OA2.5 - Structure-based model of Photosystem II light harvesting in the presence of qE

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Photosynthesis is responsible for providing food and fuel to our planet. One important determinant of crop yields is the regulation of photosystem II (PSII) light harvesting by energy-dependent quenching (qE) in the presence of variable sunlight. However, the molecular details of excitation quenching have not been quantitatively connected to the PSII yield, which only emerges on the 100 nm scale of the grana membrane and determines flux to downstream metabolism. We have developed a structure-based model that describes excitation energy transfer and light harvesting from isolated pigment-protein complexes to the 100 nm length scale of the photosystem II (PSII) in the grana membrane. Our model agrees with data taken from both isolated pigment protein complexes and intact wild-type membranes of *Arabidopsis thaliana*. Here, we will explore the emergent features of PSII light harvesting in the presence of quenchers. We find that single molecule measurements of pigment-protein complexes measured in qE conditions are consistent with a weak-quenching regime. Our model predicts that in the presence of weak quenchers the excitation diffusion length is the key degree of freedom, or design principle, that determines PSII output as it acclimates to changing light intensities. A diffusion-corrected lake model substantially improves the PSII yield determined from variable chlorophyll fluorescence measurements and offers an improved model of PSII light harvesting for photosynthetic metabolism. This work connects the structure of pigment-protein complexes to the resulting properties of photosystem II light harvesting in vivo, providing an important step towards a bottom-up model of photosynthesis.