

**THERMO-OPTICALLY DRIVEN REORGANIZATIONS IN LIGHT
HARVESTING ANTENNAE**

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Earlier we have shown, mainly by polarization spectroscopic techniques, that the main chlorophyll a/b light harvesting complex of photosystem II, LHCII, forms chirally organized macroaggregates with dimensions commensurate with the wavelength of the visible light. The high self-aggregation capability of LHCII and PSII particles (coated with LHCII) explains the lateral segregation of the two photosystems between the granum and stroma membranes, i.e. the sorting of complexes, a key structural attribute of higher plant thylakoids [1,2]. Lamellar aggregates of isolated LHCII have been shown to constitute the structural basis for the long-distance migration (or delocalization) of the excitation energy [3].

The chiral macrodomains in thylakoids as well as in isolated lamellar aggregates of LHCII have also been shown to possess a remarkable structural flexibility. Most notably, they have been shown to undergo light-induced reversible structural reorganizations [4-6]. In lamellar aggregates of LHCII, lipids have been shown to play a key role [7,8]. Prolonged illumination with intense light leads to similar but irreversible changes [9]. These structural changes are accompanied by fluorescence quenching transients, also in isolated LHCII [5,10]. These data suggest the involvement of these reorganizations in regulatory processes in excess light [11]. It is important to point out, however, that these light-induced reorganizations and fluorescence transients are largely independent of the photochemical activity of thylakoids, and occur in isolated LHCII. Further, the changes in LHCII and thylakoids are approximately linearly proportional to the light intensity, i.e. in thylakoids, they increase monotonically above the saturation of photosynthesis. Hence, simple redox or Δ pH feedback mechanisms cannot be held responsible for these changes. It is also important to stress that the apparently non-saturable nature of the reorganizations is of significant potential importance, a unique feature, with respect to protection of plants against excess excitation.

These structural transitions have been proposed to be driven by a novel, thermo-optic mechanism: fast thermal transients arising from dissipated excitation energy, which lead to elementary structural transitions in the close vicinity of the dissipation centers, due to the presence of 'built-in' thermal instability in the (macro)assembly of complexes [12-14].

As concerns the nature of the structural changes in thylakoid membranes, it has been shown that light induces (i) unstacking of membranes, followed by (ii) a lateral desorganization of the macrodomains, and (iii) monomerization of the LHCII trimers [14]. Loosely stacked lamellar aggregates of isolated LHCII

exhibit very similar rearrangements, while tightly stacked lamellar aggregates or microcrystals do not possess this ability [15].

These structural changes, in addition to their role in the regulation of energy dissipation [see also 13, 16], might play an important role in photoprotection and different light- and temperature-adaptation processes. Reorganizations of similar nature have been shown to play a role in regulating the activity LHCII phosphorylation by light at the substrate level [17] and also in the proteolytic removal of the 'unnecessary' light harvesting complexes [18].

Thermo-optically driven rearrangements have also been detected in cyanobacteria, where energy migration from the phycobilisomes to the photosynthetic membranes can be regulated by heat or excess light.

We would also like to point out, as a potential general significance of these type of reorganizations, that thermo-optically induced structural transitions lend a substantial *local and temporal* structural flexibility to molecular (macro)assemblies that otherwise possess large stability and rigidity.

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