2020 Chemical Engineering Rising Stars Workshop

October 8-9, 2020

Massachusetts Institute of Technology

Chemical Engineering

Rising Stars 2020

A message on behalf of the 2020 Workshop Steering Committee:

Welcome to the 2020 Rising Stars in Chemical Engineering Symposium!

We are pleased to welcome you to this virtual event and look forward to hearing about your research and aspirations, as well as helping you to navigate the journey toward a successful and fulfilling academic career.

The goal of this event is to bring together the next generation of leaders in chemical engineering and help prepare them for careers in academia. We aim to help strengthen the academic pipeline for women in our field, and provide opportunities for you to develop your own network of peers as you decide your own next steps.

This 2020 workshop cohort represents some of the top early career women in chemical engineering today. We hope that the next two days of workshops, discussions and presentations inspire you as you find your way in your career.

We hope you find this event informative and inspiring. We look forward to meeting you!

Karen K. Gleason
Alexander and I. Michael Kasser (1960) Professor

K. Dane Wittrup
Carbon P. Dubbs Professor of Chemical Engineering

Paula T. Hammond
David H. Koch (1962) Professor in Engineering
Department Head, MIT Chemical Engineering Department

Agenda Summary

Thursday, October 8

10am	Welcome by Paula Hammond	
10:15am	Welcome and Introduction	Anantha Chandrakasan Dean of Engineering
10:30am	Thriving as a Professor	Maria Zuber VP for Research
11am	Break	
11:30am	Senior Faculty Panel: Why Academia?	
12:15pm	Lunch with faculty	
1:30pm	Oral Presentations by Workshop Participants	
2:45pm	Panel Discussion: Getting the Job: Strategies for the Next 12 Months	
3:30pm	Faculty Applications 101	
4:45pm	Break	
5pm	Chalk Talk Workshop and Interview Day Strategies	

Friday, October 9

9:30am	Breakfast with Graduate Women in Chemical Engineering
10am	Junior Faculty Panel
10:30am	AIChE Virtual Meet the Faculty Poster Session Workshop
11:15am	Break
11:30am	Teaching Statement Workshop
12:15pm	Diversity Statement Workshop
1pm	Wrap-up

Rising Stars Cohort 2020

Aisulu Aitbekova
Stanford University

Sarah Alamdari
University of Washington

Konane Bay
Princeton University

Sarah Berlinger
UC Berkeley

Vivian Feig
MIT

Alice Gillen
Lawrence Livermore National Laboratory

Wenyu Gu
Stanford University

Stephanie Hare
University of Washington

Esther Heid
MIT

Carolyn Mills
Northwestern University

Melody Morris
MIT

Chiamaka Obianyor
Georgia Institute of Technology

Aleena Patel
Princeton University

Rebecca Pinals
UC Berkeley

Selene Pirola
Imperial College London

Ritu Raman
MIT

Beatrice Soh
Institute of Materials Research and Engineering

Sanjuna Stalin
Cornell University

Michelle Teplensky
Northwestern University

Florence Vermeire
MIT

Asher Williams
Cornell University

Rising Star 2020

Aisulu Aitbekova

Stanford University

Aisulu Aitbekova was born in Kazakhstan. She obtained her B.S. (2015) in Chemical Engineering from Nazarbayev University, Kazakhstan, and M.S. (2016) in Chemical Engineering Practice from MIT. Currently, she is a graduate research assistant at Stanford University in the Department of Chemical Engineering, where is advised by Assistant Professor Matteo Cargnello and funded by the Stanford Graduate Fellowship, Precourt Institute for Energy, and American Association of University Women. Aisulu is committed to STEM outreach and mentoring.

Catalyst Restructuring for Carbon Dioxide Conversion into Fuel and Chemicals

Aisulu's research is focused on converting carbon dioxide into fuel and chemicals. To this end, she synthesizes well-defined nanoparticles and studies them using operando X-ray absorption spectroscopy at SLAC National Accelerator Laboratory, where she works with distinguished staff scientist Simon Bare. Her research goal is to identify catalyst active sites and reaction mechanisms to develop efficient materials for converting the pollutant gas into higher value products..

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Sarah Alamdari

University of Washington

Sarah Alamdari earned a B.S. in Chemical Engineering from Arizona State University in Tempe, Arizona in 2016. She is currently a graduate research fellow at the University of Washington in Seattle, WA and expects to receive her PhD in 2021 under the guidance of Jim Pfaendtner.

Uncovering Biomolecular Structure-Property Relationships with Molecular Dynamics

My research uses a computational approach known as molecular dynamics to probe the relationship between structure and function in biomolecules. Biomolecules are versatile, specific, and efficient building blocks that can be applied in systems ranging from health to energy. Consequently, biomolecules are highly diverse both in sequence and structure and because of this, we often lack atomistic insight into the fundamental driving forces that lead to their highly specific function in macroscopic systems. When we further introduce complexities like the presence of an interface, these relationships between structure and function become increasingly more difficult to resolve with experimental techniques alone. Even the world's most powerful microscopes can provide this level of resolution, leaving room for computational researchers to further dive into these systems. To begin answering this question, my PhD research first explored the structure/function relationships in biomineralization by studying matrix proteins in the body. Moving forward I hope to extend this research in the remainder of my PhD to probe more complex systems.

