

What the #!*** am I doing here?

[How does opihi culture relate to biofuels?]

Biofuel From Algae?

(CTSA Meeting)

- Demand for high quality, fresh algae in bulk quantities
- Effluent treatment of sewage, nutrient removal
- CO₂ removal
- Treatment of industrial wastes – changes quality
- [So far this has little to do with Opihi!]

Limpets in Hawaii

Opihi – marine



Hihiwai – freshwater



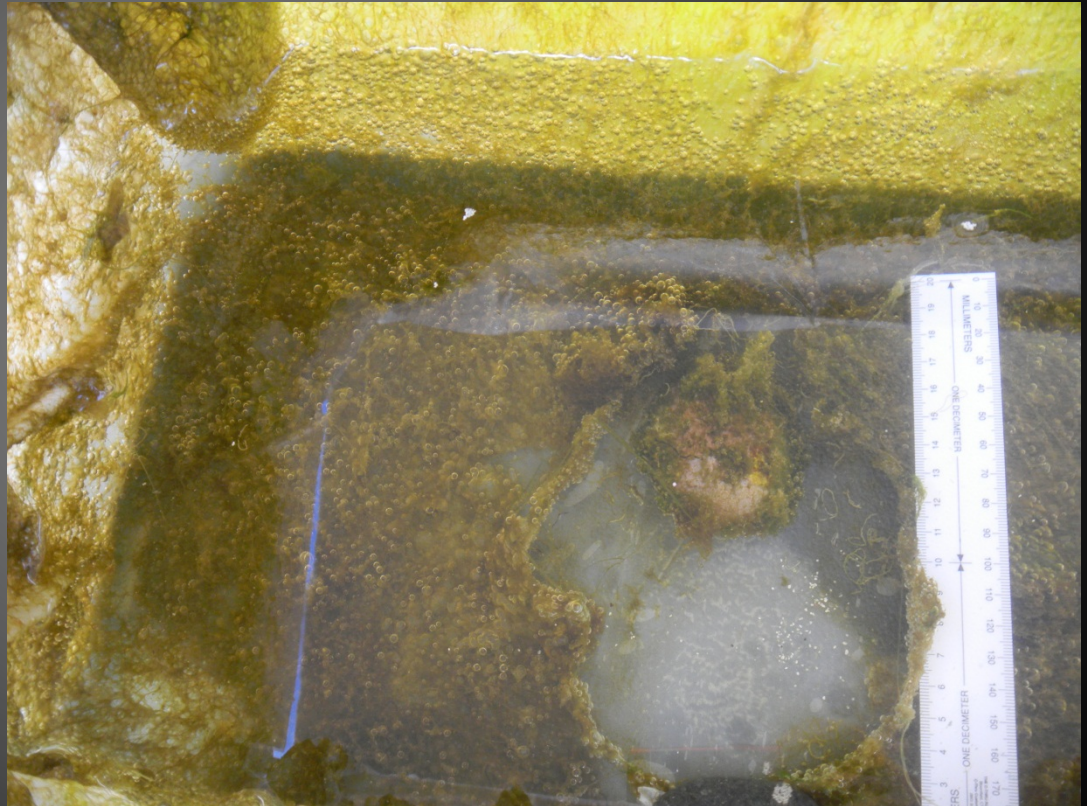


Cellana talcosa



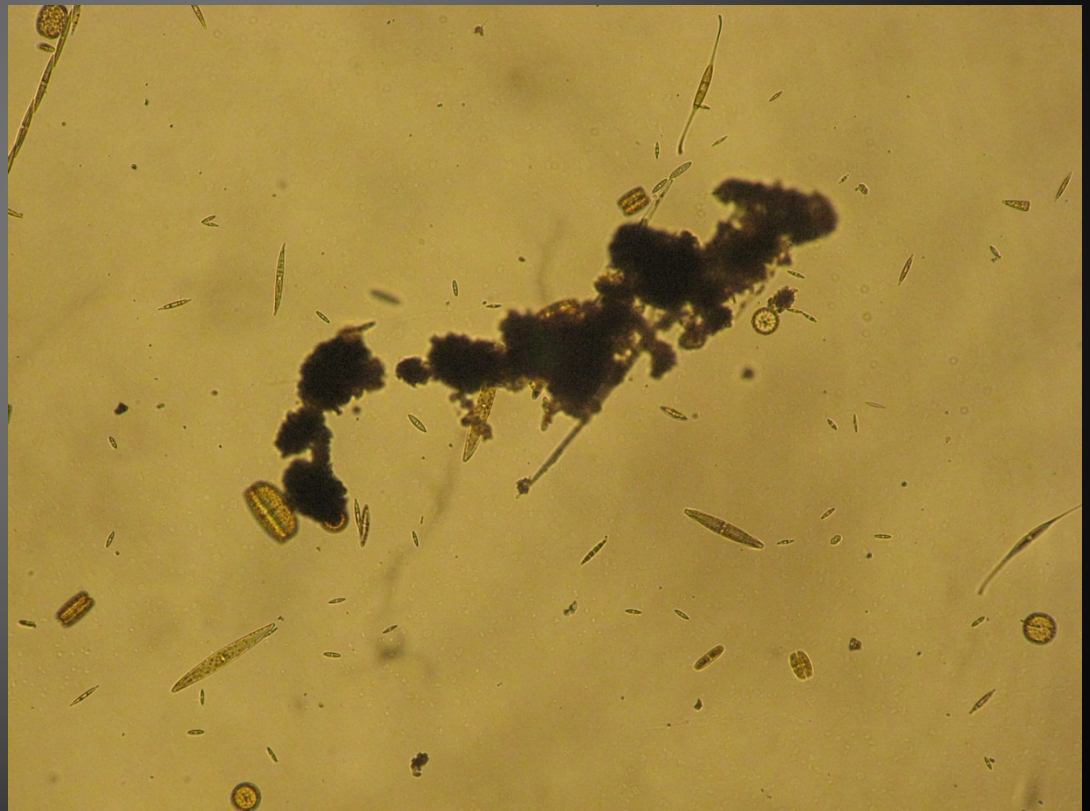
- mixture of organisms
- typical colonizers
- primarily diatoms

Opihi Tank



Microscopic View (Opihi Tank)

- Low power
- Mostly diatoms



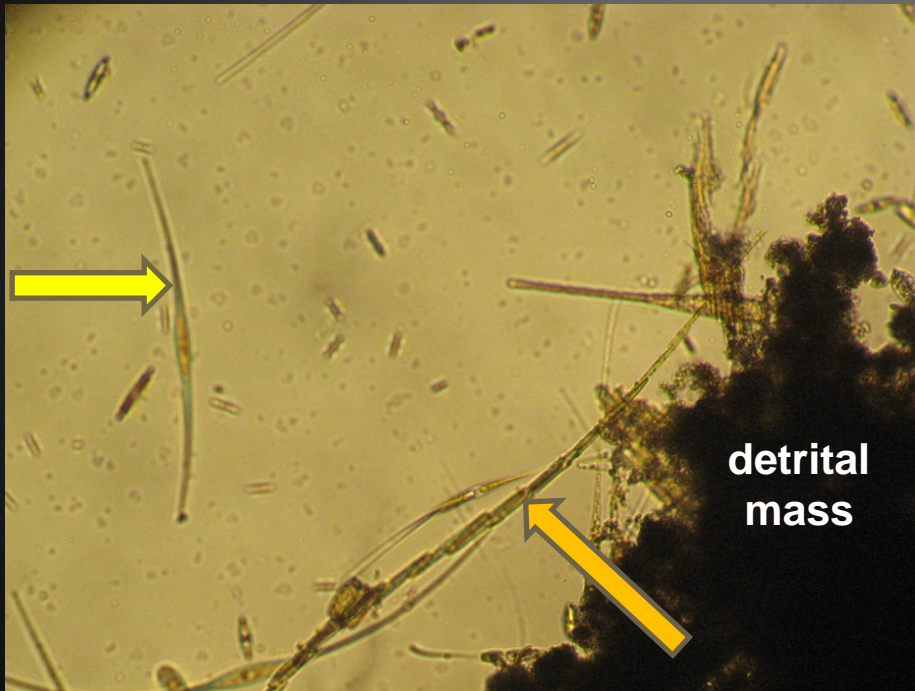
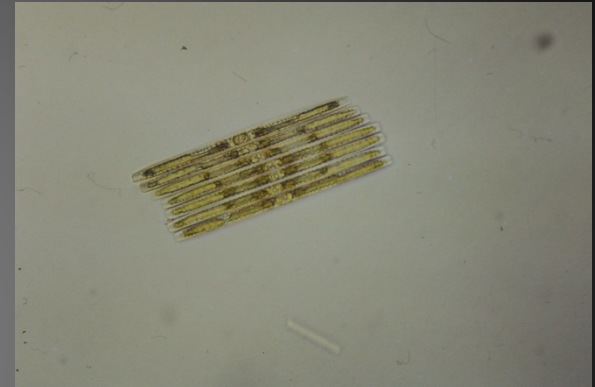
Diatoms Observed in Gut of Opihi

