The goal of our lab is to use physical concepts coming from soft matter and membrane mechanics to understand how the interactions between fluid membranes and membrane proteins contribute to cellular dynamics.

Membrane trafficking: sorting, bending, and scission

Vesicular trafficking, endocytosis and virus infection involve dramatic membrane remodeling. With our *in vitro* experiments combined with theoretical models developed by our collaborators, we study the mechanisms underlying membrane bending and membrane scission by proteins. We use membrane nanotubes of controlled diameters as well as quantitative fluorescence measurements by confocal microscopy to:

- Measure mechanical actions of proteins involved in trafficking and reciprocally the effect of membrane curvature on their enrichment/depletion from curved membrane areas. Specially we are interested in BAR-domain family proteins, toxins and viral proteins.

- Identify physical mechanisms involved in lipid sorting, in particular sphingolipids, and their involvement in protein recruitment.
- Study dynamin-independent mechanisms of membrane scission in endocytotic events.

*I-BAR domain protein (IRSp53, green) enriches on a membrane (red) and phase separates along a nanotube. (Prevost et al, 2015 Nat. Commun.)*
A membrane nanotube coated with the N-BAR domain protein, Endophilin, causes membrane scission after mechanically pulling on the nanotube. (Fox et al, 2015 Nature)

Membrane protrusions and actin

Filopodia are thin cell membrane protrusions having a tubular shape that are sustained by bundled actin filaments. They are highly dynamic, constantly growing and retracting, and are used by cells to probe their local environment.

Using both in vitro reconstitution experiments and live cells, our objectives are to decipher:

- If the curved shape of filopodia has a role in specific protein recruitment during the assembly of filopodia.
- The mechanics of the assembly process and how it couples to the actin dynamics such that filopodia can sense their environment.

Filopodia mechanics measured with optical tweezers (left) and depiction of the force acting on the filopodium tip (right). (Bornschlögl et al, 2013 PNAS)
**Our Research**

**Membranes and Cellular Functions**

**Myosin motors** interact with actin filaments and are involved in membrane remodeling events such as tubulation (e.g., myosin 1b) and scission (e.g., NMM-II). In particular, myosins contribute to the mechanical properties of the cell and to the shape of the plasma membrane.

We use reconstituted systems and mechanical experiments on live cells to build up a physical model explaining the mechanical actions of these motors on cell membranes (Collaboration with B. Goud, E. Coudrier, JF Joanny (ERC Myodyn) – Institut Curie).

![Membrane nanotubes (red) pulled by non-processive myosin motors 1b (green) along actin bundles (blue). Scale bar, 2 microns. (Yamada et al, 2014 Nat. Commun.)](image)

**Membrane proteins and ion transport across membranes**

We **reconstitute functional transmembrane proteins** (ion pumps, voltage-gated channels, transporters ...) in the membrane of GUVs (see our movie for a protocol) and use developed assays in the group, based on fluorescence microscopy and patch clamp electrophysiology measurements, to measure their activity. We study the consequences of their ion transport activity in response to membrane mechanical properties, to their lateral distribution and to their diffusion in flat or curved membranes. Coupling our experimental results to novel theoretical modeling developed by our collaborators, has provided **new physical models of biomembranes**.
Reconstitution of the voltage-gated potassium channel (KvAP) into a GUV (left). Using confocal microscopy, the surface protein fraction can be quantified (right). (Aimone et al, 2011 PLoS One)