Sugar to Diesel via Microbial Fermentation

Kirk Apt

March 30, 2010

MARTEK
life enriched.™

Biomass to Fuel

Plant Material

Corn (starch)
Stover
Wood chips
Sugarcane (sucrose)
Bagasse
Vegetable oils

Microbial
or
Chemical
Conversion

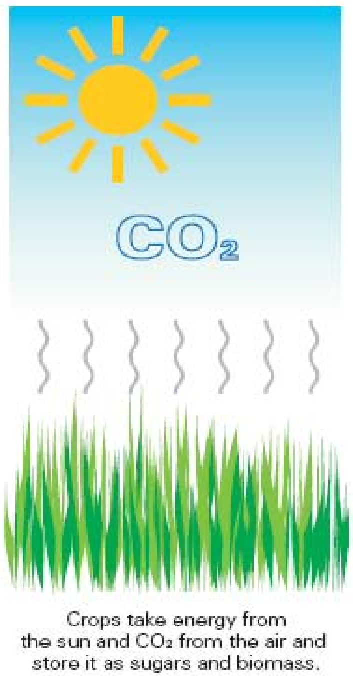
Fuels

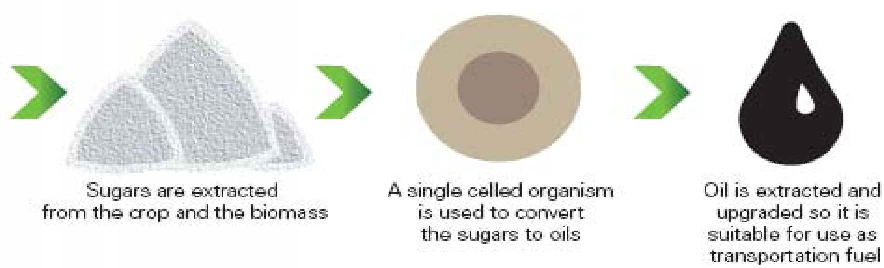
Alcohols- Gasoline
(Ethanol, Butanol)
Hydrocarbons
Lipids – Biodiesel

MARTEK life enriched.™

BP-Martek Sugar to Diesel Technology

- **Technology:**
  - **Non photosynthetic** conversion of sugars into oils for application in transportation fuels (biodiesel, aviation fuels). Alternative to vegetable oils and photosynthetic algae.
- **Steps:**
  - Access cost effective and sustainable sugar juice extracted from sugar cane or Ligno-cellulosic material
    - » Use proprietary **heterotrophic** micro- organism to convert the sugars into lipids / oils.
    - » Lipids produced have profiles and/or properties similar to conventional vegetable oils (rape seed, soya bean oil), or tailored to specific applications.
    - » "Upgrade" the lipids/oils to FAME or hydrocarbons through existing chemical or thermo-catalytic conversions





