World Biofuels Markets
with the Algal Biomass Organization
March 16, 2009, Brussels, Belgium

Algae Fuels Forum Keynote session: What's the Potential Market for Algae for Advanced Biofuels?

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General Topics for the Keynote Session

- *Identification and acceleration of sustainable algae biofuels*
- *When will commercial quantities of algae oil be available?*
- *Timeline and viability of algae for advanced biofuels*

SOME CONCLUSIONS FROM THIS PRESENTATION:

- Sustainable algae biofuels only from open pond systems.
- Commercial quantities of algae oil require long-term R&D.
- In near-term algae oil maybe byproduct of wastewater ponds
- Algae do not sequester CO_2, same effect as other biofuels.
- Productivities maybe high, but generally highly exaggerated.
- "Advanced biofuels" likely need GMOs; release major issue.
- Both economics and global potential still highly uncertain.

Why do we need Algae Biofuels?

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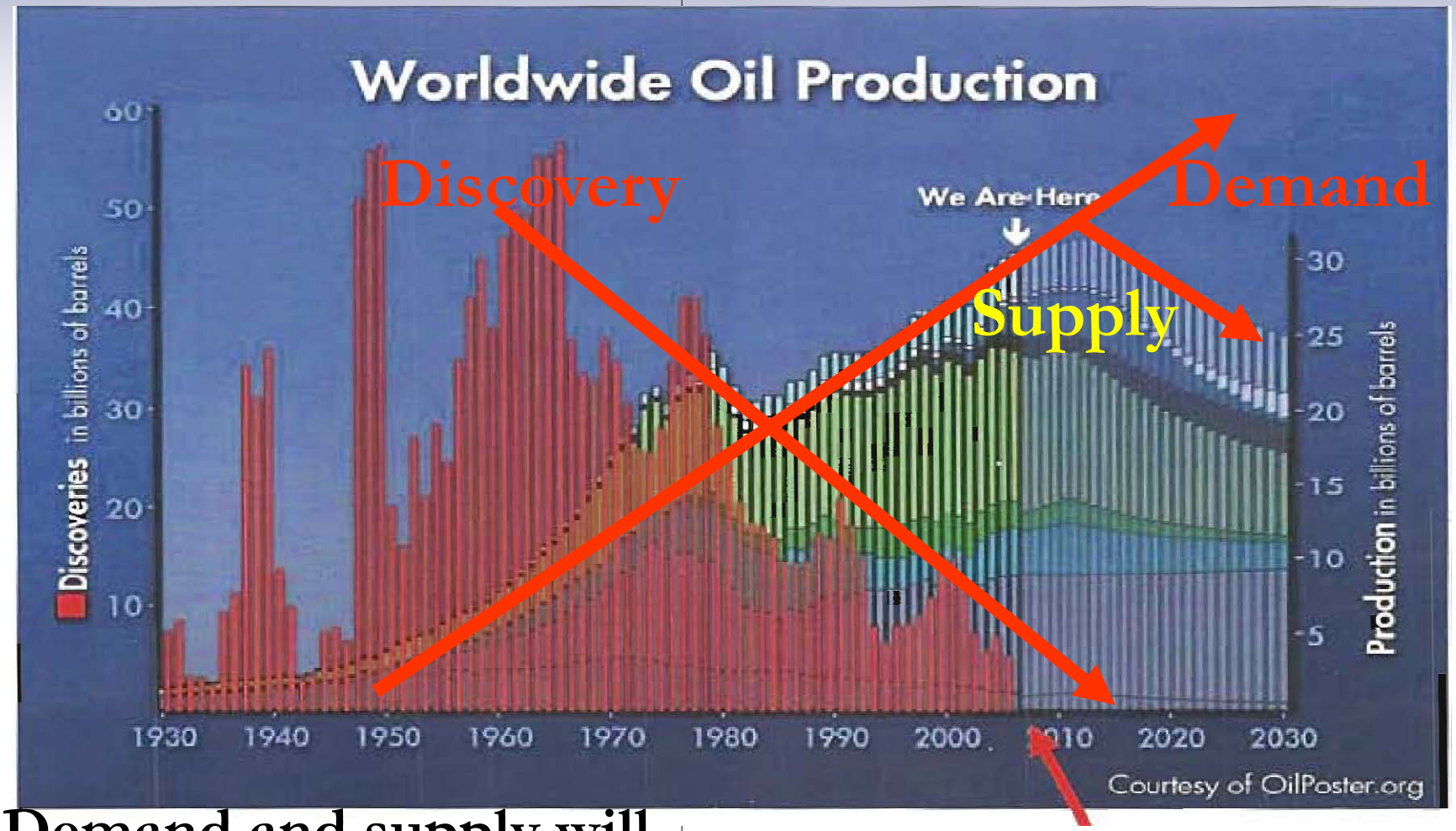
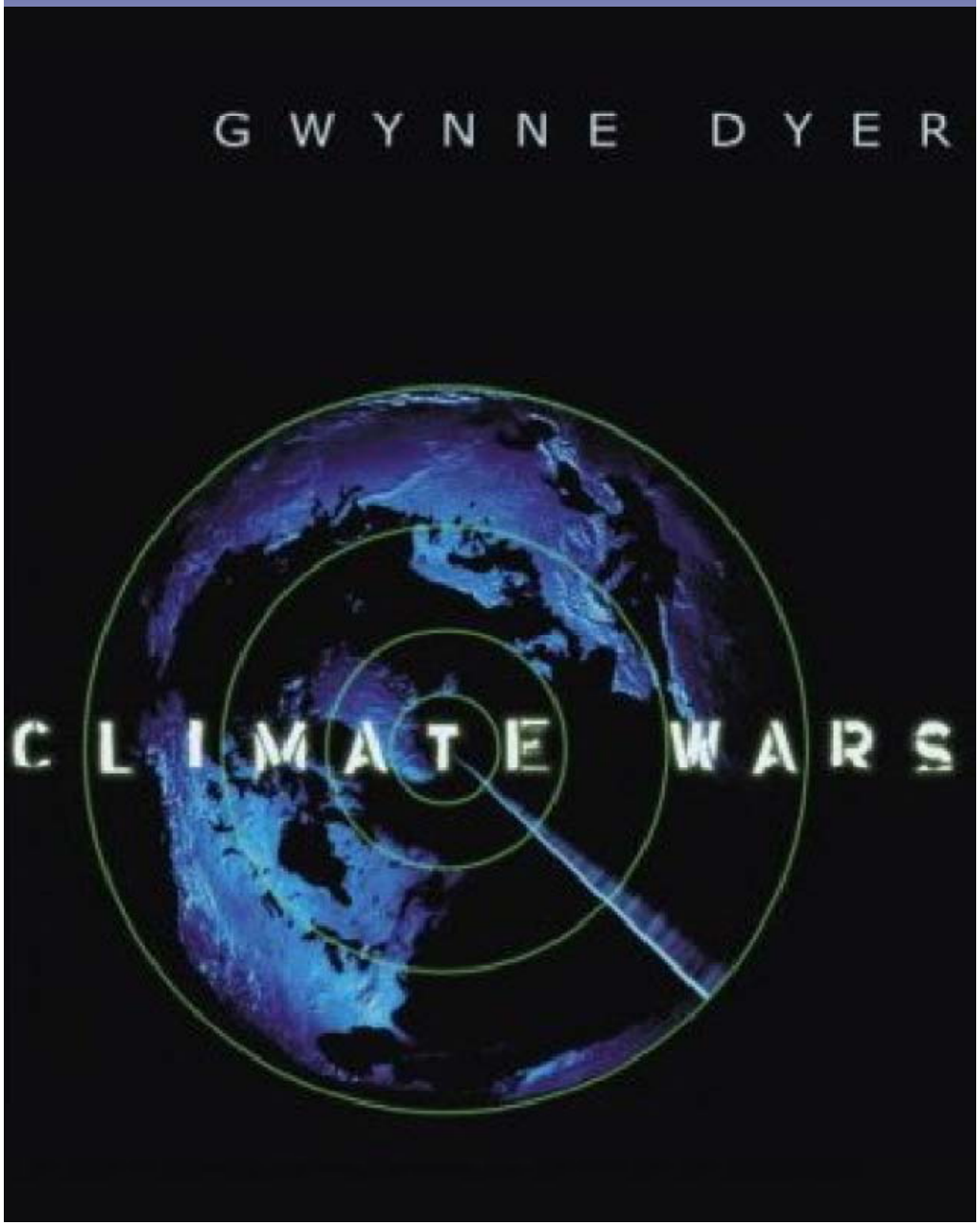
(billions barrels petroleum/year)



