IGB NEWS

Volume 11 Number 8

UPCOMING EVENTS

IGB Seminar
Why Science Needs Art
January 15, 2019, 12:00 p.m.
612 Carl R. Woese Institute for Genomic Biology

Keri Kukral
CEO and Founder
Raw Science

IGB Faculty Spotlight Lecture
Exploring and Expanding the Benefit of Beneficial Microbes
January 22, 2019, 12:00 p.m.
612 Carl R. Woese Institute for Genomic Biology

Shannon Sirk, PhD
University of Illinois
Department of Bioengineering
IGB Affiliate, Microbiome Metabolic Engineering

IGB Seminar (GEGC)
Transcriptional Regulation of Nitrogen Metabolism
January 29, 2019, 12:00 p.m.
612 Carl R. Woese Institute for Genomic Biology

Siobhan Brady, PhD
University of California, Davis
Department of Plant Biology

IGB Seminar (ONC-PM)
Profiling Cells Inside and Out with Nanostructured Materials
February 19, 2019, 12:00 p.m.
612 Carl R. Woese Institute for Genomic Biology

Shana Kelley, PhD
University of Toronto, Departments of Chemistry, Pharmaceutical Sciences, Biochemistry
Institute for Biomaterials and Biomedical Engineering

FEATURED NEWS


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RIPE project receives additional $13 million


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Jumping genes shed light on how advanced life may have emerged


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Monthly Profile: Esther Ngumbi


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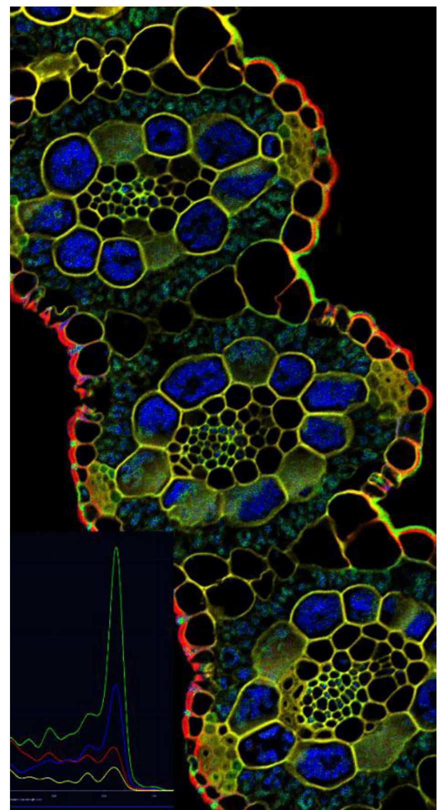
On the Grid: Happenings at IGB

IMAGE OF THE MONTH



This month features an image showing spectral detection and un-mixing of Switch Grass leaf in cross-section, using the LSM 710 Two-photon System. Image provided by Mayandi Sivaguru, and Shaojun Li from the DoKyoung Lee Lab.

IGB News

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

RIPE project receives additional $13 million

This week, families across the U.S. will gather around Thanksgiving tables in a traditional celebration of the season's bounty. By improving how key crops transform sunlight into yield, Realizing Increased Photosynthetic Efficiency (RIPE) will one day help farmers put food on more tables worldwide, especially where it is needed most.

In 2017, a $45 million, five-year reinvestment from the Bill & Melinda Gates Foundation, the Foundation for Food and Agriculture Research (FFAR), and the U.K. Government's Department for International Development (DFID) ensured the international research project could continue to address the global food challenge. Today, the Gates Foundation contributed an additional $13 million to add resources and personnel that will help accelerate the transfer of the RIPE project's successes into key food crops: soybeans, rice, cassava, and cowpea.

"Time is of the essence—especially as we look to a future filled with more people and a dramatically different climate," said RIPE Director Stephen Long, Ikenberry Endowed University Chair of Crop Sciences and Plant Biology at the University of Illinois and Distinguished Professor in Crop Sciences at Lancaster University (above, right). "We must future-proof our food supply today to ensure that these technologies are available when we need them."

A key aim of the RIPE project is to provide farmers, particularly those in some of the world's poorest countries, with seed that will yield substantially more without requiring more inputs.

However, it takes at least 15 years for any breakthroughs to journey from scientists' lab benches to farmers' fields at scale, cautioned RIPE Deputy Director Donald Ort, the Robert Emerson Professor of Plant Biology and Crop Sciences at Illinois (above, left). Likely, RIPE's technologies will not be in farmers' fields until 2030 when the world's population will have grown by more than a billion people.

