SOCIETY OF POSTDOCTORAL SCHOLARS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

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5TH ANNUAL POSTDOCTORAL RESEARCH SYMPOSIUM

FEBRUARY 6, 2015

Beckman Foyer near Auditorium and Room 1005: Registration

8:00 – 9:00 Registration and light breakfast
Posters up

Auditorium: Opening Remarks and Keynote

9:00 – 9:05 Welcome - Society of Postdoctoral Scholars, Jun Wu
9:05 – 9:10 Remarks - Postdoctoral Affairs Office

Auditorium: Talks, Session 1 Chair: Amanda Brock

9:15 – 9:30 Alireza Ramezani
Bat Robot, an Underactuated Biomimetic Micro Aerial Vehicle with Membranous Wings (1.1)
9:30 – 9:45 Meraj Khan
Identification and localization of putative oviduct glycan receptors ADAM5 and PKDREJ on boar spermatozoa: changes during capacitation and freezing (1.2)
9:45 – 10:00 Vincent Reverdy
Relativistic effects in cosmology and the backreaction conjecture (1.3)
10:00 – 10:15 Laura Chaddock-Heyman
The Importance of Aerobic Fitness and Physical Activity for the Developing Brain (1.4)
10:15 – 10:30 Amanda Brock
A Genetic Screen in Drosophila melanogaster wing imaginal discs for regeneration mutants (1.5)

Beckman Foyer near Auditorium and Room 1005: Break

10:30 – 10:45 Break: Coffee, tea, water

Auditorium: Talks, Session 2 Chair: Olivia Lee

10:45 – 11:00 Zhi Su
Compression-Induced Deformation of Individual MOF Micro-crystals (2.1)
11:00 – 11:15 Karl Palmskog
Network-oblivious programmers, network-aware program execution (2.2)
11:15 – 11:30 Bradly Alicea
Contextual Geometric Structures: abstractions of cognition and culture (2.3)
11:30 – 11:45 Santosh Misra
TheraBlob for Ultrasound-mediated Ablation Therapy (2.4)
11:45 – 12:00 Aazam Feizmohammadpour
Effect of Subject Imageability in Subject-Verb Agreement (2.5)

Beckman Atrium and Room 1005: Poster Session and Lunch

12:00 – 2:00 Lunch
12:30 – 2:00 Posters presentation

Auditorium: Talks, Session 3 Chair: Joshua Wood

2:00 – 2:15 Saiprasad Ravishankar
Highly Accelerated Imaging and Image Reconstruction Using Adaptive Sparse Representations (3.1)
2:15 – 2:30 Xin Yu
The strain induced self–rolled-up tube device platform for electronics and photonics applications (3.2)
2:30 – 2:45 Vance Martin
Exercising decision making strategies using dashboards (3.3)
2:45 – 3:00 Joshua Wood
Ambient and Thermal Stability of Black Phosphorus Films and Devices (3.4)

Beckman Foyer near Auditorium and Room 1005: Break
3:00 – 3:15 Break: Coffee, tea, water

Auditorium: Talks, Session 4 Chair: Jennifer Jeffrey
3:15 – 3:30 Sayantan Majumdar
Memory effect in sheared cross-linked actin networks (4.1)
3:30 – 3:45 Timothy Wertin
Can the BIOCRO model simulate transpiration of elite coppiced willow genotypes that achieve high biomass production with very different canopy structures? (4.2)
3:45 – 3:00 Jennifer Jeffrey
Moms matter: Maternal social stress in zebrafish (4.3)
4:00 – 4:15 Norm Tubman
Quantum dissection of a covalent bond (4.4)

Auditorium: Keynote Speech
4:20 – 5:20 Keynote: Arthur Kramer
Exercise your Brain and Mind

Auditorium: Closing Remarks
5:20 – 5:25 Closing remarks: Sumbul Khan

Beckman Atrium: Reception and Closing Remarks
5:25-6:45 Reception
Audience Choice Talk, Audience Choice Poster, and Travel Awards
Closing remarks: Sumbul Khan
6:30 Remove posters

Organizers: Jun Wu, Yan Wang, Sumbul Khan, Olivia Lee, Jia Dong

Sponsors: Office of the Provost, Beckman Institute, The Institute for Genomic Biology, College of Engineering, College of Liberal Arts and Sciences, and the Graduate College

Talk abstracts

1. 1 Bat Robot, an Underactuated Biomimetic Micro Aerial Vehicle with Membranous Wings

Alireza Ramezani (aramez@illinois.edu), Soon-Chung, Seth Hutchinson
Department of Aerospace Engineering, UIUC

Wing kinematics and its morphological properties are crucial in powered flight of flying vertebrates. Bats often demonstrate flight maneuvers in their habitat (mostly high-clutter environments) by employing sophisticated motion patterns of their pelvis, shoulder, elbow, carpus, and phalangeal joints thanks to the crucial features of their skeletal biomechanics and evolutionary musculoskeletal system. In an effort of replicating unmatched flight maneuverability of these mammals, this work explores autonomy algorithms (specifically on control, sensing, planning) and mobility (flight hardware platform) of a Biomimetic Micro Aerial Vehicle (MAV) with membranous wings with the goal of achieving autonomy in flight. The articulated wings of bats with considerable degrees of freedom has limited the understanding of the relation between the flight controllability and the intricate array of physiological and morphological specializations. Here, a MAV with limited wing kinematic--a reduced order model--that consists of the passive and active joints is structured and it is shown this model can grantee the controllability properties. Employing the reduced order model, nonlinear quasi-static aerodynamic forces and nonlinear body dynamic elements are monolithically grouped in form of a single system of equations and it is exposed to a gradient-based finite state optimizer resulting in parametrized wing kinematics. Thereafter, the flapping flight is treated in the framework of model-based nonlinear control scheme wherein the nonlinear feedback enforces the parametrized wing kinematics.

1.2 Identification and localization of putative oviduct glycan receptors ADAM5 and PKDREJ on boar spermatozoa: changes during capacitation and freezing

Meraj Khan (mhkhan@illinois.edu), David Miller
Department of Animal Sciences, UIUC

Before fertilization, spermatozoa are retained in the oviduct, forming a reservoir that prolongs sperm viability. There is evidence that sperm-oviduct interaction is mediated by carbohydrates (glycans) present on oviduct epithelium. Boar sperm bind preferentially with oviduct glycans containing Lewis X trisaccharide (LeX) or multiantennary 6-sialylated N-acetyllactosamine motifs. However, very little is known about the receptors on sperm which bind these glycans. Previous studies suggested that ADAM5 (Adhesion, Disintegrin and Mellanoprotease domain5) and PKDREJ, a polycystin protein, have affinity for both oviduct glycans. The aim of the current study was to identify and localize ADAM5 and PKDREJ on non-capacitated (immature) boar sperm and characterize the changes that occur during maturation (capacitation) and cryopreservation. Identification of ADAM5 and PKDREJ was accomplished by western blot. Result showed a 44 kDa band for ADAM5 in non-capacitated, capacitated and frozen-thawed sperm. PKDREJ antibody also yielded a 44 kDa band in non-capacitated sperm but, in contrast to ADAM5, PKDREJ in capacitated and frozen-thawed sperm also showed lower molecular weight bands. Localization of ADAM5 and PKDREJ receptors was done by incubating sperms with respective antibodies followed by secondary antibody labelled with Alexa Flour 488. Results using both ADAM5 and PKDREJ antibodies showed that fluorescence was restricted to the plasma membrane overlying the acrosomal region of the head, the area predicted for glycan receptors. However, a lower percentage of capacitated and frozen-thawed sperm bound oviduct glycans. We conclude that ADAM5 and PKDREJ are present on boar sperm in the location of predicted oviduct glycan receptors and that sperm maturation and cryopreservation caused degradation of PKDREJ and a reduction in the percentage of sperm that bound both oviduct glycans. The change during maturation may be important for releasing sperm from oviduct. The reduction during cryopreservation might be partially responsible for the reduced fertility of frozen-thawed sperm.

1.3 Relativistic effects in cosmology and the backreaction conjecture

Vincent Reverdy (vince.rev@gmail.com)
Department of Astronomy, UIUC

The anomaly of the accelerated expansion of the Universe has now been there for more than fifteen years and yet remain to be explained. Several theoretical approaches have been investigated to model the phenomenon, leading, amongst other things, to the concordance cosmological model relying on dark energy and dark matter. Most of the current and future observational programs and numerical simulations focus on precision cosmology in order to put constraints on these two mysterious components. But what if dark energy was just resulting from a misinterpretation of data coming from the oversimplification of the problem? In this presentation, I will discuss the foundations and the underlying motivations of the backreaction conjecture which raises the question of relativistic effects of structure formation on the evolution of the Universe. I will present results of simulations of light propagation through large scale cosmic structures and examine the consequences on the interpretation of cosmological data. These results will lead to a discussion on the dynamical counterpart of these effects and open directions of investigations regarding the future of cosmological simulations in the exascale era of high performance computing.

