gene Networks in Neural and Developmental Plasticity (GNDP) examines the effects of coordinated gene activity on biological diversity.

Genomic Security and Privacy (GSP) considers the implications of genomic applications on an individual's security and privacy.

Infection Genomics for One Health (IGOH) examines how microbes in human-inhabited environments influence health and disease.

Microbiome Metabolic Engineering (MME) explores the relationships among human microbiota, environment, and health.

Mining for anti-infectious Molecules from Genomes (MMG) discovers small molecules that might provide new medical solutions.

Multi-Cellular Engineered Living Systems (M-CELS) develops *in silico*, cellular, and artificial components for precision assembly of biomachinery and computing processors.

Regenerative Biology and Tissue Engineering (RBTE) studies the replacement and regeneration of tissues and organs.

You had 7 thoughtful connections in 2024

They say it takes a village. We can't do this on our own; we're glad to have so many good friends around!

African Biogenome Project (AfricaBP) is a coordinated pan-African effort to build capacity and infrastructure to generate, analyze, and deploy genomics data for the improvement and sustainable use of biodiversity and agriculture across Africa.

Chan Zuckerberg Biohub Chicago (CZ Biohub Chicago) is a biomedical research center that brings together leading Chicagoland scientific and technology institutions with the goal of solving grand scientific challenges on a 10- to 15-year time horizon.

Genomics and Eco-evolution of Multi-Scale Symbioses (GEMS) focuses on the classical species interactions between clover and honey bee pollinators as a model to understand the impact and dynamics of the myriad of microbes nested within them. GEMS takes an integrative approach to understand how molecular interactions impact the ecosystem.

High Performance Biological Computing (HPCBio) was created to address the need for a structure that could supply infrastructure, user support and training, and R&D capability in computational genomics to the Illinois research community. HPCBio provides a single, straightforward point of access, open to researchers from all campus units, helping them to find solutions to their biomedical data management and analysis problems.

Microbial Systems Initiative (MSI) aims to sustain a vibrant microbial sciences research and training enterprise at Illinois. Microbial systems research addresses critical problems in health, agriculture, energy, and many other sectors. The MSI carries out ongoing activities to build collaboration across disciplines, provide world class training opportunities, and build environments of inclusive excellence.

Molecule Maker Lab Institute (MMLI) is an interdisciplinary initiative with leaders in artificial intelligence and organic synthesis intensively collaborating to create frontier AI tools, dynamic open access databases, and fast and broadly accessible small molecule manufacturing and discovery platforms. Advanced AI and machine learning methods enable the MMLI to achieve AI-enabled synthesis planning, catalyst development, molecule manufacturing, and molecule discovery.

Personalized Nutrition Initiative (PNI) is a campus-wide initiative under the leadership of the Office of the Vice Chancellor for Research and Innovation, in partnership with the IGB and the College of Agricultural, Consumer and Environmental Sciences. It aims to facilitate transdisciplinary collaborative efforts across campus to answer fundamental questions regarding how nutrition modulates health and disease across the lifespan and to translate that information to clinical care and to the public.

Hey Science,
this year you dreamed
the new into being—
from robotic labs to
ceramic cups.

You're really cooking and
always keeping it fresh.

New beginnings

Center established to address mental illness

Illinois leads the way in biomanufacturing

Working toward one health solutions

Investments in health research

New beginnings

Center established to address mental illness

Kellner Center launch: Interdisciplinary research to improve mental health—In late 2024, the University of Illinois celebrated the launch of the Kellner Center for Neurogenomics, Behavior, and Society. Hosted by the IGB, the Center for Social & Behavioral Sciences, and the School of Social Work, the half-day event drew researchers from across campus to learn about and discuss the Center's mission to study the intersection of genes, brain, and behavior, and their collective impact on mental health as well as society more broadly.

Kellner Center Director Alison Bell began the event with an overview of the Center and its broader goals. Through two interdisciplinary panel discussions, researchers and attendees explored how the Center's work could accelerate progress in understanding the fundamental mechanisms linking genes, brain, and behavior, with the ultimate goal of addressing mental health challenges and societal perspectives on genetics.

The first panel featured external Advisory Board members Frances Champagne (University of Texas), Jonathan Flint (UCLA), Dave Schulz (University of Missouri), and Sonia Sultan (Wesleyan University) and was moderated by Hypatia Bolivar (University of Illinois Springfield). They shared insights from their fields—ranging from epigenetics to neuroscience to mental health—and how their work aligns with the interdisciplinary vision of the Kellner Center.

The panelists emphasized the importance of breaking down disciplinary silos to enable crosscutting research and that collaboration can require time to develop shared language, understanding, and methods. Panelists also stressed the importance of communicating complex science to broader audiences and addressing the societal impact of mental health research.

The second panel, moderated by Brent Roberts, included Illinois faculty members Jaime Derringer, Tom Kwapil, David Sepkoski, and Jacob Sherkow, who talked about the societal impacts and implications of the Center's work. Discussions covered topics from across the board, including the interacting and overlapping complexities of human mental health, as well as the history of scientific debates on mental health and genetics.

The event also included an icebreaker discussion on the Kellner Center's priorities over the next decade. The discussion gave attendees from across campus an opportunity to talk to each other, with an eye towards building interdisciplinary collaborations. Topics ranged from studying the biological basis of free will to refining conceptual frameworks for psychological disorders and fostering bidirectional and interdisciplinary conversations between scientists and society, especially regarding mental health.

Julie Kellner, whose generosity, along with her husband's, made the Center possible, shared her vision.

"We wanted to create systemic change—to rethink how we view, study, and treat mental health."

This vision will guide the Kellner Center as it bridges disciplines to discover insights into the connections between genes, brain, and society to improve our understanding of and reduce the stigma surrounding mental illness. The Center's commitment to responsible and impactful research ensures that results will be translated into best practices that truly benefit individuals and society.

Alison Bell, professor of evolution, ecology, and behavior (GNDP leader); **Jaime Derringer**, associate professor of psychology (GNDP); **Tom Kwapil**, professor of psychology; **David Sepkoski**, professor of history; **Jacob Sherkow**, professor of law (GSP); **Brent Roberts**, professor of psychology (GNDP)

New beginnings

Illinois leads the way in biomanufacturing

NSF to invest $5M to the Reliable and Scalable Biofoundries for Biomanufacturing and Global Bioeconomy—The NSF and partner agencies in the U.S., Canada, Finland, Japan, the Republic of Korea (ROK), and the United Kingdom announced funding awards in their Global Centers competition. One of the centers, the Reliable and Scalable Biofoundries for Biomanufacturing and Global Bioeconomy, includes researchers from Illinois.

2024 Global Centers awards focus on advancing bioeconomy research to solve global challenges, whether by increasing crop resilience, converting plant matter or other biomass into fuel, or paving the way for biofoundries to scale-up applications of biotechnology for societal benefit. The program supports holistic, multidisciplinary projects that bring together international teams and scientific disciplines, including education and social sciences, necessary to achieve use-inspired outcomes. All Global Centers will integrate public engagement and workforce development, paying close attention to impacts on communities.

"Global Centers are leveraging expertise and resources across like-minded nations and uniting multidisciplinary teams from around the world to accelerate innovations in the bioeconomy for great impact," said then-NSF Director Sethuraman Panchanathan.

Sethuraman Panchanathan, then-NSF Director

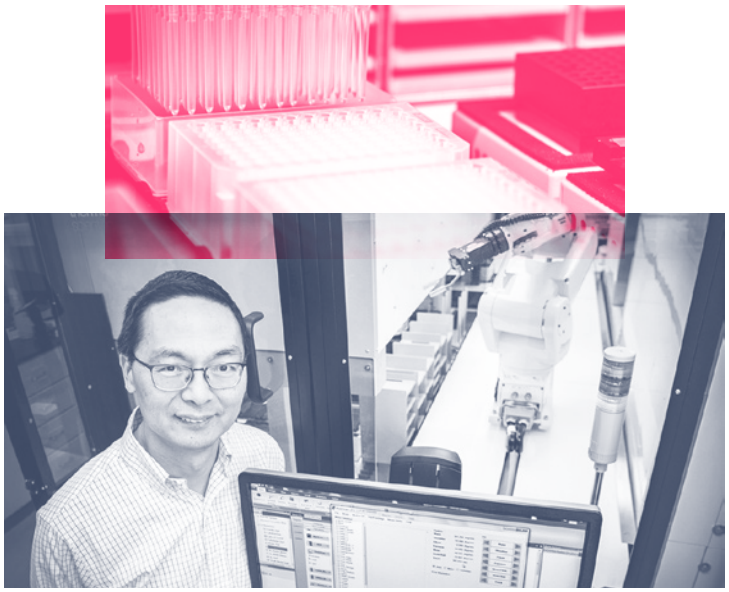
"Together, we are forging new solutions to pressing socio-economic challenges impacting all of us. These international centers of research excellence will generate crucial knowledge, empower communities and strengthen the foundations of global cooperation."

Partner agencies include the National Endowment for the Humanities in the U.S.; the Natural Sciences and Engineering Research Council and Social Sciences and Humanities Research Council of Canada; the Research Council of Finland and Innovation Funding Agency Business Finland; the Japan Science and Technology Agency; the ROK Ministry of Science and ICT and the National Research Foundation of Korea; and United Kingdom Research and Innovation.

The new Global Center, which will be based at Illinois, will leverage the expertise from seven biofoundries in the U.S., Finland, Japan, ROK, and the U.K. Led by Huimin Zhao, the team consists of 40 investigators from five countries and 17 institutions, including universities, national labs, private companies, and non-profit organizations. The Center will bring together experts in a wide array of fields, including synthetic biology, biofoundry, automation and robotics, software engineering, governance, and education. It will focus on four thrusts: developing and validating cross-national standards and metrics for biofoundry applications; performing cross-national comparisons of governance and regulatory frameworks for biofoundries to establish best practices; and developing cross-national programs for industry partnerships, public outreach, education, and workforce development.

"Biofoundries stand to be as transformative to biotechnology as computers are to information technology. However, their wide adoption for biomanufacturing and global bioeconomy is hindered by the lack of standards and metrics in data, workflows, ontologies, and regulatory considerations," Zhao said. "Together with our partners, we will address this grand challenge to enable full-scale adoption of biofoundry applications throughout society."

Huimin Zhao, professor of chemical and biomolecular engineering (BSD leader/CABBI/CGD/MMG)



Huimin Zhao will lead an NSF iBioFoundry.

NSF funds new iBioFoundry at Illinois—A newly funded NSF iBioFoundry at the University of Illinois Urbana-Champaign will build on more than a decade of research at Illinois to integrate synthetic biology, laboratory automation, and artificial intelligence to advance protein and cellular engineering. This is one of five new biofoundries to be established in the U.S.

According to the NSF, these facilities will "spur innovation, provide tools and technologies to researchers and help advance biology, biotechnology and the broader science, technology, engineering and math enterprise."

Each biofoundry will focus on a different area of biology or biotechnology. The Illinois facility will expand the use of automated

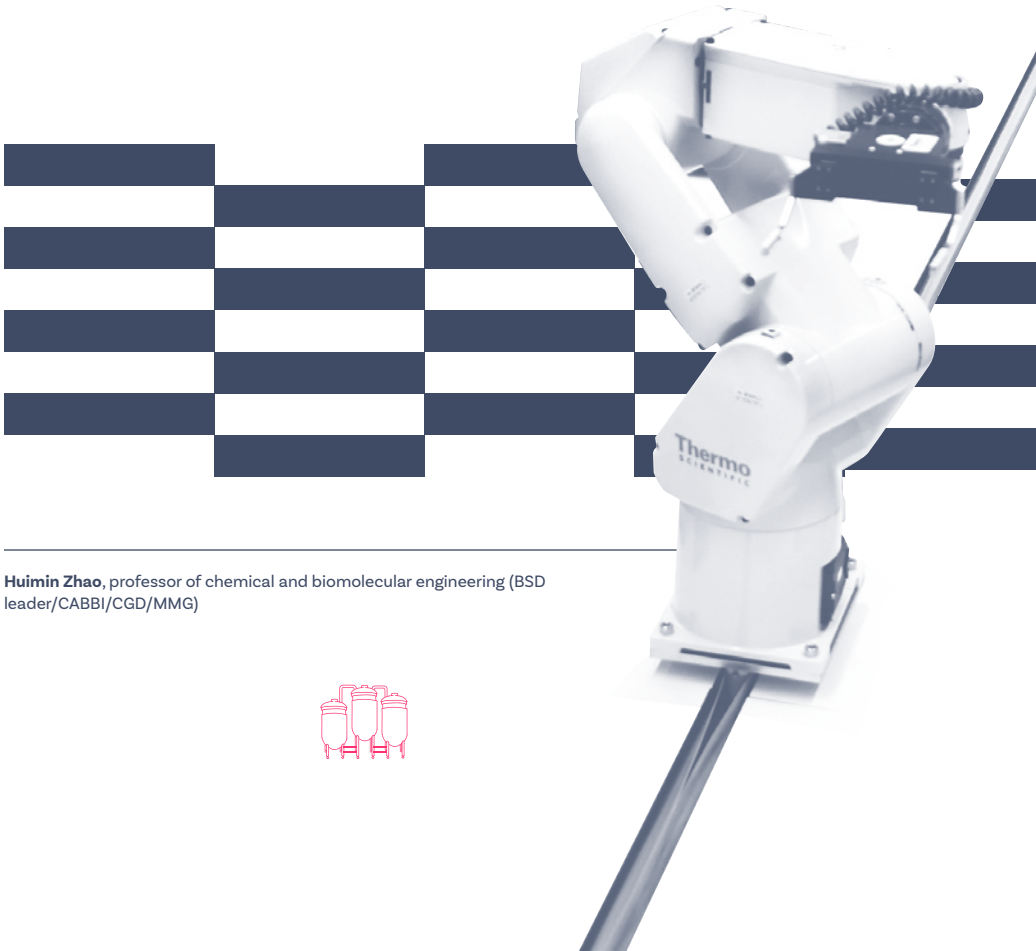
systems, machine learning, and AI to promote and optimize advances in synthetic biology, biotechnology, and genomics.

Huimin Zhao, who will lead the NSF iBioFoundry, described how previous efforts at Illinois have led to major advances in integrating these elements. Earlier milestones include the development of BioAutomata, an AI-driven, robotic biomanufacturing platform that uses living cells to produce useful chemicals; and FAST-RiPPs, an automated platform for discovering new bioactive compounds. In 2014, Illinois researchers established iBioFab, a facility at the IGB that supports the efficient design, fabrication, validation, and analysis of genetic constructs and organisms.

“The NSF iBioFoundry will serve as a hub for innovation, bringing together researchers, industry experts, and policymakers to foster collaboration and accelerate the development of sustainable biomanufacturing processes,” Zhao said. “By centralizing resources and expertise, it will streamline the creation of new bio-based products and technologies, ranging from renewable chemicals to advanced medical treatments.”

Another key focus of the NSF iBioFoundry will be to share its capabilities with “a diverse community of external users who will work to solve important scientific problems through a peer-reviewed, competitive proposal process,” Zhao said. “It also will be an open ecosystem of disruptive thinking, education, and community engagement that will revolutionize the way biology is taught and train the next generation workforce in biology, artificial intelligence, and robotics.”

The total NSF award to Illinois is $15 million for six years.



Huimin Zhao, professor of chemical and biomolecular engineering (BSD leader/CABBI/CGD/MMG)

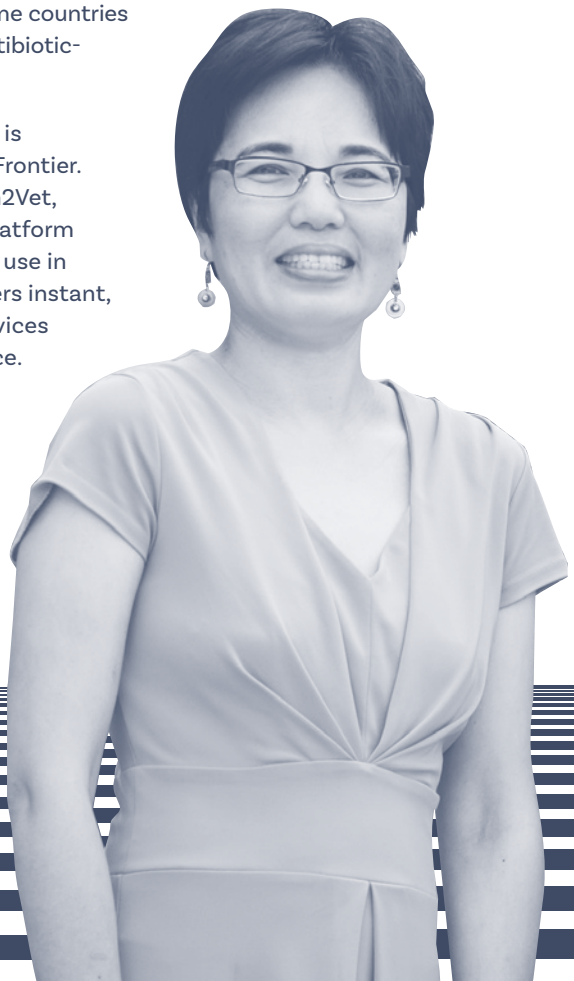
New beginnings

Working toward one health solutions

Illinois team awarded £1M for new technologies to help combat antimicrobial resistance—It is predicted that by 2050, antimicrobial resistance will result in 10 million additional deaths a year if strategies are not implemented now to counter this threat. The speed at which antibiotic resistance is growing is a direct response to misuse and overuse of antibiotics across our healthcare systems and the food industry.

To address this, the Trinity Challenge—a charity supporting the creation of data-driven solutions to help protect against global health threats—announced four winning teams of its second competition aimed at tackling the growing threat of AMR. The projects receiving funds are all focused on addressing significant data gaps in communities and lower-income countries that are disproportionately affected by antibiotic-resistant infections.

