Advances in materials science and biology have become increasingly intertwined, with progress in one field influencing the other.

In a “bottom-up” approach, the Brandeis MRSEC builds on our expertise in simple material systems — liquid crystals, colloids, polymers, oscillating chemical reactions — to explore how constraints typical of biological systems — confinement, crowding, and local forces that compete with and sometimes frustrate long range order — lead to emergent properties in these systems, in both structure and dynamics. In a complementary “top-down” approach, our team of life scientists and materials scientists study functional biological cellular components, or “devices,” to reverse engineer them, and determine how the combination of materials, constraints, and combined structural elements leads to successful function. Based on this two-pronged approach to understanding biological nano-systems, we will seek to copy nature and devise novel synthetic functional nano-systems. Projects include understanding the behavior of biological macromolecules — DNA, actin, microtubules — in constrained environments; learning how chirality directs the self-assembly of molecular building blocks into self-limited filamentary and 2D objects with novel structures; constructing “active matter” systems that self-organize to exhibit macroscopic behaviors, including locomotion; and deciphering how the combination of motors and filaments leads to wave-like motion in eukaryotic flagella.

HIGHLIGHTS . . .

Chirality reduces edge energy, transforming a disk into a star of twisted ribbons.

Droplet arrays of oscillating chemical reactions synchronize into dynamical states mimicking neural networks.
RESEARCH FUNDAMENTALS...

Computer simulations reveal how chirality of building blocks leads to assembly with complex architectures.

Microfluidic technology enables manipulation of micron-sized droplets for experiments and applications.

Cryo-electron tomography reveals the 3D structure of bio-organelles, enabling analysis and modeling of their function.

THE BRANDEIS CENTER’S OUTREACH AND EDUCATION PROJECTS...

- REU: Research experience for undergraduates, summer projects in materials science and biology.

- SCOPE program at Olin College of Engineering: A capstone project for seniors, engineering a solution for our research equipment.

- SCIENCE POSSE Program: Research jobs for members of a “posse” of inner city science undergraduates at Brandeis.

- NANO-DAYS at the Discovery Museum: Hands-on projects for elementary-school students at the museum in Acton, Massachusetts.

- NECFW: New England Complex Fluids Workshop, sponsored by the Brandeis MRSEC, with presentations by grad students and postdocs from all over New England.

- Outreach to KIST: Kigale Institute of Science and Technology in Rwanda, for future enrollment of KIST students at Brandeis, and possible faculty exchange.

More information about the workshops, internships, partnerships, and educational opportunities are available at: http://www.brandeis.edu/mrsec/edoutreach/
MRSEC Retreat Schedule
November 22, 2013

11:15am – 12:15pm, Abelson 131 – Welcome; Dean Birren and Seth Fraden. Jané Kondev
“Materials science that we can learn from yeast”

12:15pm – 1:00pm – Pizza Lunch, Shapiro Science Center Lobby

1:15pm – 2:45pm, Abelson 131 – MRSEC talks:
Steve DeCamp
"Defect Dynamics in Active Nematic liquid crystals"
Gabe Redner
"Simulation Study of Defect Dynamics in an Extensile Active Nematic"
Charlotte Kelley
"Nervous Wreck: Bending the Rules of F-BAR Induced Membrane Deformation"

2:45pm – 3:00pm, Poster set-up, Shapiro Science Center Lobby

3:00pm – 5:00pm, Poster Session, Shapiro Science Center Lobby, Beer Hour
MRSEC Retreat Poster Session

"Using Markov State Models to Study Self-Assembly"
Matthew R. Perkett, Michael F. Hagan

"Thermodynamic Model of Yeast Mating Type Switch"
Baris Avsaroglu, Gabriel Bronk, Jungoh Ham, Susannah Gordon-Messer, James E. Haber, Jane Kondev

"Spheroidal Swimmers in Shear"
Kaushik Balasubramanian, Aparna Baskaran

"Beating Cheaters At Their Own Game"
Joseph Rauch, Jane Kondev, Alvaro Sanchez

"Control of Actin Cable Length: Theory"
Lishibanya Mohapatra, Julian Eskin, Bruce Goode, Jane Kondev

"Self-Organized Flagellar Beating: A Numerical Approach"
Yaouen Fily, Michael F. Hagan

"Synchronization and Morphogenesis of Chemical Oscillators"
Ning Li, Nathan Tompkins, Camille Girabawe, Michael Heymann, Irving Epstein, Seth Fraden

"On-Demand Picoliter Droplets Generation"
Camille Girabawe, Rafael Aguade Phoenix, Seth Fraden

"Optical Control and Manipulation of Chemical Oscillators"
Nathan Tompkins, Ning Li, Michael Heymann, Irving Epstein, Seth Fraden

"Rheology of Active Networks"
Dan Chen, Stephen Decamp, Daniel Blair (Georgetown Univ.), Zvonimir Dogic

"Depletion Interaction of Microtubule Bundles"
Fiodar Hilitski, Andrew Ward, Zvonimir Dogic

"Ruthenium Complex Based Active Soft Materials"
Ye Zhang, Ning Zhou, Seth Fraden, Irving R. Epstein, Bing Xu

"Protein Structure from in Situ X-Ray Diffraction of Microfluidically Produced Protein Crystals"
Achini Opathalage, Michael Haymann, Seth Fraden

"Tunable Dynamics and Pattern Formation in an Active Suspension"
Gil Henkin, Stephen Decamp, Zvonimir Dogic

"Pulse Coupled BZ-Oscillators with Activity Dependent Coupling Strength"
Malia McAvoy, Viktor Horvath, Irving R. Epstein

"A Continuously Fed Unstirred Reactor for Microemulsion Systems"
Delora Gaskins, Khang Nguyen, Milos Dolnik, Irving Epstein

"Control of actin cable length and shape: Experiment"
Julian Eskin, Adam Johnston, Sarah Gannon, Bruce Goode

"Control of actin cable length: Theory"
Lishibanya Mohapatra, Julian Eskin, Bruce Goode, Jane Kondev

"Studies of the dynamics of a eukaryotic subcellular organelle"
Angela Niu, Lauren O’Neil (Carnegie Mellon Univ.), Michael King, Daniel Pomeranz Krummel

"High-resolution ultrastructural analysis of the Caenorhabditis elegans anterior sensory nervous system"
David B. Doroquez, Cristina Berciu, James R. Anderson, Piali Sengupta, Daniela Nicastro

"Multistable phase patterns in finite oscillator networks"
Daniel Goldstein, Michael Giver