Frequency Observed

+++	++	+
<i>Bacillaria paxillifer</i>	<i>Amphora</i> sp.	<i>Asterionella</i> sp.
<i>Fragilaria</i> sp.	<i>Climacosphenia</i> sp.	<i>Cymbella</i> sp.
<i>Melosira</i> sp.	<i>Grammatophora</i> sp.	<i>Diplonesis</i> spp.
<i>Navicula</i> sp.	<i>Licmophora</i> sp.	<i>Mastogloia</i> sp.
<i>Rhabdonema</i> sp.	<i>Nitzchia</i> sp.	<i>Opephora</i> sp.
	<i>Pleurosigma</i> sp.	<i>Surirella</i> sp.
	<i>Tabellaria</i> sp.	<i>Thalassionella</i> sp.
	<i>Trigonium</i> sp.	

Diatoms Observed in Opihi

Bacillaria paxillifer



detrital
mass

Nitzschia closterium



Diatoms Observed in Opihi

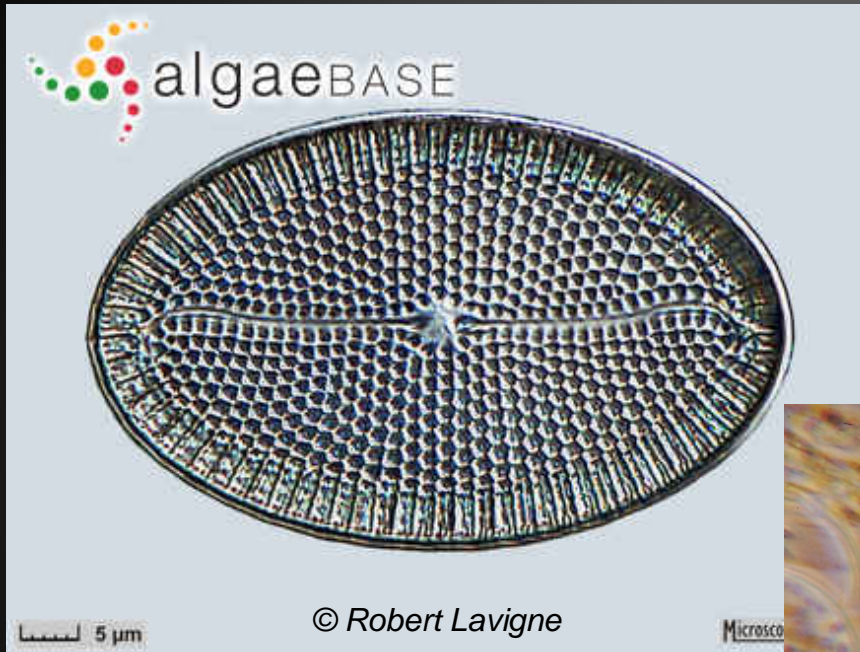


Fragilaria



Rhabdonema

Diatoms Observed in Opihi



Mastogloia splendida



Asterionella japonica

Diatoms Observed in Opihi



Licmophora sp.



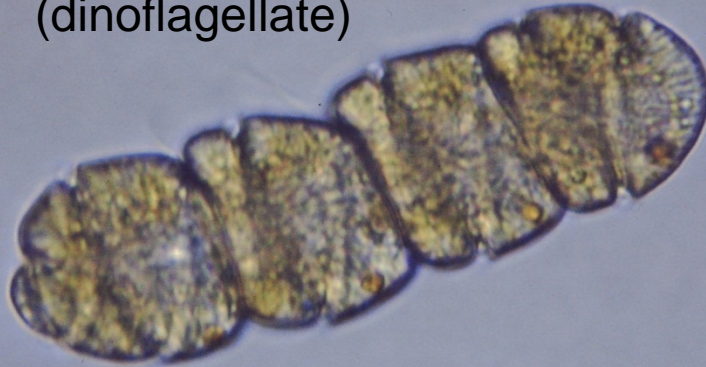
Tabellaria flocculosa

Algal Taxa

Phylum	Chlorophyll	Storage	Importance
Pyrrophyta dinoflagellates	a, c	oils, starch	"Red Tide"
Bacillariophyta diatoms	a, c	oil, chrysolaminarin	1° productivity, O ₂ production
Chrysophyta golden algae	a, c	oil, chrysolaminarin	
Phaeophyta brown algae	a, c	oil, chrysolaminarin	alginate
Rhodophyta red algae	a	floridean starch	agar, carrageenan
Chlorophyta green algae	a, b	starch	zooplankton, herbivores

