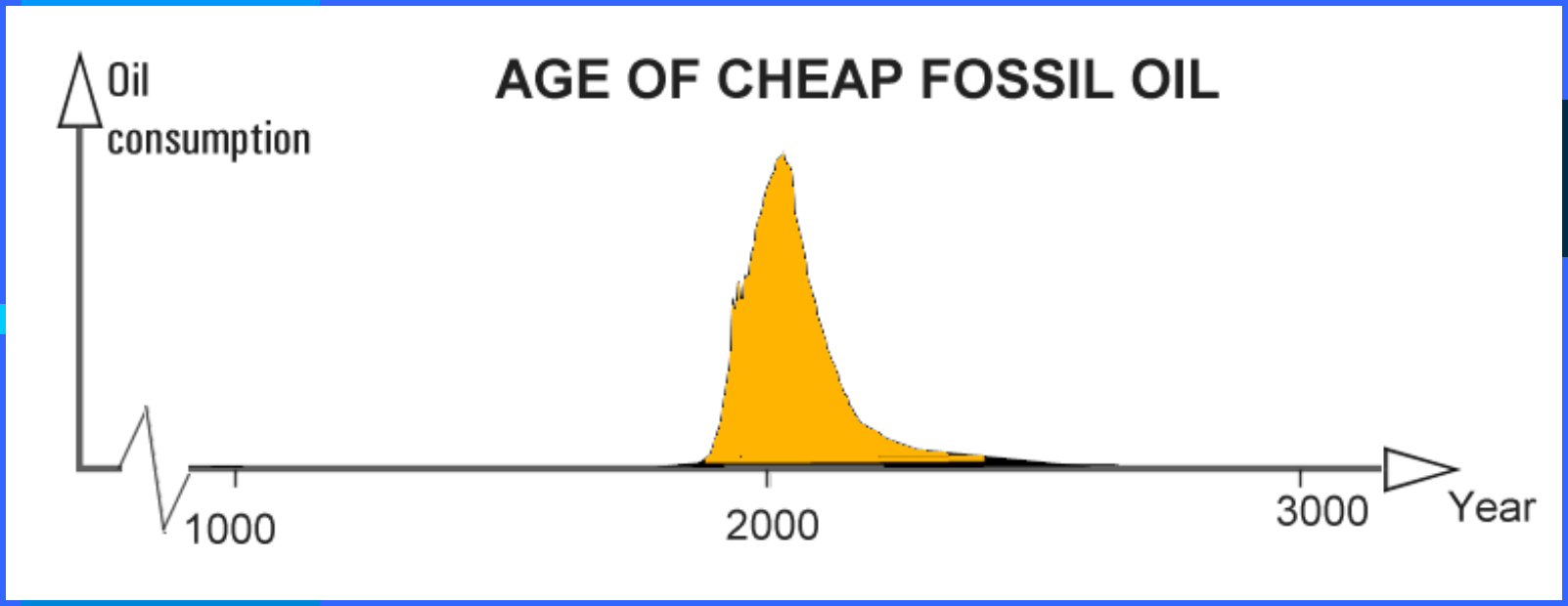
OVERVIEW

Part II

E) Geopolitics of cheap fossil fuels

F) Biofuels from algae

CO_2 for photosynthesis
supplied by
microbubbles



For the first and probably last time in history :

1) Commuter culture: people live far from where they work

2) Food travels hundreds (thousands) of kilometres between production and use

3) Increasing consumption in developing countries (China, India, ...)

Less economic activity = > lower tax receipts.

Social and education programs assume economic growth

Geopolitics of fossil oil supply

North America + Europe + Pacific Asia:
have less than 10% of world's reserves

- yet account for 78.6 % of consumption

Middle East + former Soviet Union
have 81.3 % of world's cheap oil reserves

- account for only 13.5 % of demand

Most remaining fossil oil reserves
are difficult and expensive to utilise
Drilling in deep sea, tar sands, enhanced recovery, ...
and their exploitation requires much energy

