Fall 2022 - Departmental Seminars

- Safa Jamali (8/22/22)
    - Title: Network science for understanding the physics and rheology of colloidal suspensions
    - Abstract
        - Colloidal particles suspended in a simple fluid, depending on their packing fraction and interactions can exhibit a wide range of exotic rheological behavior. For instance, when in large fractions, they may resist to large deformations under flow, which is best exemplified by running on a pool of cornstarch and water. When attractive interactions are induced between colloids, they can assemble into space spanning networks with mechanical properties of a viscoelastic solid, aka colloidal gels. Over the past couple of decades, and owing to a tremendous advance in our experimental and computational capabilities, we have built an understanding of the complex dynamics that give rise to such physical and rheological behavior: rather than particle-scale micromechanics, it is the collective dynamics of the colloids at a coarser scale that control the macroscopic/bulk properties of a particulate system. Whether it's a force network that carries the highest stresses in a shear thickening suspension, or a porous network of particles that gives a gel its elasticity, it is a "network" referring to the collective particle dynamic/behavior that is responsible for the physical characteristics of a system. Thus, understanding the physics of this particulate network is the key to controlling and designing particulate systems with desirable properties. I will discuss how borrowing well-established concepts from network science can help us interrogate and characterize these particulate networks and build a coarse-grained description of the system. These mesoscale structures, identified through community detection techniques that are commonly used in social or economic networks, provide a new understanding of physics and rheology in dense suspensions as well as attractive colloidal gels. Finally, I will discuss some of the unexplored avenues and potential directions that these new techniques can make an impact in.
    - Bio
        - I am an Assistant Professor of Mechanical and Industrial Engineering at Northeastern University. I received my PhD from Case Western Reserve University's Macromolecular Science department, followed by two years of Postdoc training at MIT's Chemical Engineering, Mechanical Engineering and Energy Initiative, and then joined Northeastern University in 2017. My research group is focused on developing and using a series of data driven and computational methods for physics and rheology of complex materials. These include biophysics of cell suspensions with focus on blood dynamics, science-based data-driven methods and machine-learning platforms for rheological applications, and physics of colloidal systems amongst other topics.
- Blanka Sharma (9/19/22)
    - Title: Engineering Biomaterials to Target Inflammatory Mechanisms During Tissue Injury and Tumor Progression

    - Abstract
        - Exciting advances have been made in the discovery of therapeutic molecules and cells to treat numerous devastating medical conditions. However, their successful application in patients is curtailed by challenges in delivering these therapeutics where an injury or disease is localized. In this talk, Dr. Sharma will describe her group's work in overcoming drug delivery challenges in osteoarthritic joints to target oxidative stress and macrophage activation. The second part of this talk will focus on cell delivery challenges in solid tumors, and how Dr. Sharma's group is applying biomaterials to understand and overcome immunosuppressive mechanisms in the tumor microenvironment that undermine the success of natural killer cell immunotherapies.
    - Bio
        - Dr. Sharma is an Associate Professor of Biomedical Engineering at the University of Florida. Her research investigates fundamental biomaterial-cell interactions to develop targeted drug and cell delivery systems for applications ranging from tissue repair to cancer therapy. Dr. Blanka Sharma received her undergraduate degree in Chemical Engineering from the University of Waterloo (Waterloo, Ontario, Canada), her Ph.D. from Johns Hopkins University (Baltimore, MD) in the Department of Biomedical Engineering, and her postdoctoral training at the Cleveland Clinic (Cleveland, OH). Dr. Sharma served as Director of Research for Cartilix Inc. from 2005-2009, a start-up company based on her doctoral research, where she worked towards clinical translation of a hydrogel technology for cartilage repair in the knee. After starting her faculty position in 2014 at the University of Florida, Dr. Sharma was featured by the American Society for Engineering Education as one of "20 Under 40" Outstanding Junior Faculty in the U.S. More recently, Dr. Sharma received the National Science Foundation Faculty Early Career Development Program (CAREER) award. In recognition of her teaching, mentorship, and research, Dr. Sharma received the Pramod P. Khargonekar Junior Faculty Award for Excellence in 2020 from the UF College of Engineering.
- Adam Melvin (9/26/22)
    - Title: Engineering novel biosensors and complex biological models to study cancer and beyond
    - Abstract
        - Cancer is a heterogeneous disease with differences between patients (intertumor heterogeneity) and among cells in the tumor (intratumor heterogeneity) requiring a multi-faceted approach to obtain a better fundamental understanding of this complex disease. This talk will highlight ongoing research by my group to develop new bioanalytical techniques to study drug resistance in multiple myeloma and creating better preclinical models to study metastatic breast cancer. These include long-lived, cell-permeable fluorescent biosensors to measure enzyme activity in intact cells and microscale approaches to study how cancer cells manipulate healthy cells, and their environment, to drive cancer progression.
    - Bio