To expedite progress, RIPE has modeled photosynthesis to virtually tweak the photosynthetic process and pinpoint the best opportunities for improvements that would increase crop productivity. The supplement's support will be used to test the model's predictions in model crops and translate yield-boosting technologies to food crops more quickly.

"Our rich knowledge from a half-century of photosynthesis research coupled with modeling has enabled our team to make blueprints to re-engineer this complex process in staple food crops," Long said, who leads the project at the Carl R. Woese Institute for Genomic Biology. "Our models predict that by combining several strategies we could achieve a 50 percent yield increase, which will go a long way to meeting the demands of this century."

Already, these computer simulations guided promising real-world results, including a 20 percent boost in productivity published in Science, and an even greater increase published in *Plant Biotechnology Journal*. Several other strategies have shown similar yield improvements through preliminary greenhouse experiments and field trials.

Other work has demonstrated in field trials that the up-regulation of a single gene protects soybean yield in futuristic climate conditions with elevated temperatures and carbon dioxide levels, as published in the *Journal of Experimental Botany*. In *Nature Communications*, the team showed how to significantly increase crop water-use efficiency.

"We are committed to ensuring that the literal fruits of our labor are globally available and royalty-free for smallholder farmers, particularly in Sub-Saharan Africa and Southeast Asia, to help meet the huge challenge of feeding the future," Long said. "While no single strategy will overcome the hurdles facing the industry—our recent success in RIPE and our sponsors' continued support give me hope that the future of agriculture is bright."

Realizing Increased Photosynthetic Efficiency (RIPE) is an international research project that is producing staple food crops that more efficiently convert the sun's energy into food to sustainably increase productivity using fewer inputs. This project is supported by the Bill & Melinda Gates Foundation, Foundation for Food and Agriculture Research, and U.K. Government's Department for International Development.

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 Essex; and the U.S. Department of Agriculture, Agricultural Research Service. ■

Written and photo by Claire Benjamin.

Jumping genes shed light
on how advanced life may have emerged

A previously unappreciated interaction in the genome turns out to have possibly been one of the driving forces in the emergence of advanced life, billions of years ago.

This discovery began with a curiosity for retrotransposons, known as "jumping genes," which are DNA sequences that copy and paste themselves within the genome, multiplying rapidly. Nearly half of the human genome is made up of retrotransposons, but bacteria hardly have them at all.

Nigel Goldenfeld, Swanlund Endowed Chair of Physics and leader of the Biocomplexity research theme at the IGB (pictured, left) and Thomas Kuhlman, a former physics professor at Illinois who is now at University of California, Riverside (pictured, right) wondered why this is.

"We thought a really simple thing to try was to just take one (retrotransposon) out of my genome and put it into the bacteria just to see what would happen," Kuhlman said. "And it turned out to be really quite interesting."

Their results, published in the *Proceedings of the National Academy of Sciences*, give more depth to the history of how advanced life may have emerged billions of years ago—and could also help determine the possibility and nature of life on other planets.

Along the way to explaining life, the researchers first encountered death—bacterial death, that is. When they put retrotransposons in bacteria, the outcome was fatal.

"As they jump around and make copies of themselves, they jump into genes that the bacteria need to survive," Kuhlman said. "It's incredibly lethal to them."

When retrotransposons copy themselves within the genome, they first find a spot in the DNA and cut it open. To survive, the organism then has to repair this cut. Some bacteria, like *E. coli*, only have one way to perform this repair, which usually ends up removing the new retrotransposon. But advanced organisms (eukaryotes) have an additional "trick" called nonhomologous end-joining, or NHEJ, that gives them another way to repair cuts in their DNA.

Goldenfeld and Kuhlman decided to see what would happen if they gave bacteria the ability to do NHEJ, thinking that it would help them tolerate the damage to their DNA. But it just made the retrotransposons better at multiplying, causing even more damage than before.

"It just completely killed everything," Kuhlman said. "At the time, I thought I was just doing something wrong."

They realized that the interaction between NHEJ and retrotransposons may be more important than they previously thought.

Eukaryotes typically have many retrotransposons in their genome, along with a lot of other "junk" DNA, which doesn't have a well-understood function. Within the genome, there must be a constant interplay between NHEJ and retrotransposons, as NHEJ tries to control how rapidly the retrotransposons multiply. This gives the organism more power over their genome, and the presence of "junk" DNA is important.

"As you get more and more junk in your DNA, you can start taking these pieces and combining them together in different ways, more ways than you could without all the junk in there," Kuhlman said.

These conditions — the accumulation of "junk" DNA, the presence of retrotransposons and their interactions with NHEJ — make the genome more complex. This is one feature that may distinguish advanced organisms, like humans, from simpler ones, like bacteria.

