SFB 1078 Protonation Dynamics in Protein Function

Colloquium

Mon,**Oct. 28**, 2024

15:15 – 17:30

Freie Universität Berlin

SupraFAB, Room 201

(Altensteinstr. 23a, 14195 Berlin)

Prof. Dr Laura Pedraza-Gonzalez – Department of Chemistry and Industrial Chemistry. University of Pisa (UNIPI). Pisa, Italy

Multiscale Computational Modeling of Photoactivated Processes in Photoresponsive Proteins

Photoresponsive proteins, essential for light sensing and response across all domains of life, mediate critical processes such as vision, photosynthesis, and photoprotection. These proteins typically consist of one or more chromophores, small organic molecules tightly bound to a protein scaffold, which "harvest" light signals and initiate biological responses. The interaction between light and these biological systems is inherently multiscale, both in space—where highly localized photoexcitation affects energetically and structurally an entire protein—and in time, with photoexcited states lasting femtoseconds to picoseconds, while biological responses (e.g., protein structural changes) take place over milliseconds to seconds. To grasp the complexities of these processes and not only understand their atomic-level mechanisms but also achieve predictive capabilities, multiscale computational modeling is essential. Quantum mechanical (QM) methods are used to study the initial, short-lived interaction of the chromophore(s) with light, accounting for electronic structure and quantum effects. The subsequent propagation of light excitation throughout the biological matrix, however, involves longer timescales and high-energy barriers, which are efficiently modeled using molecular dynamics (MD) methods, incorporating enhanced sampling techniques to reduce computational effort.

This presentation will address the theoretical and methodological challenges of modeling photoactivated processes across multiple scales, highlighting the importance of combining experimental and theoretical efforts. Two case studies will be discussed: i) color tuning and fluorescence mechanisms in rhodopsin proteins, relevant for optogenetic tool development, and ii) light-harvesting and non-photochemical quenching mechanisms in plants and mosses.

Dr. Shahaf Peleg – Research Institute for Farm Animal Biology (FBN), Head of the Energy Metabolism and Epigenetics Working Group, Dummerstorf, DE

A song of light and power – Using light as an energy replacement for human longevity

Mitochondrial dysfunction is a central hallmark of aging and many longevity interventions target mitochondrial metabolism. Mitochondria are the cellular powerhouses and much like pollution from coal burning power plants, produce toxic metabolic intermediates and reactive oxygen species while generating energy. Subsequently, metabolic enzymes and mitochondria accumulate damage and become dysfunctional with age. Rejuvenating energy production has therapeutic promise to promote longevity however, translating model organism findings has been limiting.

Mitochondria transduce energy by moving electrons through the electron transport chain and pumping protons to form an electrochemical proton gradient called the protonmotive force(PMF). The PMF can then be used to generate ATP, the cellular energy currency, amongst many other functions. Our prior research created an approach that uses light to directly power the PMF using a novel tool of mitochondrial light-activated pump called mitochondria- ON (mtON). Our research showed mtON activation generates ATP in the absence of oxygen and upstream TCA metabolite, rejuvenates the PMF and increases adult *C. elegans* lifespan.

In my talk, I will provide an overview of the field of aging, and potential applications of mtON for longevity.

Coffee and tea will be available during the break at 16:15

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