



University of Illinois at Urbana-Champaign

Biomarker

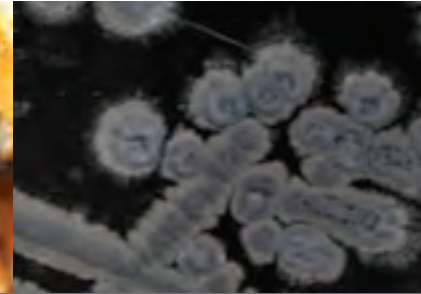
INSTITUTE FOR GENOMIC BIOLOGY

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THE MODERN SCIENTIFIC LANDSCAPE, EVOLVED

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FORWARD POTENTIAL

ONE OF THE UNIQUE ASPECTS OF THE IGB IS THAT IT DRAWS TOGETHER A DEEPLY DIVERSE COMMUNITY, WITH A VARIETY OF INTERESTS AND FIELDS OF STUDY. Working collaboratively in the areas of systems biology, cellular and metabolic engineering, and genome technology, the tremendous pool of available talent allows us to use new approaches for a great number of challenges.

This ability is most apparent in the early career successes of our younger investigators, who are bringing fresh perspectives to the table and motivating themselves and their peers to greater achievements. These men and women have already established themselves as valuable scientific contributors, with the greater portion of their careers still to come in the future. Positioning these individuals in one or more of the IGB Research Themes helps drive the creative spark to push further into the undiscovered. Here are some highlights of these early career successes.

The Biocomplexity theme has gained fascinating insight into the world of microbial and evolutionary ecology from the study of geothermal hot springs environments. This work has resulted in the discovery of evolving microbes by a team led by assistant professor of microbiology Rachel Whitaker, a Biocomplexity faculty member and an affiliate of the Host-Microbe Systems theme. Evidence for sympatric speciation—where new species evolve from a





single ancestor in the same location—is a first at the microbial level. This work has in turn led Professor Whitaker and several other IGB members to participate in a new project, funded by NASA, to discover fundamental principles in the origin and evolution of life in the universe.

Plant biology associate professor Andrew Leakey is making excellent use of SoyFACE (Soybean Free Air Concentration Enrichment), a one-of-a-kind resource designed to measure the effects of atmospheric change on crop yield and quality at a real-world scale. Professor Leakey is now performing research into the development of drought resistant strains of biofuel feedstocks. We need only remember the record-breaking droughts that plagued much of our country last summer to know how timely this research is.

From our Cellular Decision Making in Cancer (CDMC) research theme, Sua Myong joins a team of international collaborators on a Human Frontier Science Program grant, to understand the role of RNA helicases in RNA/protein body assembly and function. These grants focus on groups who undertake research too complex for individual laboratories to tackle alone. Another member of CDMC, Ryan Bailey, was named one of the world's top young innovators by *Technology Review* magazine, for developments made by those under the age of 35. And in recognition of her understanding of pioneering work on animal personality, Alison Bell from the Genomics of Neural and Behavioral

Plasticity theme was awarded the 2012 Young Investigator Award from the Animal Behavior Society.

It's so gratifying to see these early investigators, nurtured at the IGB, gaining national and international recognition for their efforts. The work they are doing alongside their colleagues, the faculty and students that intermingle every day in our labs, is remarkable and pathbreaking. And looking at these creative young scientists, it's easy to see the best is yet to come.

- Gene E. Robinson

PROFESSOR ANDREW LEAKEY IS NOW PERFORMING RESEARCH INTO THE DEVELOPMENT OF DROUGHT RESISTANT STRAINS OF BIOFUEL FEEDSTOCKS. WE NEED ONLY REMEMBER THE RECORD-BREAKING DROUGHTS THAT PLAGUED MUCH OF OUR COUNTRY LAST SUMMER TO KNOW HOW TIMELY THIS RESEARCH IS.

SCIENCE SKILLS & BUSINESS SAVVY:

The Certificate in Entrepreneurship & Management Program



NOW HEADING INTO ITS FOURTH OFFERING, THE CERTIFICATE IN ENTREPRENEURSHIP AND MANAGEMENT, OR CEM, PROGRAM OFFERS INDIVIDUALS WHO HAVE THE SCIENTIFIC AND HIGH TECH SKILLS TO DO GROUNDBREAKING RESEARCH THE OPPORTUNITY TO LEARN THE BUSINESS SAVVY NEEDED TO BRING DISCOVERIES TO MARKET.

Aimed at entrepreneurially minded MD, DVM, and PhD students, and postdoctoral associates in engineering, life sciences, and related disciplines who are interested in understanding the business, economic, and legal issues in scientific and high technical start-up ventures, the program has awarded certificates to over 100 graduates.

One aspect that sets the CEM program apart is the unique combination of classroom learning paired with experiential learning. Weekly

lectures designed to provide non-business students with a strategic framework for making informed business decisions run for ten weeks, with an additional ten weeks of training modules using the Kauffman FastTrac® TechVenture™ program.

The experiential sessions involve “learning by doing” exercises and include how to determine and successfully pursue market opportunities and business strategies, develop a solid marketing plan, build a management team, and calculate the funding needed at each stage of a new business.

For Chinmay Soman, a postdoc studying agricultural and environmental issues, learning how to commercialize technology was invaluable. “I am interested in being part of the solution and how it goes into the marketplace,” he said. “This experience has been tremendously useful. I encourage others to go for it and enter the CEM program.”

A collaborative effort between the College of Business and the Institute for Genomic Biol-

ogy, course locations are divided between the Business Instructional Facility and the IGB. Nationally recognized experts in business, law, life sciences, and related disciplines compose the faculty behind the curriculum.

Students are able to attend a two semester course, engaging in both the lecture component and the experiential sessions, or attend only one semester consisting of the Kauffman program.

Before his experience with the CEM program, Dan Wichelecki was not very informed about the commercialization process. “Now I know how to protect my research and how to set aside funds and take my research from the lab to the marketplace.”

