2016

CARL R. WOESE INSTITUTE FOR GENOMIC BIOLOGY ANNUAL REPORT

GLIMPSES OF DAILY LIFE IN THE SCIENCES:
MOMENTS THAT RANGE FROM
ROUTINE TO ADVENTUROUS,
METHODICAL TO INSPIRED,
MICROSCOPIC TO UNIVERSAL

ABOUT THE ICONS

The success of the IGB depends on collaborations that transcend traditional disciplines and close partnerships between researchers and support staff. Throughout this annual report, we use the icons below to indicate connections to four major research impact areas.

HEALTH

Research that seeks to understand the origins and mechanisms of disease and discovers new ways to promote wellness.

TECHNOLOGY

Research that imagines, develops, and refines new tools that enable discovery and create solutions.

ENVIRONMENT

Research that explores and protects ecosystems, especially those we rely on for food and fuel.

FUNDAMENTAL RESEARCH

"Blue Sky" research that creates the knowledge base needed for future progress.

COMMUNITY ENGAGEMENT

Programs that promote open dialogue between genomic research and society.

ABBREVIATIONS AND ACRONYMS

RESEARCH THEMES

ACPP:	Anticancer Discovery from Pets to People
BCXT:	Biocomplexity
BSD:	Biosystems Design
CGRH:	Computing Genomes for Reproductive Health
EBI:	Energy Biosciences Institute
GEGC:	Genomic Ecology of Global Change
GNDP:	Gene Networks in Neural and Developmental Plasticity
MME:	Microbiome Metabolic Engineering
MMG:	Mining Microbial Genomes
ONC-PM:	Omics Nanotechnology for Cancer Precision Medicine
RBTE:	Regenerative Biology and Tissue Engineering

OTHER ABBREVIATIONS AND ACRONYMS

DOE:	Department of Energy
IGB:	Carl R. Woese Institute for Genomic Biology
IUB:	NASA Astrobiology Institute for Universal Biology
NIH:	National Institutes of Health
NSF:	National Science Foundation
USDA:	United States Department of Agriculture

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FROM THE DIRECTOR
GENE ROBINSON

Science impacts all of us constantly in large and small ways. It entices and challenges us, asking us to constantly question our premises, to think imaginatively and work methodically, and to accept and build upon information that is radically new.

"It's not easy to run an institute the size and scope of the IGB and still stay active as a scientist. I am determined to succeed in combining these roles because of an unrelenting passion for my own science (I love those bees!) and the way each role enables me to better perform the other. I treasure the opportunity as director to learn so much about a wide range of topics outside of my own scientific expertise."
– Gene Robinson

This year, the style of our annual report evokes the image of a classic daily journal. The root word for journal originally meant "a record of each day's travel or work;" our report aims to be just that, reflecting the everyday efforts and accomplishments of research at the Carl R. Woese Institute for Genomic Biology (IGB). Our goal is to involve our broader communities, academic and otherwise, in the process of doing science rather than a few select moments of achievement.

There are such stories of achievement in the pages that follow, meant to hint at a more general message: when we describe breakthroughs in efforts to trace the molecular origins of mental disorders or untangle the interactions between human activity and ecosystems outside or within us, we are demonstrating the potential of genomic research to change lives for the better.

The full promise of genomics can only be realized in an environment of an informed and engaged community;

our report is also a record of our latest efforts to bring new voices into public conversations around science. In our community engagement, we emphasize events that bring scientists and other community members together in person to share ideas and experiences and look for new connections between science, art, nature, and other aspects of everyday life.

Auinash Kalsotra (p. 13), Sue Schantz (p. 16), Tim Gernat (p. 21), Paul Jensen (p. 24), Will Montgomery (p. 35), Ilsa Kantola (p. 39), Alexa Sadier (p. 44), Donald Ort (p. 49), Max Simon (p. 53), Bruce Fouke (p. 59)

In this report, we have tried to carry this openness even further by asking our researchers to share their personal views on what science means to them, and what brought them to it: a love of learning, compassion and a sense of responsibility toward others, a desire for adventure. These impulses are far from unique to scientists—in their universal nature lies possible common ground for new connections and better communication between the realm of research and the public.

In our institute's 2016 "journal," we invite you to take a closer look at the varied people and projects that have defined our year. What possibilities of genomic research mean the most to you? What common purposes do you find between those who have shared their thoughts and work here, and your own endeavors? Our institute's future work will be all the more fruitful for the contributions of our partners in every area of society.

Human enterprises do better when we engage each other with true empathy, looking for common ground and shared goals. Science is no different. When we can see another person's perspective, we may realize with surprise that ideas that at first are difficult to grasp actually open up new possibilities. The challenges our society faces are great; by working together, we can find the tools we need to meet them.

Gene E. Robinson

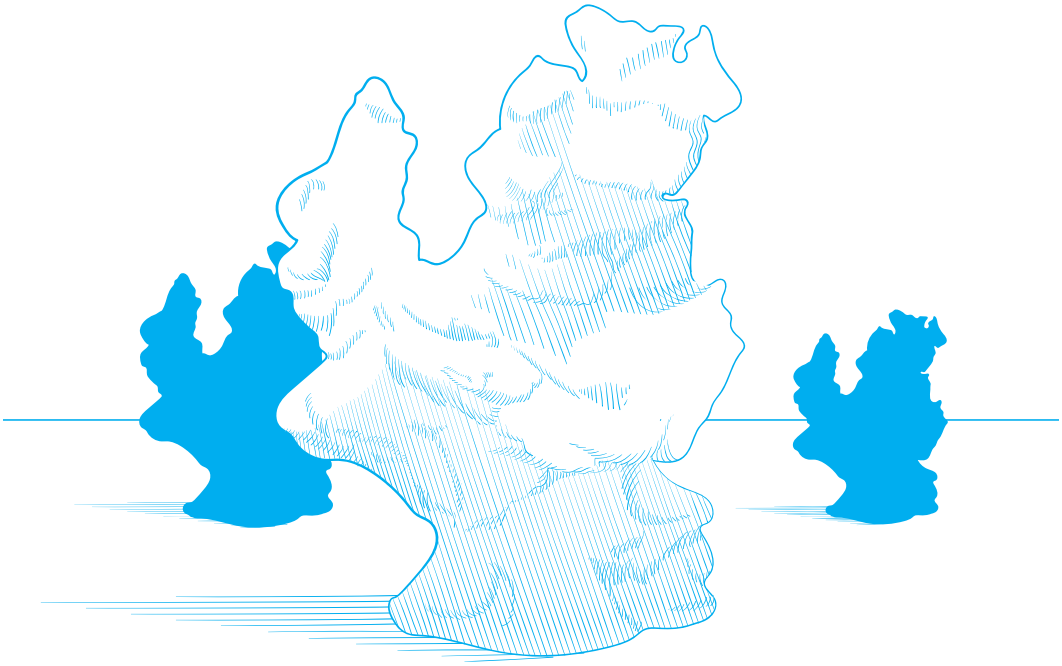
DIRECTOR,
CARL R. WOESE INSTITUTE FOR GENOMIC BIOLOGY

Our research themes are connected through their overlap within three broad areas of research: health challenges and solutions, genomic technologies, and environmental resources and conservation.

	HEALTH	TECHNOLOGY	ENVIRONMENT
ANTICANCER DISCOVERY FROM PETS TO PEOPLE Develops cancer treatments in pet animals that translate to human disease.	✓	✓	
BIOCOMPLEXITY Explores the origin of life and the behavior of biological systems.	✓	✓	✓
BIOSYSTEMS DESIGN Applies engineering principles to real and artificial biological systems.	✓	✓	✓
COMPUTING GENOMES FOR REPRODUCTIVE HEALTH Examines the interplay among genetic and environmental factors that influence disorders of reproduction.	✓	✓	
ENERGY BIOSCIENCES INSTITUTE Uses a systems approach to address the global energy challenge.		✓	✓
GENE NETWORKS IN NEURAL AND DEVELOPMENTAL PLASTICITY Examines the effects of coordinated gene activity on biological diversity.	✓	✓	
GENOMIC ECOLOGY OF GLOBAL CHANGE Studies the intersection of plant genomics and global climate change.		✓	✓
MICROBIOME METABOLIC ENGINEERING Explores the relationships between human microbiota, environment, and health.	✓	✓	✓
MINING MICROBIAL GENOMES Discovers small molecules that might provide new medical solutions.	✓	✓	
OMICS NANOTECHNOLOGY FOR CANCER PRECISION MEDICINE Develops new technology to identify and manage cancerous tumors.	✓	✓	
REGENERATIVE BIOLOGY & TISSUE ENGINEERING Studies the replacement or regeneration of tissues and organs.	✓	✓	

"To advance life science research at the University of Illinois at Urbana-Champaign and to stimulate bio-economic development in the state of Illinois."

This was the purpose for which the Carl R. Woese Institute for Genomic Biology (IGB) was established in 2007. In the years since, its large-scale initiatives and its everyday practices have enabled it to grow into its current position as a flagship institution in the field of genomic research.



WHO WE ARE

IGB members are drawn from many schools and departments, including biology, chemistry, physics, engineering, sociology, and business. What unites us is our confidence in the power of a genomics-based approach to achieve large-scale research goals. We tackle grand challenges related to health and wellbeing, technological development, environmental resources and conservation by engaging in fundamental and applied research. These goals are made achievable by IGB's culture of collaboration, flexibility, and diversity.

WHAT WE DO

The IGB provides a central gathering place to engage with genomic research, open to both the academic and the broader community. Through a variety of programs and events, the IGB welcomes researchers, industry partners, policymakers, families, and professional groups to explore how genomics could be valuable to each of them.

WHAT KEEPS US GOING

Every person is a stakeholder in the future of genomics: research in this area promises to improve myriad aspects of our society, and public and private funds make this work possible. Structuring our research around societal challenges and maintaining a dialogue with the public on where those explorations take us ensures that our scientific aims continue to be rewarding for all.

IGB

HEALTH

Research that seeks to understand the origins and mechanisms of disease and discovers new ways to promote wellness.

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TECHNOLOGY

Research that imagines, develops, and refines new tools that enable discovery and create solutions.

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ENVIRONMENT

Research that explores and protects ecosystems, especially those we rely on for food and fuel.

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COMMUNITY ENGAGEMENT

Programs that promote open dialogue between genomic research and society.

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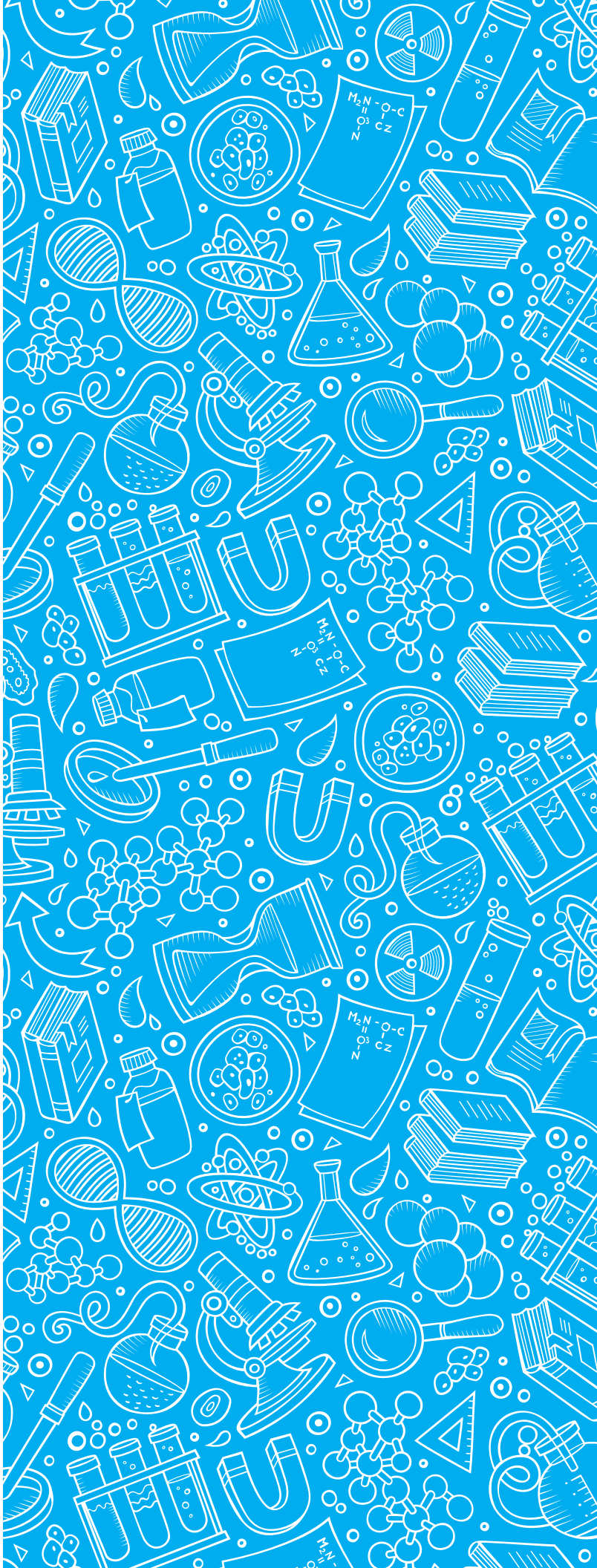


Communication about science often occurs at the culmination of a project or the attainment of a goal, even if an intermediary one. What if we could see the workings of science, not only in the moments of completion, but at the start, and in the more quiet and thoughtful interludes?

This Annual Report has plenty of stories of achievement—those moments are exciting, informative, and worthy of recognition. But we've also shared some glimpses of the most fundamental origins of science and of scientists, and the individual philosophies that keep researchers going when achievement feels like a distant goal. We hope that in the personal thoughts our members have shared, you may find an idea that speaks to you.

