# Microfluidics, biologic membranes and transmembranar proteins

**École doctorale de Physique : ED n°47**

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## Project Description

This project concerns the formation of biomimetic membranes to study specific proteins insertion and their activity. This technique has proved to be successful and its integration within microsystem including electrical measurements is a challenging work for now. It would open some nice issues in biotechnologies and biology such as drug screening and artificial cells network.

### State of the art

Since early 60's, suspended biomimetic membranes are a highlight tool to study *in vitro* biological processes linked to transmembrane transfer. Suspended membranes are very important from a fundamental point of view to study unknown proteins and, also, from an practical point of view for pharmacology, drug screening for instance. Pioneering works of Mueller [1, 2] based on the well-known Langmuir-Blodgett method enabled to form the first suspended membranes. Recent issues for biomimetic systems are the scale reduction to fulfil mainly two requirements : lab-on-chip integration and adaptation for small amounts of native biologic reagents. Another requirement is the integration of measurements which are mainly inspired by the patch-clamp technique [3]. Noting these requirements, there is a growing number of microsystems in which suspended membranes are present. These microsystems are based on a channel architecture and the formed membrane is static without any motion possibilities. Quite recently, suspended membranes have been formed using droplets and therefore opening new possibilities by coupling membranes with drop-based-microsystems (digital microfluidics). There are two attractive options of digital microfluidics :

1. Mueller, P., Rudin, D. O., Tien, H. T. and Wescott, W. C., *Reconstitution of cell membrane structure in vitro and its transformation into an excitable system*, Nature, 194, 979-980, 1962
2. M. Montal and P. Mueller, *Formation of Bimolecular Membranes from Lipid Monolayers and a Study of Their Electrical Properties*, PNAS, 69, 12, 3561-3566, 1972
3. Hiroaki Suzuki, Kazuhito V. Tabata, Hiroyuki Noji, Shoji Takeuchi, *Electrophysiological recordings of single ion channels in planar lipid bilayers using a polymethyl methacrylate microfluidic chip*, Biosensors and Bioelectronics 22 (2007) 1111-1115

– integrating a dedicated detection to characterise protein activity without any intrusion and intervention,
– creating a dynamic network made of nanodrop membranes to mimic as best as possible biological conditions.

### Objectives :

We propose an innovative approach for suspended membranes synthesis combining microfluidics, nanotechnology and biology. For this, the objectives of the thesis proposed here are :

– Understanding the mechanisms of formation of a biological membrane by approaching two droplets coated with phospholipids ; we will study in particular influences of lipid structure, their surface concentration and the dynamics of the interstitial nano-film between droplets.
– Proposing and implementing original microsystems including the integration of transmembranar protein electrical activity measurement using collaborations developed with the nanofabrication platform Nanofab.
– Study the integration and the activity of transmembranar proteins in the membranes formed, in collaboration with Éva Pébay-Péroula and Michel Vivaudou of IBS and in interaction with the postdoc engaged on this project.
– Explore membranes network and mimic a biological process (DNA replication, protein synthesis).

The thesis will be part of the project NanoBioDrop supported by the CNRS "Interface and Risk-taking" and RTRA "Nanosciences".

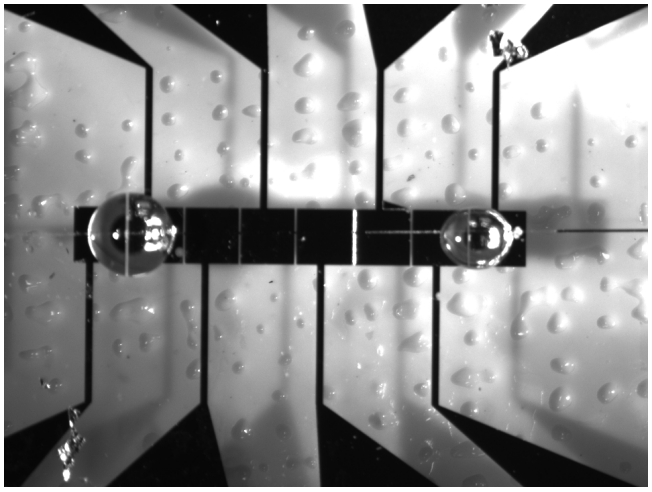

Figure 1: Sample for actuating droplets by electrowetting and study the formation of biological membranes.

## Knowledge and skills

**Formation :** Physics, Mechanics, Biophysics, Nanosciences, Chemical Engineering.
**Skills :** surface physics, nanofabrication, experimental electronics and optics.
Taste for biology and for the work in a multidisciplinary group.