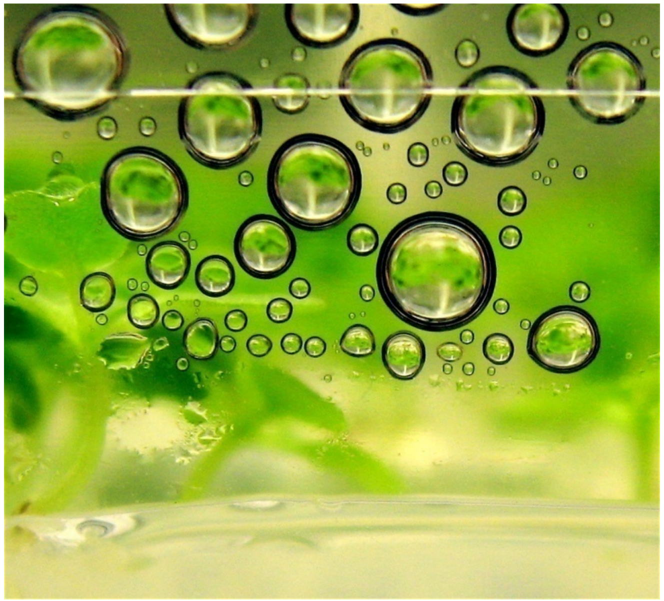
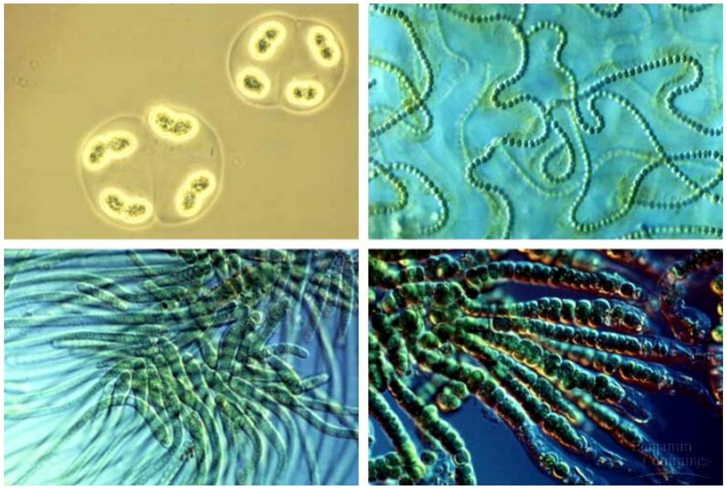
Increasing biodiesel production in *Chlorella vulgaris*



Renewable Energy in West Virginia

May 12, 2016



Derrick R. J. Kolling

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Overview

- Biodiesel research justification
  - Why biodiesel?
- Algal biodiesel
  - Triacylglycerides (TAGs)
- Research projects
  - Using glycerol to increase algal lipid production
  - Directed evolution increase algal lipid production

