Theoretical Biology Seminar

Order, Flow, and Rigidity in Biological Tissues

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Biological tissues are dense, active materials that must be solid enough to hold their shape yet fluid enough to remodel during development, wound healing, and disease. In this talk, I will show how ideas from soft matter and statistical physics reveal the structural and mechanical states of confluent tissues. First, I will discuss how tissues respond to deformation. A floppy, fluid-like tissue can rigidify under shear through a geometry-controlled stiffening transition. When external shear competes with internal active stresses, tissues near the jamming transition display rich nonlinear rheology, from yielding and shear thinning to discontinuous shear thickening. Like yield stress materials, tissues flow through avalanches of collective cell rearrangements, and their statistics allow mechanical stress to be inferred from static images alone. Second, I will show how geometry shapes tissue fluidity: on curved epithelia, surface curvature lowers the energy barriers to rearrangement and drives unjamming. Third, I will turn to structural order. Cell division and motility together give rise to a reentrant hexatic phase, while on growing lung spheroids, packing order is controlled by topology and nuclear size. Beyond local order, cellular packings can display hidden long-range order through hyperuniformity. Together, these results show that living tissues access states of matter and mechanical responses with no direct analog in passive materials.

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