        - Adam Melvin obtained a B.S. in chemical engineering and a B.A. in chemistry from the University of Arizona, an M.S. in chemical engineering (with a minor in biotechnology) and a Ph.D. in chemical engineering from North Carolina State University. He was an NIH postdoctoral fellow at the University of North Carolina at Chapel Hill in the Departments of Chemistry and Biomedical Engineering. In August of 2013, he joined the faculty in the Cain Department of Chemical Engineering at Louisiana State University. His research interests focus on biochemical/biomedical engineering including the design of peptide-based biosensors and therapeutics and the development of novel microfluidic platforms to model the breast cancer tumor microenvironment. He is an NSF CAREER awardee and has received numerous teaching and mentoring awards during his time at LSU.
- Harvinder Gill (10/3/22)
    - Title: Development of a Multiepitope Universal Influenza Vaccine Using Nanoparticle Systems
    - Abstract
        - Influenza virus strains mutate constantly, therefore the seasonal flu vaccine must be updated annually to keep it current. The vaccine is updated by swapping the influenza strains contained in the vaccine by those recommended by the World Health Organization (WHO). Since it takes almost six months to make the flu vaccine, the update begins about six months ahead of the upcoming flu season. Between the time the vaccine production begins to when it is made available to the public, the influenza strains can continue to change, and the strains that in fact end up circulating in a flu season can be different from those incorporated in the updated vaccine. The degree of match between the vaccine strains and the circulating strains dictates vaccine efficacy, which can range from high (high match) to zero (complete mismatch). The high mutation rate of influenza strains could also result in a novel pandemic strain, and the current flu vaccines would be ineffective against such a strain. For flu pandemic preparedness, and for making a seasonal flu vaccine that does not require an annual update, there are ongoing efforts to create ‘universal’ flu vaccines. In this presentation, a design of a universal flu vaccine being developed in our lab will be presented. The presentation will describe the basis of such a universal flu vaccine design, the use of different nanoparticle systems evaluated by us to enhance immune response of the universal flu vaccine, and its efficacy in animal models (mice and ferrets). In addition, the thermal stability of the vaccine and use of microneedles to deliver the universal flu vaccine will also be discussed.
- Julie Champion (10/17/22)
    - Title: Self-Assembled Protein Vesicles for Drug Delivery and Biocatalysis
    - Abstract
        - Protein vesicles incorporating functional, globular proteins have potential in a number of bio-applications such as drug delivery, biocatalysis, and sensing. We have created protein vesicles from recombinant fusion proteins such as enzymes, fluorescent proteins and antigens. We implemented non-natural amino acid

incorporation to enable photocrosslinking strategies to stabilize vesicles and control their swelling and release of cargo. We modified the hydrophobic block amino acid sequence to create pH responsive vesicles or form vesicles with different sizes and stabilities. We demonstrated assembly of biocatalytic vesicles with significant improvements in activity over soluble enzyme and produced vesicles for vaccination and drug delivery capable of carrying and releasing therapeutic cargoes.