Demand and supply will soon diverge drastically (low prices temporary)

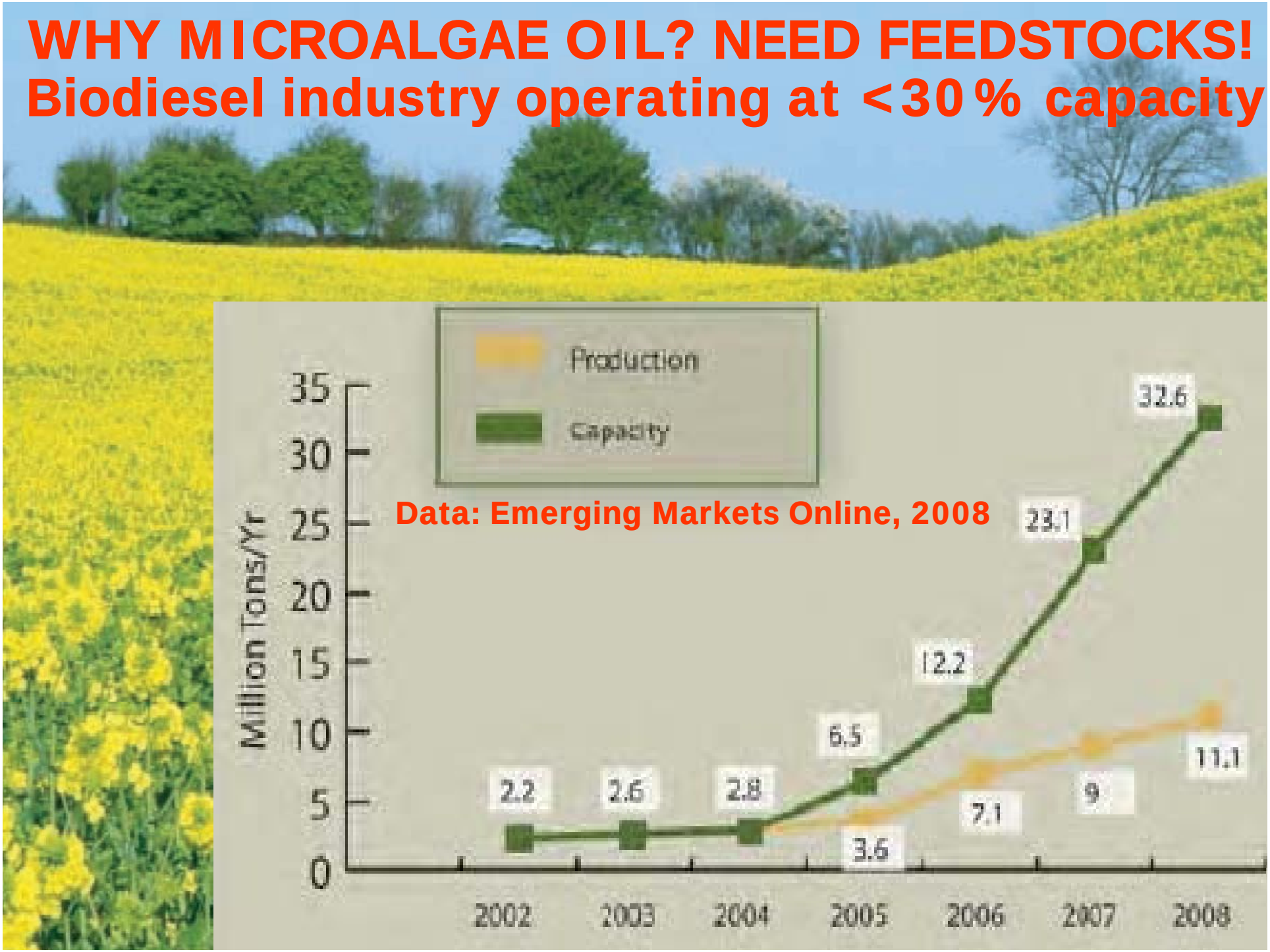
Why algae biofuels? Global Warming!