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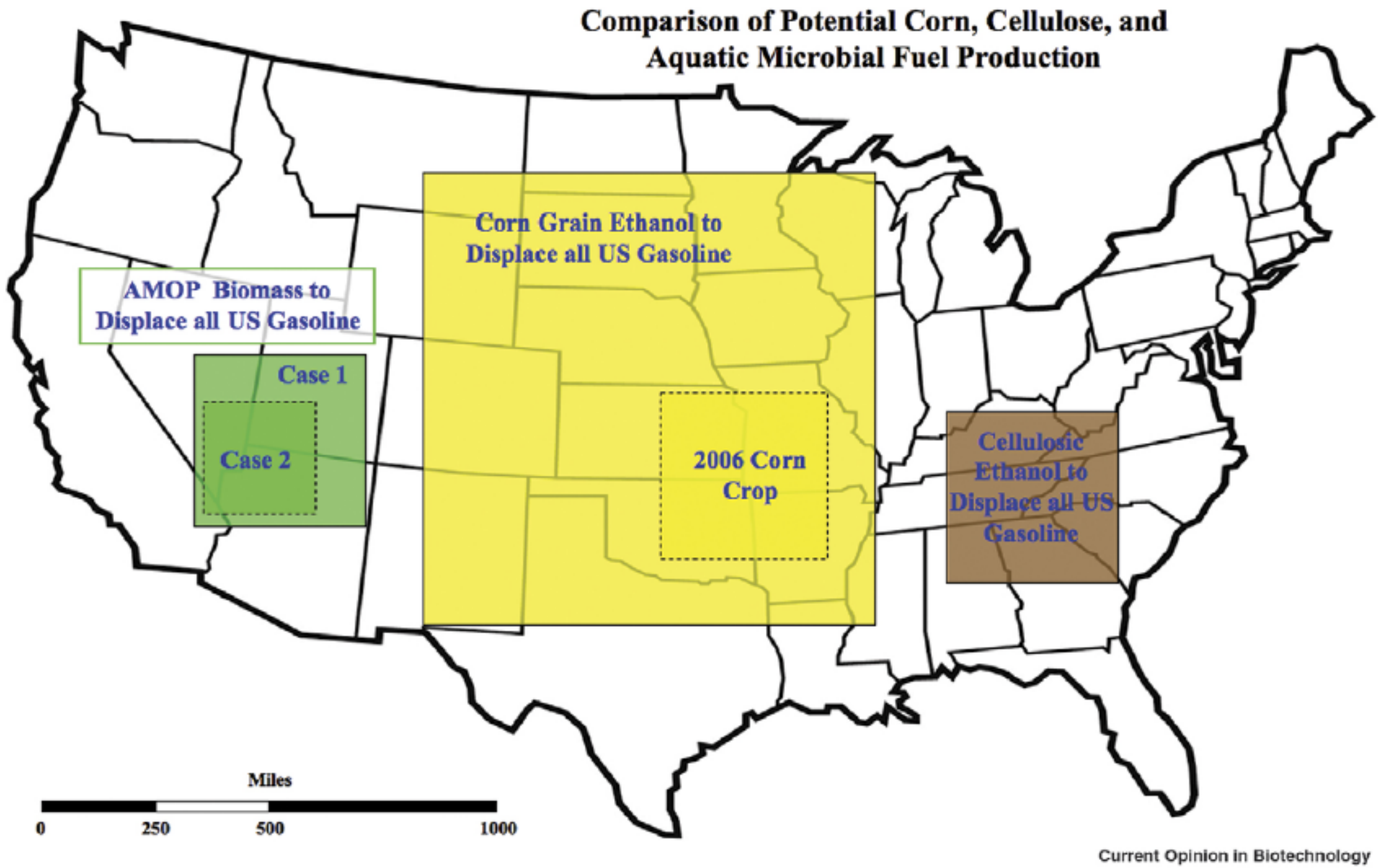
Rene

