LANL Capabilities

Algae Cultivation for Carbon Capture and Utilization

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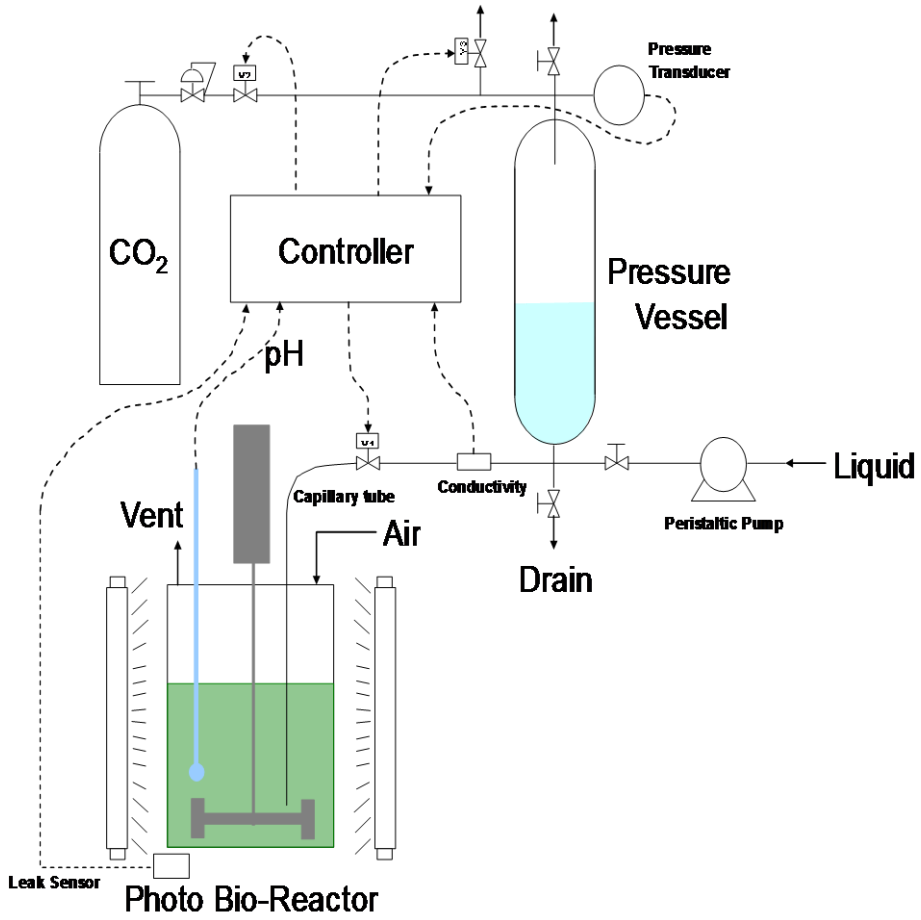
NNSA National Nuclear Security Administration

Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

Carbonic Acid Carbon Delivery System

- Increased carbon use efficiency by 30 to 50%
- Increased growth rate and biomass accumulation by 20 to 30%
- Demonstrated at 5 L bioreactor scale and 100 L open raceway
- Isotope discrimination diagnostic demonstrates continuous RuBisCO saturation