(from the book jacket):

"...the geopolitical conflicts that may unfold over the next few decades — even if we do get serious about global warming — is almost too fearsome to absorb... [among] the scientists themselves, there is a palpable sense of panic, something confirmed by Dyer in his interviews conducted around the world."

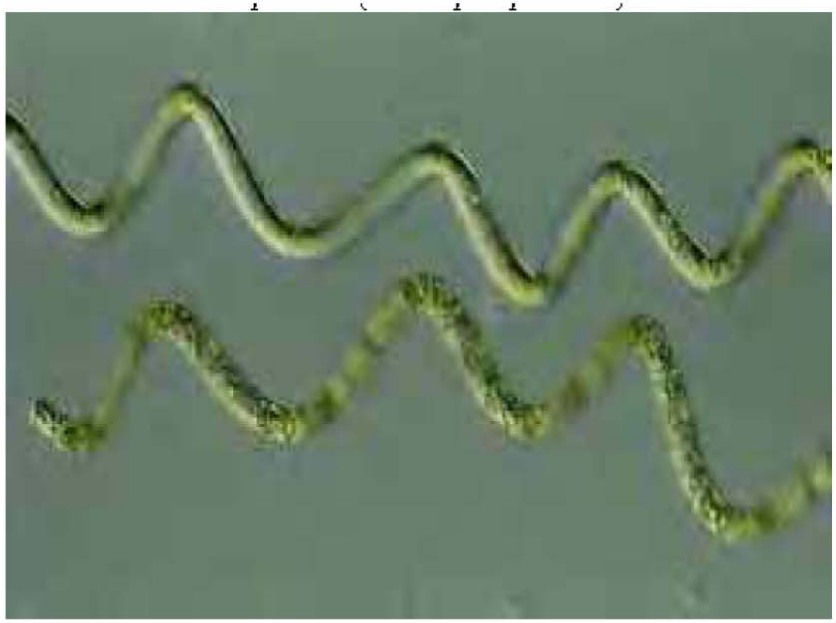
WHY MICROALGAE OIL? NEED FEEDSTOCKS!
Biodiesel industry operating at <30% capacity



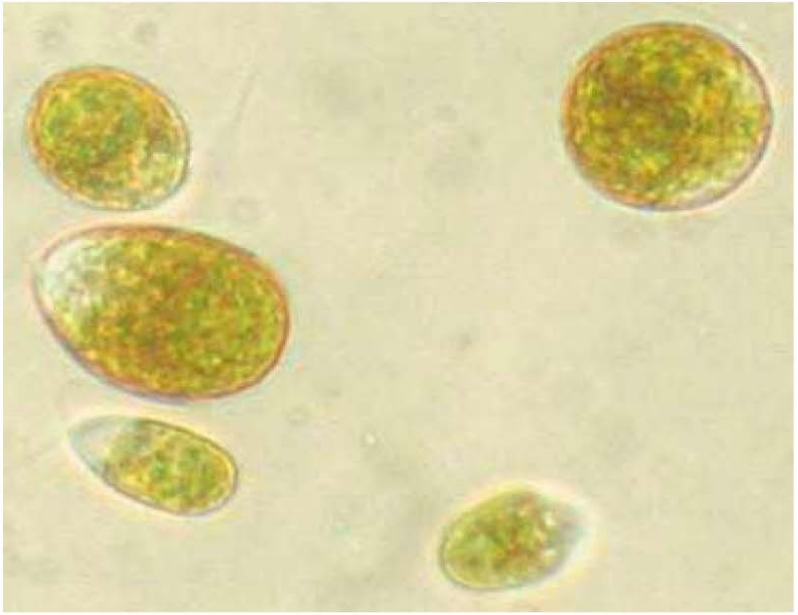
Data: Emerging Markets Online, 2008

Microalgae produced commercially now

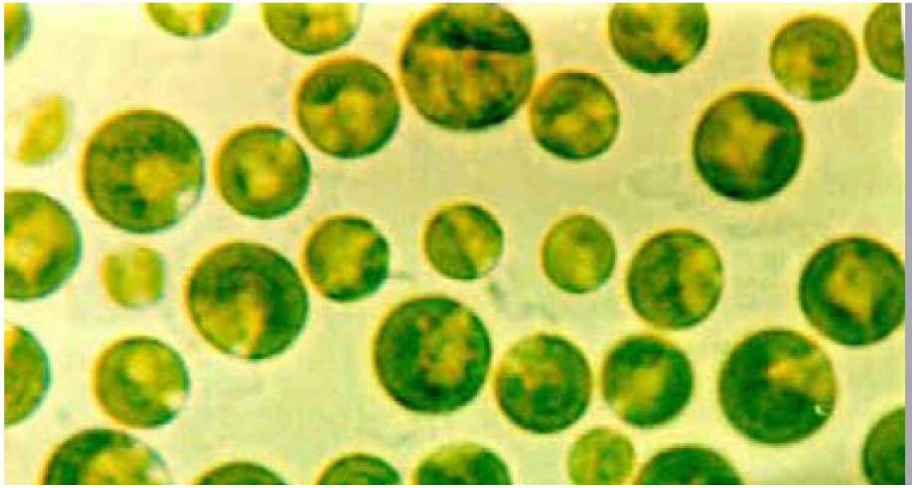
A. ***Spirulina* (*Arthrospira platensis*)**



