Investigating the Role of Excitonic Quantum Coherence in the Light-Harvesting Process of Photosynthesis

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The question of whether or not plants exploit quantum coherent effects in order to transport energy through their photosynthetic antenna is currently very controversial in the biophysics community. The aim of my project was to design an experiment which could isolate the effects of coherence in determining the efficiency of photosynthesis. This was accomplished through three-dimensional molecular modeling of a single 14-chlorophyll Light-Harvesting Complex II monomer, carried out using Mathematica. The modeling revealed that varying the polarization of light with a frequency of 660 nm from linear to circular at various light intensities could induce substantial changes in the level of coherence excited in the site and excitonic eigenbasis, with no impact on the total amount of light energy absorbed. These results provided the basis for several experiments investigating the chlorophyll fluorescence response of Cissus Rhombifolia (a general measure of how efficiently light is being used by a plant) under laser treatments provoking different degrees of coherence dynamics while holding the total light absorption constant. This experiments gave somewhat inconclusive results, with some trials revealing statistically significant differences between the chlorophyll fluorescence data from the control and experimental groups, and other trials revealing no such differences. Further experimentation and modeling will be very important in order to determine the significance of the results presented in this project, and ultimately to better understand the role of quantum effects in photosynthetic energy transfer.