Project Summary for Public Release
Title: Direct Air Capture Integration with Algae Carbon Biocatalysis
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Supplementation of carbon is critical for high productivity cultivation of most microalgae (and all commercially relevant production). Moreover, photosynthetic microalgae are ideally positioned for atmospheric CO_2 capture to combat climate change, as waste sources and atmospheric CO_2 can be utilized to produce useful products such as renewable fuels, bio-based chemicals, and bio-products for nutrition, food, and feed. The challenge is developing technologies, processes, and strategies that utilize carbon efficiently, such that the overall system is sustainable and economical. This project is unique and aims to collect feasibility data on uncoupling algae production from the co-location of algae cultivation to waste sources of CO_2 or proximity to existing CO_2 pipeline infrastructure, opening opportunities for siting near high productivity algae cultivation climate and environmental hotspots or available land. This project aims to demonstrate the integration of an innovative passive direct air capture (PDAC™) technology in outdoor algae cultivation with improvements along the CO_2 delivery train, including novel membrane gas-liquid interface solutions. With the system we propose, locations where climate and water resources are ideal for cultivation can be supplied with clean and sustainably sourced CO_2 feedstock and thus algae cultivation becomes almost infinitely scalable within TEA and LCA boundaries. While this system could be paired with any algae, integrating it with the right strains will maximize its potential and increase biological carbon capture and storage in high quality biomass for downstream valorization.

Our biocatalysis work will center on the highly productive, year-round production species *S. obliquus* UTEX 393. We will utilize targeted metabolic engineering strategies to redirect energy and carbon away from processes that reduce cell biomass yields and carbon capture efficiency. Targets include the acceleration of central carbon metabolism and storage of assimilated CO_2 through overexpression of genes governing control steps in the Calvin Benson Bassham cycle. The structure and function of extracellular carbohydrates will be studied in the context of cultivation management for maximizing intracellular carbon storage, while also conveying pest resilience with detailed interaction engineering of the algal phycosphere. We will pursue high-throughput strain improvement strategies via directed metabolic engineering informed by transcriptomics and metabolomics. As an overarching integration strategy, engineered UTEX 393 strains will be deployed with a novel PDAC™ in cultivation trials that simulate the output at >95% CO_2, with a novel low-pressure, inexpensive storage system and low PSI (e.g., 20-25 PSI) delivery into ponds. We will also optimize CO_2 delivery to ponds for high carbon transfer efficiency. Robust TEA, LCA, and biomass productivity modeling will be utilized to identify critical research and development priorities and evaluate the impact of sub-system technologies at a systems level.