HEALTH

A passion for finding a cure, curiosity to understand the natural history of a living thing, or hunger for a new engineering challenge have all brought scientists to the field of health research—and all have resulted in novel treatments and preventative measures to promote wellbeing. Whether sifting through bacterial genome sequences or tracing the molecular dialogue between viruses and human cells, these research efforts use genomics to advance our ability to improve health.

LINKING NUTRITION TO BRAIN HEALTH AND COGNITIVE AGING

go.igb.illinois.edu/BrainFood

A new study of older adults found an association between higher blood levels of phosphatidylcholine, a source of the dietary nutrient choline, and greater cognitive flexibility, the ability to regulate attention managing competing tasks. The study, reported in *Frontiers in Aging Neuroscience*, also identified a brain region at the front of the brain called the prefrontal cortex that appears to play a role in this association.

"Our findings add to a growing body of research suggesting that particular nutrients may slow or prevent age-related declines in cognition by influencing specific structures within the brain," said psychologist Aron Barbey (GNDP), who led the study with graduate student Marta Zamroziewicz. "It may be that phosphatidylcholine protects the brain from the effects of aging by supporting the structure of brain [cell] membranes, reducing inflammation or contributing to the production of neurotransmitters that support cognition."

Abbott Nutrition supported this work through the Center for Nutrition, Learning, and Memory.

Psychology professor Aron Barbey, left, graduate student Marta Zamroziewicz and postdoctoral researcher Chris Zwilling conducted a new study linking blood levels of a key nutrient to brain structure and cognition in older adults.

SCIENTISTS TEST NANOPARTICLE DRUG DELIVERY IN DOGS WITH CANCER

go.igb.illinois.edu/NanoDrugDelivery

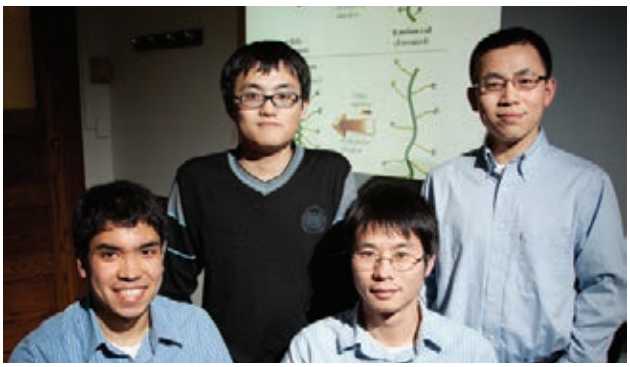
Veterinary clinical medicine professor Timothy Fan (ACPP/ONC-PM) is leading efforts to advance cancer treatments by testing promising new approaches in companion-animal dogs with spontaneously occurring cancers. As compared to standard mouse models, dogs are closer in size and biology to humans; their naturally occurring bone cancers share much more in common with human bone tumors than mice, and developed treatments can be used in veterinary medicine.

In clinical trials, the dogs tolerated tested doses of cancer-drug-laden nanoparticles with no signs of toxicity. As in mice, the particles homed in on tumor sites thanks to a coating of the drug pamidronate, which

SCIENTISTS TEST NANOPARTICLE DRUG DELIVERY IN DOGS WITH CANCER CONT.

preferentially binds to degraded sites in bone. The nanoparticles also showed anti-cancer activity in both mice and dogs, and may one day be used as a drug delivery system in humans with inoperable bone cancer.

The researchers reported their results in the *Proceedings of the National Academy of Sciences*. Their work was supported by the Morris Animal Foundation, the NIH, and the NSF.



Right: Materials science and engineering professor Jianjun Cheng (top right) and his team created a nanoparticle drug delivery system that was tested in dogs with spontaneously occurring osteosarcoma.

HUMAN TRIALS OF CANCER DRUG PAC-1 CONTINUE WITH NEW INVESTMENT

go.igb.illinois.edu/Pac1HumanTrial

Above: Pretzel and other pet dogs with naturally occurring tumors were effectively treated by PAC-1. The drug is now undergoing safety and efficacy trials in human patients.

Clinical trials of the anti-cancer agent PAC-1 are continuing to expand, thanks to a $7 million angel investment from an anonymous contributor who originally invested $4 million to help move the compound into the drug-approval pipeline. The drug was developed by Professor of Chemistry Paul Hergenrother (ACPP Theme Leader) and Professor of Veterinary Clinical Medicine Timothy Fan (ACPP/ONC-PM).

The U.S. Food and Drug Administration also granted PAC-1 orphan drug status for the treatment of glioblastoma multiforme, a deadly brain cancer. This designation is meant to encourage development of drugs to treat rare diseases or conditions affecting a small subset of the population. Some steps in the approval process are aided or expedited for orphan drugs.

An estimated 12,120 new cases of glioblastoma were expected in the U.S. in 2016. The median survival with standard-of-care therapy is 14.6 months.

A Phase I clinical trial of PAC-1 in human cancer patients began in 2015 and has so far involved about a dozen patients with a variety of late-stage cancers. A Champaign-based company, Vanquish Oncology, is the regulatory sponsor for the research.

USING DNA TO TRACK PROTEIN ACTIVITY WITHIN THE BRAIN

go.igb.illinois.edu/MeCP2

To support the genome's functions, the cell relies in part on DNA-binding proteins—molecules that latch onto the DNA strand and locally change its behavior. Researchers led by bioengineer Jun Song (ACPP) have combined careful labwork with computation to produce new, accurate predictions of the DNA interaction patterns of a key protein involved in brain disorders.

By understanding where within the genome the protein, called MeCP2, binds to DNA, the team hopes to shed light on brain development and the neurological conditions that can arise when MeCP2 does not function correctly. Their work was supported by the NIH and appeared in *Nature Communications*.

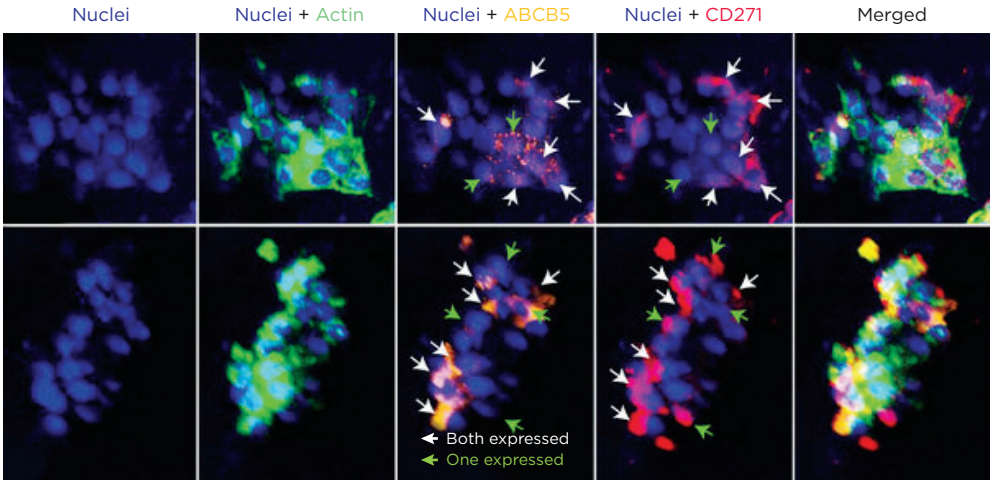
"Mutations in the *MeCP2* gene are directly linked to a severe brain disorder known as Rett Syndrome, but the genome-wide binding pattern and function of MeCP2 has remained poorly understood," said postdoctoral researcher Tomas Rube.

Previous studies have struggled to identify what DNA sequences MeCP2 is looking for because it is found attached to so many regions across the genome. Song's work used computational tools to predict binding sites by DNA sequence alone, starting from data on the binding activity observed in one specific type of cell to reduce potentially confusing variation within the experiment. Their findings clarify what types of sequence are most likely to interact with MeCP2, paving the way for a better understanding of how the protein influences health and disease.

BRIAN CUNNINGHAM

Professor, Electrical and Computer Engineering (ONC- PM Theme Leader/MMG)

Elected a 2016 Fellow of the American Association for the Advancement of Science.



SHAPE OF TUMOR MAY AFFECT WHETHER CELLS CAN METASTASIZE

go.igb.illinois.edu/TumorShape

Above: Skin cancer cells growing within a lab-created tissue environment revealed new dynamics involved in metastasis.

Only a few cells in a cancerous tumor are able to break away and spread to other parts of the body, but new findings suggest that the curve along the edge of the tumor may play a large role in activating these tumor-seeding cells. The study, published in *Nature Materials* by Professor of Materials Science and Engineering Kristopher Kilian (RBTE), veterinary clinical medicine professor Timothy Fan (ACPP/ONC-PM), and colleagues, was supported by the American Cancer Society and the NSF.

Using engineered tissue environments in various shapes and patterns, the researchers found that when clusters of skin cancer cells were grown in the laboratory, the more curved the clusters were, the more cancer cells at the edges displayed markers of stem cell characteristics—the key to spreading to other tissues. This insight has potential to further our understanding of cancer as well as our ability to develop personalized treatment plans.

"There's a lot more work to be done, but we're very excited about how a very simple materials property of a growing tumor might be a culprit of the disease spreading. We think it opens up a new avenue of investigation for drug development, guiding surgery, and understanding progression and spreading of cancer," Kilian said. "Cancer is very complex, so putting it in context is key. If there is a microenvironment that provides the context for activating cells that can spread cancer, then that's important to know."

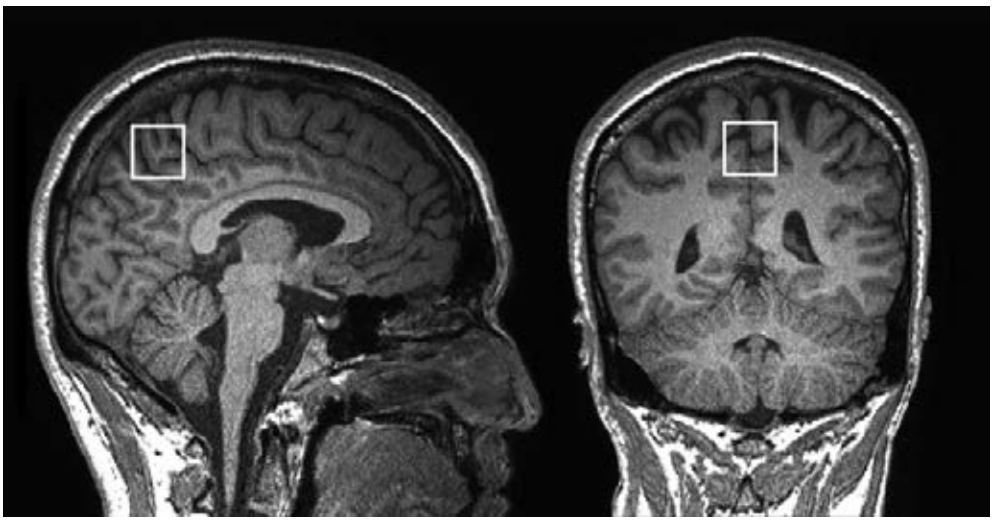
ROY DAR

Assistant Professor in Bioengineering (GNDP)

Received a Career Transition Award from the National Institutes of Health (NIH) National Institute of Allergy and Infectious Diseases.

Coming into work each day not knowing what you may discover is absolutely exhilarating for me. While the big breakthroughs do happen once in a while, it is the small steps we take every day that bring us closer to cracking the puzzles in the laboratory.

AUINASH KALSOTRA
ASSISTANT PROFESSOR, DEPARTMENT OF BIOCHEMISTRY
(GNDP/ONC-PM)



FINDING BRAIN MARKERS OF NUMERIC, VERBAL AND SPATIAL REASONING ABILITIES

go.igb.illinois.edu/FluidIntelligence

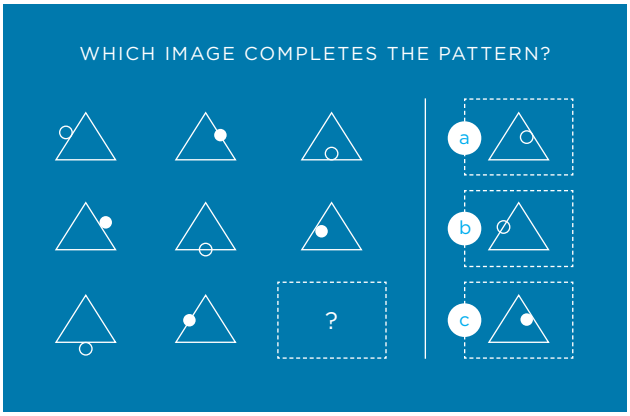
Above: These front and side images of the brain of a human participant in the study show the area in which brain metabolite levels were measured using a non-invasive imaging technique.

Right: The study tested participants' performance on a number of intelligence tests, with questions similar to this one, testing subjects' spatial reasoning.

A new study has begun to clarify how brain structure and chemistry give rise to specific aspects of "fluid intelligence," the ability to adapt to new situations and solve problems one has never encountered before. This work was supported by the Office of the Director of National Intelligence.

The research, reported in the journal *NeuroImage*, linked higher concentrations of a marker of energy production in the brain with an improved ability to solve verbal and spatial problems. It also found an association between brain size and number-related problem-solving.

The analysis involved 211 research subjects, making it the largest study to date linking brain chemistry and intelligence in living humans, said postdoctoral researcher Erick Paul, who led the work with research scientist Ryan Larsen and psychologist Aron Barbey (GNDP). The study tested participants' performance on a number of intelligence tests, with questions that tested subjects' spatial reasoning



by asking them to observe and mentally manipulate geometric shapes and patterns.

"Our findings contribute to a growing body of evidence to suggest that intelligence reflects multiple levels of organization in the brain—spanning neuroanatomy, for example brain size, and neurophysiology, such as brain metabolism—and that specific properties of the brain provide a powerful lens to investigate and understand the nature of specific intellectual abilities," Barbey said.