1.4 The Importance of Aerobic Fitness and Physical Activity for the Developing Brain

Laura Chaddock-Heyman (lchaddo2@illinois.edu), Arthur Kramer, Charles Hillman
Beckman Institute, UIUC

Higher levels of aerobic fitness and participation in physical activity are positively associated with cognitive and brain health in children. Higher fit 9- and 10-year-old children outperform lower fit peers on tasks of cognitive control and memory, scholastic achievement and real-world multitasking. These cognitive differences are paralleled by differences in the structure and function of the brain. For example, higher fit children show larger structural volumes in the basal ganglia and hippocampus, as well as different gray matter cortical thickness in frontal, temporal, and occipital cortex, compared

to lower fit children. Children with higher aerobic fitness levels also show greater estimates of microstructure in white matter tracts that travel throughout the brain and assist in efficient communication between gray matter regions. Higher fit children have also been found to show superior brain function during tasks of cognitive control. In fact, children who participated in 60+ min of physical activity, 5 days per week, for 9 months, showed changes in brain activation in the frontal cortex coupled with within-group improvements in performance on a task of attentional and interference control. Children assigned to a wait list control group did not show changes in brain function. Furthermore, at post-test, children in the physical activity group showed similar frontal brain patterns and performance to a group of college-aged young adults. Whereas children in the wait list control group still differed from the young adults in terms of activation and performance at post-test. These results suggest that physical activity during childhood may enhance specific elements of frontal cortex function involved in cognitive control. Given that children have become increasingly sedentary, unfit and overweight, understanding the benefits of aerobic fitness and physical activity on cognition is of great significance. Our results have implications for the biological potential of the brain during periods of maturation and brain development and suggest that the developing brain is plastic and sensitive to lifestyle factors.

1.5 A Genetic Screen in Drosophila melanogaster wing imaginal discs for regeneration mutants

Amanda Brock (arbrock@illinois.edu), Mabel Seto and Rachel K. Smith-Bolton
Department of Cell and Developmental Biology, UIUC

Regeneration is a complex process that requires an organism not only to recognize and repair tissue damage, but also to grow and pattern new tissue. Here we describe a system of genetically induced ablation in the Drosophila larval imaginal wing disc that enables us to perform large-scale genetic screens to identify novel regulators of regeneration. We ablate the wing primordium by inducing apoptosis in a spatially and temporally controlled manner. In order to identify genes that regulate regeneration, we are carrying out a dominant modifier screen using isogenic deficiencies, and assessing the amount and quality of regeneration by examining the adult wings. We have completed a screen of the right arm of the third chromosome. To date we have identified 21 regions that contain a gene that modifies the regenerative response. Here we present the results of our screen, plus the initial characterization of cap-n-collar, a transcription factor that is required for regenerative growth. This screen will enable us to identify and characterize genetic regulators of regeneration.

2.1 Compression-Induced Deformation of Individual MOF Mic

Zhi Su (zhisu@illinois.edu), Kenneth Suslick
Department of Chemistry, UIUC

The deformation and mechanical behavior of individual zeolitic-imidazolate framework (ZIF-8) micro- and submicro-crystals was observed under compression. Young's modulus and volume changes as a function of applied pressure were determined on individual single crystals, offering insights in the relationship among structure, morphology, and mechanical properties. Dramatic volume decreases and amorphization were detected during compression over a pressure range of 0 – 4 GPa for individual 1.2 μm ZIF-8 microcrystals, and the deformed microcrystals partially recovered after pressure release. The orientation and size effects on the mechanical behavior of ZIF-8 nano- and microcrystals were also investigated. The presence of solvates within the pores of the ZIF-8 has a dramatic effect on the mechanical properties of the single crystals. Methanol-solvated ZIF-8 microcrystals are much less deformable than the desolated microcrystals and shatter completely at very low applied force.

2.2 Network-oblivious programmers, network-aware program execution

Karl Palmskog (palmskog@gmail.com), Mads Dam, Peter Dinges, Gul Agha
Department of Computer Science, UIUC

Pools of computing resources, clouds, allow mobile applications and other software to harness massive numbers of interconnected computers - but often require explicit resource procurement by programmers, and, for good performance, knowledge of network characteristics. Based on our research, we argue that programmers should remain oblivious of how programs are executed in a cloud, while being provided with strong guarantees that the computational behavior they expect is preserved. Such guarantees still leave cloud providers considerable room for scaling their infrastructure and managing it efficiently, most directly by dynamically placing units of computation on particular network nodes to meet objectives on both performance and utilization. Mainstream programming languages generally assume that concurrent units of computation have access to a common pool of memory, most straightforwardly by living on the same computer. In contrast, our programming languages assume that units of computation are inherently distributed and communicate only by exchanging messages. In ongoing work, we investigate how shared-memory programs can be automatically translated to the message-passing model, making it possible to execute them efficiently in clouds.

2.3 Contextual Geometric Structures: abstractions of cognition and culture

Bradly Alicea (balicea@illinois.edu)
Department of Crop Sciences, UIUC

The Contextual Geometric Structure (CGS) approach allows for the bridging of dynamical cognitive models with the larger-scale process of population-wide cultural evolution. This involves a geometric representation that combines the spatial environment, cognitive classification, and evolutionary computation. The CGS approach is a form of artificial life inspired by structural anthropology and soft computation. As hybrid models, CGSs not only resemble features of complex societies, but can represent scenarios such as cultural contact to epistemic closure. CGS models exist as an alternative to both more traditional models of cultural evolution based on population genetics and evolutionarily-static cognitive models. Since the dynamics of CGSs are fundamentally geometric, the resulting cultures have defined "shapes", can "intersect", and can "collapse" and "disintegrate". As an evolutionary model, the CGS approach allows us to explore both the structure and function of so-called cultural behaviors. Yet CGS models also allow us to connect the short-term diffusion of beliefs and ideas with longer-term processes such as natural selection. To make

this point more explicit for purposes of future research directions, links between population dynamics and physical models will also be discussed.

2.4 TheraBlob for Ultrasound-mediated Ablation Therapy

Santosh Misra (skmisra@illinois.edu), G. Ghoshal, M. Ye, Z. Wu, M. Gartia, C. R. Bromfield, E. M. Williams, K. V. Tangella, K. Schulten, P. S. Ray, E. C. Burdette, D. Pan
Department of Bioengineering, Department of Materials Science, Beckman Institute, UIUC and Carle foundation Hospital

The use of ultrasound to treat tumors has been investigated in the prostate, the liver, the kidney, the brain, and for various eye conditions. Despite some promising results, current approaches remain highly dependent on operator skill, and cannot treat many tumors because of the lack of précised approach to the zone of necrosis. Here we present a way to conjugate cavitation/sonoporation technique with novel prodrug nanobubbles (Therablob) to enhance tissue penetration and ablation by thermal effects of ultrasound. Bexarotene (Targetrin), a known anti-cancer agent, was conjugated to 1-palmitoyl-2-azelaoyl-sn-glycero-3-phosphocholine to produce “Therablob” by incorporation of C3F8 in the core of pro-drug nanoparticles. Molecular dynamic simulations, Dynamic light scattering, zeta potential, Raman spectroscopy and electron microscopic analysis indicated stability of these particles and response under US exposure. Cell viability and bright field microscope show high efficacy and statistically significant cellular mortality (~60 %) for US exposed cells indicating stimuli-triggered delivery Therblobs. Ex-vivo experiments were performed on Pig liver tissues to establish highly significant localised necrosis patterns on treated sites. Thus synergistic use of Pro-drug controlled cancer targeting and US-triggered drug delivery accompanied by thermal therapy will provide unparallel safety and enhance treatment success with significant lower dose of the drug in comparison to the usual systemic clinical dose.

2.5 Effect of Subject Imageability in Subject-Verb Agreement

Aazam Feizmohammadpour (afeiz@illinois.edu), Wind Cowles
Department of Linguistics, UIUC; Linguistics Department, University of Florida

In this study, we tested the effect of imageability of subject noun in subject-verb agreement in Persian. Using elicitation of errors, Eberhard (1999) reported the effect of conceptual number in agreement; the participants produced more plural verbs with concrete distributive nouns. Persian, like many other languages, has subject-verb agreement. However, the agreement is optional when the subject is inanimate plural noun. This feature of Persian provided us with the situation to have experimental materials with inanimate plural subject nouns that allowed the grammatical use of either singular or plural morphology on the verb (no need for elicitation of errors or ambiguous sentences). In a completion task, 24 native speakers of Persian were instructed to repeat a series of preambles aloud and then complete the sentences. The target preambles consisted of an inanimate plural subject noun (concrete or abstract) plus the non-verbal part of a compound verb. Participants’ responses were coded for singular vs. plural verbal part. The results showed the effect of imageability of subject noun; more mismatched verb used with abstract subjects (70%) compared to concrete ones (45%). This confirms the influence of conceptual factors on subject-verb agreement.

3.1 Highly Accelerated Imaging and Image Reconstruction Using Adaptive Sparse Representations

Saiprasad Ravishankar (ravisha3@illinois.edu), Yoram Bresler
Department of Electrical and Computer Engineering and Coordinated Science Laboratory, UIUC

Natural signals and images are well-known to be approximately sparse in transform domains such as Wavelets and DCT. This property has been heavily exploited in various applications in image processing and medical imaging. Compressed sensing exploits the sparsity of images or image patches in a transform domain or synthesis dictionary to reconstruct images from undersampled measurements. In this work, we focus on blind compressed sensing, where the underlying sparsifying transform is a priori unknown, and propose a framework to simultaneously reconstruct the underlying image as well as the sparsifying transform from highly undersampled measurements. The proposed block coordinate descent type algorithms for image reconstruction involve highly efficient closed-form optimal updates. Importantly, we establish that although the proposed blind compressed sensing formulations are highly nonconvex, our algorithms converge to the set of critical points of the objectives defining the formulations. We illustrate the usefulness of the proposed framework for magnetic resonance image reconstruction from highly undersampled k-space measurements. As compared to popular previous methods involving the synthesis dictionary model, our approach is much faster, while also providing promising reconstruction quality.

