INTERNSHIP PROPOSAL

(One page maximum)

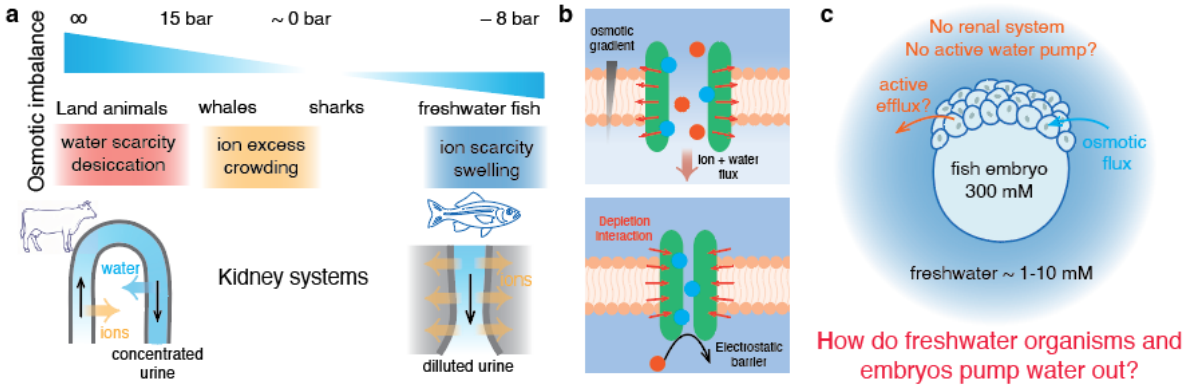
Laboratory name: Physics of Cells and Cancer – Institut Curie, Paris
CNRS identification code: UMR 168
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Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Thermodynamics of osmoregulation in freshwater

Osmosis represents a particularly harsh constraints for most forms of life and requires organisms to tightly regulate water flows [1]. For example, the kidney system of land animals actively pumps ions to reabsorb water and avoid desiccation [2]. On the other side of the spectrum, fresh water organisms face a constant osmotic fluid intake and must excrete water to compensate (see Figure **a**). Yet, in the absence of active molecular water transporters, the physical mechanisms behind active water effluxes remain unclear, as well as the associated energetic cost.

This question is particularly prevalent in the context of development, as early embryos lack dedicated osmoregulatory organs (Figure **c**). For example, fish living in freshwater face a constant osmotic water influx, which is regulated by the action of gills and kidneys – but **then why don't freshwater fish embryos, which lack either, osmotically explode?**



The goal of this internship and PhD project is to compare strategies of osmoregulation from the perspective of thermodynamics and theoretical biophysics. Models will describe the nanofluidic transport of ions and water through molecular transporters [3] (Figure **b**), and include them in effective models of osmoregulation at the cell or tissue level. Depending on the student's preferences, several aspects can be explored:

1. Thermodynamic modelling of active water transport in the kidneys
2. Electro-osmotic flows in molecular transporters
3. Osmoregulation in the zebrafish embryo, **in collaboration with C.P. Heisenberg, Vienna, Austria** (experimentalist).

[1] Wennerström, Oliveberg, QRB Discovery 3 (2022)
[2] Marbach, Bocquet, Phys. Rev. X 6 (2016)
[3] Mayer, Mitsionni, Robin et al., Nat. Nano. 21 (2026)

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: (YES) Soft Matter and Biological Physics: YES
Quantum Physics: (YES) Theoretical Physics: YES