COMPGEN TEAM BUILDS ANCESTRAL TREES TO DETERMINE DISEASE-CAUSING GENETIC VARIANTS

go.igb.illinois.edu/DiseaseGenetics

Many of our most widespread diseases, such as diabetes, cancer, cardiovascular disease, and mental illness, are associated with variants in our genes. How do these variants, small differences in genome sequence, carry across generations, and how do they ultimately affect our health? Professor of Molecular and Integrative Physiology Derek Wildman (CGRH Theme Leader) and Associate Professor of Psychology Monica Uddin (CGRH) are trying to unlock the mystery.

Right: Monica Uddin, Associate Professor of Psychology.

REX GASKINS

Professor of Immunobiology, Departments of Animal Sciences and Pathobiology (RBTE)

Received a Distinguished Scientist Award from the Society for Experimental Biology and Medicine (SEBM). The SEBM was formed in 1903 to promote investigation in the biomedical sciences by encouraging and facilitating interchange of scientific information among disciplines with a strong focus on interdisciplinary research training and early career development.

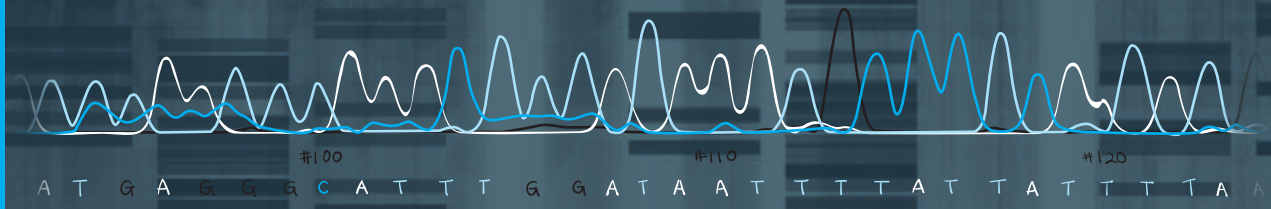
TING LU

Assistant Professor, Department of Bioengineering (BCXT/BSD/MME)

Named a 2017-2018 Center for Advanced Study (CAS) Beckman Fellow. He also received a National Science Foundation Faculty Early Career Development (CAREER) award to further his research on bacterial communities and the 2016 Young Investigator Award from the Office of Naval Research for his proposal "Developing Designer Probiotic Cocktails to Reduce Foodborne Illness among Warfighters."

I consider it like I have my own family and my academic family . . . I really love teaching people how to do research, and that includes undergrads, graduate students, postdocs. That's the most fun part of my job for me is working with students.

SUE SCHANTZ
BIOSCIENCES PROFESSOR (MME),
DIRECTOR, CHILDREN'S ENVIRONMENTAL
HEALTH RESEARCH CENTER



COMPGEN TEAM BUILDS ANCESTRAL TREES TO DETERMINE DISEASE-CAUSING GENETIC VARIANTS CONT.

Members of the molecular and integrative physiologist Derek Wildman's laboratory group.

Parsing out ancestry-related genomic variations requires some data crunching. To put the scale of the project in perspective, within each human genome there are 46 chromosomes, and a single chromosome can have millions of variants of interest. Variants can be passed down from generation to generation, creating a map of ancestral genomic history. Each of those variants may play a unique role in our health.

Using novel algorithms, researchers from CompGen, a collaborative computational genomics initiative between the Coordinated Science Laboratory and the IGB, are employing the supercomputing power of NCSA's Blue Waters to scan 2,500 human genomes originally sequenced by the 1000 Genomes Project to determine how variants transfer through ancestral ties. The work was funded by the University of Illinois.

"We're working to make better maps of ancestral and genomic history and to see the genetic landscape more accurately," said Wildman. "Ultimately, knowing what diseases you may be susceptible to, based on your genetics, means you can take action and make better-informed decisions about your health."

INTERDISCIPLINARY GROUP TO STUDY BRAIN HEALTH AS PART OF NIH BRAIN INITIATIVE

go.igb.illinois.edu/BRAIN

Biologist Martha Gillette (GNDP) and colleagues were awarded more than $2 million from the NIH BRAIN Initiative to develop an analytical platform that can lead to new developments in neuroscience and create diagnostic and therapeutic opportunities in treating neurological diseases.

"BRAIN awards are collaborative grants involving people from different disciplines and a lot of innovative technology," said Gillette. "This innovation award was possible because of the vigorous collaborative nature

SATISH NAIR

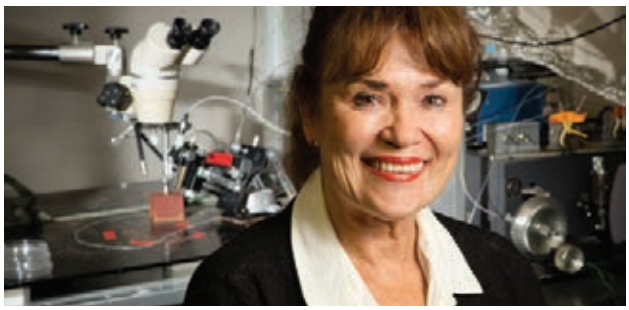
Professor, Biochemistry (MME/MMG)

Appointed to the I.C. Gunsalus Endowed Professorship in the College of Liberal Arts and Sciences.

INTERDISCIPLINARY GROUP TO STUDY BRAIN HEALTH AS PART OF NIH BRAIN INITIATIVE CONT.

of research at the Beckman Institute and the investigators' drive to interact beyond their usual disciplines. One of the exciting aspects is that students are attracted to working at the interface of neuroscience, chemistry, and engineering."

The three-year cross-disciplinary initiative, co-led by Director of the School of Chemical Sciences Jonathan Sweedler (BSD/MMG) and Bliss Faculty Scholar and Professor of Bioengineering Rohit Bhargava, will investigate molecular and chemical functions of the brain with advanced imaging techniques.



Martha Gillette, Alumni Professor of Cell and Developmental Biology.

GONE FISHIN' FOR NATURAL PRODUCTS, WITH A NEW DRAGNET

go.igb.illinois.edu/NPDragnet

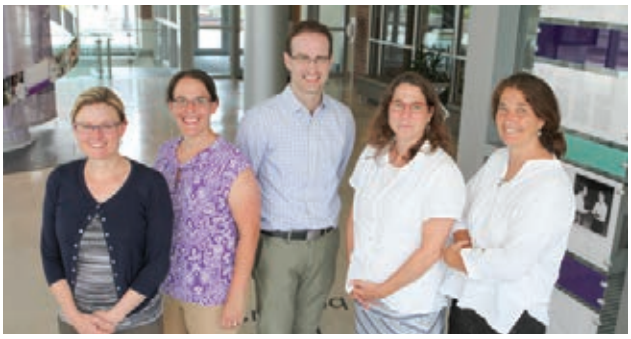
Nature contains a treasure trove of substances that could help fight human disease. A recent Nobel Prize in Physiology or Medicine honored the development of drugs based on such "natural products" that fight parasites and malaria. But finding these molecules and discovering new chemical identities is slow and painstaking work. Now, a team of researchers led by microbiologist Bill Metcalf (MMG Theme Leader) and Neil Kelleher (MMG), a chemistry professor at Northwestern University, have created a way to greatly speed up that process. Their work was reported in *ACS Central Science*.

Current methods for sussing out new molecules are much like casting a fishing line in a vast ocean. And once a compound is on the hook, there's still much more work to be done to find out what it looks like and, ideally, how it is made. Bacteria and other organisms make natural products using protein-based assembly lines; the genes that encode for them often cluster together in the genome, making them easier to recognize. Researchers surmised that if they evaluated the production of various natural products and compared those data to the presence or absence of each assembly line in the genome, they could determine which genes produced which natural products for many dozens of cases in parallel.

This work was funded by the NIH, Northwestern University and the University of Illinois.

IGB RECEIVES GRAND CHALLENGES EXPLORATIONS GRANT FOR GROUNDBREAKING RESEARCH IN GLOBAL HEALTH AND DEVELOPMENT

go.igb.illinois.edu/DrugResistanceSpread



The research team (from left): Associate Professor of Microbiology Joanna Shisler, Associate Professor of Pathobiology Rebecca Smith, Assistant Professor of Microbiology Patrick Degnan, Associate Professor of Microbiology Rachel Whitaker, and Professor of Anthropology Rebecca Stumpf.

Patrick Degnan (CGRH/MME), Assistant Professor of Microbiology, was awarded a Grand Challenges Exploration grant, an initiative funded through the Bill & Melinda Gates Foundation.

Degnan, in collaboration with Professor of Anthropology Rebecca Stumpf (BCXT/CGRH) and Associate Professor of Microbiology Rachel Whitaker (BCXT), will work to better understand how antimicrobial resistance (AMR) spreads in different environments by examining the flow of AMR genes in microorganisms between adjacent human and chimpanzee populations in eastern Africa. Their research will eventually allow for more targeted measures to slow the spread of AMR in human and agricultural pathogens.

"We can't just focus on human pathogens anymore. We can't just focus on animal pathogens or plant pathogens, but we have to think about infection biology as a whole," said Degnan. "To be able to understand how to stop transmission, we need to find out what transmission is, and our research is really geared towards that."

GENE ROBINSON

Director

Elected as Chair of the National Academy of Sciences Section 27, Evolutionary Biology. He also received the 2016 IBANGS Distinguished Investigator Award for the importance of his research discoveries and record of achievement in the area of behavioral and neural genetics.

WILFRED VAN DER DONK

Heckert Chair in Chemistry (MMG)

Received the 2017 Repligen Award in the Chemistry of Biological Processes from the Division of Biological Chemistry, American Chemical Society, in recognition of his contribution to understanding natural product biosynthesis.

NIH GRANT AWARDED TO STUDY SKIN VIRUS

go.igb.illinois.edu/SkinVirus

Associate Professor of Microbiology Joanna Shisler and graduate research assistant D. Brian Nichols display samples of poxvirus in cold storage.

Joanna Shisler (CGRH), Associate Professor of Microbiology, is the recipient of a new NIH grant focused on unraveling the mechanism of a common poxvirus with the ultimate goal of treating more deadly diseases. Shisler, together with Dr. Brian Ward from the University of Rochester, will use the grant to study the *molluscum contagiosum virus*. By developing a more detailed understanding of this virus and how it interacts with human cells, they hope to identify ways to help our innate immune responses fight not only viral infections, but also diseases such as cancer.

Molluscum contagiosum is usually a benign, mild skin disease characterized by lesions that may appear anywhere on the body. The disease typically resolves without scarring within a year, but in people with weakened immune systems (i.e., HIV-infected persons or persons being treated for cancer), these lesions can become much larger and persist indefinitely. Long-term effects include scarring and secondary infections caused by bacteria.

"Viruses are one of the most abundant microorganisms on the planet, infecting every form of life from humans to bacteria. However, these are the microbes that we understand the least. By understanding how viruses hijack the host cell, researchers can begin to answer fundamental questions about virology including how we can engineer new methods to detect and cure infectious viruses," said Shisler.

[In grade school] , we would go out into the yard. . .there was an ant colony which had a tiny hole in the ground, and I just sat there and watched it for hours. . .I remember wondering what they are doing. At that point, I didn't even know about ant trails, I noticed they made this line, and was just watching them, trying to figure out what was going on and knowing that I would not be able to figure it out. So I think I've always gravitated to patterns and things that are difficult to understand.

TIM GERNAT
GRADUATE STUDENT, COMPUTER SCIENCES
ROBINSON LAB (GNDP)

TECHNOLOGY

Biological foundries, nature-inspired nanomaterials, sequencers that translate molecules into code like a ticker tape machine—our technological research blends the evolved with the engineered, borrowing the best aspects of each. Ultimately, this work aims to create healthier living systems and stronger capabilities to explore the molecular world.

FOR FIRST NATIONS PEOPLES, EFFECTS OF EUROPEAN CONTACT ARE RECORDED IN THE GENOME

go.igb.illinois.edu/HistoricalGenomes

A genomic study of ancient indigenous remains and the present-day descendants of those peoples in British Columbia opened a new window on the catastrophic consequences of European colonization for indigenous peoples in that part of the world. Anthropology professor Ripan Malhi (CGRH/RBTE) and his colleagues found that in ancient populations, variants of an immune-related gene that were beneficial before European contact became disadvantageous once Europeans arrived.

"This is the first genome-wide study—where we have population-level data, not just a few individuals—that spans 6,000 years," said Malhi, who co-led the new research with former graduate student John Lindo (now a postdoctoral researcher at the University of Chicago) and Pennsylvania State University biology professor Michael DeGiorgio.

The research team included members and representatives of the Canadian aboriginal communities of the Lax Kw'alaams and Metlakatla First Nation, Coast Tsimshian people whose oral histories indicate they have lived in the region for millennia and were negatively impacted by the arrival of European diseases. Genomic results confirmed a steep population decline and found shifts in gene frequency among the ancestors of modern Coast Tsimshian that occurred roughly 175 years ago, about the time that European diseases such as smallpox, measles and tuberculosis were sweeping through North American native populations.

The work was reported in the journal *Nature Communications* and supported by the NSF, the Illinois Office of the Vice Chancellor for Research and the Eberly College of Science at Pennsylvania State University.

Above: Partners from Canada's northwest coast (from left, Barbara Petzelt, Harold Leighton, Bill Pahl, Wendy Pahl, Yvonne Ryan and Joycelynn Mitchell) collaborated with an international team of researchers on a genetic study of First Nations peoples—both present day and ancient. Below: Anthropology professor Ripan Malhi works with Native Americans and First Nations groups to analyze their DNA and that of their ancestors.

