LadHyX Seminar – October 18, 14:00, on Zoom

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Active mechanics in biology

How life's complexity emerges has fascinated scientists for centuries. From the Greek philosopher, Anaximander of Miletus lived in the 500s B.C.E. to the well-known Charles Darwin (1809-1882). How patterns and body structures are formed in plants and animals is still an active research topic across disciplines. One of the early contributions to explaining how complex shape emerges in life was made by D'Arcy Thompson. By applying methods and principles from the physical sciences to biological problems, Thompson demonstrated how simple mathematical reasoning reveals elegant explanations for complex processes giving the first foundation for describing and classifying the astonishing diversity of shapes and forming the living world.

Morphogenesis processes are regulated by a complex set of chemical and mechanical cues that lead to a dynamic reorganisation of cells and their environment. While the importance of biochemistry in morphogenesis, developmental biology and tissue homeostasis has been well appreciated during the last century, only during the last two decades the role of physics and mechanics has started to be uncovered. However, neither biochemistry nor physics alone can individually explain the phenomena of pattern and structure that emerge in plants, animals, and humans.

Despite significant progress in understanding the behaviour of active fluids, much less is known about how activity affects the behaviour of solid and viscoelastic materials, such as epithelial tissues or biofilms. In this talk, we will show that a viscoelastic thin sheet is driven out of equilibrium by active structural remodelling (e.g., fast growth) develops a wide variety of shapes as a result of a competition between viscous relaxation and activity. In the regime where active processes are faster than viscoelastic relaxation, shapes that are formed due to remodelling are inherently out of equilibrium. The latter regime is of particular interest in developing a physical understanding of morphogenesis, where the embryo has to undergo a series of carefully orchestrated shape changes to establish the functioning organism. Our study suggests that keeping a growing system out of equilibrium increases the range of available morphologies. These observations point to a robust mechanism b y which a system that is kept out of equilibrium could be steered toward the desired shape by chemical regulation of remodelling, relaxation, and mechanical parameters.