IGB NEWS

Upcoming Events
Monthly Profiles
Happenings at IGB

Image Of The Month
Research News
Department Announcements

Volume 15 Number 4

UPCOMING EVENTS

Fox Family Lecture
An Academia-to-Biotech Roadmap: Research and Development at the Frontiers of mRNA Therapeutics
September 20, 2022, 12:00 p.m.
612 IGB Conference Center

Jacob Becraft, PhD
Co-founder and CEO
of Strand Therapeutics

Lunch with the Core
PEG Microgels as Modular 3D Cell Scaffold and Cytokine Sensor
September 21, 2022, 12:00 p.m.
612 IGB Conference Center

Hyeon Ryoo, Graduate Student, Bioengineering
Instrument - LSM 880
Lunch will be provided

Thriving in Graduate School
Troubleshooting the Mentor Relationship
September 22, 2022, 5:00 p.m.
612 IGB Conference Center

Communication is important in any mentoring relationship, whether you are the mentor or the mentee.
The Graduate Office of Student Success will be presenting on strategies to effectively navigate conflict, and the workshop will also provide resources and tips for getting departmental support.

FEATURED NEWS

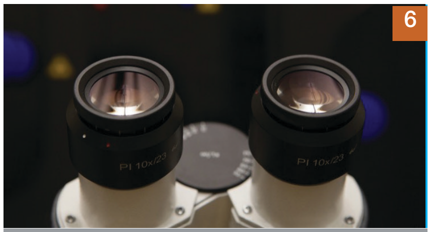


IMAGE OF THE MONTH

These images are transverse sections of stem-wood from two temperate deciduous tree species from Manistee, Michigan. The right image is White Oak (*Quercus alba*) while the left is Sugar Maple (*Acer saccharum*). These sections were used in a study analyzing how ray parenchyma cells in wood are related to radial wood nutrient translocation within trees. The ray parenchyma can be identified as the long lines of symplastically connected cells that span across each section.
Image courtesy of Dr. James Dalling and Manuel Flores.

IGB News

Share your news with the IGB. Send ideas on stories, articles, and features to *nvasi@illinois.edu*.

FEATURE

15 Years of IGB

Accelerating biological engineering through automation and artificial intelligence

One of the biggest challenges in traditional laboratory settings is performing countless hours of error-prone lab work: handling reagents, incubating reactions or living cells, synthesizing products, applying treatments, and monitoring outcomes. The Illinois Biological Foundry for Advanced Biomanufacturing was established in 2014 to bypass these cumbersome procedures and support a broad array of research goals.

"iBioFAB highlights the potential of team-based research to achieve goals that would be unreachable for the individual," said Gene Robinson (GNDP), the Carl R. Woese Institute for Genomic Biology Director and Swanlund Chair in Entomology. "Only in an interdisciplinary environment such as the IGB could such a system be not only conceived, but successfully constructed, implemented, and used to the realization of its full potential."

Developed under the leadership of Huimin Zhao (BSD/GSE/CABBI/MMG/CGD), Steven L. Miller Chair in Chemical Engineering and the Director of the Molecule Maker Lab Institute, iBioFAB is a precisely engineered set of robotic components combined with a highly adaptable software platform. Based in the concourse research lab of the IGB, iBioFAB integrates artificial intelligence/machine learning with automation, and features a robotic arm that travels along a 5-meter-long track to transfer microplates among more than 40 instruments installed on the platform.

The system houses three liquid handling devices that serve as workhorses for most tasks. Additionally, to enable unattended automated operation, iBioFAB also contains instruments for automating standard laboratory tasks: a centrifuge, a barcode labeler, four reagent dispensers, four thermal cyclers, an automated microplate heat sealer, a plate seal remover, and multiple plate shakers and block arrays. At its maximum capacity, iBioFAB can generate thousands of output samples each day using custom-designed workflows.