The winner of the grand prize of £1 million is Farm2Vet: Combatting AMR on the Farm Frontier. Led by a team of Illinois researchers, Farm2Vet, based in Vietnam, aims to create a new platform that will encourage responsible antibiotic use in food-producing animals by offering farmers instant, low-cost access to trusted veterinary services for disease diagnosis and treatment advice. As well as directly supporting farmers, the data gathered by the platform will inform policymakers by identifying hotspots of antibiotic resistance and allowing action to be taken to prevent outbreaks.



"I would like to express our tremendous gratitude to the Trinity Challenge. With their support, we can tackle AMR in a way that has never been done before," said Helen Nguyen, the Team Lead of Farm2Vet. "We will use the power of technology to extend the reach of veterinary services to remote farmers in many corners of Vietnam and, hopefully, learn lessons that can be extended to other countries too."

Pathobiology professor Csaba Varga

Csaba Varga added, "Providing trusted veterinary advice for farmers will improve disease management on farms and reduce the use of antimicrobials and the development of AMR."

All winners of the Trinity Challenge on Antimicrobial Resistance will also receive ongoing post-award innovation and scaling support as they implement their solutions from a network of technological and health organizations such as Amazon Web Services, the Gates Foundation, and the Wellcome Trust, among others.

"As a One Health Challenge, I am delighted that our winners have solutions to mitigate antibiotic resistance and improve our understanding in both human and animal health. I am excited to work with these teams as their innovations come to life."

MARC MENDELSON
DIRECTOR, TRINITY CHALLENGE

Helen Nguyen, professor of civil and environmental engineering (IGOH); **Csaba Varga**, professor of pathobiology (IGOH)

Hey IGB, what is something new you tried in 2024?

I did wheel throwing for the first time and made cute little cups and plates! It was so fun, and also really hard—Demi Moore did none of us any favors with setting up expectations.

I started my new job here at the IGB as a science writer!

I emailed the *Science* Editor-in-Chief, and from there, he mentored me through writing and submitting an e-Letter.

My partner and I fostered a shelter animal for the first time in our new place. And we failed—we kept him! 😈

I've met my book reading goal for the year—feeling proud of myself!

I was able to co-design experimental approaches to new molecular methodologies in the ancient DNA laboratory with a helpful colleague, usually a solitary area that we turned into a shared space to work together. We even had a chance to capture the moment with a Women in Science photo.

New beginnings

Investments in health research

New grant to study Ehlers-Danlos syndrome—Illinois researchers Christina Laukaitis and Brendan Harley recently received a three-year commitment of $250,000 to support research and plan workshops focused on Ehlers-Danlos syndrome.

Ehlers-Danlos syndrome is a set of inherited disorders that affect connective tissues, especially in the skin and joints and in the walls of blood vessels. Consequently, patients with this syndrome usually have overly flexible joints and fragile skin that doesn't heal properly. Unfortunately, very little is known about how the disease progresses.

"Hypermobile EDS is the most common type, and it overwhelmingly affects women. However, it is not understood. This project is exciting because we will be able to provide objective data about this understudied but significant disease."

CHRISTINA LAUKAITIS
CLINICAL ASSOCIATE PROFESSOR,
CARLE ILLINOIS COLLEGE OF MEDICINE

Building upon previous research, the Laukaitis group is interested in collaborating with the Harley group to create models that can look at how EDS tissues behave.

"Our daughter, Barbara, along with thousands of others, suffers from the many physiological conditions associated with hypermobile EDS," said Charles Bell, an Illinois alum who gave the donation along with his wife Catherine Bracken. "We were excited to learn about the work at Illinois in both research and clinical settings and hope it will lead to earlier identification of and, eventually, therapies to manage this debilitating condition."

Lead author
Christina Laukaitis

Together with Harley and Laukaitis, they also decided that it would be valuable to organize workshops that can bring in experts who can help with understanding EDS. Harley said, "Through these workshops, we want to figure out the scale of our future research projects that will include genomics, functional outputs, and imaging tissue models."

Christina Laukaitis, clinical associate professor, Carle Illinois College of Medicine (EIRH/RBTE); **Brendan Harley**, professor of chemical and biomolecular engineering (RBTE leader/EIRH)

New training grant for researchers in reproductive sciences and engineering—The NIH has approved the T32 grant "Interdisciplinary Research Training at the Interface of Reproductive Sciences and Bioengineering." The training program is aimed at predoctoral students who want to work at the interface of reproductive sciences and engineering, two long-standing areas of research excellence at the University of Illinois Urbana-Champaign.

"Both the White House and the NSF have been emphasizing the importance of looking at women's health. This grant is timely because we can use experts across the campus to bring biology and engineering together," said Amy Wagoner Johnson.

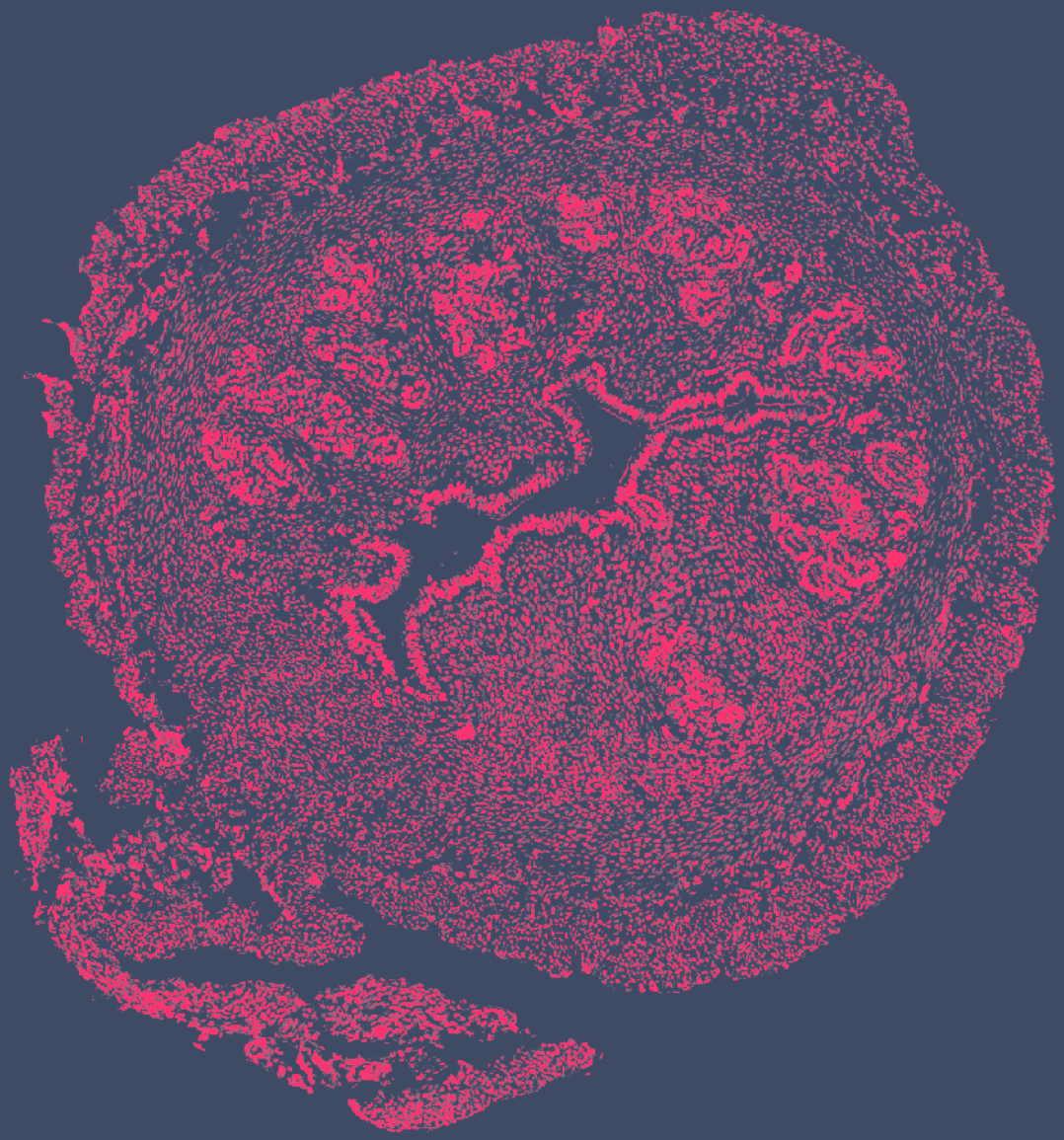
The program will draw from the rich history of interdisciplinary research, especially members of the IGB, Beckman, and Carle Illinois College of Medicine. The work will focus on germ cell development, hypothalamic-pituitary-ovarian function, spermatogenesis and fertilization, embryo-uterine crosstalk and pregnancy, and placentation and preterm birth.

"This is the first time this particular T32 grant has been approved on our campus and we are excited to have biologists and engineers work on different aspects of reproduction," said Indrani Bagchi, co-director on the grant.

The program will also emphasize co-mentorship of trainees by engineers and reproductive scientists, course requirements in both disciplines, and science communication, which will enhance team science endeavors.

"This grant was possible because of the EIRH theme at the IGB, which has members in several colleges across campus working on challenges in reproductive health," Bagchi said. "Based on our past success, we are confident that this grant will help train a new generation of researchers who will advance the field of reproductive sciences in ways that would not otherwise be possible."

Amy Wagoner Johnson, professor of mechanical science and engineering (EIRH/RBTE); **Indrani Bagchi**, professor of comparative biosciences (EIRH co-leader)



Immunostained microscope image of a mouse uterine tissue sample

Hey Science,
this year you eavesdropped on tomatoes and tracked the epic journeys of elephants.

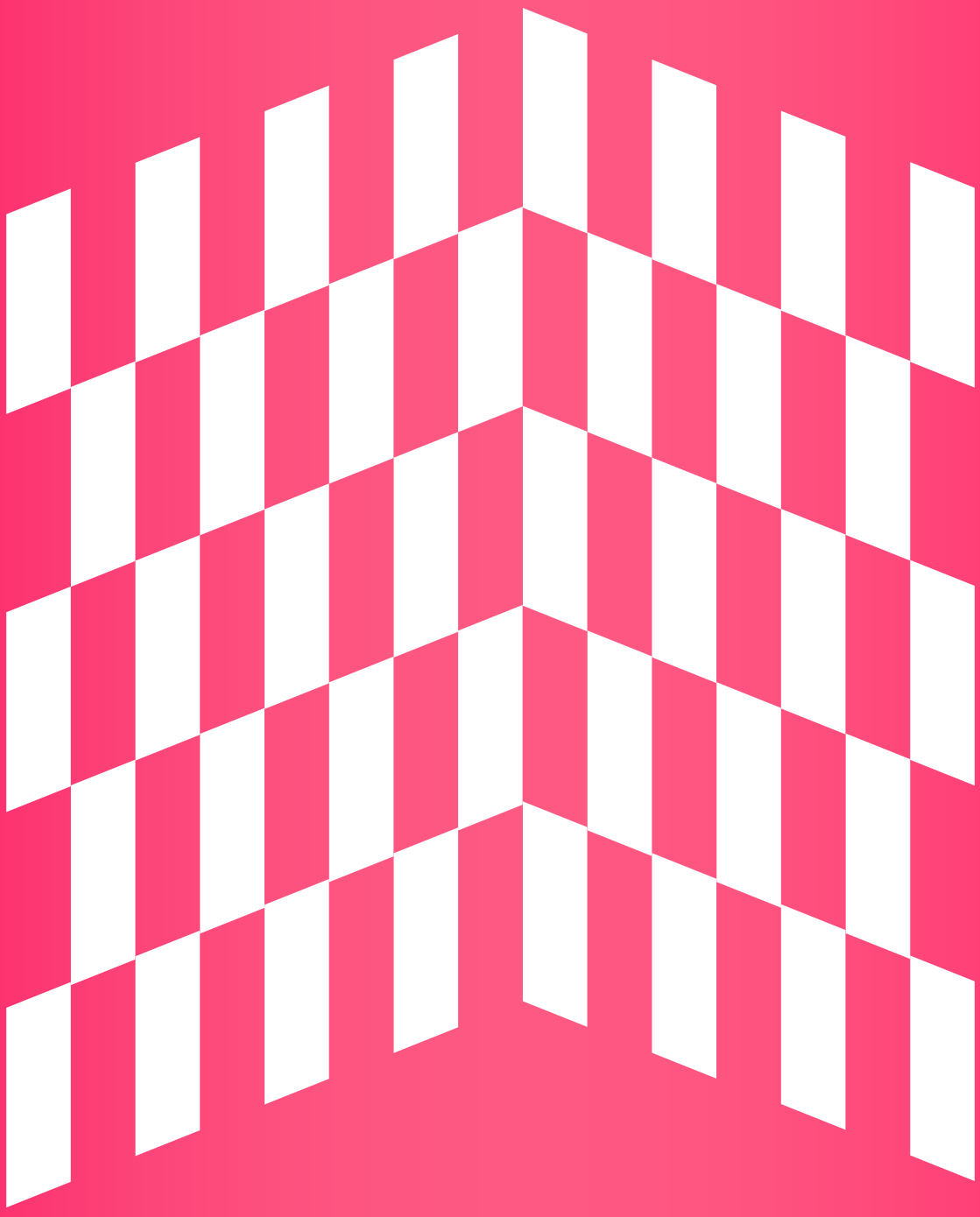
All these new discoveries?
You really understood the assignment.

Remarkable research

Voluble volatiles

Science and society

Discoveries In diverse systems



Remarkable research

Voluble volatiles

Talking tomatoes: How their communication is influenced by enemies and friends—Plants produce a range of chemicals known as volatile organic compounds that influence their interactions with the world around them. In a new study, researchers investigated how the type and amount of these VOCs change based on different features of tomato plants.

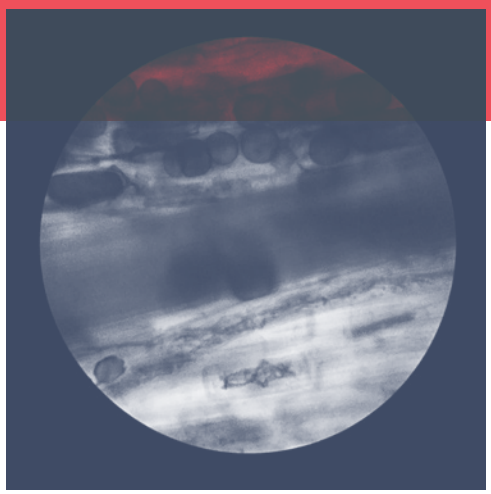
These findings were reported in the *Journal of Chemical Ecology*.

The smell of cut grass is one of the defining fragrances of summer. Smells like that are one of the ways plants signal their injury. Because they cannot run away from danger, plants have evolved to communicate with each other using chemical signals. They use VOCs for a variety of reasons: to help prepare their own defenses, to warn each other of threats, to recruit beneficial soil microbes that can help plants grow, and to alert insect predators that there is a pest chewing on that plant's leaves.

Studying the factors that influence VOC emissions, therefore, is key to understanding plant health. In the past, other studies have looked at how soil microbes like arbuscular mycorrhizal fungi or caterpillars or the variety of tomato plant can influence VOCs. In the current study, the researchers studied the collective influence of all these factors on plant chemistry using four tomato varieties—two heirlooms and two hybrids.

Esther Ngumbi and Erinn Dady working in the lab.

Above: Cherokee Purple heirloom tomatoes exposed to five days of flooding stress. Below: Microscope image of tomato roots showing the branched structures called arbuscules (meaning "tiny trees") and balloon-like vesicles.



The hybrids used were Mountain Fresh and Valley Girl, and the organic heirlooms were Amish Paste and Cherokee Purple.

The researchers compared the responses of untreated plants to those that had been exposed to AMF, caterpillars, or both. They studied the VOCs by enclosing the eight-week-old tomato plants with an odor-blocking oven bag for an hour. The AMF and the caterpillars, separately, decreased the volatile emissions in all four varieties of tomato plants. Their effect when present together was minimal compared to the effects when either one was present.

Although it is unclear why the beneficial fungal associations decreased the VOCs, it is concerning that the plants were not as

responsive to the caterpillars. Furthermore, the hybrid tomatoes emitted lower quantities of volatiles compared to the heirloom tomatoes. "Heirloom tomatoes—the big, juicy tomatoes we all love—are bred for flavor. Meanwhile, hybrids are grown for large scale conventional production, which comes at a cost to the plant," said Esther Ngumbi. "Our work suggests that we are compromising plant defenses through our breeding processes."

The plants were also evaluated based on their growth both above the ground and in the soil. The researchers found that plants that had associations with the fungi had higher leaf biomass and more complex root structures.

"AMF form partnerships in over 80% of the land plants, setting up a trade where the fungi extract nutrients from the soil in exchange for carbon from plants," Erinn Dady said. "We found that, especially in Cherokee Purple, AMF may confer additional benefits, including enhanced growth and greater emission of VOCs."

