Master's Internship Project Proposal – 2025/2026

Project title: **Quantifying and modeling tissue viscoelasticity in developing embryos**

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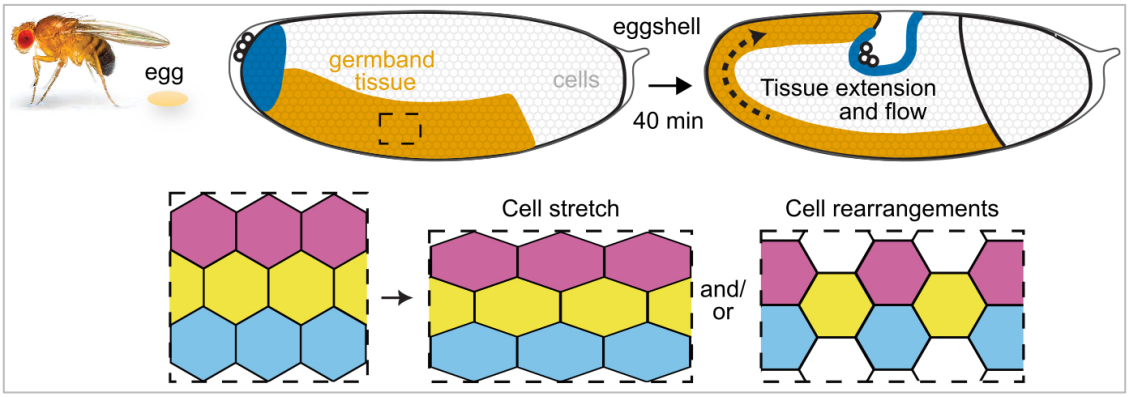
Concepts and objectives:

During embryonic development, fertilized eggs undergo a series of dynamic rearrangements to adopt their adult forms. This process of form creation depends on the mechanical properties of the tissues that make up the embryo.[1] However, tissues are composed of many cells, each with distinct physical attributes – such as cell-cell adhesion, cortical tension, and viscoelasticity – that can vary in time and space. As a result, how tissues move and deform in response to applied stress is governed by cell behaviors rather than by a well-defined viscoelasticity. For instance, tissues can display effective elasticity when cells stretch or effective viscosity when cells rearrange to dissipate stress (see figure).[2] The goal of this project is to create a physical model that details how tissue rheology arises from cell behaviors, and how the resulting tissue properties enable the flows and deformations that drive embryo development. In addition to being theoretically rigorous, this model will be firmly rooted in and challenged by experimental data.

The student will pursue this goal by quantifying and modeling how cells and tissues deform and flow to drive the development of form in *Drosophila* embryos. Form creation in *Drosophila* begins with a region of tissue (orange in the figure) rapidly extending by a factor of two, creating a large-scale flow of tissue.[3] The student will apply advanced data analysis techniques to experimental movies of this process to quantify how cells stretch and rearrange to drive tissue flow. These measurements will be used to test and compare possible models of tissue rheology. The student will then have the option to either use physics inspired neural networks to learn physical parameters of the model directly from the data, or to experimentally challenge the model by performing advanced live imaging of embryo development on a confocal microscope under different genetic perturbations.



References:

1) Bailles*, Gehrels*, Lecuit. Mechanochemical principles of spatial and temporal patterns in cells and tissues. *Annu Rev Cell Dev Biol* **38**, 321-347 (2022).
2) Tetley, Mao. The Same but Different: Cell Intercalation as a Driver of Tissue Deformation and Fluidity. *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* **373** (1759), 20170328 (2018).
3) Gehrels*, Chakrabortty*, Perrin, Merkel, Lecuit. Curvature gradient drives polarized flow in the *Drosophila* embryo. *PNAS* **120** (6), e2214205120 (2023).