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Role of differential physical properties in the collective mechanics and dynamics of tissues[1]

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Living cells and tissues are highly mechanically sensitive and active. Mechanical stimuli influence the shape, motility, and functions of cells, modulate the behavior of tissues, and play a key role in several diseases. In this talk I will discuss how collective biophysical properties of tissues emerge from the interplay between differential mechanical properties and statistical physics of underlying components, focusing on two complementary tissue types whose properties are primarily determined by (1) the extracellular matrix (ECM), and (2) individual and collective cell properties. I will start with the structure-mechanics-function relationships in articular cartilage (AC), a soft tissue that has very few cells, and its mechanical response is primarily due to its ECM. AC is a remarkable tissue: it can support loads exceeding ten times our body weight and bear 60+ years of daily mechanical loading despite having minimal regenerative capacity. I will discuss the biophysical principles underlying this exceptional mechanical response using the framework of rigidity percolation theory, and compare our predictions with experiments done by our collaborators. Next I will discuss ongoing theoretical work on how the differences in cell mechanics, motility, adhesion, and proliferation in a co-culture of breast cancer cells and healthy breast epithelial cells may modulate experimentally observed differential migration and segregation. Our results may provide insights into the mechanobiology of tissues with cell populations with different physical properties present together such as during the formation of embryos or the initiation of tumors.

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