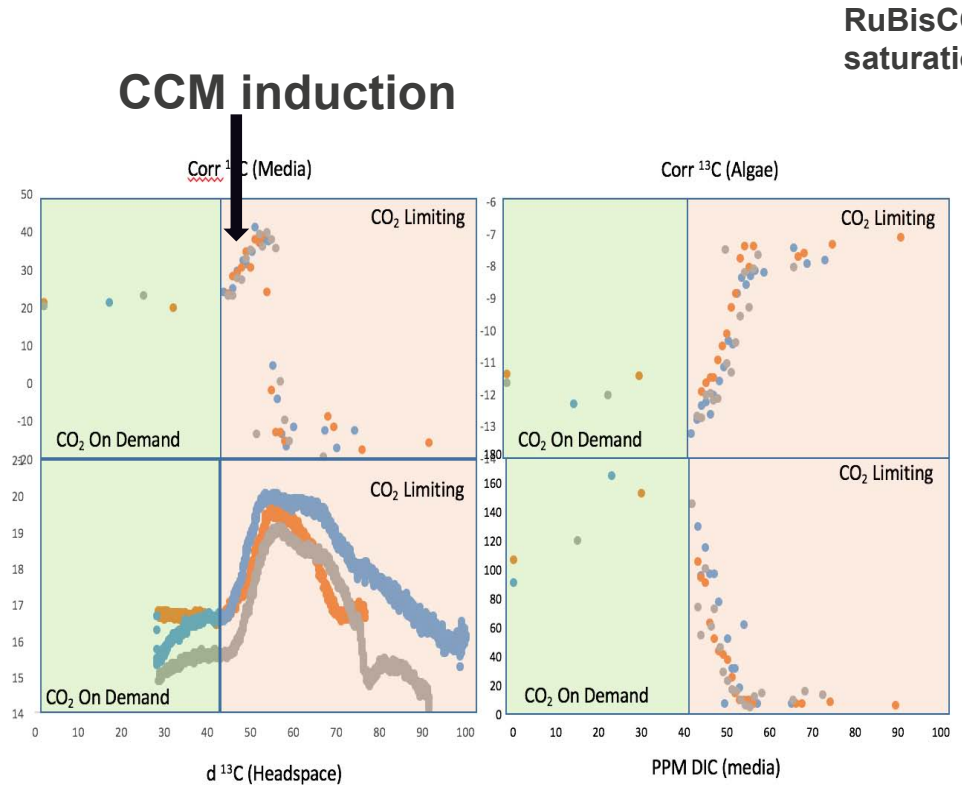


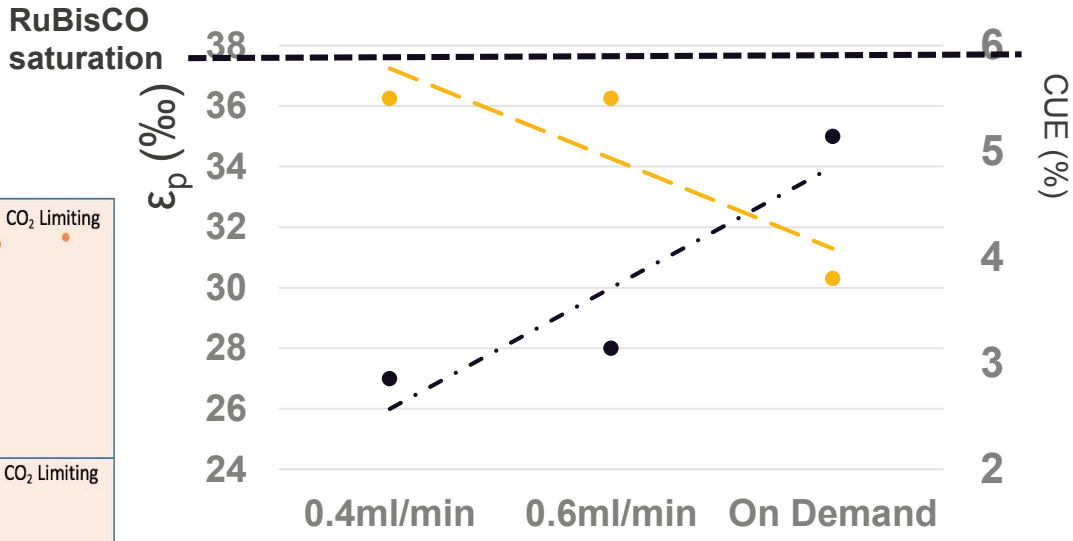
Integrate with genetic engineering

- Overexpress bicarbonate transporters
  - chloroplast and plasma membrane
- Engineer pyrenoid formation and CCM mechanisms
  - hybrid RuBisCO and associated proteins
  - carbonic anhydrases
  - carboxysomes

Diagnostic Tool for Assessing Carbon Use Efficiency in Algae
$^{12}C/\ ^{13}C$ Isotope Discrimination

$$\varepsilon_p = \delta^{13}C_{MEDIA} - \delta^{13}C_{ALGAE}$$





- ε_p is predictive of RuBisCO saturation but not carbon use efficiency
- Characterize CO_2 dynamics – informs management and genetic improvements

Related LANL Projects in Algae – Aimed at Algae Productivity

Functional 'Omics and Tool Development

Greenhouse
An omics knowledge base for algal biofuel feedstocks

https://greenhouse.lanl.gov

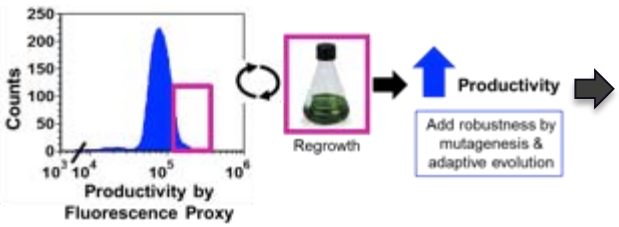
- 'Omics data gives information critical for genetic modification and molecular toolkit development
- The Greenhouse creates a centralized and standardized web-based repository to organize and integrate this important data, as well as offer public tools for intuitive use
- Houses public data as well as private sites for ≥5 BETO-funded projects
- LANL collaborates with other labs (e.g. NREL) and projects to complete additional 'omics work
- Site incorporates data generated at LANL, as well as curates data from other sites to create one "go-to" place for eukaryotic algae (most algae biofuel production strains)
- Currently the largest eukaryotic algal genome collection available online

Strain Improvement by Genetic Modification

PACE PRODUCING ALGAE FOR COPRODUCTS AND ENERGY

- Some high productivity algae strains have proved recalcitrant to genetic engineering
- PACE has now shown independent examples of transforming *C. sorokiniana* 1230 with recombinant DNA, overcoming a large barrier to further improving this strain

Strain Improvement by Flow Cytometry



Flow cytometry is a method for isolating top performing cells from a population of cells → high throughput & non-GMO

Cell Sorted *Nannochloropsis*, Cellana, 60,000L

- LANL collaborates with external partners to send improved strains outdoors for testing (ASU, Cellana)
- In Cellana's ABY1 project, Cellana grew a cell sorted *Nannochloropis* from a LANL AOP project outdoors at 60,000L scale and showed that its improved lipid phenotype can be maintained.
- LANL AOP March Go/No-Go demonstrated a new cell sorting approach to isolate cells that grow faster (previous methods focused on lipid accumulation).