Project Title: CARBON-CAB: **C**ultivating **A**griculture with **R**evolutionary **B**io-Optimized **N**aturals - **C**yanobacteria and **A**lgae for a **B**righter future

Applicant: Ginkgo Bioworks (3274-1600)

Major Participants: Los Alamos National Laboratory (LANL), New Mexico State University (NMSU)

Principal Investigator: Dr. Varghese Thomas

Objective: Agriculture, a significant contributor to greenhouse gas (GHG) emissions, is at risk from climate impacts and overuse of chemical fertilizers. By using microalgae capable of rapid growth on captured CO_2 streams as sustainable biofertilizers, this initiative aims to reduce reliance on synthetic fertilizers, sequester anthropogenic carbon, and reduce soil emission, and improve crop and soil health, thereby reducing agricultural carbon intensity.

Description: Microalgae are promising candidates for biofertilizers due to their ability to fix atmospheric nitrogen, solubilize phosphates, and produce plant growth-promoting substances[1,2]. Our project develops a biofertilizer that harnesses properties of microalgal strains while using synthetic captured flue gas as feedstock. This innovative product is designed to reduce overall GHG emissions by 20% compared with chemical fertilizers.

Method: Ginkgo Bioworks and LANL have promising TRL4 algal strains characterized through internal R&D or under DOE BETO-funded consortium Development of Integrated Screening, Cultivar Optimization and Verification Research, respectively[3]. We will fine-tune cultivation parameters to optimize strains for effective growth under captured CO_2 feedstocks and use photobioreactors to optimize performance under large-scale conditions. Top performing strain combinations will be tested in Ginkgo's robust greenhouse facilities and LANL's advanced greenhouse testbed to quantify strain impact on crop growth, root biomass, soil emissions, and under field-like conditions. NMSU will scale strain cultivation to 1000L. We will test our bioproduct in real-world field and microplot conditions in New Mexico and California for corn and in greenhouses for wheat and rice. Finally, we will assess the impact of our biofertilizer with techno-economic and life cycle analysis, and provide opportunities for student engagement.

Impact: CARBON-CAB addresses the critical challenges of climate change and food security. By combining microalgal cultivation with captured CO_2 streams, we can integrate low GHG biofertilizers into agricultural practices, while maintaining crop growth and improving soil quality. EERE funding will enable the team to develop technologies with high potential impact but for which they would not have alternative funding to pursue. For instance, though Ginkgo has seen commercial interest in biofertilizer and soil carbon products, growth of strains using captured CO_2 source and other foundational research such as this is often outside the scope of commercial investment interest.

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[1] Jochum *et al.* (2018) doi.org/10.1371/journal.pone.0203456
[2] Negi *et al.* (2024) https://doi.org/10.1016/j.algal.2023.103364
[3] Huesemann, … Negi, *et al.* (2023) https://doi.org/10.1016/j.algal.2023.102996