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Konane Bay

Princeton University

Konane Bay is currently a Presidential Postdoctoral Research Fellow in Professor Sujit Datta's group in the Department of Chemical and Biological Engineering at Princeton University. Her current research focuses on developing structure-property relationships of living biohybrid polymeric materials. She received her B.S. in Materials Engineering from Rensselaer Polytechnic Institute and M.S. and Ph.D. in Polymer Science & Engineering from the University of Massachusetts Amherst. Her Ph.D. thesis work in Professor Alfred Crosby's group focused on quantifying the mechanical properties of ultrathin polymer films. Konane is the recipient of the multiple awards for her Ph.D. research, including the ACS Eastman Chemical Student Award in Applied Polymer Science, Best Poster Award at the Annual Meeting of the Adhesion Society, and Frank J. Padden Jr. Award Finalist. Outside of research, she is one of the co-founders of the Early Career Researchers in Polymer Physics Slack and the organizer of the 2020 Virtual Polymer Physics Symposium. During her free time, Konane enjoys playing tennis or editing Wikipedia.

Designing the Next Generation of Living and Polymeric Materials

During her Ph.D., Konane worked on understanding how mechanical stresses relate to molecular structural changes within an ultrathin glassy polymer film. To quantify mechanical properties, she developed and implemented two new methods that directly measure the stress-strain response of nanometer-thick films, and access both the low and high strain mechanical response. Her work revealed that due to physical interactions between polymer chains, entanglements, the mechanical response of the ultrathin films differs from previous tensile measurements of single polymer molecules and bulk polymers (films thicker than the average polymer molecular size). As a postdoc, Konane is developing a new class of materials within the emerging field of engineered living materials. Through 3D printing, she spatially programs different strains of biofilms, a living material system, onto polymer interfaces to fabricate self-healing, self-regenerating, and responsive biohybrid composites. She is working on understanding the relationship between the biohybrid composites composition and the external environmental cues to develop design guidelines for advanced applications such as stimuli responsive coatings.

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Sarah Berlinger

UC Berkeley

Sarah A. Berlinger is a PhD candidate and NSF Graduate Research Fellow in the Department of Chemical & Biomolecular Engineering at the University of California, Berkeley, where she is co-advised by Professor Bryan McCloskey and Dr. Adam Weber (Lawrence Berkeley National Lab). Her research focuses on understanding the phenomena governing particle/polymer aggregation in fuel-cell catalyst-layer inks and the forces driving electrode microstructure formation. Prior to her graduate studies, she completed a Bachelor of Science in Chemical Engineering at Columbia University. There, she researched both lead-acid battery charging protocols for capacity recovery, as well as bioelectrochemical non-photosynthetic fuel and chemical production pathways under the direction of Professor Alan C. West. Outside of research, Sarah is passionate about mentorship and outreach. She has mentored five undergraduate researchers over the past few years and is actively involved with Bay Area Scientists in Schools.

Probing Interfacial Phenomena in Electrochemical Energy Devices

Fuel-cell catalyst layers (electrodes) are complex, heterogeneous porous electrodes. How to control electrode microstructure, morphology, and resulting properties (i.e. performance) is poorly understood: studies have been almost entirely empirical, with little understanding of the forces governing microstructure formation. Therefore, our work aims to address this: by probing and understanding interactions within the ink (dispersions of catalyst particles, ion-conducting polymers, and solvent) from which these electrodes are made, we can learn how and why specific structures and interfaces form, enabling control of the electrode morphology and polymer/particle interactions. Using a variety of techniques, including light and x-ray scattering, electron microscopy, calorimetry, rheology, and quartz-crystal microbalance, we systematically study the interactions that control the convoluted multi-component phenomena in the ink: polymer/solvent and polymer/particle interactions. More specifically, over the past few years, we've elucidated how solvent controls polymer solution conformation, how this changing structure modulates the way the polymer adsorbs to surfaces, the degree to which it interacts with different catalyst surfaces, and how these parameters affect ink aggregation phenomena.

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Vivian Feig

MIT

As a materials engineer with expertise in bio-interfacing polymers and electronics, I harness the versatility of polymers to endow therapeutics with unprecedented functionalities that enhance human health. I obtained my B.S. in Chemical Engineering from Columbia University in 2012 and then spent 3 years working for the ExxonMobil Chemical Company, where I developed a fascination with polymers. Combining my interest in polymeric materials with a desire to make an impact in the biomedical space, I came to Stanford University in 2015 to pursue a Ph.D. in Materials Science and Engineering with Prof. Zhenan Bao. As a National Defense Science and Engineering Graduate (NDSEG) fellow, I designed new conducting polymer-based materials to address the challenge of intimately coupling electronics with biological systems, which is critical for emerging therapies in areas like neuromodulation and regenerative medicine. My research culminated in numerous honors, including selection to the American Chemical Society (ACS)'s Excellence in Graduate Research and the Materials Research Society (MRS)'s Graduate Student Award symposia. Currently, I am receiving postdoctoral training at Brigham and Women's Hospital and MIT, where I work with Prof. Giovanni Traverso and Prof. Robert Langer on developing stimuli-responsive systems for ingestible long-term drug delivery. Besides research, I am passionate about mentorship and outreach, and was honored to receive the 2020 MRS Arthur Nowick Graduate Student Award for my efforts in these areas. My ultimate goal is to train the next generation of innovators by running an academic research lab that develops materials-driven and translatable approaches to understanding, targeting, and treating disease.

