Structures of a cyanobacterial phycobilisome in the light harvesting and the quenched states

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In the model organism Synechocystis PCC 6803 light-harvesting is carried out by the phycobilisome (PBS), a 6.2 MDa macromolecular antenna that captures incident sunlight and transfers the energy via a network of pigments to the photosynthetic reaction centers. One known mode of PBS regulation is mediated by Orange carotenoid protein (OCP) that binds to the PBS during high light conditions and prevents overloading of the photosystem in a process called non-photochemical quenching (NPQ). However, the structural organization of the PBS in either the unquenched or the OCP induced quenched state is not sufficiently understood. Using cryo-EM, and taking advantage of streptavidin affinity grids, we solved four structures of the Synechocystis PCC 6803 PBS with and without OCP at overall resolutions of 2.1-2.7Å. The structures reveal how large-scale rearrangements of the peripheral PBS rods give access to, or block OCP binding, suggesting that not every PBS is equally susceptible to NPQ. Further, we show that OCP dimerizes and that two such dimers are found in each PBS complex. Our data allow us to computationally recapitulate the energy flow through the pigment network of the PBS and show how OCP could quench this reaction. Finally, we also find a previously unknown protein located at the interface between PBS and the thylakoid membrane. Together, our results provide new insights into the biophysical underpinnings of cyanobacterial light harvesting that are of interest for bioengineering applications and for our deeper understanding of the photosynthetic biosphere.

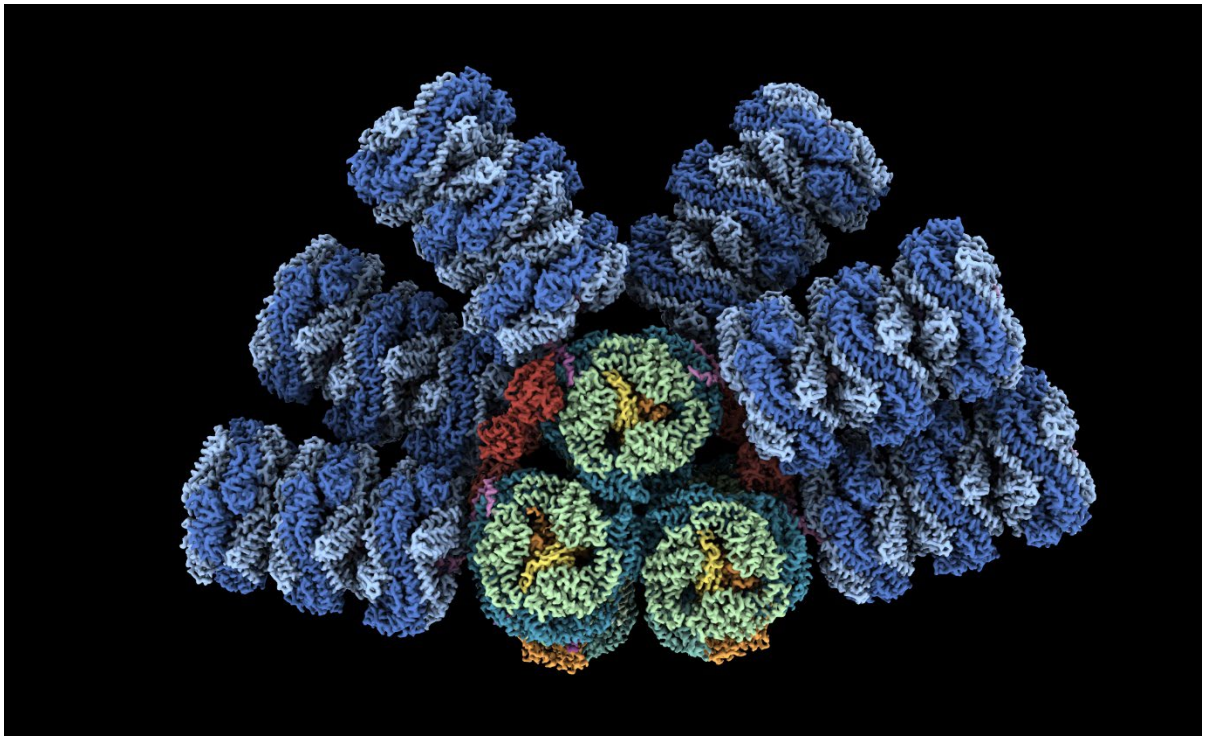

Figure 1