Algal Taxa

Cochlodinium catenatum
(dinoflagellate)

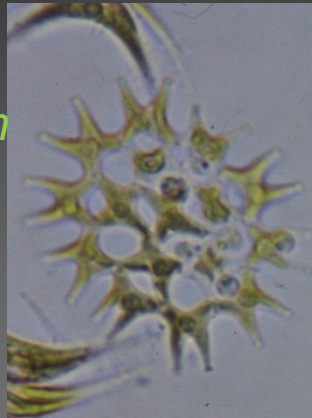


Prymnesium parvum
(golden algae)



Algal Taxa

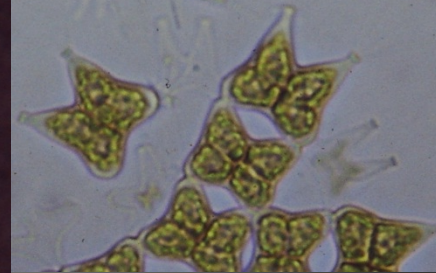
Pediastrum
(green)



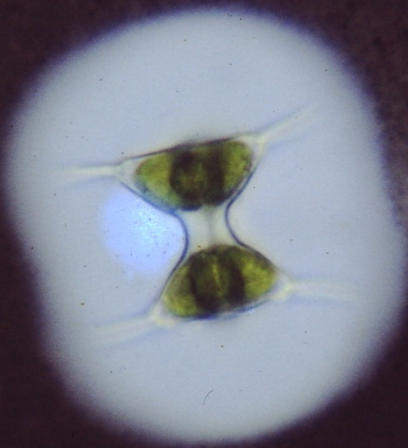
Thalassiosira
(diatom)



Scenedesmus
(green)



Staurastrum
(green)



Algal Concentrates

- Live algae
- Frozen or preserved algae

✓ *Nannochloropsis*

✓ *Pavlova*

✓ *Isochrysis*

✓ *Tetraselmis*

✓ *Thalassiosira*

- Reed Mariculture
- Aquatic Ecosystem

Instant Algae®

Marine Microalgae Concentrates

www.Instant-Algae.com / www.Microalgae.com

*** March 1st, 2005 - New Formula ***



Reed Mariculture

<http://reed-mariculture.com/>

Species	Finfish Hatchery	Shellfish Hatchery	Shrimp Hatchery
Nanno 3600 (<i>Nannochloropsis</i>)	X	X	
<i>Tetraselmis</i> 3600		X	X
<i>Isochrysis</i> 1800	X	X	X
<i>Pavlova</i> 1800	X	X	
TW 1200 (<i>Thalassiosira weissflogii</i>)		X	X

Nannochloropsis

Product Description – 1 Liter Bags

(http://reed-mariculture.com/product_instant_algae.html)



Cell Count	Live Algae Equivalent	Type	Size in microns	Dry Weight	Shelf Life
68 X 10⁹ (cells/ml)	3600 liters @ 19 million cells/ml	Non-flagellated Yellow-Green Eustigmatophyceae	1.5-2	>18%	12-14 weeks 2 years frozen

		Price		
1-9	10-39	40-79	80-199	200+
\$70.00	\$58.80	\$53.90	\$49.70	\$45.50

Tetraselmis

Product Description – 1 Liter Bag

(http://reed-mariculture.com/product_instant_algae.html)



Cell Count	Live Algae Equivalent	Type	Size in microns	Dry Weight	Shelf Life
800 X 10 ⁶ (cells/ml)	3600 liters @ 0.2 million cells/ml	Chlorophyte green	12	18%	12-14 weeks 2 weeks frozen

		Price		
1-9	10-39	40-79	80-199	200+
\$75.00	\$63.00	\$57.75	\$53.25	\$48.75

Isochrysis, Pavlova

Product Description – 1 Quart Bag

(http://reed-mariculture.com/product_instant_algae.html)