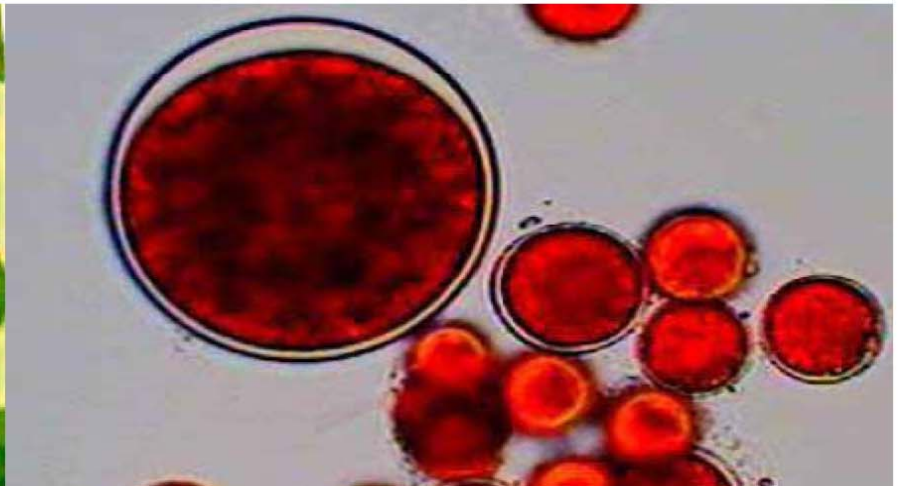
B. ***Dunaliella salina***



C. ***Chlorella vulgaris***



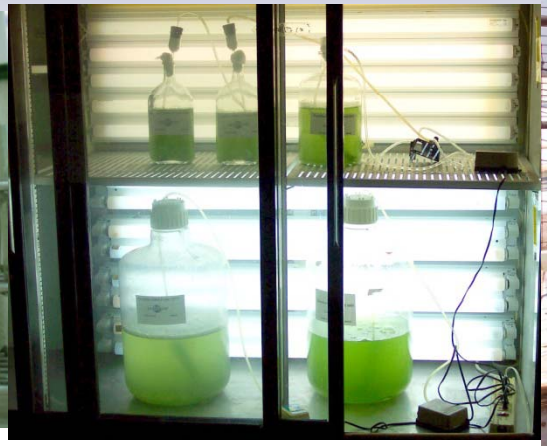
D. ***Haematococcus pluvialis***



Commercial microalgae production - paddle wh
mixed raceway ponds (~0.5 ha) (Earthrise, Cali

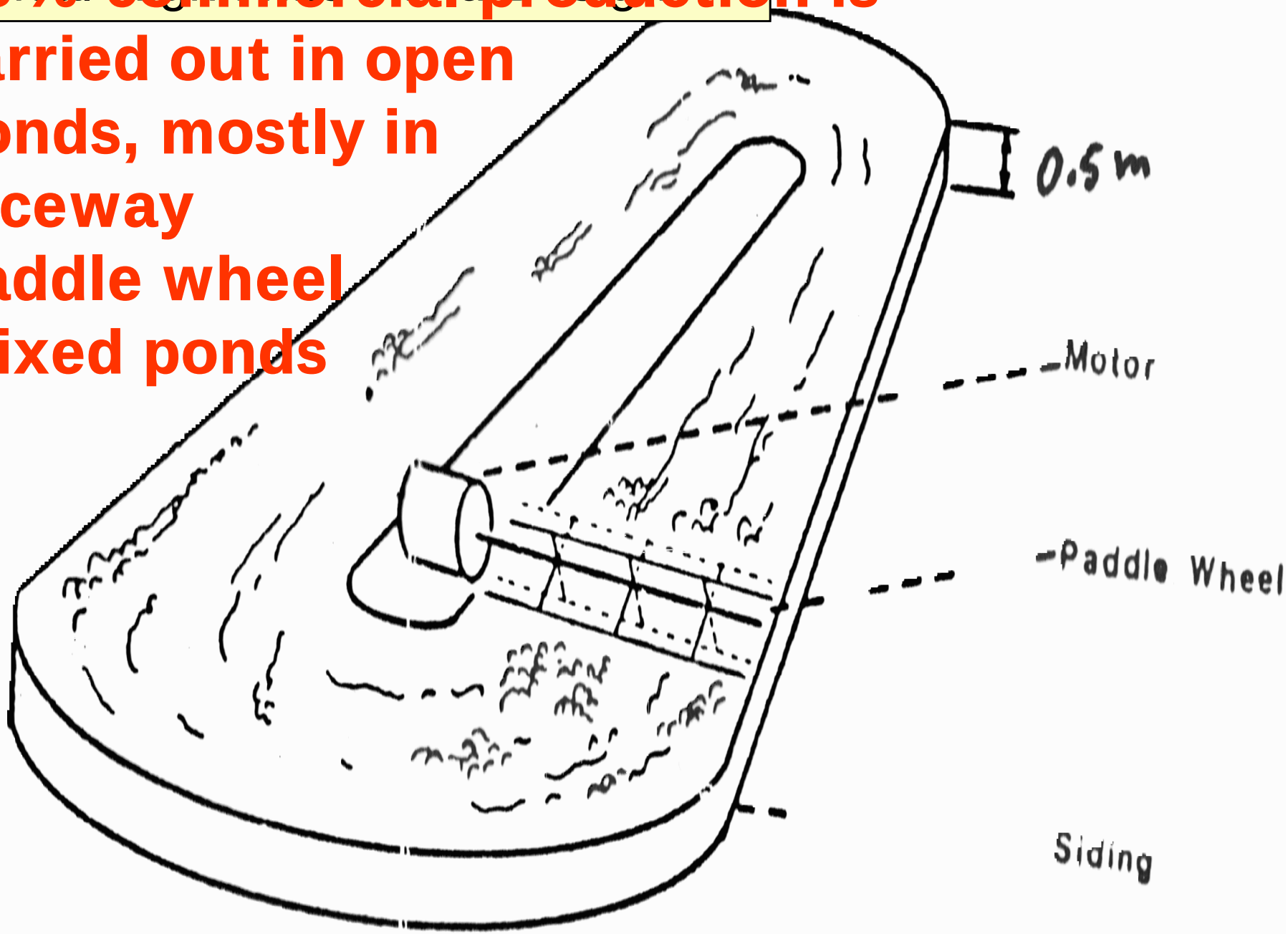
Microalgae Products: >95% "nutraceuticals", total world production only ~10,000 tons