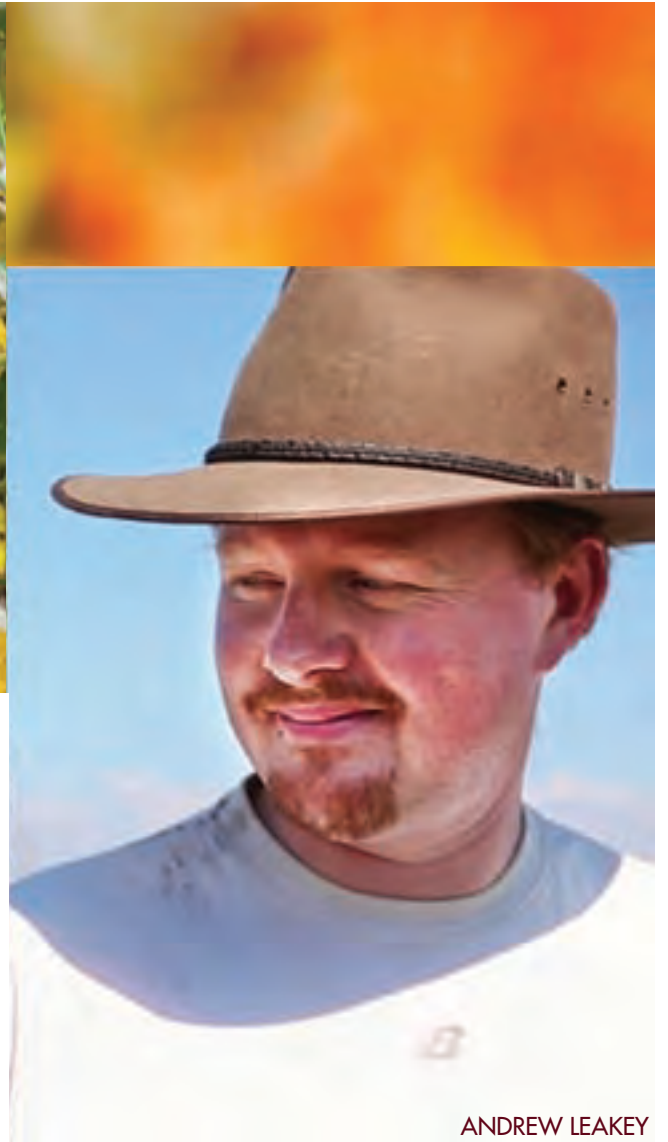
The current program runs from September 2012 to April 2013. To learn more about what is offered, register for courses or internships, and apply for scholarships, please visit <http://www.igb.illinois.edu/cem>.



LEAKEY LAB RESISTS DROUGHT

IGB FACULTY MEMBER AND PLANT BIOLOGY PROFESSOR ANDREW LEAKEY IS PART OF AN EFFORT TO IMPROVE DROUGHT TOLERANCE IN BIOENERGY GRASSES →





ANDREW LEAKEY

IMPROVING DROUGHT RESISTANCE of BIOFUEL GRASSES

THE U.S. DEPARTMENT OF ENERGY HAS AWARDED A FIVE-YEAR, \$12.1 MILLION GRANT TO A MULTI-INSTITUTIONAL EFFORT TO DEVELOP DROUGHT RESISTANT GRASSES FOR USE IN BIOFUELS. The Donald Danforth Plant Science Center in St. Louis will lead the initiative with researchers from the Carnegie Institution for Science, the University of Illinois at Urbana-Champaign, the University of Minnesota, and Washington State University.

The grant is timely, said Illinois plant biology professor Andrew Leakey, whose lab will receive \$1.8 million of the funding. “The Midwest saw one of the worst droughts in decades,” he said, “and anything scientists can do to enhance a crop’s ability to endure such conditions will be a boon to agriculture in general.”

The 2012 drought season was seen as one of the costliest natural disasters in US history, due to a combination of extreme heat, lack of precipitation, and a mild winter. Over 60% of the country was in a state of drought, including all of Illinois.

Drought is the number one limiting factor of crop yields and will continue to be of concern in relation to climate change and diminishing global water supply. Determining how to best engineer bioenergy crops for increased heat and drought resistance will make them more practical to produce and more attractive to farmers, guaranteeing an adequate supply.

The new research will focus on *Setaria viridis*, a grass that is closely related to next-generation biofuel feedstocks such as *Miscanthus* and switchgrass, as well as corn and wheat. *S. viridis* is particularly amenable to genetic analysis, allowing for ease of transformation and characterization of traits.

Leakey, a faculty member at the Institute for Genomic Biology, and his colleagues at Illinois will lead field experiments on a variety of *Setaria* plants to determine the genetic basis of drought tolerance in these and other closely related plants.

“Our team is really focused on how you produce the greatest amounts of grass biomass,” said Leakey. “In other words, if you went out and harvested it, how you can produce the greatest amount of dry material at the end of the year—and do that on the smallest possible land area with the smallest possible environmental impact.”



“So that’s what we’re really trying to explore, how you can maximize production if you’re not using the best soils, not having to irrigate as much as you might otherwise, not using too much fertilizer. Those are very important features in producing a biofuel that actually has a net environmental benefit.”

Leakey will be utilizing SoyFACE (Soybean Free Air Concentration Enrichment), an outdoor facility at Illinois for growing crops under a variety of atmospheric climatic conditions. Because SoyFACE has developed ways of simulating drought stress, differing CO2 concentrations, and elevated

temperatures, it provides the perfect outdoor lab to test *Setaria* under a number of stressors. By planting a genetically diverse selection of *Setaria* plants, Leakey’s lab can compare the genetic markers of those that do well under drought stress to those that do poorly, allowing them to identify target genes for stress resistance.

“Our big-scale objective is to reduce reliance on fossil fuels, which at the minute are largely imported from outside the country,” said Leakey. “We’re also trying to slow the release of carbon emissions and slow the climate change that those are causing.”

