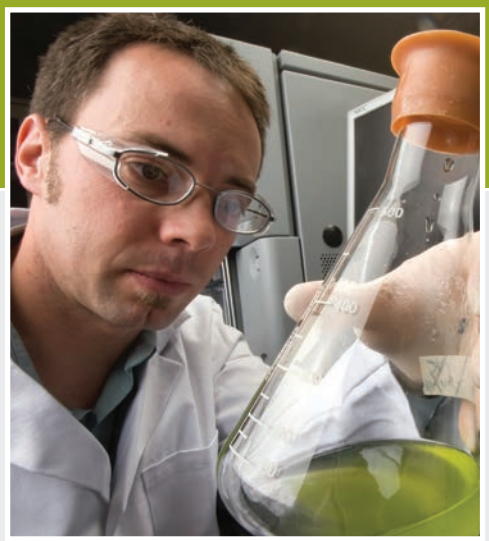
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Algal Biofuels Research Laboratory

Enabling fundamental understanding of algal biology and composition of algal biomass to help develop superior bioenergy strains



NREL researchers use the fluorescence activated cell sorter (FACS) to isolate algae cells and sort them by type. *Photo by Patrick Corkery, NREL 15592*

NREL's algal biofuels laboratory capabilities are focused in these areas:

- Microbiology, biochemistry, genetics, and molecular biology of eukaryotic algae
- Compositional analysis of algal biomass
- Conversion of algal biomass to fuels and other products
- Technoeconomic analysis of algal biofuel production.

NREL's algal biofuels research capabilities include:

- Growth platforms from 0.2 mL to 270 L scale in multi-well plates, shake flasks, photobioreactors, and open ponds
- Algal genetic engineering capabilities, promoter identification, and a robust transformation procedure
- Systems biology expertise: transcriptomics, proteomics, and metabolomics
- Bioprospecting for novel strains well suited for cultivation at prospective production facilities
- Robust lipid analysis procedures routinely used and applied to a large range of algal species
- Algal carbohydrate and protein analysis by GC and LC with MS detection
- Rapid high-throughput lipid analysis
- Detailed spectroscopic analysis of algal biomass fractions by FTIR and mass spectroscopy
- Biomass process research combining pretreatment and extraction operations.

Laboratory Resource Highlights	
Microbiology	500 strain culture collection Liquid nitrogen freezer for strain cryopreservation 50 parallel 150-mL photobioreactors with precise gas mixing for high-throughput screening Photobioreactor system for simulated flue gas experiments 270-L open ponds with CO_2 supply
Cell and molecular biology	Fluorescence activated cell sorting High-throughput fluorescence imaging of cell populations Light, epi-fluorescence, laser scanning confocal, and electron microscopes
Characterization and conversion	Dedicated gas and liquid chromatography systems Automated solvent extraction setup IR spectrometer systems with fiber-optic probe for high-throughput spectroscopy Microwave enhanced thermal treatment systems

**NREL is a national laboratory of the U.S. Department of Energy,
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Applications

Microbiology

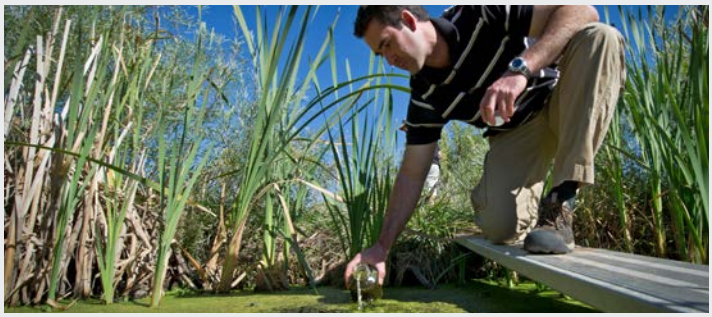
- Measurement of productivity in continuous culture using natural light
- Parallel, normalized, and fully controlled high-throughput screening of up to 50 strains
- Detailed study of photosynthesis and cell metabolism in algal cultures
- Study of the tolerance of selected algal cultures to the presence of flue gas and measurement of gas uptake and effect on metabolism
- Bioprospecting for and isolation of unique algal phenotypes.

Cell and molecular biology

- Targeted genetic and metabolic engineering of algal cells using our transformation procedure and knowledge of promoters to drive expression of genes
- Screening (high-throughput imaging and cell sorting) of algal cell populations based on fluorescence
- Detailed structural analysis of algal cells by electron microscopy.

Characterization

- Accurate quantification of algal lipid content followed by detailed chromatographic speciation of the individual lipids
- Detailed characterization of the carbohydrate and protein content of algal biomass
- Rapid analysis by NIR spectroscopy to complement traditional wet chemical methods that are time consuming and expensive
- Detailed study of the conversion of algal biomass and residuals to soluble sugars, using thermal and chemical upgrading processes.



An NREL researcher bioprospects for algae, searching for the most promising strains for biofuels production. *Photo by Dennis Schroeder, NREL 18632*

Associated publications

Dong, T., S. Van Wychen, N. Nagle, P.T. Pienkos, and L.M.L. Laurens. "Impact of biochemical composition on susceptibility of algal biomass to acid-catalyzed pretreatment for sugar and lipid recovery." *Algal Research* 18 (2016): 69–77. doi:10.1016/j.algal.2016.06.004

Dong, T., E.P. Knoshaug, R. Davis, L.M.L. Laurens, S. Van Wychen, P.T. Pienkos, and N. Nagle. "Combined algal processing: A novel integrated biorefinery process to produce algal biofuels and bioproducts." *Algal Research* (2016). doi:10.1016/j.algal.2015.12.021

Markham, J.N., L. Tao, R. Davis, N. Voulis, L.T. Angenent, J. Ungerer, and J. Yu. "Techno-Economic Analysis of a Conceptual Biofuel Production Process from Bioethylene Produced by Photosynthetic Recombinant Cyanobacteria." *Green Chemistry* (2016). doi:10.1039/C6GC01083K

Davis, R., J. Markham, C. Kinchin, N. Grundl, E.C.D. Tan, and D. Humbird. *Process Design and Economics for the Production of Algal Biomass: Algal Biomass Production in Open Pond Systems and Processing Through Dewatering for Downstream Conversion*. Golden, CO: National Renewable Energy Laboratory, NREL/TP-5100-64772, 2016. www.nrel.gov/docs/fy16osti/64772.pdf

Laurens, L.M.L., N. Nagle, R. Davis, N. Sweeney, S. Van Wychen, A. Lowell, and P.T. Pienkos. "Acid-Catalyzed Algal Biomass Pretreatment for Integrated Lipid and Carbohydrate-Based Biofuels Production." *Green Chemistry* 17, no.2 (2015): 1145–1158. doi:10.1039/C4GC01612B

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