# Protomembranes at the origin of life

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Compartimentalization is a key point in the evolution of life, since it allowed to form cells, and define an inside and an outside. It allowed cells to create chemical gradients and harvest their energy. The origin of the first membranes which has been proposed to occur at hydrothermal vents still remains problematic, since high temperatures, which favor the efficiency of organic syntheses, also increase molecular motion of membrane lipids, leading to increased permeability, and decreased rigidity. Thus, under such fluctuating conditions, a protocell membrane is expected to have had limited stability and high permeability [1], which is in apparent contradiction with a possible origin of life in hydrothermal conditions.

The archetypical adaptative strategy in hyperthermophilic organisms, is the synthesis of membrane-spanning, dipolar tetraether lipids [2]. However, the existence of these molecules on the young Earth is unlikely. Recently, a novel membrane architecture was proposed to explain the stability of lipid membrane bilayers in the hyperthermophilic archaeaon *Thermococcus barophilus* by the group of P. Oger (http://map.univ-lyon1.fr/spip.php?article251&lang=en) [3]. This novel membrane architecture predicts the presence of apolar lipids in the mid-plane of the bilayer (Figure 1A), which would limit charge transfer between the two sides, leading to a decrease in proton and water permeability, as well as an increase of membrane rigidity, providing a rationale for the ability of this organism to withstand temperatures above the boiling point of water [4].

These observations have important impact on how we understand membrane adaptation to extreme environments, but more importantly on possible scenarios for the membranes of the first cells. Indeed, simple monopolar amphiphilic molecules were readily available on the Young Earth, making the spontaneous formation of bilayer membranes reasonable. If temperature, pH, or hydrostatic pressure stability domains of bilayers can be extended to comply with the fluctuating conditions of hydrothermal vents, therefore it may answer parts of the questions raised by the origin of life at hydrothermal vents scenarios.

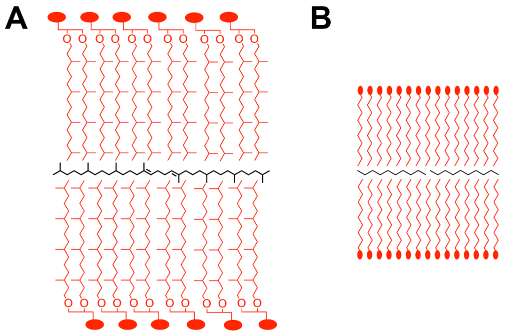


**Figure 1: A:** Schematic representation of the novel membrane architecture proposed for *T. barophilus*, showing squalane (black) in the mid-plane of a bilayer (red) [15]. B**:** Schematic representation of the putative protomembrane architecture, showing the alkane (black) in the mid-plane of a bilayer (red) composed of simple protolipids.

***Objectives:***

The aim of this project is to 1) demonstrate experimentally – using elastic and inelastic neutron scattering **-** the validity of the novel protomembrane architecture (Figure 1 B), 2) explore its physical and chemical parameters, 3) characterize the impact of the presence of apolar lipids on membrane biological function (proton and water permeability, fluidity, viscosity, rigidity) and 4) determine the relative contribution of each lipid type (monopolar, apolar,) and lipid moiety (polar head-group, core) on membrane physical parameters.

We are looking for a motivated candidate with a background in biophysics or chemical physics. Experience with neutrons is a plus but is not required.

This is an ILL PhD position funded by ILL. The PhD candidate will be located at ILL in Grenoble.

To apply for this position send a CV, a description of your education and a motivation letter to the three supervisors before July 7, 2017.

## Literature cited

**[1]** Mansy, S.S. and Szostak, J.W. *Proc. Nat. Acad. Sci. USA* (2008) 105(36):13351–13355.
**[2]** P. Oger, A. Cario, *Biophys. Chem.* 15 (2013) 42-56.
**[3]** A. Cario, V. Grossi, P. Schaeffer, P. Oger, *Front. Microbiol.* 6 (2015).
**[4]** T.H. Haines, *Prog. Lipid Res.* 40 (2001) 299-324.