17th Annual Fall Symposium

Nanotechnology to Combat COVID – Prevention, Detection and Therapy

Nov 17th, 2021: 9.00 am – 4.00 pm **PST**

Talk: 40 min; Question time: 10 min

Agenda	
9:10 am – 10:00 am	Biomimetic Nanoparticles for the Treatment of Infectious Diseases, Liangfang Zhang, PhD
10: 10 am – 11:00 am	An overview of AI-enabled multi-scale simulations for targeting SARS-CoV-2; Dr. Arvind Ramanathan
11: 10 am – 12:00 pm	Corona Phase Molecular Recognition of SARS-CoV-2 and Associated Biomarkers; Professor Michael Strano
1:00 pm – 1:50 pm	Key to successful development of mRNA manufacturing and lipids based RNA delivery; Erica Weiskircher-Hildebrandt
2:00 pm – 2:50 pm	Biology-Powered Transistors: A merger of bio and nanotechnology; Francie Barron, PhD
3:00 pm – 3:50 pm	Nanotraps for the containment and clearance of SARS-CoV-2; Dr. Jun Huang

Biomimetic Nanoparticles for the Treatment of Infectious Diseases

Liangfang Zhang, PhD

Professor of Nanoengineering, Bioengineering, and Chemical Engineering
University of California San Diego

Abstract: The global incidence of infections caused by bacteria and viruses has been increasing, which imposes a major threat to public health given the high morbidity and mortality rates associated with these diseases. Nanoparticle technology has enabled a wide array of improvements in the treatment of infectious diseases, ranging from improved efficacy in drug delivery to enhanced immunogenicity of vaccines. Among the different bio-inspired nanotechnology strategies, utilization of cellular membrane material for nanoparticle preparation presents a unique top-down approach that offers the advantage of being able to completely replicate the surface antigens and functions of source cells. Herein, I discuss the biological functionalization of polymeric nanoparticles with a layer of membrane coating derived from natural cells. Specifically, I will focus on the use of these cell-mimicking nanoparticles for the treatment of bacterial and viral infections including SARS-CoV-2 infection.

Biography: Dr. Liangfang Zhang is Joan and Irwin Jacobs Chancellor Professor of Nanoengineering and Bioengineering and Director of Chemical Engineering Program at the University of California San Diego. Dr. Zhang received his Ph.D. in Chemical & Biomolecular Engineering from the University of Illinois at Urbana-Champaign in 2006 under the supervision of Prof. Steve Granick. He was a postdoctoral associate in the laboratory of Prof. Robert Langer at MIT during 2006-2008. He joined the Department of Nanoengineering at UC San Diego as an Assistant Professor in 2008 and was promoted to Professor in 2014. Dr. Zhang's research aims to create cutting-edge biomimetic nanotechnologies and exploit them for various biomedical applications with a particular focus on biomimetic nanodelivery, countermeasure nanotherapeutics, and vaccine nanotechnology. He has published 240 peer-reviewed articles and was among the Clarivate Analytics list of "Highly Cited Researcher" during 2017-2021. He is an inventor of 116 patents and patent applications worldwide. He has received numerous mainstream recognitions, including the Victor K. LaMer Award (2009) and Unilever Award (2012) from the American Chemical Society, MIT Technology Review's TR35 Innovator Award (2013), Allan P. Colburn Award (2014) from the American Institute of Chemical Engineers, Popular Science's Brilliant 10 Award (2016), U.S. Department of State ASPIRE Award (2017), and Kabiller Young Investigator Award (2017). Professionally, Dr. Zhang was elected to the Fellows of the American Institute for Medical and Biological Engineering (AIMBE) in 2015, the Fellows of the American Association for the Advancement of Science (AAAS) in 2018, and the Fellows of the National Academy of Inventors (NAI) in 2020. (http://nano.ucsd.edu/~l7zhang/)

An overview of AI-enabled multi-scale simulations for targeting SARS-CoV-2

Dr. Arvind Ramanathan

Computational biologist in the Data Science and Learning Division at Argonne National Laboratory