- Jessica Winter (10/26/22)
    - McNeill Nanomedicine Seminar Series: Quantum Dots for Clinical Diagnostics: A Commercialization Journey
    - Abstract
        - Quantum dots (QDs), semiconductor nanoparticles that fluoresce upon light excitation, were introduced for biological imaging in 1998. They were heralded as a revolutionary product that would transform biological imaging. Yet, despite 20 years of research, there are no clinically approved QD products. My group has identified and solved the numerous challenges hindering translation of this promising technology into practice, which I will discuss. To overcome these challenges, we developed a micelle encapsulation strategy and scale-up methodologies that led to a company. I will discuss the adventure of starting a company, and the journey of one idea from conception to realization.
- Billy Bardin (10/28/22)
    - CBE Mentoring Program Special Seminar: How to be a Better Mentor
    - Abstract
        - As leaders in any profession, career, or personal endeavor, leaving a legacy of impact for and with those that follow us is one of the most important responsibilities we have. Paths to positively support those with whom we interact include mentorship, coaching, championship, and sponsorship. Mentoring others can bring benefits not only to those being mentored, but also to those that are mentoring. For a mentoring relationship to be successful, it is important that those involved understand the objectives and desired outcomes for success from the beginning, as well as realizing when other, more direct forms of engagement such as coaching or sponsorship may be needed. Mentoring relationships can be of short duration or life-long, however both parties should be clear on the intents and needs. This presentation will discuss some ideas and approaches for successful mentoring outcomes as well as provide a framework of questions to be considered by those involved in mentoring to drive critical thinking and objective exploration.
    - Bio
        - Billy B. Bardin is the Global Digitalization Director for Dow Inc. He leads efforts to explore, evaluate, and implement emerging and next generation digital technologies that are required to maintain and improve Dow's competitive position. He also drives initiatives to ensure Dow's workforce has the required skills, characteristics, and training to be digital ready. He has held numerous global leadership roles in research, development, and manufacturing in which he

has developed and commercialized technologies including new heterogeneous catalysis research capabilities, novel catalytic processes for feedstocks and derivative products, process technologies for improved olefins production, and advanced digital manufacturing capabilities, among others. Bardin holds a Bachelor of Science in Chemical Engineering from North Carolina State University, and a Master of Science and a Doctor of Philosophy in Chemical Engineering from the University of Virginia. He is a Registered, Professional Engineer (PE) with the W. V. State Board of Registration for Professional Engineers. He is the 2023 President of the American Institute of Chemical Engineers (AIChE).

- Charles Jones (11/4/22)
    - BTEC Seminar: Unlocking the Power of mRNA Through Innovation
    - Abstract
        - mRNA is at the heart of a therapeutic revolution. The COVID-19 pandemic showcased the ability of mRNA-based technology to produce vaccines against an infectious disease, a feat that was made possible due to over 60 years of research and successful collaboration across the academic and pharmaceutical industries. To unlock the power of mRNA, we need to fully realize the potential of RNA-based technology platforms and continue to innovate at each stage of the production process. Here we will discuss one facet of this technology, therapeutic delivery mechanisms, a field that is undergoing a rapid evolution in line with the developing scientific landscape. In this presentation, we will see that mRNA-based technology is on a scientific journey that has only just begun.
- Lukasz Bugaj (11/7/22)
    - Title: Uncovering principles of signal perception and protein condensation with precision molecular probes
    - Abstract
        - Cell signals are the “brains” that allow cells to perceive their environment and execute the appropriate response. Recent advances in light-activatible “optogenetic” control of signals now permit a causal understanding of how features like duration, dynamics, intensity, and location contribute to signal perception, and also how proper perception can be altered in disease. Protein condensation plays an increasingly recognized role in signal transmission, and its dysregulation drives many human diseases, including in cancer. In this talk I will briefly describe how optogenetic tools can be applied to study signaling events, including through inducible clustering/condensation. I will then describe how we are applying these tools to uncover new potential mechanisms of drug resistance in cancers driven by oncogenes that disrupt host cell signaling through protein condensation. Finally, I’ll describe our efforts towards a proteome-wide understanding of protein condensation using a new reporter that visualizes small, endogenous protein clusters in living cells.
    - Bio
        - Lukasz Bugaj is an assistant professor of Bioengineering at Penn. Lukasz earned his Ph.D. with David Schaffer at Berkeley where he developed the first method

to cluster proteins using light, and he applied these tools to study how cell signal dynamics regulate stem cell decisions. As a postdoctoral fellow at UCSF with Wendell Lim, Lukasz further advanced optogenetic technologies and applied them to discover that oncogenes could dynamically alter signal transmission kinetics that control proliferation. At Penn, the Bugaj Lab develops novel tools to probe living cells to understand cell signal regulation. These tools include proteins that use light or temperature as an input, as well as a new class of fluorescent reporters that visualize submicroscopic and endogenous protein clustering. The lab applies these and other approaches to examine cancer-associated changes in how cell signals are regulated, with a goal of understanding how interactions between oncogenes, targeted therapies, and host cells lead to drug resistance.

