Mechanical and hydrodynamic roles of tissue and fluid flows in animal morphogenesis

UMR7009 Laboratory of Developmental Biology in Villefranche (LBDV)
Institut de la Mer de Villefranche
181 Chemin du Lazaret
06230 Villefranche-sur-Mer.
Encradrement Tsuyoshi MOMOSE

Co-director: Arezki Boudaoud (LadHyX, Ecole Polytechnique)

Fluid dynamics play fundamental roles in animal embryogenesis, yet their direct mechanical contributions to morphogenesis remain poorly understood. This PhD project addresses how bidirectional tissue and fluid flows mechanically drive tubular morphogenesis in the hydrozoan jellyfish *Clytia hemisphaerica*, a genetically tractable model organism. The project focuses on primary polyp formation, where rhythmic epithelial contractions at 4-5 mHz generate bidirectional cytoplasmic flow and luminal fluid oscillations. Unlike other cnidarian species that rely on tissue elongation, *Clytia* polyps extend their stalks through horizontal cell migration during forward-flow phases, suggesting novel biomechanical mechanisms.

The PhD candidate will investigate two central questions: (1) How are rhythmic epithelial contractions controlled—through intrinsic cellular properties or neuronal coordination? (2) How do bidirectional flows generate unidirectional morphogenetic forces? We hypothesise that planar cell polarity acts as a biomechanical ratchet, converting oscillatory shear stress into directed mechanical forces. The candidate will employ live imaging with fluorescent reporters, physical measurements, including microindentation to quantify tissue stiffness, pharmacological perturbations targeting myoneme contractions, and mathematical modelling to elucidate force generation mechanisms. This interdisciplinary approach, combining developmental biology, cell biology, genetics, and physics, will provide unprecedented insights into how mechanical stresses from tissue and fluid flows are converted into morphogenetic forces, advancing our understanding of the physical principles governing animal development.