Spirulina: from inoculum to outdoor cultures



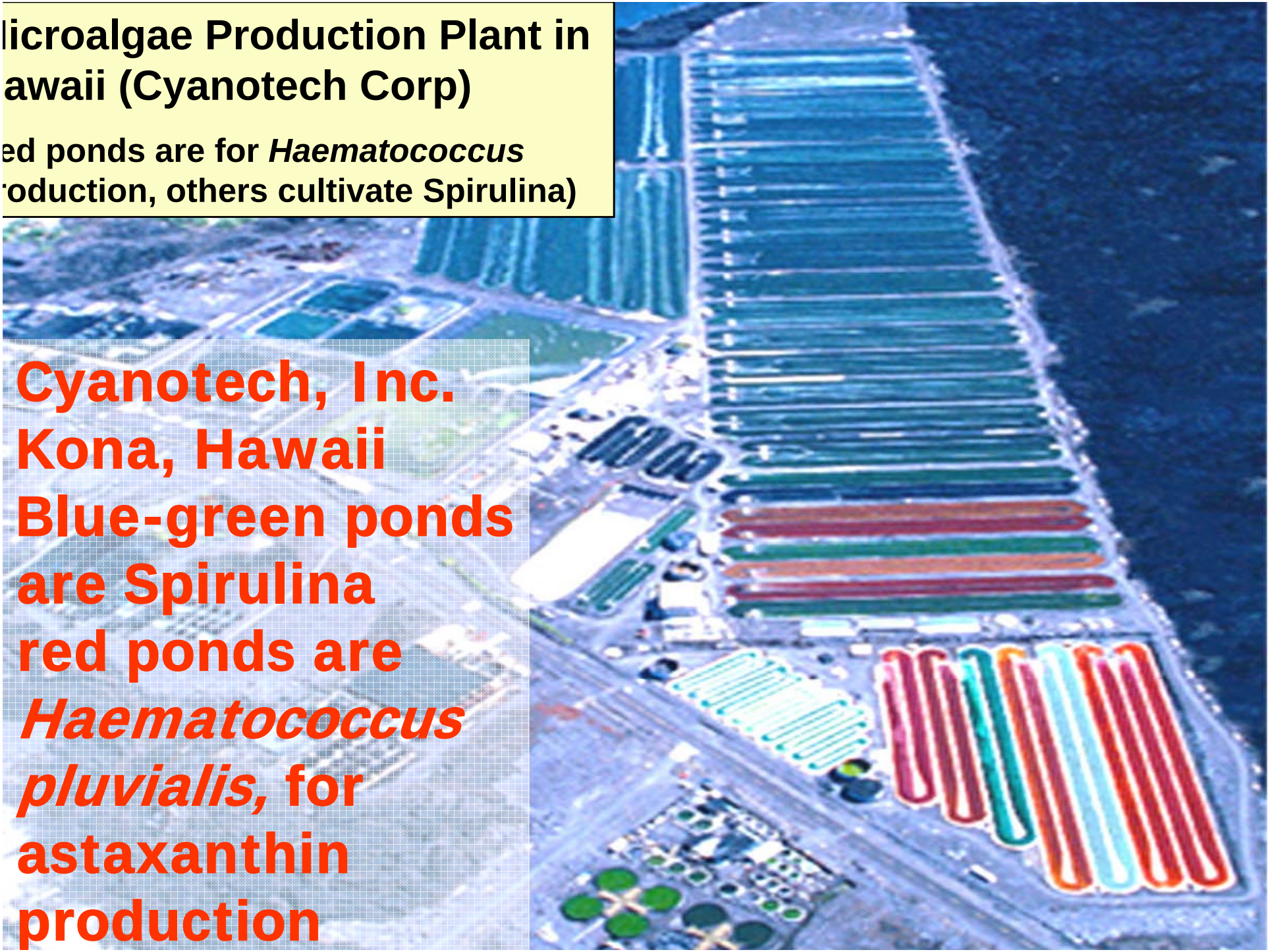
Typical High Rate Pond Design

98% commercial production is carried out in open ponds, mostly in raceway paddle wheel mixed ponds



licroalgae Production Plant in awaii (Cyanotech Corp)

ed ponds are for *Haematococcus* roduction, others cultivate Spirulina)

