Toy models of protocells for the origin of life

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Possibilité de thèse: Oui
Financement: Non

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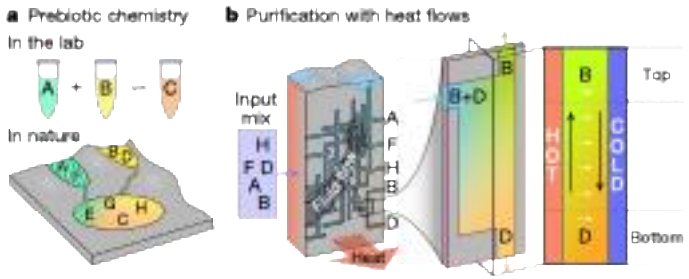

(a) Prebiotic chemistry reaction requires precisely timed mixing and reaction of well-defined products. In nature, starting solutions are complex mixtures that produce many undesirable products. (b) Ubiquitous heat flows form a geo-microfluidic system that can separate chemicals in the presence of fluid convection (black arrow). Figure taken from Ref [1].

Summary

We plan to build a thermodynamically consistent model of a protocell, to understand some aspects in the Origin of life (OL). We will incorporate metabolic reactions in a highly coarse-grained way which we will couple to an energy flux, produced by a (thermal of chemical) gradient between the outside and inside of the protocell.

During this internship, we would like to characterize the heat or dissipation current that exist together with matter currents and explore theoretically how this heat current can drive the selection for certain products in this non-equilibrium system. We expect that the strength of the selection should be related to the thermodynamic efficiency that bounds the heat current.

On the numerical side, the model will be numerically solved using a recently developed finite elements software package. The results will be compared to experiments carried out in the group of D. Braun at University LMU in Munchen [1].

This project builds on previous works carried out in the group on the topic of the Origin of Life: on the the emergence of homochirality in large chemical reaction networks [2], on the identification of autocatalysis within large chemical networks [3] and on transient compartmentalization dynamics [4]. This theoretical internship will benefit from strong interactions with experimentalists in ESPCI and with M. Castellana at Curie Institute.

[1] Heat flows enrich prebiotic building blocks and enhance their reactivity, T. Matreux et al., Nature, vol 628, 110 (2024).

[2] Emergence of homochirality in large molecular systems, G. Laurent, D. Lacoste, and P. Gaspard, Proc. Natl. Acad. Sci. U.S.A., 118, (2021)

[3] Universal motifs and the diversity of autocatalytic systems, A. Blokhuis, D. D. Lacoste, and P. Nghe, PNAS, 117, 25230 (2020).

[4] Selection dynamics in transient compartmentalization, A. Blokhuis, D. Lacoste, P. Nghe and L. Peliti, Phys. Rev. Lett., 120,158101 (2018)

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