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Collective dynamics of cell migration and cell rearrangements

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Understanding multicellular processes such as embryo development or cancer metastasis requires to decipher the contributions of local cell autonomous behaviours and long range interactions with the tissue environment. A key question in this context concerns the emergence of large scale coordination in cell behaviours, a requirement for collective cell migration or convergent extension. I will present a few examples where physical and mechanical aspects play a significant role in driving tissue scale dynamics.

1. Geometrical confinement is one of the key external factors influencing large scale coordination during collective migration. Using a combination of in vitro experiments and numerical simulations, we show that the velocity correlation length, measured in unconfined conditions, provides a convenient length scale to predict the dynamic response under confinement. The same length scale can also be used to quantify the influence range of directional cues within the cell population.

2. Heterogeneity within motile cell populations is frequently associated with an increase in their invasive capability and appears to play an important role during cancer metastasis. Using in silico experiments, we studied the way cell invasion is influenced by both the degree of cell coordination and the amount of variability in the motile force of the invading cells. Results suggest that mechanical heterogeneity dramatically enhances the invasion rate through an emerging cooperative process between the stronger and weaker cells, accounting for a number of observed invasion phenotypes.

3. Effective convergent extension requires on a consistent orientation of cell intercalation at the tissue scale, most often in relation with planar cell polarity mechanisms to define the primary axes of deformation. Using a novel modelling approach for cells mechanical interactions, we studied the dynamics of substrate free motile cell populations. Ongoing work shows in particular that nematic order emerges from interacting cells without the need for biochemical cues setting tissue polarity.