3rd National Congress on Physical Sciences, 29 Sep. – 2 Oct. 2016, Sofia
Section: Physics of Living and Soft Matter. Physics in Medicine

The Cytochrome b_6f Complex as a Perpetual Mobile for Adaptive Structural Reorganizations of the Photosynthetic Membranes in Chloroplasts and Cyanobacteria

R. Vladkova

Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Acad. G. Bonchev, Bl. 21, 1113 Sofia, Bulgaria

Abstract. The cytochrome *bc*-complexes in bacteria, plants and animals are essential for the energy transduction systems of the fundamental life processes photosynthesis and respiration. In the oxygen-evolving photosynthetic species (cyanobacteria, algae and plants), the cytochrome b_6f complex (cyt b_6f) is also known to trigger the short-term (in the minute range) adaptive mechanism state-transitions. State transitions balance the distribution of the excitation light energy to photosystem II and photosystem I in response to changes in the redox state of the plastoquinone (PQ) pool. The changes in the redox state of the PQ pool are the fastest indicator for a change in the environmental conditions. In addition to having many other benefits, a detailed understanding of the ability of cyt b_6f to regulate photosynthetic electron transport and to sustain its optimal efficiency is also a versatile and power tool for governing the stability and function of future artificial photosynthetic systems under variable environmental conditions. However, until recently, it was unclear how the cyt b_6f plays the role of redox sensor for the PQ pool redox changes, how this signal is transduced across the membrane and how it leads to activation of structural reorganizations, which accompany state transitions.

In this presentation, we will present examples from our recent work [Vladkova (2016) J Biomol Struct Dyn] illustrating the benefits from both the analyses of the diversity of cyt *bc* crystal structures and the application of the hydrophobic mismatch concept for answering the above questions. The available bacterial and mitochondrial cyt bc_1 and cyanobacterial and algal cyt b_6f X-ray crystal structures in the Protein Data Bank were used for analysis. The molecular volume of the single chlorophyll a molecule in the cyt b_6f was found different in the variety of the cyt b_6f crystal structures. It correlated with conformational changes at both the positive and the negative membrane sides of cyt b_6f. These correlations were accompanied by changes in the hydrophobic thickness of cyt b_6f. No such changes were observed in the analyzed cyt bc_1 crystal structures. It was concluded that the cyt b_6f governs the state transitions via

its chlorophyll a molecule, which plays the roles of the crucial redox sensor and of the transmembrane signal transmitter for the changes in the redox state of the PQ pool. The driving force for membrane reorganization during the induction and progression of state transitions is the hydrophobic mismatch induced by the changed hydrophobic thickness of the cyt b_6f upon the change in the redox state of the PQ pool. Therefore, the cyt b_6f can be envisioned as a perpetual mobile for adaptive structural reorganizations of the oxygenic photosynthetic membranes upon changes in the redox state of the PQ pool.

This work was supported by the Bulgarian Academy of Sciences.