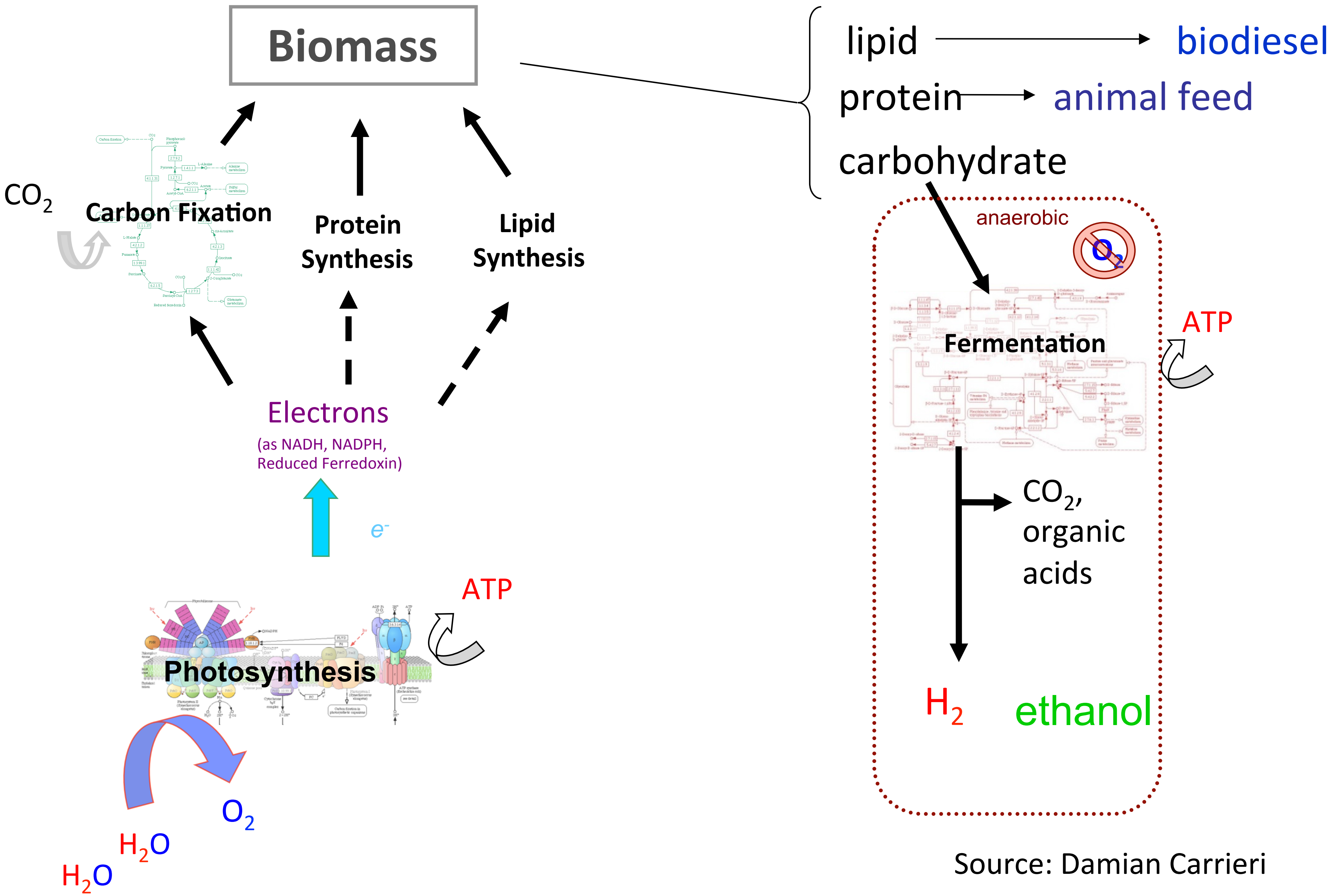
- Biofuels
- Solar power
- Wind power
- Tidal power
- Hydropower
- Geothermal

Biofuel Footprint



Dismukes *et al*. (2008)

Algal Biofuel



Source: Damian Carrieri

Algal Biofuel

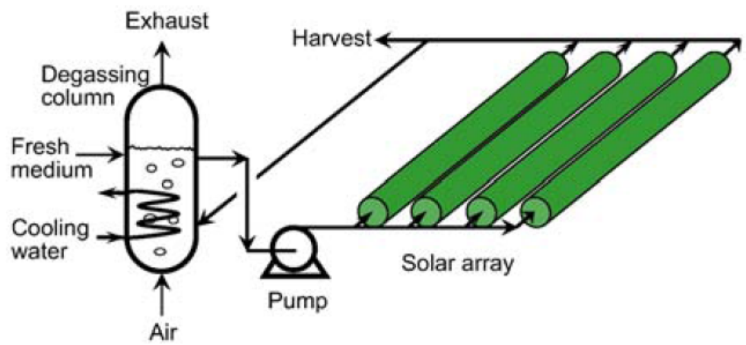


Fig. 2. A tubular photobioreactor with parallel run horizontal tubes.