Geopolitics of fossil oil supply -2

OPEC (Organisation of Petroleum Exporting Countries) holds

75,7 % of estimated cheap oil reserves

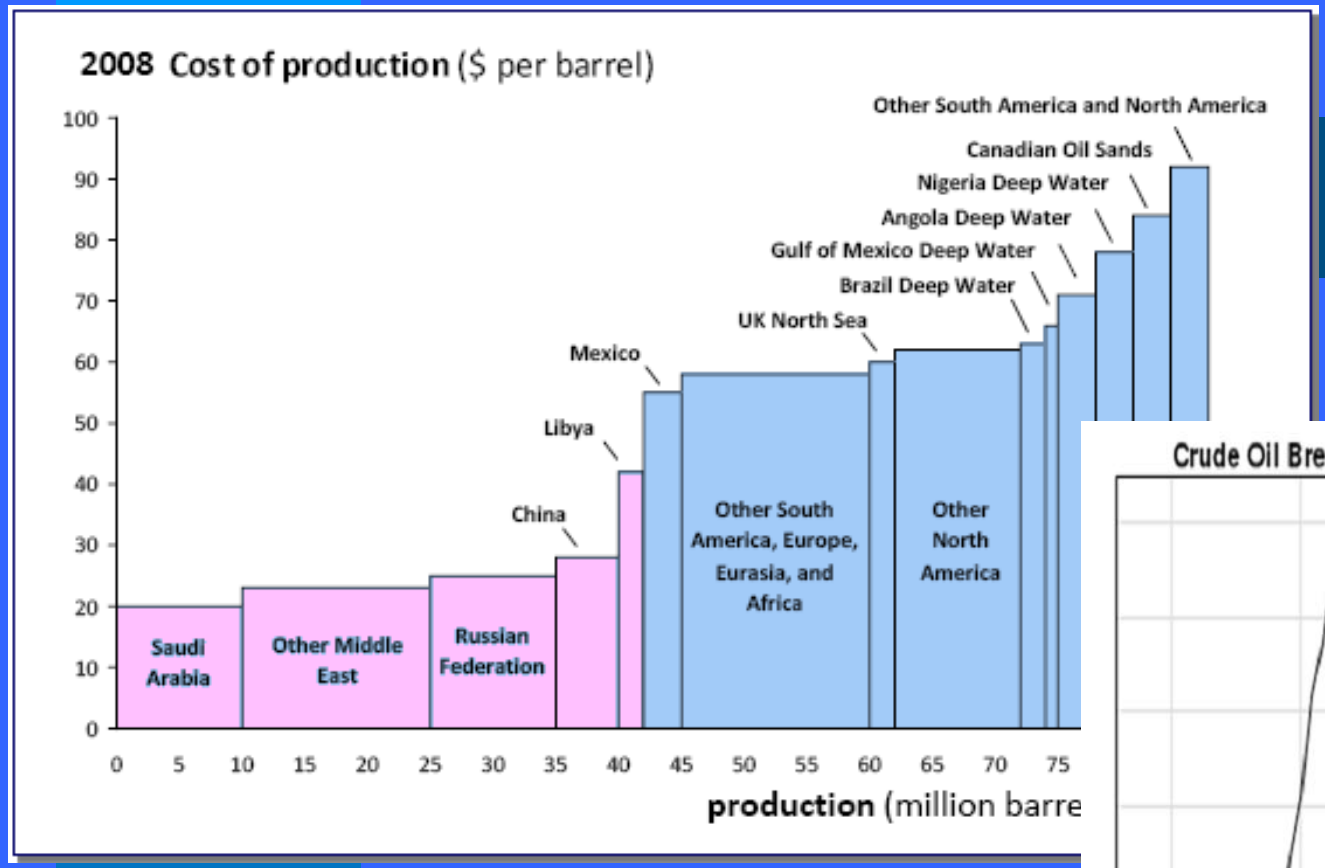
Algeria, Saudi Arabia, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Venezuela, ..

– mostly countries of high political risk rating

Production in non-OPEC countries has already peaked
(remaining reserves require too high production costs)

In addition, sensitive bottlenecks:

88 % transported through Strait of Hormuz, Strait of Malacca, Suez Canal, Bab el-Mandeb,...



Crude oil prices

Currently grown beyond levels considered 10 years ago

"absolutely not acceptable"

Renewable energy sources

Presently: wind turbines, photovoltaics, biogas from higher plants, tides, seawaves...

- Cannot secure full 100 % replacement of the present 16 TW oil consumption
- RE is not available when needed
- No suitable storage method is known

Nuclear: also needs storage.

