Physics of Morphogenesis

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Understanding how biological tissues are shaped during development is one of the most fascinating questions in biology. Epithelial tissues form robust mechanical and chemical barriers. This property is essential for the physiology of adult organs. Epithelia also show tremendous plasticity during embryonic development, organ regeneration and in the adult, namely the capacity to adapt and respond to intrinsic or extrinsic signals or perturbations.

There are 3 principle modalities of tissue plasticity. First, tissues are remodelled by cell movements or cell shape changes during morphogenesis. Second, during tissue growth, epithelial cells need to accommodate new space for growing and dividing cells. Cells may also extrude live or by apoptosis. Together, cell movement, cell division and cell extrusion endow epithelial tissues with fluid properties (reviewed in Guillot and Lecuit, 2013a). Tissue robustness and plasticity relies on unique properties of cell contacts, in particular adhesive mechanisms and actomyosin tensile forces that are generated and transmitted at the cell cortex. Disruption of tissue cohesion and plasticity leads to loss of tissue homeostasis and profound tissue disorders such as perturbation of the polarized organization and growth control as manifested in solid tumours, loss of cell polarity and adhesion being associated with malignant progression.

Our research integrates developmental, cellular and physical understanding of how tissue cohesion and plasticity are controlled in animals. This lecture will introduce the basic mechanical properties of cells and cell-cell contacts and how they are regulated during tissue morphogenesis, in development and in the adult.