3-Dimensional Bio-Electronic Interfaces

Electronics open the door to a wealth of promising biomedical therapies, from implanted devices that therapeutically stimulate organs, to regenerative medicines that use electrical cues to guide stem cell differentiation towards target lineages. However, in stark contrast to the 3D nature of cell-cell and cell-environment interactions, typical electronic interfaces are planar, which not only limits the potential density of bio-electronic interactions but can also negatively impact cell fate.

My research vision is to develop next-generation 3D bio-interfacing electronics that recapitulate the dimensionality of the natural tissue environment. To tackle this challenge, I will first systematically elucidate structure-property relationships for a class of conductive materials that exhibit dynamic mechanical behavior so that they can be readily mixed with cells to form conductive 3D scaffolds. Next, I will develop 3D bioprinting techniques to pattern conductive scaffolds and incorporate additional stimuli-responsive functionalities. Finally, I will collaborate with organoid engineers to address the question: can neural circuitry in brain organoids be programmed using electrical stimulation that is spatially-defined through 3D conductive wires? These experiments will illuminate new insights into the process of neural development and potentially enable novel treatment strategies for neurodegenerative disease.

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Alice Gillen

Lawrence Livermore National Laboratory

Alice received her B.A. (Mod) in Nanoscience, Physics and Chemistry of Advanced Materials from Trinity College Dublin (University of Dublin, Ireland) in 2015. After a brief period of working in investment banking she started her Ph.D. in Chemical Engineering in 2016 at École Polytechnique Fédérale de Lausanne (EPFL, Switzerland) under the supervision of Ardemis A. Boghossian. Her PhD research focused on engineering optical sensors using single-walled carbon nanotubes for biomedical sensing applications, with a specific focus towards engineering improved sensors for neurochemical detection. Starting in October 2020, Alice will begin a postdoctoral research position at Lawrence Livermore National Laboratory (LLNL, California, USA) in the group of Aleksandr Noy working in the area of nanofluidics.

New approaches for engineering SWCNT optical biosensors for neurochemical sensing

Irregularities in neuromodulation can result in a variety of diseases, such as Parkinson's disease, Alzheimer's disease, or schizophrenia. As a result, accurate measurement of the concentration of key neurotransmitters is imperative for improved clinical diagnostics and patient care. However, limitations in the spatiotemporal resolution achievable using existing biosensor technologies has hindered our ability to study the complex nature of these molecules and as a result prevented us from improving our understanding of their role in regulating biological functions.

My work shows new approaches for overcoming these limitations and presents new methods that have been developed to rationally engineer optical biosensors using single-walled carbon nanotubes (SWCNTs). SWCNTs benefit from stable and sensitive near-infrared fluorescence, whose emission wavelengths overlap with the window of transparency for biological material, making these an attractive material for deep-tissue sensing and imaging applications. However, recent studies have shown that the fluorescence of the ssDNA-functionalized nanotube sensors can be severely impacted by changes in local cation concentrations. This is particularly problematic for neurotransmitter sensing applications as spatial and temporal cation fluctuations play a central role in neuromodulation. These fluctuating ion concentrations can interfere with the sensors and lead to inaccuracies in concentration readouts, thereby limiting the use of ssDNA-SWCNT sensors in vitro and in vivo. I address this issue by combining xeno nucleic acids with DNA-SWCNTs to create optical biosensors with improved stability towards cation-induced fluorescence changes. Specifically, by incorporating locked nucleic acid (LNA) I show that it is possible to improve the stability of DNA-SWCNTs to cation-induced fluorescence changes in both gel- and solution-based sensors. Furthermore, by carefully designing the LNA sequences I demonstrate that it is possible to enhance their stability while simultaneously improving their responsivity towards dopamine. This approach introduces a complementary means for enhancing nanotube optoelectronic behaviour, unlocking previously unexplored possibilities for developing nano-bioengineered sensors with augmented capabilities.

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Wenyu Gu

Stanford University

Wenyu Gu is an expert in microbial genetics and physiology who aspires to establish a research group of quantitative microbial physiology. Wenyu grew up in Qingdao, China and moved to U.S. for graduate studies in 2011. She holds a master's degree from Johns Hopkins University in environmental engineering and conducted PhD research in Professor Jeremy D. Semrau's lab at University of Michigan with a focus on environmental microbiology. Currently, she is a postdoctoral researcher at Alfred. M. Spormann's lab at Stanford University. She enjoys gardening and spending time with her dog.

Slow Growth of Methanogenic Archaea

Majority microorganisms in the environment spend a significant time in a mode of maintenance or slow metabolism under limited nutrient flux rather than fast growing. How microbes adjust to slow growth physiologically is underexplored. To investigate the cellular features of slow growth in a methane-producing archaeon, we are systematically characterizing proteome allocation, protein synthesis, and macromolecule composition of Methanococcus maripaludis as an environmentally relevant model microbe.

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Stephanie Hare

University of Washington

Stephanie grew up in the small farm town of Snohomish, WA. After high school, she went to the University of Washington and went on to graduate with a major in Chemical Engineering in 2013. She pivoted away from engineering in graduate school, obtaining a Ph.D. in Physical Chemistry from the University of California Davis's Department of Chemistry. Her research was in applied computational chemistry, determining the mechanisms of organic reactions, with a focus on reactions containing post-transition state bifurcations. She then completed a 1.5-year postdoctoral research position from September 2018 with Barry Carpenter at the University of Bristol in Bristol, England. In April 2020, she went back to her academic roots in the Chemical Engineering Department at the University of Washington, where she is currently working with Prof. Jim Pfaendtner on condensed phase molecular dynamics simulations.