Although many fields have already turned to automation, several factors make synthetic biology's transition using iBioFAB unique. First, an automated system that produces synthetic biological systems has to take the unpredictability of biology into account. Second, it must be versatile enough to deal with multiple research efforts. In the pharmaceutical industry, for example, automated systems are used for only one task. But in synthetic biology, researchers could be using the system to work on one project one day, and another project the next day. Third, workflows in synthetic biology are complex and therefore the system needs to be adaptable and programmable. And fourth, it needs to deal with data-rich projects; while a researcher might struggle to remember a genome with thousands of genes, an algorithm can keep track.

From 2013-2019, seven papers have been published that highlight iBioFAB's usefulness.

Plasmids—small, circular DNA molecules—are used by scientists to introduce new genes into a target organism. Known for their applications in the production of therapeutic proteins like insulin, plasmids are broadly used in the large-scale production of many bioproducts. However, designing and constructing them remains one of the most time-consuming and labor-intensive steps in biology research. To address this issue, researchers at the Center for Advanced Bioenergy and Bioproducts Innovation developed a versatile and automated platform for plasmid design and construction called PlasmidMaker. Once the plasmid was designed, it was built with iBioFAB. With all the improvements it brings to the table, the team members at CABBI hope that PlasmidMaker and iBioFAB will accelerate the development of synthetic biology for biotechnological applications.

In addition to synthesizing DNA, iBioFAB can also edit it. Genome editing tools that can target specific DNA sequences are becoming increasingly important in health, industrial, and food biotechnology applications. However, designing and implementing such tools on a large scale has always been a challenge. Due to iBioFAB, IGB researchers have been able to develop recombinant transcription activator-like effectors and transcription activator-like effector nucleases that can be tailored to specifically target any user-defined DNA sequence. Both TALEs and TALENs can be synthesized efficiently and a low cost, making it easy for researchers to use this tool.

The automated platform of iBioFAB can also create multiple DNA edits, including overexpressing some genes while deleting others, in a single step. Developed in 2017, the genome-scale engineering was carried out in *Saccharomyces cerevisiae*, an important eukaryotic model organism and widely used microbial cell factory. Such manipulations have since helped researchers to quickly identify and improve diverse cellular pathways, including those involved in the production of enzymes and chemicals.

In 2019, researchers at Illinois combined iBioFAB with artificial intelligence/machine learning to form a closed-loop fully automated system, called BioAutomata, that designed, built, tested, and learned complex biochemical pathways to produce lycopene, a red pigment found in tomatoes and commonly used as a food coloring. "BioAutomata was able to reduce the number of possible lycopene-production pathways constructed from over 10,000 down to about 100 and create an optimized quantity of lycopene-overproducing cells within week—greatly reducing time and cost," Zhao said.

Former students and postdoctoral researchers from the Zhao group have set up similar integrated robotic systems in three institutions in China, including the Chinese Academy of Sciences Shenzhen Institute of Advanced Technology, Zhejiang University, and the Chinese Academy of Sciences Tianjin Institute of Industrial Biotechnology. Additionally, Illinois is the founding member of the global biofoundry alliance that currently consists of over 30 institutions around the world.

"We are very proud that we built the first integrated robotic system more than eight years ago," Zhao said. "By integrating the recent advances in synthetic biology and artificial intelligence/machine learning with iBioFAB, I envision that iBioFAB can be turned into a self-driving biofoundry that can autonomously design and execute experimental plans and analyze experimental results. We are particularly interested in applying this self-driving biofoundry for enzyme engineering and metabolic engineering for synthesis of chemicals, fuels, and materials from renewable plant biomass, which is one of the main goals of our Center for Advanced Bioenergy and Bioproducts Innovation." ■

Written by Ananya Sen. Photo courtesy GCOE.

RESEARCH

RIPE researchers prove bioengineering better photosynthesis increases yields in food crops first time ever

For the first time, RIPE researchers have proven that multigene bioengineering of photosynthesis increases the yield of a major food crop in field trials. After more than a decade of working toward this goal, a collaborative team led by the University of Illinois has transgenically altered soybean plants to increase the efficiency of photosynthesis, resulting in greater yields without loss of quality.