Abstract: Our work addresses both the fundamental biological mechanisms of the SARS-CoV-2 virus and the disease, while simultaneously targeting the entire viral proteome to identify potential therapeutics. We have been developing machine learning (ML), deep learning (DL) and artificial intelligence (AI) techniques to: (i) identify and build accurate three-dimensional structural models of the SARS-CoV-2 proteome by integrating experimental structural and systems biology datasets, (ii) accelerate adaptive conformational sampling of the viral proteins to potentially identify novel binding sites/ pockets that can be targeted by compound libraries, (iii) rapidly filter, rank, and search for small molecules across widely available chemical libraries and to integrate virtual screening with experimental high throughput screening, and (iv) characterize the evolutionary 'traits' of the virus including identification of epitopes and the viral genome that can be targeted for vaccine design. The immediate impact of our current research is an ecosystem of open source AI/ML tools and conventional physics-based simulations that can accelerate timely response for treating such pandemics. We have made significant progress across the aforementioned goals, including the release of over 60 terabytes of machine readable data for various open-source chemical compound libraries (https://2019-ncovgroup.github.io/data/), development of scalable AI/ML methods for rapidly filtering the chemical space that can bind specifically to viral protein targets, and adaptive conformational sampling using molecular dynamics (MD) simulations to quantify the stability and binding of AI-predicted compounds to specific targets. The outputs from physics-based models are used iteratively to improve the prediction capabilities of our AI/ML approaches, thus successively improving the overall yield of drug candidates that can be refined further using biochemical and biological assays. Together, our integrated approach provides insights into how the overall drug-design and discovery process can be improved for emerging pandemics

Biography: Arvind Ramanathan is a computational biologist in the Data Science and Learning Division at Argonne National Laboratory and a senior scientist at the University of Chicago Consortium for Advanced Science and Engineering (CASE). His research interests are at the intersection of data science, high performance computing and biological/biomedical sciences.

His research focuses on three areas focusing on scalable statistical inference techniques: (1) for analysis and development of adaptive multi-scale molecular simulations for studying complex biological phenomena (such as how intrinsically disordered proteins self-assemble, or how small molecules modulate disordered protein

ensembles), (2) to integrate complex data for public health dynamics, and (3) for guiding design of CRISPR-Cas9 probes to modify microbial function(s).

He has published over 30 papers, and his work has been highlighted in the popular media, including NPR and NBC News. He obtained his Ph.D. in computational biology from Carnegie Mellon University, and was the team lead for integrative systems biology team within the Computational Science, Engineering and Division at Oak Ridge National Laboratory. More information about his group and research interests can be found at http://ramanathanlab.org.

Corona Phase Molecular Recognition of SARS-CoV-2 and Associated Biomarkers

Professor Michael Strano

Carbon P. Dubbs Professor of Chemical Engineering, MIT

Biography: Professor Michael S. Strano is currently the Carbon P. Dubbs Professor in the Chemical Engineering Department at the Massachusetts Institute of Technology. He received is B.S from Polytechnic University in Brooklyn, NY and Ph.D. from the University of Delaware both in Chemical Engineering. He was a post-doctoral research fellow at Rice University in the departments of Chemistry and Physics under the guidance of Nobel Laureate Richard E. Smalley. From 2003 to 2007, Michael was an Assistant Professor in the Department of Chemical and Biomolecular Engineering at the University of Illinois at Urbana-Champaign before moving to MIT. His research focuses on biomolecule/nanoparticle interactions and the surface chemistry of low dimensional systems, nano-electronics, nanoparticle separations, and applications of vibrational spectroscopy to nanotechnology. Michael is the recipient of numerous awards for his work, including a 2005 Presidential Early Career Award for Scientists and Engineers, a 2006 Beckman Young Investigator Award, the 2006 Coblentz Award for Molecular Spectroscopy, the Unilever Award from the American Chemical Society in 2007 for excellence in colloidal science, and the 2008 Young Investigator Award from the Materials Research Society and the 2008 Allen P. Colburn Award from the American Institute of Chemical Engineers. From 2014 to 2015 he served as member of the Defense Science Study Group, and is currently an editor for the journals Carbon and Protocols in Chemical Biology. Michael was elected to the National Academy of Engineering in 2017 and the recipient of the Acrovos Professional Progress Award in 2019.

Key to successful development of mRNA manufacturing and lipids based RNA delivery

Erica Weiskircher-Hildebrandt

Director, Business Development and Field Marketing - Formulation and Drug Delivery at MilliporeSigma

Abstract:

1. The success of mRNA-based vaccines for COVID-19 lays the path to accelerate the development of this modality for many other diseases. While production of these vaccines took place in record time, critical decisions must be made when developing novel mRNA applications.
2. This presentation covers the key factors in mRNA manufacturing and best practices to ensure success

Learning points:

1. Therapeutic potential of mRNA: COVID-19 and beyond
2. Design principles and specifications for lipids used in RNA formulations
3. Critical parameters to enable the rapid development and consistent performance of lipids
4. Regulatory considerations for lipids used in drug delivery

Biography: Erica Weiskircher-Hilderbrandt is the Director of Formulation Business Development and Field Marking at MilliporeSigma. She holds a Master's of Science in biochemistry, microbiology, and molecular biology from The Pennsylvania State University. With a career spanning over 15 years in the pharmaceutical industry, she has held various postitions from R&D to operations to marketing/sales. She joined the global organization of Merck KGaA Darmstadt Germany (operating as MilliporeSigma in the US and Canada) in 2015 as a technical product manager for pharmaceutical polymers. In her current role, she and her team are responsible to technical sales of Advanced Drug Delivery solutions and mRNA in the Americas.

