SELF-ORGANIZED CABLE FORMATION AND FORCE TRANSMISSION IN AN ACTIVE VERTEX MODEL FOR BIOLOGICAL TISSUES

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Biological tissues, as complex materials, have been receiving increased interest in recent years. An important example is an epithelial monolayer, a single layer of packed cells. This type of tissue lines the surfaces of animal organs and plays fundamental roles in life. In a commonly used approach, termed the vertex model[1,2], an epithelial monolayer is described by a network of active edges representing boundaries between neighbouring cells (**Fig. 1** right). Biologically, each edge represents bundled polymeric filaments (actin) crosslinked by molecular motors (myosin). These edges actively contract and sustain tension, which is thus transmitted throughout the tissue. Vertex models display intriguing rheology, transitioning between solid and fluid states as cell parameters change[3].

The mechanical response of epithelial tissues involves interactions of many elements. Traditionally it is believed that genes and biochemistry instruct mechanics. Recently, it is becoming clear that mechanics feeds back onto and drives gene expression and biochemical signalling[4,5], but how mechanical feedback affects tissue behaviour remains poorly understood.

Inspired by experimental observation, we propose a vertex model with a coarse-grained description of passive edge viscoelasticity as well as active molecular motor activities. The model incorporates a known feedback loop in which edge tension regulates motor recruitment (**Fig. 1** left). We study the emergent response of this type of tissues to external forces using both theory and computations. Through a mechanical instability caused by the feedback, a tissue can become patterned with long focused paths consisting of chains of strongly contracting edges spanning many cells (**Fig. 1** right). We characterize the properties of such contractile cables.

Our theory provides a potential explanation for the formation and refinement of actomyosin cables, which are ubiquitous in the development of organisms and whose origins are largely unclear. From the physics point of view, the spontaneous contractile paths offer mechanisms for long-range force transmission, highlighting novel mechanical states in active materials.

References

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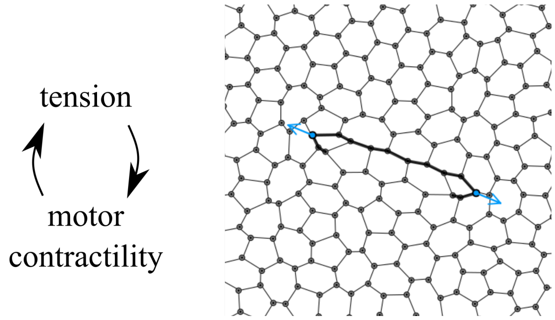

Figure 1: A feedback loop in which edge tension and motor contractility enhance each other (left). A vertex model with the feedback loop predicts a focused contractile cable when an external forces (blue arrows) are exerted on the tissue (right).

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