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Diving into the unknowns of LHCII PTMs: the forgotten dark side of photosynthesis

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Post-translational modifications (PTMs) control protein stability, localization, turn-over and interactions, thus represent a fine-tuned regulatory mechanism to reversibly adjust cellular physiology.
In photosynthetic eukaryotes, light-dependent phosphorylation of thylakoid proteins dynamically regulates the light-harvesting apparatus in response to environmental fluctuations. In the chloroplast of land plants, threonine phosphorylation regulates the repair cycle of photodamaged photosystem II (PSII) reaction centers and controls state transitions (ST). ST equilibrate the excitation pressure between photosystem I and II (PSI and PSII) upon shifts in light quality to avoid redox imbalances along the electron transport chain. We previously showed that phosphorylation of Lhcb2 Thr40 by by the state transition 7 kinase (STN7) is necessary and sufficient to promote state 1 −state 2 transition in Arabidopsis thaliana, while Lhcb1 phosphorylation is dispensable. Furthermore, extensive phosphorylation was detected on serines of the Light harvesting Complex proteins of PSII (LHCII) independently from the STN7 kinase and light cues.
The plastid NUCLEAR SHUTTLE INTERACTING (NSI)/GNAT2 (general control non-repressible 5 (GCN5)-related N-acetyltransferase 2) GNAT acetylase was reported to regulate state transitions3,4, possibly under (light-dependent) redox regulation. Intriguingly, several phosphorylated LHCII isoforms are also acetylated by GNAT, suggesting a possible cross-talk between PTMs. However, it is currently not known whether LHCII phosphorylation and acetylation are mutually exclusive events and whether they play synergistic or antagonistic roles.
Our preliminary data show that removal of an experimentally described Lhcb2 acetylation site neighboring the major p-Thr does not impair state transitions, suggesting that other LHCII acetylation events, possibly of Lhcb1 isoforms, could be involved in GNAT/NSI-dependent regulation of state transitions. Overall, we suggest that the interplay between PTMs of chloroplast proteins is a rather overlooked biological process, which adds another layer of complexity to the understanding of photosynthetic regulation.

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