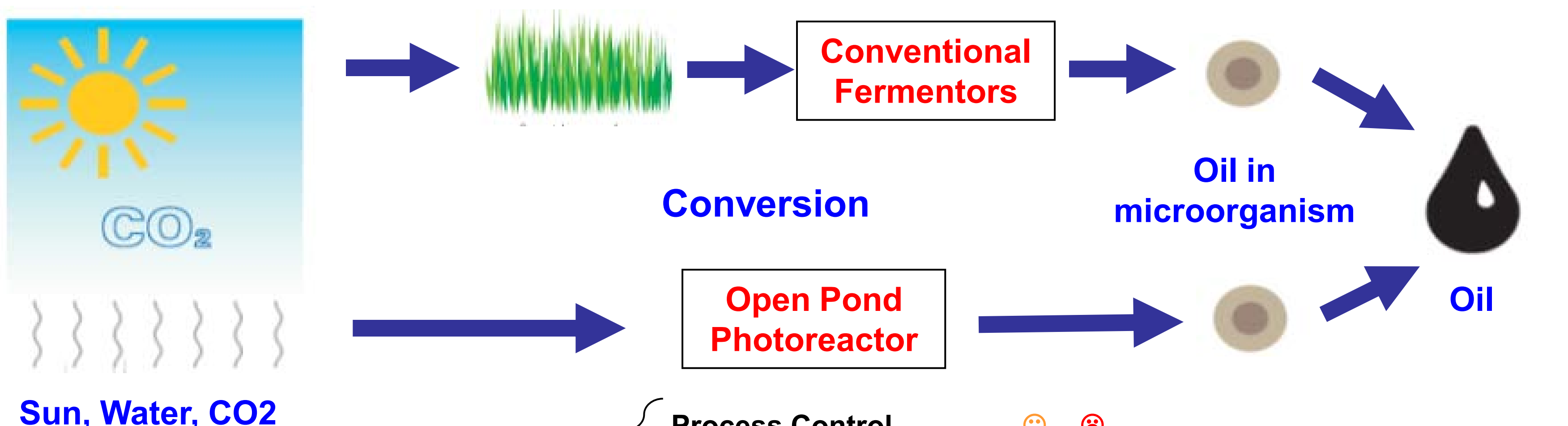
Photosynthetic versus Heterotrophic

Criteria for judging opportunities:

Low cost / Low-carbon / Scalable / Sustainable

Heterotrophic

Process Control	☺
Productivity	☺
Production costs	😐
Scalability	☺
Technical risks	☺



Photosynthetic

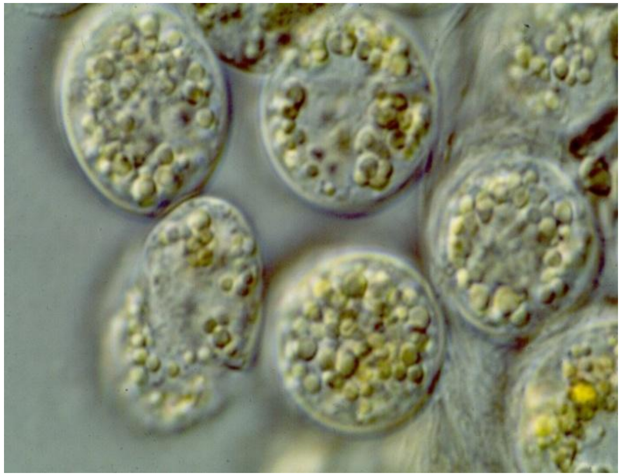
Process Control	😐 - ☹
Productivity	😐 - ☹
Production costs	😐 - ☹
Scalability	☹
Technical risks	☹

MARTEK life enriched.™

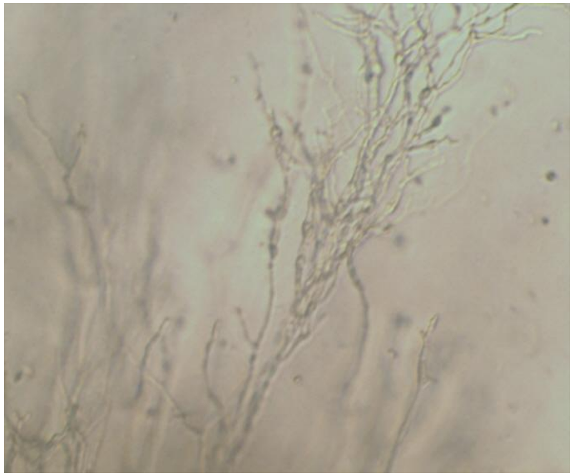
bp

Martek Microbial Technology

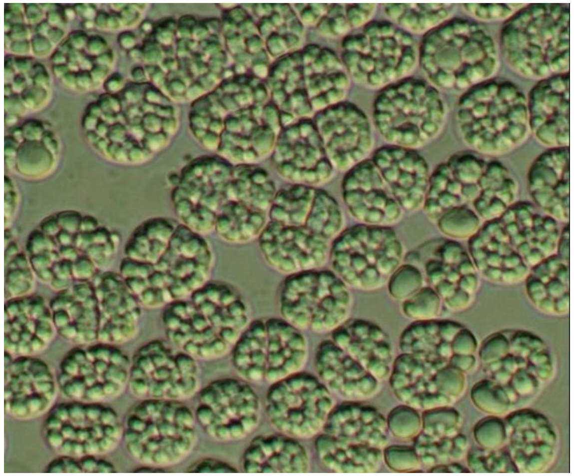
- **Expertise in algae and fungi with over 20 years commercialization experience. Including multiple successful oil products.**
- **Extensive expertise in the isolation, and characterization of algal and microbial species. Continue to conduct regular new collections**
- **Culture collection containing over 5000 microbial isolates, both photosynthetic and heterotrophic. Representatives from most algal groups. Many already characterized for lipid productivity.**



