

High-resolution structures of plant and cyanobacterial Photosystem I

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Abstract

Plant Photosystem I (PSI) is one of the most intricate membrane complexes in Nature. It is comprised of two complexes, a reaction center and light-harvesting LHCI. We developed a method for obtaining better mass spectroscopy data from membrane complexes. Using the corrected amino acid sequences an improved plant PSI structure was obtained. An atomic-level structural model of higher plant PSI at 2.8 Å resolution has been constructed based on new crystal form. The crystal belongs to P212121 symmetry space group, with one protein complex in each asymmetric unit. The structure includes 16 subunits and more than 200 prosthetic groups, the majority of which are light harvesting pigments. The model reveals detailed interactions, providing mechanisms for excitation energy transfer and its modulation in one of Nature's most efficient photochemical machine.

An operon encoding PSI was identified in cyanobacterial marine viruses. We generated a PSI that mimics the salient features of the viral complex containing PsaJ-F fusion subunit. The mutant is promiscuous for its electron donors and can accept electrons from respiratory cytochromes. We solved the structure of the PsaJ-F fusion mutant as well as a monomeric PSI at 2.8 Å resolution, with subunit composition similar to the viral PSI. The novel structures provided for the first time a detailed description of the reaction center and antenna system from mesophilic cyanobacteria, including red chlorophylls and cofactors of the electron transport chain. Our finding extends the understanding of PSI structure, function and evolution and suggests a unique function for the viral PSI.