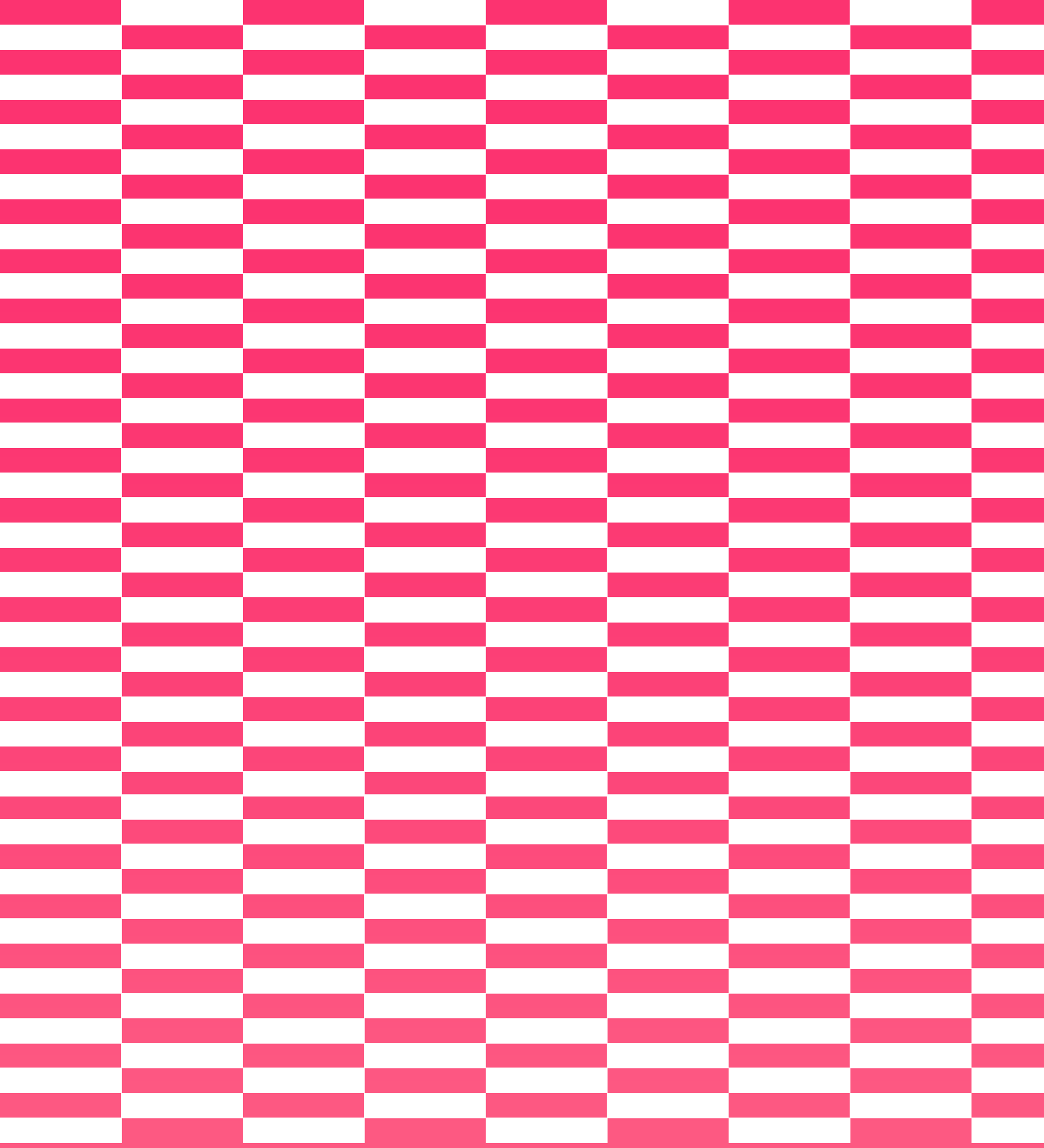
Surprisingly, the plants that were treated with caterpillars had greater plant growth, and the researchers are interested in further investigating this growth response. "It's possible that the plants decided that the number of caterpillars we were using was not sufficient to be considered a threat and that's why they kept growing. It is also possible that the caterpillars weren't hungry enough to cause enough damage," Ngumbi said.

"There's a lot going on behind the scenes that we don't yet understand. For example, we are barely scratching the surface in understanding the role of different microbes. People tend to think that plants are not intelligent, but our studies have shown that they are actively responding to the environment around them using chemistry."

ERINN DADY
GRADUATE STUDENT, NGUMBI LAB

Esther Ngumbi, professor of integrative biology (CIS/MMG); **Erinn Dady**, graduate student in entomology

This work was funded by the University of Illinois Urbana-Champaign.



Remarkable research

Science and society

Revisiting the Myriad gene patenting case a decade after decision—In a case that was a cultural phenomenon at the time, the Supreme Court of the United States determined that isolated human genes were not patentable when it issued its decision for the 2013 patent case *Association for Molecular Pathology v. Myriad Genetics, Inc.* Over 10 years later, experts from Illinois, Arizona State University, and Stanford University revisited the Myriad decision in a retrospective article.

A patent is granted by individual countries and gives an inventor the legal right to exclude others from making, using, selling, or importing their invention without permission of the patent holder. Patentable subject matter must be concrete, rather than an abstract idea, and laws of nature, products of nature, and natural phenomena are not patentable.

"Law and science as disciplines are often in misalignment with one another," said Jacob Sherkow. "The law is slow to keep up with biotechnology or it's written at a level that's not granular enough to take care of the exact thing that you're otherwise worried about."

In 1994 and 1995, biotechnology company Myriad Genetics won the race to determine the locations and DNA sequences of *BRCA1* and *BRCA2*—genes associated with increased breast cancer risk. Myriad was eventually awarded seven different patents, giving them exclusive rights to cancer screening and genetic testing involving

these genes. This made them more than 2.5 billion dollars between 1998 and 2013.

But since the first gene patent was awarded in 1982, people debated the legal and ethical issues associated with patenting human genes.

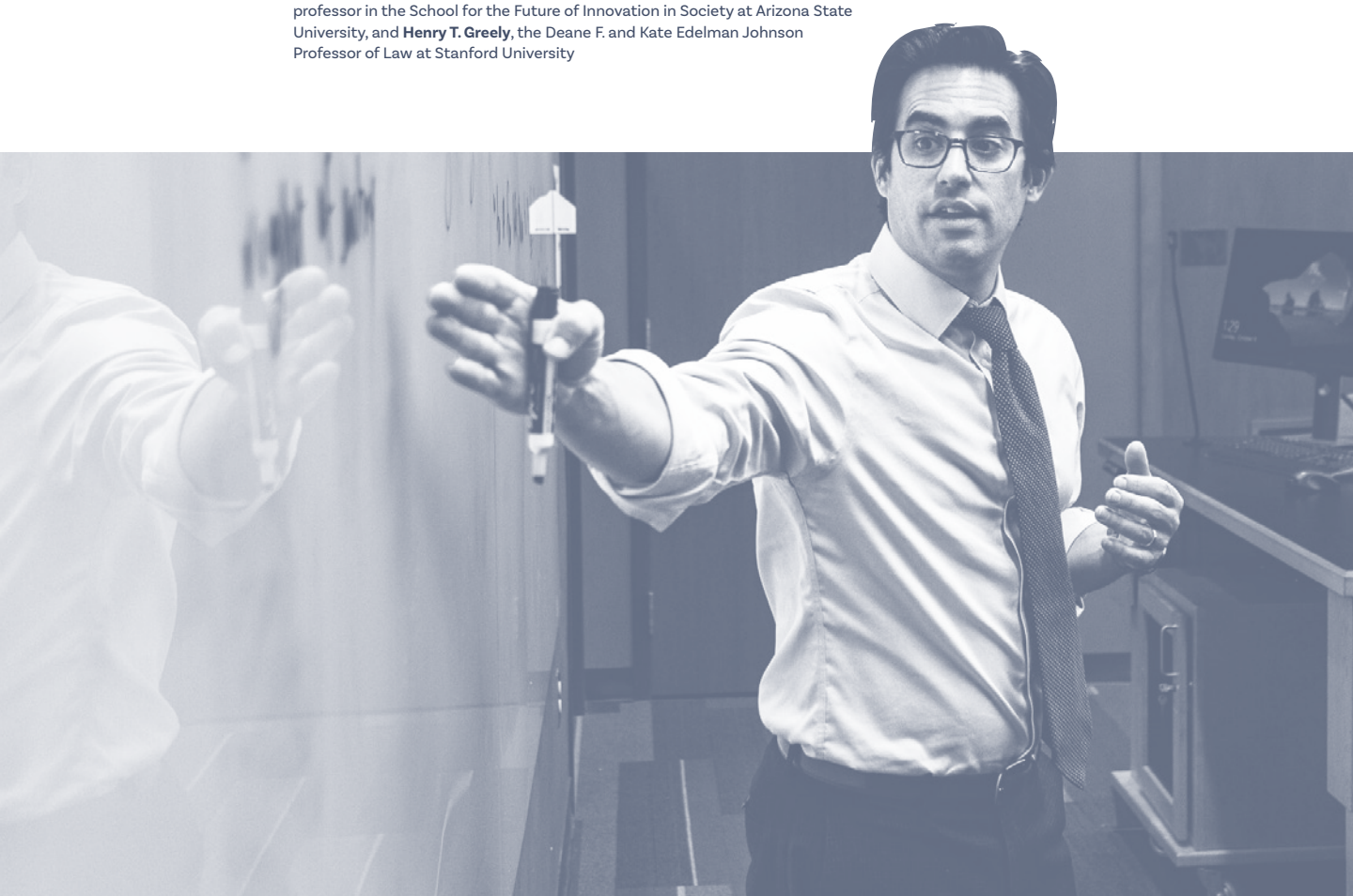
“There were generally these two sides. One of which says that patenting human genes will impede on new advances in biotechnology,” Sherkow said. “Then the other side says, if you don’t allow patents, then no one is going to do research in this area or develop the tools that you need to do research in this space.”

After years of litigation, the Supreme Court ruled in 2013 that isolated human genes were not patentable because the location and order of nucleotides in gene sequences are dictated by nature, not human intervention.

Sherkow said, “One of the things that we found in the retrospective was the muted impact the *Myriad* case had relative to the public interest at the time that it was being litigated. Technology has radically outclassed the single gene, semi-automated Sanger sequencing that Myriad Genetics was doing back in 1994.

So, to a certain extent, the case is now one of historical context as opposed to policy interest.”

Jacob Sherkow, professor of law (GSP); Sherkow’s coauthors are **Robert Cook-Deegan**, a professor in the School for the Future of Innovation in Society at Arizona State University, and **Henry T. Greely**, the Deane F. and Kate Edelman Johnson Professor of Law at Stanford University



Can genetic genealogy restore family narratives disrupted by the transatlantic slave trade?—Some political figures seek to remove references to slavery from the study of American history, adding to the vast knowledge gaps that stem from the transatlantic slave trade. To better understand these histories, scholars and individuals are turning to genetic genealogy to discover and retrace descendant-family lineages. In a recent paper published in the journal *American Anthropologist*, LaKisha David described these efforts. This article summarizes David's remarks during a conversation with News Bureau life sciences editor Diana Yates.

For African Americans descended from enslaved ancestors, genealogical records alone are often insufficient to trace lineages prior to 1870 when the U.S. census began recording African Americans by name. This makes it incredibly difficult to trace family lineages through documentation alone. Moreover, slavery systematically fractured African American family structures

Prof. David's new work concludes that "Genetic genealogy reconstruction is a viable, feasible, and timely anthropological pursuit to reclaim a more cohesive family narrative for descendants of those who were enslaved in the Transatlantic Slave Trade."

through the domestic slave trade and forced family separations, leading to huge gaps in knowledge.

Genetic genealogy offers a way to restore some of these lost connections by combining DNA testing with traditional family history research. Autosomal DNA tests from companies like 23andMe can identify shared genetic segments that indicate cousin relationships going back several generations. This technology is particularly valuable for descendants of ancestors who left little or no documentary trace due to social, political, or economic marginalization.

Discovering African relatives and hearing those new family narratives provides African Americans with new sources of socialization to reshape identity and belonging. By engaging with distant cousins who share specific ancestral lineages, people can recover lost branches of their family trees and gain a more complete sense of the histories that may have impacted their lives.

Genetic genealogy also contributes to dialogues about how slavery and colonialism have impacted Black identities worldwide. By revealing genetic relatedness across Africa and the diaspora, genetic genealogy empowers African descendants to redefine identities and kinship beyond the slaveholding frame.

The inhumanity of chattel slavery relied on the legal and cultural negation of African family integrity and history.

For African Americans who have grown up with a sense of ancestral loss and disconnection, this reclamation of family history is deeply humanizing and healing. It is ultimately about (re)claiming the humanity, dignity, and agency of enslaved Africans and their descendants, which is an essential component of repairing the harms of slavery.

LaKisha David, professor of anthropology (CIS/GSP)

Addressing concerns of genetic determinism of behavior by linking environmental influences and genetic research— It has long been known that there is a complex interplay between genetic factors and environmental influences in shaping behavior. Recently it has been found that genes governing behavior in the brain operate within flexible and contextually responsive regulatory networks. However, conventional genome-wide association studies often overlook this complexity, particularly in humans where controlling environmental variables poses challenges.

In an article, published in *PLOS Biology*, researchers from the University of Illinois and Rutgers University underscore the importance of integrating environmental effects into genetic research. The authors discussed how failure to do so can perpetuate deterministic thinking in genetics, as historically observed in the justification of eugenics movements and, more recently, in cases of racially motivated violence.

The authors proposed expanding GWAS by incorporating environmental data, as demonstrated in studies on aggression in fruit flies, in order to get a broader understanding of the intricate nature of gene-environment interactions. Additionally, they advocated for better integration of insights from animal studies into human research. Animal experiments reveal how both genotype and environment shape brain gene regulatory networks and subsequent behavior, and these findings could better inform similar experiments with people.

"Advances in genomic technology have really illustrated how changes in the environment lead to changes not only in behavior, but in the expression of genes, in a way that's not determined just by heredity," said co-author Matthew Hudson. "We now understand that even the same genes can function very differently across individuals depending on their expression."

Furthermore, the authors stressed the importance of multidisciplinary collaboration to understand the roots of behavior, especially among the animal and human research communities. Co-author Rina Bliss added, "We really need these kinds of collaborations among social scientists and biologists to illuminate the complexity of gene-environment interactions, especially as they relate to human behavior."

The article also suggested that emerging technologies such as brain organoids and new forms of brain imaging will be necessary to elucidate the molecular mechanisms linking genetic and environmental influences on behavior.

"Studying the roots of behavior holds great potential for insights that can help better understand brain function, in health and

disease. We hope this article helps researchers to make the most of the opportunities while avoiding reductionist pitfalls," said co-author Gene Robinson.

The authors suggested that a holistic perspective and fostering interdisciplinary collaboration could help researchers navigate the complexities of human behavior, while mitigating the risks associated with deterministic thinking in genetics.

Matthew Hudson, professor of crop sciences (CABBI/GNDP); **Rina Bliss**, Professor of Sociology at Rutgers; **Gene Robinson**, IGB director and professor of entomology and neuroscience (GNDP)

Study links neighborhood violence and lung cancer progression—Scientists have identified a potential driver of aggressive lung cancer tumors in patients who live in areas with high levels of violent crime. The findings were detailed in the journal *Cancer Research Communications.*

The study was designed to address the higher incidence of lung cancer in Black men than in white men, said Zeynep Madak-Erdogan, who led the research with Sage Kim, the principal investigator of the project. This disparity persists even though, on average, Black men smoke less and start smoking later in life than white men, Kim said.

The analysis focused on glucocorticoids, a group of steroid hormones like cortisol. These hormones bind to receptors that regulate the activity of other genes. Glucocorticoids and their receptors are involved in a variety of key functions, including metabolism, inflammation, and immune function, Madak-Erdogan said.

The researchers first assessed patterns of gene expression in lung cancer tumors and in cancer-free lung tissue from patients who lived in various Chicago zip codes—some with higher or lower levels of violent crime. The team also determined where the glucocorticoid receptors were binding on DNA in those tissues.

Both analyses revealed that GR binding and gene-expression patterns were different in healthy versus tumor tissues, and that the patterns also differed by a patient's zip code. Overall, GR binding was highest in people who lived in high-violence areas. But within the tumor tissues, those living in high-crime zip codes had lower GR binding. They also had lower levels of GR-regulated genes in the tumor tissues.

Professor Zeynep Madak-Erdogan and her team work on cell cultures and imaging equipment as they pursue methods that will provide answers in the fight against cancer.

The analyses also revealed that, within tumors, the GRs were activating genes for enzymes that degrade cortisol. This accounted for the lower cortisol levels—thus lower GR binding—in the tumors than in normal lung tissue. The lower cortisol levels were likely influencing the overall behavior of the receptors in the lung cancer tumors, Madak-Erdogan said.

"While we didn't prove a direct relationship in this study, our findings suggest that glucocorticoids and GRs are a main driver of adverse tumor outcomes in patients living with chronically high levels of environmental stress."

ZEYNEP MADAK-ERDOGAN
PROFESSOR, FOOD SCIENCE AND HUMAN NUTRITION

Prior to the new study, scientists suspected that stress hormones played a role in cancer or other health disparities, Madak-Erdogan said. "I think this study really crystallizes the idea that it's not just that individuals in these areas are more stressed. It's also that their stress responses are dysregulated. There is a direct effect of these hormones on normal cellular physiology."

Zeynep Madak-Erdogan, professor of food science and human nutrition (CGD/EIRH/GSP); **Sage Kim**, professor of health policy and administration, University of Illinois Chicago School of Public Health

The NIH supported this research.

Remarkable research

Discoveries in diverse systems

Elephants on the move: Mapping connections across African landscapes—Habitat loss and urbanization in southern Africa mean that elephants are increasingly restricted to protected areas like game reserves. The risk? Contained populations could become genetically isolated over time, making elephants more vulnerable to disease and environmental change.

A recent study published in *Biodiversity and Conservation* from the University of Illinois and the University of Pretoria in South Africa offers a map showing landscape connections that would support elephants' habitat needs and allow for more gene flow among populations.

