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Photosystem II-Cyclic Electron Flow Powers Exceptional Photoprotection and Record Growth in the Microalga *Chlorella ohadii*†

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†We dedicate this manuscript to the memory of Itzhak Ohad, friend and pioneer in photosynthesis research.

Abstract

The desert microalga *Chlorella ohadii* was reported to grow at extreme light intensities with minimal photoinhibition, tolerate frequent de/re-hydrations, yet minimally employs antenna-based non-photochemical quenching for photoprotection. Here we investigate the molecular mechanisms by measuring Photosystem II charge separation yield (chlorophyll variable fluorescence, Fv/Fm) and flash-induced O_2 yield to measure the contributions from both linear (PSII-LEF) and cyclic (PSII-CEF) electron flow within PSII. Cells grow increasingly faster at higher light intensities ($\mu E/m^2/s$) from low (20) to high (200) to extreme (2000) by escalating photoprotection via shifting from PSII-LEF to PSII-CEF. This shifts PSII charge separation from plastoquinone reduction (PSII-LEF) to plastoquinol oxidation (PSII-CEF), here postulated to enable proton gradient and ATP generation that powers photoprotection. Low light-grown cells have unusually small antennae (332 Chl/PSII), use mainly PSII-LEF (95%) and convert 40% of PSII charge separations into O_2 (a high O_2 quantum yield of 0.06 mol/mol PSII/flash). High light-grown cells have smaller antenna and lower PSII-LEF (63%). Extreme light-grown cells have only 42 Chl/PSII (no LHCII antenna), minimal PSII-LEF (10%), and grow faster than any known phototroph (doubling time 1.3 h). Adding a synthetic quinone in excess to supplement the PQ