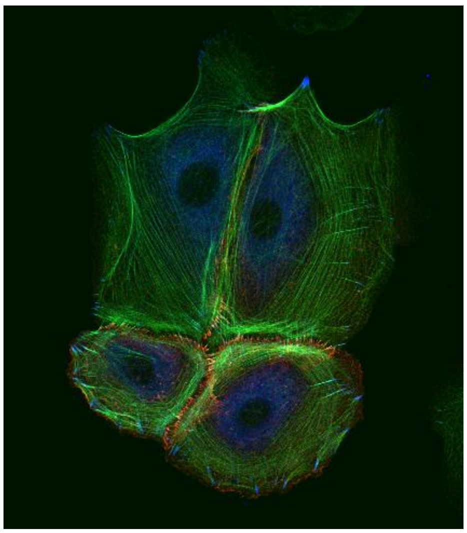
What controls surface tension and cell sorting in tissue formation and morphogenesis?

Living tissues are soft materials with well-defined mechanical properties, largely unexplored. A key question in morphogenesis is understanding how embryonic structures and organs are formed by segregation of different cell types and the formation of large-scale boundaries among cell compartments. In passive materials, intermolecular forces yield the condensation of molecules into a dense phase and manifest themselves as an emergent material property called surface tension. Similarly, cohesive interactions between cells, mediated by cadherins and other adhesive molecules, cause them to form dense colonies. The origin of the effective surface tension of cohesive cells is, however, more complex than conventional surface tension. Like in liquids, traction forces in cells and cell colonies appear to be concentrated at the cell or colony boundary, and there is evidence that other mechanisms contribute to the surface tension of the colony, including the contraction of the cytoskeletal actomyosin network, cell migration and biochemical signaling. In addition, some tissues transition from liquid-like behavior to solid-like behavior, allowing buckling phenomena and generating new boundary conditions. In this theory project the student will use a combination of numerical and analytical tools to explore the interplay of all these mechanisms in controlling cell sorting and the emergence of tissue segregation. The goal is to gain a quantitative understanding of the mechanisms that control morphogenesis and to increase our ability to control tissue formation in vitro.



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Tools:

- Numerical simulations
- Continuum mechanics of "active matter"
- Theory of phase transitions
- Close collaboration with experimentalists

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