The Influence of Environment on Chemical Reactions: A Computational Perspective

Stephanie's research interests are primarily in determining reaction mechanisms using computational methods. Her Ph.D. was focused specifically on computational investigations of organic reactions containing post-transition state bifurcations, which exist when a single transition state structure can lead to multiple products without any intervening minima or barriers to overcome. In the past several years, she has also been interested in using dimensionality reduction techniques to visualize reaction mechanisms in a new way and understand how solvent affects the behavior of a reaction mechanism. Very recently, she has also been investigating a silica oligomerization reaction in order to understand the external influences that affect the reactions that generate marine diatoms' exoskeletons. In the future, she plans to use condensed phase molecular dynamics simulations to understand the effect of solvent on chemical reactions, particularly those with unique potential energy surface features.

Rising Star 2020

Esther Heid
MIT

Currently working on the computer-aided design of multi-enzyme networks as a Postdoc at the Massachusetts Institute of Technology, Esther's research interest and ideas are focussed around combining computational approaches and chemistry in new and innovative ways. She graduated from the University of Vienna with a Bachelor and Master of Science in Chemistry in 2014 and 2016 top of her class, receiving multiple excellence scholarships. She then obtained a DOC fellowship of the Austrian Academy of Sciences to fund the research ideas she wanted to pursue in her graduate studies, and earned a doctoral degree in Chemistry with a focus on Theoretical Chemistry from the University of Vienna in 2019. Her PhD thesis 'Concepts of solvation dynamics in molecular dynamics simulations' was awarded with the prestigious Karl Schloegl Award of the Austrian Academy of Sciences. Her publication record comprises 21 publications in high-impact journals, of most of which she is the main author. She furthermore presented her research ideas at various talks and invited talks at conferences and summer schools. She is also known for her excellent teaching at the University of Vienna, where she held courses on mathematics, spectroscopy and theoretical chemistry, summing up to 16 seminars over the course of three years. Her current research is funded by a Postdoctoral Fellowship of the Austrian Science Fund, which is awarded to high-potential young researchers with excellent track records and promising research ideas.

Hidden patterns in nature: Tapping into the full potential of computational approaches in chemistry and biology

In her PhD thesis, Esther investigated how computer simulation can be utilized to study solvation dynamics and other solvent effects in bulk phase and close to biomolecules such as saccharides and proteins, giving her a strong background in molecules dynamics simulations, quantum mechanical calculations, method development, automation and machine learning. Her postdoctoral research focusses on the development of computer-aided tools for finding novel multi-enzyme cascades for an efficient, selective and environmentally friendly synthesis of desired target molecules, such as pharmaceuticals. She currently works on predicting the activity of known enzymes on new substrates using a combination of heuristic algorithms, machine learning and data mining. Her innovative approaches have already produced promising preliminary results. Her future research interests include the combination of computational approaches with chemistry and biology, especially where the creation of huge amounts of experimental data prohibits an in-depth manual analysis. For example, data from 'omics' experiments, protein sequencing or reaction databases hold a multitude of currently untapped patterns and insights simply because they cannot be analyzed efficiently. New computational solutions are needed – an exciting new research area Esther is keen to explore in the next years.

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Carolyn Mills

Northwestern University

Dr. Carolyn Mills is a postdoctoral fellow at Northwestern University in Professor Danielle Tullman-Ercek's lab where she is researching self-assembling protein nanoreactors with a focus on how they can benefit metabolic engineering applications. Dr. Mills completed her B.S. in Chemical Engineering in 2013 at the University of California, Santa Barbara after transferring from Pasadena City College. At UCSB, Dr. Mills carried out research as a Beckman Scholar, using atomistic simulations to study the mechanism of diphenylalanine peptide self-assembly with Professors M. Scott Shell and Patrick Daugherty. She received her M.S. in Chemical Engineering Practice and Ph.D. in chemical engineering at the Massachusetts Institute of Technology. As an NSF graduate research fellow, Dr. Mills completed her PhD in Professor Bradley Olsen's lab, where she focused on self-assembly and high-throughput processing of fusion protein materials. During her PhD, Dr. Mills was recognized as a finalist in the Excellence in Graduate Polymer Research session at the AIChE National Meeting in 2018 and as a poster award winner at the Polymer Materials: Science and Engineering poster session at the ACS National Meeting in 2016. In addition to her primary work at Northwestern University, she initiated a collaboration to study an enzymatic route to the upcycling of plastics and is active in outreach with the BioTreks and BioBuilders programs.

An in-depth study of the importance of pentamers in forming closed nanoscale protein scaffolds

Spatial organization of biological processes is key to metabolic efficiency in many organisms. Harnessing such strategies has the potential to transform metabolic engineering efforts. In bacteria, proteinaceous organelles called microcompartments (MCPs) encapsulate specific pathways, where this encapsulation is believed to sequester toxic intermediates produced in these pathways, provide a local privileged cofactor pool, and overcome slow enzyme kinetics. Repurposing these MCPs for non-native pathways that may similarly benefit from encapsulation requires understanding how MCPs assemble into closed structures. Here, we investigate the role of the PduN shell protein on the assembly of the 1,2-propanediol utilization (Pdu) MCP from Salmonella enterica serovar Typhimurium LT2. PduN is similar in sequence to the pentameric shell proteins from other MCP systems, and, like other pentamers, is hypothesized to play an essential role in capping the vertices of the polyhedral Pdu MCP shell. In this work, we use a combination of transmission electron microscopy (TEM), phase contrast microscopy, and fluorescence microscopy to establish that PduN is essential for the formation of closed Pdu MCPs. We also establish that the expression of the Pdu operon without PduN present leads to a linked cell phenotype that can be correlated with the level of PduN expression. This combination of results further supports the essential role of PduN in formation of closed Pdu MCP shells, and provides a potential route to generating open Pdu-based scaffolds that can be used for enzyme colocalization but not encapsulation.