- Matteo Cargnello (11/21/22)
    - Title: Understanding and Engineering Catalytic Materials Using Nanocrystal Precursors
    - Abstract
        - Catalytic processes are central to the goal of a sustainable future. A promising approach in developing catalytic materials is represented by the design of catalytic sites based on the knowledge of structure- property relationships, and in the precise synthesis of these sites at the atomic level. Colloidal nanocrystals, with tunable active sites and compositions, can help in this mission. The goal of this talk is to show how this approach can provide not only fundamental understanding of catalytic reactions, but also a way to precisely engineer reaction sites to produce efficient catalysts that are active, stable and selective for several important transformations. Advances in the synthesis of these materials will be presented. Examples of the use of these building blocks as supported systems or in combination with hybrid organic materials will be shown, both to understand trends in methane and CO2 activation, and in the preparation of optimized catalytic systems combining multiple active phases. In all these examples, important efforts to obtain precious structure- property relationships will be highlighted, with this knowledge used to prepare more efficient and stable catalysts for reducing the emission of greenhouse gases and for the sustainable production of fuels and chemicals.
- Kristen Fichthorn (11/28/22)
    - Title: Surface Science of Shape-Selective Metal Nanocrystal Synthesis from First-Principles
    - Abstract
        - Efforts to understand the growth of Cu and Ag nanocrystals through a multi-scale approach. Using first-principles density-functional theory (DFT), we confirm experimental hypotheses that several commonly used capping molecules, such as PVP and various alkylamines, could facilitate nanoshape formation through their selective binding to particular crystal facets. To scale our calculations to the solution phase, we develop a metal-organic many-body force field with high fidelity to DFT. Using the example of the PVP-mediated growth of Ag nanocubes, we employ molecular-dynamics simulations to predict both

thermodynamic and kinetic Wulff shapes of Ag crystals. These studies indicate that the relatively large (100 nm) cubic nanoshapes grown in experiments are kinetic in origin and can originate from differences in the Ag flux to different crystal facets. Fivefold-twinned Ag nanowires can also be grown in solution with PVP. Our calculations with absorbing Markov chains indicate that Ag nanowires with high aspect ratios, comparable to experiment, arise from surface diffusion. On the other hand, a synergistic interaction between adsorbed chloride and capping molecules leads to a higher flux of solution-phase cuprous ions to the ends of Cu nanowires and promotes their growth. We also find that surface diffusion can play a significant role in producing chlorine-covered Cu nanowires with high aspect ratios.

- John Blazeck (12/5/22)
    - Title: Engineering Efforts to Remodel the Tumor Immunometabolic Environment to Enhance Immune Responses
    - Abstract
        - Cancer cells have dysregulated metabolism, resulting in the accumulation of metabolic byproducts in tumors. These accumulated metabolites can directly inhibit the antitumor function of immune cells. More specifically, the ribonucleoside adenosine accumulates in tumors to levels 1000-fold higher than compared to healthy tissues and negatively impacts nearly every aspect of antitumor T cell immunity. Here, we will detail our lab's ongoing efforts to prevent the impact of adenosine using two strategies. First, we will show how administration of an ADOase enzyme (an enzyme engineered to eliminate adenosine) directly to a cancer mouse model can prevent adenosine-immunosuppression, slowing tumor growth and delaying mortality in treated animals. Second, we will detail our efforts to engineer T cells that can actively remodel the tumor immunometabolic environment.
- Karen Burg (12/9/22)
    - CBE Distinguished Alumni Seminar
- Hakho Lee (12/12/22)