Meanwhile, Tom Brutnell, Director of the Enterprise Rent-A-Car Institute for Renewable Fuels, will pursue genetic dissection of drought response in *S. viridis*. Brutnell, who is serving as Principal Investigator on this grant, will work with colleagues using computational and synthetic biology tools to produce one of the most extensive molecular characterizations of plant growth to date. In doing so, they will generate candidate genes to improve closely related bioenergy grasses, improving their yields and water efficiency.

“The opportunity to use the newest genomic and genetic tools available on this project provides an incredible opportunity for us to advance our understanding of the genes that confer drought tolerance to some C4 crops such as Miscanthus and switchgrass,” Leakey said. “Given the importance of C4 crops for fuel and food and the likelihood that droughts like those seen this year will become more frequent as the result of climate change, that’s an exciting prospect.”



“THE MIDWEST SAW ONE OF THE WORST DROUGHTS IN DECADES. ANYTHING SCIENTISTS CAN DO TO ENHANCE A CROP’S ABILITY TO ENDURE SUCH CONDITIONS WILL BE A BOON TO AGRICULTURE IN GENERAL.”

- Andrew Leakey



Curtain Goes Up on EBI'S NEW BERKELEY HOME



AS MARA BRYAN SAT AT HER BRAND-SPANKING-NEW THIRD-FLOOR OFFICE DESK, SHARING TALES OF THE GREAT BIOENERGY LABORATORY MOVE OF 2012, she was interrupted by chemical analyst Valerie Mitchell from the first floor. Mitchell wondered where she could get a trash can, since she hadn't brought one from her old workspace in Calvin Lab.

"Here, take mine," Bryan said, reaching under her desk for the black receptacle. And that—plus her constantly ringing cellphone with needs from researchers, moving crews, contractors, campus representatives, and vendors—illustrated the prior five weeks of her hectic life. Mara Bryan: Problem solver.

Bryan, along with hundreds of other researchers, students, faculty, and staff, is part of the Energy Biosciences Institute (EBI), which was formed between the University of Illinois, the University of California, Berkeley, and the Lawrence Berkeley National Laboratory, with global energy company BP in late 2007. Funded for 10 years and \$500 million (\$350

million for the public institutions), the EBI broadly pursues the application of biological knowledge to energy solutions. The focus is on bioenergy development on both cellulosic fuels (derived from non-food plants) and fossil fuel microbiology. With headquarters in Illinois at the Institute for Genomic Biology, this summer brought a location shift for the Berkeley campus facilities.

The solutions to the challenges of the EBI's move into the new downtown Berkeley high-rise this summer were constant for Bryan, the EBI's Research Operations Manager in Berkeley. As the EBI's chief liaison for the move, she had to deal daily with the challenges of a new building in which not everything works perfectly, utilities and furnishings aren't exactly where they need to be, and sensitive equipment requires deft and careful handling. Change orders for dozens of construction workers, many of whom were still finishing the structure in mid-August, numbered in the hundreds.

Nonetheless, on July 30 the first wave of occupants arrived, and business as usual be-

gan in a new five-story, 113,000-square-foot home—2151 Berkeley Way. All spit and polish, with fine recycled teak wood ceilings and gray-and-orange interior color scheme—and don't forget the dramatic winding staircase through its spine—the Energy Biosciences Building (EBB) came to life, thanks in great part to the efforts of Bryan and her colleagues. This consolidation of almost 300 researchers, students, and staff from buildings on campus emphasizes the EBI's primary operating philosophy of collaboration and interdisciplinary partnership.

"We have seen great progress in our mission so far through the dedicated work of teams and partnerships," said EBI Director Chris Somerville, Philomathia Professor of Alternative Energy. "This new structure and its outstanding facilities will serve to enable and accelerate the innovations that we expect will come in the next few years."

For Bryan, this has actually been a three-year project, from the beginning when architects first presented the plans for this state-of-the-art research center.



“The biggest challenge was trying to predict what we would need years in the future,” she recalled. “The layout of the rooms, the walls, the doors and utilities ... certain things would be quite difficult, and expensive, to change. In Calvin, if we needed a new gas line, we would just run the plumbing. In the new building, utilities are built into the ceilings and walls. So it took careful planning.”

Except for a few glitches—for example, specialty gases in one lab needed an inventive solution to reach the right stations—the building move was fairly smooth. Research space for most scientists was both improved and expanded. Work desks and bench space for postdocs and graduate students were numerous and convenient. Light was abundant from the glass-dominant walls. Lab bench areas were quieter, thanks to noisy equipment placement across a corridor and the automated new fume hoods that were installed in all labs. Additional fume hoods for the chemists alone work out to about one hood for every two scientists.

“The biggest energy users in any research building are the fume hoods and the minus-

80-degree freezers,” Bryan said. “And most of that energy from the fume hoods is used when they are open. Ours now have motion detectors that close the hoods when no one is there.” Such amenities are expected to lead to an LEED gold rating for energy efficiency, among the highest bestowed by the U.S. Green Building Council.

But beyond the laboratories, Bryan says the real hallmark of the EBB is in its interaction spaces—places set aside for interdisciplinary collaboration, brain-storming, and simple comparing of notes. The areas are omnipresent on every floor, replete with comfortable chairs and white boards. When architects asked the EBI how many white boards they wanted, Bryan said they replied, “as many as possible.” Scribbling on the white glass walls in the EBB is not only tolerated, it’s encouraged.

Like the humble star baseball player who deflects his own credit for a great game and thanks his teammates, Bryan ascribed most of the move’s success to “how well all the researchers performed in all of this. It can

produce a lot of anxiety, but everybody has pitched in and done what they needed to do.” She in particular cited Kelly Wetmore from the Arkin Lab for overseeing the move of research teams from Hildebrand Hall, assistant laboratory manager Crystal Chan for her similar duties at Calvin and for ordering supplies to stock the new facility, Heidi Szymenyei from Chris Somerville’s team for coordination of the growth chamber moves, and Stefan Bauer for managing his complex Analytical Chemistry Group equipment transfers. IT Manager Adam Cohen, Financial Manager Mark Shaw, and Facilities Manager Zack Phillips were also instrumental in move and installation logistics.

