Aug 24, 2015
10:40 AM
Room 1011 EB1

Dr. Danielle Tulman-Ercek
University of California, Berkeley

Getting Through the Gatekeepers: Changing the Selectivity of Semi-Permeable Cellular Membranes

The phospholipid bilayer has long been described as the cellular gatekeeper, preventing the passive transport of proteins, small molecules, and even ions. It was recently discovered that some bacteria use compartmental systems as well, contrary to the long-held belief that bacteria lack such organization, but the bacterial compartment membranes are made entirely of proteins. We explore the gatekeeping functions of each of these distinct types of membranes, studying protein and small molecule transport and sequestration in each case. Using various synthetic biology approaches, we are also engineering the protein-based parts of these systems in order to 1) sequester metabolic pathway enzymes and intermediates in the protein compartments and 2) gain control and alter the specificity of lipid membrane transporters for small molecules and proteins. In this talk, I will discuss our recent progress and provide examples of how this work will lead to advances for bioenergy and chemical production.

Aug 31, 2015
10:40 AM
Room 1011 EB1

Dr. Zhenan Bao
Stanford University

Skin-Inspired Flexible and Stretchable Electronic Materials and Devices

Skin is the body's largest organ, and is responsible for the transduction of a vast amount of information. This conformable, stretchable and biodegradable material simultaneously collects signals from external stimuli that translate into information such as pressure, pain, and temperature. The development of electronic materials, inspired by the complexity of this organ is a tremendous, unrealized materials challenge. However, the advent of organic and carbon-based electronic materials may offer a potential solution to this longstanding problem. In this talk, I will describe organic and carbon nano electronic materials to mimic skin functions. These new materials enabled unprecedented performance or functions in medical devices, energy storage and environmental applications.

Sep 14, 2015
10:40 AM
Room 1011 EB1

Dr. Suzanne Kresta
University of Alberta

Writing Well: Building Traction and Triumph into co-Authorship

Writing productively, effectively, and in the context of a healthy, sustainable lifestyle is a core skill for graduate students and faculty members. Accomplishing this requires that we all write well, independently, and collaboratively. Several workshops held at the University of Alberta were held in 2010, and the outcomes from those workshops have been helpful and informative. Three main points will be discussed in this seminar. First, the list form of an abstract is not tractable for most students and technical writers. Alternate forms of organizing ideas can change the initial collaborative conversation dramatically. Second, writing research shows that most students learn more from each other than from their supervisors during the thesis preparation stage of a graduate degree. Peer-to-peer editing can dramatically speed up the writing process in a medium to large group. Third, there is a big difference between reading a paper as a reader, or as a writer. Once this shift in perspective is applied, many lessons in formatting and the rules of technical writing become clearer. When these practices are applied consistently, the learning curve in collaborative writing becomes easier to navigate and the writing process is much faster and more fun for everyone.

Sep 16, 2015 4:00 PM Room 1010 EB1	**Dr. Manish Kumar** Penn State University

Mimicking Biological Membranes Using Designer Synthetic Molecules

Biological membranes combine high permeability with high selectivity, a feature that is challenging to replicate in synthetic systems. This is due to the presence of specialized proteins such as the water channel protein, aquaporin, present in biological membranes. Current artificial analogs of aquaporins, carbon nanotubes (CNTs), are challenging to synthesize in sub nanometer dimensions and difficult to align in membrane systems. There has been interest in artificial water channels that can be created using synthetic chemistry. In this talk I will discuss results from a new architecture of artificial water channels, peptide-appended-pillar[n]arenes (PAPs). The average single channel osmotic permeability for PAPs is 1.0(±0.3)x10-14 cm3/s or 3.5(±1.0)x108 H_2O molecules/s, which is within the range of biological water channels′ aquaporins 3.4~40.3x108 H_2O molecules/s and CNTs ($9.0x10^8$ H_2O molecules/s). This is orders of magnitude improvement over first-generation artificial water channels reported before. PAP channels combine and improve upon the advantages of protein channels and CNTs through their relatively simple synthesis, chemical stability, simple alignment in membranes and efficient cross-sectional are (~33% effective pore area/channel vs ~0.8% for aquaporins and ~68% for CNTs(12,12). The ability to chemically modify the versatile chemical architecture of the pillar[n]arene channels shows promise for further improving water permeability and selectivity.