Crypthecodinium



Mortierella



Schizochytrium

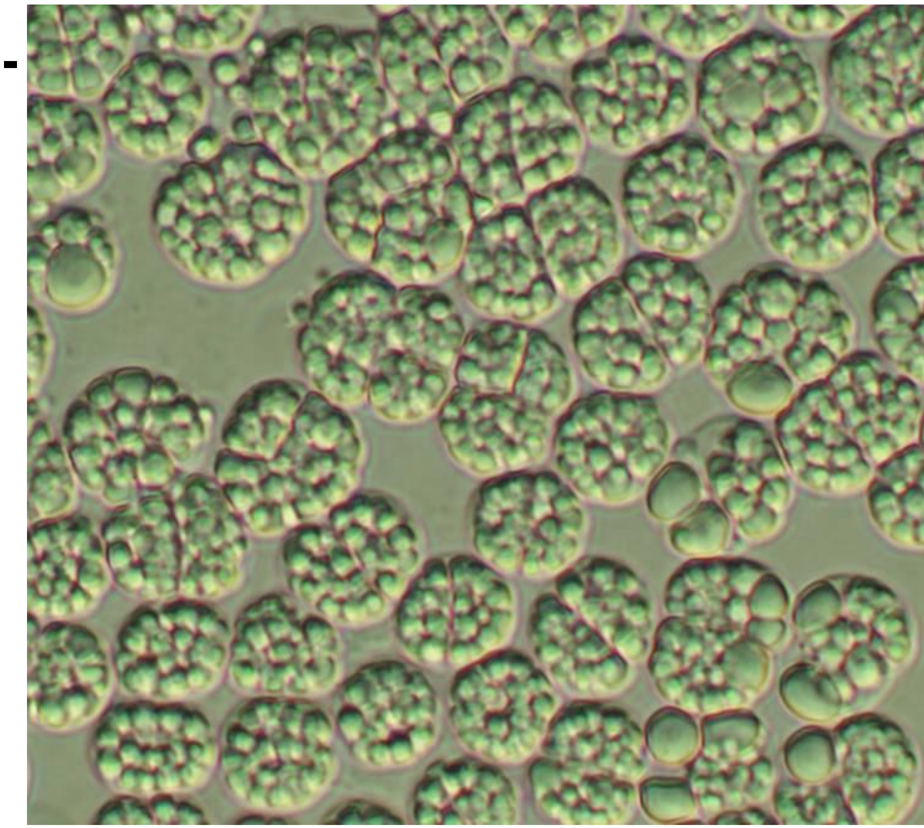
MARTEK life enriched.™

Schizochytrium

- Marine Thraustochytrid (eukaryote - microalga)
- Used for commercial production
- DHA enriched oil and biomass
- Heterotrophic; no plastids
- >100 g/L biomass
- 50-70% of cell weight is TAG

    40% 22:6 ω3 (DHA)

- >30 g/L DHA



MARTEK
life enriched.™

Major Process Changes on DHA Production

Major Scale-up Process Changes	Cell Conc. (g/L)	DHA Titer (g/L)	Lipid Conc. (% dry wt)	DHA in Oil (% FAME)	DHA Prod (g/L/hr)
Initial Lab Scale	21	2	39	26	0.05
Scale-up to 10,000 L	40	4	35-40	25-28	0.07
Low Chloride	65-70	8	35-40	32	0.10
Fed Batch + Low DO	170-210	40-50	50-73	35-45	0.45-0.55

Barclay 2005

MARTEK life enriched.™