Fig. 5. Microalgal biomass recovered from the culture broth by filtration moves along a conveyor belt at Cyanotech Corporation (www.cyanotech.com), Hawaii, USA. Photograph by Terry Luke. Courtesy of Honolulu Star-Bulletin.

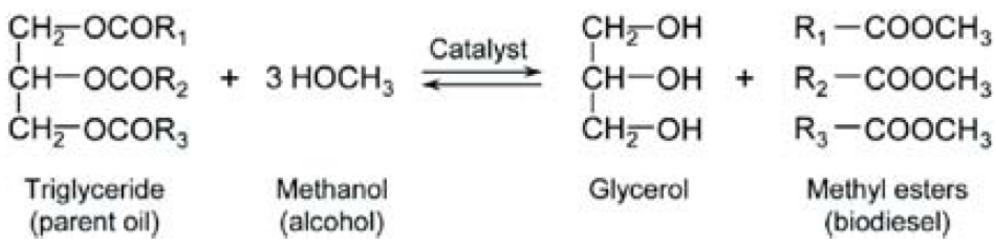
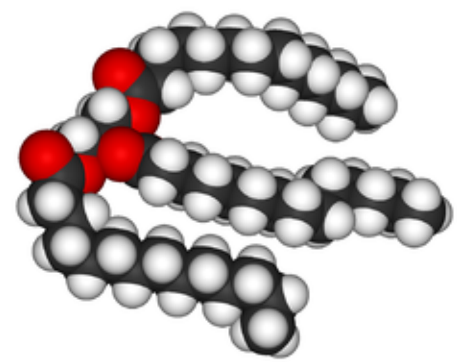


Fig. B1. Transesterification of oil to biodiesel. R_{1-3} are hydrocarbon groups.



Chisti (2007) *Biotech. Advances*

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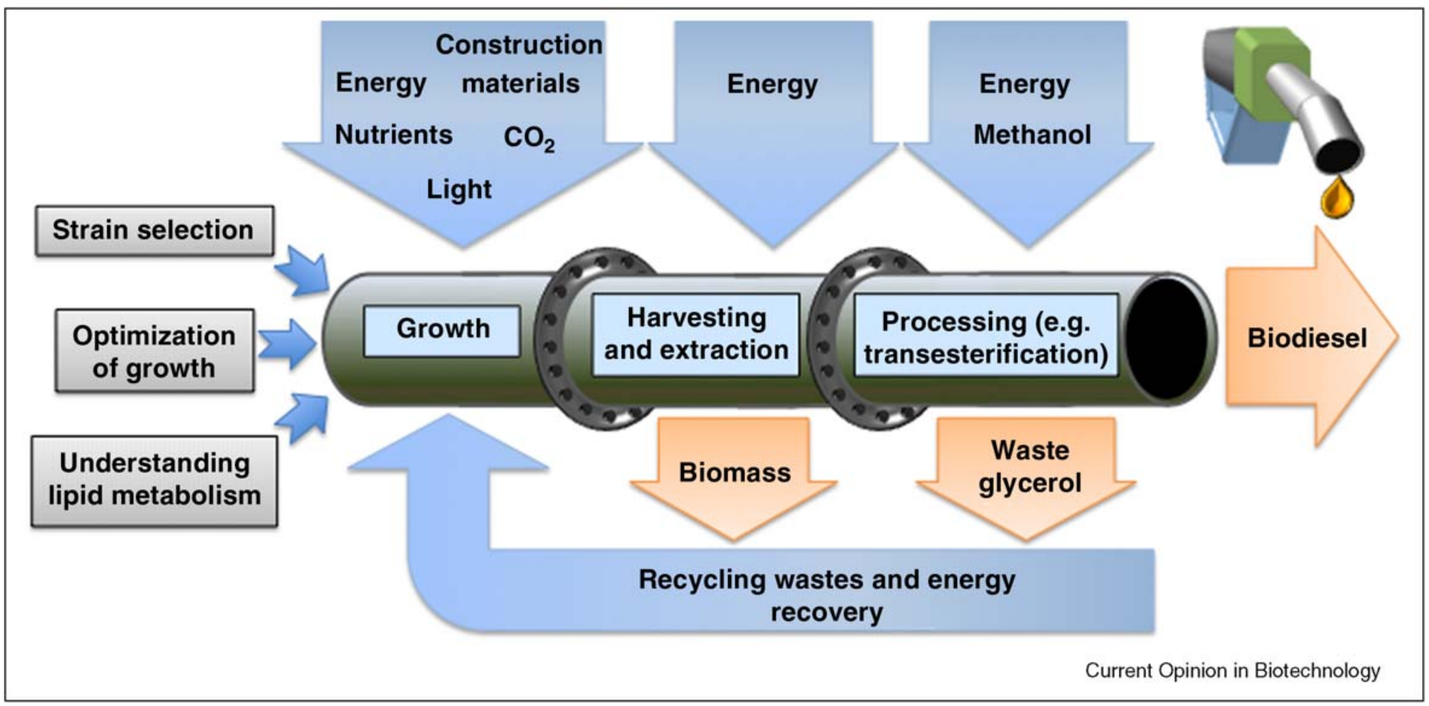
Algal Biofuel