3.2 The strain induced self–rolled-up tube device platform for electronics and photonics applications

Xin Yu (xinyu82@illinois.edu), Lynford Goddard, Xiuling Li, Oliver Chen
MNTL, UIUC

I will present a novel strain induced self–rolled-up tube device platform for electronics and photonics applications. The materials of the tubular nano-membranes have been studied for a dozen of years, because of its novel 3D coiled structures with from sub-microns to microns of inner diameter, which is determined by the residual stress, young's modulus and thickness of membranes. Compared to single and compound crystalline semiconductors, the amorphous silicon nitride (SiNx) attracts more attentions on electrical, optical and biological applications, because of low-cost and compatibility to standard silicon process. Employing this 3D SiNx tubular platform, we have developed on-chip tube inductor and monolithic integrated vertical optical coupler. Compared to the planar spiral inductors with similar inductances and Q factors, the footprint of tube inductors are reduced by as much as two orders of magnitude, the frequency at peak Q factor improve more than 5 times. As well as, I will demonstrate the first monolithically integrated SiNx tube based vertical photonic coupler on top of a planar ridge waveguide. Strong light coupling between the vertical coupler and the waveguide

was observed experimentally, which provided a novel route for 3D heterogeneous photonic integration.

3.3 Exercising decision making strategies using dashboards

Vance Martin (vmart02s@illinois.edu)
National Center for Professional and Research Ethics, UIUC

"Big data" and "data science" are becoming more prominent. With more data comes the ability to make better decisions about many facets of our personal and professional lives. What decisions are we making, what data are we using, and does that lead to better decisions? The National Center for Professional and Research Ethics (NCPRE) has been working with administrators to understand sound data-informed decision-making. As part of this initiative, we have developed dashboards illustrating university departmental information. These dashboards have been developed using real, public data of university departments, to create a mostly graphical display of: departmental demographics, financial vitality, scholarly indicators, and educational indicators. These dashboards contain twenty five separate graphs as well as numerical data, to offer a snapshot of a department. This method of assessing academic units is becoming more common and raises important questions. Which data should be used to assess an academic unit, and how? What trends can data usefully illuminate? What other data are necessary to help make more informed decisions? What caveats must be applied? These are the issues we plan to discuss.

3.4 Ambient and Thermal Stability of Black Phosphorus Films and Devices

Joshua Wood (joshua.wood@northwestern.edu), S. A. Wells, X. Liu, D. Jariwala, K.-S. Chen, E. Cho, V. K. Sangwan, L. J. Lauhon, T. J. Marks, and M. C. Hersam
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Black phosphorus (BP) is a two-dimensional, semiconducting allotrope of phosphorus, demonstrating uses in nanoelectronics and photonics. Despite an extensive history of BP crystal synthesis, little is known about the ambient and thermal stability of BP films with nanoscale thickness. We determine exfoliated, unencapuslated BP flakes chemically degrade to oxidized phosphorus compounds after modest ambient exposure. When we place BP on hydrophobic substrates, it degrades two fold faster than on hydrophilic substrates, incriminating O2 saturated H2O as a major source of ambient BP oxidation. Unencapsulated BP field-effect transistors (FETs) decrease in mobility and current on/off ratio by factors of 1000 in only 48 hours in ambient. Conversely, AlOx encapsulated BP flakes do not chemically degrade. AlOx encapsulated BP FETs possess mobilities of ~100 cm2V-1s-1 and on/off ratios of 1000 for over one month in ambient. Finally, basic thermal stability parameters for exfoliated BP are unknown. Using scanning/transmission electron microscopy, we find that exfoliated BP sublimes at ~400 °C, in contrast to the bulk temperature. Ultimately, the thermal decomposition begins at eye-shaped cracks along the [001] direction, culminating in an amorphous, red phosphorus like skeleton. Our thermal stability studies will provide insight for phase transformations and self-heating in exfoliated BP structures.

4.1 Memory effect in sheared cross-linked actin networks

Sayantan Majumdar (majumdar@uchicago.edu), Margaret L. Gardel
James Franck Institute, University of Chicago

Is it possible to control the bulk shear modulus of a material mechanically? We reconstitute a network of cross-linked actin filaments and show that the system has remarkable property to respond under shear reversibly in a deformation history dependent manner. When a large shear stress pulse is applied to the system, the system remembers the direction of deformation long after the stress pulse is removed. For next loading cycle, shear response of the system becomes anisotropic; if the applied pulse direction is same as the previous one, the system behaves like a visco-elastic solid but a transient liquefaction is observed if the pulse direction is reversed. Further experiments suggest that this anisotropic response comes from stretching dominated and bending dominated deformation directions induced by the large shear deformation giving rise to a direction dependent mechano-memory. The long time scale over which the memory effect persists has relevance in various deformations in cellular and multi-cellular systems.

4.2 Can the BIOCRO model simulate transpiration of elite coppiced willow genotypes that achieve high biomass production with very different canopy structures?

Timothy Wertin (twertin@illinois.edu), David LeBauer, Timothy A. Volk, Stephen P Long and Andrew DB Leakey
IGB, UIUC

Biofuels have the potential to meet future energy needs. Coppiced hybrid willow is among the most promising woody biofuel sources. However, models used to assess the potential viability and sustainability of production by willow in the northeastern, USA remain unsophisticated. Most significantly, models do not explicitly represent the coppiced growth form. This study tests the ability of a canopy model to predict water fluxes in two highly productive, but structurally distinct hybrid willows (Salix miyabeana and Salix purpurea) grown in central NY. S. miyabeana has only a few, large diameter stems per stool prior to harvest, while S. purpurea maintains numerous, small diameter stems until harvest. Canopy structure also varies substantially within a growing season. For example, in S. sachalinensis stem number decreased by 40% while total basal area increased by 50% within year 2 of the third coppice cycle. Sensitivity of predicted fluxes to variation between genotypes in key physiological parameters is tested. Model predictions of water use, compared with measured stand transpiration, were dramatically improved by using genotypic specific parameters compared to generic willow or deciduous hardwood parameters highlight the need to accurately and specifically calibrate process based models to achieve accurate and reliable water flux estimates.

4.3 Moms matter: Maternal social stress in zebrafish

Jennifer Jeffrey (jenjeffrey@gmail.com), Kathleen M Gilmour
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Social stress results in chronically elevated levels of cortisol, the main glucocorticoid stress hormone in fish, in subordinate individuals. The objective of the present study was to evaluate the effect of maternal social status/stress on development and activity of the stress axis in zebrafish (Danio rerio). Eggs from female zebrafish, confined in pairs for 48 h to establish dominant/subordinate hierarchies, were fertilized in vitro and sampled up to 144 hours post-fertilization (hpf). Even in the absence of differences in maternal cortisol contribution (thought to be a key programmer of offspring phenotype), once zebrafish offspring began to synthesize cortisol de novo (48 hpf), larvae of dominant females exhibited significantly lower baseline cortisol levels compared to offspring of subordinate females. The lower cortisol levels in these fish may have resulted from reduced hypothalamic-pituitary-interrenal (HPI) axis activity, as corticotropin-releasing factor (CRF) and cytochrome P450 side chain cleavage enzyme (P450scc) mRNA levels also were lower in larvae from dominant than subordinate females at 48 hpf. Furthermore, at 144 hpf, maternal subordinance significantly decreased larval stress-induced levels of cortisol. Together, these results suggest maternal programming by both maternal dominance (48 hpf) and subordinance (144 hpf) of stress axis function in zebrafish offspring.

4.4 **Quantum dissection of a covalent bond**

Norm Tubman (ntubman@illinois.edu), ChangMo Yang
Physics, UIUC

Introductory chemistry textbooks present molecular orbital theory as the main explanation of how covalent bonding works in molecules. Unfortunately, more sophisticated theories are generally much more complicated and less useful. Molecular orbital theory works for many systems, and has been applied extensively. However, there are many systems in which it fails, which involves some very simple systems. We take the ad hoc aspects of molecular orbital theory, that have been in place for decades, and replace them with rigorous properties that are generated from the field of quantum information and entanglement. Quantum entanglement has been instrumental in recent breakthroughs with regards to applications in quantum computing, string theory, black holes, and topological phase transitions. These same ideas also happen to encode how molecules form covalent bonds. In our work we present a new theory for describing bonding in molecules that completely supersedes molecular orbital theory. Everything that was already well described in molecular orbital theory still retains the same description, but our new theory now includes the important many-body fluctuations and correlations that were missing. Our main results include resolving the controversies of the bonding in the carbon and beryllium diatomic molecules.

Posters abstracts

5.1 Functional and Evolutionary Characterization of the CONSTANS Gene Family in Short-Day Photoperiodic Flowering in Soybean

Faqiang Wu, Brian William Price, Waseem Haider, Gabriela Seufferheld, Randall Nelson, Yoshie, Hanzawa
Department of Crop Sciences, UIUC

CONSTANS (CO) plays a central role in photoperiodic flowering control of plants. However, much remains unknown about the function of the CO gene family in soybean and the molecular mechanisms underlying short-day photoperiodic flowering of soybean. We identified 26 CO homologs (GmCOLs) in the soybean genome, many of them previously unreported. Phylogenic analysis classified GmCOLs into three clades conserved among flowering plants. Two homeologous pairs in Clade I, GmCOL1a/GmCOL1b and GmCOL2a/GmCOL2b, showed the highest sequence similarity to Arabidopsis CO. The mRNA abundance of GmCOL1a and GmCOL1b exhibited a strong diurnal rhythm under flowering-inductive short days and peaked at dawn, which coincided with the rise of GmFT5a expression. In contrast, the mRNA abundance of GmCOL2a and GmCOL2b was extremely low. Our transgenic study demonstrated that GmCOL1a, GmCOL1b, GmCOL2a and GmCOL2b fully complemented the late flowering effect of the co-1 mutant in Arabidopsis. Together, these results indicate that GmCOL1a and GmCOL1b are potential inducers of flowering in soybean. Our data also indicate rapid regulatory divergence between GmCOL1a/GmCOL1b and GmCOL2a/GmCOL2b but conservation of their protein function. Dynamic evolution of GmCOL regulatory mechanisms may underlie the evolution of photoperiodic signaling in soybean

5.2 Frequency Spectroscopy. Towards the understanding the CO2 electroreduction on ionic liquid-metal

Natalia Garcia Rey, Dana D. Dlott
Department of Chemistry, UIUC

Understanding the molecular dynamics on buried electrodes is of significant interest in electrochemistry. There is a big gap of knowledge in the CO2 electroreduction mechanism due to the limitations to access to the liquid- metal interface. Vibrational Sum Frequency Spectroscopy (VSFS) is a non-invasive and surface sensitive technique, with molecular level detection that can be used to probe electrochemical reactions occurring on the electrolyte-electrode interface [1]. In this study, we observed the CO2 electroreduction to CO in ionic liquid on poly Ag using VSFS synchronized with cyclic voltammetry. In order to follow the CO2 reaction in situ on the ionic liquid-Ag interface, the CO, CO2 and imidazolium vibrational modes (resonant SFS) were monitored as a function of potential. We identified at which potential the CO was produced and how the EMIM+-BF4- played an important role in the electron transfer to the CO2, lowering the intermediate, CO2- , energy barrier. We also present a new approach to reveal the double layer dynamics to the electrostatic environment by the study of the nonresonant SFS as a function of potential. In this analysis, we observed a strong third order effect in the susceptibility of the high electric field created in the double layer [2]. Finally, we discuss the intrinsic technical difficulties of probing deeply buried electrodes, as the IR absorption from the species of the electrolyte and how we tackled this problem.