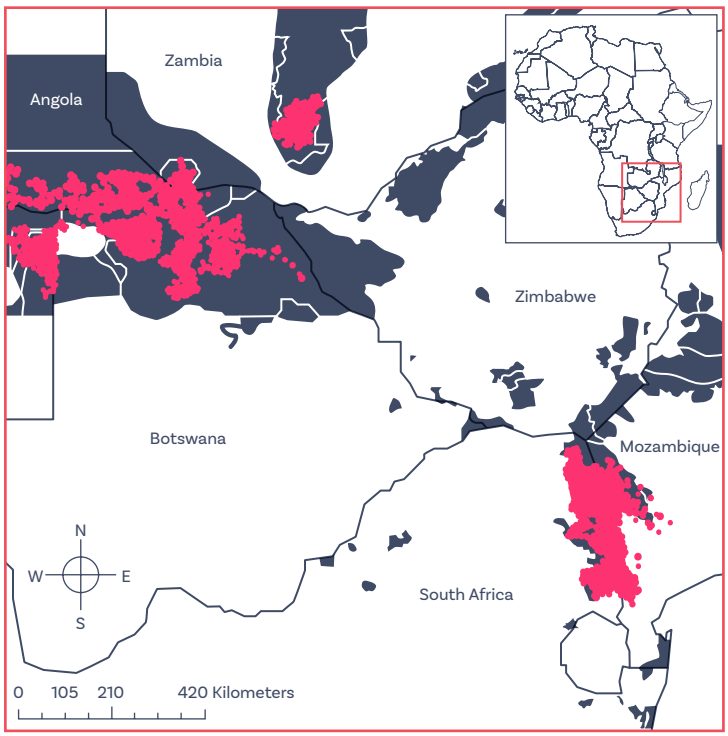
"Other research groups have integrated genetic and spatial data before, but usually it's done on a more local scale," said first author Alida de Flamingh, who completed the study as part of her doctoral program.

Alida de Flamingh and Professor Al Roca collect elephant dung for DNA analysis. This non-invasive approach allows for sample collection without direct contact with the animals.

Scale is meaningful because African elephants have very large home ranges—roaming more than 2.7 million acres—and they often travel long distances out of their way to avoid unsuitable habitat.

"This was a massive effort. We went out with our partners in the Conservation Ecology Research Unit at the University of Pretoria to collect non-invasive DNA samples from elephant dung across the whole range," de Flamingh said. "CERU also contributed data from GPS trackers on 80 collared elephants across nearly 54,000 locations."

GPS collar data shows how elephants move across the landscape but can't indicate whether that movement leads to gene flow. Conversely, DNA data document gene flow, but can't show how elephants moved to make that happen. Integrating the two datasets required a landscape genetics approach which examined the costs elephants encounter as they move along multiple pathways through the region, such as steep slopes, barren areas with little to no vegetation, densely populated human settlements, and areas far from water.



The model was based on elephant occurrence points that correspond with areas of known elephant range (pink dots represent occurrence data and gray areas represent the current elephant range as demarcated by the IUCN Red List of Threatened Species; Blanc 2008).

The researchers combined these environmental challenges with DNA data to explain how elephants might navigate their habitat, identifying key routes to maintain gene flow across protected areas.

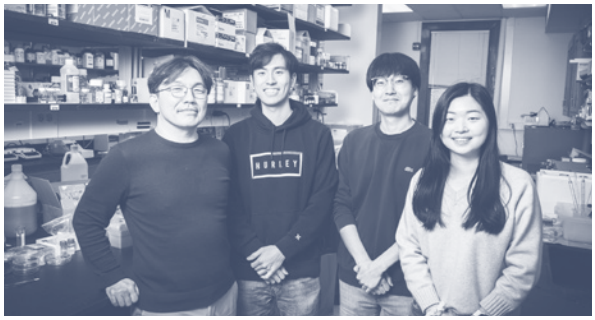
"Intermediate habitats aren't necessarily dictating their movements as much as these really unsuitable habitats. That's positive, if you think about it. They're tolerant of intermediate habitats and can still move through them," de Flamingh said.

The researchers identified areas like the vegetation-free Makgadikgadi salt pans in Botswana, as well as densely populated human settlements as unsuitable habitats. Providing connections for elephants that avoid these areas will also reduce human-elephant conflict, a distinct threat to elephants.

Alida de Flamingh, postdoctoral fellow, ecology, evolution, & conservation biology; **Al Roca**, professor of animal sciences (EIRH/GNDP)

The International Fund for Animal Welfare and the African Elephant Conservation Fund of the U.S. Fish and Wildlife Service supported this work.

Nerves prompt muscle to release factors that boost brain health—Exercise prompts muscles to release molecular cargo that boosts brain cell function and connection, but the process is not well understood. New research found that the nerves that tell muscles to move also prompt them to release more of the brain-boosting factors.



From left: Professor Joon Kong and students Kai-Yu Huang, Yujin An, and Sehong Kang

"The molecules released from the muscle go into the bloodstream and then to the brain, producing crosstalk between the muscle and brain. But the muscle itself is highly innervated. So we wondered, what is the effect of the neurons on this activity of the muscle, and further down to the communication between muscle and brain?" said Hyunjoon Kong, leader of the study published in the *Proceedings of the National Academy of Sciences.*

Research on exercise has found that muscles secrete hormones and extracellular vesicles, tiny packages containing molecules that enhance communication between brain cells. However, while much attention has been paid to the function of muscle-derived factors, the role of the nerves that stimulate the muscle is poorly understood, said Kai-Yu Huang, first author of the study.

To fill this gap, the researchers compared two muscle tissue models—one with neuron innervation and one without. They found that the innervated muscle produced more molecules that promote brain neuron activity and regulate muscle development than the muscle without nerves.

Then, the researchers stimulated the nerves with glutamate, a neurotransmitter. They found that the innervated muscle emitted higher levels of irisin—a hormone associated with beneficial effects of exercise—and released more extracellular vesicles than plain muscle.

"We analyzed the cargo carried in the vesicles, and we found that there was a greater diversity of microRNA associated with impact on neurodevelopment," Huang said. "These findings highlight the importance of neuron innervation."

Next, the researchers plan to look further into mechanisms at the junction where the neurons meet the muscle cells. They seek to

determine how nerve impulses stimulate the muscle and whether they affect the production of the brain-boosting factors, or just mediate their release—an important distinction for possible treatments for those who have lost nerves or muscle.

"It underscores the importance of exercise. Exercise creates a more robust interface between motor neurons and muscle. So we could look at the benefits of exercise focused on fostering that connection more than simply increasing the volume or strength of the muscle."

HYUNJOON KONG
PROFESSOR OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Hyunjoon Kong, professor of chemical and biomolecular engineering (M-CELS leader/EIRH/RBTE); **Kai-Yu Huang**, graduate student in chemical & biomolecular engineering

The NSF, NIH, Alzheimer's Disease Association, and CZ Biohub Chicago supported this work.

PFAS found in nearly all fish tested from four northern Illinois rivers—Scientists tested nine fish species from four northern Illinois rivers for contamination with per- or polyfluoroalkyl substances, synthetic chemicals found in numerous industrial and commercial products and known to be harmful to human health. The findings are reported in the journal *Science of the Total Environment*.

The qualities that make PFAS desirable for industrial uses—their durability and stability under stresses such as high heat or exposure to water, for example—also make these chemicals particularly problematic in the environment and hazardous to human and animal health, said Joseph Irudayaraj.

There are nearly 15,000 PFAS chemicals, according to the EPA, and they have been identified in groundwater, soil, and human tissues. Despite a voluntary phasing out of some PFAS in industry in the U.S. and efforts to reduce PFAS pollution, these chemicals are still found in drinking water, household products, food packaging, and agricultural products.

Focusing on fish in northern Illinois rivers because they are close to urban and industrial areas, the researchers collected dozens of samples from nine species of fish in the Pecatonica River, Rock River, Sugar River, and Yellow Creek from 2021-22. These included bluegill, channel catfish, common carp, northern pike, smallmouth bass, and walleye. The fish represented different levels of the food

Found at the top of the food chain, channel catfish were shown to have the highest levels of PFAS contamination.

Bioengineering professor Joseph Irudayaraj

chain, from those that feed only on plants, like bluegill, to those eating other fish, such as channel catfish and northern pike.

Back in the lab, the scientists analyzed fish tissues for 17 PFAS chemicals. They found PFAS-contaminated fish in every river they tested and in every one of their 15 sampling sites. Fish from the Rock River had the highest concentrations of PFAS in their tissues. Contamination levels were highest in channel catfish, at the top of the food chain, and lowest in the plant eaters.

Four chemicals known as perfluorooctanesulfonic acids, or PFOS, were detected in fish from every site tested.

Because fish are mobile, it is problematic to tie their contamination levels to the locale where they were sampled, Irudayaraj said. But the finding is worrisome for people who are exposed to the water or eating the fish from these sites.

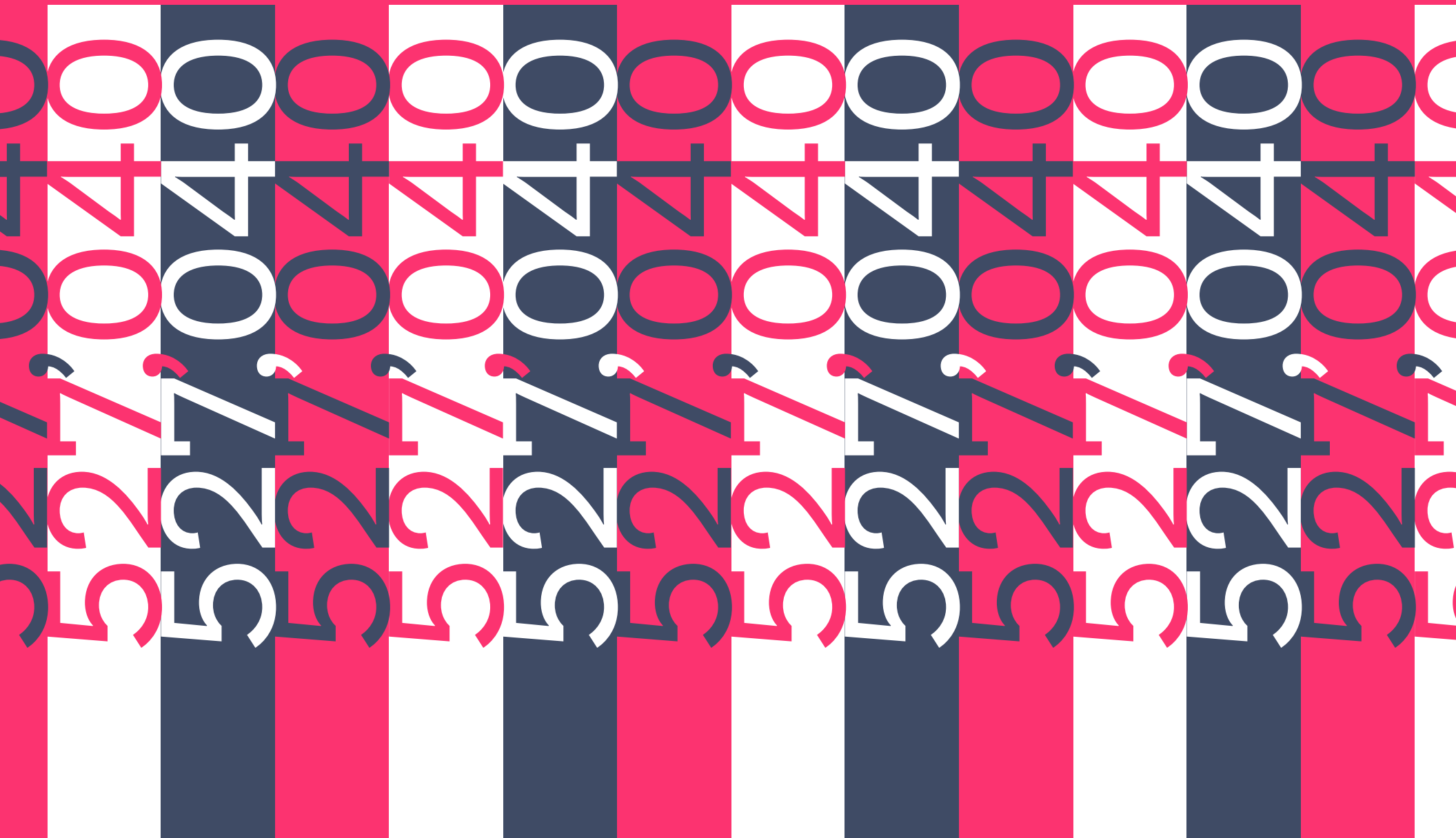
"Further studies are warranted to comprehensively evaluate the occurrence and sources of PFAS throughout the state of Illinois," the researchers wrote. "Such information is crucial to better understand the distribution and potential risks of these compounds to the environment."

Joseph Irudayaraj, professor of bioengineering (CGD/EIRH)

The Illinois Department of Natural Resources and the University of Illinois funded this work.

IN 2024, YOUR TOTAL RESEARCH TIME WAS 527,040 MINUTES.

Science never sleeps. That means there was contribution towards research every single minute in 2024 at the IGB.



Hey Science,
this year you built one of the largest Plinko games and one of the smallest robots we've ever seen.

You always find a way to connect, and we're here for it.

Connected communities

Science extravaganza for all ages

Aesthetics in action

Bringing genomics out of the lab

Sparking science careers

Connected communities

Science extravaganza for all ages

World of Genomics returns to Chicago—Usually, the rotunda of the Griffin Museum of Science and Industry in Chicago acts as a beautiful central space, teasing the museum's different exhibits in all four directions. On October 13 and 14, however, it was filled with the sights of drivable crop robots, a giant DNA model, and live beehives; the smells of soil microbes; and the satisfying sounds of Plinko, drowned out only by enthusiastic scientific discussion. As one of the world's largest science museums, which welcomes thousands of curious visitors every day, Griffin MSI served as a premier venue to bring back the World of Genomics after a five-year hiatus.

Hosted by IGB, World of Genomics offers a one-of-a-kind experience for people of all ages to engage directly with scientists and learn about the role of genomics in our everyday lives.


first time today.
First time coming and having an amazing experience Full of New Nolage.
I learned that some bacteria is good and bad.
good
bad
I learned that male ants only live for a couple weeks.
Sometimes things that look simple are actually really complex. I would like to share this with my class at school.
My favourite Station was Science and society because I had fun learning about fish
you learned more about today.
Something that I learned today is how bacteria actually give soil its smell.
Food and fuel. I can eat Pizza and still be healthy.
first time today.
I touched a bug with my bare hands for the first time.
BEST SCIENCE FAIR EVER!
CAN I PLEASE PLEASE HAE A STICKER
LOVED the interactive displays, thoughtful games and enthusiastic presenters! AMAZING!
Thank you!
Parent of 8yo
your favorite station.
Ro Bots
(Robots)

"Sharing the biology of DNA and genomes in an institution as beloved as Griffin MSI was simultaneously a privilege and a fascinating challenge in science communication. It was a joy to see families have fun engaging with what can feel like an obscure or intimidating area of science."

CLAUDIA LUTZ
ASSISTANT DIRECTOR OF OUTREACH, IGB

The successful two-day exhibit reached over 5000 attendees who participated in activities, games, and demonstrations developed and facilitated by IGB's researchers and staff. These activities were organized into six interactive stations inspired by IGB's different research themes: Introduction to Genomics, Food and Fuel, Science and Society, Health and Humanity, Cybernetic Cells, and DNA to Drugs.

Attendees enjoyed collecting stamps from each station to earn chances to play Plinko and win prizes like microbe keychains and science books. Feedback—gathered via notes stuffed into giant

test tubes—was overwhelmingly positive and highlighted that there was a fun activity to suit everyone's interests. Some of the crowd favorites included controlling the robot dog and crop robots, examining plants' stomata under microscopes, finding out their "Veggie Meter" scores, and observing insects up close. Many people also commented they learned something new during their visit and credited their interactions with IGB's scientists.

Over 50 IGB researchers and staff worked the different stations and used their expertise to explain the science behind the activities with the visitors. "The activities were designed to engage both kids and adults," said Abby Weber. "My favorite moment was when I taught a child how muscles contract and relax using a wooden model that I made, and they later returned with their parents to explain it back to them."

Putting on an event as large-scale as the World of Genomics truly took an IGB team effort. From development and careful logistical planning in Urbana to transporting a semi-trailer truck's worth of equipment and actually running the event in Chicago, every office across IGB from the Outreach team to Core Facilities helped bring this event to life. World of Genomics was also made possible with the time and support of sponsors including ThermoFisher Scientific, Illumina, Zeiss, Abbvie, and Germin8 Ventures.

To top off the successful weekend, an after-hours reception, sponsored by the Catherine and Don Kleinmuntz Center for Genomics in Business and Society, was held to celebrate the return of World of Genomics and further explore the innovative potential of genomics research.

"I was delighted to see the World of Genomics program restarted after the pandemic-influenced hiatus, as it is one of our flagship programs in public engagement," said Gene Robinson. "The 2024 Griffin Museum of Science and Industry edition was spectacular, and we are deeply appreciative of the tremendous effort and creativity brought forth by IGB's staff and researchers to make it such a success."

Claudia Lutz, assistant director of outreach; **Abby Weber**, graduate student in evolution, ecology, and behavior; **Gene Robinson**, IGB director and professor of entomology and neuroscience (GNDP)

We love what we do, but sharing it
with someone new really gives us life.

13,000

PARTICIPANT HOURS

In 2024, people from Illinois and beyond spent 13,000 hours engaging with us. For one person, or two, or for thousands, a seed was planted. A next generation scientist got excited. A new fact was shared to family and friends over dinner. We gave someone a new perspective.

Connected communities

Aesthetics in action

State Farm Center unveils concourse art installation in conjunction with IGB—State Farm Center unveiled a brand-new collaborative art installation with its campus partners at IGB. The artwork was installed as part of the Institute's Art of Science exhibit series and joins a variety of similar displays in other prominent locations throughout the state of Illinois and across the country. The exhibits are intended to help educate and connect the public with the incredible scientific research work being done right here on our campus.

"I'm delighted that Art of Science has made it to State Farm Center, one of the premier venues in Illinois and across the country, and I thank Illinois Athletics and the venue's staff for their collegial partnership," said Gene Robinson. "We hope that fans will enjoy the science that animates these stunning images as they take in an exciting Illini game or show on campus. I-L-L!"

