IGB NEWS

Upcoming Events
Monthly Profiles
Happenings at IGB

Image Of The Month
IP @ IGB
Department Announcements

Volume 8, Number 7

UPCOMING EVENTS

IGB Seminar (BCXT)

Genome Engineering using Programmable Nucleases

December 1, 2015, 12:00 p.m.

612 Carl R. Woese Institute for Genomic Biology

Xiaoxia Cui, Ph.D.
Sage Labs
Vice President of Research and Development

Lunch with the Core

STED Superresolution Microscope

December 2, 2015, 12:00 p.m.

612 Carl R. Woese Institute for Genomic Biology

Austin Cyphersmith Ph.D.
Research Specialist in Life Sciences, Core Facilities
University of Illinois

Chambana Science Cafe

Living Foods: The Microbiology of Food and Drink

December 2, 2015, 5:30 p.m.

Pizza-M

208 W. Main, Urbana

Dipti Nayak
Carl R. Woese Institute for Genomic Biology Fellow
University of Illinois

IGB Seminar (GNDP)

Title to be Announced

December 8, 2015, 12:00 p.m.

612 Carl R. Woese Institute for Genomic Biology

Marcelo Nobrega, PhD
Department of Human Genetics
University of Chicago

FEATURED NEWS

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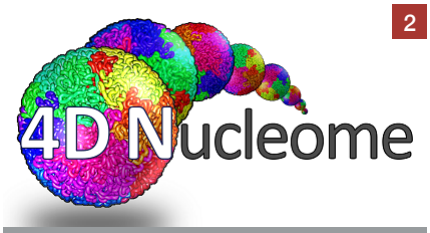
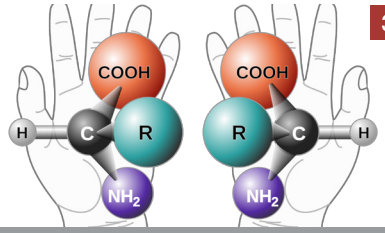