5.3 Dynamic Label-free Live Cell Imaging With Photonic Crystal Enhanced Microscopy (PCEM)

Yue Zhuo, Ji Sun Choi, Hojeong Yu, Brendan A.C. Harley, Brian T. Cunningham
MNTL, UIUC

The complex interaction between cells and the extracellular matrix (ECM) molecules is an essential element of the regulation and mediation of various cellular activities, including adhesion, migration and differentiation. In this work, we utilize a near real-time imaging modality (named Photonic Crystal Enhanced Microscopy -PCEM) using a photonic crystal (PC) biosensor surface and a newly developed label-free microscopy system to dynamically image live cell adhesion profiles. In PCEM, the reflected color of the PC surface is locally tuned by the attachment of cell components within a ~200 nm deep evanescent electric field. The PC nano-structure prevents lateral light propagation, enabling the PCEM system to gather high resolution images (0.5 micron pixels) of cell attachment in near-real-time (10 seconds per image) for extended time periods, using low intensity broadband illumination. Therefore, as a label-free imaging system, PCEM does not suffer from limitations such as fluorescence photobleaching, and can quantitatively measure the dynamic cellular material change and cell–ECM interactions (within the sensing zone) atop of PC surface. It can also be applied with substrates functionalized with different types or concentrations of ECM molecules, and thus can be broadly used in many extracellular conditions

5.4 That reminds me: The influence of prior episodes on current behavior

Jonathan Tullis, Aaron Benjamin, Brian Ross
Indiana University

One aspect of successful cognition is the efficient use of prior relevant knowledge when navigating novel situations. Remindings – stimulus-guided retrievals of prior episodes – allow us to link prior knowledge to current problems by prompting retrieval of relevant knowledge from events that are distant from the present. Here, I explore the causes and consequences of remindings for interpretation and memory. I will present research showing how remindings bias the interpretation of ambiguous stimuli, that memory for the first item in a reminded pair is enhanced, and that the benefits of remindings depend upon the association and lag between related presentations. Remindings are an important cognitive mechanism that enables our past experiences to influence our current behavior.

5.5 Enabling Multiplex genome engineering in yeast by RNAi and CRISPR

Tong Si, Ran Chao, Huimin Zhao
IGB, UIUC

Successful metabolic engineering practice often requires simultaneous manipulation of many genes. Whereas recombination-based genetic engineering (recombineering) is able to create combinatorial genetic diversity on a genome scale, such method is mainly limited to bacterial cells. Here we report a strategy that can generate multiplex modifications in the Saccharomyces cerevisiae genome, by combining the advances in full-length cDNA library construction, RNA-interference technology and CRISPR-Cas system. Briefly, upon introduction of specific double-stranded breaks (DSBs) in the repetitive sequences by CRISPR-Cas nucleases, both the overexpression and knockdown cassettes of every yeast gene can be integrated at high efficiency into the genomic loci of repetitive sequences. This process may be iteratively performed to accumulate dozens of genetic modifications in a single cell of an evolving yeast population. We are automating this process through an integrated robotic platform, enabling generation of vast genetic diversity from which new or improved properties may emerge. We envision this new tool can greatly accelerate genome engineering in S. cerevisiae for basic and applied biological research and medicine.

5.6 Multiplexed detection of clinically-relevant biomarker panels using a silicon photonic biosensing platform

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In recent years, major advances related to improving the sensitivity and specificity have been achieved in biomolecular detection, with direct applications for biomarker-based clinical diagnostic. Accordingly, significant effort has been focused on the development of clinical decision-support tools to help physicians to diagnose and monitor the progression of a wide spectrum of diseases and disorders. However, additional improvements related to the accuracy of results obtained, the level of multiplexing, assay time, and sensitivity remain to be achieved. In support of these goals, our group has developed a multiplexed silicon photonic technology that enables the rapid detection of biomarker panels at low concentrations. We have applied this platform to the detection of several biomarker panels of high clinical interest, as are related to cardiological and respiratory diseases, and many types of cancer. The technology is generally applicable to the detection of a wide range of biomarkers, and we have recently added the capability to detecting more than 20 new biomarkers for different diseases. Additionally, we have optimized many aspects of assay performance that we feel position the platform as a promising technology for the point-of-care detection of clinically-relevant biomarker panels that require moderate levels of multiplexing, good sensitivity, and rapid time-to-result.

5.7 Fighting ROS and Aging Related Diseases

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Reactive oxygen species (ROS) are associated with a number of aging related diseases in humans, such as cancer, Alzheimer's Disease, and cardiovascular disease. Research suggests that diets rich in phenolic antioxidants may help prevent the onset of these diseases by preventing oxidation damage caused by ROS. However, a multitude of cross-sectional studies conducted in developed countries, including the United States, showed that consumption of fruits and vegetables traditionally recognized for containing high levels of phenolic antioxidants follows a socioeconomic gradient. Low socioeconomic status groups, defined by lack of education and income, tend to consume cheap, highly processed, and energy-dense foods rather than fruits and vegetables containing phenolic antioxidants. However, grains, especially maize, are known to possess high amounts of phenolic antioxidants. Furthermore, grains are key ingredients in processed snack foods and ready-to-eat cereals. As a first step toward improving the phenolic antioxidant content of maize-endosperm based foods through breeding, the variation in type and quantity of phenolic antioxidants such as ferulic acid, p-coumaric acid, and sinapic acid were examined in elite U.S. maize germplasm typical of that used in the production of maize-endosperm based foods.

5.8 Big Data-Theoretic Foundations and Algorithm for Probabilistic Risk Assessment of Complex Socio-Technical Systems: Application to Nuclear Power Safety

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Organizational Failure Mechanisms (OFMs) have contributed as root causes in major accidents. The ability to detect and quantify organizational weakness is critical for the improvement of performance, and ensuring the safety of workers, the public and the environment. Probabilistic Risk Assessment (PRA), a pillar of Nuclear Regulatory Risk-Informed decision-making, is an effective tool for calculating risk from the interactions of equipment and human error; however, it cannot explicitly assess risk of specific OFMs. To incorporate these factors into technical system PRA, the Socio-Technical Risk Analysis (SoTeRiA) framework was developed, considering systematic causality among theoretical constructs at multiple levels of analysis, for social aspects (e.g., safety culture) and structural features of organizations. This research demonstrates the first application of Big Data for PRA by introducing (1) the Big Data-Theoretic; a philosophy and epistemological approach that uses theory to guide analytics in big data science, and (2) the Big Data-Theoretic Algorithm; a technique for extracting and interpreting organizational performance information from unstructured textual communications. This research provides practical contributions to organizational science and risk analysis, proving that the influence of OFMs can be; quantified, demonstrated in nuclear power safety, and applied in diverse high-hazard industries (e.g., aviation, healthcare, and oil and gas).

5.9 Stimulation of executive-control brain regions influences sentence processing

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Recent research demonstrates that performance on executive-control measures can be enhanced through brain stimulation of prefrontal regions (i.e., inferior frontal gyrus, IFG). Separately, psycholinguistic work emphasizes the importance of executive-control during sentence processing,

especially when readers or listeners must override early, incorrect interpretations when faced with temporary ambiguity. We explore whether modulating executive-control via high-definition transcranial direct current stimulation of left IFG has discriminate effects on syntactic ambiguity resolution, versus unambiguous forms not requiring revision/executive-control (While Anna dressed the baby cried loudly; The baby cried loudly while Anna dressed). Comprehension questions that probe the ambiguity (Did Anna dress herself?) were presented. Participants were randomly assigned to receive Active (anodal) or Control (sham) stimulation over left IFG while they processed sentences in a word-by-word self-paced reading task and performed an n-back memory task containing interference lure items that also rely on executive-control. As hypothesized, only conditions requiring executive-control (ambiguous sentences; n-back lures) improved for the Active, but not the Control stimulation group. Importantly, performance on task conditions was unaffected when the need for executive-control was removed. Together, these findings add to the mounting evidence that suggests a mediating role of left IFG for executive-control processes supporting linguistic and non-linguistic measures.