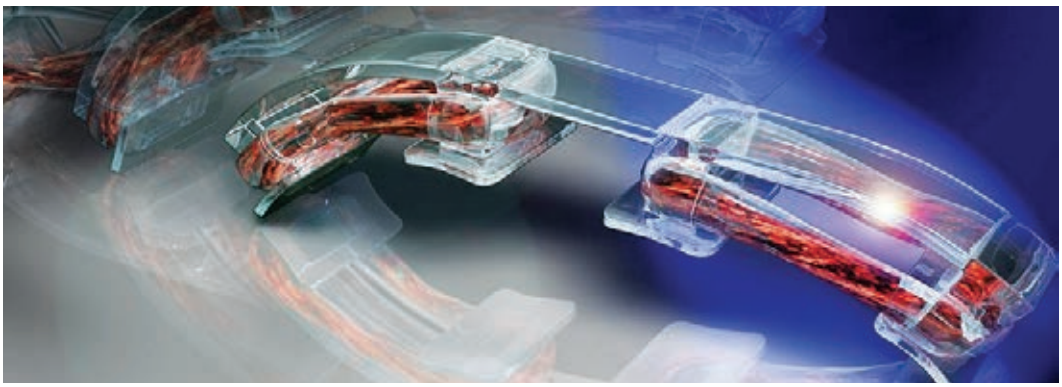
ANDREW ALLEYNE

Professor of Mechanical Science & Engineering (BSD)

Awarded the 2016 Charles Stark Draper Innovative Practice Award from the American Society of Mechanical Engineers.

Even Carl Woese didn't set out saying 'there must be a third domain of life,' he just started looking and decided 'oh, these ribosome sequences are weird, let's keep looking.' That kind of scientific-mindedness is the most important thing, not the need to find some specific thing but a willingness to just keep looking.

PAUL JENSEN
RESEARCH ASSISTANT PROFESSOR
DEPARTMENT OF BIOENGINEERING (MMG)



LIGHT ILLUMINATES THE WAY FOR BIO-BOTS

go.igb.illinois.edu/BioBots

Above: This new class of muscle-powered walking bio-bots responds to light and has a modular design. Below: Researchers at Illinois developed the miniature biological robots. Pictured from left: research assistant professor Parijat Sengupta, graduate student Caroline Cvetkovic, Bioengineering Department Head Rashid Bashir and graduate student Ritu Raman.

A new class of miniature biological robots, or bio-bots, can see the light—and are following where the light shines.

The bio-bots are powered by muscle cells that have been genetically engineered to respond to light, giving researchers control over the bots' motion, a key step toward their applied use. Led by Rashid Bashir (ONC-PM/RBTE), Bioengineering Department Head and Abel Bliss Professor of Engineering, the researchers published their results in *Proceedings of the National Academy of Sciences*. This work was part of the Emergent Behaviors of Integrated Cellular Systems (EBICS) project funded by the NSF.

"Light is a noninvasive way to control these machines," Bashir said. "It gives us flexibility in the design and the motion. The bottom line of what we are trying to accomplish is the forward design of biological systems, and we think the light control is an important step toward that."

Bashir's group previously demonstrated bio-bots that were activated with an electrical field, but electricity can cause adverse side effects to a biological environment and does not allow for selective stimulation of distinct regions of muscle to steer the bio-bot, Bashir said. The new light-stimulation technique is less invasive and allows the researchers to steer the bio-bots in different directions. The bio-bots turn and walk toward the light stimulus, Bashir said.

RASHID BASHIR

Bioengineering Professor and Department Head (RBTE)

Named as the first Grainger Distinguished Chair in Engineering.

STEPHEN A. BOPPART

Abel Bliss Professor of Engineering (RBTE)

Received the 2016 Technical Achievement Award from the Institute of Electrical and Electronics Engineers (IEEE) Engineering in Medicine and Biology Society.

SOMETHING NEW UNDER THE ARIZONA SUN: A ROBOTIC REVOLUTION IN PLANT BREEDING

go.igb.illinois.edu/TERRAbot

On a bright, hot June day in Arizona, a vehicle the size of a Golden Retriever, designed and constructed at the IGB, rolled on miniature tank treads between two rows of young plants. A group of researchers, policymakers, and farmers gathered to see the early fruits of an unusual hybridization in modern agriculture: a crop of semi-autonomous robots designed to monitor

Above: Researchers have developed the TERRA-MEPP robot as a low-cost way to monitor biofuel crops throughout the growing season. The robot treks between rows of crops evaluating the plants on each side simultaneously.

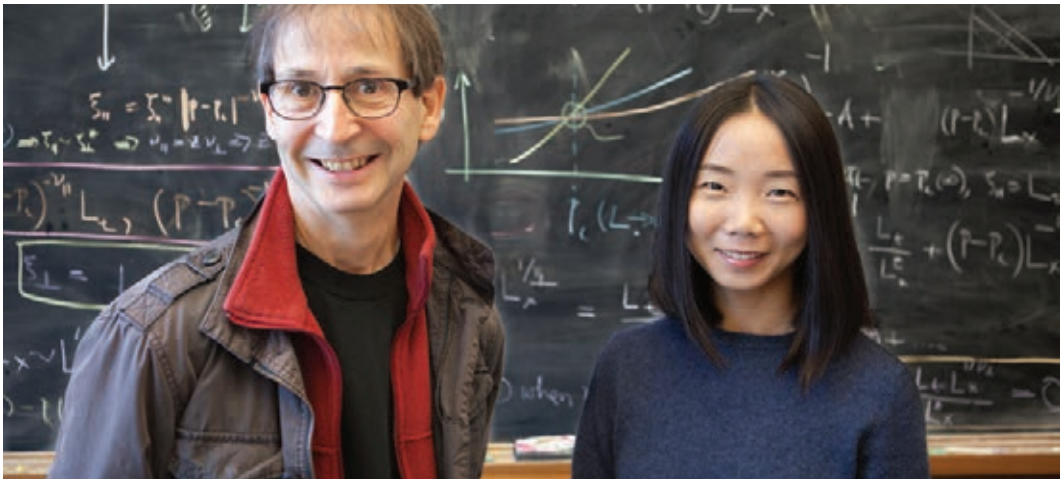
the growth of sorghum and other crops, born of a cross between plant biology and engineering.

Researchers from IGB, among many others, demonstrated prototypes of several crop-monitoring systems during a day-long event at Arizona's Maricopa Agricultural Center. Development of the rover was supported by the Transportation Energy Resources from Renewable Agriculture (TERRA) program within the DOE's Advanced Research Projects Agency-Energy (ARPA-E).

The TERRA-Mobile Energy-Crop Phenotyping Platform (MEPP) robot is based on autonomous rovers that search for accident victims in collapsed buildings and other confined, hazardous spaces. Team members are modifying this robust base to include miniature sensors that will quantify key aspects of plants and the growing environment.

These data from the sensors will be used to create a 3D reconstruction of each plant in order to estimate biomass yield. An analytical pipeline will associate these data with genome sequence information to identify high-yielding combinations of bioenergy plant lines, environmental conditions, and management practices.

TERRA-MEPP is the work of a team of researchers from IGB, Cornell University, and Signetron Incorporated, directed by Gutgsell Endowed University Professor of Crop Sciences and Plant Biology Stephen Long (BSD/EBI/GEGC). Associate Professor of Plant Biology Carl Bernacchi (EBI/GEGC) is a co-director.



SLOW MOTION WAVES OF JUMPING GENES IN THE HUMAN GENOME

go.igb.illinois.edu/GeneWaves

Above: Physicists Nigel Goldenfeld (left) and Chi Xue have made detailed predictions about an intriguing mechanism of genomic evolution.

Nature is full of parasites—organisms that flourish and proliferate at the expense of another species. Surprisingly, these same competing roles of parasite and host can be found in the microscopic molecular world of the cell. A new study by physicists Chi Xue and Nigel Goldenfeld (BCXT Theme Leader/CGRH/GNDP) has demonstrated that dynamic elements within the human genome interact with each other in a way that strongly resembles the patterns seen in populations of predators and prey.

The findings, published in *Physical Review Letters* and supported by NASA and the NSF, are an important step toward understanding the complex ways that genomes change over the lifetime of individual organisms, and how they evolve over generations. Goldenfeld and Xue embarked on this work because of their interest in transposons, small regions of DNA that can move from one part of the genome to another during the lifetime of

JIANJUN CHENG

Professor, Materials Science and Engineering (RBTE)

Elected a 2016 Fellow of the American Association for the Advancement of Science.

SLOW MOTION WAVES OF JUMPING GENES IN THE HUMAN GENOME CONT.

a cell—a capability that has earned them the name "jumping genes."

Some transposons cannot jump on their own, and instead can only steal spots from others. Xue and Goldenfeld's results predicted that these competing populations of jumping genes are expected to oscillate. Too many "parasitic" elements, and their "hosts" start to suffer, and soon there are not enough to exploit. The parasites start to suffer, and their hosts make a comeback.

Their model made the additional, surprising prediction that these oscillations occur over a timescale that is longer than the human lifespan—waves of transposons pushing and pulling at each other in slow motion across generations of the human genomes that carry them.

ILLINOIS AND SYNGENTA SIGN AGREEMENT FOR ACCESS TO RIPE INTELLECTUAL PROPERTY

go.igb.illinois.edu/RIPEIP

Illinois and Syngenta Crop Protection, LLC, have signed an agreement to implement a commercialization strategy for intellectual property developed under the "RIPE: Realizing Increased Photosynthetic Efficiency for Sustainable Increases in Crop Yield" project, which is funded by the Bill & Melinda Gates Foundation. RIPE researchers at the IGB are collaborating with seven other institutions to improve photosynthetic efficiency in food crops in an effort to help resource-poor farmers increase their sustainable yields.

The Illinois and Syngenta collaborative partnership brings leading academic groups studying photosynthesis together with a major agriculture industry partner to evaluate and advance the technologies developed by the RIPE project. Syngenta will serve as a commercialization

BRENDAN HARLEY

Associate Professor, Chemical & Biomolecular Engineering (RBTE Theme Leader)

Selected to participate in the National Academy of Engineering's 22nd annual U.S. Frontiers of Engineering symposium.

IWONA JASIUK

Professor, Mechanical Science and Engineering (RBTE)

Named the recipient of the 2016 American Advanced Materials Award from the International Association of Advanced Materials. She was also named a 2017-18 Center for Advanced Study (CAS) Associate.

Being open to other people's ideas, getting to know people outside of your field, that's what makes really impactful research . . . I love the interdisciplinary nature of science at the IGB—I work with experts in their fields who are still open to learning about new things, and it lets us do totally paradigm-shifting research.

JESSICA SAW
GRADUATE STUDENT, MOLECULAR AND INTEGRATIVE PHYSIOLOGY
WILDMAN LAB (CGRH)

ILLINOIS AND SYNGENTA SIGN AGREEMENT FOR ACCESS TO RIPE INTELLECTUAL PROPERTY CONT.

partner by providing research materials and facilities to support RIPE project goals, as well as bringing an industry perspective for bridging key, fundamental photosynthetic research to commercial product development.

The collaboration is the first of its kind for a Gates Foundation-funded project. It will ensure that products, technologies, and services are promptly and broadly distributed to developing nations while reserving potential IP rights in developed countries.

MOVEMENT ANALYSIS APP DETECTS LUNG DISEASE SEVERITY

go.igb.illinois.edu/GaitApp

Nearly 16 million Americans are afflicted with chronic obstructive pulmonary disease (COPD), a progressive disease in which the lungs gradually lose their ability to pump enough oxygen to the rest of the body. Under the direction of Professor of Medical Information Science Bruce Schatz (CGRH), a team of scientists is developing mobile technology that can accurately monitor COPD patients' symptoms through smartphones that they carry in their pockets.

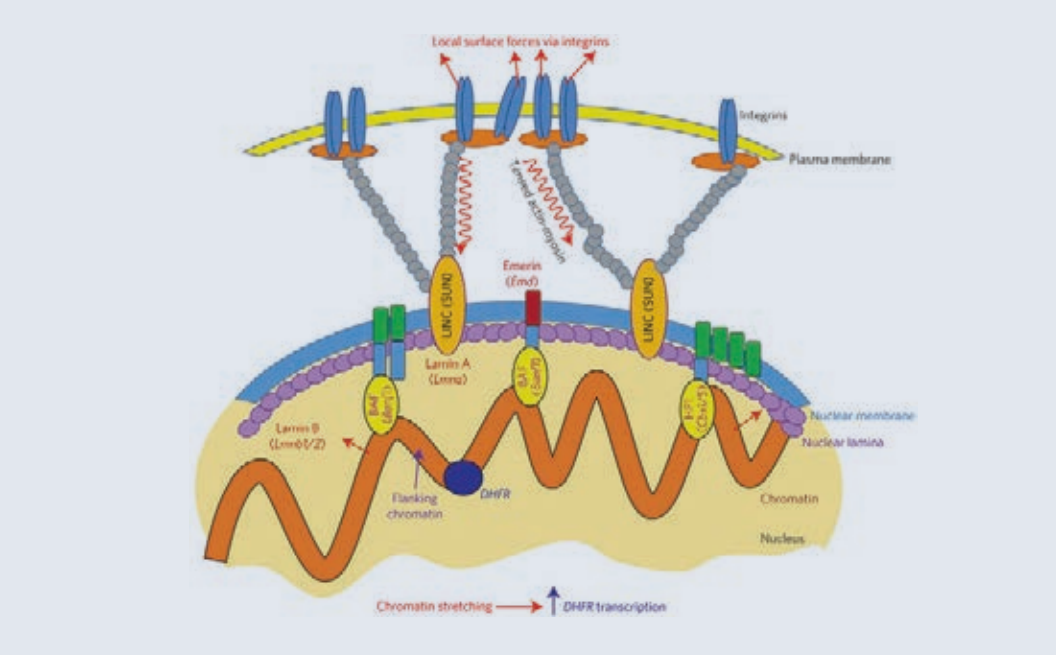
Qian Cheng, a computer science graduate student, led development of software that uses only the phone sensors to estimate several measures of the health condition of COPD patients. The group's model predicted with perfect accuracy the severity of each patient's disease: mild, moderate, severe, or more severe. A description of the system was published in *Telemedicine and e-Health.*

Cheng received a $10,000 award as a top 10 finalist in the annual Student Technology Prize for Primary Healthcare, administered by Massachusetts General Hospital associated with Harvard University (formerly known as the CIMIT Prize). He used the prize money to further develop and test his app as patients carried the smartphone in their pocket during everyday activity at home. This passive monitoring requires nothing special from the patient, yet the model predicts their status with clinical accuracy. The software development effort was also funded by the Regional College of Medicine and the USDA.