Rising Star 2020

Melody Morris

MIT

Melody A. Morris is a postdoctoral research associate in the Department of Chemical Engineering at MIT. She earned her B.S. in Chemical Engineering with an emphasis in materials from Caltech and her Ph.D. in Chemical Engineering from the University of Delaware under the guidance of Thomas H. Epps, III. Her doctoral research on block copolymer electrolytes for lithium-ion batteries was acknowledged as a Padden Award finalist at the 2019 American Physical Society meeting and at the Excellence in Graduate Polymer Research Symposium at the 2019 American Chemical Society meeting. In her time at the University of Delaware, she was also awarded the Pigford Fellowship, Pigford Teaching Assistant Award, and Frasier and Shirley Russell Teaching Fellowship. Currently, in Prof. Bradley D. Olsen's group at MIT, Melody is developing high-throughput methods for the optimization of protein materials and engineering materials with selective biomolecular transport properties.

High-throughput sequence-modulated protein synthesis for rapid materials generation

My research uses polymer chemistry, polymer physics, bioengineering, and chemical engineering in tandem to synthesize, characterize, and optimize materials development. In my doctoral work, we employed a macromolecular strategy in order to create an electrolyte material that was more resistant to mechanical failure, while maintaining much of the ionic conductivity. Using scattering techniques combined with polymer physics, we were able to elucidate key polymer properties to understand how additives change the behavior of the polymer electrolyte material. Currently, I am focused on using the biosynthetic toolbox to create automated, high-throughput procedures for optimizing protein expression conditions. This process involves using a combinatorial methodology to scan DNA vectors and cell strains to monitor cell growth and protein yields using a low-cost, open-source robotics platform. We will also be using this tool in future development of difficult-to-express proteins, such as human nucleoporin proteins (hNups) and human nucleoporin-like proteins (hNLPs). Looking forward to my independent research career, I will be centering my lab's research around the idea of conceptualizing biomacromolecules and polymers as inherently indistinguishable materials to gain insight in both dominions.

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Chiamaka Obianyor

Georgia Institute of Technology

Chiamaka Obianyor received a B.S. in Chemical Engineering (Summa Cum Laude with highest thesis honors) from Texas Tech University in 2016. As an undergraduate, she worked with Dr. Ted Wiesner to design an underground coal gasification reactor for carbon capture. She is currently a PhD candidate in Chemical Engineering at Georgia Institute of Technology where she is jointly advised by Dr. Martha Grover and Dr. Nicholas Hud. As a member of the Center for Chemical Evolution she works with a diverse team of chemists, geologists, and engineers to study the chemical origins of biopolymers. Specifically, her thesis work focuses on investigating parameters that influence non-enzymatic nucleic acid replication in both aqueous and non-aqueous solvents. She has presented her work at several conferences, including the Astrobiology Science Conference (AbSciCon), American Institute of Chemical Engineers (AIChE) Annual meeting, and Georgia Tech 3MT (Three-minute thesis) competition where she placed as a finalist in 2019. Chiamaka was selected a recipient of the 2020 "Georgia Tech Chemical and Biomolecular Engineering (ChBE) Team-work" award for her dedication to mentoring and fostering community within the graduate program. More recently, Chiamaka has been working on the Governor's State Task force team to develop more COVID-19 test kits for the state of Georgia. Beyond her graduate tenure, Chiamaka is looking forward to performing research at the intersection of chemical engineering and biochemistry, and using her platform to influence the next generation of scientists.

RNA as a molecular evolution and nanotechnology tool

The use of non-enzymatic ligation is widespread in the generation of synthetic DNA structures and in the ligation of non-Watson-Crick base pairs, systems for which enzymes are less suited. In addition, non-enzymatic ligation is also necessary for the discovery of the chemical origins of RNA, a precursor to modern life. In this work, we will address the challenges often associated with non-enzymatic RNA ligation within the context of origins of life and RNA nanotechnology. Our first goal will be to demonstrate enzyme free RNA replication in non-aqueous solvents using wet-dry cycles. The accomplishment of this goal will solve both the strand inhibition problem prevalent in aqueous conditions and the low reactivity of the synthesis of RNA oligonucleotides. In the second part of this study, we will investigate the abiotic assembly of ribosomal RNA (rRNA). The ribosome is considered to be a molecular wheelhouse which has maintained records of primordial molecules, while conserving its common core through rRNA secondary and 3D structures. The second part of this study will be aimed at reconstructing the accretion model of the rRNA, in order to gain insight into the relationship between structure and possible RNA selection. The third goal of this project will be to investigate the abiotic ligation of the 3WJ domain of phi29 pRNA in order to facilitate in vivo assembly, ligation and delivery of therapeutics. Altogether, this research portfolio aims to demonstrate how RNA can be utilized as both a molecular evolution and nanotechnology tool.

