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Optical Properties of Microalgae for Enhanced Photosynthetic Productivity

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Photosynthetic organisms are under selective pressure to synthesize and assemble a large light-harvesting chlorophyll antenna size, so as to ensure sufficient sunlight absorption and survival in their microenvironment. However, when aquatic green microalgae are mass cultivated under direct and bright sunlight, cells near the surface of the mass culture absorb at a rate that far exceeds the rate at which photosynthesis can utilize them, resulting in wasteful dissipation and loss of the excess photons as fluorescence or heat. Meanwhile cells deeper in the culture are deprived of much-needed sunlight. Algal strains having a truncated, chlorophyll antenna size will avoid the over-absorption and wasteful dissipation of excitation and photoinhibition of photosynthesis at the surface, while allowing for greater transmittance of sunlight deeper into the mass culture. Such altered optical properties of the cells would result in greater photosynthetic productivity and better solar conversion efficiency in the mass culture. This truncated light-harvesting Chl antenna size (tla) property may find application in the commercial exploitation of microalgae by the nutraceutical, chemical and bioenergy industries. The Chlamydomonas reinhardtii tla1 mutant strain was shown to have smaller chlorophyll antenna sizes in both photosystems and lower levels of Chl b per cell relative to the wild type. The tla1 strain required a higher light intensity for the saturation of photosynthesis and showed greater solar conversion efficiencies and a higher photosynthetic productivity than the wild type under mass culture conditions. Molecular analysis of the tla1 mutant revealed insertion of the transforming vector just prior to the start codon of a hitherto unknown gene (termed Tla1). Western blotting analysis shows that the mutant has reduced amount of the Tla1 protein compared to the wild type strain. The tla1 mutant was complemented by a wild type Tla1 gene. Tla1 is the first gene to be identified as a genetic determinant in the regulation of the chlorophyll antenna size in chloroplasts. Characterization of tla1-like truncated antenna mutants will contribute both to understanding of the signal transduction pathway involved in irradiance acclimation of photosynthetic organisms, to discovering novel genes that can be genetically manipulated for the generation of strains having smaller Chl antenna size in commercially important microalgae.