



Master in Photonics – “PHOTONICS BCN” Master ERASMUS Mundus “EuroPhotonics”

MASTER THESIS PROPOSAL

Starting full time from April 2025

Presentation at the end of July or beginning of September 2025

Laboratory: Single Molecule Biophotonics (SMB)

Institution: Institut de Ciències Fotòniques (ICFO)

City, Country: Barcelona, Spain

Title of the master thesis: Optical manipulation of biological membranes' properties and lateral organization

Name of the master thesis supervisor and co-supervisor:

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Keywords: photo-manipulation, biological membranes, photo-active molecules, fluorescence microscopy

Summary of the subject (maximum 1 page):

The plasma membrane of cells is mainly composed of lipids and proteins that separate the interior of the cell from its external environment. Interactions between specific lipids and proteins drive the lateral organization of the membrane, dynamically forming microscopic regions with different properties. These regions play a crucial role in essential cellular functions such as signal transduction, trafficking, adhesion, motility, and many other cellular functions. In recent years, there has been increasing interest in developing innovative methods and tools to visualize and characterize these elusive membrane domains.

In our laboratory, we harness the power of light to explore and also manipulate biological lipid membranes. Light is an extraordinary tool, offering unparalleled flexibility, specificity and precision. Its effects are instantaneous, allowing us to trigger or halt processes with a simple flick of a switch. This provides us with exceptional control and spatiotemporal resolution, enabling precise stimulation and interrogation of complex biological systems. Very recently, we demonstrated the ability to modulate the properties and microscopic organization of lipid membranes using blue light and a photo-active molecule called Flipper (Torra *et al*, *J. Am. Chem. Soc.*, 2024). Building on this, we are now advancing into the controlled photo-manipulation of lipid membranes within mammalian cells. This exciting project holds great potential to reveal the mechanisms governing membrane organization and could ultimately allow us to fine-tune the biological functions of key membrane receptors, opening new avenues for understanding cellular behaviour and signalling.



The Single Molecule Biophotonics research group at ICFO, led by Prof. Dr. Maria Garcia-Parajo, is looking for a highly motivated graduate student who wish to enhance his/her scientific career in a friendly, international and stimulating environment within the glowing fields of Fluorescence Microscopy and Photo-MechanoBiology.

Objectives:

This project seeks to explore innovative approaches for the photo-manipulation of biological membranes, with two key objectives:

(1) Investigating the potential of Flipper to perturb membrane properties and organization under controlled illumination.

We will focus on the ability of Flipper, a photoactive molecule characterized in our previous study, to generate reactive oxygen species (ROS) under blue light. ROS interact with unsaturated lipids (those containing double bonds in their acyl tails), potentially altering the biophysical properties and the lateral organization of the plasma membrane in mammalian cells. The selected candidate will evaluate these effects, aiming to uncover how light-driven manipulation can modulate membrane dynamics.

(2) Expanding the palette of optical tools with new photo-active compounds.

Beyond Flipper, we will explore alternative photo-active fluorophores and smart compounds that respond to light in diverse ways. The goal is to create a versatile toolkit for membrane studies, leveraging various light-based mechanisms to extend the range of controllable factors in biological systems. This will allow deeper exploration into how these compounds influence membrane structure and function, potentially offering new insights into cell signalling and behaviour.

The selected candidate will engage in hands-on research using a wide range of fluorescent sensors and lipids with different properties. He/she will combine photophysical methods and advanced fluorescence microscopy techniques, including fluorescence lifetime imaging microscopy (FLIM) and super-resolution microscopy, to probe the effects of these compounds at unprecedented spatiotemporal resolution.

Candidates with a background in physics/chemistry/biology are encouraged to apply. The student will work in an interdisciplinary group and will acquire wet lab skills, hands-on experience in fluorescent tools, spectroscopic and fluorescence microscopy techniques, photophysics of light-activatable molecules, preparation and study of lipid membranes and experience in writing and presenting the research results to a multidisciplinary audience.