Cell Count	Live Algae Equivalent	Type	Size in microns	Dry Weight	Shelf Life
4.1 X 10⁹ (cells/ml)	1800 liters @ 2.28 million cells/ml	Chrysophyte golden	5	9%	12-14 weeks refrigerate

		Price		
1-9	10-39	40-79	80-199	200+
\$44.00	\$36.96	\$33.88	\$31.24	\$28.60

Thalassiosira weissflogii

Product Description – 1 Quart

(http://reed-mariculture.com/product_instant_algae.html)

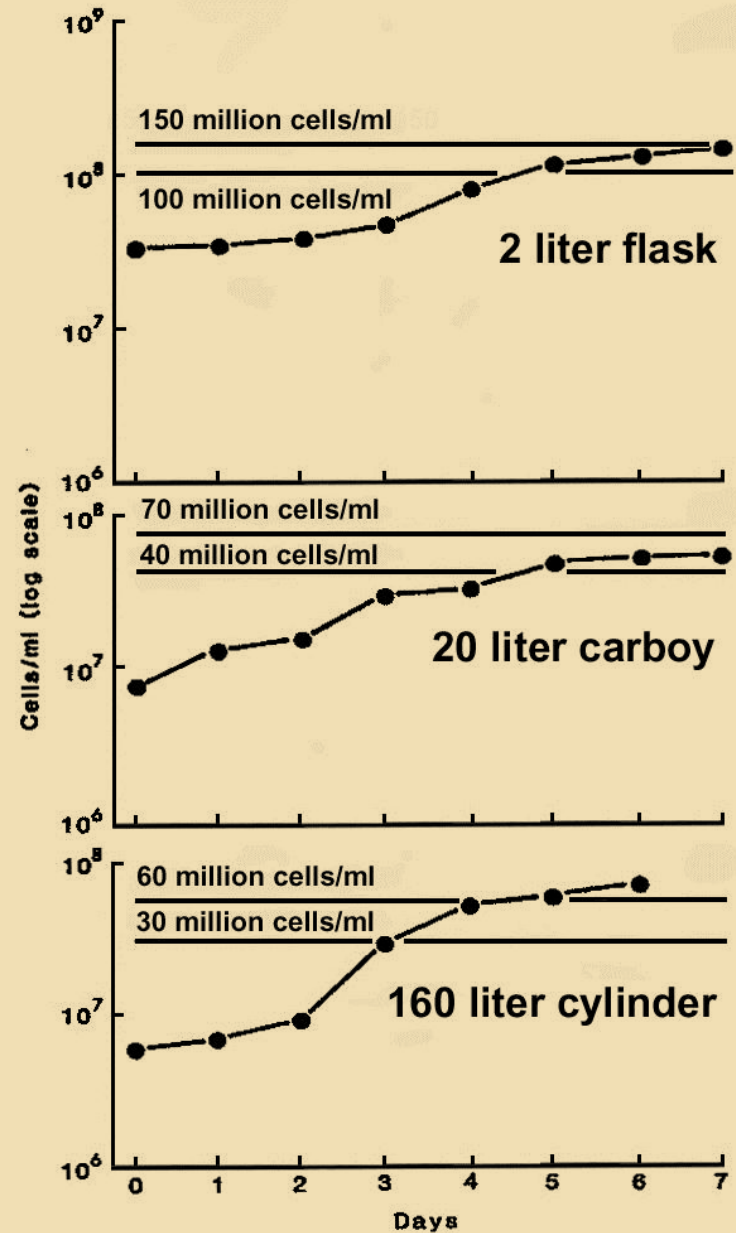


Cell Count	Live Algae Equivalent	Type	Size in microns	Dry Weight	Shelf Life
320 X 10 ⁶ (cells/ml)	1200 liters @ 0.27 million cells/ml	diatom	5-20	6%	12-14 weeks refrigerate