The IGB's Art of Science program is a celebration of common ground between science and art. Each exhibit comprises images from IGB's research portfolio, enhanced to highlight the beauty and fascination encountered daily in scientific endeavors. The Art of Science includes subjects from the microscopic to the holistic, from the physical to the abstract. Art of Science is one of the first of IGB's outreach

The pieces displayed at the State Farm Center are titled “Those Level Miles” and “Vista Esplosa” and were created by Art of Science Curator Julia Pollack.

initiatives to relate science to the broader public in a relevant and beautiful way. The first Art of Science exhibit took place in 2011 and the IGB has since hosted a yearly exhibit open to the public.

“We’re proud to play a part in showcasing some of the amazing scientific research being done on our campus to the hundreds of thousands of visitors who enjoy Illini basketball games, our diverse entertainment lineup, and many other campus and community events each year,” John Marquardt said. “The Art of Science display will do just that, while adding visual appeal to a portion of our public concourses. We thank the IGB for their partnership and hope it assists in furthering their noble mission!”

Gene Robinson, IGB director and professor of entomology and neuroscience (GNDP);
John Marquardt, State Farm Center director and associate director of athletics

'Roots of Genomics' installation celebrates the diverse history within the field of genomics—Located on the concourse floor of the IGB Gatehouse, a new installation, titled 'Roots of Genomics,' beckons visitors to peruse significant milestones and achievements that have shaped the field of genomics. The artwork features plexiglass ribosomal shapes mounted onto metal standoffs, creating a captivating three-dimensional effect. Each ribosome is etched with key events in genomics history, set against a backdrop of human chromosomes artfully arranged to resemble a karyotype.

The piece serves as an inclusive timeline, highlighting not only the well-documented history of genomics but also the contributions of scientists whose work has often been overlooked.

"The IGB Task Force proposed the idea to create an installation that spoke to the unsung voices within the history of science," said Nicholas Vasi.

Julia Pollack brought the idea to life after being inspired by an article describing how life began and the key role ribosomes played in this development. The article included a figure of the structure of a ribosome, highlighting the innermost and oldest part nestled in the middle. This inner structure, where amino acids click together to form complex proteins, is nearly identical across vastly different organisms, suggesting its essential role in life.

"Carl Woese discovered the third domain of life through sequencing ribosomes, and ribosomes are also an important and ancient mechanism that all living things throughout time have in common. That's why I decided to use the shape of ribosomes to capture the content of our timeline."

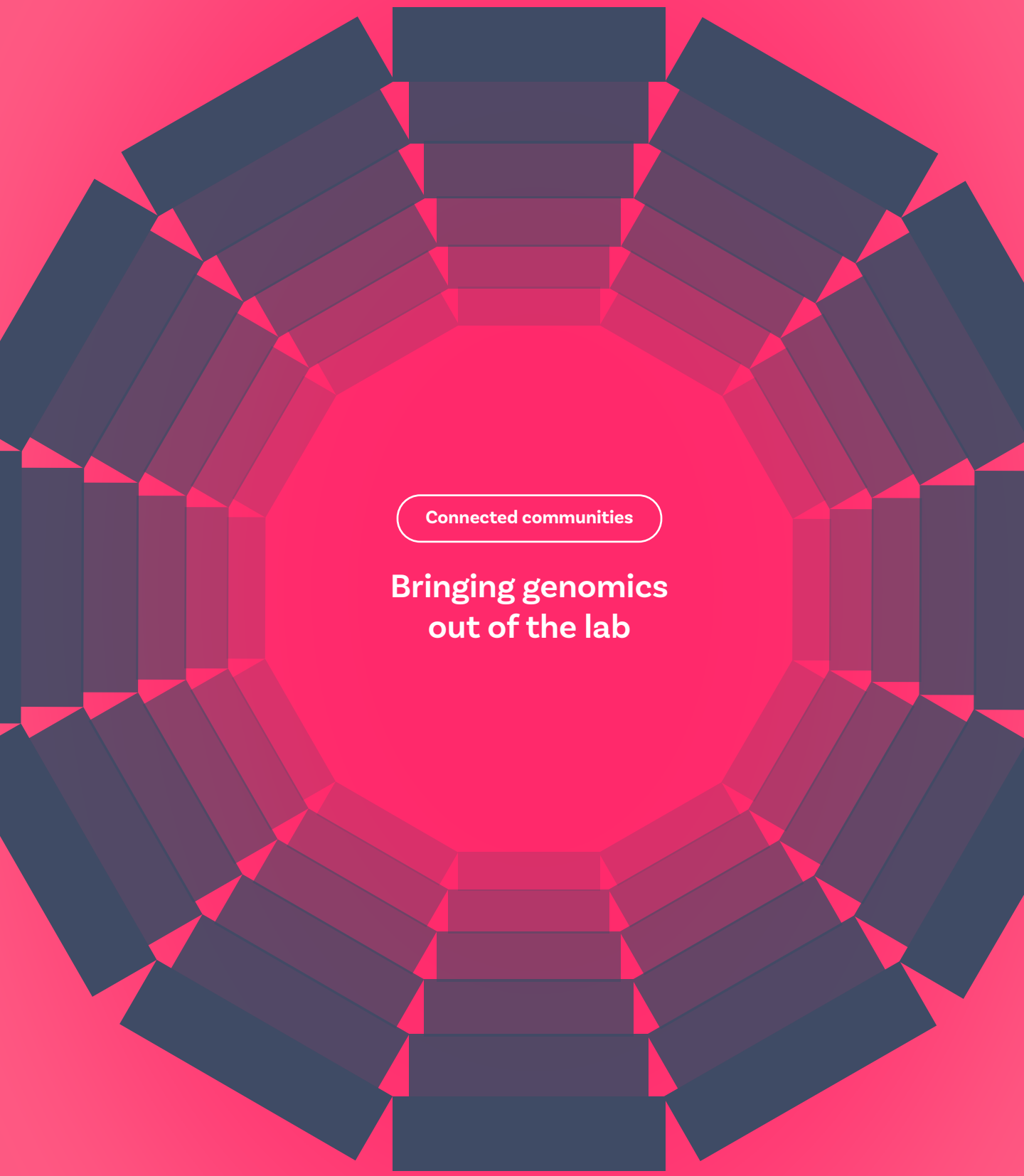
JULIA POLLACK
CREATIVE PROGRAM MANAGER, IGB

With this vision in mind, the IGB communications and outreach teams, faculty, and Task Force collaborated to meticulously sift through the history of genomics. They identified influential moments in the field, giving special attention to those often omitted from mainstream history. After the design was completed, Dean's Graphics and the IGB facilities team worked to expertly assemble the installation.

Pollack emphasized that the timeline's design was intended to be a collection of intriguing snippets rather than a standard, rigid timeline, to encourage both casual browsing and in-depth exploration. Viewers of the installation will also find an invitation within the text on the wall, encouraging them to share information on individuals or events that may have been overlooked. These contributions will be displayed on a digital screen next to the installation, which will be continually updated.

The 'Roots of Genomics' installation not only honors the past but also invites ongoing engagement and discovery, ensuring that the vibrant history of genomics continues to inspire, and to evolve.

Nicholas Vasi, executive director of communications and engagement; **Julia Pollack**, creative program manager



Connected communities

Bringing genomics out of the lab

Genomics workshop equips judges with knowledge to navigate emerging legal questions—The legal system faces the challenge of protecting individuals from potential misuse of genetic data, such as unfair denial of health insurance, while also allowing for the leveraging of its benefits, like improving early interventions for disease.

The IGB hosted its third Genomics for Judges workshop this June. The workshop, funded by the State Justice Institute and offered in partnership with the National Courts and Sciences Institute, aimed to equip judges with the knowledge necessary to navigate the legal landscape shaped by advances in DNA sequencing, analysis, and more recently, artificial intelligence.

"The Genomics For™ program is a vivid demonstration of our commitment to engage all sectors of the public with clear and trusted information on genomics. We're pleased and honored to again collaborate with the NCSI, one of the premier judicial training organizations in the country."

GENE ROBINSON
DIRECTOR, IGB

The two-day workshop offered a comprehensive curriculum that included expert seminars and panels, interactive discussions, and hands-on experiments. By examining the intersection of genomics with the legal system, the event sought to prepare judges for the challenges and opportunities these technologies present.

The workshop featured numerous seminars, including one by Derek Hoiem who emphasized the importance of understanding AI's training processes,

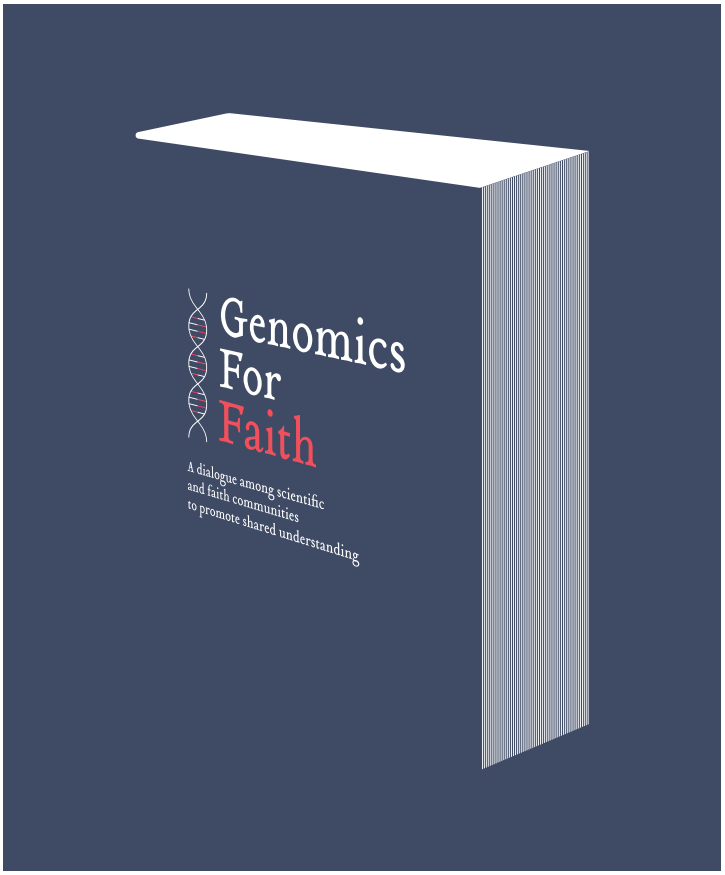
potential biases, and the role of digital forensics in verifying the authenticity of AI-generated media, a growing concern in legal contexts. Another notable seminar, led by Brian Allan, discussed regulatory ambiguities and legal questions judges might face concerning genetically modified organisms.

Alta Charo delivered a compelling keynote address on equity and access to emerging genome editing therapies. Her seminar also emphasized the critical role of the judiciary in ensuring that legal decisions regarding these technologies compel companies to address and devise solutions to these equity issues.

Attendees also participated in case studies that allowed the judges to apply their newfound knowledge to hypothetical legal scenarios and took part in a hands-on experiment. Led by Dan Urban, judges tested whether snacks labeled as GMO-free actually contained GMOs by using gel electrophoresis. This experiment offered a practical demonstration of genetic testing techniques and their applications, and it quickly became a favorite among the judicial participants.

Overall, the workshop underscored the critical role of education in bridging the gap between advancing technology and the judiciary. By equipping judges with a robust understanding of genomics and AI, the IGB aims to ensure that legal decisions involving these technologies are informed, fair, and just.

Derek Hoiem, professor of computer science; **Brian Allan**, professor of entomology (IGOH); **Alta Charo**, Warren P. Knowles Professor Emerita of Law and Bioethics, University of Wisconsin-Madison; **Dan Urban**, regional outreach program manager



Genomics for Faith explores potential and ethics of stem cell research—Supported by the Wayfarer Foundation, Genomics for Faith aims to bridge the gap between scientific knowledge and faith-based perspectives by fostering dialogue and mutual understanding. Recently, IGB hosted the third installment of the series, which explored stem cell research. Stem cells, known for their remarkable capacity to differentiate into various cell types, hold much potential for medical applications such as tissue repair and regeneration.

Throughout the workshop, participants, including both scientists and faith leaders, engaged in group discussions while enjoying lunch. Illinois researchers Sara Pedron-Haba and Haiting Ma, who had met with faith leaders prior to the workshop, also joined the conversations to offer their insights.

Throughout the discussions, a consensus emerged that the controversy surrounding stem cell research primarily relates to the sourcing of embryonic stem cells. It became evident that a prevailing misconception in society equates the term “stem cell” with “embryonic stem cell.” While embryonic stem cells have

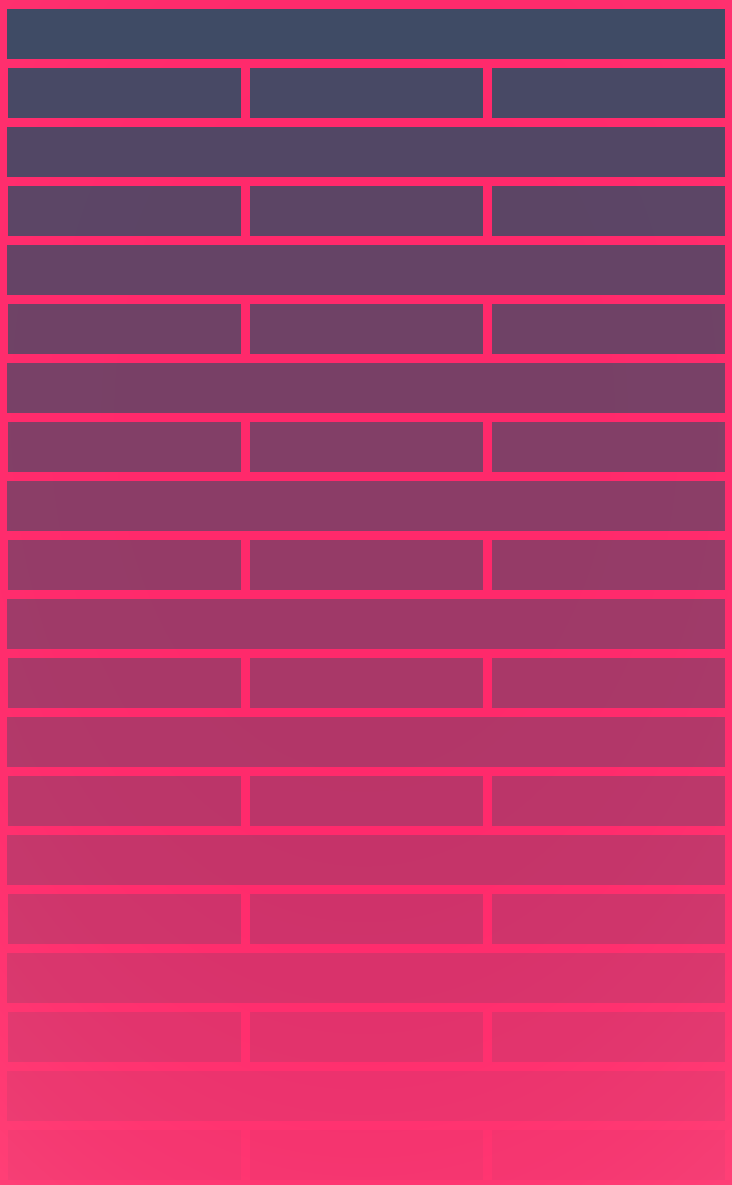
garnered significantly more attention due to their versatility in medicine compared to other stem cell types, stem cells derived from alternative sources—such as bone marrow or organs—still offer promising avenues for therapeutic development without ethical dilemmas and are already commonplace in medical treatments today.

Faith leaders emphasized the crucial role of effective communication in fostering broader acceptance and understanding of stem cell research. Scientists and faith leaders alike agreed that by informing the public on the tangible benefits to society and emphasizing the ethical frameworks guiding their work, scientists can better inform public discourse on and perception of the use of stem cells in research.

Sara Pedron-Haba, professor of chemical and biomolecular engineering (RBTE); **Haiting Ma**, professor of cell and developmental biology

Connected communities

Sparking science careers



New IGB research education program for undergraduate students—IGB is renowned for its interdisciplinary research that spans various departments across the University of Illinois Urbana-Champaign. A new program, supported by Mark Tracy, will focus on cultivating interdisciplinary thinking among undergraduate students and preparing them for industry careers.

The program, called the Tracy Undergraduate Team Science Training Program, was launched in late 2024. It was designed to incorporate case studies, active learning, and panel discussions drawn from the 15 interdisciplinary research themes at the IGB. The workshops are led by industry professionals and provide internship opportunities for the students. They also earn a certificate at the end of the course. The funding provided by Tracy, founder and president of Tracy BioConsulting, LLC, will support the program for two years.

Tracy graduated with a bachelor's degree in chemical engineering from Illinois and went on to earn a PhD in chemistry at Stanford University. He then pursued a research career in the biotechnology industry that included developing novel therapeutics, most recently leading to the development of RNA-based medicines and COVID vaccines.

"I was drawn to the IGB because the research had so many dimensions to it. I also attended a World of Genomics exhibit in Chicago, and I thought that IGB's communications with the non-academic world was particularly effective," Tracy said.

Previously, Tracy had provided funding for the Mark Tracy Undergraduate Translational Research Fellowship, which afforded undergraduate students the opportunity to participate in innovative research with direct applications to the biotechnology industry.

"I wanted to focus on undergraduates for two reasons: there aren't many programs that cater to them and the earlier you introduce them to new career options, the more open they will be,"

Tracy said. “Hopefully, this course will give the students an edge after they graduate.”

Tracy also believes that the program will encourage students to work across traditional boundaries in academia and help prepare them for careers in industry. “Research problems have become increasingly complex over time. Instead of organic chemists collaborating with physical chemists, we now have chemists, biologists, engineers, physicians, and many others all working together,” Tracy said. “These disciplines have very different languages and approaches to solving problems, and it is important to learn how to communicate with people from different backgrounds.”