Results of this magnitude couldn't come at a more crucial time. The most recent UN report, The State of Food Security and Nutrition in the World 2022, found that in 2021 nearly 10% of the world population was hungry, a situation that has been steadily worsening over the last few years and eclipsing all other threats to global health in scale. According to UNICEF, by 2030, more than 660 million people are expected to face food scarcity and malnutrition. Two of the major causes of this are inefficient food supply chains (access to food) and harsher growing conditions for crops due to climate change. Improving access to food and improving the sustainability of food crops in impoverished areas are the key goals of this study and the RIPE project.

Realizing Increased Photosynthetic Efficiency, or RIPE, is an international research project that aims to increase global food production by improving photosynthetic efficiency in food crops for smallholder farmers in Sub-Saharan Africa with support from the Bill & Melinda Gates Foundation, Foundation for Food & Agriculture Research, and U.K. Foreign, Commonwealth & Development Office.

"The number of people affected by food insufficiency continues to grow, and projections clearly show that there needs to be a change at the food supply level to change the trajectory," said Amanda De Souza, RIPE project research scientist, and lead author. "Our research shows an effective way to contribute to food security for the people who need it most while avoiding more land being put into production. Improving photosynthesis is a major opportunity to gain the needed jump in yield potential."

Photosynthesis, the natural process all plants use to convert sunlight into energy and yield, is a surprisingly inefficient 100+ step process that RIPE researchers have been working to improve for more than a decade. In this first-of-its-kind work, recently published in *Science*, the group improved the VPZ construct within the soybean plant to improve photosynthesis and then conducted field trials to see if yield would be improved as a result.

The VPZ construct contains three genes that code for proteins of the xanthophyll cycle, which is a pigment cycle that helps in the photoprotection of the plants. Once in full sunlight, this cycle is activated in the leaves to protect them from damage, allowing leaves to dissipate the excess energy. However, when the leaves are shaded (by other leaves, clouds, or the sun moving in the sky) this photoprotection needs to switch off so the leaves can continue the photosynthesis process with a reserve of sunlight. It takes several minutes for the plant to switch off the protective mechanism, costing plants valuable time that could have been used for photosynthesis.

The overexpression of the three genes from the VPZ construct accelerates the process, so every time a leaf transitions from light to shade the photoprotection switches off faster. Leaves gain extra minutes of photosynthesis which, when added up throughout the entire growing season, increases the total photosynthetic rate. This research has shown that despite achieving a more than 20% increase in yield, seed quality was not impacted.

"Despite higher yield, seed protein content was unchanged. This suggests some of the extra energy gained from improved photosynthesis was likely diverted to the nitrogen-fixing bacteria in the plant's nodules," said RIPE Director Stephen Long (CABBI/BSD/GEGC), Ikenberry Endowed University Chair of Crop Sciences and Plant Biology.

The researchers first tested their idea in tobacco plants because of the ease of transforming the crop's genetics and the amount of seeds that can be produced from a single plant. These factors allow researchers to go from genetic transformation to a field trial within months. Once the concept was proven in tobacco, they moved into the more complicated task of putting the genetics into a food crop, soybeans.

"Having now shown very substantial yield increases in both tobacco and soybean, two very different crops, suggests this has universal applicability," said Long. "Our study shows that realizing yield improvements is strongly affected by the environment. It is critical to determine the repeatability of this result across environments and further improvements to ensure the environmental stability of the gain."

Additional field tests of these transgenic soybean plants are being conducted this year, with results expected in early 2023.

"The major impact of this work is to open the roads for showing that we can bioengineer photosynthesis and improve yields to increase food production in major crops," said De Souza. "It is the beginning of the confirmation that the ideas ingrained by the RIPE project are a successful means to improve yield in major food crops."

The RIPE project and its sponsors are committed to ensuring Global Access and making the project's technologies available to the farmers who need them the most.

"This has been a road of more than a quarter century for me personally," said Long. "Starting first with a theoretical analysis of theoretical efficiency of crop photosynthesis, simulation of the complete process by high-performance computation, followed by application of optimization routines that indicated several bottlenecks in the process in our crops. Funding support over the past ten years has now allowed us to engineer alleviation of some of these indicated bottlenecks and test the products at field scale. After years of trial and tribulation, it is wonderfully rewarding to see such a spectacular result for the team."