Advanced organisms can also manage their genome by using their spliceosome, a molecular machine that sorts through the "junk" DNA and reconstructs the genes back to normal.

Some parts of the spliceosome are similar to group II introns, bacteria's primitive version of retrotransposons. Introns are also found in eukaryotes, and along with the spliceosome are evolutionarily derived from group II introns. Goldenfeld said this poses an evolutionary question.

"What came first, the spliceosome or the group II introns? Clearly the group II introns," he said. "So then you can ask: where did the eukaryotic cell first get those group II introns in order to build up the spliceosome early on?"

This study suggests that group II introns, the ancestors of introns in the spliceosome and retrotransposons in eukaryotes, somehow invaded early eukaryotic cells. Then, their interactions with NHEJ created a "selection pressure" that helped lead to the emergence of the spliceosome, which helped life become advanced billions of years ago.

The spliceosome helped life become advanced by enabling eukaryotes to do more with their DNA. For example, even though humans have roughly the same number of genes as *C. elegans*, a worm, humans can do more with those genes.

"There's not much difference between this very simple worm and humans, which is obviously insane," Goldenfeld said. "What's happening is that humans are able to take these genes and mix and match them in many combinations to do much more complicated functions than *C. elegans* does."

Not only did NHEJ and retrotransposons help with the creation of the spliceosome; this study suggests that they may also have assisted in making chromosomes — DNA molecules that contain genetic material — more advanced. Interactions between NHEJ and retrotransposons may have aided in the transition from circular chromosomes (which bacteria generally have) to linear ones (which more advanced organisms have), another indicator of advanced life.

Goldenfeld said that before this research, many researchers studied the role of retrotransposons, but the importance of NHEJ was not fully appreciated. This research proves that it played a part, billions of years ago, in eukaryotes becoming the advanced organisms we know today.

"This certainly was not the only thing that was going on," Goldenfeld said. "But if it hadn't happened, it's hard to see how you could have complex life."

This study contributes to the larger questions that the Institute for Universal Biology, a NASA Astrobiology Institute that Goldenfeld directs, seeks to answer — questions like: what had to happen in order for life to become advanced?

Answering this question in greater detail could help scientists determine the possibility of life on other planets.

"If life exists on other planets, presumably one would expect it to be microbial. Could it ever have made this transition to complex life?" Goldenfeld said. "It's not that you're inevitably going to get advanced life, because there are a bunch of things that have to happen."

The physics perspective of this study helps to quantify these theoretical questions. This quantification comes from simply taking measurements in a laboratory and using those measurements to make models of evolution, as was done in this study.

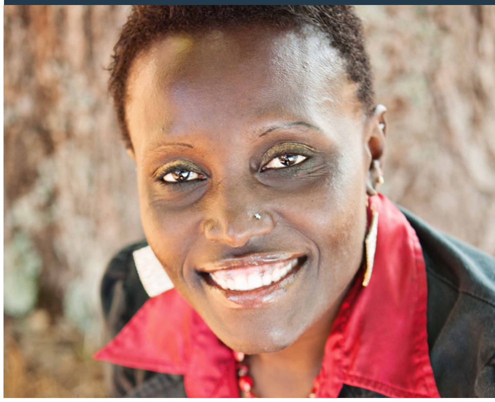
In doing so, basic measurements in a laboratory become a time machine to the past.

"We're doing laboratory evolution," Goldenfeld said. "We're looking at what evolutionary processes must have happened billions of years ago."

This research was supported by the NSF Center for the Physics of Living Cells, the Alfred P. Sloan Foundation, and the NASA Astrobiology Institute (NAI) through the Science Mission Directorate. The conclusions presented are those of the researchers and not necessarily those of the funding agencies.

Written by Emily Scott.

MONTHLY PROFILE



Esther Ngumbi is a entomology postdoctoral researcher at Illinois and community leader, with research directed at basic and applied aspects of using microbial inoculants to promote growth and enhance tolerance to drought stress in multiple crops. She is also the founder of several organizations that empower farmers and youth in Kenya.

Esther Ngumbi
brings science advocacy to the public

Throughout her childhood in Kenya, Esther Ngumbi was fully aware of the challenges that farmers face. Many people in her community, including her own family members, were farmers. But they frequently saw their crops destroyed by insects and pests, and this often led to food insecurity.

Years later, when Ngumbi decided to pursue a career in science, she was motivated by this problem she had witnessed firsthand.

"I wanted to make sure I did something that was going to help fight the insects and pests and contribute to food security," she said. "I had that guiding ambition of doing something that would help farmers."