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Aleena Patel

Princeton University

Aleena has always been fascinated by autonomy in life. How do cells "know" how to synthesize the right components, change shape, and communicate? These questions led her to study Biological Engineering as an undergraduate at Caltech, where she learned that establishing quantitative rules and principles in biology is a crucial goal to make sense of the apparent chaos in living systems. She is currently a senior PhD student co-advised by three principal investigators at Princeton University: Stanislav Shvartsman at the Lewis Sigler Institute, Rebecca Burdine in Molecular Biology, and Jared Toettcher in Molecular Biology. Her work lies at the intersection of fields and model organisms. In the past 5 years her focus has been to design and implement optogenetic systems for probing signaling systems and transcriptional responses in Drosophila and zebrafish embryos that today provide the foundation for brand new research directions and collaborations.

Illuminating developmental gene control

Surprisingly, only a handful of signaling pathways, cell-cell communication networks, generate immense complexity of cell fates and orchestrate tissue movements in developing embryos. New approaches are needed for connecting signaling molecules, to transcriptional responses, to systems-level effects on patterning and morphogenesis. We have harnessed the protein-level effects of disease-relevant mutations in one signaling kinase, MEK, to understand how the molecule is activated and to design a new approach for generating optogenetic signals. A new optogenetic tool allows us to now measure the quantitative parameters of the transcriptional processes immediately downstream of MEK activation, and the tissue-level responses to time-dependent signaling perturbations, integrating information from a complex cascade of events following transcription. These studies have contributed to developing predictive computational models for gene regulation, systems-level measurements of the dynamic phospho-proteome, and novel implementation of optogenetic signals in vertebrate and invertebrate embryos.

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Rebecca Pinals

UC Berkeley

Rebecca is an NSF Graduate Research Fellow pursuing her PhD in UC Berkeley's Chemical and Biomolecular Engineering Department. Her current research with Professor Markita Landry focuses on engineering fluorescent carbon nanomaterial-based sensors to probe biological systems. Prior to her PhD, Rebecca graduated with her BS in chemical engineering with honors from Brown University in 2016, where she worked with Prof. Peterson on heterogeneous catalysis for biofuel production. Through numerous summer research experiences, she has ventured from the tall glass towers of pharmaceutical drug development in Boston, down to the mud in Tennessee riverbeds to analyze nutrient bioavailability. Beyond research, Rebecca is actively involved in leading local science outreach programs that encourage participation in STEM, including Expanding Your Horizons and Bay Area Scientists in Schools. She is passionate about mentoring in research and teaching college and graduate level courses.

Engineering at the nano-bio interface: from fundamentals to functionality

In her PhD, Rebecca investigates the interactions of nanomaterials with biomolecules and applies this knowledge to develop more robust fluorescent nanosensors towards in vivo applications. A major gap in the nanosensor field is in the translation from the chemist's bench to the biologist's model system, where numerous reports of promising in vitro validated nanosensors fail to perform in vivo. Accordingly, Rebecca employs chemical engineering concepts to study the mechanisms and effects of protein adsorption on nanosensors functioning in biological environments. Rebecca has developed a multimodal experimental approach and theoretical framework of analysis to understand how nanomaterials interact with biomolecules. Probing the composition, driving forces, and dynamics of this so-called "protein corona" formation provides an understanding of how our engineered nanoparticles are affecting, and being affected by, complex bioenvironments. In turn, this knowledge can be leveraged to rationally design and develop corona-mediated nanosensors with tunable auxiliary properties.

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Selene Pirola

Imperial College London

Dr. Pirola completed her BSc's and MSc's degrees in Biomedical Engineering at Politecnico di Milano (Milan, Italy) in 2012 and 2015, respectively. She then continued her studies and obtained a PhD in Chemical Engineering from Imperial College London in 2019. In particular, her PhD thesis dealt with the impact of different aortic valve replacement procedures on aortic haemodynamics and was awarded the "2019 Dudley Newitt PhD Thesis Prize for Theoretical/ Computational Excellence" from Imperial College London. Currently, she holds the positions of Research Associate and Assistant Supervisor in the Biofluids and Transport Group of the Department of Chemical Engineering at Imperial College London.

Image-Based Patient-Specific Computational Modelling for Prediction of Cardiovascular Disease Development and Medical Device Assessment

Dr. Pirola's research focuses on the application of computational modelling and imaging techniques to predict the behaviour of cardiovascular diseases and to support surgical intervention planning, as well as to design, assess, and optimise cardiovascular devices. Notably, her work exploits patient-specific image-based computational methods to study the growth and development of Thoracic Aortic Aneurysm (TAA) and dissection. Indeed, this research will help understand the mechanism of ascending TAA development, growth, and rupture, assisting clinicians in targeting the best treatment according to patients' needs. Recently, her work has also expanded on the development of fluid-structure interactions and multiscale modelling of flow and transport in order to investigate thrombus formation in medical devices.

