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# New Light on Photoprotection Spectral Resolution of Non-Photochemical Quenching

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New Light on Photoprotection - Spectral Resolution of Non-Photochemical Quenching

**Abstract**

This thesis investigates non-photochemical quenching (NPQ), emphasizing molecular mechanisms, thylakoid organisation and photosynthetic variability in plants. Spectro-kinetic analysis using ChloroSpec enabled detection of direct energy transfer from photosystem II (PSII) to photosystem I (PSI) - "spillover" - and the dissection of a unified NPQ mechanism, revealing photosystem II subunit S (PsbS) and zeaxanthin as critical regulators. PsbS facilitates light harvesting complex II (LHCII) quenching and spillover, while zeaxanthin accelerates spillover formation, ensuring rapid energy dissipation. The absence of these components severely impaired spillover, underscoring their synergistic roles in photoprotection. Hybrid aspen mutants highlighted conserved functions of PsbS and zeaxanthin in angiosperms, with plant species-specific differences in NPQ kinetics. Aspen exhibited faster spillover occurrence and superior spillover characteristics compared to *Arabidopsis*, reflecting its enhanced photoprotective capacity. Transmission electron microscopy (TEM) linked NPQ to changes in thylakoid ultrastructure. Light-induced NPQ decreased grana layers per stack and increased stack numbers in wild-type *Arabidopsis*. Zeaxanthin levels affected the trends in thylakoid reorganisation. The Swedish aspen collection (SwAsp) study explored photosynthetic variation between genotypes and across latitudes, showing limited geographic influence but robust photoprotection via rapid NPQ induction and relaxation processes. These findings provide mechanistic insights into NPQ, its evolutionary conservation and genetic underpinnings, with implications for enhancing photosynthetic efficiency in plants under light stress.

**Keywords**

Non-photochemical quenching (NPQ), chlorophyll fluorescence, spectro-kinetic analysis, thylakoid organisation, photosynthesis, natural variation, aspen, *Arabidopsis*

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