Biology-Powered Transistors: A merger of bio and nanotechnology

Francie Barron, PhD

VP Innovation Partnerships, Cardea Bio Inc

Abstract: Biological networks are infinitely complex and dynamic systems. Unfortunately, current methods of observing these networks remain woefully inadequate. Most methods rely on optics and can only sense one type of molecule (RNA, DNA, etc.) at a time – a mere snapshot of biology. Since most biomolecules are smaller than a wavelength of light, optics require heavy amplification and artificial conditions, providing an indirect and out-of-context view of biology. Additionally, optics require bulky expensive lab infrastructure with complex protocols, limiting practical solutions to real problems. At Cardea, we believe to truly understand biology, we need to understand it as a system in context with multi-omics data streams and not just frozen single-omics datasets. To do this, we have created a Biosignal Processing Unit, or BPU, which like the CPUs and GPUs we use in the palm of our hands, enables us to create a gateway between the live signals in biology and the digital world. For the first time, our BPUs offer a direct communication with biology by translating near real-time streams of multiomics signals into digital information. At this talk, learn how our BPUs work, how we have produced them at scale, and how we are using them to innovate in human health applications.

Biography: Dr. Francie Barron has made it her mission in life to always follow her “nerdy delight,” which has led to a diverse career in science and business. Dr. Barron obtained her BS in Biochemistry/Cell Biology at the University of California, San Diego where her emphasis was on cancer and immunology. She continued to a PhD in Cell Biology, Stem Cells, and Development from the University of Colorado, Denver Anschutz Medical Campus where she elucidated a gene transcriptional pathway in lower jaw development. As a postdoctoral fellow at Stanford University, Dr. Barron used iPSC-induced cardiomyocytes as a disease model for drug toxicity studies of novel anti-arrhythmics. She then returned to San Diego where she was a Regulatory Affairs and Medical Writing consultant, until she joined Cardea Bio in 2015. Cardea Bio is the first semiconductor company to produce Biosignal Processing Units, or BPUs, providing a Gateway to Biology by translating real-time streams of multi-omics signals to digital information. As VP R&D and Regulatory Affairs, Dr. Barron learned more physics, nanotechnology, engineering, and software then she ever thought she would, and combined with her background was able to launch the first drug discovery research tool utilizing mass-produced BPUs, which is still in use today. In 2019, Dr. Barron transitioned to business development at Cardea Bio as VP Innovation Partnerships, where she interacts with commercial and academic partners to create and execute on projects to bring Powered by Cardea products to the market.

Nanotraps for the containment and clearance of SARS-CoV-2

Dr. Jun Huang

Assistant professor at the Pritzker School of Molecular Engineering, University of Chicago

Biography: Jun Huang is an assistant professor at the Pritzker School of Molecular Engineering, Committee on Cancer Biology, Committee on Immunology, and the Graduate Program in Biophysical Sciences of the University of Chicago. He received his Ph.D. in Bioengineering from Georgia Institute of Technology where he worked with Prof. Cheng Zhu to measure the *in situ* binding kinetics of T cell receptors. As a postdoctoral fellow working with Prof. Mark Davis at Stanford University, he developed a single-molecule imaging method to quantify T cell sensitivity.

His lab performs basic and translational research with the objective of developing effective vaccines and cell immunotherapies for the treatment of cancer, infection, and autoimmunity. He carries out basic immunological research, focusing on molecular mechanisms of T cell recognition and signaling at the single-molecule level. He performs systems immunology, studying the development, differentiation, and metabolism of T cells at the single-cell level. He engineers CAR-T cells, aiming at the treatment of cancer and autoimmunity. He develops new biomaterials, enabling the detection, profiling, and manipulation of T cells and other immune cells for diagnosis and treatment. He is a recipient of the NSF Career Award, the NIH Director's New Innovator Award, the Cancer Research Foundation Young Investigator Award, and the NIH Pathway to Independence Award.