Department of Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

Fall 2026
Seminar Series

Physical principles of cellular self-organization in cardiovascular health and disease

Alexander Dunn, PhD
Professor
Department of Chemical Engineering
Stanford University



The remarkable capabilities of living tissues reflect the self-assembly of biological macromolecules into structures far larger and more complex than their individual components. My laboratory seeks to understand the physical principles that allow molecular interactions to produce organized, functional tissues. In this talk, I will focus on cardiomyocytes (heart muscle cells), whose contractile machinery, built from repeating units called sarcomeres, provides a striking example of biological self-assembly. Using measurements that apply controlled forces to single protein molecules, we find that α-actinin-2, a core component of muscle fibers, binds actin filaments with a strength that depends sharply on both the magnitude and the direction of the applied force. This behavior suggests how the forces generated during contraction can help organize and stabilize the architecture of the muscle as a whole. In parallel, we are investigating how mutations that cause inherited cardiomyopathies (diseases of the heart muscle) perturb sarcomere mechanics and organization. In particular, we are using cryo-electron tomography to directly visualize the structure of heart muscle fibers at the molecular scale. These and other data suggest that changes in sarcomere organization may be closely linked to the development of cardiomyopathies. Finally, I will describe new single-molecule approaches that move beyond measuring one interaction at a time to systematically surveying hundreds of molecular variants. These approaches now make it possible to study mechanobiology at scale and to design and characterize new proteins that sense and produce force.

ABOUT the SPEAKER

Alexander Dunn is a Professor of Chemical Engineering at Stanford University. His laboratory studies how molecular interactions within the cytoskeleton and at cell adhesion complexes drive the assembly and self-organization of cells and tissues. More recently, the lab has expanded into cryo-electron tomography to investigate the molecular-scale organization of complex subcellular structures. Outside the lab, his interests include the works of James Joyce, birdwatching, and attempting to feed his children palatable and nutritious food that is not summarily rejected.

Monday, November 16 at Noon
1003 Engineering Centers (Tong Auditorium)