Crop	Oil content per tonne of biomass (wt% dry mass)	Oil production (t/ha/y)	Biodiesel yield (L/ha/y)
Oilseed (UK) [2]	40–44% (of seed)	1.4	1560
Soya [1••]	20% (of seed)	0.48	544
Jatropha [45]	30% (of seed)	2.4	2700
Chlorella vulgaris [26]	Up to 46%	7.2§	8200
Nannochloropsis [12•]	Up to 50%	20–30§	23 000–34 000



Scott *et al.* (2010) *Current Opinion in Biotechnology*

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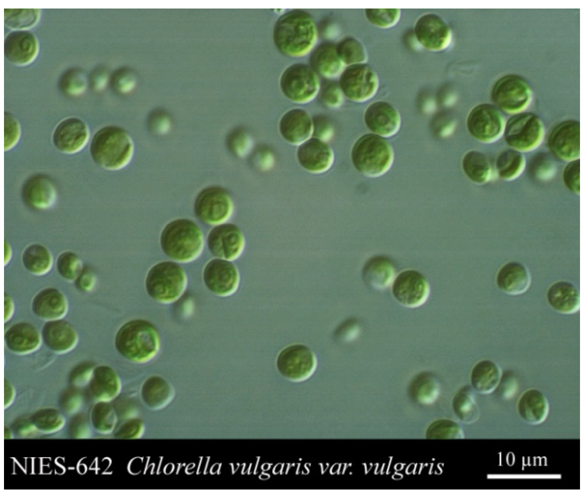
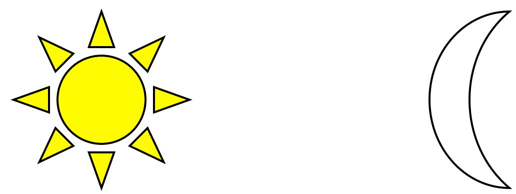
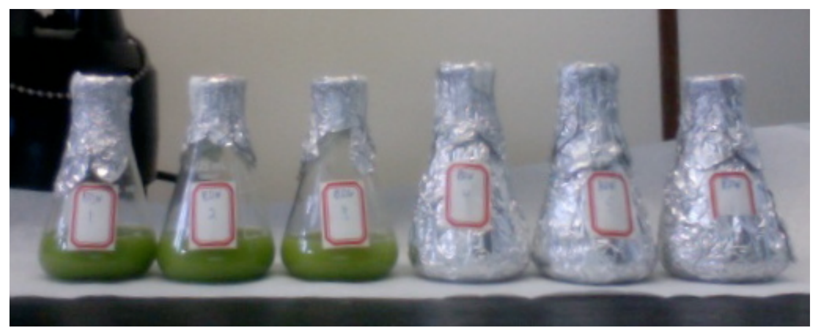
Comparison of lipid accumulation in photomixotrophically and heterotrophically grown *Chlorella vulgaris*