In its new home, the EBI will continue to pursue the technical and socio-economic challenges that non-food-sourced, renewable cellulosic biofuels present. Investigators and their research groups in feedstock development, biomass depolymerization, biofuels production, ecological and social impacts, and fossil fuel bioprocessing are seeking alternative and improved methods for meeting the world’s transportation energy needs.



INSECTS HAVE PERSONALITIES TOO, RESEARCH ON HONEY BEES INDICATES

A NEW STUDY IN *SCIENCE* SUGGESTS THAT THRILL-SEEKING IS NOT LIMITED TO HUMANS AND OTHER VERTEBRATES. SOME HONEY BEES, TOO, ARE MORE LIKELY THAN OTHERS TO SEEK ADVENTURE. THE BRAINS OF THESE NOVELTY-SEEKING BEES EXHIBIT DISTINCT PATTERNS OF GENE ACTIVITY IN MOLECULAR PATHWAYS KNOWN TO BE ASSOCIATED WITH THRILL-SEEKING IN HUMANS, RESEARCHERS REPORT.

The findings offer a new window on the inner life of the honey bee hive, which once was viewed as a highly regimented colony of seemingly interchangeable workers taking on a few specific roles (nurse or forager, for example) to serve their queen. Now it appears that individual honey bees actually differ in their desire or willingness to perform particular tasks, said Institute for Genomic Biology director and University of Illinois entomology professor Gene Robinson, who led the study. According to Robinson, these differences may be due, in part, to variability in the bees' personalities.

"In humans, differences in novelty-seeking are a component of personality," he said. "Could insects also have personalities?"

Robinson worked with colleagues, including research student Zhengzheng Sophia Liang and IGB affiliate and animal sciences professor Sandra Rodriguez-Zas, to study two behaviors that looked like novelty-seeking in honey bees: scouting for nest sites and scouting for food.

When a colony of bees outgrows its living quarters, the hive divides and the swarm must find a suitable new home. At this moment of crisis, a few intrepid bees—less than 5 percent of the swarm—take off to hunt for a hive.

These bees, called nest scouts, are on average 3.4 times more likely than their peers to also become food scouts, the researchers found.

"There is a gold standard for personality research and that is if you show the same tendency in different contexts, then that can be called a personality trait," Robinson said. Not only do certain bees exhibit signs of novelty-seeking, he said, but their willingness or eagerness to "go the extra mile" can be vital to the life of the hive.

The researchers wanted to determine the molecular basis for these differences in honey bee behavior. They used whole-genome microarray analysis to look for differences in the activity of thousands of genes in the brains of scouts and non-scouts.

"People are trying to understand what is the basis of novelty-seeking behavior in humans and in animals," said Robinson, who also is affiliated with the Neuroscience Program at Illinois. "And a lot of the thinking has to do with the relationship between how the [brain's] reward system is engaged in response to some experience."

The researchers found thousands of distinct differences in gene activity in the brains of scouting and non-scouting bees.

"We expected to find some, but the magnitude of the differences was surprising given that both scouts and non-scouts are foragers," Robinson said.

Among the many differentially expressed genes were several related to catecholamine, glutamate, and gamma-aminobutyric acid (GABA) signaling, and the researchers zeroed in on these because they are involved in regulating novelty-seeking and responding to reward in vertebrates.

To test whether the changes in brain signaling caused the novelty-seeking, the researchers subjected groups of bees to treatments that would increase or inhibit these chemicals in the brain.

Two treatments (with glutamate and octopamine) increased scouting in bees that had not scouted before. Blocking dopamine signaling decreased scouting behavior, the researchers found.

"Our results say that novelty-seeking in humans and other vertebrates has parallels in an insect," Robinson said. "One can see the same sort of consistent behavioral differences and molecular underpinnings."

The findings also suggest that insects, humans, and other animals made use of the same genetic "tool kit" in the evolution of behavior, Robinson said. The tools in the tool kit—genes encoding certain molecular pathways—may play a role in the same types of behaviors, but each species has adapted them in its own, distinctive way.

"It looks like the same molecular pathways have been engaged repeatedly in evolution to give rise to individual differences in novelty-seeking," he said.

The National Science Foundation, National Institutes of Health, and Illinois Sociogenomics Initiative supported this research. Support was also provided by Bruce Schatz, PI of the Beespace Project, funded by a NSF Frontiers in Biological Research grant.

Collaborators on this study included researchers from Wellesley College and Cornell University.

"IN HUMANS, DIFFERENCES IN NOVELTY-SEEKING ARE A COMPONENT OF PERSONALITY. COULD INSECTS ALSO HAVE PERSONALITIES?"

- Gene Robinson

COMPUTATIONAL COLLABORATION:

HPCBio at the University of Illinois

A NEWLY FORMED EFFORT TO ADDRESS THE NEEDS OF THE ILLINOIS RESEARCH COMMUNITY IN BIOINFORMATICS, HIGH-PERFORMANCE BIOLOGICAL COMPUTING (OR HPCBIO, FOR SHORT) IS NOW AVAILABLE TO SUPPLY DATA MANAGEMENT AND ANALYSIS SOLUTIONS.

A collaborative effort between several partners in the university community, HPCBio draws on the expertise of the Roy J. Carver Biotechnology Center and their Bioinformatics Unit, the genomics research capabilities of the IGB faculty and affiliates, and the supercomputing power and technical capacity of the National Center for Supercomputing Applications (NCSA). Financial and oversight support is provided by the Office of the Vice Chancellor for Research.

“Biology is increasingly becoming a large-scale data-driven science. Biologists around the world are producing data on the same scale as astronomy or particle

physics, but at many more centers,” says Victor Jongeneel, Director of HPCBio. “This is particularly true for genomic biology.”

Created to supply infrastructure, user support, training, and applied R&D capability in computational genomics, HPCBio provides a single, straightforward point of access, open to researchers from all campus units.

