KN4 - Structural basis of phycobilisomes for light harvesting and energy transfer

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Light harvesting is the first step in photosynthetic conversion of solar energy to chemical energy, which is extremely important to life on earth. Photosynthetic organisms have developed a variety of light-harvesting systems to capture light energy. Phycobilisomes (PBS) are the major light-harvesting antenna in cyanobacteria and red algae and they are among the largest protein-pigment complexes in living world. PBS is water soluble and structurally it is composed of a central core with peripheral rods attached. Both the central core and the peripheral rods of PBS are composed of phycobiliproteins and linker proteins. While the dynamic process of PBS assembly remains to be revealed, recent determination of a red alga PBS structure at 3.5 Å resolution through single-particle cryo-electron microscopy shed some light on how PBS components are assembled together and how the absorbed light energy transfers within PBS. It also provides some clues about energy transfer to photosystems and its regulation (state transitions). We found that the linker proteins are organized as linker skeleton within PBS and play a vital role in assembly of PBS. For the first time, the structures of γ-linkers are determined and their roles in light-absorbing as well as PBS assembly are revealed. The linker protein are also very useful in our understanding of protein-protein interactions in general. The energy transfer paths within PBS and the routes to either photosystem I or photosystem II are deduced based on the distances among the bilins which are effectively spaced in PBS. ApcD and ApcF play important roles in energy transfer in the core. Previous work has shown that ApcD is required for energy transfer to photosystem I while ApcF is needed for energy transfer to photosystem II. Based on structural and proteomic information mutagenesis was performed with ApcD and ApcF in the cyanobacterium *Synechococcus* 7002 and *Anabaena* 7120, the two key components in the central core, and the results demonstrated that an Tyr residue is critical to energy transfer from ApcF to ApcE (and to PSII). We found an ApcD mutant that was performing a faster state II to state I transition when a Lys residue is replaced by an Ala residue, implying that the cyanobacterial PBS could be mobile in state transitions.

References

Chang, L. *et al.* Structural organization of an intact phycobilisome and its association with photosystem II. *Cell Res.* **25,** 726–737 (2015).

Dong, C. *et al.* ApcD is necessary for efficient energy transfer from phycobilisomes to photosystem I and helps to prevent photoinhibition in the cyanobacterium Synechococcus sp PCC 7002. *Biochim. Biophys. Acta* **1787,** 1122–1128 (2009).

Sidler, W. A. Phycobilisome and phycobiliprotein structures. In: Bryant DA, ed. *The Molecular Biology of Cyanobacteria. The Netherlands: Kluwer Academic Publishers, 1994:139-216.*

Zhang, J. *et al.* Structure of phycobilisome from the red alga *Griffithsia pacifica*. *Nature*. **551,** 57-63 (2017).