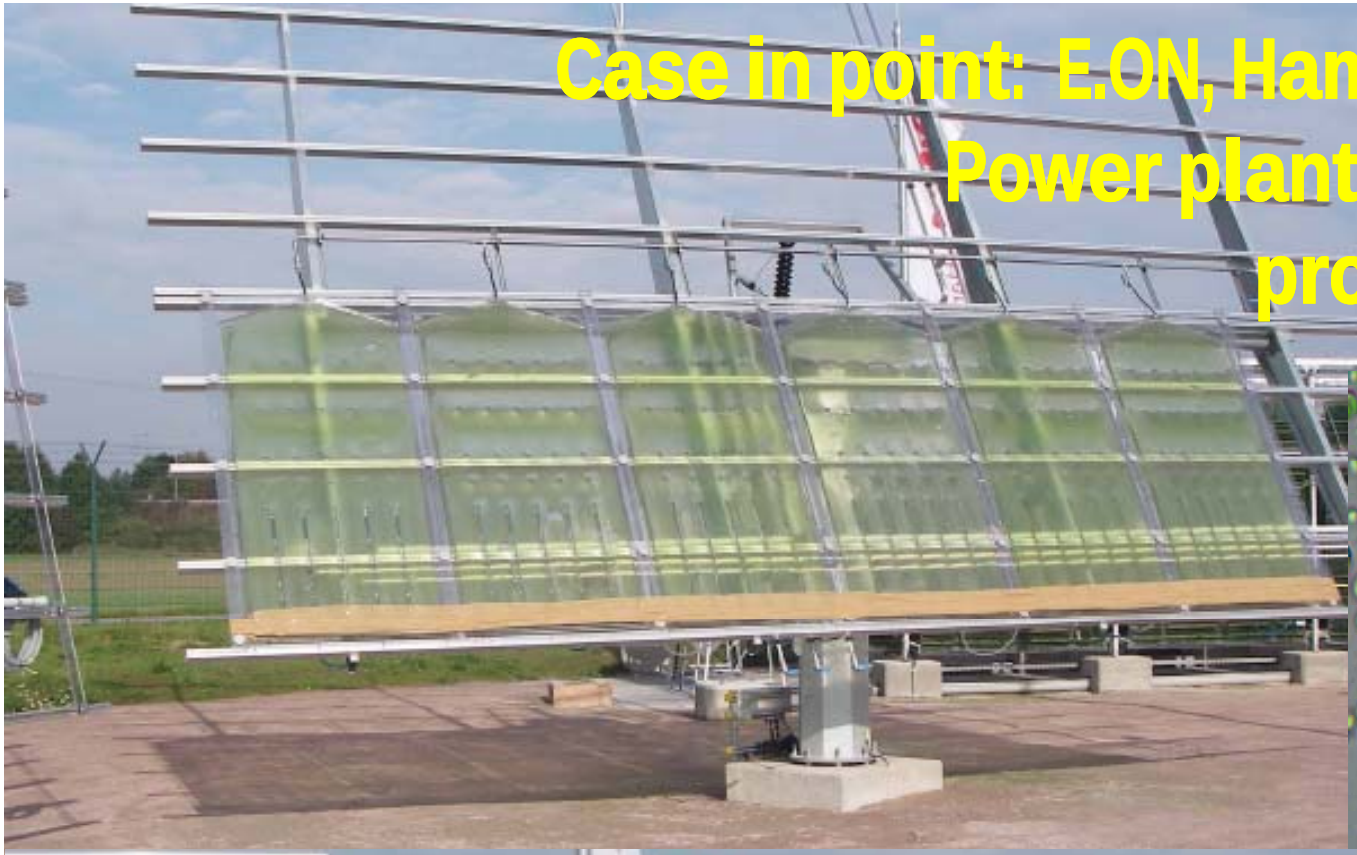


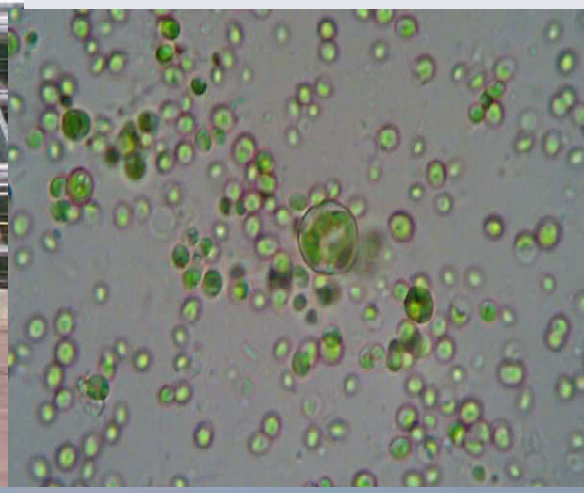
Only 1-2% of commercial production in closed photobioreactors. Such as *H. pluvialis* in Israel]

Tubular photobioreactors of Algatech Ltd., Israel. Despite selling prices of >$100,000/t biomass, plant was not successful

Such photobioreactors cost >10x that of ponds
But it seems that 98% R&D, even for biofuels, now focusing on PBRs!

