

Scaling of epithelial morphogenesis with animal size.

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During development, the collective movement of thousands of cells is essential to form functional organs and tissues of defined shape and organization. These so-called morphogenetic movements are controlled by gene expression. However, moving cells also requires mechanical forces to be exerted and sensed, powering their collective displacement and tissue deformation (Figure) ¹. How gene expression and mechanics together control collective cell dynamics to generate reproducible shapes during development remains an outstanding question in biology. In the lab, we combine *Drosophila* with advanced methods, spatial transcriptomics, time-lapse imaging, force measurement, and optogenetics²⁻⁵, to explore the mechanisms of morphogenesis.

Within the framework of the internship, we propose to explore how morphogenetic processes adapt (scale) with animal size. For more than 100 years, it has been known that even half-size embryos can develop perfectly, indicating that collective flow can be tuned to embryo size. We recently discovered that one of the central morphogenetic movements, collective migration, tunes its velocity to animal size, a scaling behavior that depends on both gene expression and tissue mechanics. We will use collective migration to address two questions: (i) how gene expression patterns are translated into the mechanical forces that power cell displacement; and (ii) how tissue mechanical forces ensure that migration velocity is proportional to animal size. Together, this work will advance our understanding of tissue morphogenesis and identify mechanisms that ensure robust development.

The intern will take ownership of one of these questions, combining quantitative live imaging and optogenetic perturbation with tissue-scale data analysis to test how cells coordinate their movements across animals of different sizes. Beyond hands-on training in cutting-edge imaging and biophysical approaches, the project offers a stimulating, collaborative environment and can naturally develop into a PhD thesis for a motivated student.

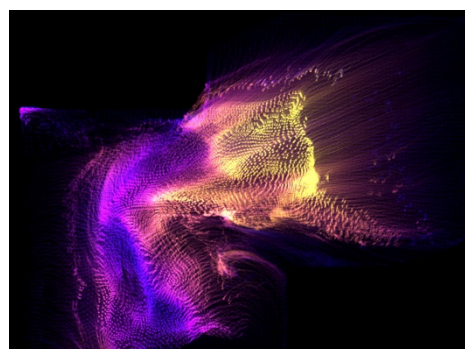


Figure 1: Tissue flow during epithelial morphogenesis

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References

1. Pinheiro, D., and Bellaïche, Y. (2018). Mechanical Force-Driven Adherens Junction Remodeling and Epithelial Dynamics. *Dev. Cell* 47, 3–19. <https://doi.org/10.1016/j.devcel.2018.09.014>.
2. Guirao, B., Rigaud, S.U., Bosveld, F., Bailles, A., López-Gay, J., Ishihara, S., Sugimura, K., Graner, F., and Bellaïche, Y. (2015). Unified quantitative characterization of epithelial tissue development. *Elife* 4, e08519. <https://doi.org/10.7554/eLife.08519>.
3. López-Gay, J.M., Nunley, H., Spencer, M., di Pietro, F., Guirao, B., Bosveld, F., Markova, O., Gauge, I., Pelletier, S., Lubensky, D.K., et al. (2020). Apical stress fibers enable a scaling between cell mechanical response and area in epithelial tissue. *Science* (1979). 370, eabb2169. <https://doi.org/10.1126/science.abb2169>.
4. di Pietro, F., Herszterg, S., Huang, A., Bosveld, F., Alexandre, C., Sancéré, L., Pelletier, S., Joudat, A., Kapoor, V., Vincent, J.P., et al. (2021). Rapid and robust optogenetic control of gene expression in *Drosophila*. *Dev. Cell* 56, 3393-3404.e7. <https://doi.org/10.1016/j.devcel.2021.11.016>.
5. Leroy, A., Leen, E. van, Balakireva, M., Alpar, L., Gartner, F., Gauge, I., Pelletier, S., Pigache, R., Ech-Chouini, M., Delpierre, J., et al. (2026). Morphodynamic domains enable integration of live morphometrics and spatial transcriptomics. *bioRxiv*, 2026.08.13.744578. <https://doi.org/10.64898/2026.08.13.744578>.