Acclimation of electron flow as a response to environmental changes.

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The photosynthetic apparatus is a flexible molecular machine capable of responding to metabolic and light fluctuations in a time scale ranging from seconds to days. This occurs via changes in the light harvesting capacity and in the mode of electron flow, which happen in the short time range. Moreover, changes in the protein composition also take place, as a result of intracellular signaling between the nucleo-cytosol and the chloroplast. Changes in the electron flow capacity reflect the necessity to evacuate excess reducing pressure under conditions of over-excitation. They also stem from the need to balance the production of reducing equivalents and ATP, when these elements are not generated in the proper stoichiometry for photosynthetic metabolism.

Different strategies have evolved in oxygenic photosynthesis to achieve these objectives, as evidenced by the analysis of green algae and diatoms from different environments: in the green alga *Chlamydomonas reinhardtii*, photosynthetic growth, and therefore biomass production, critically depends on enhanced photosystem (PS) I turnover elicited by cyclic electron flow (CEF) in relationship with state transitions. This is indicated by the reduced growth capacity of mutants impaired in state transition and lacking most of the mitochondrial respiratory complexes. Reduced growth in the double mutants reveals a concurrent contribution of CEF and of respiration to supply "extra" ATP: when the latter cannot be provided by respiration, increased PSI absorption capacity (state 2) is required for photosynthetic metabolism. In the oceanic ecotype RCC 809 of the marine pikoeukaryote Ostreococcus, substantial rerouting of electrons from PSII to molecular oxygen to establish a H_2O-to-H_2O cycle is observed. This process involves a potential plastid plastoquinol terminal oxidase (PTOX) and allows bypassing electron transfer downstream of the cytochrome b_6f complex. It also provides the chloroplast with a proton gradient in conditions where PSI and the cytochrome activity are down regulated, e.g. by iron limitation. By promoting the generation of a ΔpH, the H_2O-to-H_2O cycle facilitates ATP synthesis and the onset of nonphotochemical quenching upon exposure to excess excitation. Eventually, removal of excess electrons by a mitochondrial alternative oxidase (AOX) protects Fe starved cells of the pennate diatom *Phaeodactylum tricornutum*, thereby allowing growth and efficient photoprotection.

Overall, common features can be observed in these acclimation strategies:

i. the mode of electron flow changes to achieve a balance between light absorption and photosystems turnover, ultimately leading to photoprotection of PSII.

ii. The pumping of ''extra'' protons into the thylakoid lumen (CEF, PTOX) or into the chloroplast matrix (AOX) is capable of supplying ATP to carbon assimilation, and to fuel the cellular energetic metabolism in stress conditions.