Rising Star 2020

Ritu Raman

MIT

Ritu Raman is an engineer with a passion for biohybrid design: building machines powered by biological materials that work with the human body to fight disease and damage. She is also an educator and a writer and has developed biofabrication and bioethics curricula for classrooms and makerspaces around the country. Ritu is currently a postdoctoral fellow with Robert Langer at MIT, funded by L'Oréal USA Women in Science and NASEM Ford Foundation Fellowships. She received her B.S. magna cum laude from Cornell University and her Ph.D. from the University of Illinois at Urbana-Champaign as an NSF Fellow. She holds many awards for scientific innovation, including being named a Kavli Fellow by the National Academy of Sciences and being named to the MIT Technology Review 35 Innovators Under 35 and Forbes 30 Under 30 lists. Ritu grew up in India, Kenya, and the United States, learning to appreciate and thrive in diverse dynamic environments. She is passionate about increasing diversity in STEM and has championed many initiatives to empower women in science, including being named a AAAS IF/THEN ambassador and founding the Women in Innovation and STEM Database at MIT (WISDM).
Website: RituRaman.com | Twitter: @DrRituRaman

Biohybrid Design: integrating biological and biomimetic materials with machines

Biological materials dynamically sense and adapt their form and function to changing environments, but these capabilities have not been fully replicated in the synthetic materials traditionally used by engineers. My research has shown that integrating biohybrid and biomimetic materials with engineered systems yields devices capable of complex behaviors such as self-assembly, self-maintenance, and self-healing. These responsive behaviors are especially desirable in machines that interface with the dynamic human body, as they enable sensing and responding to individualized patient needs. This talk will introduce my fundamental research in understanding and engineering biohybrid neuromuscular tissues. These advances will enable my future lab to restore motility in diseased or damaged bodily systems, and also implement engineered tissues as efficient adaptive actuators for powering implantable devices. This talk will make the case that the next generation of biologically relevant machines must integrate our dynamic natural world with our own adaptive bodies.

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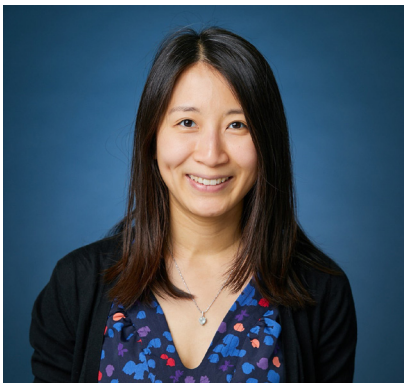

Beatrice Soh

Institute of Materials Research and Engineering

Beatrice Soh is currently a research scientist at the Institute of Materials Research and Engineering in Singapore. She recently completed a PhD in Chemical Engineering at MIT, where she worked with Prof. Patrick Doyle on single-molecule polymer dynamics. Beatrice earned a bachelor's degree in chemical engineering from Princeton University. Her research interests lie at the interface of microfluidics and soft matter.

Studying Topologically Complex DNA at the Single-Molecule Level

Over two decades ago, with advances in microfabrication techniques and fluorescence microscopy, single-molecule studies emerged as a powerful approach to investigate polymer dynamics at the molecular level. By providing a platform for the direct observation and precise manipulation of individual polymer molecules, single-molecule studies allow for the probing of microscopic interactions that give rise to the macroscopic properties of the polymer system. Single molecule studies have been widely used to investigate the static and dynamic properties of double-stranded deoxyribonucleic acid (DNA) as a model polymer. Such studies not only help to develop a fundamental understanding of key topics in polymer physics that cannot be easily accessed via traditional bulk experimental methods, but also facilitate the development of emerging DNA mapping and sequencing techniques. The majority of single-molecule studies to date have involved linear DNA molecules. It is known that topological constraints on the molecular level have a significant influence on polymer dynamics. A nascent area in the field of polymer physics is the study of polymers with complex topologies. In my research, we use single-molecule experiments and Brownian dynamics simulations to investigate the polymer physics of topologically complex DNA.

Rising Star 2020

Sanjuna Stalin

Cornell University

Sanjuna (she, her, hers) was born in Tanjore, India and raised in Singapore and Chennai, India. She is a fourth year PhD Candidate in Chemical and Biomolecular Engineering in Dr. Lynden Archer's lab. Her research is on enabling the next generation of high energy density lithium batteries through design of functional polymeric electrolytes and interphases. She hopes to make an impact and be part of the ongoing movement to revolutionize and promote e-mobility through better batteries. She wants to pursue a career in academia as a professor in the future.

Design of Functional Polymeric Interphases for Reactive Metal Anodes

Safe, cost-effective, and long-lasting electrical energy storage (EES) devices are essential to sustain progress in electrified transportation, consumer electronics and autonomous machines. Over the past few decades, Lithium Ion Batteries (LIBs) have emerged as the dominant technology in this commercial space. Future applications and demands however cannot be restricted by LIBs' limited energy density (~200 Wh/Kg) and require new configurations with higher energy densities. This has led the community to consider Lithium Metal Batteries (LMBs) where pure lithium metal is used as the anode as opposed to graphite in LIBs. The lithium metal anode doubles energy density values compared to LIBs and can also be paired with variety of cathodes like Sulfur, O2 etc, enabling energy densities equivalent to gasoline. However, LMBs are not available today because of their own set of challenges- because of its highly reactive nature, the metal anode reacts with the surrounding electrolyte components to form an inhomogeneous passivation layer on its surface. This inhomogeneous passivation layer, known as the Solid Electrolyte Interphase (SEI), causes the metal to nucleate and grow in a very non-uniform manner during electrodeposition when charging. This electrodeposited metal can continue to grow like rough needles called dendrites, that can eventually short circuit the cell and lead to thermal runaway in these energy dense systems. This non-uniform deposition behavior also has significant impact on the reversibility of the anode. Addressing these issues require- (i) Electrolytes that are capable of mechanically suppressing dendrite propagation in the growth phase and (ii) Solid electrolyte interphases (SEI) (in-built or artificial) that can influence and stabilize deposition of lithium right at the initial nucleation phase. My research experience has been focused on using functional polymeric materials as mechanically robust bulk electrolytes and as artificial interphases to solve these issues. The main goal has been to understand how the physical, mechanical, and electrochemical properties of these polymeric materials correlate with Li deposition during the nucleation and growth phases.