Sep 21, 2015 10:40 AM Room 1011 EB1	**Dr. Robert Weiss** University of Akron

Designing Tough Hydrogels

Hydrogels are three-dimensional networks composed of chemically and/or physically-crosslinked hydrophilic polymers that have application as biomedical materials, sensors, actuators, soft machines, battery components, separation media, food products, sealants and adhesives. Even though hydrogels may be greater than 90% water, they behave mechanically as elastic solids, but they generally exhibit poor mechanical strength (< 100 kPa) and toughness (<10 J/m2), because they lack a mechanism for energy dissipation. In the biomedical field alone, mechanical robustness can be a challenge for hydrogels used in applications such as drug delivery, ophthalmology, wound healing and tissue engineering. In 2003, Gong and coworkers[i] developed a new class of hydrogel, termed a *double network* (DN), that was purportedly an interpenetrating network (IPN) and exhibited exceptionally high strength (~1 MPa) and toughness (> 100 J/m2). Subsequent work by other research groups have demonstrated other structures for achieving tough hydrogels that are largely based on the incorporation of physical, reversible crosslinks. Although covalent hydrogels provide the optimum ability for shape retention, physical hydrogels include an inherent mechanism for energy dissipation, namely supramolecular, reversible crosslinks. Fracture toughness values of > 1000 J/m2, which is the inherent toughness of natural cartilage, have been achieved with physical hydrogels. The viscoelastic nature of physical hydrogels, however, can produce unacceptable shape retention. Hybrid hydrogels, incorporating both covalent and physical crosslinks, can have excellent shape-retention and energy dissipation, and that approach has been usde to achieve robust hydrogels with good shape reversibility and mechanical properties.

This talk will discuss the design of tough hydrogels using primarily our own research on DN hydrogels[i], physical hydrogels and hybrid hydrogels[ii]-[iii][iv]. Among the topics we plan to discuss are the actual microstructure of DN hydrogels, which are not IPNs as originally proposed, and the advantages of physical and hybrid hydrogels with regard to shaping hydrogels by melt extrusion or injection molding, injectability of physical gels for biomedical applications, electrospinning hydrogel nanofibers and shape memory behavior.

[i] Es-Haghi, S. S., A. I. Leonov and R. A. Weiss. On The Necking Phenomenon in *Pseudo*-Semi-Interpenetrating Double-Network Hydrogels, *Macromolecules*, **2013**, *46*, 6203-6208.

[ii] Hao, J.; Weiss, R. A. Viscoelastic and Mechanical Behavior of Hydrophobically Modified Hydrogels, *Macromolecules*, **2011**,*44*, 9390-9398.

[iii] Hao, J.; Weiss, R. A. Mechanical behavior of hybrid hydrogels composed of a physical and a chemical network. *Polymer*,**2011**, *54*, 2174-2182.

[iv] Hao, J.; Weiss, R. A. Mechanically Tough, Thermally Activated Shape Memory Hydrogels. *ACS Macro Lett. 2013*, *2*,86-89.

[i] Gong, J. P., Katsuyama, Y., Kurokawa, T. & Osada, Y. Double-Network Hydrogels with Extremely High Mechanical Strength.*Advanced Materials* **15,** 1155-1158 (2003).

Sep 28, 2015
10:40 AM
Room 1011 EB1

Dr. Mark Uline
University of South Carolina

Curvature, Tension and Local Environmental Effects on the Sorting of Proteins in Phase-Separated Model Lipid Bilayers

Research in the functionality of cell membranes has surged over the past decade, beginning with the realization that biological membranes are functionally active, directly governing diverse biological processes. Much progress has been made in detailing the complexities and the organizational tendencies of membrane architecture that confer its physiological activity. Particularly, heterogeneity of lipids within the bilayer may act as platforms that incorporate specific proteins or ions to initiate bio-chemical processes, such as signal transduction, endo- and exocytosis, transport, and cytoskeleton organization.

To understand the thermodynamic properties of biological membranes, it is necessary to be able to interpret changes in the relative concentrations of the lipids, with alterations in lipid type, and with adjustments to the symmetry between the bilayer leaflets. Such understanding can be gained from the examination of model membranes. Experimental model membranes containing cholesterol, dipalmitoyl-phophatidylcholine (DPPC), and dioleoylphosphatidylcholine (DOPC) are known to phase separate into liquid-ordered (lo) and liquid-disordered (ld) phases. It has long been hypothesized that certain proteins and lipid chain anchors would be enriched, either in the lo or in the ld phase, thereby increasing their efficacy. We use this model system to calculate the partition coefficient (mole fraction in the lo phase to the mole fraction in the ld phase) of proteins within the phase separated model system.