5.10 Poly(A) binding protein C1 is developmentally regulated and controls cardiac hypertrophy

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Posttranscriptional regulation of gene expression is highly important in development and disease and can be controlled at many levels. Although majority of studies to date have focused on mRNA splicing, mRNA transport, mRNA stability little is known about role of translation control in regulating gene expression in eukaryotes. Lack of correlation between mRNA level and protein in the cells have further highlighted the importance of translational control. This proposal aimed to determine role of translational regulation of Pabpc1protein expression and its role in mouse heart development and hypertrophy. PolyA binding protein C1 (PABP C1) specifically binds the polyadenosine tail of mRNA and have been shown to be important for RNA polyadenylation, translation initiation, and mRNA stability. Although constitutively expressed in all tissues, its expression in heart is developmentally regulated. However, its re-expression in cardiac hypertrophy is puzzling. Cardiac hypertrophy is major hallmark of heart failure. Development of cardiac hypertrophy is complex process and it is essential to identify molecular events involved in the hypertrophic process. Here we show novel role of polyA tail length in controlling Pabpce1 expression. In this study I will analyze polyA tail length of Pabpc1 mRNA and its lack of translation in adult but re-expression in hypertrophic heart. Next I will analyze the whether Pabpc1 re-expression is necessary and sufficient to cause cardiac hypertrophy. Further I will analyze how Pabpc1 modulates signaling pathway in cardiac hypertrophy. Findings from this study will provide novel insight into role of translational control via polyA tail length in Pabpc1 expression and its impact on cardiac hypertrophy.

5.11 High fat diet induced DNA methylation at transcription factor binding region and repressed gene expression of a metastasis suppressor E-cadherin in primary site of murine metastatic breast cancer (MBC), and promoted invasion of MBC cells to lung and liver of BALB/c mice

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High fat diet (HFD) is associated with increased BC risk. We aimed to examine the effects of a HFD (47% kcal from fat) on metastatic breast cancer (MBC) using preclinical mouse models. To access the dietary effect on metastatic mammary tumor, we injected MBC cells into mammary duct of BALB/c mice. To evaluate the dietary effect on MBC invasion from bone to other tissues, MBC cells were inoculated into tibia cavity of BALB/c mice. Growth and invasion of MBC were monitored in real-time by bioluminescence imaging (BLI). Three weeks post injection, animals were sacrificed and tissues were collected. HFD promoted invasion of MBC to lung and liver of mice. H&E staining showed HFD-fed mice developed 50% more lung tumors than control-fed mice after tibial injection, and 7 out of 16 HFD-fed mice versus 0 out of 17 control-fed mice developed liver tumors. Expression of Cdh1, a metastasis suppressor, was decreased by HFD. Intensity of methylation at a CpG-rich promoter region of Cdh1, was increased by HFD in mammary tumors. As the first to report that HFD induced DNA methylation and decreased expression of Cdh1 in metastatic mammary tumor, we proposed a mechanism by which HFD enhanced the invasiveness of MBC.

5.12 Characterization of the chloroplast inner membrane protein Bass6

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Improving photosynthetic efficiency has been a long standing goal toward increasing output and crop yield. As climate changes globally and human population increases there is a growing demand to adapt and improve agricultural production on ever limiting land and water availability. Roughly 25% of Rubisco activity is the fixation of oxygen instead of carbon dioxide resulting in the conversion of RuBP to one molecule of phosphoglycerate and one molecule of glycolate. C3 plants recover the carbon in glycolate through the C2 photorespiratory pathway. The C2 pathway uses energy in the form of ATP and reducing equivalents and loses fixed CO2 resulting in a reduction in photosynthetic efficiency by 30%. Though the soluble proteins involved in photorespiration are well characterized information on the transport processes are limited. We characterized T-DNA insertion lines in Arabidopsis of chloroplast inner membrane proteins for defects in photorespiration utilizing a fluorescence based screen. Our results identifed the Na / Bile acid symporter BASS6 as a previously unknown chloroplast inner membrane protein involved in photorespiration The Arabidopsis bass6-1 T-DNA plants exhibit a classic photorespiratory phenotype (lethal or slow growth) that is rescued at elevated CO2 concentrations, as well as show reduced photosynthetic rates. In addition, genetic complementation in yeast suggests that BASS6 protein is able to transport glycolate and glycerate two known photorespiratory intermediates. There have been multiple photorespiratory bypass pathways engineered into Arabidopsis to reduce the loss of CO2 and utilize less energy but modelling suggests the majority of glycolate produced is

still shuttled through the endogenous photorespiratory pathway. Identification and characterization of chloroplast inner membrane transporters involved in photorespiration will provide insight into the development of improved bypass strategies increasing photosynthetic efficiency in C3 crops by upwards of 20% potentially increasing crop yield.

5.13 Microstructural characterization of potato discs during frying using X-ray micro computed tomography

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Microstructural properties play a key role to affect oil uptake and product quality during frying of foods. The objective of this study was to observe the complex micro structural changes and mass transfer mechanism of fried potato discs during frying. Potato discs (thickness~1.65mm) were fried at 190 °C for 0, 20, 40, 60 and 80 s. X-ray micro computed tomography was used for three dimensional (3D) imaging of microstructure of porous potato discs for different frying durations. Total porosity, pore size distribution, oil content and air content of potato discs were measured from resulting 3D data sets. Oil and air content measured by analysis of micro CT images followed trends similar to SOXTEC and air content methods, respectively, which validated the imaging analysis procedure. Image analysis showed a significant change in pore size distribution as a function of frying time. Frying time was also observed to have an effect on tortuosity, which is an important microstructural transport property. Tortuosity was measured by path length ratio method from 3D data sets obtained from image analysis. A linear relationship was established between porosity and tortuosity where tortuosity decreased with the increase of porosity. It was also observed that during frying, oil content increased with the decrease of tortuosity. This phenomenon indicated that the lower tortuosity created a less complicated and sinuous path, thus resulting in less resistance in oil penetration. Micro CT technique can be an effective tool for quality control of fried foods without performing tedious trial-and-error method.

5.14 Multi-Scale Multi-Physics Computational Electromagnetics Using Equivalence Principle Algorithm

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The conventional integral equation-based solvers have difficulty dealing with large and multi-scale multi-physics problems. Disparate meshing (nonuniform meshing), where some parts of the mesh are much denser than the other parts, results in the coexistence of varied physics (i.e., ray physics, wave physics, and circuit physics) in different regions and consequently an ill-conditioned matrix system with slow convergence or no convergence. Equivalence principle algorithm (EPA), as a domain decomposition method, has shown a great potential to address some of these issues. The equivalence principle algorithm initially divides an original large problem into smaller ones by defining appropriate enclosing surfaces, and then solve each of them independently. Later, it uses the equivalence principle or Huygens' principle to move the solutions to the surface and stitch them together to produce a solution for the original problem. This provides a level of parallelization of the solution, flexibility for selecting the mesh strategy, its reuse, and also improved condition number of the matrix system. As a result, EPA not only can solve classical problems but also target new applications such as photonic crystals, radio frequency identification (RFID)tags, nano-scale structures, metamarials, pixelled antennas, plasmonic nano-particles, and solar cells.

5.15 Soil fungal community composition and ecosystem functioning in restored tallgrass prairies managed for bioenergy

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In the Midwest, there is increasing interest in managing ecosystems for both commodity production and ecosystem services. However, it is unclear how these practices may impact soil communities that provide key ecosystem services. Because soil fungi are critical to storing and cycling plant nutrients and carbon (C), we evaluated soil fungal communities and soil C and nutrient resources in three bioenergy production systems: continuous corn monoculture and reconstructed tallgrass prairie with and without inorganic nitrogen (N) fertilizer. Fungal community richness and diversity were ~45% greater in both prairies compared with corn (Prich=0.04, PH'=0.009), and there were more unidentified fungi in prairies (P=0.001). Corn communities were associated with available nutrients including extractable N (P=0.003) and total phosphorous (P=0.02). Root biomass (P=0.005), microbial biomass C (P=0.009) and N (P=0.02), and total C and N (P=0.04) were most highly correlated with fungal communities in both prairie types. Addition of inorganic N fertilizer did not alter fungal community establishment in prairie; however, extracellular enzyme activity (P=0.04) and total soil C and N (P=0.02) were greater in fertilized prairie than unfertilized prairie. Thus, management for optimized aboveground primary production can also meet goals for improved ecosystem services including soil C and N retention and storage.

5.16 Element Intermixing and Cu-rich Domains at PVD-CdS/PVD-CuIn1–xGaxSe2 Heterointerfaces

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Elemental intermixing across the CdS/Cu(In,Ga)Se2 (CIGS) heterojunction is a leading factor affecting the efficient separation of photo-generated carriers in CIGS photovoltaic devices. Here we systematically study the intermixing for all-PVD fabricated CdS/CIGS heterojunctions using scanning transmission electron microscopy and energy dispersive X-ray spectroscopy spectrum imaging. We observe the presence of high-quality epitaxial regions of both zincblende (zb) and wurtzite (wz) CdS at the interface. Furthermore we observe local regions with high Cu contents in the CdS. We find the buffer crystal structure additionally influences the extent of Ga depletion at the CIGS surface which are more pronounced in zb-CdS. Density functional theory calculations reveal that and more pronounced Ga depletion layer in zb-CdS and Cu rich layer parallel to the interface in both phases can be attributed to differences in CIGS point-defect migration barriers and the inherent anisotropy of CdS

respectively. Understanding the influence of these effects on device properties is a critical step in developing more efficient CdS/CIGS-based photovoltaics.

5.17 Nonlinear reference phases in synthetic optical holography

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In synthetic optical holography (SOH), a hologram is assembled point by point in a scanning optical system. This lets us perform holographic experiments in situations where a reference would be difficult or impossible to construct, such as in near-field microscopy. It also provides the opportunity to study and implement nonlinear reference phases.

