TOWARDS NEUTRON CRYSTALLOGRAPHY OF MICROBIAL RHODOPSINS

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Microbial rhodopsins are a large family of seven-helical transmembrane retinal-binding proteins, currently comprising tens of thousands of representatives. Their primary biological functions include light-driven ion transport across biological membranes and photoreception. Owing to their versatile biological roles and relatively simple architecture, microbial rhodopsins have become a major focus of modern biophysical research, particularly in bioenergetics. At the same time, they have found important practical applications, most prominently in optogenetics, where engineered rhodopsins are widely used to control cellular activity with light.

Among the most widespread functions within this protein family is light-driven proton transport across the membrane bilayer. Since proton transfer is fundamentally governed by the positions and dynamics of hydrogen atoms, neutron diffraction represents an especially attractive approach for studying microbial rhodopsins. Unlike X-ray crystallography, neutron diffraction can directly visualize hydrogen/deuterium atoms and protonation states, providing unique information about hydrogen-bond networks, internal water molecules, Schiff base chemistry, and proton-transfer pathways.

In this talk, we will discuss the key requirements for successful neutron diffraction experiments on crystals of microbial rhodopsins, summarize recent progress toward obtaining neutron-diffraction-quality crystals of microbial rhodopsins, outline the methodological advances that make such experiments feasible, and discuss the major unresolved problems that still limit the application of neutron crystallography to this important class of light-driven membrane proteins.