Mark Tracy, Founder and President, Tracy BioConsulting, LLC

Full STEAM ahead for science! Another year of STEAM TRAIN comes to completion—The STEAM (Science, Technology, Engineering, Arts, and Mathematics) TRAIN (Transdisciplinary Research Across Institutional Near-peers) program is a collaboration among IGB, Franklin STEAM Academy, and Uni High, that encourages middle school students to explore any science or engineering projects that interest them, with no limits other than their own creativity.

STEAM TRAIN is organized by Daniel Urban and Zanne Newman. The program, which recently completed its fourth successful year, empowers student-driven research, giving middle school students the opportunity to conceive and design their own scientific and engineering projects. With guidance from their near-peer mentors—including Uni High students, graduate students, and professors—middle schoolers learn to formulate hypotheses, refine their research questions, collaborate effectively, and take the lead on their investigations.

This year, the program started in September 2023, and the five groups presented the culmination of their projects in May 2024.

Some groups researched the ecology of different animals, with one focusing on habitats, diets, and potential threats to marine

species, and another examining the different locomotions of snakes and the environments those movements are used in. The third group explored computer science, coding a pong-like video game using Python. Another group, fascinated by the regenerative abilities of planaria flatworms due to their stem cells, conducted an experiment in which worms were bisected and observed for regrowth. The last group took an engineering approach, deciding to test the tensile strength of different materials, including wood, plywood, cloth, silk, and various metals.

"I am always impressed by the types of questions our students ask. They choose incredibly interesting and challenging topics to research, and the levels of excitement and ingenuity they tackle these problems with are amazing."

DANNY RYERSON
OUTREACH ACTIVITIES COORDINATOR, IGB

The STEAM TRAIN program exemplifies the power of creativity and mentorship in inspiring the next generation of scientists and engineers, showing that with guidance and resources, young minds can achieve extraordinary things.

Dan Urban, regional outreach program manager; **Danny Ryerson**, outreach activities coordinator; **Zanne Newman**, Franklin STEAM Academy Magnet Site Coordinator

This program is funded by the University of Illinois Community Research Partnership Program.

Hey Science,
this year you were recognized for everything from feeding the world to fighting pandemics.

You're lowkey dominating, and we're glad you were seen.

Congrats

IGB staff go above and beyond

Spotlight on faculty achievement

Talented trainees

Congrats

IGB staff go above and beyond

IGB employees honored with Chancellor's Staff Excellence Award—Sixteen academic professionals and civil service staff members, including two from the IGB, have received the Chancellor's Staff Excellence Award recognizing exceptional performance at Illinois. A CSEA committee recommends finalists, who are approved by Chancellor Robert Jones. Each awardee receives $1,500 and a commemorative award.

From the Administrative and Public Engagement category, Susan Thomas was recognized. When she started as a postdoctoral fellow in one of the earliest research themes at IGB, Thomas quickly recognized the importance of interdisciplinary work, its potential for broad impact, and the need for high-level programmatic support that was trained with a vision for science in society. As a program manager for multiple IGB initiatives and programs, Thomas has dedicated herself to this mission with selfless and strong leadership.

During the COVID-19 pandemic, Thomas was on the front line of what became SHIELD Illinois, a screening testing program and infrastructure designed to safely open schools and workplaces. Thomas assisted in coordinating equipment movement, submitted RAPID proposals to support the collection of wastewater sampling

technology, and helped with the development of the Rockefeller Foundation return-to-school protocols that were adopted at the national level. In addition, she worked with a team of researchers to extend university resources for the testing and support of marginalized essential laborers in surrounding communities. This work included coordinating communication of faculty, students, staff volunteers, local community leadership groups, and local and statewide officials at departments of public health.

Her integrity and focus on outcomes extend into complex negotiations on everything including budgets, space, scientific priorities, communication strategies, student success, and conflict resolution. Thomas' dedication and support are what make research at both IGB and our university proactive, impactful, and relevant to the challenges of today.

From the Research category, Amy Ahmed was recognized. A research laboratory manager, Ahmed consistently goes the extra mile to ensure that work at the IGB goes as smoothly as possible. When the COVID-19 pandemic hit, she was instrumental in getting the right equipment prepped and ready for travel very quickly, so that it could be loaned to Carle Foundation Hospital until the equipment they ordered for this purpose arrived. Her efforts helped to provide for life-saving testing before there was a widespread testing protocol or option.

Ahmed works to educate herself on new research techniques as well as leadership, management, and communication skills.

Her work ethic and attention to detail make her a great asset in developing alternatives when hardships present themselves or when something critical needs to be done correctly the first time. Her efforts at the Bee Research Facility greatly assist researchers by providing the necessary equipment, allowing the research staff to begin working almost immediately while ensuring the health and welfare of the bees.

She is expert at supporting new students and postdoctoral researchers as they learn to perform complex molecular protocols. She removes many barriers to entry for students less accustomed to molecular work, while at the same time enabling them to build independence and confidence as they progress in their research. Ahmed is also adept at learning and troubleshooting new protocols, helping the lab stay at the cutting edge of genomics, and contributing to the esteemed reputation of the lab and IGB.

Susan Thomas, program manager; **Amy Ahmed**, research laboratory manager

Congrats

Spotlight on faculty achievement

CZ Biohub Chicago announces first cohort of Investigators— Sixteen Illinois researchers, including twelve from the IGB, have been selected to become part of the inaugural cohort of CZ Biohub Chicago Investigators. The group, which will focus on instrumented tissues, inflammation, and the functions of the immune system, also includes investigators from Northwestern University and the University of Chicago.

CZ Biohub Chicago, which was announced in 2023, brings together researchers to develop technologies capable of making precise, molecular-level measurements of biological processes within human tissues. Understanding and treating the inflammatory states that underlie many diseases is its ultimate goal.

"The CZ Biohub Chicago is focused on high-risk, high-reward research, and the selection of these 16 Illinois investigators—from so many colleges and institutes across the university—underscores the breadth of research excellence on our campus," said Susan Martinis.

In addition to the IGB, Illinois colleges and research institutes represented in the Biohub cohort include the Carle Illinois College of Medicine, Grainger College of Engineering, the College of Liberal Arts & Sciences, the College of Veterinary Medicine, Beckman, the Cancer Center at Illinois, and the NCSA.

The CZ Investigator Teams consist of the following: Amy Wagoner Johnson, Mechanical Science & Engineering (EIRH/RBTE), Indrani Bagchi, Comparative Biosciences (EIRH co-leader), Bradley Sutton, Electrical & Computer Engineering, and Ayelet Ziv-Gal, Comparative Biosciences; M. Taher Saif, Mechanical Science & Engineering (M-CELS/RBTE); Hyunjoon Kong, Chemical & Biomolecular Engineering (M-CELS leader/EIRH/RBTE) and Qian Chen, Materials Science & Engineering (M-CELS); Bumsoo Han, Mechanical Science & Engineering (M-CELS) and Martha Gillette, Cell & Developmental Biology (GNDP/M-CELS); and Catherine Murphy, Chemistry, and Rohit Bhargava, Bioengineering (CGD). The remaining investigators are Auinash Kalostra, Biochemistry (CGD/GNDP); Mei Shen, Chemistry (GNDP); Shannon Sirk, Bioengineering (MME/MMG); Jonathan Sweedler, Chemistry (BSD/CABBI/MMG), and Yurii Vlasov, Electrical and Computer Engineering.

Susan Martinis, vice chancellor for research and innovation

IGB faculty elected to American Academy of Arts and Sciences—Five Illinois faculty members, including three from the IGB, have been elected members of the American Academy of Arts and Sciences, one of the oldest honorary societies in the United States. Nancy M. Amato, Rashid Bashir, Alison Bell, Charles Gammie, and Paul Selvin are among the 250 inductees for 2024.

Founded in 1780, the academy recognizes scientists, artists, scholars, and leaders who have distinguished themselves in the public, private, and nonprofit sectors.

Nancy M. Amato works at the intersection of robotics, parallel and distributed computing, computational geometry, and biology. Her research group develops novel algorithms in applications ranging from robotic tasks and motion planning to computer-aided design and protein folding. She is passionate about broadening participation in the field of computing. Amato is a Fellow of the American Association for the Advancement of Science, the Association for the Advancement of Artificial Intelligence, the Association for Computing Machinery, and the Institute of Electrical and Electronics Engineers.

All five new AAAS members are, from left: Nancy M. Amato, Rashid Bashir, Alison Bell, Charles Gammie and Paul Selvin

Rashid Bashir's research focuses on integrating engineering and technology with biology and medicine, from the molecular scale to tissues and systems. His group has developed various lab-on-a-chip and point-of-care diagnostic devices to detect disease, infection, and sepsis from bodily fluids, as well as miniature biological robots for applications in medicine and engineering. Bashir is a member of the National Academy of Medicine, the National Academy of Inventors, the American Association for the Advancement of Science, the Institute of Electrical and Electronics Engineers, the Biomedical Engineering Society, and others. He was on the founding team of the Carle Illinois College of Medicine at Illinois and is currently on the leadership advisory committee of the CZ Biohub Chicago.

Alison Bell studies the evolution of behavior in the three-spined stickleback fish. She is a pioneer in the study of animal personality, using genomics and other tools to understand the causes and consequences of individual behavior differences. She is a member of the Animal Behavior Society, the International Society for Behavioral Ecology, and the American Society of Naturalists. She is a Fellow of the American Association for the Advancement of Science and a recipient of a Guggenheim fellowship. She also is affiliated with Beckman.

Nancy M. Amato, professor of computer science (M-CELS); **Rashid Bashir,** professor of electrical and computer engineering (CGD/M-CELS); **Alison Bell**, professor of evolution, ecology and behavior (GNDP leader); **Charles Gammie**, professor of physics; **Paul Selvin**, professor of physics

Congrats!

IN A YEAR OF STRONG SCIENCE, YOU STOOD OUT

Amy Cash Ahmed

Lisa Ainsworth

Rashid Bashir

Alison Bell

Qian Chen

Timothy Fan

Ying Fang

Jodi Flaws

Rebecca Fuller

Kaiyu Guan

Paul Hergenrother

Paul Kenis

Madhu Khanna

Praveen Kumar

Andrew Leakey

Mirhee Lee

Stephen Long

Zeynep Madak-Erdogan

Rosa M. Espinosa Marzal

Erik Nelson

Helen Nguyen

Lori Raetzman

Brent Roberts

Taher Saif

Jacob Sherkow

Stephen Sligar

Tommie Sturgeon

Susan Thomas

Wilfred van der Donk

Amy Wagoner Johnson

Hua Wang

Tandy Warnow

Matthew Wheeler

Nicholas Wu

Huimin Zhao

Amy Cash Ahmed (GNDP); Lab Manager; 2024 Chancellor's Staff Excellence Award

Lisa Ainsworth (CABBI/GEGC); Charles Adlai Ewing Chair of Crop Physiology; Professor, Center for Advanced Study

Rashid Bashir (CGD/M-CELS); Dean of Grainger College of Engineering, Grainger Distinguished Chair in Engineering, Professor of Bioengineering; Member, American Academy of Arts and Sciences

Alison Bell (GNDP leader); Lowell Getz Scholar, Professor of Evolution, Ecology and Behavior; Member, American Academy of Arts and Sciences; Guggenheim Fellow

Qian Chen (M-CELS); Racheff Faculty Scholar, Professor of Materials Science and Engineering; 2024 Outstanding Early Career Investigator Award, Materials Research Society

Timothy Fan (ACPP/CGD); Professor of Veterinary Clinical Medicine; Khan Family Chair, Veterinary Oncology Research

Ying Fang (MMG); Professor of Pathobiology; Fellow, National Academy of Inventors

Jodi Flaws (EIRH co-leader); Professor, Assistant Head of Comparative Biosciences; Professor, Center for Advanced Study

Rebecca Fuller (GNDP); Professor, Head of Evolution, Ecology and Behavior; Fellow, American Association for the Advancement of Science

Kaiyu Guan (CABBI); Professor of Natural Resources and Environmental Sciences; 2024 Clarivate Analytics Highly Cited Researchers

Paul Hergenrother (ACPP leader/MMG); Kenneth L. Rinehart Jr. Endowed Chair in Chemistry; Outstanding Investigator, National Cancer Institute

Paul Kenis (RBTE); Elio Eliakim Tarika Endowed Chair in Chemical Engineering, Director of the School of Chemical Sciences; Fellow, International Society of Electrochemistry

Madhu Khanna (CABBI); Alvin H. Baum Family Chair, Director of iSEE, ACES Distinguished Professor of Environmental Economics; Fellow, European Association of Environmental and Resource Economics

Praveen Kumar (GEGC); Colonel Harry F. and Frankie M. Lovell Professor of Civil and Environmental Engineering, Executive Director of the Prairie Research Institute; Fellow, American Association for the Advancement of Science

Andrew Leakey (CABBI leader/GEGC); Michael Aiken Endowed Chair of Plant Biology; Charles F. Kettering Award, American Society of Plant Biologists

Mirhee Lee (Communications); Assistant Art Director; Second Place, Design, Illinois Brand Contest

Stephen Long (BSD/CABBI/GEGC); Stanley O. Ikenberry Endowed Chair Emeritus of Plant Biology and of Crop Sciences; 2024 Clarivate Analytics Highly Cited Researchers

Zeynep Madak-Erdogan (CGD/EIRH/GSP); Associate Dean of the Graduate College, Syvia D. Stroup Scholar, Associate Professor of Food Science and Human Nutrition; University Scholar; 2024 Michael B. Kastan Award for Research Excellence, American Association for Cancer Research

Rosa M. Espinosa Marzal (EIRH); Donald Biggar Willet Faculty Scholar, Professor of Civil and Environmental Engineering; Ivan Racheff Professor of Environmental Engineering

Erik Nelson (ACPP); Associate Professor of Molecular and Integrative Physiology; 2024 Researcher to Know, Illinois Science & Technology Coalition; Laureate Award, Endocrine Society

Helen Nguyen (IGOH); Ivan Racheff Professor of Environmental Engineering; 2024-2025 Fulbright Scholar, Fulbright Specialist

Lori Raetzman (EIRH/GNDP); Professor, Associate Head of Molecular and Integrative Physiology; Laureate Award, Endocrine Society; LAS Dean's Distinguished Professorial Scholar

Brent Roberts (GNDP); Professor of Psychology; 2024 Clarivate Analytics Highly Cited Researchers; Edward William and Jane Marr Gutsgell Endowed Professor

Taher Saif (M-CELS/RBTE); Edward William and Jane Marr Gutsgell Professor of Mechanical Engineering, Grainger Distinguished Chair in Engineering; Member, National Academy of Engineering

Jacob Sherkow (GSP); Professor of Law; University Scholar

Stephen Sligar (ACPP); Maybelle Leland Swanlund Endowed Chair Emeritus in Biochemistry; National Academy of Sciences

Tommie Sturgeon (CNRG); Senior Research Programmer; 2024 cohort, IT Leadership Workshop

Susan Thomas (IGOH); Deputy Program Manager; 2024 Chancellor's Staff Excellence Award

Wilfred van der Donk (MMG leader); Richard E. Heckert Endowed Chair in Chemistry; Alfred Bader Award in Bioinorganic or Bioorganic Chemistry, American Chemical Society

Amy Wagoner Johnson (EIRH/RBTE); Andersen Faculty Scholar, Professor of Mechanical Science and Engineering and of Biomedical and Translational Science; Fellow, American Society of Mechanical Engineers

Hua Wang (RBTE); Assistant Professor of Materials Science and Engineering; Distinguished Scientist Award, The Sontag Foundation

Tandy Warnow (IGOH); Grainger Distinguished Chair in Engineering, Associate Director of the Siebel School of Computing and Data Science; Senior Scientist Accomplishment Award, International Society for Computational Biology

Matthew Wheeler (RBTE); Professor of Animal Sciences and of Bioengineering; 2024 Animal Physiology and Endocrinology Award, American Society of Animal Science

Nicholas Wu (IGOH/MMG); Assistant Professor of Biochemistry; Vallee Scholar, Vallee Foundation

Huimin Zhao (BSD leader/CABBI/CGD/MMG); Steven L. Miller Chair of Chemical and Biomolecular Engineering; 2024 Charles D. Scott Award, Society for Industrial Microbiology and Biotechnology

Congrats

Talented trainees

Early Innovator Program pitch contest winners announced— It was a busy summer for a group of postdoctoral and graduate student researchers who participated in the 10-week Early Innovator Program at IGB. During the summer, six aspiring entrepreneurs made their final pitches to a judging panel, and three were awarded tiered funds ranging from $2,000-$5,000 to continue to advance their novel innovations.

Shraddha Shirguppe received first prize for Genvivo Solutions, a platform technology focused on the development of precise, genetically engineered cancer animal models across a range of species. Shirguppe is a graduate student in bioengineering in the Perez Lab.

Jongwon Lim was awarded second prize for his D3 Solution (Direct, Dry, Diagnostic), which would allow rapid detection of sepsis utilizing low-cost blood drying techniques. Lim is a graduate student in bioengineering in the Bashir Lab.

Kyle Timmer received third prize for RotatorRenew, an implantable, regenerative biomaterial for rotator cuff repair. The material is designed to structurally mimic the tendon-to-bone interface and promote appropriate cell behavior to improve repair effectiveness. Timmer is a graduate student in chemical and biomolecular engineering in the Harley Research Lab.