RIPE is led by the University of Illinois in partnership with The Australian National University, Chinese Academy of Sciences, Commonwealth Scientific and Industrial Research Organisation, Lancaster University, Louisiana State University, University of California, Berkeley, University of Cambridge, University of Essex, and U.S. Department of Agriculture, Agricultural Research Service. ■

Written by Allie Arp. Photo by Allie Arp.

MONTHLY PROFILE

Abbi Turner is a graduate student in the Department of Evolution, Ecology, and Behavior, in the lab of Professor Mark Hauber.

Abbi Turner

Using new techniques to test role of hormones in egg rejection

The American robin is virtually everywhere in North America, and often overlooked because of its commonality. But talk with Abbi Turner, and her passion for her research with the robins is sure to make anyone give these "common" birds a closer look. Born and raised in Indianapolis, Indiana, Turner has always had a passion for wildlife, which landed her in Ohio Wesleyan University, where she earned a bachelors in zoology in 2019. During her undergraduate career, she worked closely with Dustin Reichard, a prominent avian behavioral ecologist, studying mate-switching behavior in house wrens, where she says her love of birds blossomed. An inspiring behavioral endocrinology class, along with a well-timed Twitter post announcing a position for a graduate student, led Turner to the University of Illinois Urbana Champaign in 2020 to study the effects of hormones on behavior in birds. She is currently a 3rd year graduate student in the lab of Mark Hauber, a professor in the Evolution, Ecology, and Behavior department.

Turner's research explores the effects of hormones on egg rejection behavior in robins, specifically rejection of brood parasitic cowbird eggs. In the bird world, brood parasites are birds that don't take the typical route of building their own nest and raising their young. Rather, they find other birds that have already built their own nest, into which the brood parasite will slip their own egg in, letting the host do the work of raising the parasite's young. In North America, the brown-headed cowbird — or cowbird for short — is the main brood parasite, parasitizing over 200 species across the continent. Cowbirds also parasitize robins, but Turner knows the robins have a trick up their sleeves (or feathers, so to speak). Robins are exceptionally good at spotting rogue cowbird eggs in the nest and will promptly throw them out, an ability not shared by most cowbird hosts.

"You see these birds all the time you think, oh, there's a robin again," said Turner, "but they have this totally neat behavior that you may know nothing about. It reminds you to appreciate the things that are right in front of you, because my whole study system is a common backyard bird that has this behavior that not a lot of brood parasite hosts have."

Turner uses robins as a model to study the role of corticosteroids on the birds' ability to reject eggs of various colors. Corticosteriods are hormones that are used as a proxy to measure stress responses and the body's readiness to engage in high-energy endeavors — basically a measure of fight or flight response. Manipulating these hormones in a natural setting can be challenging, and often involves invasive implants or injections that can cause nest abandonment. However, Turner is helping to pioneer a non-invasive technique, first tested in tree swallows, which involves mixing gel with powdered hormone and spreading it atop of eggs, such that when the female incubates the eggs, the hormone is absorbed through her brood patch: the bare spot on the chest that warms the eggs. "Using this gel on the eggs is a cool, non-invasive way to let you temporarily tinker with their hormones without causing them to abandon their nests," said Turner.

> *"Positive energy activates constant elevation."*

Using this technique, Turner has looked at rejection behavior, nest survival, as well as where robins take the eggs they reject, which she says involved another up-and-coming technique – 3D printing eggs and placing radio transmitters inside of them. Using receivers, Turner's team could then track if and when the eggs were rejected, and where they were taken to. Turner described the difficulty of finding the tiny 3D printed eggs in tall grass: "It was a fun project but it was it was tough sometimes because they would drop them in not the easiest places to find a tiny model egg," recalled Turner, "but I have lots of funny stories of us trying to find those eggs, and actually, they're probably some of the best memories that I have so far. Trying to find these frickin' eggs."

