PhD Projects in Dr. Elisabet Romero Group at ICIQ:

Design, Construction, and Investigation of Chromophore-Protein systems able to perform Ultrafast Energy and Electron Transfer Processes

The motivation for this Project is the need to face the **global challenge** of achieving a renewable, widespread and inexpensive **energy supply** towards a **sustainable future**. The energy of the **Sun** fulfils these conditions, however, the efficient and inexpensive **conversion** and **storage** of **solar energy into a fuel** remains a **fundamental challenge**.

Within this **Project**, the **PhD Student** will **develop a new generation** of **solar-energy conversion systems** based on the **design principles** of **Photosynthesis,** the most advanced one being the **utilization of coherence**[1] (for a recent review see **Romero *et al.*, *Nature*, 2017**[2]**)**.

More specifically, the **Student** will design, construct, and investigate **chromophore-protein assemblies** (Figure 1) composed by renewable and abundant materials capable to perform **efficient and ultrafast energy and electron transfer processes**.

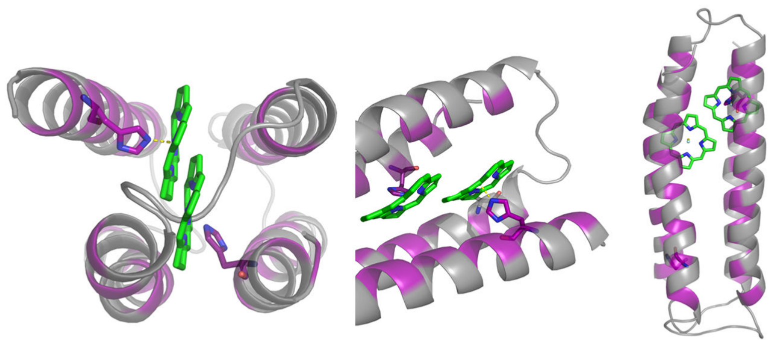

Figure 1. Illustrative chromophore-protein assembly. The chromophores are shown in green and the protein is represented as purple and grey ribbons. (*Left*) top view, (*center*) titled side view, (*right*) side view.

The static and dynamic properties of the newly created assemblies will be studied by several methods, with a strong focus on **spectroscopic techniques** [time-resolved: **Two-Dimensional Electronic Spectroscopy (2DES), Transient Absorption**, Time-correlated Single Photon Counting (TCSPC); steady-state: Absorption, Fluorescence, Linear and Circular Dichroism, Stark, Raman, FTIR, Fluorescence Line-Narrowing]**.**

The **optimized** systems will be integrated into **solar cells** to generate **electricity** and, ultimately, they will be **coupled to catalysts** (developed by collaborators) to construct **devices** able to achieve cost-effective **solar-energy conversion to fuel.**

The PhD student background should be on **(Bio)Physics or Physical Chemistry**.

References

1 Romero, E. *et al.* Quantum coherence in photosynthesis for efficient solar-energy conversion. *Nat. Phys.* **10**, 676-682, doi:10.1038/nphys3017 (2014).

2 Romero, E., Novoderezhkin, V. I. & van Grondelle, R. Quantum design of photosynthesis for bio-inspired solar-energy conversion. *Nature* **543**, 355-365, doi:10.1038/nature22012 (2017). [SharedIt link]

The Role of Coherence in Enhancing the Efficiency of Light Harvesting and Charge Separation in Photosynthesis.

Photosynthesis is the biological process whereby the **Sun´s** energy is collected and stored by a series of events that convert this energy into the **biochemical energy** needed to power life. The success of Photosynthesis depends on its initial steps: the **ultrafast and highly efficient light harvesting and charge separation** mechanisms (that is, **energy and electron transfer** processes, respectively). During the last decade, growing evidence points to the **key role of coherence** in determining the high efficiency of Photosynthesis[1] owing to the fact that coherence provides directionality, speed and efficiency to energy and electron transfer processes.

The concept of **coherence-enhanced function in Photosynthesis** is an ongoing matter of passionate debate within the scientific community because it encloses a **fundamental question**:

*Is Photosynthesis, and by extension **Nature**, utilizing **coherence** to achieve its amazing efficiency?*

Within this **Project**, the **PhD Student** will address this question by investigating **light harvesting and charge separation** processes in a series of **natural and genetically-modified** photosynthetic complexes.

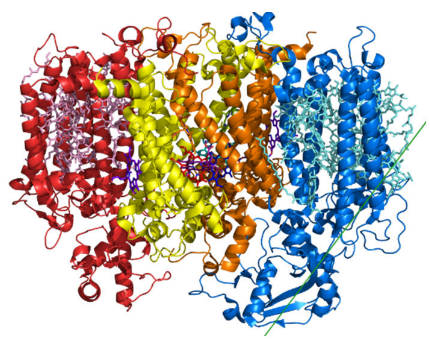

Figure 1. The Photosystem II core complex. Chromophores shown as sticks and protein represented as ribbons. The Light harvesting complexes are shown in red and blue, and the reaction center (site of charge separation) in yellow and orange (adapted from ref. [2])

The static and dynamic properties of these complexes will be studied by **spectroscopic techniques** [time-resolved: **Two-Dimensional Electronic Spectroscopy (2DES), Transient Absorption**, Time-correlated Single Photon Counting (TCSPC); steady-state: Absorption, Fluorescence, Linear and Circular Dichroism, Stark, Raman, FTIR, Fluorescence Line-Narrowing].

The **results** obtained will provide both **fundamental** insights as well as **refined design principles** to aid in the quest for the **rational design** of human-made systems to achieve cost-effective **solar-energy conversion to fuel.**

The PhD student background should be on **(Bio)Physics or Physical Chemistry**.

References

1 Romero, E., Novoderezhkin, V. I. & van Grondelle, R. Quantum design of photosynthesis for bio-inspired solar-energy conversion. *Nature* **543**, 355-365 (2017). SharedIt link

2 Umena, Y., Kawakami, K., Shen, J.-R. & Kamiya, N. Crystal structure of oxygen-evolving photosystem II at a resolution of 1.9 Å. *Nature* **473**, 55-60 (2011).