RUBY MENDENHALL

Associate Professor in Sociology, African American Studies, Urban and Regional Planning, and Social Work (CGRH/GNDP)

Received an Innovation Excellence Award from the International Data Corporation (IDC), which recognizes noteworthy achievements by users of high performance computing technologies.



FORCE TRIGGERS GENE EXPRESSION BY STRETCHING CHROMATIN

go.igb.illinois.edu/ChromatinForce

Above: When a cell's surface experiences a pulling force, molecules inside the cell transfer that force to the DNA inside, resulting in changes in gene activity. This diagram shows the positions and names of the molecules involved.

The translation of the DNA sequence of our genes into physical traits within a cell is a complicated dance among many chemical players. However, an NIH-funded collaboration between IGB researchers and colleagues in China has demonstrated that external mechanical force can directly regulate gene expression, one of the first steps in this molecular choreography.

Identifying the ways in which mechanical forces send cellular signals and cause genes to change their expression—that is, how much protein each one produces—has applications not only in fundamental cell biology, but also for cancer, stem cells and regenerative medicine, said mechanical science and engineering professor Ning Wang (RBTE), who led the study with cell and developmental biology professor Andrew Belmont (BSD). The researchers published their work in the journal *Nature Materials*.

"Each cell in your body has the same DNA, but tissues behave very differently because genes are expressed differently," Wang said. "There is so much we don't know about gene expression. I think this work is the beginning to unravel some of the unknowns."

The researchers stuck tiny magnetic beads to proteins attached to the external membranes of cells. They were able to change the direction and angle of the force the beads exerted while maintaining a consistent magnitude of the force, and track the path of the force through the cell to DNA deep inside. They found an increase in expression of the genes in regions of DNA that were stretched by the force.

GENOME-EDITING PROTEINS RIDE A DNA ZIP LINE

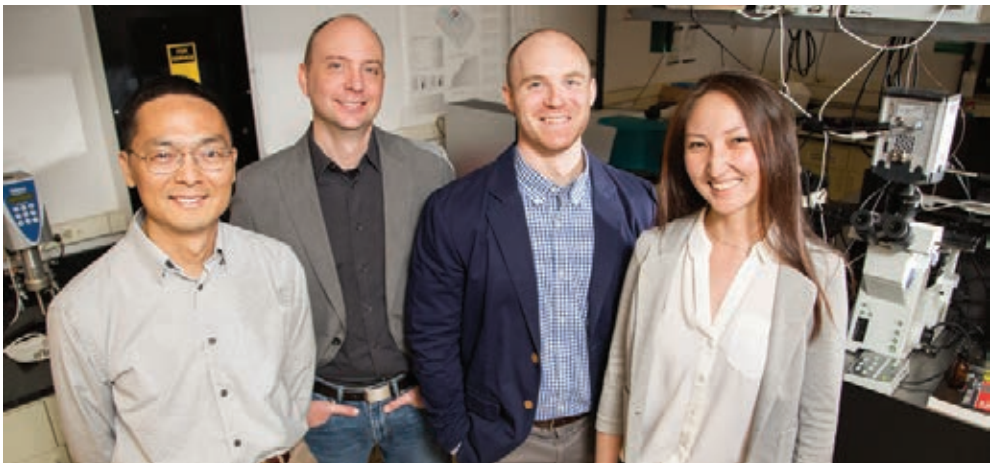
go.igb.illinois.edu/DNAZipLine

How can gene-editing proteins find the one specific site they're supposed to edit in the vastness of the human genome, which is 3 billion "letters" long?

Steven L. Miller Chair in Chemical Engineering Huimin Zhao (BSD Theme Leader/EBI/MMG) and Ray and Beverly Mentzer Faculty Scholar in Chemical and Biomolecular Engineering Charles Schroeder (BSD), along with graduate students Luke Cuculis and Zhanar Abil, have demonstrated that a class of genome-editing proteins called transcription activator-like effectors (TALEs) solves this problem by rapidly traveling along a strand of DNA like a rider on a zip line—a unique behavior among documented DNA-binding proteins.

"We uncovered a new search process for DNA-binding proteins that doesn't fit into previous binding classifications," said Cuculis, now a consultant at the Boston Consulting Group. "We performed several experiments to test these theories, and the results were unexpected based on current thinking about how proteins move along DNA in search of a target site or gene."

The unusual mechanism could hold advantages for researchers looking to develop TALE proteins for new biomedical applications, Cuculis said. The IGB and the David and Lucile Packard Foundation supported this work, which was published in *Nature Chemical Biology.*



From left: Illinois chemical and biomolecular engineering professors Huimin Zhao and Charles Schroeder, along with graduate students Luke Cuculis and Zhanar Abil, published their work in the journal Nature Chemical Biology.

AMY J. WAGONER JOHNSON

Associate Professor, Mechanical Science and Engineering (RBTE)

Named a 2017-18 Center for Advanced Study (CAS) Associate.

NEW CENTER INNOVATES COMPUTING SOLUTIONS TO LARGE-SCALE GENOMIC PROBLEMS

go.igb.illinois.edu/CCBGM

The human genome consists of three billion nucleotide "letters" that, when strung together, offer a glimpse into the basic processes of life and risk for disease. However, breakthroughs in the use of this genomic information have been limited because it is difficult to quickly and accurately analyze the large volumes of genomic data we can now generate.

Illinois is leading the development of a center that will address this challenge by establishing a platform to handle genomic data for a wide variety of applications. Working with colleagues at Mayo Clinic, researchers in the Center for Computational Biotechnology and Genomic Medicine (CCBGM) are advancing pressing societal issues, such as enabling patient-specific treatment of cancer and other diseases or understanding and modifying microbial communities related to human health and agriculture.

The center is funded for five years through the NSF's Industry-University Cooperative Research Centers (IUCRC) program. The center researchers also will collaborate with colleagues at the University of Chicago. As an IUCRC, industry will also play a large role in work within the center.

"The big picture goal is to apply computational genomics across the life sciences industry, but currently it's challenged by our inability to generate, interpret, and apply genomic data quickly, efficiently, and accurately," said Ravi Iyer (CGRH), principal investigator and the George and Ann Fisher Distinguished Professor of Engineering. "The amount of data is increasing at such a rapid rate that our ability to apply computing to a wide range of genomic problems is still very limited."

WATCHING 'JUMPING GENES' IN ACTION: REAL-TIME OBSERVATION OF TRANSPOSON ACTIVITY IN LIVING CELLS

go.igb.illinois.edu/RealTimeTransposons

"Jumping genes" are ubiquitous. Every domain of life hosts transposons, which are sequences of DNA that can move themselves from one position to another along a chromosome. In fact, nearly half the human genome is made up of transposons.

As reported in the *Proceedings of the National Academy of Sciences*, physics professors Thomas Kuhlman (BCXT) and Nigel Goldenfeld (BCXT Theme Leader/CGRH/GNDP) and their colleagues have observed jumping gene activity in real time within living cells. The study is the collaborative effort at the Center for the Physics of Living Cells, an NSF Physics Frontiers Center, and the NASA IUB housed within the IGB.

To observe these individual cellular-evolution events in living cells, the research team devised a synthetic biological system using the bacterium *Escherichia coli.* The scientists genetically coupled the production of blue

WATCHING 'JUMPING GENES' IN ACTION: REAL-TIME OBSERVATION OF TRANSPOSON ACTIVITY IN LIVING CELLS CONT.

and yellow fluorescent proteins to the jumping activity of the transposons.

"We hooked that activity up to a molecular system, such that when they start hopping around, the whole cell fluoresces. In our experiment, cells fluoresced most when they weren't very happy," said Kuhlman. "A increased mutation rate [caused by transposon movement] might be an advantage in such unhappy conditions, for cells to diversify."

GLOBAL BIOFOUNDRY CONSORTIUM EMBRACES GRAND CHALLENGE OF SYNTHETIC BIOLOGY

go.igb.illinois.edu/GlobalBiofoundry

Synthetic biology has emerged from the intersection of engineering and biology, with an emphasis on standardization, modularization and automation. The newly established Global Biofoundry Consortium, led by Steven L. Miller Chair Professor of Chemical and Biomolecular Engineering Huimin Zhao (BSD Theme Leader/EBI/MMG), is investing in the systematized approach of engineering to touch off the next wave of biological discovery and innovation.

The consortium, whose founding members include the University of Illinois, Boston University, the University of Manchester, Tianjin University, the Tianjin Institute of Industrial Biotechnology of Chinese Academy of Sciences, and corporate partner Thermo Fisher Scientific, held its inaugural meeting on April 15, 2016. Participants gathered at the IGB to develop a strategic plan to achieve the consortium's central aim: to develop biofoundries for accelerated biological engineering and fundamental research.

Biological foundries like the one Zhao and his colleagues have established within the IGB combine cutting-edge robotics, standardized parts and protocols, and computational methods. The resulting experimental platform makes it possible to perform automated engineering at the DNA, protein, pathway and genome levels on a massive scale.

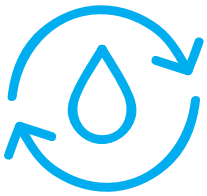
HUIMIN ZHAO

Centennial Endowed Chair Professor of Chemical and Biomolecular Engineering (BSD)

Received the 2016 Charles Thom Award, recognizing exceptional merit in industrial microbiology and biotechnology, independence of thought, and originality that added appreciably to scientific knowledge. He was also selected by the University of Illinois as the Steven L. Miller Chair in Chemical Engineering.

What matters most is intellectual curiosity: you become interested in something, and you just keep asking 'why?' until you find some satisfying answer, something new.

WILL MONTGOMERY
POSTDOCTORAL RESEARCHER, CHEMISTRY
IGB FELLOW (ACPP)



ENVIRONMENT

Our environment might include forest, plains, a river or ocean, an arid, temperate or tropical climate; it also includes farmlands and factories, social groups, and the communities of microbes that live on or under our skin. Research at our Institute that examines how genomics can be used to boost our food supply, conserve natural resources, understand how other species interact with us and with each other, and prepare for future climate change all falls in this broad category.

DESERT ELEPHANTS PASS ON KNOWLEDGE —NOT MUTATIONS— TO SURVIVE

go.igb.illinois.edu/ElephantLearning

Research led by Professor of Animal Sciences Alfred Roca (CGRH/GNDP) evaluated the nuclear DNA and mitochondrial DNA of both desert-dwelling and non-desert-dwelling elephant populations throughout Namibia, revealing that the two groups are not so genetically different: their unique behaviors are learned, not inherited.

"The ability of species such as elephants to learn and change their behavior means that genetic changes are not critical for them to adapt to a new environment," Roca said. "The behavioral changes can allow species to expand their range to novel marginal habitats that differ sharply from the core habitat."

Namibian desert-dwelling elephants are a critical species to understand and protect due in part to their environmental contributions, including their role in creating paths and digging watering holes that benefit other species. They have learned to prevent overheating in triple-digit temperatures by covering their bodies with sand wetted by their urine or water regurgitated from a specialized pouch beneath their tongue, a behavior that is passed from one generation to the next. They are also able to remember the location of scarce water and food resources across their home ranges, which are unusually large compared to those of other elephants.

The research, published in *Ecology and Evolution*, was supported by a U.S. Fish and Wildlife Service African Elephant Conservation Fund Grant.

Namibian elephants are an important species to conserve as their ability to thrive in a desert environment facilitates the survival of other species in arid habitats.

RESEARCHERS FIND CULTURAL VARIATIONS PRODUCE DIFFERENCES IN GUT MICROBIOME

go.igb.illinois.edu/GutBiomeDiet

*Gozo, bitter manioc root (top) and Koko leaves (bottom) (*Gnetum africanum*) in peanut sauce, two staple foods in the region.*

Our growing understanding of human microbiomes, the communities of microscopic living things that thrive inside our bodies and contribute to our physiological functions, has reinforced the idea that you are what you eat.

A new publication in *Cell Reports* compared the gut microbiomes of two neighboring societies from the Central African Republic: a hunter-gatherer society and a farming society with access to Westernized foods. These two types of microbiomes were also compared with that of a typical Western society.

The findings suggested that characteristics of diet may influence microbial community composition more strongly than geographic or other cultural factors; traits of the species that make up microbiomes, including the ability to digest fibrous material, are correlated with diet.

Andres Gomez, first author and microbial ecologist and staff scientist at the J. Craig Venter Institute in California, published the findings with colleagues including Illinois Professor of Animal Sciences Rex Gaskins (RBTE), Professor of Microbiology Brenda Wilson (MMG), Professor of Anthropology Rebecca Stumpf (BCXT/CGRH), Professor of Animal Sciences Bryan White (BCXT/CGRH), and Adjunct Professor of Anthropology Steven Leigh. Their findings could further support the understanding of the impact of diet and lifestyle in relation to metabolic and colonic disorders.

This work was funded by the NSF, the Czech Science Foundation, and the University of Minnesota College of Biological Sciences.

LISA AINSWORTH
Associate Professor of Plant Biology, Adjunct Assistant Professor of Crop Sciences (GEGC)

STEPHEN LONG
Gutgsell Endowed University Professor of Crop Sciences and Plant Biology (BSD/EBI/GEGC)

YI LU
Jay and Ann Schenck Professor of Chemistry (BSD/ONC-PM)

DONALD ORT
Robert Emerson Professor of Plant Biology and Crop Sciences (GEGC Theme Leader)

BRENT ROBERTS
Professor of Psychology (GNDP)

Named to the Clarivate Analytics Highly Cited Researchers list for 2016 (previously known as the Thomson Reuters Highly Cited Researchers list).

