Uncapping Carbon Capture – Elucidating and Engineering the “Ceiling” of Photosynthesis

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Photosynthetic CO_2 assimilation sits at the nexus of two of the 21st century's greatest challenges: feeding a growing population with shrinking resources and combating greenhouse gas-driven climate change. While the limiting factors governing CO_2 uptake are well-characterized at low-to-ambient CO_2 concentrations, higher carbon atmospheres induce sink limitations – termed triose phosphate utilization limitation – that remain much less understood. This limitation represents the upper “ceiling” of photosynthesis and is therefore a necessary and productive target for increasing carbon capture and crop yields, especially as atmospheric CO_2 levels continue to increase. To better understand and engineer this limitation, we employ a novel combination of reverse genetics, synthetic biology, and leaf-level physiology to unravel the mechanisms governing triose phosphate utilization and plant responses to high-flux carbon metabolism. A novel high-throughput chlorophyll fluorescence imaging approach screened over 1000 EMS-mutagenized *Arabidopsis thaliana* lines and identified several promising mutant lines with aberrative TPU-associated phenotypes. Transient transformation was also paired with leaf-level gas exchange to test metabolic engineering hypotheses in a rapid, modular fashion. As CO_2 levels continue to rise, understanding and engineering triose phosphate utilization will be critical for contextualizing the impacts of climate change and informing rational-design crop improvement strategies.