Rising Star 2020

Michelle Teplensky

Northwestern University

Michelle Teplensky is a postdoctoral fellow at Northwestern University in Professor Chad Mirkin's group. She is working on the rational design of cancer vaccines to treat prostate and skin cancer as well as gain fundamental understanding of immunological function. By designing and synthesizing nanoscale architectures capable of controlling the delivery of vaccine components, Michelle seeks to understand the structure-function relationship between vaccine design and biological response. In conjunction with this work, Michelle mentors young researchers and leads the group's "Biology Subgroup." Michelle completed her PhD in Chemical Engineering at the University of Cambridge where she was a Gates Cambridge Scholar, and spent her degree developing and applying metal-organic frameworks to the delivery of insoluble chemotherapeutics and fragile biomacromolecules for gene knockdown. Michelle obtained her B.S in Chemical-Biological Engineering from MIT. For fun, she enjoys playing any form of hockey and running Spartan races.

Leveraging biomacromolecules and porous materials to address problems in immune malfunction

Michelle's ongoing research focuses on the structure function relationship between vaccine structure and immune processing. Cancer vaccines, composed of "adjuvant" (immune stimulator) and "antigen" (target for the immune system), can elicit drastically different responses in potency and tumor reduction based on the way in which the components are arranged. Michelle's recent work has demonstrated that arranging a human prostate cancer antigen that previously failed clinical trials into a particular architecture restores its function and mice are able to recognize target cells ex vivo. Michelle's future work will continue the theme of structurally controlling the immune system, leveraging biomacromolecules and porous materials to solve immune malfunction. One focus is the prevention of acute toxicity caused by chimeric antigen receptor (CAR)-T cell therapy (cytokine release syndrome (CRS)) by harnessing porous adsorptive networks that can control and tune the kinetics of cytokine release from the cells. Another focus is the manipulation of synthetic tools to engineer signaling pathways that can replace immune cell function in harsh tumor microenvironments.

Rising Star 2020

Florence Vermeire

MIT

I received my Masters and Ph.D degree in Chemical Engineering from Ghent University in Belgium. During my Ph.D thesis I focused on gas-phase kinetic modeling under the supervision of prof. Kevin Van Geem and prof. Guy Marin at the Laboratory for Chemical Technology. Related to my research on combustion kinetics, I spent time in France and China to conduct experiments on their unique experimental units. Since August 2019, I am a postdoctoral researcher at MIT in the group of prof. William Green. During my time at MIT, I have been actively involved with the Harvard-MIT Belgium Society, Diversity, Equity and Inclusion groupings within MIT and the MIT Energy Initiative by organizing the MIT Energy Night.

Modeling of molecular properties and chemical reactions – from gas to liquid

My research focuses on the prediction of molecular properties and chemical reaction kinetics using quantum chemistry and machine learning. As part of my Ph.D research, I focused on automatic kinetic modeling of gas-phase reactive systems based on quantum chemistry and structure-related approximation techniques for the prediction of thermodynamic and kinetic properties. In my postdoctoral research, I use state of the art graph convolutional neural networks combined with quantum chemistry for the prediction of thermodynamic liquid phase properties. As part of my future research, I want to further explore liquid phase chemistry and improve the kinetic modeling and predictive capabilities to the state where gas-phase modeling is today.

Rising Star 2020

Asher Williams

Cornell University

Asher Williams is currently a Presidential Postdoctoral Fellow at Cornell University where her research is aimed at developing a platform for cell-free biosynthesis of conjugate vaccines against bacterial infections and engineering ex vivo immune organoids for modeling immune response. Originally from Trinidad & Tobago, she pursued a B.S. in Chemical & Biomolecular Engineering at New York University then a Ph.D. in Chemical Engineering at Rensselaer Polytechnic Institute. Her graduate research focused on harnessing bacterial production systems to generate nutraceutical and anticoagulant drugs through metabolic engineering. Dr. Williams was awarded RPI's Presidential Graduate Research Fellowship and throughout her graduate career mentored several students, presented at research conferences, and published over 10 co-authored papers in peer-reviewed journals, with a pending patent. She also served as vice president of the Black Graduate Students Association at RPI, working on initiatives to increase the recruitment and retention of minoritized students in graduate education, and was named an RPI Class of 2020 Changemaker.

Engineering Bacterial Glycosylation Systems

Protein-linked glycans are vital for protein folding, immunogenicity, and biological function, making protein glycosylation one of the most ubiquitous and structurally complex post-translational modifications. As a result, bacterial mechanisms for glycoengineering are emerging as viable and valuable methods for optimizing protein properties through innovative new platforms. When equipped with orthogonal *O*-linked glycosylation pathways, engineered *E. coli* cells, which do not intrinsically possess protein glycosylation systems, offer the unique opportunity for bottom-up biosynthesis of structurally similar *O*-glycoforms by assembling heterologous enzyme pathways. The required sugar donors and biosynthetic pathway enzymes can be provided through rewiring cellular metabolism, to produce a myriad of glycoproteins for making conjugate vaccines as well as other biomedical products; while modifications like genetic knockouts in the host strain present opportunities for enhancing glycan production. By harnessing the modular and "open" nature of cell-free production platforms for *O*-glycoprotein biosynthesis, the physiochemical environment of these reactions can be optimized and fine-tuned for specific applications.

Chemical Engineering

Rising Stars 2020

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