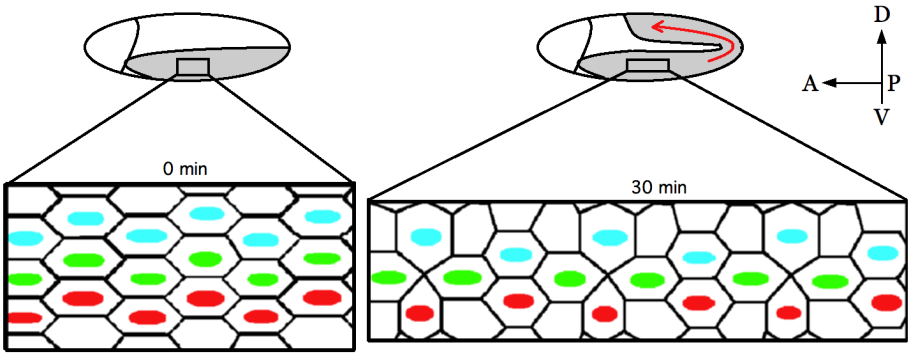
Role of fluctuations in tissue elongation

IBDM, Turing Center for Living Systems, Marseille

During embryonic development, tissue morphogenesis relies on the ability of cells to produce forces and to coordinate to generate large-scale deformations. Understanding the mechanics of elementary tissue shape changes, such as tissue elongation or tissue folding, is therefore crucial to elucidate the biophysical principles guiding embryonic morphogenesis.

During the development of the fruitfly, the so-called germband, a monolayered epithelium, elongates in a rapid and reproducible manner. Over the past 20 years, the germband has become a canonical model to study the fundamental principles of tissue elongation. Early reports first concluded that elongation was primarily motored by active, oriented reduction of cell junctions' length, that cause oriented neighbor exchanges between cells (or T1 transitions), resulting in the overall elongation of the tissue. However, recent reports show that the germband is simultaneously pulled on one side by an adjacent, moving tissue, the posterior midgut. The actual contributions of the active T1s and of the external pulling force to the elongation are not clear.

Our working hypothesis is that fluctuations of junctions' length might not motor the elongation per se, but rather act as an active thermal bath that facilitates remodeling (T1 transitions), to cope with the external pulling force exerted by the migrating posterior midgut. Indeed, in the absence of T1s, we anticipate that elongation would be limited by the elastic response of deformed cells. In other words, we hypothesize that fluctuations facilitate tissue flow while the midgut pulls on its posterior part. This view is supported by a variety of genetic perturbations that allow to selectively affect fluctuations or external pulling forces.



Source - https://en.wikipedia.org/wiki/Germ-band_extension

We propose to test this hypothesis by implementing the external pulling force and the fluctuations in a numerical model, to actually pinpoint their respective contributions to tissue elongation. We will use a "vertex" type of model, in which cells are represented by their contour and vertices. The project requires a solid background in physics, computational skills and a strong interest in living systems. It will be carried in a biophysics lab that combines experimental and theoretical approaches. This master project can eventually be continued by a PhD funded by the Turing Center for Living Systems.

Keywords: mechanics, complex systems, morphogenesis, developmental biology, fluctuations, physical models.

Team*: Physical Approaches to Cell Dynamics and Tissue Morphogenesis*

Contacts: R. Clément & P.-F Lenne: raphael.clement@univ-amu.fr, pierre-francois.lenne@univ-amu.fr