SACRAMENTO STATE

Department of Physics and Astronomy

SPRING 2024 Colloquium Series

"Active Mechanics of Cells and Tissues"

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Living matter is active in that it comprises nanoscale machines called molecular motors that consume chemical energy and generate mechanical forces and motion. These mechanical forces drive tissue shape change and organization during essential life processes such as wound healing and tissue development. Motivated by such molecular motor-driven active deformations of elastic structures in biology, such as the cytoskeleton and tissue extracellular matrix, we will show how new physical models for active solids can be built to explain biological phenomena. We will consider two related biological systems: cells embedded in extracellular fibrous matrices and synthetic linear elastic substrates. Elastic fiber networks occur ubiquitously in living matter and exhibit unique mechanical properties such as elastic nonlinearities, rigidity transitions, non-affine deformation modes, as well as long-range but heterogeneous force transmission. In this presentation, we show how the actively generated forces are transmitted through the network and how this depends on fiber stiffness and connectivity. Further, we predict an atypical fiber buckling-induced softening regime under external shear, before the well-characterized stiffening regime. Both these predictions are supported by experiments on platelet-contracted blood clots carried out by our experimental collaborators. Next, we consider how multiple cells can self-organize into ordered structures through their mechanical interactions mediated by mutual deformations of an extracellular elastic medium. Again, our predictions are quantitatively supported by cell culture experiments on hydrogel substrates with tunable stiffness. Altogether, we show the mechanical properties of biological tissue are relevant for their structural organization and function, and how studying such systems inspires new types of active matter physics.

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