HPCBio operates as a fee for service unit, and its fees are based on a strict cost recovery model. A diverse range of services is available, from experimental planning and design to full-service data management and analysis. They also offer training through workshops and tutorials, and can be utilized to help submit joint grant proposals and papers, and perform collaborative research.

“The diversity and scale of research involving genomics, and the number of specialized fields involved, mean that most bioinformatics analysis needs



VICTOR JONGENEEL

to occur within specialized research groups,” says Jongeneel, who was previously the founding director of the Swiss Bioinformatics Institute and who holds a doctorate in microbiology and immunology. “For this reason, training and infrastructure should be consolidated and expanded so that individual researchers can acquire the skills and resources to complete their own analysis,” he adds.

The HPCBio group is already handling a rapidly expanding portfolio of projects for research groups on and off campus. To date, HPCBio has set up a local instance of the Galaxy cyberenvironment for high-throughput sequence analysis, and is organizing a series of workshops to familiarize users with its operation. It has also taken on collaborative R&D projects with the Mayo Clinic and the Archon Genomics X-Prize.



NEW SUPERCOMPUTER TO AID GENOMICS RESEARCH

A gift from the NCSA bolsters the IGB's computing services

THE NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS (NCSA) IS GIFTING THE IGB A HIGHLY PARALLEL SHARED MEMORY SUPERCOMPUTER NAMED EMBER. ORIGINALLY FUNDED BY THE NSF, EMBER WILL BE MANAGED BY THE HPCBIO GROUP.

“We’ve been using Ember for a while now through the NCSA, mainly in computational genomics,” said Victor Jongeneel, Director of HPCBio. “It can perform a lot of tasks that our existing systems just can’t. Having it under our own management will allow us better access and faster results.”

The Ember computing system will become part of the IGB bio-cluster, adding 1536 cores and eight terabytes of memory spread across four nodes.

Ember was installed in the server room at the IGB after its October 1st decommission by NCSA. It would cost two million to purchase today, and is only a year and a half old. Ember will be available to anyone on campus for a service fee, which will be placed in a fund to replace the infrastructure as it becomes dated.

For ease of use, Ember runs a Linux operating system, and can be used in many applications including chemistry, fluid mechanics, and imaging. However, its most called for use at the IGB will likely be in genomics and transcriptomics research.

Currently, the Carver Biotechnology Center sequences DNA in short segments of around 250 base pairs. These thousands of segments, however, overlap and are distributed randomly, making it difficult to see the “big picture” of the genome. Ember’s very large shared memory—2 terabytes in a single system—will enable the applications to run much more efficiently as they organize and connect these segments, and has already facilitated several projects.

“It will be a wonderful addition to our research community,” said Jongeneel. “In the past, some projects like these were left incomplete, or spent thousands of dollars on computer time. This will enable larger projects that we’ve had trouble with in the past, and easier genome and transcriptome assemblies.”



Team Discovers **MICROBES SPECIATING**



NOT THAT LONG AGO IN A HOT SPRING IN KAMCHATKA, RUSSIA, TWO GROUPS OF GENETICALLY INDISTINGUISHABLE MICROBES PARTED WAYS.

They began evolving into different species—despite the fact that they still encountered one another in their acidic, boiling habitat and even exchanged some genes from time to time, researchers report. This is the first example of what the researchers call sympatric speciation in a microorganism.

The idea of sympatric speciation (one lineage diverging into two or more species with no physical or mechanical barriers keeping them apart) is controversial and tricky to prove, especially in microbes, said University of Illinois microbiology professor and IGB faculty member Rachel Whitaker, who led the study.

“One of the big questions, from Darwin on, is how do species diverge if they are living together?” she said. “That question really hasn’t been answered very well, even in the macroorganisms that we’ve studied for hundreds of years.”

Bacteria and their distantly related microbial cousins the archaea are even more difficult to study because they have so many ways to share genetic information, Whitaker said.

The microbes divide to conquer, producing exact or near-exact clones of themselves. If this were their only way of getting established, their genetic diversity would be quite low, the result of a few random copy errors and mutations, Whitaker said. But they also can link up with each other to pass genes back and forth, suck up random genetic elements from the environment, and acquire new genes from the viruses that infect them and their neighbors.

Before scientists were able to dissect the genetic endowment of individual microbes, they had a hard time telling the bugs apart—so much so that they once confused bacteria and archaea. Researchers now know that the archaea belong to a third domain of life—as different from bacteria as plants and animals are.

“Every time we look, everywhere we look we see variation in microbial populations using these molecular tools,” Whitaker said. “You have to use these molecules, these DNA sequences, to tell the difference between species.” But even with new sequencing technologies, the task of studying microbial evolution is daunting.

Whitaker and her colleagues focused on *Sulfolobus islandicus*, a heat-loving organism from the archaeal domain of life, because it is one of few microorganisms that live in distinct “island” populations created by geothermal hot springs.

“We’re looking at an environment that’s not very complex in microbial terms,” Whitaker said. “There are not that many organisms that can handle it, and the ones that can don’t successfully move around very often.”

The researchers sequenced the genomes of 12 strains of *S. islandicus* from a single hot spring in the Mutnovsky Volcano region of Kamchatka. By comparing sequences at multiple sites on the microbes’ single (circular) chromosome using the new software programs ClonalFrame and ClonalOrigin, the researchers were able to reconstruct the genetic history of each of the strains. The analysis revealed two distinct groups of *S. islandicus* among the 12 strains. The microbes were swapping genes with members of their own group more than expected, but sharing genes with the other group less than expected, Whitaker said. And the exchange of genetic material between the two groups was decreasing over time.

This indicates that the two groups are already separate species, even though they share the same habitat, Whitaker said. The differences

between the two groups were slight, but speciation was clearly under way, she said.