University of Illinois Awarded $8M from NIH

3



New Model Derives Homochirality from Basic Requirements for Life

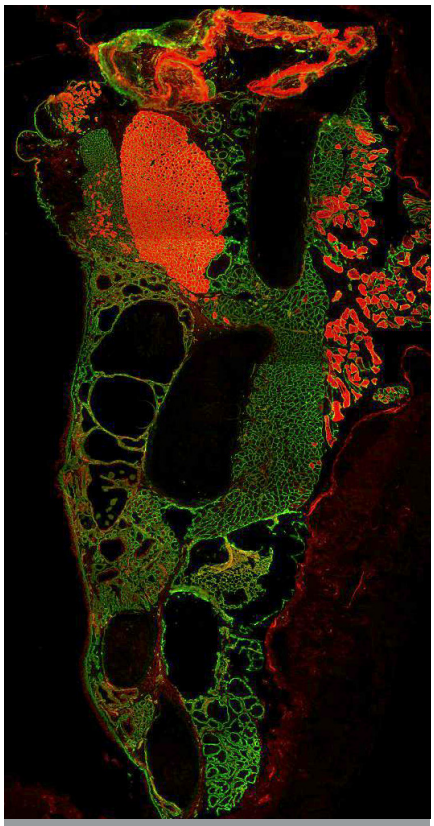
4

Profile: Monica Uddin

5

On the Grid: Happenings at IGB

IMAGE OF THE MONTH

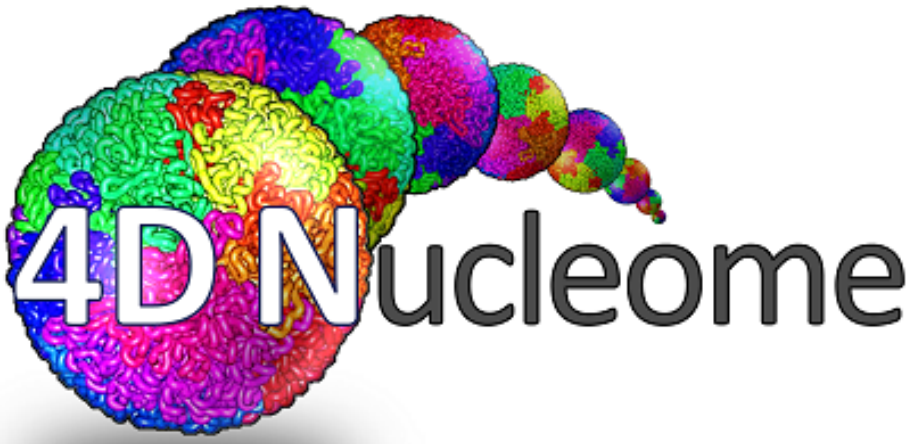


This month's image features a coronal section of a rat larynx. Muscle fibers are outlined in green and type IIb muscle fibers are stained red in the paired lateral thyroaryntenoid muscles (part of the vocal folds).

This image is provided courtesy of Charles Lenell of the Department of Speech and Hearing Science, College of Applied Health Sciences.

IGB News

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



University of Illinois Awarded $8M from NIH to Study Nuclear Structure

For years genome-mapping technology has understood DNA as a linear code, but that's not how it exists in the cell: it's tangled up in 3D inside the nucleus, with higher- and lower-density areas. Moreover, it exists in the fourth dimension as well—gene clusters can shift their positions over time. But what does this differential positioning within nuclei imply, and what does it mean when it changes?

Professor of Cell and Developmental Biology and Principal Investigator Andrew Belmont from the University of Illinois heads a team of Investigators that has been awarded an $8M grant over five years to study nuclear structure from the National Institutes of Health (NIH) Common Fund as part of the recently-unveiled 4D Nucleome Program. His project, titled "Combined cytological, genomic, and functional mapping of nuclear genome organization" includes four additional investigators: Jian Ma, Associate Professor of Bioengineering and Huimin Zhao, Professor of Chemical & Biomolecular Engineering, both at the University of Illinois, David Gilbert at Florida State University, Department of Biological Sciences, and Bas van Steensel at the Netherlands Cancer Institute. Belmont, Ma, and Zhao are also members of the Carl R. Woese Institute for Genomic Biology.

"For many years, people thought DNA in interphase chromosomes was just like spaghetti, folded randomly within the cell nucleus," said Belmont, describing a popular perception of DNA. In reality, however, chromosomal DNA isn't homogeneously compacted or straight–it can fold and coil around itself, with non-coding and inactive regions compacted several thousand-fold and more active regions still compacted hundreds to thousands-fold. At the same time, different chromosome regions are positioned in different parts of the nucleus.

"Certainly there's a strong correlation between compaction and function," explains Belmont. "Things that are less folded replicate earlier, and are more active in transcription. But at the same time, particularly in mammalian cells, there's an increased density of genes lying together on the DNA in certain chromosome bands and a markedly decreased density in other bands." These gene-rich areas tend to cluster near nuclear speckles, small objects located toward the center of the nucleus, or other regions in the nuclear interior, while gene-poor regions are often located near the nuclear periphery.

"Adding to the complexity, these positions change when gene activity changes. We don't really know why genes are ordered along the chromosome DNA sequence and why chromosomes are specifically positioned within the nucleus these ways, but it's very striking."

Measuring exactly where different parts of the genome are located within the nucleus is a major goal of Belmont's team. Collaborator Bas van Steensel invented a tagging method that adds a distinctive mark to DNA in direct contact with the nuclear wall, while Belmont's own research group has developed a complementary method, which uses antibody staining to measure the cytological distance between DNA and the stained nuclear compartment.

