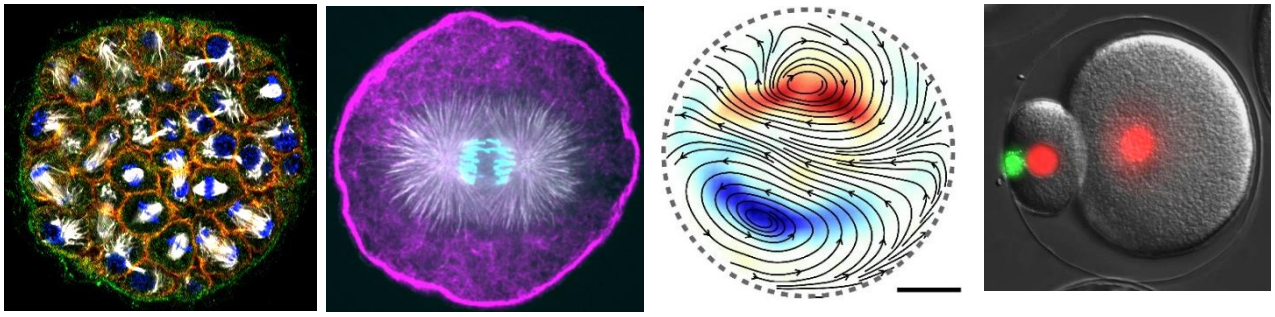
Cytoplasm Mechanics and Early Embryo Development

Many studies of cell and tissue mechanics have focused on the actin-rich cortex, underappreciating the role of the cytoplasm. The cytoplasm is a complex material crowded with large macromolecules and entangled cytoskeletal networks. In this Master project, we would like to explore the role and evolution of bulk cytoplasm mechanics during the development of early embryos. We hypothesize, that changes in cell sizes, shapes and fates, that accompany the reductive divisions during early embryogenesis, may be accompanied by large alterations in the mechanical properties and/or crowding of the cytoplasm. Notably, we would like to explore how cytoplasm anatomy and rheology may be regulated in polarized epithelial cells that delineate the outer surface of early embryos. The project will build upon a suit of disruptive experimental assays and imaging methods developed in our team to study the contribution of cytoplasm mechanics to cell organization in early marine embryos of sea urchins (Minc et al., *Cell* 2011; Tanimoto et al. *J. Cell Biol* 2016; Pierre et al. *Dev Cell* 2016; Palenzuela et al; *Curr Biol*, 2020). Notably, we have recently pioneered the use of *in vivo* magnetic tweezers to directly apply calibrated forces to the cytoplasm at various length and time scales in live sea urchin embryos (Tanimoto et al. *Nature Physics* 2018; Sallé et al. *J. Cell Biol*, 2019; Xie et al. *PNAS* 2022; Najafi et al. PNAS 2023). The project's goal includes: (i) An in-depth characterization of cytoplasm anatomy in epithelial cells, using live imaging, electron microscopy and AI-based image registration. (ii) The use of magnetic tweezers combined with live imaging to study cytoplasm material properties in developing embryos and (iii) the use of chemical and genetic interventions to affect cytoplasm anatomy and/or viscoelasticity and monitor impact on early embryo development. This project will address important gaps in the physical biology of the cytoplasm and its function in organizing embryo morphogenesis.



Methods used: Advanced live microscopy and image analysis (e.g. PIV for flows); Magnetic tweezers in vivo; Computational Models; Early embryo development.

PhD: This master project may be prolonged by a PhD in the lab for which we have funding secured.

Lab Website: **www.minclab.fr**

Contact: Nicolas Minc **;** email: **nicolas.minc@ijm.fr**