Case in point: E.ON, Hamburg, Germany, Power plant CO2 abatement project (Oct. 2008)





THE ALLURE OF MICROALGAE OIL PRODUCTION

Oil yields	liters/ha-yr	barrels/ha-yr
Soybeans	400	2.5
Sunflower	800	5
Canola	1,600	10
Jathropha	2,000	12
Palm Oil	6,000	36
Microalgae	10,000-1,000,000*	360 -1500*

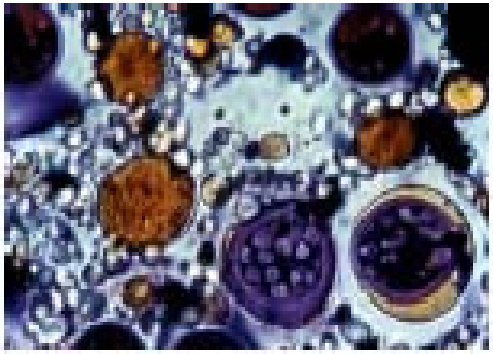
*High yield proclaimed by Valcent Products, USA, but is almost ~10x theoretical efficiency Low yield what is achievable today. Long-term R&D goal ~50,000 l/ha-yr (will require GMOs)

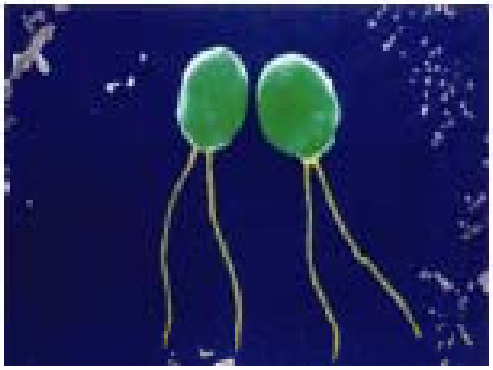

Valcent claims 100,000 gallons/acre-yr
(about 1,000,000 liters/ha-yr) algal oil.
Violates 1st law of thermodynamics!
CNN

National Renewable Energy Laboratory

NREL/TP-580-24190

A Look Back at the U.S. Department of Energy's Aquatic Species Program: Biodiesel from Algae





Close-Out Report

Aquatic Species Program Report 1998

Executive Summary
J. Sheehan (NREL)

Part 1. Algal Cultures and Genetics (P. Roessler and T. Dunnahay, consultants)

Part 2. Algal Mass Cultures and Production Technology (J. Benemann, Principal Investigator, and J. Weissman, consultant).

Report only summarizes extensive work by the ASP

Production of Microalgae for Fuels

Microalgae biodiesel production, Aquatic Species Program, DOE NREL 1987 Note Raceway and settling-harvesting ponds

FINAL REPORT

to the Electric Power Research Institute
Prepared under a grant from the U.S. Department of Energy
Pittsburgh Energy Technology Center

SYSTEMS AND ECONOMIC ANALYSIS

OF MICROALGAE PONDS

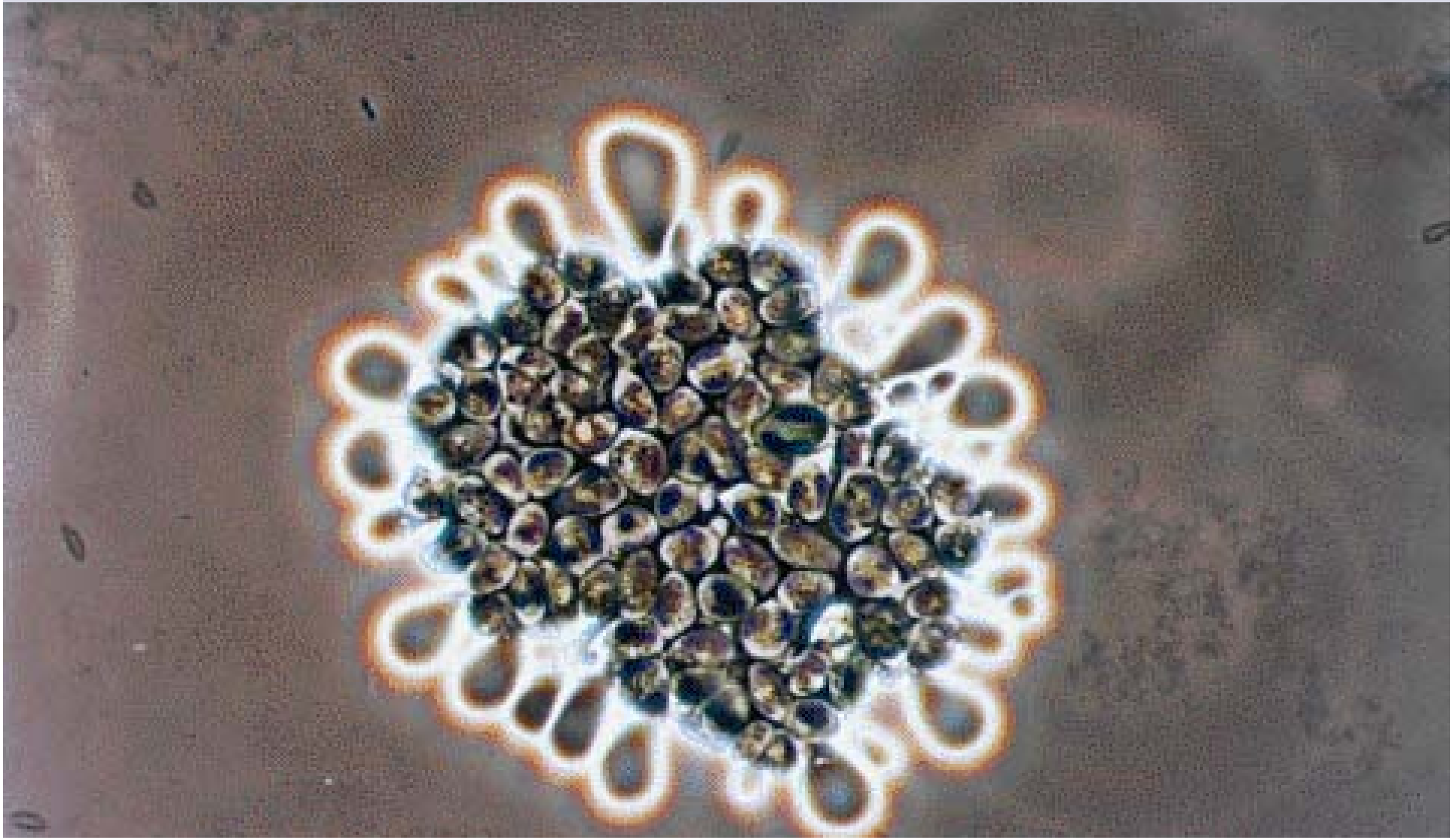
FOR CONVERSION OF CO_2 TO BIOMASS

Submitted by John R. Benemann and William J. Oswald,
Dept. of Civil Engineering University of California Berkeley