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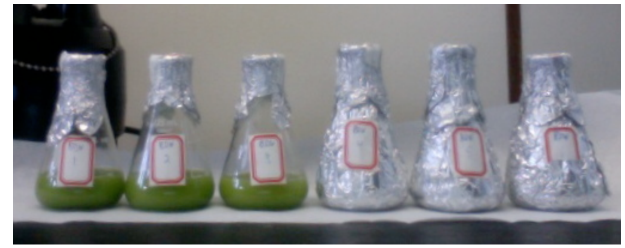
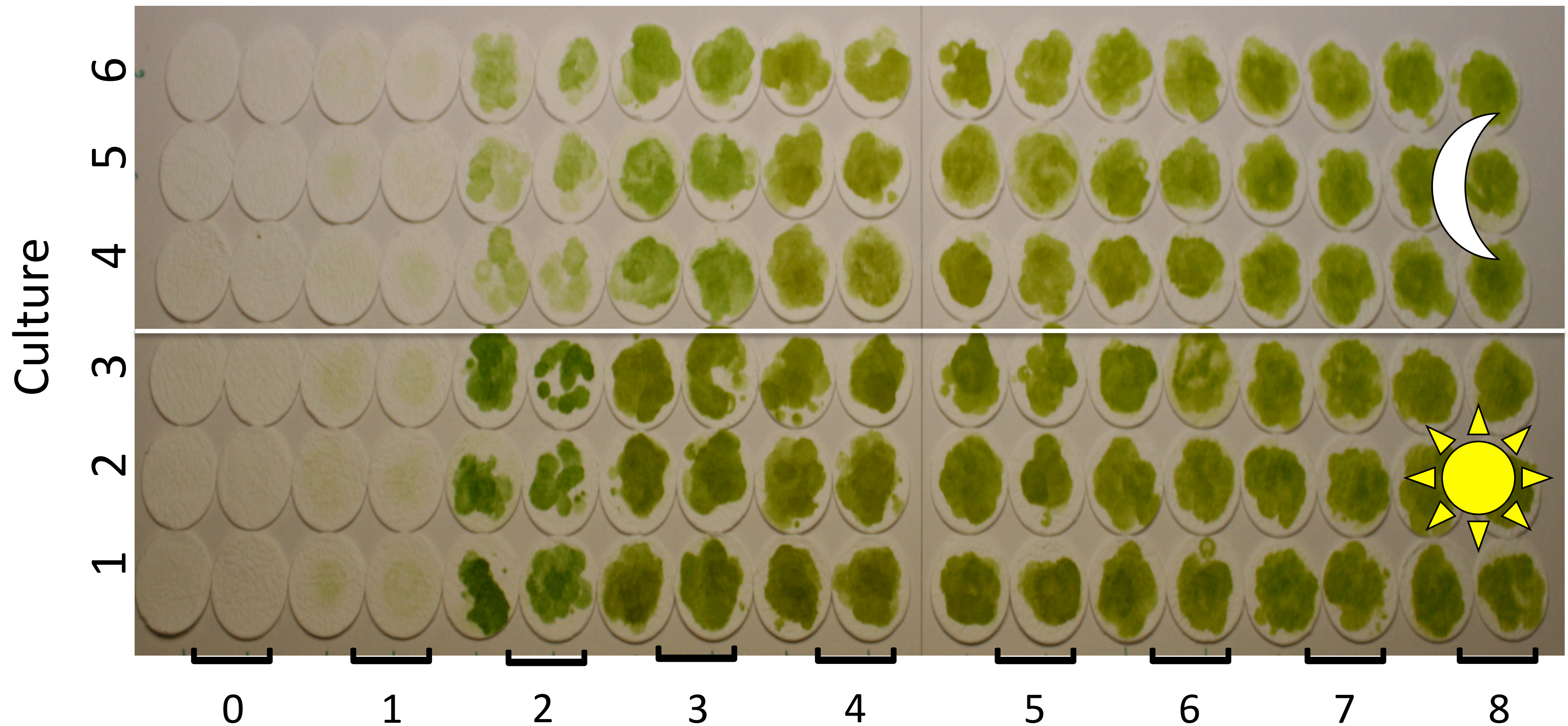
Measured:

- -[Chl *a*]
- -turbidity
- -dry mass
- -lipid dry mass





Biomass weights

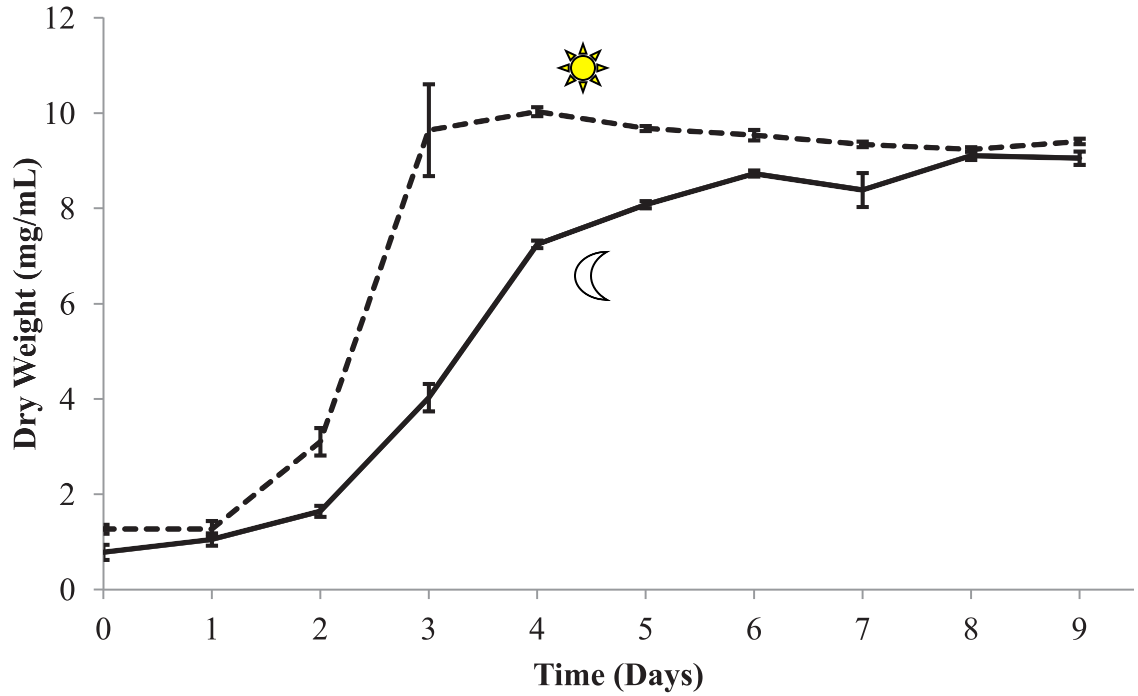


Fig. 2. Dry biomass weights for photomixotrophic (dashed) and heterotrophic (solid) cultures. Error bars show SEM for triplicate cultures.