Agriculture is so common
that many people don't appreciate
the complex science that goes into
improving crops and balancing soil nutrients.
Agriculture uses nature to feed people:
as humans we have a responsibility to be
good stewards of our environment, and as
scientists we can discover and teach the best
ways to feed ourselves while preserving
our ecosystems. Pairing agriculture
with climate change research lets
me work at the forefront of science
in our changing world.

ILSA KANTOLA
POSTDOCTORAL RESEARCHER, RANGELAND ECOLOGY (GEGC)

ENDANGERED VENOMOUS MAMMAL PREDATES DINOSAURS' EXTINCTION, STUDY CONFIRMS

go.igb.illinois.edu/VenomousMammal

Researchers at Illinois and the University of Puerto Rico have completely sequenced the mitochondrial genome for the *Hispaniolan solenodon*, filling in the last major branch of placental mammals on the tree of life.

The study, led by Professor of Animal Sciences Alfred Roca (CGRH/GNDP) and published in *Mitochondrial DNA*, confirmed that the venomous mammal diverged from all other living mammals 78 million years ago, long before an asteroid wiped out the dinosaurs.

"It's just impressive it's survived this long," said co-first author Adam Brandt, a postdoctoral researcher at Illinois. "It survived the asteroid; it survived human colonization and the rats and mice humans brought with them that wiped out the solenodon's closest relatives."

Brandt and co-first author Kirill Grigorev, a bioinformatician at the Caribbean Genome Center, analyzed samples using two different methods to determine the sequence of the solenodon's mitochondrial genome. Rather than representing a remix of both parents' genes, mitochondrial DNA is passed down only through the maternal line, making evolutionary relationships easier to trace.

The Dominican Republic made this study possible by supporting the collection of samples. Funding was provided by the Russian Ministry of Science.

ZooDom veterinarian Adrell Núñez (center) draws blood from a solenodon for DNA samples. Pictured from left to right: Nicolas De J. Corona, Adrell Núñez, Taras K. Oleksyk, and Yimell Corona.

SCIENTISTS TWEAK PHOTOSYNTHESIS TO BOOST CROP YIELD

go.igb.illinois.edu/BoostCropYield

To fight for future food security, plant biologist Stephen Long (BSD/EBI/GEGC) has set out to do what millennia of evolution have not: optimize the efficiency of photosynthesis in order to increase plant yield.

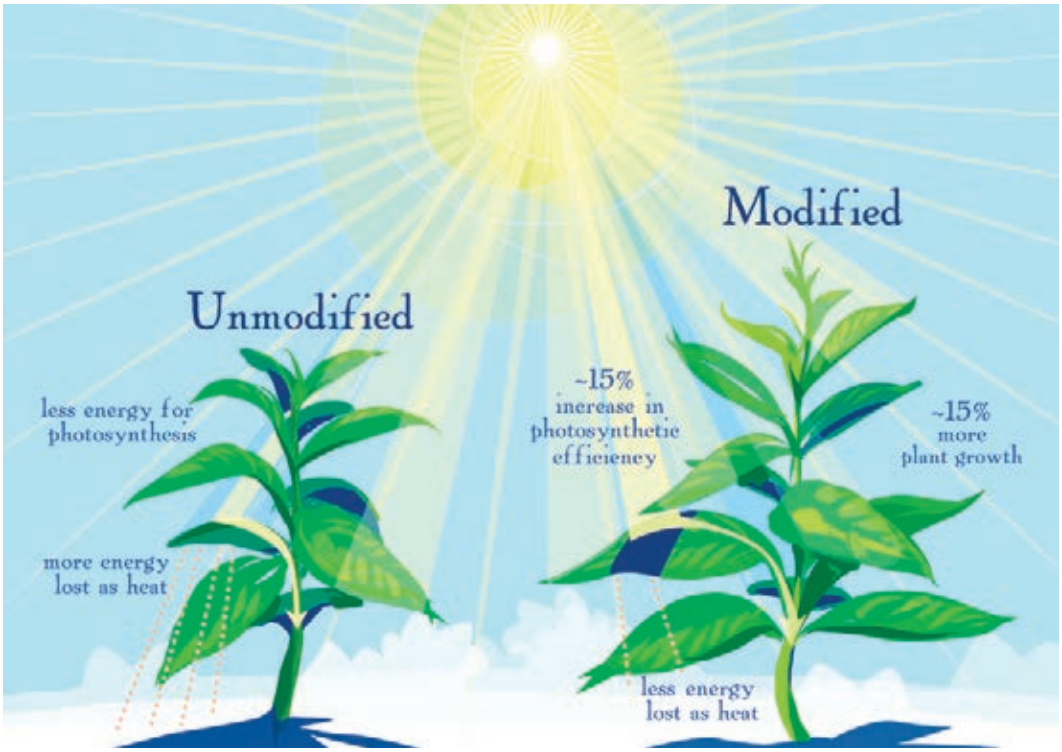
Above: Stephen Long, a professor of crop sciences and of plant biology (center) with postdoctoral researchers Johannes Kromdijk (left) and Katarzyna Glowacka, increased plant yield by altering a mechanism plants use to protect themselves from excess solar energy. Below: As computer models predicted, genetically modified plants are better able to make use of the limited sunlight available when their leaves are shaded, researchers report.

Researchers reported in *Science* that they can increase plant productivity by boosting levels of three proteins involved in photosynthesis. In field trials, the scientists saw increases of 14 to 20 percent in the growth of their modified tobacco plants.

To test their concept, the team inserted a "cassette" of three genes taken from the model plant *Arabidopsis* into tobacco. Many years of computational analysis and laboratory and field experiments led to the selection of the genes targeted in the study. "Now we can do this genetically, and we are actively working on repeating our work in various food crops," said Long.

"The United Nations predicts that by 2050 we're going to need to produce about 70 percent more food on the land we're currently using," said Long, who led the study with postdoctoral researchers Katarzyna Glowacka and Johannes Kromdijk. "My attitude is that it is very important to have these new technologies on the shelf now because it can take 20 years before such inventions can reach farmer's fields. If we don't do it now, we won't have this solution when we need it."

The Bill & Melinda Gates Foundation funded this research with the stipulation that any new agricultural products that result from the work be licensed in such a way that the technology is freely available to farmers in the developing nations of Africa and South Asia.



SOYBEAN PLANTS WITH FEWER LEAVES YIELD MORE

go.igb.illinois.edu/FewerLeaves

Above: Researchers manually cut off new leaflets to decrease leaf area by just five percent and increased yields by eight percent. Below: Colonel Harry F. and Frankie M. Lovell Endowed Professor of Civil and Environmental Engineering Praveen Kumar and Gutgsell Endowed Professor of Crop Sciences and Plant Biology Stephen Long

Using computer simulations, scientists have predicted that modern soybean crops produce more leaves than they need, to the detriment of yield—a problem made worse by rising atmospheric carbon dioxide.

The project was led by Praveen Kumar, Lovell Professor of Civil and Environmental Engineering, and Stephen Long (BSD/EBI/GEGC), Gutsgell Endowed Professor of Plant Biology and Crop Sciences. Their paper, published in *Global Change Biology*, found that soybean plants produce too many leaves, most of which are shaded and inefficient and whose growth therefore wastes resources including water, carbon and nitrogen.

The research team tested their prediction by removing about one third of the emerging leaves on soybeans and found an 8 percent increase in seed yield in replicated trials. The team attributed this boost in yield to increased photosynthesis, decreased respiration, and diversion of resources that would have been invested in leaves rather than seeds.

Next, researchers plan to bioengineer plants or search for varieties that naturally have fewer leaves to test these preliminary findings on a larger scale.

Funding from NSF and the Bill & Melinda Gates Foundation supported this research.

FUTURE DROUGHT WILL OFFSET BENEFITS OF HIGHER CO_2 ON SOYBEAN YIELDS

go.igb.illinois.edu/FutureDrought

How will crops respond to the altered climatic conditions expected to appear by 2050? An eight-year study that exposed crops to such conditions has yielded a new and worrisome finding: higher atmospheric CO_2 concentrations will boost plant growth under ideal growing conditions, but drought—expected to worsen as the climate warms and rainfall patterns change—

will outweigh those benefits and cause yield losses much sooner than anticipated.

The new discovery, reported in the journal *Nature Plants*, contradicts a widely accepted hypothesis about how climate change will affect food production, said Associate Professor of Plant Biology Andrew Leakey (EBI/GEGC), who led the research. IGB received funding for this research from the USDA and the DOE, along with a generous gift from David Sigman.

"All of the model predictions up to this point were assuming that in 2050, elevated CO_2 was going to give us a 15 percent increase in yield over what we had at the beginning of this century," he said. "And what we're seeing is that as it gets hotter and drier, that number diminishes to zero. No gain."

GRANT HELPS PROJECT REALIZE 'ULTRA-PRODUCTIVE' BIOFUEL CROPS, ATTRACT INVESTORS

go.igb.illinois.edu/UltraproductiveBiofuel

Imagine, instead of acres of oil wells on barren land, endless fields of towering green sugarcane, with each stalk producing renewable and sustainable biofuel.

The University of Illinois and the University of Florida have been awarded a third round of funding from the DOE's Advanced Research Projects Agency-Energy (ARPA-E) to realize that end, by ultra-productive biofuel crops. Nearly $300,000 of additional funds will sustain the ongoing research project called Plants Engineered To Replace Oil in Sugarcane and Sweet Sorghum (PETROSS) for another year while it seeks additional investors and commercial partners.

With ARPA-E's continued funding, the project will work to further increase yields and improve cold tolerance to expand the growing region of sugarcane, which is currently limited to small regions in Florida, Louisiana and Texas.

"Our research project is on a trajectory to produce sugarcane that could give the U.S. an inexhaustible and environmentally friendly oil supply that could satisfy

MADHU KHANNA

Professor of Agricultural and Consumer Economics (EBI)

Named a Fellow of the American Applied Economics Association. She was also selected as one of five Agricultural & Applied Economics Association (AAEA) 2016 Fellows, which are recognized for their continuous contribution to the advancement of agricultural or applied economics via research, teaching, extension, and other contributions to public or private sector decision-making.

I think fieldwork is what I like the most, just being outside and catching animals and studying them in nature, not only in the lab. And I'm also from the Montagne originally, so I used to be a skier in competitions, I really wanted to keep the adventurous side also in my research.

ALEXA SADIER
POSTDOCTORAL RESEARCHER, ANIMAL BIOLOGY
SEARS LAB (RBTE)

GRANT HELPS PROJECT REALIZE 'ULTRA-PRODUCTIVE' BIOFUEL CROPS, ATTRACT INVESTORS CONT.

one quarter of the nation's fuel and provide a renewable source of jet fuel," said Project Director Stephen Long (BSD/EBI/GEGC), Gutgsell Endowed Professor of Crop Sciences and Plant Biology. "These crops could be grown in areas of the Southeast that can no longer produce food crops, giving the region a much needed economic boost."

GIANT REED IS A PHOTOSYNTHETIC OUTLIER, STUDY FINDS

go.igb.illinois.edu/GiantReed

Arundo donax, *also known as giant reed, grows abundantly in the Mediterranean climate zones of the world.*

Arundo donax, a giant reed that grows in Mediterranean climate zones, is not like other prolific warm-weather grasses, researchers report. This grass, which can grow annually to six meters (nearly 20 feet) in height, uses a type of photosynthesis that is more common in crop plants like soybeans, rice and peanuts.

"Most highly productive grasses, like sugarcane, miscanthus and switchgrass, use this type of photosynthesis called C4, which we know to be very efficient," said study leader Stephen Long (BSD/EBI/GEGC), Gutsgell Endowed Professor of Crop Sciences and Plant Biology. "We confirmed that giant reed uses C3, a less efficient type of photosynthesis, and yet it's really productive. We just had to find out how."

Despite questions about its invasive tendencies, *Arundo donax* attracted attention as a potential bioenergy crop due to its high productivity. The new findings, published in *Scientific Reports*, could help scientists improve C3 photosynthesis in other plants and shed light on the cellular underpinnings of the grass' production of biomass.

The research was supported by a Natural Environment Research Council Advanced training award, the British Ecology Society and the *Journal of Experimental Botany.*

BIODIESEL FROM SUGARCANE MORE ECONOMICAL THAN SOYBEAN

go.igb.illinois.edu/Oilcane

Sugarcane, a traditional food source, is now being developed by researchers as a promising biofuel crop.

In 2007, Congress mandated a move away from petroleum-based oils toward more renewable sources, designed to reduce America's unsustainable rate of oil consumption. Soybeans are the current primary source of plant-based oils used for biodiesel production, and the plant many turned to to meet Congress' renewable fuel standards. However, soy only yields about one barrel per acre, far beneath what will be required to make up our energy deficit.

To address this issue, the DOE's Advanced Research Projects Agency-Energy (ARPA-E) program called for high-risk, high-reward projects that could develop new drop-in fuels. A team led by Gutsgell Endowed Professor of Crop Sciences and Plant Biology Stephen Long (BSD/EBI/GEGC) answered the call by engineering sugarcane that produces large quantities of oil, a new crop Long's group calls "oilcane."

Their most recent study, funded by the ARPA-E program and published in *Biofpr,* demonstrated the economic benefits of this technology relative to soybean oil. The analysis suggested that oilcane with 20 percent oil in the stem, grown on under-utilized acres in the southeastern United States, could replace more than two-thirds of the country's use of diesel and jet fuel.

"We need to start building for a future when gas is no longer as low as $1.50 per gallon, and we need to avoid any future dependency on other countries for our oil," said Long. "We are lucky to have the land resources to do this and, in doing so, to ensure that future generations have a supply of oil that is domestic and renewable."