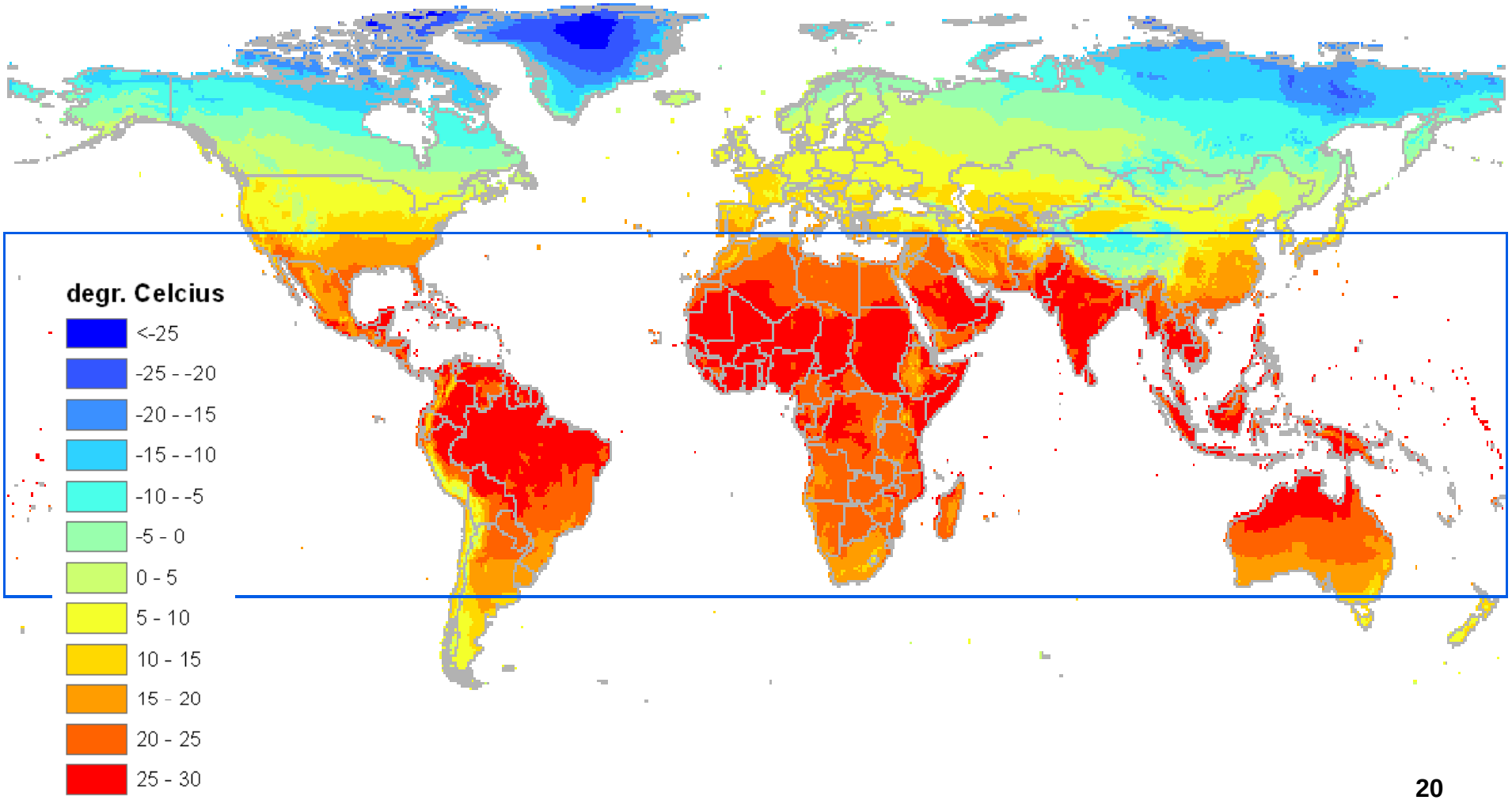
Attention: Dr. Perry Bergman U.S. Dept. of Energy Pittsburgh Energy Technology Center Pittsburgh, PA 15234

March 21, 1996

Botryococcus braunii a hydrocarbon producer. The goal of algal oil production R&D is to mass culture this alga, and do it cheaply!



Suitable climatic regions for microalgae : annual average temperatures of > 15 °C



First car running on algal biodiesel (10%)
Dec. 2006

Conclusions

- We don’t need to showcase cars running on algal oil, we need to develop technology that can produce algal at high productivity, at very low cost and in very large amounts.
- Mixed raceway open ponds are the only practical way to produce algae biofuels at a large scale and low cost
- Photobioreactors are much too expensive, capital & operating; provide few if any advantages over open ponds
- Current production systems, even with open ponds are too expensive and not productive enough, need to greatly reduce costs and equally important increase productivities
- Microalgae biofuels require long-term R&D in all aspects
- Can be combined with wastewater treatment processes


ANY QUESTIONS?

Public Service Announcement:
ALGAL BIOMASS ORGANIZATION
Membership Drive and Meeting
3rd Annual Algae Biomass Summit

ALGAL BIOMASS ORGANIZATION

3rd Annual Algae Biomass Summit: October 7-9, San Diego

www.algalbiomass.org

ALL INVITED TO BECOME ABO MEMBERS!

Annual Membership Meeting: April 23-24, Washington D.C.