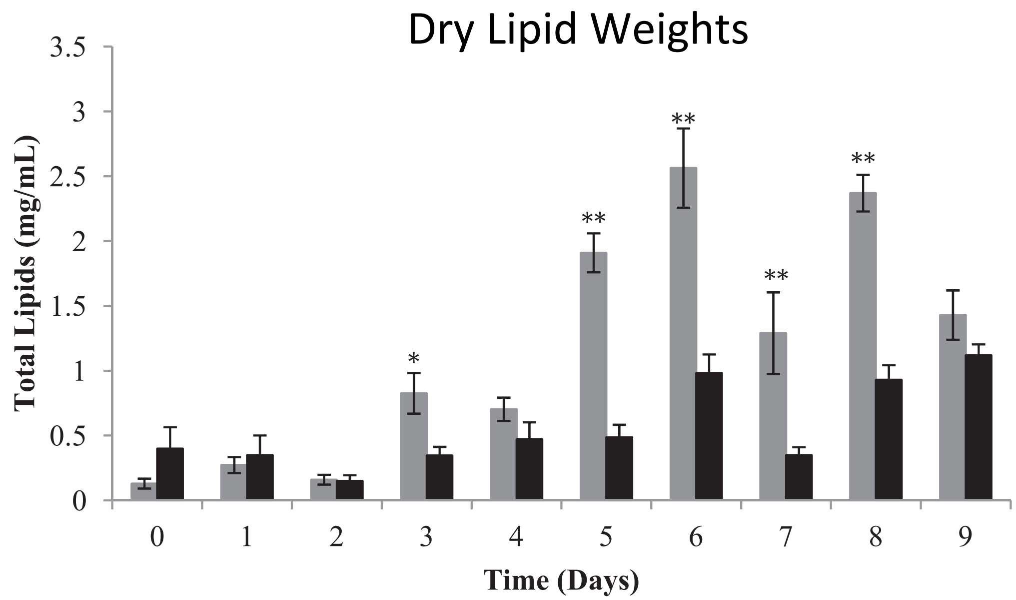


Fig. 6. Dry lipid weights for photomixotrophic (gray) and heterotrophic (black) cultures. Photomixotrophic cultures contain close to 100% more lipids on average over the days 5–9 than the heterotrophic cultures. $P < 0.05$ and $P < 0.01$ are indicated by single or double asterisks, respectively. Error bars show SEM for triplicate cultures.

C 16: palmitic acid
C 18: stearic acid
C 18:1(n-9): oleic acid
C 18:2(n-6): linoleic acid

Algal Biodiesel: Findings

- Photomixotrophically grown cells produce ~2X as many lipids as do heterotrophically grown cells
  - Same maximum biomass accumulation in both cultures
- Photomixotrophically grown cells reach stationary phase sooner
  - Due to the light reactions of photosynthesis
- Cells produce palmitic, stearic, oleic, and linoleic acids

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Photosynthetic light reactions increase total lipid accumulation in carbon-supplemented batch cultures of *Chlorella vulgaris*

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HIGHLIGHTS

- *C. vulgaris* generates equivalent biomasses in hetero/photomixotrophic batch cultures.
- Light enhances lipid production in *C. vulgaris* batch cultures.
- Differences in lipid to biomass ratio are a result of photosynthetic light reactions.

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ABSTRACT

Microalgae are an attractive biofuel feedstock because of their high lipid to biomass ratios, lipid compositions that are suitable for biodiesel production, and the ability to grow on varied carbon sources. While algae can grow autotrophically, supplying an exogenous carbon source can increase growth rates and allow heterotrophic growth in the absence of light. Time course analyses of dextrose-supplemented *Chlorella vulgaris* batch cultures demonstrate that light availability directly influences growth rate, chlorophyll production, and total lipid accumulation. Parallel photomixotrophic and heterotrophic cultures grown to stationary phase reached the same amount of biomass, but total lipid content was higher for algae grown in the presence of light (an average of 1.90 mg/mL vs. 0.77 mg/mL over 5 days of stationary phase growth).

1. Introduction

are produced as industrial byproducts; however, they could provide a dependable source for a smaller portion of the energy

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