Peering more closely at the patterns of change, the researchers saw a mosaic of differences along the chromosome, with vast “continents” of variation and smaller “islands” of stability. Those islands likely represent regions that are under selective pressure, Whitaker said; something in their environment is weeding out the microbes that don’t have those genes or sets of genes. The variable regions are more fluid, with genes coming and going (a process called recombination) and mutations increasing diversity.

The findings provide the first evidence that sympatric speciation occurs in a microbe, Whitaker said.

“We caught them speciating,” she said. “They do exchange some genes—just not very many. So now we know you don’t have to have a [geographic or mechanical] barrier to recombination for speciation to occur. All you have to have is selection pulling the two groups

apart, which nobody knew before.”

This study provides a glimpse of the profound genetic diversity that likely occurs everywhere in wild microbial populations, Whitaker said.

“What we see as two different species are 0.35 percent different across the chromosome; that’s about one-third of the distance between human and chimp,” she said. The two distinct groups of microbes are “orders of magnitude” more similar to each other than groups normally considered separate species, she said.

“That means there are orders of magnitude more species of microbes than we ever thought there were,” she said. “And that’s kind of mind-boggling.”

The study appears in the journal *PLOS Biology*. The research team included scientists from Arizona State University; the University of California, Davis; and the University of Oxford.



“ So now we know you don’t have to have a [geographic or mechanical] barrier to recombination for speciation to occur. All you have to have is selection pulling the two groups apart, which nobody knew before. ”

— RACHEL WHITAKER

IGB RESEARCH BRIEFS



HARRIS LEWIN ELECTED TO NATIONAL ACADEMY OF SCIENCES

Harris Lewin, an emeritus faculty member in the Department of Animal Sciences and founding director of the Institute for Genomic Biology, has been elected to the National Academy of Sciences (NAS). Lewin was recognized for research he conducted during his 27 years at the University of Illinois. He is now vice chancellor for research at the University of California, Davis, where he earned his doctorate in 1984.

Lewin joins an august body of 2,200 members and 420 foreign associates. Members are elected to the NAS in recognition of their distinguished research achievements. Election to the National Academy is one of the highest professional honors a scientist can receive.

EVALUATION OF MICROSCOPY TECHNIQUES MAY HELP SCIENTISTS TO BETTER UNDERSTAND ANCIENT PLANTS

In a paper published in PLOS ONE, scientists released their findings on what microscopy techniques are needed to identify the shape and texture of pollen grains. Because pollen morphologies often align quite closely to taxonomic groupings, understanding the appearance of ancient pollen allows scientists to better understand prehistoric flora in the context of modern-day ancestors.

The team's research, led by IGB members Surangi Punyasena and Mayandi Sivaguru, focused on comparing how several reflected

and transmitted light microscopy techniques image individual pollen grains. By choosing three pollen samples of diverse grain size and texture, they were better able to understand how each technique functions in different situations.

"The accuracy and consistency of pollen analysis relies on our ability to see as much morphology as possible," explains Punyasena. "Images like those produced by this research are the foundation of my lab's quantitative morphological work—work that we hope will allow us to break through the many taxonomic limitations of pollen identification in the very near future."

LESSONS FROM EPIGENOME EVOLUTION

The sequencing of the human genome has provided a wealth of genetic information, yet the goal of understanding the function of every gene remains outstanding. New research published in *Cell* suggests determining the purpose of genes through a new method they call "comparative epigenomics."

"Comparative epigenomics is to use interspecies comparison of DNA and histone modifications as an approach for annotation of the regulatory genome," says Sheng Zhong, of the Institute for Genomic Biology and Department of Bioengineering.

While the genome of an organism contains all its genes, it is the epigenome that decides which are expressed, or "turned on." Though

genomic science has long focused on comparative genomics—comparing the genomes of similar species and finding the commonalities to determine how common traits are regulated—comparative epigenetics provides a more in-depth look at regulatory functions.

Understanding the genome is one of the most pressing problems for science, and this study sheds light on a promising alternative method. "Comparative epigenomics enables us to find more clues from evolution about the functions of our genomes," adds Shu Xiao, the first author of the paper and member of the Zhong lab.

TEAM DISCOVERS HOW BACTERIA RESIST 'TROJAN HORSE' ANTIBIOTIC

A new study in the *Proceedings of the National Academy of Sciences* describes how bacteria use a previously unknown means to defeat an antibiotic. The researchers found that the bacteria have modified a common "housekeeping" enzyme in a way that enables the enzyme to recognize and disarm the antibiotic.

Bacteria often engage in chemical warfare with one another, and many antibiotics used in medicine are modeled on the weapons they produce. But microbes also must protect themselves from their own toxins. The defenses they employ for protection can be acquired by other species, leading to antibiotic resistance.

The researchers focused on an enzyme, known as MccF, that they knew could disable a potent “Trojan horse” antibiotic that sneaks into cells disguised as a tasty protein meal. The bacterial antibiotic, called microcin C7 (McC7) is similar to a class of drugs used to treat bacterial infections of the skin.

“How Trojan horse antibiotics work is that the antibiotic portion is coupled to something that’s fairly innocuous—in this case it’s a peptide,” said University of Illinois biochemistry professor and IGB faculty member Satish Nair, who led the study. “So susceptible bacteria see this peptide, think of it as food and internalize it.” The meal comes at a price, however: Once the bacterial enzymes chew up the amino acid disguise, the liberated antibiotic is free to attack a key component of protein synthesis in the bacterium, Nair said.

This information could grant researchers—and eventually, doctors and other clinicians—the ability to scan the genomes of disease-causing bacteria to find out which ones have genes with an antibiotic-resistance loop in them, Nair said. “If we know what type of bacteria are causing an infection we know what kind of antibiotic to give and what kind not to give,” he said.

NEW ANTIBIOTIC MAY MAKE FOOD SAFER AND COWS HEALTHIER

Food-borne diseases might soon have another warrior to contend with, thanks to a new molecule discovered by chemists at the University of Illinois. The new antibiotic, an analog of the widely used food preservative nisin, also has potential to be a boon to the dairy industry as a treatment for bovine mastitis.