		Price		
1-9	10-39	40-79	80-199	200+
\$29.00	\$24.36	\$22.33	\$20.59	\$18.85

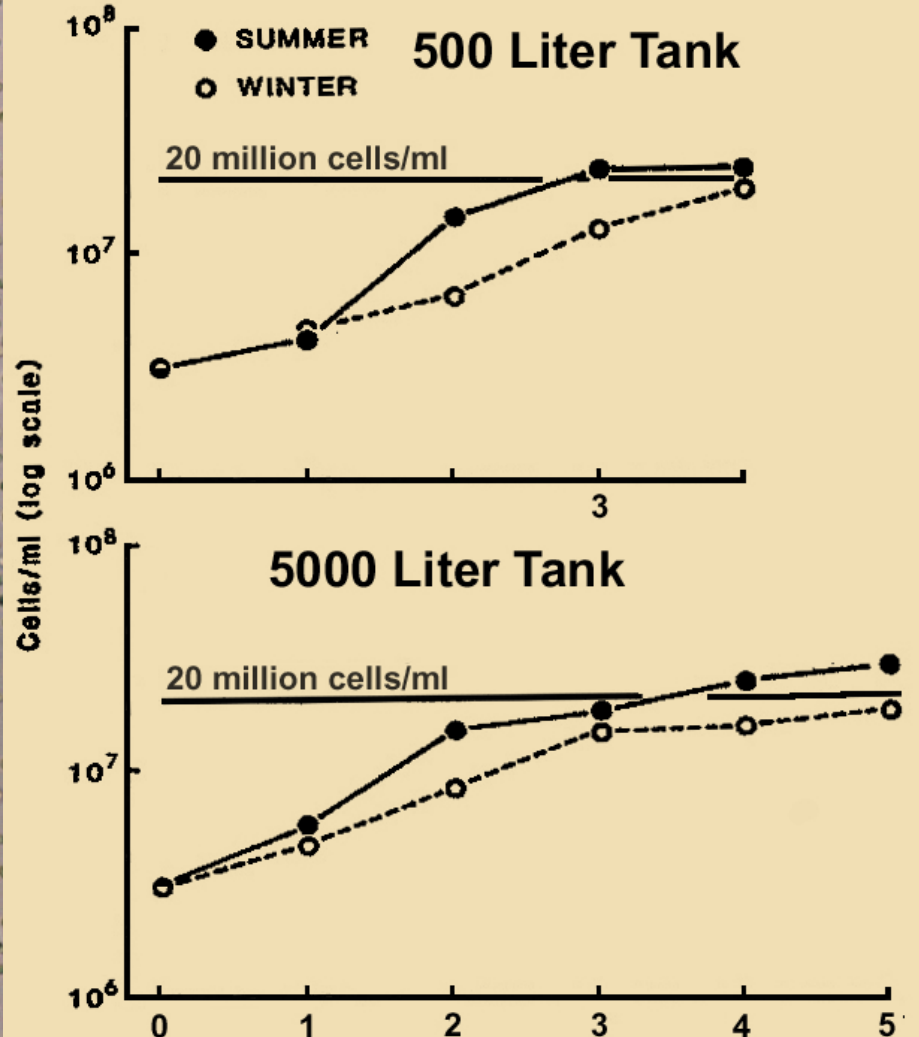
Growth Pattern: Indoor Cultures

- *Nannochloropsis oculata*
- Understand growth patterns
- Manage for consistency and reliability
- Harvest within target densities