Using a theoretical model of a bilayer membrane containing cholesterol, DPPC, and DOPC that qualitatively reproduces experimental phase diagrams of giant unilaminar vesicles (GUVs) of the same three components, we calculate how the curvature of lipid vesicles determines the amount of binding of molecules with lipid tail anchors. By explicitly determining the chemical potential difference of species across a curved bilayer under different modes of deformation in both lo and ld phases, we are able to calculate the equilibrium binding concentrations of lipid tail anchors as a function of membrane curvature, concentration of lipids and solution environment. Our results are in excellent agreement with recent experiments. We also calculate the partition coefficients of protein chain anchors into lo and ld phases as a function of surface tension, temperature, and degree of saturation of the chain anchors. We are able to take into account the exact molecular architecture of protein chain anchors and calculate the orientations and positions of proteins as they arrange themselves at the order-disorder phase boundary.

Oct 5, 2015 10:40 AM Room 1011 EB1	**Dr. Veronica Augustyn** NCSU

Understanding Interfacial Mechanisms in Transition Metal Oxides for Energy Storage and Conversion

Transition metal oxides are often the materials of choice for energy storage and conversion applications due to their numerous oxidation states, mixed electronic/ionic conductivity, and structural variability. First, I will discuss a long-standing challenge for electrochemical energy storage to achieve both high energy and high power densities in the same device. This inability arises from the fundamental differences between storing energy within the solid state, as in batteries, as opposed to the surface, as in capacitors. Bridging the gap between energy and power is the motivation for the development of new high-energy and high-power energy storage materials. I will describe how such materials are possible with pseudocapacitance in transition metal oxides, whereby charge storage occurs via rapid redox reactions. Second, the search for highly active, non-precious metal electrocatalysts for efficient hydrogen production relies on correlating material properties with catalytic activity. I will describe the need to understand the material surface formed during electrocatalysis by discussing the behavior of a new class of oxygen evolution reaction catalyst materials, layered lithium transition metal oxides. In these materials, pseudocapacitive features before the onset of the oxygen evolution reaction give clues to the chemical and structural transformations occurring before and during the electrocatalytic reaction.

Oct 19, 2015 10:40 AM Room 1011 EB1	**Dr. Weiwei Hu** Biogen

Improving Biomanufacturing Processes through Interdisciplinary Collaborations

Biologic drugs such as monoclonal antibody therapeutics play an important role in addressing unmet medical needs. Instead of chemical synthesis, these products are manufactured through cultures of living cells. Even though it has evolved significantly since the 1980′s, the manufacturing process is still complicated and expensive. This presentation will be focusing on innovations in bioreactor engineering, where stirred and sparged tanks are used for culturing mammalian cells at large scale. In recent years, cell culture processes have been intensified significantly to improve productivity. This trend resulted in new challenges which require more interdisciplinary collaborations (engineering, biology, biochemistry, colloid chemistry, material science, and etc.) to solve the problems. Technical gap analysis was performed first to understand the challenges. Interfacial phenomenon such as mass transfer limitations, foam control, and cell/bubble damage were considered to be critical. Then, we investigated bioreactor sparger design since it directly affects bubble formation and bubble size distribution. The information was used to design drilled-hole spargers with better performance. Concurrently, we studied the sensitivity differences by cell line. Cells from different hosts and multiple stages of cell line development were investigated in order to understand the root causes of bubble/shear sensitivity. The impacts of media components including lot-to-lot variation of poloxamer were evaluated. Last but not least, suggestions about future improvement will be shared.

Oct 22, 2015 4:30 PM Room 135, BTEC	**Dr. Alex Alexeev** Georgia Institute of Technology

Modeling stimuli-sensitive polymer networks using dissipative particle dynamics

MRSEC Seminar Series

Using dissipative particle dynamics, we examine transport properties, swelling kinetics, and applications of stimuli-sensitive polymer networks. Such networks are common in various biological and synthetic systems. Our mesoscale computational model employs a bond-bending bead-spring approach to capture the micromechanics of random polymer networks. First we demonstrate that our model can properly describe transport properties of random networks and examine how the transport changes when a network undergoes mechanical deformation. We then employ our model to study the kinetics of responsive microgels during swelling volume transition and probe how hollow microgel capsules can be harnessed in controlled release applications. Finally, we probe how a bi-layered microgel sheet composed to two layers with dissimilar stimuli sensitivity can be used to design a microscopic self-propelling swimmer.

Oct 26, 2015
10:40 AM
Room 1011 EB1

Dr. Darlene Taylor
North Carolina Central University

Stimuli-Responsive Materials: From Photoinduced Charge Carriers in Metallopolymers to Temperature Sensitive Drug Delivery Depots

Smart materials that respond to changes in external triggers of light, redox potentials, and temperature are receiving a significant amount of attention in applications that range from active layers in organic solar cells to drug delivery systems. In this talk, we will summarize our synthetic approach and characterization of three families of stimuli-responsive materials.