The antibiotic nisin occurs naturally in milk, a product of bacteria resident in the cow’s udder. It helps keep milk from spoiling and kills a broad spectrum of bacteria that cause food-borne illness, most notably listeria and clostridium. It was approved as a food additive in 1969, and since then has become prevalent in the food industry in more than 50 countries.

“It’s good to know that there are natural products added to our food that protect us from diseases,” said lead researcher Wilfred van der Donk, a chemistry professor and IGB faculty member. “Many people probably don’t even realize that, or think it’s some kind of a non-natural chemical.”

While studying the genome of another bacterium that lives at high temperatures, van der Donk’s group found genes to make a molecule with a similar structure and function to nisin, known as an analog. They isolated the genes and inserted them into *E. coli* so they could produce the new antibiotic, dubbed geobacillin, in large enough quantities to study its structure and function.

“As it turns out, geobacillin is more stable, both in respect to pH and temperature,” van der Donk said. “We think this is good news for potential use of geobacillin in food.”

MAPS OF MISCANTHUS GENOME OFFER INSIGHT INTO GRASS EVOLUTION

Miscanthus grasses are used in gardens, burned for heat and energy, and converted into liquid fuels. They also belong to a prominent grass family that includes corn, sorghum, and sugarcane. Two new, independently produced chromosome maps of *Mis-*

canthus sinensis (an ornamental that likely is a parent of *Miscanthus giganteus*, a biofuels crop) are a first step toward sequencing the *M. sinensis* genome. The studies reveal how a new plant species with distinctive traits can arise as a result of chromosome duplications and fusions.

Stephen Moose, a University of Illinois crop sciences professor and Energy Biosciences Institute program leader, led a study with colleagues who used information gleaned from the sugarcane genome to develop hundreds of genetic markers to target specific regions of the *M. sinensis* genome. Then they crossed two *M. sinensis* plants and grew 221 offspring in a laboratory. By comparing how the genetic markers from each parent were sorted in the offspring, the team reconstructed 19 “linkage groups” corresponding to the 19 chromosomes of *Miscanthus*. This rough map of the chromosomes is a first step toward a *Miscanthus* genome, Moose said.

The new findings and the eventual publication of the *Miscanthus* genome will help scientists understand the evolution of grasses and the genetic mechanisms that give them their desirable traits.



NAIR



VAN DER DONK



MOOSE

ADVANCING DISCOVERY AND INNOVATION

in the life sciences

GRANTS

METIN BILGIN

Illinois Soybean Association
*Soybean Diseases and Insect Pests MRA
FY12*

STEPHEN LONG

Department of Energy
*Engineering Hydrocarbon Biosynthesis
and Storage Together with Increased
Photosynthetic Efficiency into the
Saccharinae*

SARAH DAVIS

University of Illinois at Chicago/EPA
*Assessing the Carbon Footprint of
Combined Corn and Cellulose Ethanol
Production Using the DAYCENT Model*

KRISTINA TEIXEIRA

Department of Energy
*Carbon Dynamics of Forest Recovery
Under a Changing Climate: Forcings,
Feedbacks, and Implications for Earth
System Modeling*



IGB AWARDS

ELIZABETH AINSWORTH (*Genomic Ecology of Global Change*) has been named the recipient of the Charles Albert Shull Award by the American Society of Plant Biologists for her research on current and potential impacts of global and environmental change on plant ecosystems. This annual award is designed to recognize young researchers for outstanding investigations in the field of plant biology.

RYAN BAILEY (*Cellular Decision Making in Cancer*) has been named one of the world's top young innovators by *Technology Review*. The list, called the TR35, honors the top innovators under the age of 35 for contributions in diverse fields such as biomedicine, energy, computing, the Web, and other developing areas.

ALISON BELL (*Genomics of Neural & Behavioral Plasticity*) received the 2012 Young Investigator Award from the Animal Behavior Society. The award is given to one researcher each year who has made significant contributions to the field of animal behavior as a new investigator.

SRIRAM CHANDRASEKARAN, a Ph.D. student in the Nathan Price lab, was a Lemelson-MIT \$30,000 Illinois Student Prize Finalist. Finalists were chosen by a distinguished panel of entrepreneurs as well as faculty members and professionals from across the Illinois campus.

H. REX GASKINS (*Host-Microbe Systems, Regenerative Biology & Tissue Engineering*) was elected President-elect of the Society for Experimental Biology and Medicine. The Society publishes the journal *Experimental Biology and Medicine*.

HYUNJOON KONG (*Regenerative Biology & Tissue Engineering*) was named a recipient of the 2012 Engineering Dean's Award for Excellence in Research. This award is made annually to four assistant professors in the College of Engineering at the University of Illinois.

STEPHEN LONG (*Energy Biosciences Institute, Genomic Ecology of Global Change*) has been named the recipient of the Charles F. Kettering Award by the American Society of Plant Biologists for his work in the role of photosynthesis in mitigating climate change and changes in the physical environment.

PING MA (*Genomics of Neural & Behavioral Plasticity*) received *The Canadian Journal of Statistics* award for his paper "Nonparametric Regression with Cross-Classified Responses." The Statistical Society of Canada presents this award each year to the author of an article published in the journal, in recognition of the quality of the paper's methodological innovation and presentation.

