High-light-inducible proteins in complex with chlorophyll synthase and their role in Photosystem II biogenesis

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Abstract:

The biogenesis of Photosystem II (PSII) is a complicated process depending on numerous auxiliary factors. In cyanobacteria, the PSII assembly requires Ycf39 protein, which forms a stress-induced complex with two High-light-inducible proteins (Hlips) HliC and HliD. Hlips are small transmembrane proteins that are able to bind chlorophyll (Chl) and carotenoid pigments in a configuration dissipating exciton energy. The Ycf39-HliC-HliD complex has been reported to participate in the insertion of Chl molecules into the core D1 subunit of PSII [1]; however, how this process is organized remains unknown. Using the model cyanobacterium *Synechocystis* sp. PCC 6803, we demonstrate that the Ycf39 and both HliC and HliD can form distinct complexes with Chl synthase (ChlG). We isolated and characterized ChlG complexes from multiple strains subjected to different growth conditions and provided mechanistic insight into the interactions between Ycf39, ChlG and both Hlips. We found that, under low-stress, Chl is produced by a relatively large (90 KDa) ChlG-HliD$_2$-ChlG complex. We determined the structure of this complex in both substrate-free and bound states at 3.4 Å and 3.6 Å respectively by cryogenic electron microscopy, confirming the association of four Chl and two zeaxanthin molecules with the HliD homodimer. The exposure of cells to high light induces a massive synthesis of HliC, which leads to the replacement of HliD homodimers with HliC-HliD heterodimers. Unlike HliD, HliC is unable to interact directly with either ChlG or Ycf39, therefore the original ChlG-HliD$_2$-ChlG complexes are converted in less than 2 h into smaller ChlG-HliD-HliC hetero-trimers. We hypothesize that this structure transiently associates with Ycf39 and the nascent D1 polypeptide, facilitating the delivery of Chl to D1 during stress-induced Chl deficiency. We propose that HliD homodimers attached to ChlG may serve not only as ChlG stabilising agents, but also as an emergency reservoir of Chl for the PSII assembly intermediates. The pigments binding by HliD will be also discussed.

References:

[1] Knoppová J. et al. The Plant Cell 26.3: 1200-1212, 2014.