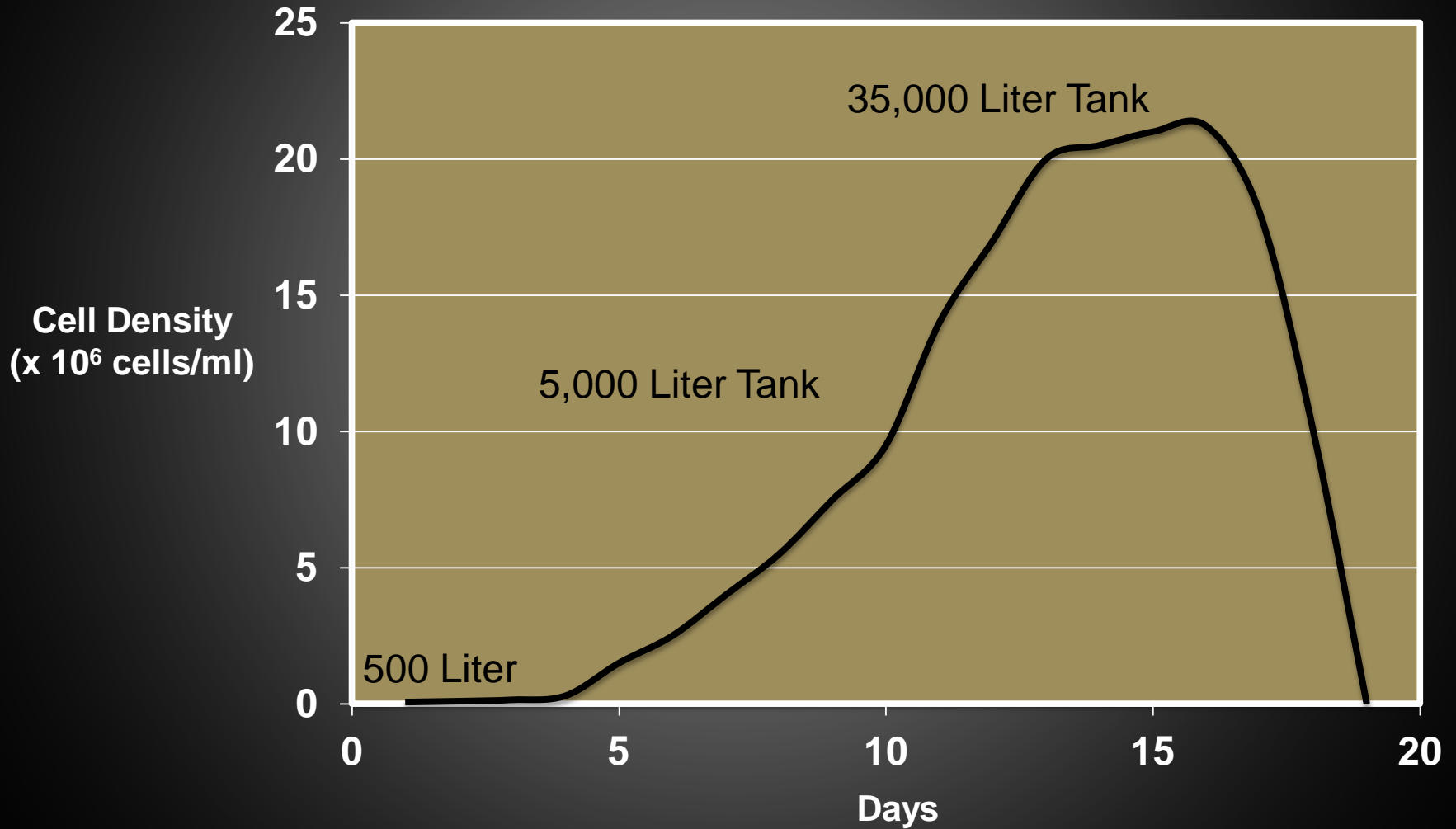


Growth Pattern: Outdoor Cultures

- *Nannochloropsis oculata*
- Target density = 20 million cells/ml
- Growth slows in winter
- Growth is slower in larger (5,000 liter and 35,000 liter) tanks



Growth of *Nannochloropsis oculata*



Biofuel Production

Chlamydomonas reinhardtii

- Biohydrogen reactor
- Produces hydrogen when deprived of sulfur
- Current price = \$13.53/kg
- Target price = \$2.60/kg
- One kg is the energy equivalent of a gallon of gasoline.

Biofuel Production

Botryococcus braunii Kützing

http://en.wikipedia.org/wiki/Botryococcus_braunii

- lipid biofilm matrix
- dissolved inorganic phosphorus
- high amounts of hydrocarbons (oils as triterpenes) ^a
- 30-40 percent dry weight ^a
- thick cell wall - extraction difficult
- high alkalinity
- 86% can be long chain hydrocarbons ^b
- oils are inedible
- hydrocracking produces gasoline, kerosene, and diesel ^b

^a (P. Metzger C. Largeau (2005). "Botryococcus braunii: a rich source for hydrocarbons and related ether lipids". Applied Microbiology and Biotechnology 6 (25): 486–96.)

^b (L.W. Hillen et al. (1982). "Hydrocracking of the Oils of Botryococcus braunii to Transport Fuels". Biotechnology and Bioengineering 24 (1): 193–205.)