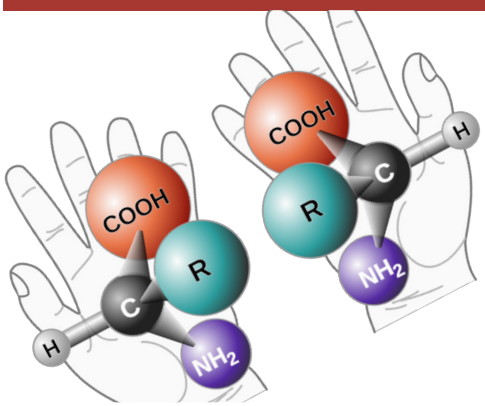
These two techniques have shown a high degree of correlation—chromosomal areas van Steensel's group has shown to be close to the nuclear wall are far away from genes that Belmont's group suggests are near speckles and other staining locations located toward the center of the nucleus. "Combining these two methods ... creates verifiable location maps," said Belmont.

"Now the idea is to label different structures within the nucleus, generating contact frequency and distance maps for all the chromosomes ... eventually, our goal is to come up with machine-learning computer algorithms that will take all these data and better predict where chromosomes are in the nucleus." This algorithm and data mining approach will be the focus of Ma's group, whose goal is to use this modeling to better predict chromosome position and trajectories within the nucleus.

A second goal of Belmont's team is to overlay this structural map with a complementary functional genomic map. Ma's group will use a computational model to assemble replication-timing data from the Gilbert group and reporter-gene activity from the van Steensel group, together with other genomic data, to correlate DNA sequence and nuclear position with gene function. By inserting large DNA pieces synthesized by Zhao's group, Belmont's team will "rewire" chromosome regions to different nuclear locations and then determine the functional consequences of this rewiring.

Belmont believes this research, together with other 4D Nucleome projects, will dramatically further our understanding of the connections between nuclear organization and genomic function. "The 4D Nucleome Program's longer-term goal is then to apply these new technologies and insights in order to ask how nuclear organization changes during development and in human disease … understanding nuclear structure at this level is an important first step." ■

Written by Kathryne Metcalf. Photo courtesy of NIH.



A mathematical model developed by a group of physicists at the University of Illinois suggests that homochirality can be used as a universal biosignature.

Straight Up, With A Twist: New Model Derives Homochirality from the Basic Requirements for Life

Life is quirky. Although the molecules that make up all living things obey physical and chemical laws, they do so with a puzzling twist. How did the distinctive molecular features of life emerge, and what can they tell us about life on Earth and elsewhere in the universe?

University of Illinois Swanlund Professor of Physics Nigel Goldenfeld, graduate student Farshid Jafarpour, and postdoctoral researcher Tommaso Biancalani have made a breakthrough in one of the most central chemical quirks of life as we know it: homochirality, the uniform "handedness" of biological molecules. Their new model addressing the emergence of this feature, published in *Physical Review Letters* (**doi: 10.1103/PhysRevLett.115.158101**) and highlighted by *Physics* suggests that homochirality can be used as a universal signature of life.

All three researchers are members of the Biocomplexity research theme within the Carl R. Woese Institute for Genomic Biology, and performed their work with funding from the NASA Astrobiology Institute for Universal Biology at UIUC, which Goldenfeld directs.

Many chemicals, organic or otherwise, are chiral; that is, if the structure of each was reflected in a mirror, its "looking-glass" copy could not be turned or flipped to match the original. Like a pair of gloves, the left-handed and right-handed versions of a chiral molecule are functionally equivalent, but their fundamental asymmetry makes them distinct.

Inorganic reactions produce and consume both versions of chiral molecules at equal rates. This is what makes the chirality of biological molecules, such as sugars produced by microbes and plants or the amino acids that make up proteins, so shocking. In every living thing on Earth, all amino acids are left-handed, and all sugars are right-handed. Goldenfeld highlighted the central mystery of this phenomenon.