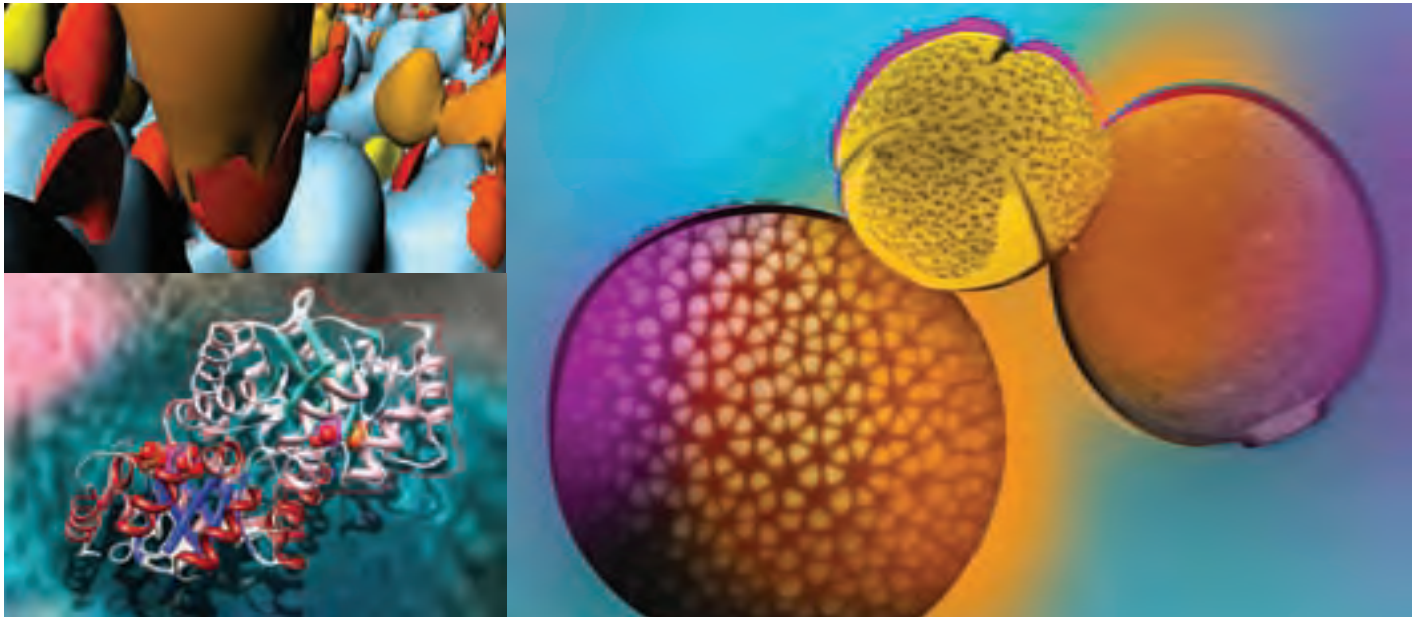
SUA MYONG (*Cellular Decision Making in Cancer*) has been awarded a Human Frontier Science Program research grant. These grants are provided for collaborative teams of scientists from different countries and disciplines to combine their expertise in innovative approaches to life science questions unable to be answered by individual laboratories.

CHRISTOPHER RAO (*Energy Biosciences Institute, Regenerative Biology & Tissue Engineering*) received the 2012 Outstanding Young Researcher award from the Computing and Systems Technology Division of the American Institute of Chemical Engineers. This award is given to an individual under the age of 40 in recognition of outstanding contributions to the field of chemical engineering computing and systems technology.

HUIMIN ZHAO (*Mining Microbial Genomes*) has been awarded a 2012 Guggenheim Foundation Fellowship. Zhao was one of 181 distinguished scholars chosen to receive the annual award, on the basis of achievement and exceptional promise.

SHENG ZHONG (*Cellular Decision Making in Cancer*) was selected as a 2012 Alfred P. Sloan Research Fellow. This fellowship is awarded yearly to 118 researchers across the United States and Canada in recognition of distinguished performance and a unique potential to make substantial contributions to their field.

Where (The Art of) SCIENCE MEETS SOCIETY



FROM FLEXING TADPOLES TO BEE BRAINS, ENORMOUS POLLEN TEXTURES TO 3-D MISCANTHUS STEMS, THE INNOVATIVE CREATIONS OF THE ART OF SCIENCE: IMAGES FROM THE INSTITUTE FOR GENOMIC BIOLOGY RETURNED TO INDI GO GALLERY FOR ITS SECOND YEAR. Showcasing imagery from the Core Facilities at the IGB, the exhibit highlighted some of the University of Illinois at Urbana-Champaign's research addressing significant problems in the environment, medicine, energy use and production, and fundamental research. The Art of Science 2.0 exhibition exemplifies the IGB's commitment to scientific discovery and the collaborative spirit that makes it all possible.

Co-sponsored by the IGB and BodyWork Associates, the exhibit was attended by over

two hundred and fifty community members, students, faculty, and staff, who enjoyed the melding of progressive scientific ideas with innovative state-of-the-art methods of conducting research. Not to mention the Countryside Middle School students who received their own guided tour.

Bringing the general public into contact with the scientific community is one of the goals of the exhibit. "Many attendees from the community commented to me that they had no idea that the IGB was working on such a vast scope of problems that affect society as a whole," said Doug Nelson, owner of BodyWork Associates.

The 1.0 exhibition traveled to such places as Richland Community College in Decatur, Illinois, and the Alice Campbell Alumni Center on campus, and select pieces

from 2.0 could be seen in the I-Hotel and Conference Center near Research Park.

Research instrumentation in the Core Facilities provides state-of-the-art resources for biological microscopy and image analysis for faculty and students from across campus and to scientists in Research Park. The facility provides IGB faculty, as well as faculty from across campus, with the tools and expertise to meet their imaging goals.

Core Facilities staff trains more than 100 new users on research instrumentation every year. For more information, visit core.igb.illinois.edu.



WHERE SCIENCE MEETS SOCIETY

Give to IGB

Research at the Institute for Genomic Biology impacts society. Merging progressive scientific ideas and innovative state-of-the-art methods of conducting research has been a hallmark of the IGB since it was established in 2003. These ideas and methods are solidifying the University of Illinois at Urbana-Champaign as a world leader in the use of genomics to answer large-scale biological questions. In essence, this research aims to transform our world in health, the environment, and energy use and production.

Philanthropic support for IGB is crucial because the pace and scope of change in the field of genomic biology require large investments on an ongoing basis. The IGB must bring together world-class researchers and students, laboratory space, materials, and equipment. All research is funded by external sources. Your donation will help us continue shaping the future of science and society.

www.igb.illinois.edu/about/giving

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