First, polymers with side chain ruthenium polypyridyl chromphores will be discussed. Through this class of photo-responsive materials, we have exploited the distance dependent optimization of the metal-ligand charge transfer sites in order to tailor the design of new rigid rod backboned polymers with side chain ruthenium chromophores. Photophysical characterizations by UV/Vis, cyclic voltametry, and femtosecond laser spectroscopies assisted in our understanding of the band gap and excited state electron lifetimes of these polymers.

Second, materials derived from a polystyrene backbone functionalized with sulfonated calixarene rings will be discussed. The electro-responsive nature of these materials were exploited through cyclic voltametry studies as well as calorimetric studies where we found that there is significant binding interaction between the charged calixarene ring and small molecules such as methyl viologen.

Third, a thermoresponsive N-isopropylacrylimide based copolymer will be discussed. The novelty of this copolymer arises from its ability to be post-functionalized with dyes, prodrugs, or biologics affording an injectible drug delivery system that operates by multiple orthogonal triggers: 1) drug entrapment and gradual release through matrix degradation and 2) manipulation of dynamic covalent bonding through a second stimuli trigger. Together, the three stimuli responsive material classes that will be presented are promising platforms for further development.

Nov 2, 2015
10:40 AM
Room 1011 EB1

Dr. Clare McCabe
Vanderbilt University

Understanding the Self-Assembly and Phase Behavior of Skin Lipids

The outermost layer of the skin (the stratum corneum) consists of skin cells embedded in a rich lipid matrix, whose primary role is to provide a barrier to foreign agents entering the body and to water leaving the body. This lipid system is unique in biological membranes in that it is composed of ceramides, cholesterol, and free fatty acids, with phospholipids, which are the major components of most biological membranes, being completely absent. This unique composition enables the lipids of the stratum corneum form highly organized lamella, which in turn are believed to control barrier function.

While much is known about the nature of the skin lipids from extensive experimental studies, a clear understanding of how and why these molecules assemble into the structures observed through microscopy and biophysical measurements does not yet exist. In order to probe lipid phase behavior and molecular level arrangement, we are performing molecular simulations with both atomistic and coarse-grained models of key stratum corneum lipids and water.

The development and validation of the coarse-grained models will be discussed alongside the results of simulation studies for simple mixed lipid systems that provide insight into the lamellar organization and enable us to validate the models developed while working towards the study of more complex stratum corneum systems.

Nov 16, 2015
10:40 AM
Room 1011 EB1

Dr. Matthew DeLisa
Cornell University

Adventures in Bacterial Glycobiology: Engineering Sweet Solutions to Sticky Situations

Carbohydrates add a level of diversity across all forms of life that is unparalleled by the information content of nucleic acids and proteins. The lack of a simple template to translate a glycan code into defined sugar structures contributes to this complexity and provides a challenge for efforts aimed at the production of biologically important glycans and glycoconjugates. With the discovery of glycoprotein synthesis in bacteria and functional transfer of glycosylation pathways between species, Escherichia coli cells have become a tractable host for understanding glycosylation and the underlying glycan code of living cells. Moreover, efforts to manipulate the pathways from sugar nucleotides to glycolipids to glycoproteins have transformed E. coli into a living factory for scalable, bottom-up production of complex glycoconjugates by design. Here, I will discuss our efforts to develop E. coli for the biosynthesis of a diverse array of glycan structures, which can be used to tailor the activity, stability, half-life, and immunogenicity of a given biopharmaceutical. I will also discuss our efforts to unify protein glycosylation in E. coli with the advanced tools of protein engineering such as cell surface and phage display technologies. The result is a powerful new way to engineer the enzymes, pathways, end-products, and genomes of glycoengineered bacteria for creating the next generation of protein therapeutics and vaccines for a wide range of human diseases.

Nov 19, 2015
4:30 PM
Room 135, BTEC

Dr. Chinedum Osuji
Yale University

Scalable and New Approaches for Directing Self-Assembly in Nanostructured Soft Materials

MRSEC Seminar Series

Self-assembly of block copolymers and small molecule surfactants gives rise to a rich phase behavior as a function of temperature, composition, and other variables. The ability to precisely control their chemical functionality combined with the readily tunable characteristic length scales (~1-100 nm) of their self-assembled mesophases identifies these systems as a versatile and attractive class of materials for compelling applications ranging from selective transport to lithography. A longstanding problem in this area is the inability to reliably and rapidly generate well-ordered structures with specified orientations in, and over, application-relevant geometries, and dimensions, respectively, i.e. to direct their self-assembly in useful ways. In this presentation I will discuss recent advances in scalable approaches for directing the assembly of soft nanostructured materials, and novel routes for generating highly ordered soft heterostructures.