Now she is a postdoctoral researcher in the lab of May Berenbaum, a professor of entomology and faculty member of the IGB's GEGC and IGOH themes. Ngumbi's research is focused on finding sustainable ways to grow food by using alternatives to pesticides.

She is currently researching the navel orangeworm, a pest that is detrimental to almonds and pistachios grown in California. Her work is investigating the mechanisms behind this pest's resistance to pesticide. Specifically, she is looking into how cuticular hydrocarbons, which cover insects' bodies, may act as a barrier to pesticide.

Ngumbi also studies beneficial microbes, which are microscopic organisms in soil that have a mutually beneficial relationship with plants. A past study she conducted found that beneficial microbes can help plants repel insects, providing an alternative to pesticides.

"I've been working on finding sustainable ways to grow our food by using alternative pesticides, whether they're natural enemies or whether they're beneficial microbes," she said.

An upcoming research project will allow Ngumbi to study how beneficial microbes interact with tomato plants that are grown in lead-polluted soils. She'll look at how this pollution affects the plants' interactions with beneficial microbes, and how this ultimately affects the plants' interactions with insects.

"They truly just want to know why—why this research is important; how does it affect me and my busy life? I think all the science we do is applicable, you just have to find a way."

As her research has evolved, Ngumbi has advocated for alternatives to pesticides and become passionate about communicating her work to the public.

"I had all this beautiful work with the soils and how they interact with plants to repel insects, but I was not portraying that amazing research that do," she said. "I realized that so many of us scientists, we're doing so much amazing work, yet we don't talk about it."

She began writing about her own research, as well as topics related to agriculture, climate change, women's rights and education. So far, she's been published in *Scientific American, NPR, Los Angeles Times*, and more.

Ngumbi enjoys the challenge that comes with communicating science to a general audience.

"They truly just want to know why—why this research is important; how does it affect me and my busy life?" she said. "I think all the science we do is applicable, you just have to find a way."

She teaches a science communication course in the Department of Entomology, where she tells her students that unless they talk about their research, no one else will.

"We spend so much time doing it, the hours that you spend, doing the experiments, then you have to repeat it, sometimes it works, sometimes it won't," she said. "Then when it's done — I tell the students, probably only one person will quote you. Some of the papers have only been quoted once. And that's the life of your work."

She hopes to expand her science communication course along with her own research. Her goal is to continue in academia and continue studying beneficial cell-plant interactions, the mechanisms of pesticide resistance, and invasive species, a problem that she said will escalate as time goes on.

"That's becoming one of the biggest global problems that we have," she said. "We're bound to continue to have invasives, (we need to) try to understand how people can prepare and anticipate, and once the insect is there, what are the mechanisms that the insects use to resist insecticides?"

Ngumbi's passion for her work is unmistakable. She's excited to come to work every day and potentially be the first person to discover something, no matter how big or how small that something is.

"It's a privilege that sometimes scientists will forget, that we see it first before we ever report it," she said. "Not many people get that opportunity." ■

Written by Emily Scott. Photo provided by Esther Ngumbi.

ON THE GRID
HAPPENINGS AT THE IGB

AWARDS

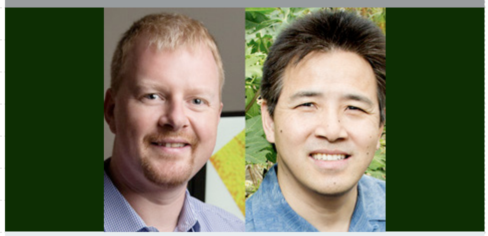
RASHID BASHIR

Rashid Bashir, Dean of the University of Illinois College of Engineering and Grainger Distinguished Chair in Engineering (ONC-PM/RBTE) was named a National Academy of Inventors Fellow, a program which highlights academic inventors who have demonstrated a prolific spirit of innovation in creating or facilitating outstanding inventions having a tangible impact on quality of life, economic development, and the welfare of society.

HANNAH HOLSCHER

Hannah Holscher, Assistant Professor of Nutrition (MME) was appointed to the Scientific Advisory Board of uBiome, comprised of leading scientists and doctors from around the world who bring insight on the impact of nutrition on the human gut microbiome. uBiome is a leader in microbial genomics looking to advance the understanding and application of the microbiome.

AAAS



TWO IGB FACULTY ELECTED AAAS FELLOWS

Two IGB faculty members have been elected 2018 Fellows of the American Association for the Advancement of Science. Plant biology professors Andrew Leakey (CABBI/GEGC) and Ray Ming (GEGC) are among the 416 people to be awarded the distinction of AAAS Fellow this year.