"Imagine you've got a coin, and it's perfectly made, so it's not biased at all, and you start flipping the coin. Each time you flip it, it keeps coming up heads," he said. "So then you say, something must be operating that's causing this to happen . . . you get the same puzzle with these biological molecules, and that's the problem of homochirality."

Many scientists have proposed hypotheses for how this remarkable asymmetry became dominant. Perhaps the most prominent, put forward by noted physicist Sir Charles Frank in 1953, argued that homochirality could be produced by one of the fundamental properties of life—autocatalysis, the ability to self-replicate. He argued that in a system where one left-handed or right-handed molecule begets more like itself, and each type inhibits the self-replication of the other, an initial unevenness in the ratio, appearing by chance, would ultimately allow one handedness to completely outcompete the other.

Frank's work was ground-breaking, but it left unanswered questions that no subsequent work has adequately addressed. His idea appeared to rely on the inhibition of self-replication of each chirality by the other, a mechanism that might not have existed early on in life's history.

The Illinois team wanted to develop a simpler model, one based on only the most basic properties of life: self-replication and disequilibrium. They showed that with only these minimal requirements, homochirality appears when self-replication is efficient enough.

"There are other models, and they may be correct for the origin of homochirality on earth, if you can prove that those prerequisites existed during the emergence of life," said Jafarpour. "But whether those foundations exist or not, for life that emerged anywhere in the universe, you'd expect that it would

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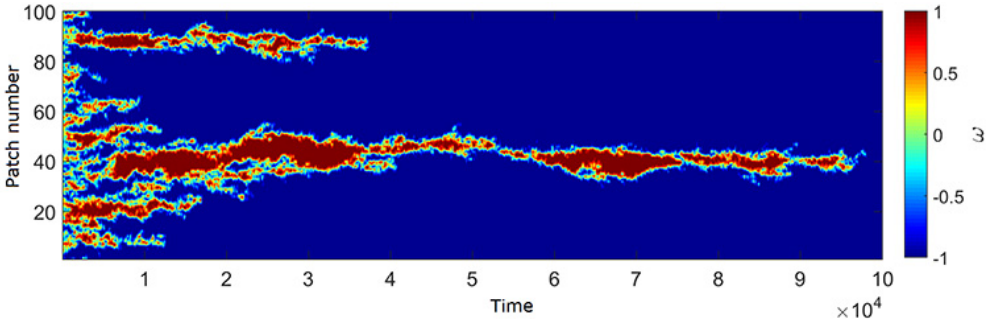

Computer simulation of the emergence of homochirality. The vertical axis represents space, here in only one dimension for simplicity, while the horizontal axis is time. The colors represent the degree of chirality, with red being (e.g.) right and blue being (e.g.) left. At the beginning the mixture has equal numbers of right and left-handed molecules, and during the time evolution, the red and blue phases compete over the spatial domain, resulting in the eventual dominance of the blue chiral phase.

have self-replication, and our model says that's enough to get homochirality."

The model relies on mathematical and computational techniques that were not available in Frank's time. It takes into account the chance events involving individual molecules–which chiral self-replicator happens to find its next substrate first. The detailed statistics built into the model reveal that if self-replication is occurring efficiently enough, this incidental advantage can grow into dominance of one chirality over the other. The forerunner of this mathematical mechanism came from Biancalani's previous work on how chance events influence the foraging patterns of ant colonies.

Goldenfeld attributes part of their success to the interdisciplinary environment of the IGB and of the Institute for Universal Biology, a member of the NASA Astrobiology Institute. "If we hadn't been in this environment, we wouldn't have been so prepared to think about this problem; we might have just stuck with ants, and never made the jump to realizing that we can apply this to this origin of life problem," he said.

The work leads to a key conclusion: since homochirality depends only on the basic principles of life, it is expected to appear wherever life emerges, regardless of the surrounding conditions.

