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New Mechanisms for Control of Photosynthetic Energy Transfer

All photosynthetic organisms contain a light-harvesting antenna system. Photosynthetic antenna systems are extremely diverse in terms of structural organization and type of pigment utilized. In addition to the light absorption function of the antenna, it is essential for all photosynthetic organisms to have regulatory mechanisms that serve to protect them against excess light. Several of these regulatory mechanisms involve excited state quenching processes, and are referred to as Non-Photochemical Quenching (NPQ) to distinguish them from the normal excited state quenching by photochemistry that leads to productive energy storage. There are several different types of NPQ that are distinct mechanistically.

This talk will center on two of the mechanisms of NPQ. These are the Orange Carotenoid Protein (OCP) that is found in photosynthetic cyanobacteria and the redox--induced quenching that has recently been discovered in the Fenna--Matthews--Olson (FMO) protein found in Green Sulfur Bacteria. Cyanobacterial OCP serves to regulate energy collection in the phycobilisome antenna complex, and contains a photoactivated carotenoid molecule as the pigment, which is photoconverted from an orange form to a red form. While in the red form, the OCP binds to the phycobilisome and quenches excitations. The regulation in the FMO protein takes place via a pair of redox--active cysteine residues, which are near to two of the bacteriochlorophyll pigments. Under oxidizing conditions, these residues oxidize to form thyl radicals, which directly quench the excited states of the nearby bacteriochlorophylls by electron transfer processes. These regulatory systems have been investigated using an interdisciplinary approach involving ultrafast spectroscopy, mass spectrometry, mutational analysis, molecular modeling, X-ray and neutron crystallography, EPR spectroscopy and electrochemistry.