5.18 Tumor Microenvironment Responsive Nanoparticles for siRNA Delivery Using Cationic Cell-penetrating Peptides

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RNA interference (RNAi) holds broad potential as a therapeutic to specifically silence abnormal genes in tumor treatments. To achieve RNAi, appropriate delivery systems are required to transport small interfering RNA (siRNA) to the target cells. Cationic helical cell-penetrating polypeptides possess unique advantages of both therapeutic gene drugs loading and excellent cell-penetrating ability. To optimize the siRNA delivery systems, linear anionic poly-glutamic acids with flexible chains were introduced to facilitate the interaction between siRNA and cationic helical cell-penetrating polypeptides yielding nanoparticles. To further increase the in vivo stability and achieve tumor-specific delivery, extra poly-glutamic acids were used as the coating. The coated nanoparticles were proved to be negatively charged and stable in serum. In acidic tumor microenvironment, the poly-glutamic acids could be protonated and dissociate from the nanoparticles with the help of cationic proteins in tumor extracellular matrix such as collagen. The de-coated nanoparticles could play their cell-penetrating effects evidenced by improved siRNA accumulation and retention in tumor sites after intravenously administration. The tumor growth inhibition was observed after injections of nanoparticles loaded with therapeutic siRNA in tumor bearing mice. The siRNA delivery nanoparticles designed in this study hold great promise for further clinical RNAi based tumor gene therapy.

5.19 DMRG study of Many-Body Localization

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Numerical studies on many-body localization (MBL) problems have heavily relied on exact diagonalization (ED) techniques so far which has severely limited the system size that can be studied. Here we report a density matrix renormalization group (DMRG) based method for simulations in the many-body localized phase allowing us to reach system sizes inaccessible to ED. We describe our techniques and report on our results applying DMRG to larger systems.

5.20 Facile Size Controlled Synthesis of Carbon Nanoparticles

Aaron Schwartz-Duval, Jasleena Singh, Dipanjan Pan
Department of Bioengineering

Herein, we report facile methods for preparing monodisperse carbon nanoparticles of tunable sizes (8- 250 nm) by manipulating the concentration of the carbon source and particle incubation time. Carbon nanoparticles have thus far been utilized as infra-red, fluorescent, and photoacoustic probes to noninvasively locate pathologies while remediating said pathologies through delivery of therapeutics. Nanoparticle imaging probes and drug delivery systems have advantages over systemic delivery in that they can concentrate the imaging contrast agent/drug, elicit controlled release/degradation, and have a high surface area to volume ratio beneficial for attaching targeting ligands. The size of these nanoparticles affects delivery/retention, degradation rate, clearance, and sometimes the radiological properties of the particles. Our methods have the ability to fabricate carbon nanoparticles of concise sizes ranging from 8 – 250 nm and will likely prove fundamental in the current medical track where personalized medicines are on the front. The true advantage is in the simplicity of the preparation, being slightly less involved than preparing caramel.

5.21 Influence of epicuticular physiochemical properties on porcine rotavirus attachment to 24 salad vegetables

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Foodborne diseases are a persistent problem in the United States. Fresh produce, especially those used as raw foods like salad vegetables, can be contaminated causing food poisoning. In this study, we conducted viral attachment assays with porcine rotaviruses (OSU strain) on 24 genotypes of leafy vegetables and tomato fruits. We also characterized the physiochemical properties of each produce's outermost surface layer, known as the epicuticle. We found significant negative correlations between viral attachment and the concentrations of alkanes, fatty acids, and total waxes on the epicuticular surface. Based on the epicuticular physiochemical properties partial least square prediction model was constructed, which can explain 62% of viral attachment. Three-dimensional crystalline wax structures on the epicuticular surface were found to significantly contribute to inhibition of viral attachment to the produce surfaces. Porcine rotaviruses were found to be attached to a wide range of different genotypes of produce, even after three washing treatments with phosphate buffer. Up to 10.8 % of the originally applied viral particles adhered to produce surfaces after these treatments, suggesting a potential public health concern regarding the rotavirus contamination of the produce.

5.22 In situ 7Li NMR and ab initio structure search of discharge products in the lithium-sulfur battery

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Next generation battery systems must go beyond the current, ubiquitous Li-ion intercalation technology which uses relatively scarce resources and exhibits a fundamentally low capacity limitations. In order to progress toward more sustainable and lighter weight systems, chemistry involving more intensive conversion reactions must be considered. To this end, the Li-S battery system is an ideal candidate due to the extremely high theoretical gravimetric capacity of S, which is 5 times that of the intercalation materials, and its world-wide abundance. The reduction of S that occurs during discharge of the Li-S battery involves a variety of steps which are currently poorly understood due to the difficulty in characterizing the transient species and the various phases of species that are formed. We have used in situ 7Li NMR to characterize these species and show the evolution of solubilized vs. solid Li+ containing species during S reduction (discharge). The 7Li NMR clearly shows a solid phase forming early in the discharge process which invalidates the currently accepted mechanistic picture of a step-wise reduction of S. Additionally, ab initio structure search calculations suggest that this phase is most likely Li2S. We have used the information gained in both the experimental in situ 7Li NMR studies and the ab initio calculations to develop a ternary diagram which accurately describes not only our results, but the trends observed in the literature.

5.23 Distributed Production of Ready-to-Use Gasoline/Diesel from Low Value Waste Plastics

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Plastic constitutes 12% of municipal solid waste in the US and out of this only 9% of the plastic is recovered. Therefore, waste plastic is becoming a major issue for the solid waste management industry because of the growing cost of landfilling. Aside from the challenge of plastic waste disposal, another global issue is the energy crisis. Transportation consumes one third of the world's energy. US itself consume 200 billion gallons of liquid fuel every year. The challenge of plastic waste management and the demand of energy can simultaneously be addressed by the production of fuel from plastics. The catalytic and non-catalytic thermochemical conversion were used for the conversion of polyethylene and polypropylene to plastic crude oil in the absence of oxygen. The crude oil recovery was 70-90 wt%.The use of catalyst reduced the energy requirement by using 50-60℃ lower temperature for conducting depolymerization. The crude oil was distillated into gasoline and diesel fractions. The catalyst improved the gasoline and diesel yields. The ultimate and proximate analysis were conducted to study the fuel properties in distillate fractions. These distillate fractions have high heating value ~50 MJ/kg, ~85% and ~15% carbon and hydrogen content, negligible oxygen and olefin content makes plastic fuels similar to fossil fuels.

5.24 Development of a Commercially Amenable Carbo-Scavenger for Efficient Crude Oil Entrapment and Removal

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Crude oil spills continue to cause environmental harm to oceanic and coastal ecosystems with detrimental economic impacts. Large scale remediation techniques partially alleviate the issue leaving residual ecologically dangerous hydrocarbon layers on the micrometer scale. Here we fabricate an amphiphilic dual shelled hybrid carbon nanoparticle (carbo-scavenger) through pentacosadiynoic acid (PCDA) cross linking on agave based carbon nanoparticles with PS-b-PAA block copolymer coatings. This hybrid design allows for crude oil absorption in aqueous environments of various grades, compositions, and distillate varieties. The mechanism involves aqueous scattering and organic material absorption within the inner PCDA hydrophobic shell. Through the treatment of crude oil contaminated water with our hybridized carbo-scavengers, we have observed successful absorption and extraction of hydrocarbon layers. Our low fabrication costs and ease of high yield extraction demonstrate the viability for incorporating these into large scale crude oil remediation techniques. Details of synthesis of carbo-scavengers, their physico-chemical characterization, and their functional ability for the successful removal of the hydrocarbon contaminants from aqueous environment will be presented.

5.25 Long-term Fertilizer and Crop-Rotation Treatments Differentially Affect Soil Microbial Community Structure and Function

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Microbial communities in soil have the potential to improve agricultural sustainability, but the impact of agronomic practices such as fertilization and crop-rotation on the structure and function of soil microbial communities is not fully understood. A better understanding of these effects would enable the design of agronomic practices that optimize microbial communities for agricultural sustainability. We examined microbial community structure in soils under contrasting long-term fertilizer and crop-rotation treatments at the Morrow Plots in Illinois with 16S rDNA sequencing, automated ribosomal intergenic spacer analysis, and terminal restriction fragment-length polymorphism analysis of amoA and nosZ genes. Community function was examined with the BIOLOG multi-substrate utilization assay while nifH gene abundance was quantified as a marker for nitrogen fixation potential. Statistical analyses reveal significant effects of fertilizer and rotation treatments on community structure, while substrate utilization and nifH abundance exhibited small differences between fertilizer but not crop-rotation treatments. Differential enrichment of taxa between fertilizer treatments partly explains these observed functional differences. This study demonstrates the effects of long-term rotation and fertilization treatments on soil microbial communities and points to the need for functional metagenomic analyses order to better understand the specific differences between community function under different treatments.

5.26 ADARs antagonize deadenylation-dependent destabilization of nuclear-retained CTN-RNA

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A-to-I editing by Adenosine Deaminases Acting on RNA (ADAR) is a transcriptome-wide modification that occurs mostly in non-coding RNA sequences such as SINE repeats. However, the functional significance of editing in repeats is largely unknown. Here we show that editing of SINE repeats in the 3'UTR of nuclear-retained CTN-RNA promotes its stability. In the absence of ADARs, CTN-RNA abundance and half-life was significantly reduced. Furthermore, the poly-(A) tail length of unedited CTN-RNA was shortened concomitant with increased binding of the deadenylase, poly(A)-specific ribonuclease (PARN). Since deadenylation reduces transcript stability, these results show that ADARs promote CTN-RNA stability by antagonizing its deadenylation by PARN. These findings suggest a regulatory paradigm wherein by editing the 3'UTR, ADARs limit the interaction of RNA-destabilizing proteins with their substrates, thereby promoting RNA stability.