Turner also discussed her use of Twitter to promote increasing minority representation in science, and the need for field safety protocols, particularly for women and people of color. After an incident in Spring 2021 when the police were called on her and her fieldwork team, she wrote a Twitter post that went viral, sparking a conversation about the need for labs to have field safety protocols for scenarios like police, stalking, and other potential fieldwork dangers.

When graduate school gets overwhelming, Turner says her dog, also known as the "love of her life in dog form", her partner, her friendships, and especially her family, help keep her grounded. As a first-generation college student, Turner describes how her family is always asking her questions about nature and science now. "There's no biologist in my family before me, and so it's cool that they actually listen to my work and think about these things as different experiences in their life," said Turner. She is incredibly close with her family, whom with they all share a tattoo in memory of her father. The tattoo reads "positive energy activates constant elevation", or P.E.A.C.E. "My dad growing up… used to say 'peace' all the time," said Turner. "On the phone he never said goodbye to people, he always said peace. It's a family tattoo now so me, my mom, and my siblings all have it, and I try my best to live by it. It means a lot to me." ■

Written by Shelby Lawson. Photo by Julia Pollack.

ON THE GRID
HAPPENINGS AT THE IGB

AWARDS


KATHRYN CLANCY
KATY HEATH

Kathryn Clancy, Associate Professor of Anthropology (EIRH), and Katy Heath, Associate Professor of Plant Biology (IGOH) were named Dean's Distinguished Professorial Scholars by the College of Liberal Arts and Sciences, for their contributions in education and research at the University of Illinois.

PETER FOX

Peter Fox, Founder and Principal of Fox Ventures, LLC and IGB Leadership Council member, received the Distinguished Service Award from the University of Illinois Alumni Association, presented to individuals whose consistent, exceptional and meritorious service to the University has made a significant impact on the institution's overall welfare and advancement of its mission.

SARA PEDRON HABA

Sara Pedron Haba, Research Assistant Professor of Chemical and Biomolecular Engineering (RBTE) was named a 2022 awardee of the American Association for Cancer Research (AACR).

HEE-SUN HAN

Hee-Sun Han, Mark A. Pytosh Scholar and Assistant Professor of Chemistry (GNDP/IGOH) has received the Amy L. Devine Award from the Illinois chapter of Alpha Omega Epsilon for willingness to "go above and beyond" to ensure that her students are understanding the concepts being taught in her class.

MARK HAUBER

Mark Hauber, Harley Jones Van Cleave Professor of Host-Parasite Interactions, Evolution, Ecology, and Behavior (GNDP), received the Alexander von Humboldt Research Award from the Alexander von Humboldt Foundation, which invites awardees to conduct the research project of their choice in collaboration with specialist colleagues located at a research institution in Germany.

MADHU KHANNA

Madhu Khanna, Professor of Agricultural and Consumer Economics (CABBI) was named the Alvin H. Baum Family Chair and Director of the Institute for Sustainability, Energy, and Environment.

CECILIA LEAL

Cecilia Leal, Associate Professor and Racheff Faculty Scholar in Materials Science and Engineering (M-CELS), is the recipient of the 2022 College Award for Sustained Excellence in Diversity, Equity and Inclusion from the Grainger College of Engineering.

DONALD ORT

Donald Ort, Robert Emerson Professor in Plant Biology and Crop Sciences (GEGC Leader/BSD/CABBI) received the Jalal Aliyev Lecture Scholarship from the International Society of Photosynthesis Research, which recognizes extraordinary achievements in photosynthesis research, particularly in applied environmental and ecological aspects of photosynthesis.

TANDY WARNOW

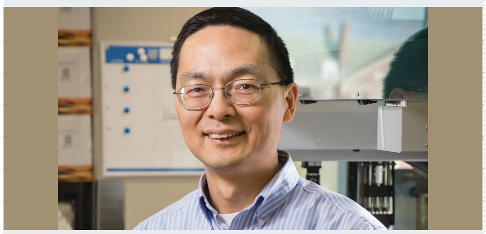
Tandy Warnow, Associate Head for Research and Faculty Development in the Department of Computer Science (IGOH) received the 2022 College Award for Excellence in Faculty Mentoring from the Grainger College of Engineering.