Leakey studies plant responses to climate change as well as the development of crops that will require less water and are more drought tolerant. According to the AAAS, he is recognized in the field of agriculture, food and renewable resources "for distinguished contributions to plant science, particularly for advancing integrative understanding of crop carbon and water relations in the context of global environmental change."

Ming is an expert on sex chromosome evolution and the reproductive biology of selected tropical crop plants. According to the AAAS, he is recognized in the field of agriculture, food and renewable resources "for distinguished contribution to the field of sex chromosome evolution, particularly using genomic technologies to study early stages of sex chromosomes relevant to crop improvement."

RESEARCH

ANT SPECIES POSSESSES FASTEST ANIMAL APPENDAGE

According to a new study, the Dracula ant, *Mystrium camillae*, can snap its mandibles at speeds of up to 90 meters per second (more than 200 mph), making it the fastest animal movement on record.

"The high accelerations of *Mystrium* strikes likely result in high-impact forces necessary for predatory or defensive behaviors," the researchers wrote in a report of their findings in the journal Royal Society Open Science.

"These ants are fascinating as their mandibles are very unusual," said University of Illinois animal biology and entomology professor Andrew Suarez (GNDP), who led the research with Fredrick J. Larabee, a postdoctoral researcher at the Smithsonian National Museum of Natural History; and Adrian A. Smith, of the North Carolina Museum of Natural Sciences and North Carolina State University, Raleigh. Read the full story here.

IGEM

IGEM TEAM WINS BRONZE

The Illinois iGEM team won a bronze medal at the 2018 International Genetically Engineered Machine (iGEM) competition for their work on the relationship between lactic acid bacteria and baker's yeast. iGEM brings together undergraduate students from across the world to present their research in synthetic biology.

HIGHLY CITED

Clarivate Analytics

ILLINOIS RESEARCHERS WORLD'S MOST INFLUENTIAL

Nine faculty members at the University of Illinois at Urbana-Champaign have been named to the 2018 Clarivate Analytics Highly Cited Researchers list, including four from the IGB: USDA ARS, crop sciences and plant biology professor Lisa Ainsworth (CABBI/GEGC, highly cited in plant and animal science), crop sciences and plant biology professor Stephen Long (BSD/CABBI/GEGC, plant and animal science), chemistry professor Yi Lu (BSD/CABBI/ONC-PM, chemistry), and plant biology professor Donald Ort (BSD/CABBI/GEGC, plant and animal science). The list recognizes "leading researchers in the sciences and social sciences from around the world," and is based on an analysis of journal article publication and citation data, an objective measure of a researcher's influence, from 2005-17.

DEPARTMENT ANNOUNCEMENTS

CNRG

BIOCLUSTER

CNRG is planning an outage of Biocluster on 12/18-19. During this outage, CNRG will be: removing the CEPH filesystem; moving the physical location of the GPFS filesystem; migrating the cluster network to a new switch; upgrading slurm to resolve some memory management issues; removing the budget queue; and adding the new lowmemory queue. We are hoping that we can finish this work in less time, but please plan for the cluster to be out two full days.

We have also ordered five new 72 core nodes which will eventually replace the computation resources provided by the normal queue. Look for these to move into the cluster in late January or February of 2019. ■

BUSINESS

HOLIDAY BREAK REDUCED SERVICE DAYS

As we approach the holiday season we are providing a reminder of the upcoming holiday schedule and the accompanying gift days.

Monday, December 24, 2018
½ Gift Day (from President & Chancellor) and ½ Excused Day p.m
Tuesday, December 25, 2018
Christmas Day Holiday
Wednesday, December 26, 2018
Day After Christmas Holiday (Designated Holiday)
Thursday, December 27, 2018
Gift Day**
Friday, December 28, 2018
Gift Day**
Monday, December 31, 2018
Gift Day**
Tuesday, January 1, 2019
New Year's Day Holiday Observed

Reduced Service Days:
As in the past, IGB will be closed starting December 24, 2018, thru January 1, 2019, and most employees will not be working those three days. Please note the three gift days must be used December 27th, 28th, and 31st; they cannot be "saved" to use at another point in time.

Questions regarding reduced service days, please contact Jacinda King at 244-2276 or *jkking@illinois.edu*. ■

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.

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Collins, K., & Warnow, T. (2018). PASTA for proteins. *Bioinformatics*, 34(22), 3939-3941. https://doi.org/10.1093/bioinformatics/bty495

RECENT PUBLICATIONS

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IGB News is published by the IGB Communications Office.
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