5.27 Model Predictive Control: Concept to Application

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Most physical and biochemical systems around us change with respect to time. However, we would like to influence this change to our benefit and use by controlling these dynamical systems. For example, temperature, economy, blood sugar, prosthetics, robots, internet, satellites, power grids exhibit complex changing behavior but can be controlled. The challenge is these systems have limitations in size of their inputs (heat, motors, prolusion etc.) used to control their outputs (temperature, joints, concentrations etc.) called constraints. Model Predictive Control (MPC) provides a systematic means of handling all forms of constraints leading to tremendous impact on industrial control practice. MPC transcribes the control objective into minimization of the difference between desired and actual behavior while respecting the constraints by manipulating the inputs and solves this constrained optimization online. The development and analysis of fast MPC for linear, nonlinear and distributed (system composed of interacting subsystems) systems will be presented together with experimental results on industrial test benches such as automatic transmissions and flight control.

5.28 Higher plant yields through the expression of a cyanobacterial enzyme?

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The biological basis of agricultural production is photosynthesis – the conversion of solar light energy into chemical energy. Modification of photosynthetic enzymes has been suggested as a method to enhance photosynthesis and thus plant productivity and agricultural yields. Here we test how expression of the bifunctional FBPase/SBPase enzyme affects physiology and yield in a major agricultural crop under current and future climate conditions. Wild type and FBPase/SBPase overexpressing soybean plants were grown in a fully factorial experiment under ambient / elevated CO2 (400 / 600 ppm) and ambient / elevated temperature (+3.5°C) at the Soy-T-FACE field site near Urbana-Champaign in 2014. We measured photosynthetic parameters throughout the growing season and yield parameters at harvest. First results indicate that the FBPase/SBPase plants had higher seed yield than WT plants under the combined CO2 and temperature treatment. We are currently investigating which component of seed yield (pods per plant, seeds per pod, seed weight) is the underlying cause. Further analysis will investigate the relationship between yield and photosynthetic parameters. Our results will help to understand if overexpression of FBPase/SBPase could be a means to improve soybean yields under future climate conditions.

5.29 Directed Intermolecular Hydroamination of Imino- and Amino-alkenes

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Rh-catalyzed intermolecular hydroamination of N-allylimines and N-allylamines are presented. Coordinating groups proximal to the olefin bind to the catalyst and promote the aminometallation. The reaction affords very good yields of 1,2-diamines, is functional group tolerant, and is highly diastereoselective.

5.30 Causality in Temporal Networks

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It is the goal of this study to devise a method for quantifying the importance of individual agents in a temporal network in terms of their dynamic functionality. In particular, we consider a network with fixed nodes but varying connectivity in discrete time steps. Such dynamic connectivity can reveal valuable information about the network. There are several dynamic features in a network among which we use the tendency of individual agents to interact with others. We propose an iterative algorithm based on the Bayesian approach to estimate the interaction probability of agents, given a temporal network. Finally, we propose a measure of importance for agents based on the amount at which they have influenced the dynamic features of other agents.

5.31 E-Cadherin mechanotransduction: not just a local issue

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Department of Biochemistry

Epithelial cells express cadherin and integrin receptors in the membrane and are established adhesion proteins and force transducers. These receptors are spatially isolated, but there is increasing evidence that they share signaling pathways and coordinate to regulate cell mechanics, cell shape, and tissue functions. To investigate the mechano-chemical pathways by which these adhesion proteins interact, we combined magnetic twisting cytometry and traction force microscopy. With this approach, we identified intracellular (cytoskeleton and signaling proteins) and extracellular (ligand and rigidity) factors that mechanically influence either receptors in real time. We further demonstrated that E-Cadherin dependent signals that alter cell mechanics require active integrin adhesions, and that mechanical perturbations

of E-Cadherin receptors enhances integrin mediated traction and causes focal adhesion (integrin) remodeling. The results indicate that E-cadherin mechanotransduction globally propagates signals that alter integrin mechanoreceptors. The dissection of these mechanotransduction mechanisms exposes a mechano-chemical network, which is biochemically regulated through specific ligands and downstream kinases. These results reveal that these adhesion proteins are essential mechanical and signaling hubs in cells that coordinate to regulate cell adhesion, cell mechanics, and tissue functions.

5.32 Prior exposure to dengue-4 virus reduces susceptibility of Aedes aegypti to dengue-2 virus

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Dengue viruses are responsible for causing dengue fever, currently the most important arboviral disease affecting humans. There are four serotypes of DENV, designated as DENV 1-4. Circulation of multiple DENV serotypes, genotypes, and/or strains in endemic areas is fairly common, but the epidemiological implications of vector exposure to multiple DENVs are poorly understood. Thus, the objective of our study was to determine how prior infection of Aedes aegypti mosquitoes with dengue 2 virus affects vector susceptibility to dengue 4 virus and vice versa. We tested the hypothesis that prior infection with one virus will reduce vector susceptibility to the second virus. We found that prior infection with DENV-2 virus had no effect on DENV-4 infection and dissemination rates in Ae. aegypti mosquitoes, while prior infection of Ae. aegypti mosquitoes with DENV-4 resulted in lower DENV-2 infection and dissemination rates. Our results demonstrate the potential for DENV-4 to displace DENV-2 in nature.

5.33 In-situ Raman Spectroscopy of Sulfur Speciation in Lithium-Sulfur Batteries

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In-situ Raman spectroscopy and cyclic voltammetry were used to investigate the mechanism of sulfur reduction in lithium-sulfur battery slurry cathodes with 1M lithium bis(trifluoromethane sulfonyl)imide (LiTFSI) and tetraethylene glycol dimethyl ether (TEGDME)/1,3-dioxolane (DIOX) (1/1, v/v). Raman spectroscopy shows that long chain polysulfides (S82-) were formed via S8 ring opening in the first reduction process at ~2.4 V vs Li/Li+ and short chain polysulfides such as S42-, S4-, S3.- and S2O42- were observed with continued discharge at ~2.3 V vs Li/Li+ in the second reduction process. Elemental sulfur can be reformed in the end of the charge process. Rate constants obtained for the appearance and disappearance polysulfide species shows that short chain polysulfides are directly formed from S8 decomposition. The rate constants for S8 reappearance and polysulfide disappearance on charge were likewise similar. The formation of polysulfide mixtures at partial discharge was found to be quite stable. The CS2 additive was found to inhibit the sulfur reduction mechanism allowing the formation of long chain polysulfides during discharge only and stabilizing the S82- product.

5.34 Activation and characterization of a cryptic gene cluster via a synthetic biology approach

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Polycyclic tetramate macrolactams (PTMs) are a widely distributed class of natural products with important biological activities. However, many of these PTMs have not been characterized. Here we apply a plug-and-play synthetic biology strategy to activate a cryptic PTM biosynthetic gene cluster SGR810-815 from Streptomyces griseus and discover three new PTMs. This gene cluster is highly conserved in phylogenetically diverse bacterial strains and contains an unusual hybrid polyketide synthase-nonribosomal peptide synthetase, which resembles iterative polyketide synthases known in fungi. To further characterize this gene cluster, we use the same synthetic biology approach to create a series of gene deletion constructs and elucidate the biosynthetic steps for the formation of the polycyclic system. Interestingly, we find that instead of following a sequential reaction order, this single gene cluster may involve three parallel pathways leading to three different products. Similar cluster structure is identified within another PTM biosynthesis gene cluster as well, which indicates that this parallel pathway structure is conserved in PTM biosynthesis. The synthetic biology strategy we employ here bypasses the traditional laborious processes to elicit gene cluster expression and should be generally applicable to many other silent or cryptic gene clusters for discovery and characterization of new natural products.

5.35 Variational study of bosonic phases in two dimensions

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We numerically study the model wave-functions of interacting bosons in two dimensions. The candidate wave-functions are based on the projective construction approach where a boson is decomposed into two (slave) fermions. We give strong evidence that these wave-functions have the correct properties to generate both symmetry breaking phases such as superfluidity and Mott insulators as well as topological phases such as the fractional Chern insulator. This unifying framework is not only aesthetically pleasing but also allows us to investigate transitions between any two of the above phases - something that is inherently difficult.

5.36 Effect of Larval Competition on Extrinsic Incubation Period and Vectorial Capacity of Aedes albopictus for Dengue Virus

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Larval resource competition can influence many adult mosquito life history traits including the ability to transmit pathogens. However, the net effect of larval competition on the vectorial capacity of mosquito vectors remains poorly understood. We used dengue-2 virus and its vector Aedes albopictus to examine how intraspecific larval competition affects the extrinsic incubation period of DENV and Ae.

albopictus vectorial capacity. Adult Ae. albopictus from low or high-larval density conditions were exposed to DENV-2 and then assayed at 6, 9, or 12 days post exposure using qRT-PCR. We then modeled the effect of competition on vectorial capacity using parameter estimates from peer-reviewed studies. Larval competition resulted in longer development times, lower emergence rates, and smaller adults, but had a weak effect on the extrinsic incubation period of DENV-2 in Ae. albopictus. Our vectorial capacity models suggest that the effect of larval competition on adult mosquito longevity likely has a greater effect on vectorial capacity relative to any competition-induced changes in vector competence. Our results indicate that mosquito populations that experience competitive stress in the larval environment will likely have a reduced vectorial capacity, even when susceptibility to pathogens is enhanced.

5.37 Introducing luminescent silicon nanoparticles as a functional layer in layer-by-layer growth of polymer microcontainers for tracking and imaging applications

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Polymer capsules or coatings can be produced by alternate layer-by-layer self-limiting growth of polyelectrolytes. The polymers should be selected carefully according to their charge and adsorption qualities. In this work, we investigate the feasibility of using neutral polarizable semiconductor nanoparticles in a polymer-semiconductor layer-by-layer procedure. We use microclusters of calcium carbonates as the templates, two polyelectrolytes of opposite ionic charge, and H-terminated luminescent Si nanoparticles. Our results indicate that the nanoparticles can be efficiently implemented as a "positive" or "negative" layer with the particles being drawn more efficiently to the negatively-charged polymer than to the positively-charged polymer. The results are explained in terms of electrostatic polarization forces and ionic interaction. Dissolving the calcium carbonate template creates a hollow luminescent polymer-silicon capsule. Optically functionalized capsules may find applications in optical marking/tracking for underground or biomedical applications. We also report a complex formation between nanoparticles and a molecule of either of two polymers in suspension. This is proved by analyzing time-dependent luminescence spectra of the mixture.