ANDREW LEAKEY

Associate Professor of Plant Biology (GEGC)

Received the Melvin Calvin-Andrew Benson Award from the International Society for Photosynthesis Research, in recognition of outstanding investigation into metabolic and cellular aspects of the photosynthetic process.

TEAM CALLS FOR INTEGRATED FIELD RESEARCH NETWORK IN MIDWEST TO ADDRESS CLIMATE ADAPTATION

go.igb.illinois.edu/ClimateAdaptation

Despite recent record-high yields of corn and soybean across the United States, experts warn that rising temperatures and future extreme weather may soon put Midwest crop yields in danger.

Along with a team of colleagues, Stephen Long (BSD/EBI/GEGC), Gutgsell Endowed Professor of Crop Sciences and Plant Biology, recently discussed the agricultural implications of expected climate change in the journal *BioScience*. By midcentury, temperatures in Illinois will likely be closer to those experienced today in the mid-South, and precipitation amounts will range between those in East Texas and the Carolinas. These predictions, the authors said, will mean reduced productivity for Midwest farmers, threatening global food security as a result.

In response to these challenges, the team urges increased spending on agricultural research in the Midwest and the creation of an integrated network of field research sites where data on the performance of current and future crops and cropping systems, as well as on-farm management practices, could be gathered.

Funding for the development of the article was provided by Washington University in St. Louis through the Workshop on Climate Change and Agriculture in the Midwest.

NEW METHOD PROMISES TO SPEED DEVELOPMENT OF FOOD CROPS

go.igb.illinois.edu/ddPCR

A new study led by plant scientists at the IGB demonstrated the speed, convenience and precision of a new method to confirm the results of transgenic work.

The study, published in *Plant, Cell and Environment*, addresses a central challenge of transgenic plant development: how to reliably evaluate whether genetic material has been successfully introduced.

Researchers at the University of Illinois, the Polish Academy of Sciences, the University of Nebraska-Lincoln and the University of California, Berkeley compared the traditional method of gene transfer to several new ones that have emerged from advances in genomic technology. In doing so, they were able to identify one that's much faster than the standard approach, yet equally reliable. The study was led by Illinois postdoctoral fellows Kasia Glowacka and Johannes Kromdijk.

"For plants with long life cycles, such as our food crops, this will greatly speed the time between genetic transformation or DNA editing, and development of pure breeding lines," said Stephen Long (BSD/EBI/GEGC), Gutgsell Endowed Professor Crop Sciences and Plant Biology and the principal investigator for the study.

Plant breeding efforts, like the Illinois field trial shown here, will benefit from fast and precise technologies to evaluate transgenics.

The work was funded by the Bill & Melinda Gates Foundation as a part of Realizing Photosynthetic Efficiency, a multi-institutional project directed by Long that aims to address global food needs by developing crops with greater photosynthetic efficiency and higher yields.

MACHINE LEARNING PROVIDES QUALITY CONTROL FOR PLANT GENOMIC DATABASES

go.igb.illinois.edu/PlantGenomeQC

DNA represents a cell's potential, not its focus: even though each cell contains the entire genome of its host organism, it knows how to differentiate, to become part of a stem, a root, or a leaf. These differences are related to each cell's transcriptome—the array of messenger RNAs (mRNAs) that describes which parts of the genome are expressed as they are translated into proteins.

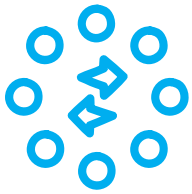
A study published in *The Plant Journal* shed light on the transcriptomic differences between different tissues in *Arabidopsis*, an important model organism, by creating a standardized "atlas" that can automatically annotate samples to include lost metadata such as tissue type. By combining data from over 7000 samples and 200 labs, this work, funded by the DOE, represents a way to leverage the increasing amounts of publicly available -omics data while also improving quality control.

Though this abundance of data opens the door for large and inexpensive studies, there are often issues integrating multiple data sets. For example, Bliss Faculty Scholar and Professor of Bioengineering Sergei Maslov (BCXT) noted that "different researchers use different vocabularies to describe the same tissue, [... and] errors exist during the data submission process."

"Our ultimate goal is to provide cloud-based computer infrastructure for the study of energy/agriculture related plants, such as poplar and maize," Maslov said. "If our strategies have been successfully applied on *Arabidopsis*, they can be applied on other species as well."

There are times you need to sprint—there's a deadline, it's field season, the plants are there—but there are also times where you just need to sit with your research, to be intellectually honest with yourself about what your data really mean, what your motivations are, what you should do next.

DONALD ORT
ROBERT EMERSON PROFESSOR
DEPARTMENTS OF PLANT BIOLOGY AND CROP SCIENCES
(GEGC THEME LEADER)



COMMUNITY ENGAGEMENT

Curiosity, passion, altruism, and appreciation of detail are not uniquely science-minded traits; they are aspects of human nature shared by many. Similarly, an interest in genomic research and a share in its outcomes are for everyone, not only researchers like ours. Part of our mission is to engage the public and welcome every person's voice into the conversation about what genomics is and how it can help all of us.

LOCAL STUDENTS LEARN ABOUT GENES, DNA AND MORE AT FIFTH ANNUAL GENOME DAY

go.igb.illinois.edu/5thGenomeDay

Members of the Tap In Leadership Academy, a nonprofit academic enrichment organization, took part in the activities of the day.

One Saturday in November, over 500 adults and children from the surrounding community gathered at the Orpheum Children's Science Museum to explore topics in genomics and biology at the fifth annual Genome Day, presented by the IGB. Researchers and students from the IGB, HPCBio, the National Center for Supercomputing Applications, the Center for the Physics of Living Cells, and the Biomedical Engineering Society led hands-on activities related to diverse areas of genomic biology, including ancient DNA, developmental biology, and organisms in extreme environments.

Genome Day 2016 offered 18 learning stations staffed by 130 volunteers. Spanish and Chinese translation was provided by volunteers from the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) and the Chinese Students and Scholars Association (CSSA) to make the event more accessible to community members.

"I love Genome Day because one of my daughters is learning about Punnett squares and components of the cell [in school]," said Sandra, a mother of three young daughters, two of whom were at the event. "She loves being able to interact with the science outside the classroom."

ILLINOIS TEAM CLAIMS BRONZE AT THE ANNUAL IGEM GIANT JAMBOREE IN BOSTON

go.igb.illinois.edu/iGEMBronze

The University of Illinois International Genetically Engineered Machine (iGEM) team received a bronze medal at the annual iGEM Giant Jamboree this September for its development of a unique genetic component. Their designed promoter, a region of DNA that helps control the activity of a nearby gene, allows for greater predictability and control of that activity.

The iGEM Foundation is a non-profit organization devoted to promoting synthetic biology through education and competition within a collaborative community. High school and undergraduate teams design and construct genetically engineered machines—known as "BioBricks"—using standard biological parts. The submitted BioBricks are then added to iGEM's Registry of Standard Biological Parts, which is available to researchers worldwide.

The 2016 team was the ninth from the University of Illinois to compete at the iGEM Giant Jamboree. The team of six undergraduate students—Caroline Blassick, Jonathan Chang, Viraat Goel, Augustine Koh, Mariam Saadah, and Hiba Shahid—received guidance from two faculty advisors: Assistant Professor of Chemistry Auinash Kalsotra (GNDP/ONC-PM) and Assistant Professor of Bioengineering Ting Lu (BCXT/BSD/MME).

Funding for the 2016 team was provided in part by the IGB, the University of Illinois, Integrated DNA Technologies, New England Biolabs, and MathWorks.

iGEM Team 2016

MARNI BOPPART

Associate Professor of Kinesiology and Community Health (RBTE)

Received a Campus Excellence in Undergraduate Teaching Award from the University of Illinois for her positive impact on student learning.

LEE DEVILLE

Associate Professor of Mathematics (BCXT)

Received a Campus Excellence in Undergraduate Teaching Award from the University of Illinois for his positive impact on student learning.

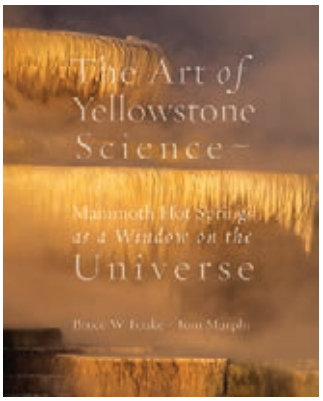
As a student, you're only producing a small part of it, but you have to remember that in the big picture those small early steps are equally important as the ones that find the drug that treats cancer, or the one that helps—you're still moving the research forward.

MAX SIMON
GRADUATE STUDENT, BIOENGINEERING
VAN DER DONK LAB (MMG)

AT YELLOWSTONE, ART AND SCIENCE FLOURISH TOGETHER

go.igb.illinois.edu/YellowstoneArtScience

The Art of Yellowstone Science: Mammoth Hot Springs as a Window on the Universe *by Professor of Geology and Microbiology Bruce Fouke and wildlife photographer Tom Murphy.*



Mammoth Hot Springs in Yellowstone National Park represents a confluence of two seemingly contrasting views of the world. Its dramatic rock formations, diverse wildlife, and the flow of water for which it is named offer countless examples of natural beauty, yet scientists are drawn to these same features because of the unique opportunities they represent to better understand geological and biological processes.

A recently published volume created by Professor of Geology and Microbiology Bruce Fouke (BCXT/EBI) and internationally known nature photographer Tom Murphy, *The Art of Yellowstone Science: Mammoth Hot Springs as a Window on the Universe*, uses a meticulously crafted collection of photographs to show that these views both stem from a common origin of curiosity and awe.

"In the pages of this book, Mammoth Hot Springs photographic art is melded with the natural sciences to search for common laws of nature through the power of observation and willingness to embrace the unexpected," Fouke and Murphy wrote in a description on the book's website. "This new appreciation of nature at Mammoth is then applied to challenges faced by society, now and in the future."

CAMPERS EXPLORE THE PAST AND FUTURE OF GLOBAL CLIMATE AT POLLEN POWER SUMMER CAMP

go.igb.illinois.edu/4thPollenPower

For the last week of June, 13 middle-school girls from as near as Champaign and as far as Putnam County traveled to the IGB to learn about plant response to global climate change in both the distant past and the coming century. The girls, participants in the IGB's Pollen Power summer camp, learned about geologic time, technology, and plant structure through engaging with IGB members and staff representing several departments.

"It is interesting, super fun, amazing, totally awesome and one of the best camps I've ever been to in my whole life," said one attendee. "You get to try new things and learn new things!"

The girls had the opportunity to use million-dollar microscopes under the guidance of skilled volunteers from the IGB's Core Facilities, visit high-tech research fields at the SoyFACE experimental farm, and learn about pollinators in campus laboratories and at the University of Illinois Pollinatarium. Throughout the week, the girls worked in groups to learn how to identify individual grains of pollen, then image and finally 3D print blown-up models of common plant pollens like sunflower, cattail and lily.

Pollen Power camp, offered in 2016 for the fourth consecutive year, is funded in part by the NSF and the IGB. The camp is co-organized by plant biologists Lisa Ainsworth (GEGC) and Andrew Leakey (EBI/GEGC), IGB Core Facilities, and IGB Outreach staff.

Left page, bottom: Attendees of the fourth consecutive Pollen Power camp at the IGB.

COLLABORATING TO STRENGTHEN THE RESEARCH WORKFORCE OF TOMORROW

go.igb.illinois.edu/KnowEnGFisk

The Knowledge Engine for Genomics (KnowEnG) Center at the IGB partnered with Fisk University, a historically black university in Nashville, Tennessee, in an innovative program to promote diversity in the biomedical, behavioral, and clinical research workforce. IGB's collaboration prepares underrepresented minority undergraduates for entry into competitive medical or graduate programs by teaching them to apply computational thinking and statistical and informatics tools to address biomedical research challenges.

KnowEnG is one of 11 Centers of Excellence funded through the NIH Big Data to Knowledge (BD2K) Initiative to develop new methodologies for handling

REBECCA FULLER

Associate Professor of Animal Biology (GNDP)

Received a Campus Award for Excellence in Guiding Undergraduate Research from the University of Illinois for her excellence in involving undergraduate students in scholarly research.

JESSICA SAW

MD Program, Mayo Medical School / Graduate Student, Molecular and Integrative Physiology (Wildman Lab)

Received a Scholar Award from the ARCS Foundation, a national organization that recognizes outstanding graduate and undergraduate students around the country in science, engineering, mathematics, and biomedical fields.

COLLABORATING TO STRENGTHEN THE RESEARCH WORKFORCE OF TOMORROW CONT.

biological big data. NIH provides additional funding opportunities for collaborations between institutions with BD2K Centers and institutions serving students from backgrounds that are underrepresented in research. These collaborations allow students to have learning and research experiences at the intersection of computer science and biology, biochemistry, molecular biology, and mathematics.

KAREN SEARS

Associate Professor of Animal Biology (RBTE)

Received the Lynn Martin Award for Distinguished Women Teachers from the College of Liberal Arts and Sciences, as well as a Campus Excellence in Undergraduate Teaching Award from the University of Illinois for her positive impact on student learning.

REBECCA STUMPF

Associate Professor of Anthropology (BCXT/CGRH)

Received a 2016 Campus Distinguished Promotion Award, recognizing those scholars whose contributions and achievements within their respective fields are particularly excellent. She was also named a 2016 Guggenheim Fellow and a University Scholar, the latter via a program created to recognize the university's most talented teachers, scholars and researchers.

MATTHEW WHEELER

Professor of Animal Sciences (RBTE)

Received a Campus Award for Excellence in Faculty Leadership from the University of Illinois for his service and loyalty to the university.

Left: One of the first two interns in the Fisk program, Shelby Clark, plans to become an obstetrician/gynecologist and assist women in developing countries. Right: Fisk intern Carleigh Frazier is working toward owning her own practice as a dermatologist and continuing research within her field.