Botryococcus braunii Kützing

http://en.wikipedia.org/wiki/Botryococcus_braunii

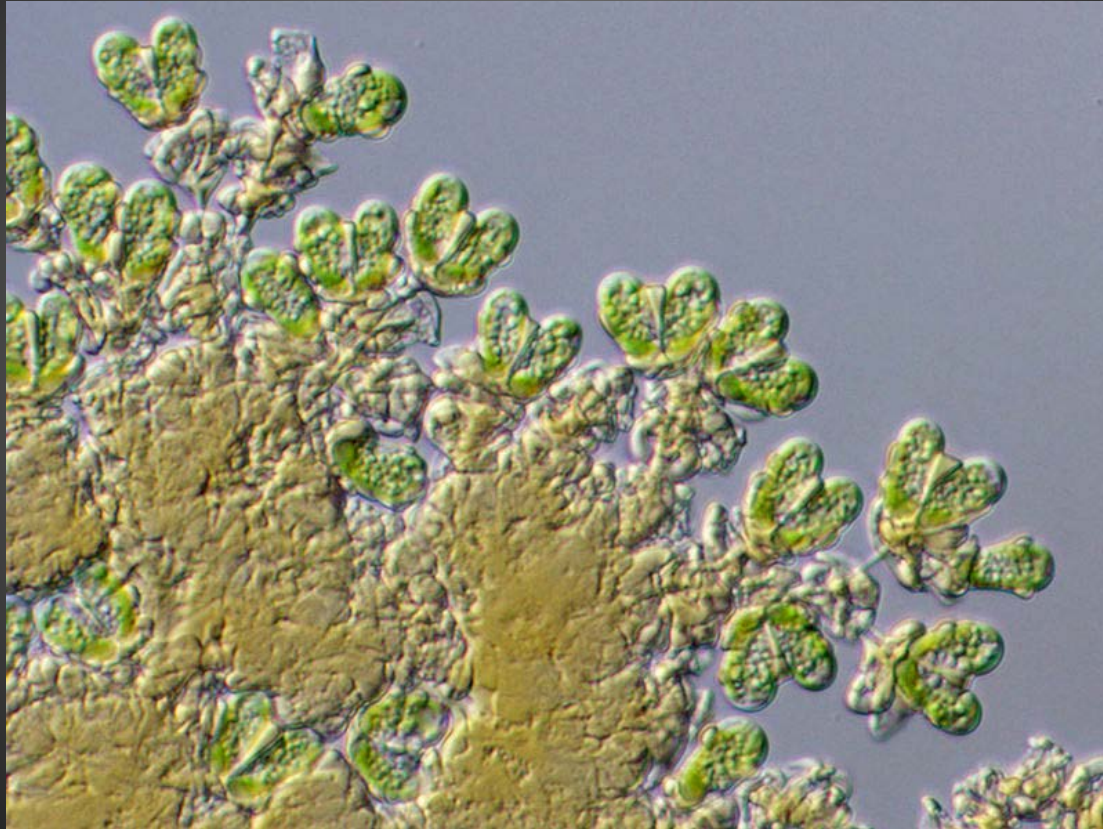


Photo courtesy of: [ja>User:NEON / User:NEON_ja](#)

Oil Yield from Crops

(Source: http://oakhavenpc.org/cultivating_algae.htm)

Crop	Oil (gallons/acre/year)
Corn	18
Soybeans	48
Safflower	83
Sunflower	10
Rapeseed	127
Palm	635
Micro Algae	5,000-15,000

Oil Content

(<http://www.oilgae.com/algae/oil/yeild/yeild.html>)

Green Algae	Oil (% DW)	Diatoms	Oil (% DW)	Cryptic Species	Oil (% DW)
<i>Ankistrodesmus</i>	28-40	<i>Cyclotella</i>	42	<i>Crptheodinium cohnii</i>	20
<i>Botryococcus braunii</i>	29-75	<i>Hantzschia</i>	66	<i>Schizochytrium</i>	50-77
<i>Chlorella</i> sp.	29	<i>Nitzschia</i>	28-50	<i>Nannochloropsis</i>	46(31-68)
<i>Chlorella protothecoides</i> (auto-/heterothrophic)	15-55	<i>Phaeodactylum tricornutum</i>	31		
<i>Dunaliella tertiolecta</i>	36-42	<i>Thalassiosira pseudonana</i>	(21-31)		
<i>Nannochloris</i>	31(6-63)				
<i>Scenedesmus</i>	45				
<i>Stichococcus</i>	33(9-59)				
<i>Tetraselmis suecica</i>	15-32				
<i>Neochloris oleoabundans</i>	35-54				

Summary:

Biofuels from ~~Opihi~~ Algae

- 10 to 15 years of technology development
- Current business exists in high quality, fresh algae
- Research needed on strains, biomass production, environmental manipulation, harvest, processing
- Cost must be competitive with petroleum