5.38 Electrophysiological brain signatures of number word-quantity mapping in preschoolers

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Preschool children acquire symbolic number concepts that form the basis of counting and later mathematical abilities. The cognitive and brain mechanisms that drive this cognitive development in children are poorly understood. Here, we measured the brain response to numbers in counting and pre-counting preschoolers to determine similarities and differences in numerical processing over development. Specifically, children were presented with a number word followed by a number of animal pictures (1-3) and asked whether the picture they saw contained more or less animals than the number word they heard. This task allowed us to study the cognitive mapping between the number words and quantities they represent. Our measure revealed that pre-counting children showed modulation of a large mid-latency posterior component (P2p) by the numerical ratio between the number word they heard and the quantity they saw, with the closest ratios showing the largest response. This suggests that pre-counters were processing the approximate numerical relationship between words and quantities before exact number knowledge was present. In contrast, counters showed a distance effect with more distant numbers showing greater amplitudes compared to closer numbers. The contrasting patterns between counters and non-counters suggest that they are representing the numerical relationships in fundamentally different ways.

5.39 Event-related potentials (ERPs) reveal the change of processing strategy in comprehending syntactically anomalous sentences

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Syntactically anomalous sentences (e.g., the cat will eating…) elicit an Anterior Negativity (AN) at 300-500 milliseconds post the onset of the anomalous word (e.g., eating) followed by a centro-parietally distributed positivity at 500-800 milliseconds (P600). Some researchers (e.g., Hagoort, 2003) interpreted the AN as reflecting automatic detection of morphosyntactic violation during first-parses and the P600 as reflecting reanalysis or revision during later parses. The present study asked thirty-three native speakers of Mandarin to read syntactically incorrect Mandarin sentences that were created by deleting the required classifier before a quantified noun, and compared those responses to syntactically correct sentences (e.g., Correct: There is a book-classifier book on the table; Incorrect: There is a book on the table). Anomalous sentences elicited the P600 effect during the first half of the experiment and the AN during the second half. The AN was resulted because the P600 diminished in the second half, leading to less cancelling out of the N400 component at anterior sites. These findings indicated that 1) AN was caused by component overlap rather than reflecting distinct processing mechanism, consistent with Tanner et al. (2014); and 2) readers devoted less effort to revise such syntactic violation as they get accustomed to it.

5.40 Large Scale Characteristic Mode Analysis

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Characteristic mode analysis (CMA) poses challenges in computational electromagnetics as it calls for efficient solutions of dense generalized eigenvalue problems. Conventional electric field integral equation based theory is susceptible to the internal resonance problem when the characteristic modes are iteratively computed. Such a scheme can only be used for analyzing small scale problems. We present a combined field integral equation based approach to remove this difficulty in characteristic mode analysis. The electric and magnetic field integral operators are shown to share a common set of characteristic eigenpairs, leading to a generalized eigenvalue problem which is immune to the internal resonance corruption. Besides, the multilevel fast multipole algorithm (MLFMA) is

incorporated into the implicitly restarted Arnoldi method for the calculation of characteristic modes, where MLFMA with the sparse approximate inverse preconditioning technique is employed to accelerate the construction of Arnoldi vectors. The computational complexity and memory cost for matrix-vector-product are hence greatly reduced, which paves the way of CMA for large scale and complex three-dimensional objects with limited computational resources.

5.41 Topology in Networks and Signal Processing

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Algebraic topology is a relatively new field in mathematics and in the recent years, it has spawned a new branch of data analysis called Topological Data Analysis. I will briefly introduce the basic concepts in this field and demonstrate its unique capabilities with applications in analysis of sensor networks, social networks, signal processing, and topological summaries of point clouds.

5.42 Modeling Agriculture and Sustainable Development in the Brazilian Amazon Basin Utilizing the Overview Design Concepts and Details (ODD) Protocol

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Several case studies conducted on forest engineering in tropical rainforests have recently emerged creating international attention to sustainable development and agriculture. Environmental degradation due to spreading agriculture and road construction, increased contact with remote, isolated indigenous people and a rapidly developing Brazil pose considerable challenges for sustainable development within the Brazilian Amazon Basin. Sustainable development seeks to balance interests of social, economic and environmental parameters and concerns over a defined period of time. Integrated systems, management models combining different aspects of sustainable development for a more inclusive analysis, are used to varying degrees in case studies but are often not holistic. This study examined recent case studies of the Brazilian Amazon Basin to determine effectiveness and outcomes of sustainable development utilizing the Overview Design concepts and Details (ODD) Protocol. The ODD Protocol modeled economic, environmental and social dimensions of sustainability measured over time. The case studies examined had rarely reported specifically on temporal components of sustainability as well as the effect of road construction through the Brazilian Amazon Basin. Recommendations for further analysis and policy decision-marking for forest engineering were determined from the model outcome.

5.43 The cognitive basis of graph comprehension, a crucial ability for STEM students

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An important skill for every scientist or engineer is interpreting graphically-presented data, yet students--from the elementary level, all the way through college level--struggle with graph comprehension. At the core of this skill is our cognitive ability to perceive, attend, and remember relations between two or more things that we see. Reasoning about relations requires attention and therefore uses up cognitive resources. What is the limit on the number of visually-depicted relations we can reason about at once? Is the answer determined by the number of items to be related? The number of relations between them? Using mathematical models, neural-network models, and behavioral experiments, we found that the number of visual relations that can be maintained and manipulated at once is limited by the number of items (two pairs of items, to be exact), and that you can remember multiple relations between those items. Can we surpass that limit? Yes, but it requires a trade-off. Representing a comparison between two objects using a single object (e.g. a symbol) is a way to double the number of relations that can fit comfortably in the limit, but the vocabulary of symbols required to represent the comparisons increases exponentially.

5.44 Assistance of gait during walking by using Portable Powered Ankle-Foot Orthosis

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Ankle foot orthoses (AFO) are external devices that provide assistance for individuals with lower limb muscle impairments. A Large population in United States, (for example stroke (4.7M), polio(1M), multiple sclerosis (400K), spinal cord injury (200K), and cerebral plasy (100K)) can get benefit from the use of powered AFO. Effective control of the AFO critically depends on the detecting gait events. For controlling AFO, we need to estimate the percentage of gait cycle instantaneously during human walking. Using 2 Force resistive sensors and angle sensor, the percentage of gait cycle is estimated in real time and compared to previously developed estimator. The actuation scheme plays an important role for walking in level ground, stair descent and star ascent mode. Wrong actuation scheme for these different modes can cause falls or trips. Gait mode recognition technique is developed for detecting these different modes by attaching Inertial Measurement Unit (IMU) and using machine learning algorithms. This new algorithm can get rid of one step delay limitation which was a drawback for previous techniques found in literature. Preliminary studies have been conducted preliminary to evaluate the effects of applied ankle torque for gait assistance (with able-bodied and disabled groups). We have achieved promising advances in controls, runtime, and function.

5.45 Demonstrating the Monetary Value of Risk-Informed Deciciosn Making in High-Risk Socio-Techncial Systems

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For most modern industries, safety is a goal that is given the same priority as efficient and economical production and, therefore, the connection between profitability and safety has long been an issue of interest to researchers. However, the economic gains of incorporating Probabilistic Risk Assessment (PRA) insights into various layers of

organizational and technical decision-making (Risk-Informed Decision-Making) are yet to be discovered. The key questions in this research include: Can Risk-Informed Decision-Making based on PRA help High-Risk, Socio-Technical Systems become more profitable and, at the same time, meet safety requirements? If PRA applications help avoid costly power plant outages (which run nearly two million U.S. dollars per day), should PRA still be considered as an "expensive" tool? Should industry and regulatory agencies continue to implement, regulate and enforce the use of PRA? This is a first of-its-kind research aimed at uncovering the financial advantage of conducting PRA-based applications in complex, high-risk, technological systems such as Nuclear Power Plants (NPPs). By discovering the causal relationships between system safety and financial performance, this research will (1) model and quantify the costs and benefits associated with PRA programs (2) provide critical insights for the industry and regulatory agencies on the enhancement of risk informed applications and the enforcement of risk-informed regulations (3) advance methodologies to quantify a socio-technical risk framework, where organizational and environmental factors dynamically interact and shape financial outcome and system safety risk (4) help identify and mitigate the underlying organizational root causes of accidents, such as managerial decision-making.

5.46 Cell adhesion biophysics on mobile polymer films

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The biophysical characteristics of cell adhesion from single protein to cell length scales have primarily been studied using purely elastic substrates. However, natural extracellular matrix (ECM) is viscoelastic and contains mobile components. In this work, we combined chemistry and cell biology tools to design and characterize laterally mobile viscoelastic polymer films that promote receptor-specific cell adhesion. The addition of a trace hydrophobic homopolymer in the supported bilayer block-copolymer films is used to tune the lateral mobility of the films. NIH 3T3 fibroblasts demonstrate a non-linear spreading response against the mobility of RGD-displaying polymer films associated with the partial contributions of focal adhesions (FA) and integrin-RGD complexes on cell adhesion. Furthermore, our results suggest that cells preferentially use αvβ3 and α5β1 integrins to control spreading and polarization in response to mechanical properties of their substrate. Overall, the present work demonstrates the potential of amphiphilic block copolymers to form artificial substrates that can capture a key feature of cell-ECM interactions: specifically, the ability of cells to induce changes in the substrate over time.