"For me, the most exciting thing is that this mechanism shows that homochirality is really a biosignature of life, a 100% signature, and should be expected anywhere life emerges," said Goldenfeld. "So for example, we just learned that there is a global ocean of liquid water under the ice of Enceladus ... I think that looking for homochirality in the organic molecules that have been detected there would be a fantastic way to look for life there." ■

Written by Claudia Lutz. Photos from Goldenfeld Lab and Wikimedia Commons.

PROFILE

Monica Uddin is an Associate Professor of Psychology. Her research group's goal is to identify genetic and epigenetic predictors of stress-related mental disorders, with a particular focus on depression and post-traumatic stress disorder.

Monica Uddin:
Transgenerational Transmission of Disorders

In 1994, extremist Hutus slaughtered an estimated 800,000 Tutsis and moderate Hutus in the small east African country of Rwanda in the span of just 100 days. But the effects of this genocide would last much longer–manifested in the genes of survivors.

Epigenetics is the study of how environmental and external factors can influence how our genes are activated or deactivated. Evidence from animal models shows that some of these epigenetic changes can be passed down to future generations.

Monica Uddin (CGRH), an associate professor of psychology, is interested in studying the "transgenerational transmission" of psychiatric disorders such as post-traumatic stress disorder (PTSD).

In past studies, researchers observed epigenetic changes in the genes related to stress response in offspring who were *in utero* during the genocide. Her research would also look at their younger siblings to begin to gauge how long this epigenetic manifestation can last.

Uddin's work focuses on the molecular underpinnings of stress-related disorders, particularly PTSD, which is characterized by a constellation of symptoms that occurs following a traumatic event (i.e. perceiving your life being threatened or witnessing someone else's life being threatened).

Using data from the Detroit Neighborhood Health Study, she investigates what biomarkers are associated with increased risk for or resilience against PTSD in a population-based sample. That way, doctors working without a rich history of their patients' lived experiences can identify people who may benefit from early intervention.

"When you can go out in a city like Detroit, and collect biospecimens as well as very rich phenotypic data, and pair the two, that can tell us a lot about the way we interact with the world and the impact the world has on us," said Uddin.

"For me, the value of my work is an improved understanding of the way biologically, and more specifically genomically, how our experiences in the world are reflected back in our genomic makeup; the aspects of our genome that control the way our genes are expressed."

Uddin joined the University of Illinois in 2014. Today she is a member of the newly formed Computing Genomes for Reproductive Health (CGRH) research theme, led by her spouse Derek Wildman.

"When I visited, it was clear to me that there was an institutional will to do interdisciplinary work that was more than just lip service," she said. "Here I met people who really seemed to have the will and the way to make it happen. We are situated in the middle of a corn field but we aren't working in silos."

Uddin earned her bachelor's degree in human biology from Stanford University, and went on to earn her doctorate in anthropology from New York University. ■

Written by Claire Benjamin. Photo courtesy of University of Illinois.

ON THE GRID
HAPPENINGS AT THE IGB

OUTREACH

GENOME DAY

The IGB's fourth annual Genome Day at the Orpheum Children's Science Museum in Champaign was another big success, with more than 400 people in attendance.

Out thanks to faculty chair Dr. Patrick Brown of Crop Sciences (EBI/GEGC) and the over 130 volunteers from all of the IGB research themes, IGB staff, HPCBio, NCSA, Center for the Physics of Living Cells, and the Biomedical Engineering Society, as well as the SACNAS volunteers who provided bilingual support for the activities. We'll see you next year!

BLOOD DRIVE

BLOOD DRIVE RESULTS

Our recent blood drive with the Community Blood Services of Illinois was successful in collecting 24 pints of blood, just short of our goal. However the number of first time donors was very high and may lead to an increase in the amount of regular donors. Our thanks to everyone who participated and we look forward to seeing you for our next blood drive in January.