ON THE GRID
HAPPENINGS AT THE IGB

AWARDS

NICHOLAS WU

Nicholas Wu, Assistant Professor of Biochemistry (IGOH) was selected for the new class of Searle Scholars to pursue ground-breaking research in chemistry and biomedical sciences.



HUIMIN ZHAO

Huimin Zhao, Steven L. Miller Chair in Chemical and Biomolecular Engineering (BSD/GSE lead/CABBI/CGD/MMG), was appointed editor-in-chief of ACS Synthetic Biology by the Publications Division of the American Chemical Society (ACS), and received the 2022 Food, Pharmaceutical and Bioengineering Division Award in Chemical Engineering from the American Institute of Chemical Engineers (AIChE).

DIRECTOR

IGB WELCOMES NEW DIRECTOR OF COMPUTATIONAL GENOMICS

Sihai Dave Zhao, a professor in the department of statistics at the University of Illinois Urbana-Champaign, is the new IGB Director of Computational Genomics.

Dave has been an IGB member for over 8 years, serving in both the Gene Networks in Neural Development and Plasticity theme and the former theme Computing Genomes for Reproductive Health. Through statistical approaches to genomics he looks to develop analysis patterns for genomic data, innovate statistical applications to biology, and investigate spatial transcriptomics and behavioral genomics.

SEMINAR SERIES

THRIVING IN GRADUATE SCHOOL SEMINAR SERIES

Funded by a grant from the IGB Diversity, Equity, and Inclusion initiative, the student-run Thriving in Graduate School seminar series will provide a workshop for the first year of graduate school, how to troubleshoot your mentor relationship, an international student panel, and coping mechanisms to support mental health.

Sign up for the mailing list at https://forms.illinois.edu/sec/398930130

CORE FACILITIES

LUNCH WITH THE CORE FALL '22 SCHEDULE

The IGB Core Facilities is hosting a Fall 2022 seminar series covering the instrumentation in the Core and some of the research taking place in the Core. The seminars are typically held from 12:00 - 1:00 pm in the Carl R. Woese Institute for Genomic Biology, Room 612 (Concourse level). Pizza will be provided.

September 14, 2022
"Introduction to the IGB Core"
Dr. Glenn Fried, Director of Core Facilities, Carl R. Woese Institute for Genomic Biology

September 21, 2022
"PEG Microgels as Modular 3D Cell Scaffold and Cytokine Sensor"
Hyeon Ryoo, Graduate Student, Bioengineering
Instrument - LSM 880

September 28, 2022
"Exploring chloroplasts of C4 plants with microscopy"
Moonsub Lee, Postdoctoral Research Assoc., Plant Biology
Instrument: LSM 880 & SBF-SEM

October 5, 2022
"Emergent behavior and phase transition in cell-ECM systems mediated by long range cell-cell mechanical interaction"
Umnia Doha, PhD Student, Mechanical Science & Engineering
Instrument: LSM 710

October 12, 2022
TBA
Mahmoud Mahrous, Graduate Student, Mechanical Science & Engineering
Instruments: SBF-SEM & X5000 CT Scanner

Full schedule at https://www.igb.illinois.edu/corefacilities/news/lunch-core-fall-2022.

RECENT PUBLICATIONS

Please include your connection to the IGB in your author byline when submitting publications, as it will greatly help track potential newsworthy items and increase the possibility of coverage.

Carson, D. A., Kopsco, H., Gronemeyer, P., Mateus-Pinilla, N., Smith, G. S., Sandstrom, E. N., & Smith, R. L. (2022). Knowledge, attitudes, and practices of Illinois medical professionals related to ticks and tick-borne disease. *One Health*, 15, [100424]. https://doi.org/10.1016/j.onehlt.2022.100424

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Albiol Tapia, M., & Lee, S. Y. (2022). Variations in consumer acceptance, sensory engagement and method practicality across three remote consumer-testing modalities. *Food Quality and Preference*, 100, [104616]. https://doi.org/10.1016/j.foodqual.2022.104616

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