First, we consider the directed self-assembly of such soft mesophases using magnetic fields, principally through the use of in situ x-ray scattering studies. Field alignment is predicated on a sufficiently large product of magnetic anisotropy and grain size to produce magnetostatic interactions which are substantial relative to thermal forces. We examine the role of field strength on the thermodynamics and alignment dynamics of a series of soft mesophases. The ability to produce highly ordered functional materials over macroscopic length scales is demonstrated and we explore the role of alignment and connectivity in controlling anisotropic ionic transport in nanostructured systems.

Second, we examine electrospray deposition as a novel tool to generate well-ordered block copolymer thin films in a manner inspired by physical vapor deposition processes used in hard materials. The success of the method relies on slow deposition of sub-attoliter quantities of material delivered in sub-micron droplets produced by electrospray atomization. We demonstrate the ability to continuously deposit thin films with controlled orientation of microstructure, and to assemble heterostructures through sequential depositions of materials.

Nov 23, 2015
10:40 AM
Room 1011 EB1

Dr. Jorg Thommes
Biogen Idec

Driving Value through Manufacturing: Innovation in a Hybrid Biologics Manufacturing Network

Over the last 30 years, the Biopharma Industry has had remarkable successes and has delivered tremendous value to society through the development of innovative medicines. During this time our industry has also matured to an extent that the traditional paradigm of value creation solely through development and commercialization of innovative science may change. The economics of developing a drug pipeline became more challenging, the reimbursement environment is changing, biosimilars and increasing globalization add opportunities and competition. For the longest time, manufacturing was not part of the value equation; the transformation going on in our industry, however, requires that operations becomes part of the value chain. This presentation will discuss how biologics manufacturing can be turned from a necessary evil to a competitive advantage.

Dramatic improvements in productivity over the past decade coupled with the development of robust platforms have enabled our industry to break with the paradigm of large stainless steel manufacturing facilities as the sole option for producing biologics. Smaller facilities became possible and single use technology has added flexibility. These are the foundations to Biogen's hybrid manufacturing network. Utilization of a manufacturing network is as big a driver of manufacturing economics as the productivity of the processes executed in these facilities. While the basic technology utilized in biologics manufacturing has been established decades ago, there is still great demand for innovation, which has to be directed towards optimizing network utilization. This presentation will discuss a set of improvements to conventional manufacturing technology, the role of process control in manufacturing, and the importance of understanding scale effects as examples of Biogen's approach to innovation in our existing network.

Since the fundamental technology in biologics manufacturing has only changed incrementally over the past 30 years, an important question is whether the time has come for disruptive innovation to radically increase efficiencies or whether continued sustaining innovation will be sufficient to answer the challenges of a changing industrial environment. It is not clear whether our industry has come to this crossroads and the presentation will attempt to stimulate this debate.

Nov 30, 2015
10:40 AM
Room 1011 EB1

Dr. Sergei Sheiko
UNC - Chapel Hill

Graphene Oxide in Supercapacitors and Fuel Cells

Solvent-free elastic materials with a Young's modulus below 1 atm (100 kPa) are vital for the creation of biocompatible implants with mechanical properties matching that of living tissues. Currently, polymer gels are the only viable class of synthetic materials for low modulus applications, yet with a caveat: their properties are entirely dependent on the fraction of solvent in the system. Solvent is a potential source for various complications including phase separation, drying, and leakage upon deformation that not only compromise the gel elasticity, but may also elicit severe inflammatory response in surrounding tissues. Herein, we elucidate, both theoretically and experimentally, a concept for the design of super-soft and super-elastic solvent-free elastomers using bottlebrush macromolecules.

On the opposite front, we are dealing with a problem of making hydrogels that combine high rigidity, strength at break, extensibility, high elasticity. Through free-radical copolymerization of *N,N*-dimethylacrylamide and methacrylic acid, we have designed a network system based on tunable composition of covalent bonds (permanent cross-links) and hydrogen bonds (sacrificial and recoverable crosslinks). By tuning the chemical composition and microstructure we have obtained materials with superb mechanical properties. The hydrogels contain 70 wt% water (similar to living cartilage, skin, and ligaments), while display modulus of 28 MPa, strength of 2 MPa, fracture energy of 9300 J×m-2, extensibility of 800%, excellent fatigue-resistance, and great elasticity allowing for complete and fast strain recovery. The results agreed with theoretical predictions for modulus relaxation of dual networks with dynamic and permanent crosslinks.