From left to right, Shraddha Shirguppe, Sarah Schwartz, Kyle Timmer, Jongwon Lim, Nora Liu, Joe Crawford, and Tracy Parish

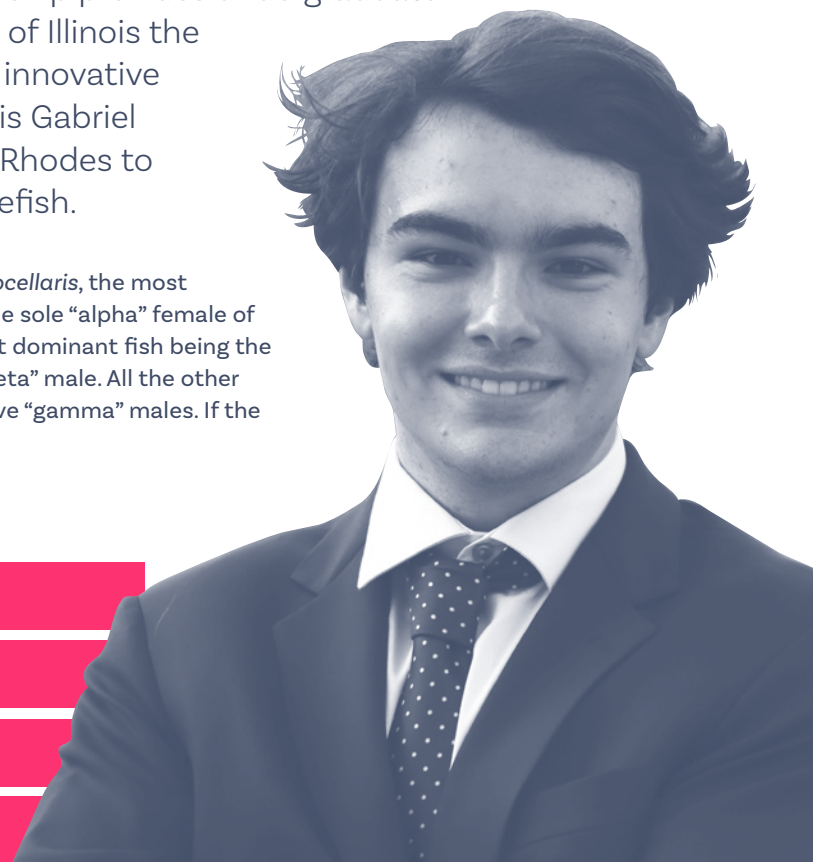
This year's EIP judges included Jesse Dill, Jack Marck, and Tom Parkinson. The judges had a difficult decision to make and applauded all the participants for their innovative concepts and solid presentations.

Other participants in the pitch competition included Shivali Banerjee, a postdoctoral researcher at CABBI developing products based on natural pigments; Joe Crawford, a postdoctoral researcher at CABBI developing a tool to measure water use based on leaf structures to improve irrigation decisions; and Nora Liu, a graduate student in the BSD theme working to discover natural products for use in antibiotics.

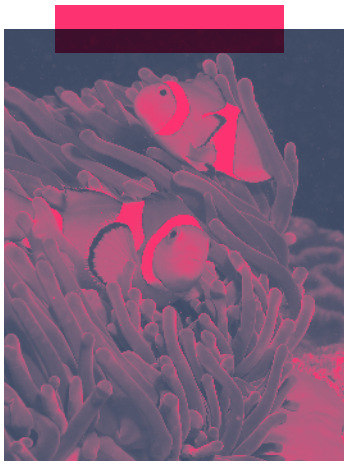
The EIP program is designed to teach participants the skills necessary to become innovative leaders in their fields and to support IGB scientists in considering creative ways to bring science to society. Trainees learn from subject matter experts about the process of innovation, protecting and developing discoveries beyond the laboratory, and bringing new technologies and services to the marketplace.

Jesse Dill, Senior Director of Business Development, Ginkgo Bioworks; **Jack Marck**, Managing Director, Gener8tor Ventures' Illinois AgTech Accelerator; **Tom Parkinson**, Senior Director, Illinois Ventures

Gabriel Graham selected for the 2024 Tracy Undergraduate Research Fellowship—The Mark Tracy Undergraduate Translational Research Fellowship provides undergraduate students from the University of Illinois the opportunity to participate in innovative research. The 2024 recipient is Gabriel Graham, working with Justin Rhodes to study sex change in anemonefish.



In anemonefish, *Amphiprion ocellaris*, the most dominant fish will become the sole "alpha" female of the group, with the next most dominant fish being the only reproductively active "beta" male. All the other fish are reproductively inactive "gamma" males. If the



Purple anemone and resident anemonefish in East Timor

dominant female is killed or removed, the beta male changes sex and becomes the new alpha female, and all the subsequent fish move up one position in the hierarchy.

"We're trying to understand what happens during the sex change process—is it a linear process or is there a weird intermediary stage that is different from both a male and a female? Our data suggests the latter."

GABRIEL GRAHAM
SENIOR, PSYCHOLOGY AND BEHAVIORAL NEUROSCIENCE

Recently the lab discovered that multiple cell types in the hypothalamus and telencephalon differ. Both these regions are known to play important roles in regulating behavior across different animals. Graham will be developing and applying statistical models to determine the similarities between the brains of the sex-changing fish to the male and female brains.

"I will learn new cutting-edge techniques, have the opportunity to publish my work, and create new connections with other researchers," Graham said. "Since my post-graduation goal is to pursue a PhD in neuroscience, all of these factors will be instrumental to my professional development."

Mark Tracy, Founder and President, Tracy BioConsulting, LLC; **Gabriel Graham**, senior majoring in psychology and behavioral neuroscience with a minor in molecular and cellular biology; **Justin Rhodes**, professor of psychology (GNDP)

Hey Science,
this year you snagged
a virus with a nanoclaw and
built a tool for gardening
in space.

It's giving future glow up.

Futureproofing

Next-generation nanoscale therapeutics

Collaborating on tomorrow’s crops

Research to build a better world

Futureproofing

Next-generation nanoscale therapeutics

Nanorobot hand made of DNA grabs viruses for diagnostics and blocks cell entry—A tiny, four-fingered "hand" folded from a single piece of DNA can pick up the virus that causes COVID-19 for highly sensitive rapid detection and can even block viral particles from entering cells to infect them, researchers report. Dubbed the NanoGripper, the nanorobotic hand also could be programmed to interact with other viruses or to recognize cell surface markers for targeted drug delivery, such as for cancer treatment.

Led by Xing Wang , the researchers describe their advance in the journal *Science Robotics*. Inspired by the gripping power of the human hand and bird claws, the researchers designed the NanoGripper with four bendable fingers and a palm, all in one nanostructure folded from a single piece of DNA. Each finger has three joints, like a human finger, and the angle and degree of bending are determined by the design on the DNA scaffold.

"We wanted to make a soft material, nanoscale robot with grabbing functions that never have been seen before, to interact with cells, viruses, and other molecules for biomedical applications," Wang said.

"We are using DNA for its structural properties. It is strong, flexible, and programmable. Yet even in the DNA origami field, this is novel in terms of the design principle. We fold one long strand of DNA back and forth to make all of the elements, both the static and moving pieces, in one step."

Schematic depicting the NanoGrippers binding the viral spike proteins and wrapping around the virus

The fingers contain regions called DNA aptamers that are specially programmed to bind to molecular targets—the spike protein of the virus that causes COVID-19, for this first application—and trigger the fingers to bend to wrap around the target. On the opposite side, where the wrist would be, the NanoGripper can attach to a surface or other larger complex for biomedical applications such as sensing or drug delivery.

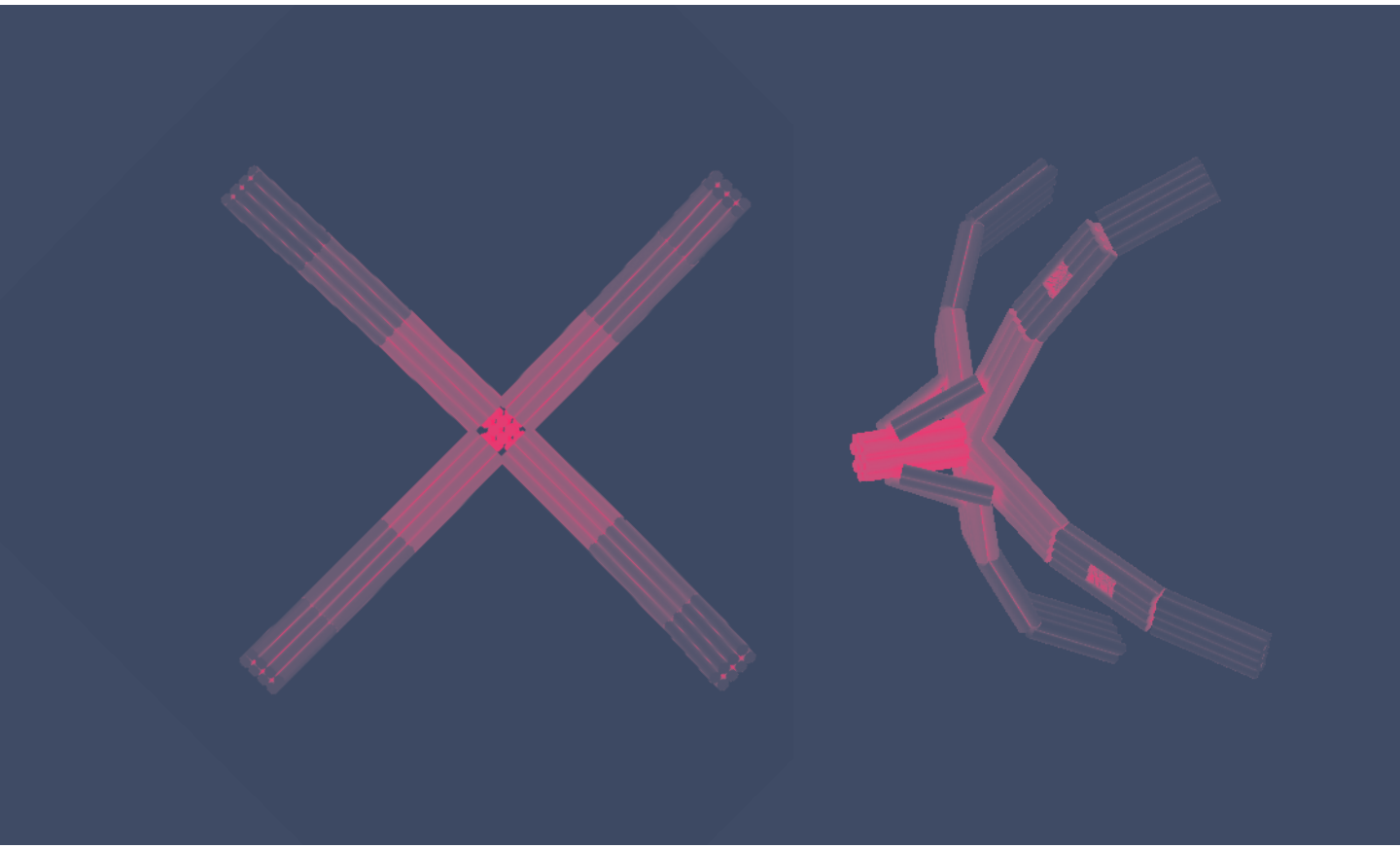
To create a sensor to detect the COVID-19 virus, Wang's team partnered with a group led by Brian Cunningham, who specializes in biosensing. They coupled the NanoGripper with a photonic crystal sensor platform to create a rapid, 30-minute COVID-19 test matching the sensitivity of the gold-standard qPCR molecular tests used by hospitals, which are more accurate than at-home tests but take much longer.

"Our test is very fast and simple since we detect the intact virus directly," Cunningham said. "When the virus is held in the NanoGripper's hand, a fluorescent molecule is triggered to release light when illuminated by an LED or laser. When a large number of fluorescent molecules are concentrated upon a single virus, it becomes bright enough in our detection system to count each virus individually."

In addition to diagnostics, the NanoGripper could have applications in preventive medicine by blocking viruses from entering and infecting cells, Wang said. The researchers found that when NanoGrippers were added to cell cultures that were then exposed to COVID-19, multiple grippers would wrap around the outside of the viruses. This blocked the viral spike proteins from interacting with receptors on the cells' surface, preventing infection.

The NanoGripper could also easily be engineered to target other viruses, such as influenza, HIV or hepatitis B, Wang said. In addition, Wang envisions using the NanoGripper for targeted drug delivery. For example, the fingers could be programmed to identify specific cancer markers, and grippers could carry cancer-fighting treatments directly to the target cells.

Xing Wang



Top view (left) and side view (right) diagrams of the NanoGripper

"This approach has bigger potential than the few examples we demonstrated in this work. There are some adjustments we would have to make with the 3D structure, the stability, and the targeting aptamers or nanobodies, but the potential applications for cancer treatment and the sensitivity achieved for diagnostic applications showcase the power of soft nanorobotics."

XING WANG
PROFESSOR, BIOENGINEERING

Xing Wang, professor of bioengineering (CGD); **Brian Cunningham**, professor of electrical and computer engineering (CGD leader)

The NIH and NSF supported this work.

Futureproofing

Collaborating on tomorrow's crops

New greenhouse will accelerate CABBI bioenergy research— A new greenhouse custom-designed to support CABBI research is now open at the University of Illinois Research Park.

The Plant Biology Innovation Greenhouse features unique cutting-edge capabilities that are already benefiting plant and microbial science researchers on the Illinois campus. It will propel research by CABBI to develop an economically viable and ecologically sustainable domestic biofuel and bioproducts industry from dedicated bioenergy crops.

This innovative facility will allow CABBI researchers to monitor the growth and water use of next-generation bioenergy crops—automatically and in real time, said Andrew Leakey.

"This will accelerate development of crops that are more productive, sustainable, and resilient to climate extremes as part of our work to produce feedstock for sustainable aviation fuel and other bioproducts," Leakey said at the grand opening last November.

The greenhouse project was a team effort led by the Illinois Provost's Office, Department of Plant Biology, College of Liberal Arts and Sciences, College of Agricultural, Consumer and Environmental Sciences, School of Integrative Biology, and Department of Crop

Sciences. Susan Martinis and Laura Appenzeller also provided key leadership in the facility's development and construction.

"This state-of-the-art facility is a testament to our commitment at this university to advancing research and innovation that addresses grand challenges in our world, sustainable energy solutions being among those," said John Coleman.

Undergraduates will also benefit through CABBI's summer Research Internship in Sustainable Bioenergy (RISE), Leakey said.

The greenhouse is home to a large high-throughput plant phenotyping facility and state-of-the-art walk-in growth rooms, with space for future expansion. The phenotyping facility, inside the three bays of the greenhouse, allows scientists to control growing conditions and study specific plant characteristics, with the first experiment centered on water use efficiency in transgenic sugarcane. In the mirror-lined growth chambers, mature sorghum plants were recently harvested from sealed plexiglass containers where they received water, light, and fertilizer for growth. Researchers are already planting new sorghum seeds, to be fed isotopically labeled carbon dioxide.

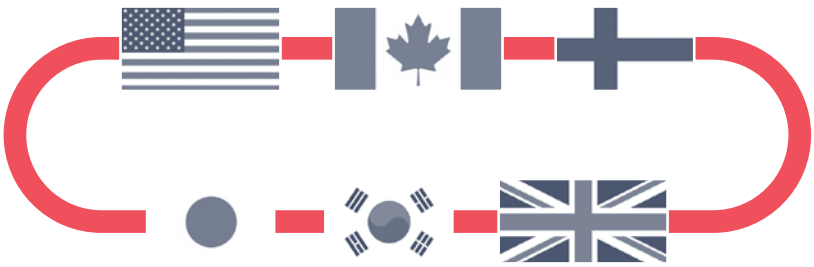
Leakey said the scientific discoveries, technological innovations and training opportunities that come out of the greenhouse will drive positive change for the bioeconomy and environment of the state of Illinois and the nation.

Located on Fourth Street, just south of St. Mary's Road, the greenhouse project was completed by Fox/Atkins Development. The energy-efficient facility also features a solar array made possible by generous support from the Student Sustainability Committee at Illinois.

Andrew Leakey, professor of plant biology (CABBI leader/GEGC); **Susan Martinis**, vice chancellor for research and innovation; **Laura Appenzeller**, Research Park executive director; **John Coleman**, provost and executive vice chancellor for academic affairs

The greenhouse project was funded by CABBI's DOE grant.

NSF, international partners to invest nearly $10M in ASAP Global Center—The NSF and partner agencies in the U.S., Canada, Finland, Japan, the Republic of Korea, and the United Kingdom announced funding of new international centers of excellence in their Global Centers competition.



One of the centers, the Alliance for Socially-acceptable & Actionable Plants, is led by the University of Illinois Urbana-Champaign and will feature international partners supported by the Research Council of Finland, Japan Science and Technology Agency, and United Kingdom Research and Innovation.

"Faster progress towards a sustainable bioeconomy is essential to reduce carbon emissions and ensure the production of cleaner energy. One key goal is improving feedstock-crop performance and resilience. We are excited to be working with partners from around the world to tackle this important challenge, including understanding the social elements of technology acceptance."

TRACY LAWSON
PROFESSOR, PLANT BIOLOGY
DIRECTOR, ASAP

2024 Global Centers awards focus on advancing bioeconomy research to solve global challenges, whether by increasing crop resilience, converting plant matter or other biomass into fuel, or paving the way for biofoundries to scale-up applications of biotechnology for societal benefit. The program supports holistic, multidisciplinary projects that bring together international teams

Sorghum at the University of Illinois South Farms

and scientific disciplines, including education and social sciences, necessary to achieve use-inspired outcomes. All Global Centers will integrate public engagement and workforce development, paying close attention to impacts on communities.

The ASAP Global Center at Illinois is led by Lawson and Andrew Leakey. The other project investigators from Illinois include Matthew Hudson, Diwakar Shukla, and Huimin Zhao.

ASAP delivers synthetic biology solutions to produce high-energy, water use efficient crops. To do so, it exploits natural biodiversity in gene sequences to engineer crops with increased lipid content and greater water use efficiency. The Global Center draws on the expertise of a multi-disciplinary team of scientists from four countries to integrate recent breakthroughs in genetics, protein modeling, synthetic biology, AI, and biotechnology.