IGB October Blood Drive:

Goal	30
Collected	24
Temporary Deferrals	3
First Time Donors	8

RECOGNITION

MILESTONES IN EXCELLENCE

The University of Illinois received a rare honor, recognized for its contributions to microbiology by being named a "Milestones in Microbiology" site by the American Society for Microbiology. This honor, awarded to just 10 universities, was granted based on Illinois' rich history of major microbiological achievements, and on being the home of many outstanding microbiologists who have made seminal discoveries that significantly increased biological understanding and advanced the field of microbiology. Among the past professors honored was Carl Woese, for his discovery of the archaea.

Attending the event were IGB members John Cronan, head of the Department of Microbiology and Professor of Biochemistry, William Metcalf, G. Williams Arend Professor in Molecular and Cellular Biology and Professor of Microbiology, Brenda Wilson, Professor of Microbiology, and Gene Robinson, IGB Director.

TOUR

IGB BIOENGINEERING TOUR

Assistant Professor of Bioengineering Roy Dar's BIOE 206 class visited the IGB for a tour, with nearly 70 sophomores from the class in attendance. The class was split into four smaller groups and toured specific locations around the IGB, including the main atrium and the Art of Science installation, a visit with Director of Core Facilities Glenn Fried for an overview of our microscopy and imaging suite, a stop at the Carl R. Woese Memorial display to learn more of the work of Carl Woese and the events of his life that led to the renaming of our institute, and a talk from Sara Pedron, postdoc from Brendan Harley's lab, to hear about some of the specific research taking place within our labs.

Many thanks to Professor Dar and his class for spending the afternoon with us.

THEME HOPS

IGB THEME HOPS

IGB Theme Hops provide the different groups at IGB the opportunity to meet members of the other themes, learn who they are, and what they are working on. Join us on December 4 from 4:00 p.m. to 5:30 p.m. on second floor of the IGB research building. Refreshments and hors d'oeuvres will be served.

ON THE GRID
HAPPENINGS AT THE IGB

WORKSHOP

IGB POSTDOC CAREER WORKSHOP

The IGB Postdoctoral Association organized its first Career Development Workshop for IGB Postdoctoral Researchers on November 6th, 2015. The half-day event featured a combination of informative presentations from the Postdoctoral Affairs Office, interactive discussion groups and a panel discussion with former postdocs. The aim of the event was to provide postdocs with career advice and tools to better prepare for their future career path.

The thirty-eight participants learned about potential career options after the postdoc phase and how to prepare for the next step in their careers by writing an Individual Career Development Plan. The five invited speakers—all former postdocs who are now pursuing a career in academia, industry or science-related fields—were happy to share their diverse experiences and advise in a very interactive panel discussion and in smaller group discussions focusing on specific career paths.

After evaluating formal feedback from the event, the organizing committee was happy to find that participants nearly unanimously agreed that they now feel much better informed about the different career paths and said that the workshop helped provide them with concrete steps to prepare for their chosen career paths. Given the great success of the workshop, the IGB Postdoctoral Association is planning to have this event become a regular occurrence.

The IGB Postdoctoral Association provides professional guidance and social opportunities for post-doctoral scholars. It holds seminars to inform postdocs of the tools and services available at the IGB, organize workshops and resources for career development, and host events to encourage social interaction and professional collaboration among members of the postdoc community. Every postdoctoral researcher at the IGB is welcome to contribute their ideas and suggestions for events. For further information, contact Michael Carter at *micscart@illinois.edu*.

DEPARTMENT ANNOUNCEMENTS

BUSINESS

PUBLIC ACCESS TO PUBLICATIONS FROM FEDERALLY FUNDED RESEARCH

The White House Office of Science and Technology Policy recently issued a directive that requires researchers whose work has been funded by a federal agency to deposit a version of their article(s) in an open access repository, following an embargo period of 12 months.

What does this mean for you?

- If your research is federally funded, you should plan now to comply with the directive.
- Requirements and implementation timelines vary by agency (generally the requirement will begin in late 2015 – 2016)
- University librarians can help! See: **http://www.library.illinois.edu/scholcomm/access_mandates/mandates.html** for extensive information about the directive and resources to properly deposit materials.