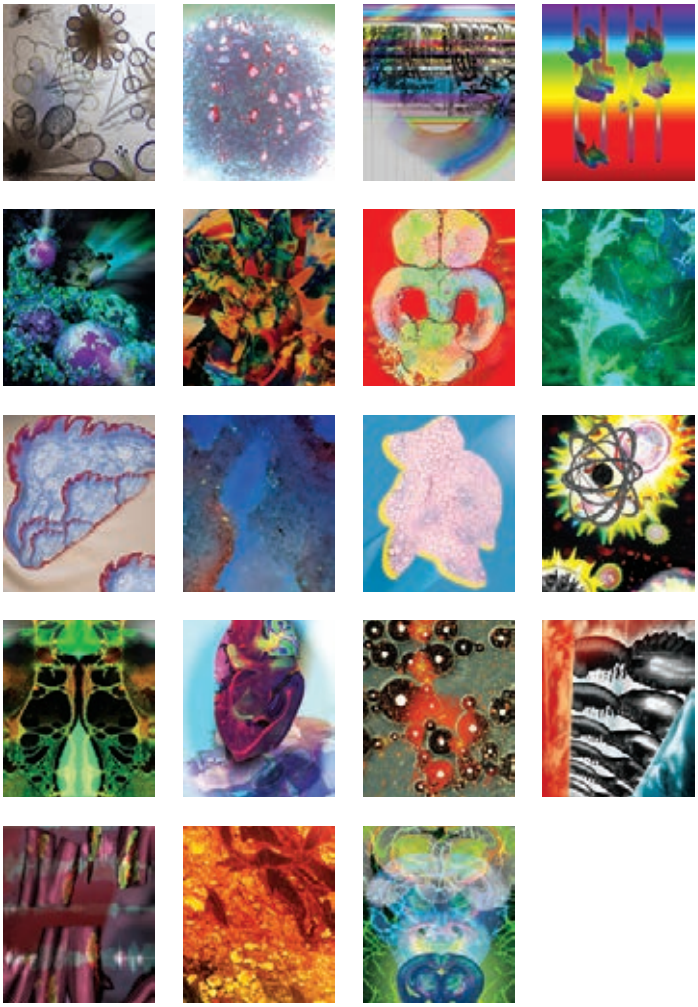
The partnership extends Fisk's course catalog by offering bioinformatics seminars taught at the IGB to Fisk students and faculty. Educational tools developed by the BD2K Center are integrated into Fisk undergraduate courses and laboratories.

Carleigh Frazier and Shelby Clark were the first two Fisk interns to come to the IGB. Frazier hopes to be a dermatologist and do research in her own practice. Clark plans to be an obstetrician/gynecologist helping women in developing countries.

ART OF SCIENCE 6.0

go.igb.illinois.edu/AS6

The IGB's Art of Science program, now in its sixth year, features images drawn from genomic research whose natural beauty has been highlighted through artistic enhancements. The exhibits invite scientists and the public to unite in appreciation of the diverse, unexpected, and breathtaking views offered by the study of the natural world.



Art of Science has been displayed in many locations:

Boneyard Arts Festival
Chicago Midway International Airport
Chicago O'Hare International Airport
EnterpriseWorks Incubator
Gallery 217
German Center for Research and Innovation
I Hotel and Conference Center
IAA Credit Union
Orpheum Children's Science Museum
Richland Community College
University of Illinois Alice Campbell Alumni Center
University of Illinois Atkins Building
University of Illinois Willard Airport

Keep an eye out for us in future venues!

IGB WELCOMES TWO WOESE UNDERGRADUATE RESEARCH SCHOLARS

go.igb.illinois.edu/WoeseUndergrads

Carl R. Woese Undergraduate Research Scholarship 2016 awardees Rebecca Wipfler and Elijah Karvelis.

Not every student dreams of spending their summer on the beach. Some would rather pursue their passions on campus, spending the long summer days in an air-conditioned lab crunching numbers or growing microbes. For two lucky undergraduates at the IGB that dream became a reality in the summer of 2016, made possible by the Carl R. Woese Undergraduate Research Scholarship.

"I'm learning to never be afraid to ask questions, never be afraid to ask people to repeat themselves and to clarify information," said Woese scholar Rebecca Wipfler, a rising sophomore in Molecular and Cellular Biology. "But I'm also learning to be more independent, and to pay attention to details and what's going on around me. [...] It's given me the opportunity to see what it's like to be a full-time researcher."

The Woese Undergraduate Research Scholarship offers exceptional students a stipend to fund their room and board for a ten-week summer program. Recipients continue work begun with an IGB member or affiliate during the academic year, with the intention of completing a largely independent project and final report by the end of the summer.

Wipfler and fellow Woese Scholar Elijah Karvelis were chosen via a competitive application process. Wipfler's research focused on physically characterizing the exterior protein coat of *Sulfolobus islandicus*, an archaeal species found in hot springs; Karvelis, a rising senior in Chemical and Biomolecular Engineering, worked on microfluidic devices in the study of glioblastoma multiforme, a particularly deadly form of brain cancer.

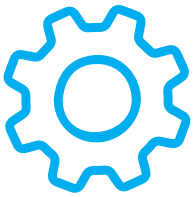
CHENGXIANG ZHAI

Professor of Computer Science (BSD)

Received a Campus Award for Excellence in Graduate Student Mentoring from the University of Illinois for his dedication in mentoring more than 60 graduate students.

[I loved] this whole notion that where I was at in these cornfields in Iowa, there was a time when I was standing physically in a location that had a mile of ice above it, and in the same location going back in time 3 million years, that I'd be about 30 meters water depth in a turquoise-blue ocean. So the big draw for me was being transported through time, and to know how drastically different the same location could be from time to time.

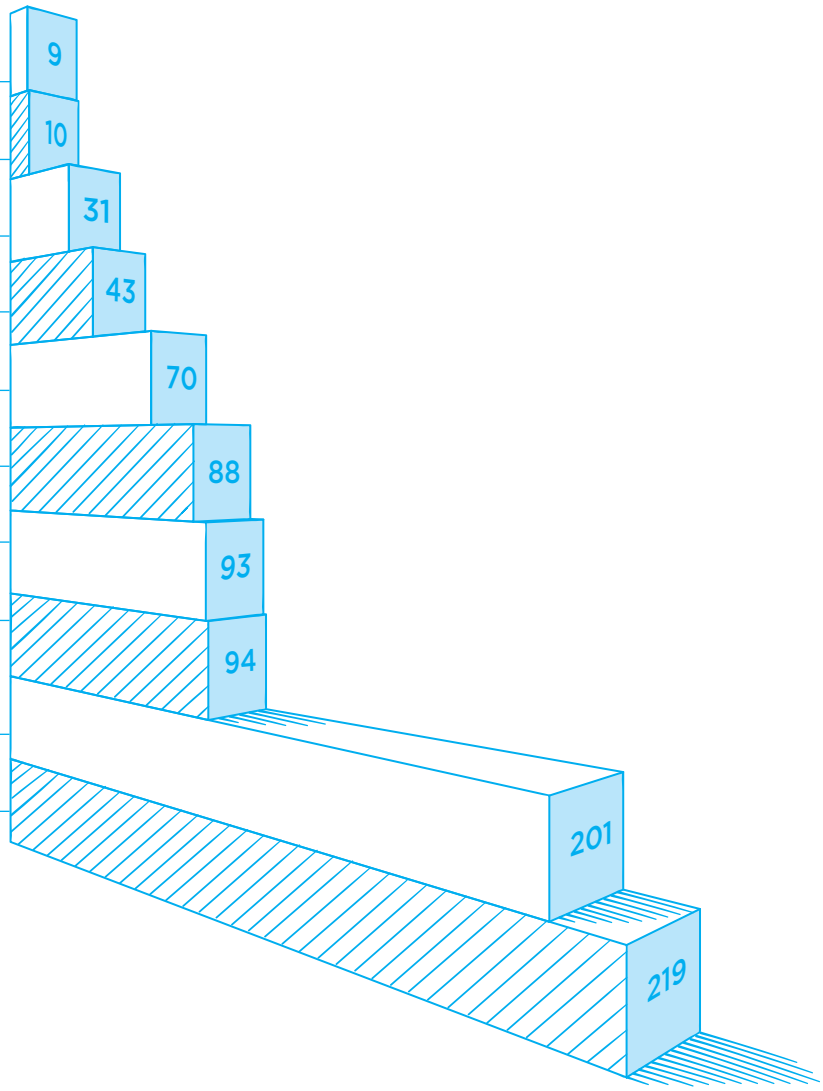
BRUCE FOUKE
PROFESSOR, DEPARTMENTS OF GEOLOGY AND MICROBIOLOGY (BCXT)



IGB NUMBERS IN 2016

With each passing year, we remain grateful for the opportunities we have to delve deeper into the scientific questions that excite us, and to apply what we're learning to real-world problems. This section is another way of looking at what we have been up to and where we are going next.

PEOPLE



Student Staff **9**

IGB Fellows **10**

Visiting Researchers **31**

Administration **43**

Postdoctoral Researchers **70**

Research Staff **88**

Affiliates **93**

Faculty **94**

(7 Colleges, 54 Departments)

Graduate Students **201**

Undergraduates **219**

TOTAL **858**

PUBLICATIONS

896 papers published,

8 Science *and 1* Nature

IGB faculty in bold

M. Raghavan, M. Steinrücken, K. Harris, S. Schiffels, S. Rasmussen, M. DeGiorgio, A. Albrechtsen, C. Valdiosera, M. C. Ávila-Arcos, A.-S. Malaspinas, A. Eriksson, I. Moltke, M. Metspalu, J.R. Homburger, J. Wall, O.E. Cornejo, J.V. Moreno-Mayar, T.S. Korneliussen, T. Pierre, M. Rasmussen, P.F. Campos, P.B. Damgaard, M.E. Allentoft, J. Lindo, E. Metspalu, R. Rodríguez-Varela, J. Mansilla, C. Henrickson, A. Seguin-Orlando, H. Malmström, T. Stafford Jr., S.S. Shringarpure, A. Moreno-Estrada, M. Karmin, K. Tambets, A. Bergström, Y. Xue, V. Warmuth, A.D. Friend, J. Singarayer, P. Valdes, F. Balloux, I. Leboreiro, J.L. Vera, H. Rangel-Villalobos, D. Pettener, D. Luiselli, L.G. Davis, E. Heyer, C.P. E. Zollikofer, M.S. Ponce de León, C.I. Smith, V. Grimes, K.-A. Pike, M. Deal, B.T. Fuller, B. Arriaza, V. Standen, M.F. Luz, F. Ricaut, N. Guidon, L. Osipova, M.I. Voevoda, O.L. Posukh, O. Balanovsky, M. Lavryashina, Y. Bogunov, E. Khusnutdinova, M. Gubina, E. Balanovska, S. Fedorova, S. Litvinov, B. Malyarchuk, M. Derenko, M. J. Mosher, D. Archer, J. Cybulski, B. Petzelt, J. Mitchell, R. Worl, P.J. Norman, P. Parham, B.M. Kemp, T. Kivisild, C. Tyler-Smith, M.S. Sandhu, M. Crawford, R. Villems, D.G. Smith, M.R. Waters, T. Goebel, J.R. Johnson, **R.S. Malhi**, M. Jakobsson, D.J. Meltzer,

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M. Berenbaum, "Speaking of insects..." *Science*, vol. 353, pp. 1343, 2016

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IGB faculty in bold

IGB CORE FACILITIES USAGE

135 Research Groups

352 active users

ECONOMIC DEVELOPMENT

Disclosures

17 FY2016, 125 total

Patent Applications

12 FY2016, 81 total

Licenses Optioned

12 total

Patents Issued

4 FY2016, 18 total

1. "Methods and Compositions for Producing Solvents"
   Hans Blaschek, Zhen Shi

2. "Microfluidic Systems and Methods"
   David Beebe, Dongshin Kim, Matthew Wheeler

3. "Prairie Cordgrass (Spartina Pectinata) Cultivar 'Savoy' for a Bioenergy Feedstock Production"
   Alllen Scott Parrish, DoKyoung Lee

4. "Design, Synthesis and Evaluation of Procaspase Activating Compounds as Personalized Anti-Cancer Drugs"
   Diana West, Grace Chen, Jennifer Pearson, Karson Putt, Paul Hergenrother, Quinn Peterson

GRANT FUNDING

Other **$8,865,390**

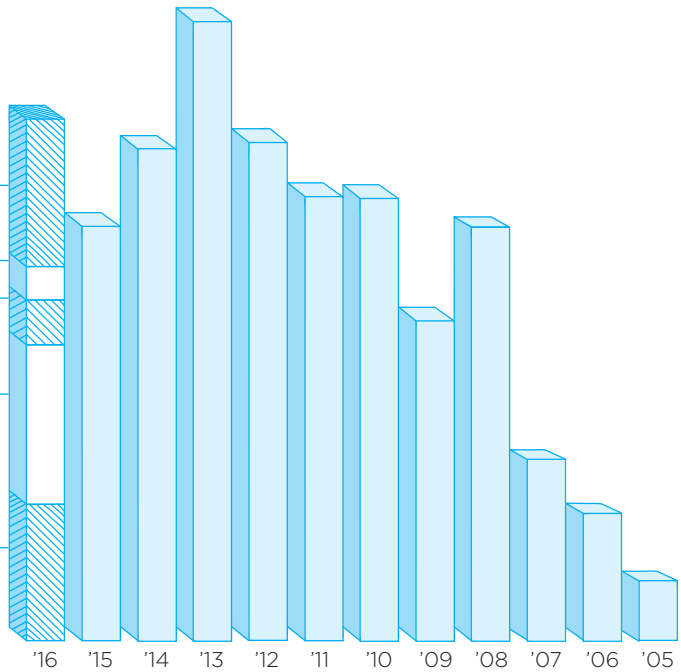
UCB/BP **$2,014,035**

NSF **$2,700,102**

NIH **$9,586,894**

DOE **$8,202,797**

FY2016 TOTAL **$31,369,218**



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