ASAP also investigates attitudes among stakeholder groups toward biotechnology to achieve sustainability goals. Public and industry engagement strengthen its technological enterprise, accounting for consumer attitudes and market preferences.

"Global Centers are leveraging expertise and resources across like-minded nations and uniting multidisciplinary teams from around the world to accelerate innovations in the bioeconomy for great impact. Together, we are forging new solutions to pressing socioeconomic challenges impacting all of us."

SETHURAMAN PANCHANATHAN
THEN-DIRECTOR, NSF

Tracy Lawson, professor of plant biology and director of ASAP; **Andrew Leakey,** professor of plant biology and deputy director of ASAP (CABBI leader/GEGC); **Matthew Hudson**, professor of crop sciences (BSD/CABBI/GNDP); **Diwakar Shukla**, professor of chemical and biomolecular engineering (MMG); **Huimin Zhao**, professor of chemical and biomolecular engineering (BSD leader/CABBI/CGD/MMG)

Hey IGB,
what are you looking forward to in science in 2025?

Futureproofing

Research to build a better world

New antibiotic kills pathogenic bacteria and spares healthy gut microbes—Researchers have developed a new antibiotic that reduced or eliminated drug-resistant bacterial infections in mouse models of acute pneumonia and sepsis while sparing healthy microbes in the mouse gut. The drug, called lolamicin, was effective against more than 130 multidrug-resistant bacterial strains in cell culture.

The findings were detailed in the journal *Nature*.

"People are starting to realize that the antibiotics we've all been taking—that are fighting infection and, in some instances, saving our lives—also are having these deleterious effects on us," said Paul Hergenrother, who led the study with Kristen Muñoz.

Numerous studies have found that antibiotic-related disturbances to the gut microbiome increase vulnerability to further infections and are associated with gastrointestinal, kidney, liver, and other problems.

"Most clinically approved antibiotics only kill gram-positive bacteria or kill both gram-positive and gram-negative bacteria," Muñoz said.

Gram-positive and gram-negative bacteria differ in the composition of their cell walls. The few drugs available to fight gram-negative infections also kill other potentially beneficial gram-negative bacteria.

To tackle the many problems associated with indiscriminately targeting gram-negative bacteria, the team focused on a suite of drugs developed by the pharmaceutical company AstraZeneca. These drugs inhibit the Lol system, a lipoprotein-transport system that is exclusive to gram-negative bacteria and genetically different in pathogenic and beneficial microbes.

In a series of experiments, Muñoz designed structural variations of the Lol inhibitors and evaluated their potential to fight gram-negative and gram-positive bacteria in cell culture. One of the new

compounds, lolamicin, selectively targeted some gram-negative pathogens and had no detectable effect on gram-positive bacteria in cell culture.

When given orally to mice with drug-resistant septicemia or pneumonia, lolamicin rescued 100% of the mice with septicemia and 70% of the mice with pneumonia, the team reported.

Extensive work was done to determine the effect of lolamicin on the gut microbiome. "The mouse microbiome is a good tool for modeling human infections because human and mouse gut microbiomes are very similar," Muñoz said.

Treatment with standard antibiotics amoxicillin and clindamycin caused dramatic shifts in the overall structure of bacterial populations in the mouse gut, diminishing the abundance of several beneficial microbial groups, the team found.

"In contrast, lolamicin did not cause any drastic changes in taxonomic composition over the course of the three-day treatment or the following 28-day recovery," the researchers wrote.

More research is needed to extend the findings, Hergenrother said. Lolamicin must be tested against more bacterial strains and detailed toxicology studies must be conducted.

The study team included, back row, from left, graduate student Rebecca Ulrich; chemistry professor Paul Hergenrother; Chris Fields, of the Roy J. Carver Biotechnology Center; research scientist Po-Chao Wen; graduate student Matt Sinclair; and, front row, from left, senior scientist Hyang Yeon Lee; Jessica Holmes, of the Roy J. Carver Biotechnology Center; and biochemistry professor Emad Tajkhorshid. (Study lead author Kristen Muñoz not pictured)

Paul Hergenrother, professor of chemistry (ACPP leader/MMG); **Kristen Muñoz**, then-graduate student in chemistry

The NIH supported this research.

Study brings scientists a step closer to successfully growing plants in space—New, highly stretchable sensors can monitor and transmit plant growth information without human intervention, researchers reported in the journal *Device*.

The polymer sensors are resilient to humidity and temperature, can stretch over 400% while remaining attached to a plant as it grows, and send a wireless signal to a remote monitoring location, said Ying Diao, who led the study with Andrew Leakey. The study detailed some of the early results of a NASA grant awarded to Diao to investigate how wearable printed electronics will be used to make farming possible in space.

Diao's team approached this project using an Earth-based laboratory to create the 'Stretchable-Polymer-Electronics-based Autonomous Remote Strain Sensor,' or SPEARS2, a very thin film device that helps restrain the crystal growth during assembly and printing.

Lunar, martian greenhouses designed to mimic those on earth

"It is an exciting technical advance in our ability to perform precise, noninvasive measurements of plant growth in real-time. I look forward to seeing how it can complement the latest tools for interrogating genomic and cellular processes," Leakey said.

"I think the wearable electronics research community has ignored plants for too long. We know that plants are experiencing a lot of stress during climate adaptation, and I think soft electronics can play a bigger role in advancing our understanding so we can ensure that plants are healthy, happy, and sustainable in the future—whether that is in space, on other planets or right here on Earth."

YING DIAO
PROFESSOR, CHEMICAL AND BIOMOLECULAR ENGINEERING

Ying Diao, professor of chemical and biomolecular engineering; **Andrew Leakey**, professor of plant biology (CABBI leader/GEGC)

The study was supported by NASA and Beckman; researchers at NASA and Illinois researchers from bioengineering, crop sciences, materials science and engineering, IGB, and Beckman contributed to this study.

Machine learning used to classify fossils of extinct pollen— While previous attempts to utilize neural networks in classifying extinct organisms within phylogenetic trees have struggled, a new study published in *PNAS Nexus* heralds a significant breakthrough. The team includes Marc-Élie Adaimé, first author of the paper; Surangi Punyasena; and Shu Kong.

From left: Marc-Élie Adaimé and Surangi Punyasena

"There was no method previously that included phylogeny a priori into the model, so models did not learn to make sense of the features in an evolutionary or phylogenetic context," Adaimé said. "The goal of our research was to create a new modeling approach that would be trained on images in a phylogenetic context."

To accurately position organisms within a phylogenetic framework, neural networks must be trained not only to discern defining traits of various organism classes but also to recognize phylogenetic synapomorphies—derived features shared between organisms due to their common ancestry.

The team chose to apply their model to the classification of pollen and spores—an ubiquitous and ancient entity found throughout the fossil record. To validate the model's efficacy, the researchers tested it on micrograph specimens of extinct pollen from Panama, Peru, and Columbia. Impressively, the neural network model mirrored the placements made by the paleoecologists for nearly all specimens, underscoring its capacity to leverage morphological features learned during training to accurately position extinct species within a phylogenetic context.

"This work demonstrates that the amount of evolutionary information captured in pollen morphology had been previously underestimated. The history of a plant species is captured in its shape and form. Machine learning allows us to discover these novel phylogenetic traits," Punyasena said.

Surangi Punyasena, professor of plant biology (CAIM); **Shu Kong**, professor of science and technology, University of Macau; **Marc-Élie Adaimé**, graduate student in plant biology

The study was funded by NCSA and Illinois.

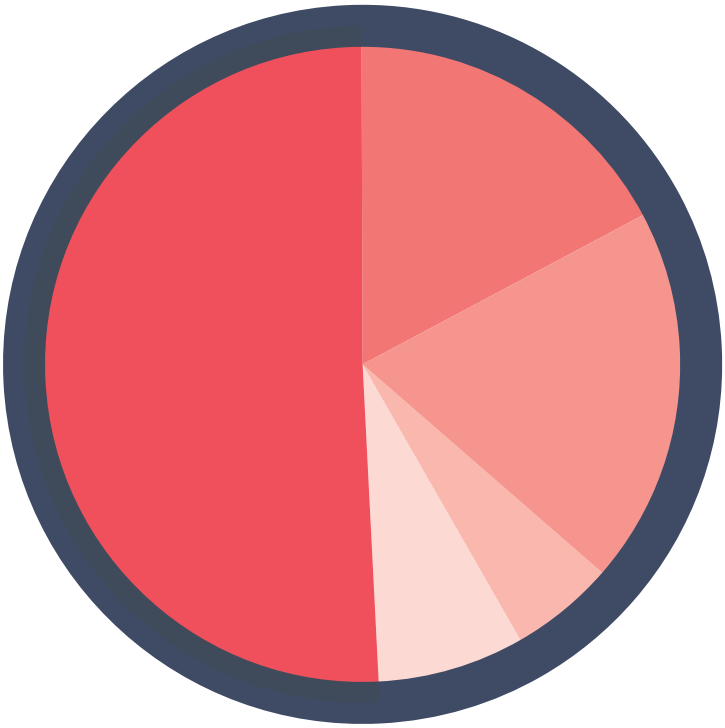
Hey Science,
this year speaks for itself—
your worth is priceless.

But looking at the data
still hits different.

Grant Funding FY24

$57,953,107

Every grant, award, and gift, large or small, helps to pay for research to tackle societal challenges and to maintain the infrastructure that makes science possible.



DOE
$29,577,527

NIH
$9,901,645

NSF
$11,221,153

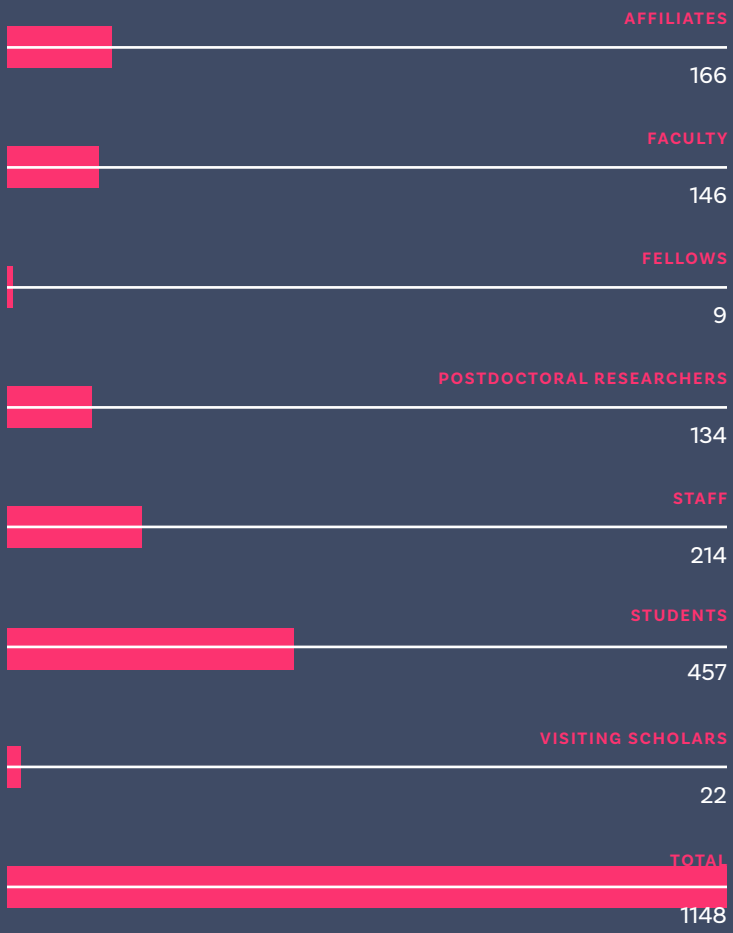
Gates
$2,936,548

Other
$4,316,234

People in IGB

1,148

We grew by 24% over the last 5 years
—that's 224 people!



Economic Development FY24

PATENTS

Small Molecules Active Against Gram-Negative Bacteria
Paul J. Hergenrother

Genome Editing in Archaea
William W. Metcalf

Non-Invasive Analysis of Embryo Metabolites
Matthew B. Wheeler

Saliva-Based Molecular Testing for SARS-CoV-2
Christopher Brooke, Diana Ranoa, Martin D. Burke, Paul J. Hergenrother, Timothy M. Fan

Free Fatty Acid Separation and Recovery Using Resin
Vijay Singh

Publications

papers were published in 2024.
And that's with 9 in *Science* and *Nature*!

A Gram-negative-selective antibiotic that spares the gut microbiome. Muñoz, K. A., Ulrich, R. J., Vasan, A. K., Sinclair, M., Wen, P.-C., Holmes, J. R., Lee, H. Y., Hung, C.-C., Fields, C. J., Tajkhorshid, E., Lau, G. W. & **Hergenrother, P. J.**, *Nature*

Complexity of avian evolution revealed by family-level genomes. Stiller, J., ... **Warnow, T.**, Braun, E. L., Gilbert, M. T. P., Jarvis, E. D., Mirarab, S. & Zhang, G., *Nature*

The structure and physical properties of a packaged bacteriophage particle. Coshic, K., Maffeo, C., Winogradoff, D. & **Aksimentiev, A.**, *Nature*

Transcription–replication interactions reveal bacterial genome regulation. Pountain, A. W., Jiang, P., Yao, T., Homaee, E., Guan, Y., McDonald, K. J. C., Podkowik, M., Shopsin, B., Torres, V. J., **Golding, I.** & Yanai, I., *Nature*

A new type of antibiotic targets a drug-resistant bacterium. Gugger, M. K. & **Hergenrother, P. J.**, *Nature*

Computational prediction of complex cationic rearrangement outcomes. Klucznik, T., Syntrivanis, L. D., Baś, S., Mikulak-Klucznik, B., Moskal, M., Szymkuć, S., Mlynarski, J., Gadina, L., Beker, W., **Burke, M. D.**, Tiefenbacher, K. & Grzybowski, B. A., *Nature*

Porin-independent accumulation in *Pseudomonas* enables antibiotic discovery. Geddes, E. J., Gugger, M., Garcia, A., Garcia Chavez, M., Lee, M. R., Perlmutter, S. J., Bieniossek, C., Guasch, L. & **Hergenrother, P.J.**, *Nature*

Tuning sterol extraction kinetics yields a renal-sparing polyene antifungal. Maji, A., ... Fan, T. M., Rienstra, C. M. & **Burke, M. D.**, Nov 30 2023, *Nature*

Delocalized, asynchronous, closed-loop discovery of organic laser emitters. Strieth-Kalthoff, F., ... **Burke, M. D.** & Aspuru-Guzik, A., *Science*

Core Facilities

390

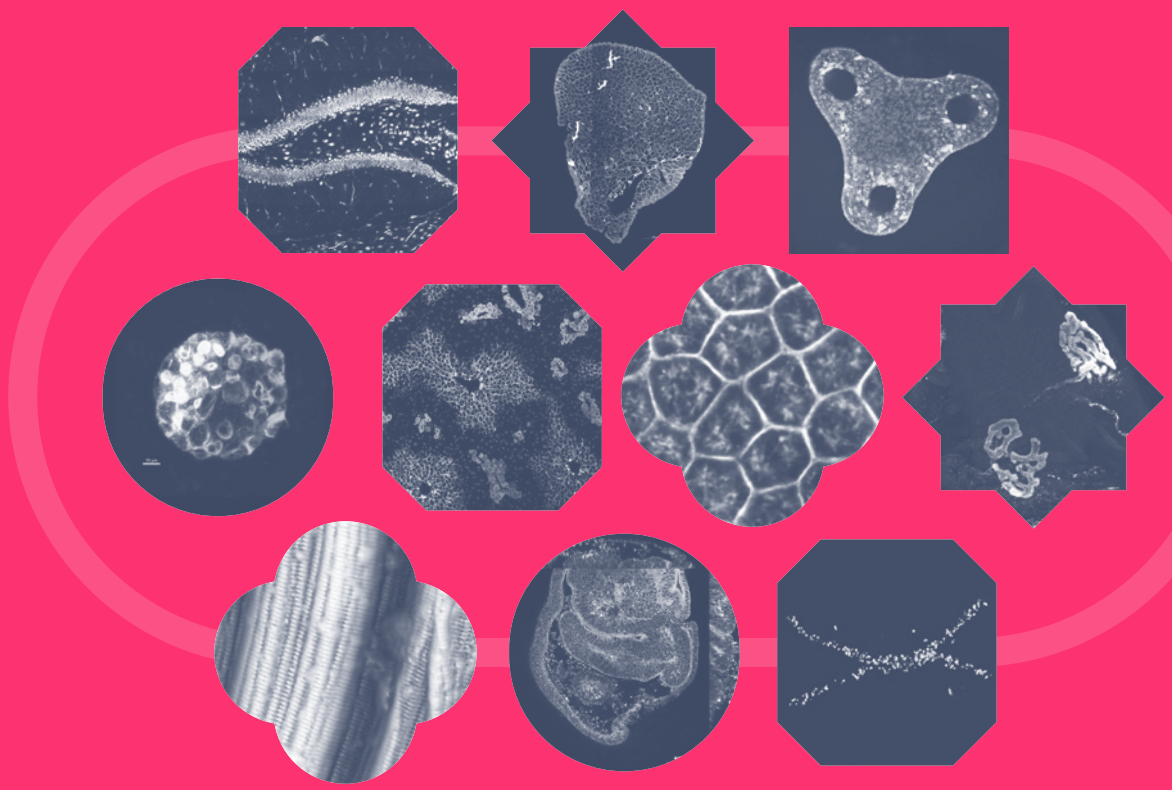
Active users

21

Instruments

10

Images of the month



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Hey Science,

Look back. Feel proud of who you are. A researcher at a bench, a lecturer giving a talk, a family at a museum, a programmer building a database—you are science. We all are science. And we are remarkable. Let's keep going, together.

Carl R. Woese Institute
for Genomic Biology
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Where Science Meets Society

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