Data management and public access requirements are evolving issues, and the University Library and the Office of the Vice Chancellor for Research will provide updates as regulations become clear. If you have questions, please contact Beth Namachchivaya, Associate University Librarian for Research, at *sandore@illinois.edu*. ■

DEPARTMENT ANNOUNCEMENTS

UNIVERSITY LIBRARY

IMAGE OF RESEARCH COMPETITION

Submissions are now being accepted for the 2016 Image of Research competition, which is co-sponsored by the Scholarly Commons and the Graduate College. The Image of Research celebrates the diversity of graduate student research at the University of Illinois at Urbana-Champaign.

Graduate and professional students from all disciplines are invited to submit entries, which include an image that represents their research (either concretely or abstractly) and a brief written narrative. Entries can be submitted through January 15, 2016 via the Image of Research website (**http://publish.illinois.edu/imageofresearch/**).

Awards will be presented at a reception on April 6, 2016 in conjunction with the Annual Graduate Student Appreciation Week. The awards are: First Prize ($500), Second Prize ($300), Third Prize ($200), Honorable Mention ($100), and a People's Choice Award ($100).

Please consider submitting an entry or encouraging a graduate student to submit an entry! ■

RECENT PUBLICATIONS

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

Sears KE, Capellini TD, Diogo R. On the serial homology of the pectoral and pelvic girdles of tetrapods. *Evolution*. 2015;69(10):2543-2555.

Chen J, Lee MK, Qin E, Misra S, Kong H. Van der waals force-induced loading of proangiogenic nanoparticles on microbubbles for enhanced neovascularization. *Nanoscale*. 2015;7(40):17139-17147.

Zhou Y, Schideman LC, Park DS, et al. Characterization of a *chlamydomonas reinhardtii* mutant strain with improved biomass production under low light and mixotrophic conditions. *Algal Res*. 2015;11:134-147.

Maslov S, Sneppen K. Diversity waves in collapse-driven population dynamics. *PLoS Comput Biol*. 2015;11(9).

Dong Y, Li C, Luan F, et al. Low mitochondrial DNA diversity in an ancient population from china: Insight into social organization at the fujia site. *Hum Biol*. 2015;87(1):71-84.

Jones BM, Wcislo WT, Robinson GE. Developmental transcriptome for a facultatively eusocial bee, *megalopta genalis*. *G3 Genes Genome Genet*. 2015;5(10):2127-2135.

Chowdhury F, Li ITS, Leslie BJ, et al. Single molecular force across single integrins dictates cell spreading. *Integr Biol*. 2015;7(10):1265-1271.

Schachtschneider KM, Madsen O, Park C, Rund LA, Groenen MAM, Schook LB. Adult porcine genome-wide DNA methylation patterns support pigs as a biomedical model. *BMC Genomics*. 2015;16(1).

Zhang G-, Liu J-, Kong II, Kwak S, Jin Y-. Combining C6 and C5 sugar metabolism for enhancing microbial bioconversion. *Curr Opin Chem Biol*. 2015;29:49-57.

Mazor T, Pankov A, Johnson BE, et al. DNA methylation and somatic mutations converge on the cell cycle and define similar evolutionary histories in brain tumors. *Cancer Cell*. 2015;28(3):307-317.

Tabatabaei Yazdi SMH, Yuan Y, Ma J, Zhao H, Milenkovic O. A rewritable, random-access DNA-based storage system. *Sci Rep*. 2015;5.

Traniello I. Bringing science to prisons is not enough. *Science*. 2015;349(6253):1176.

Kreig A, Calvert J, Sanoica J, Cullum E, Tipanna R, Myong S. G-quadruplex formation in double strand DNA probed by NMM and CV fluorescence. *Nucleic Acids Res*. 2015;43(16):7961-7970. ■

ILLINOIS

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www.igb.illinois.edu 15.133