Growth, form and active mechanics in biology

D. A. Matoz-Fernandez[1] and Fordyce A. Davidson[1], Nicola R. Stanley-Wall[1], Rastko Sknepnek [1,2]

[1]School of Life Sciences, University of Dundee, Dundee, United Kingdom DD1 5EH.
[2]School of Science and Engineering, University of Dundee, Dundee, United Kingdom DD1 5EN.

D'Arcy Thompson set the mathematical foundation for describing and classifying the astonishing diversity of shapes and form in the living world. A century later, our understanding of biological processes at the molecular level has been vastly improved and yet a complete understanding on how particular biological forms are generated during development, and how they change over evolutionary time remains largely unknown. A unifying feature of all higher organisms is that they start as a single cell, a zygote, and autonomously develop into an individual, without external input. The genome provides a template that steers development towards the desired body plan.
The formation of large structures such as tissues and organs are a result of a complex set of guided collective mechano-chemical processes. To select a specific morphology, the number of possible shapes must be large. Furthermore, transition between them should be feasible at a reasonably low cost, which is hard to achieve in equilibrium. In this talk, using active mechanics as a framework, I will explore how out of equilibrium competing processes can help biology-inspired shapes to access morphologies that are unavailable if restricted to the adiabatic evolution alone. We argue that the out of equilibrium regime studied here is of interest in developing physical understanding of morphogenesis.

[1] Matoz-Fernandez, D. A., Elisabeth Agoritsas, Jean-Louis Barrat, Eric Bertin, and Kirsten Martens. "Nonlinear rheology in a model biological tissue." Physical review letters 118, no. 15 (2017): 158105.
[2] Matoz-Fernandez, D. A., Fordyce A. Davidson, Nicola R. Stanley-Wall, and Rastko Sknepnek. "Wrinkle patterns in active viscoelastic thin sheets." arXiv preprint arXiv:1904.08872 (2019).