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Systems Analysis of Trophic Transitions in Chromochloris zofingiensis, an Emerging Model Green Alga with Promising Biofuel Potential

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Abstract: As a core component of a sustainable bio-economy, microalgae have the potential to become a major source of biofuels and bioproducts without exacerbating environmental problems. These photosynthetic microbes utilize solar energy, grow quickly, consume CO2, and can be cultivated on non-arable land. However, there are presently considerable practical limitations in the photosynthetic production of biofuels from microalgae, resulting in low productivity and high costs. Integrative systems biology and engineering of emerging model systems are needed to expand the possibilities of microbial production of biofuels and bioproducts. The unicellular green alga, Chromochloris zofingiensis (formerly called Chlorella zofingiensis), is one of the highest producers of the preferred lipid precursor for biofuel products, triacylglycerol (TAG), making it a promising biofuel feedstock. Chr. zofingiensis accumulates TAG under nutrient stress as well as during trophic transitions. Our objective is to perform a comprehensive, large-scale systems analysis to understand how the energy metabolism of the cell is redirected based on energy/carbon source. To achieve this goal, we will characterize the responses of Chr. zofingiensis cells during trophic transitions and nutrient deficiencies, including transcriptomics, proteomics, metabolomics, and microscopy. We have sequenced and assembled a chromosome-level genome and high-quality transcriptome for Chr. zofingiensis as well as conducted preliminary experiments, which will facilitate an accelerated timeline to achieve the research objective. This proposal leverages the expertise and capabilities of DOE JGI (microbial RNA-seq, ChIP-seq, LC-ESI-MS/MS & HILIC) and EMSL (MS-Orbitrap, GC-MS, IMS-MS, CryoTEM, Confocal Airyscan, SIM, Live Cell Single Molecule Fluorescence Microscope, NanoSIMS, EM-EDS) to take a whole systems approach, which will enable modifying and manipulating microalgae for sustainable biofuel production. The FICUS program is uniquely suited for the project because of the integration of a suite of 'omics and imaging analyses to obtain an understanding of the biochemical, cellular, and molecular biology in this emerging oleaginous model system.