F) Biofuels from algae

1. Solution: photosynthesis
2. Promise of unicellular plants
3. Necessity of providing CO_2 by microbubbles
4. Synthetic biology: creating mutants

Solution: ALGAE as fuel source

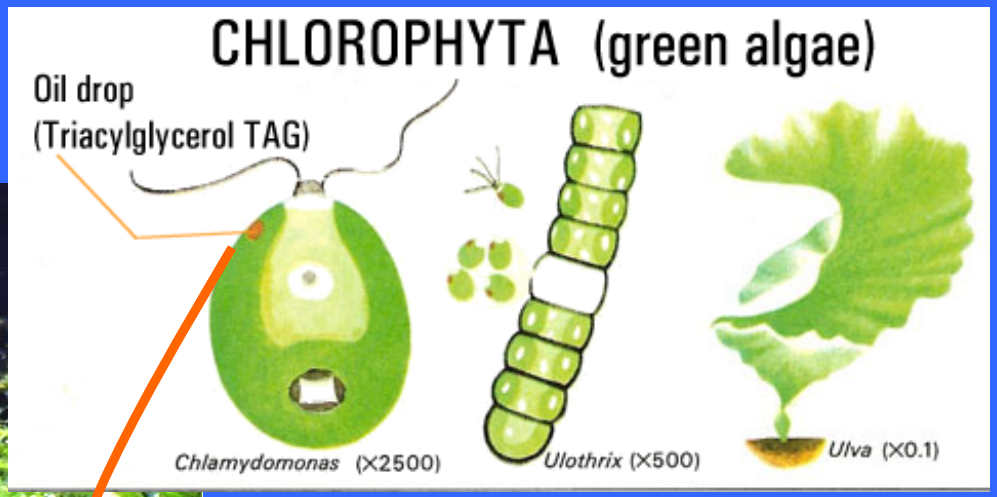
Microalgae (unicellular): more efficient than higher plants

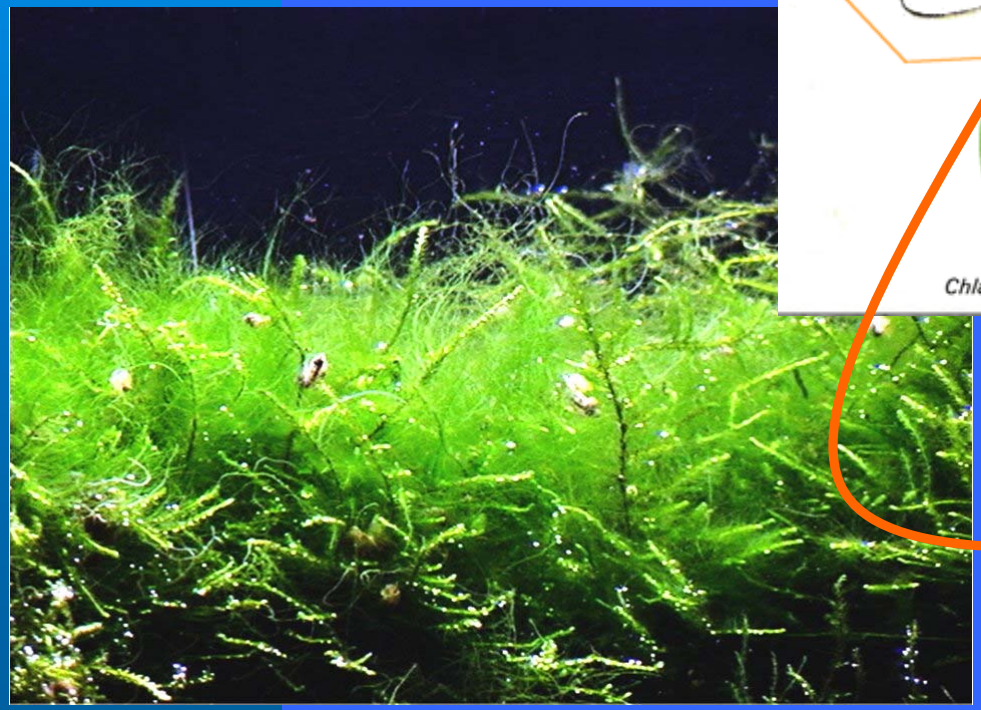
— proven to produce e.g., up to 100 times the oil yield of soybeans per acre

Not unnatural: After all, ancestors of marine microalgae responsible for the formation of the fossil crude oil ~ 300 million years ago

MICROALGAE – unicellular plants

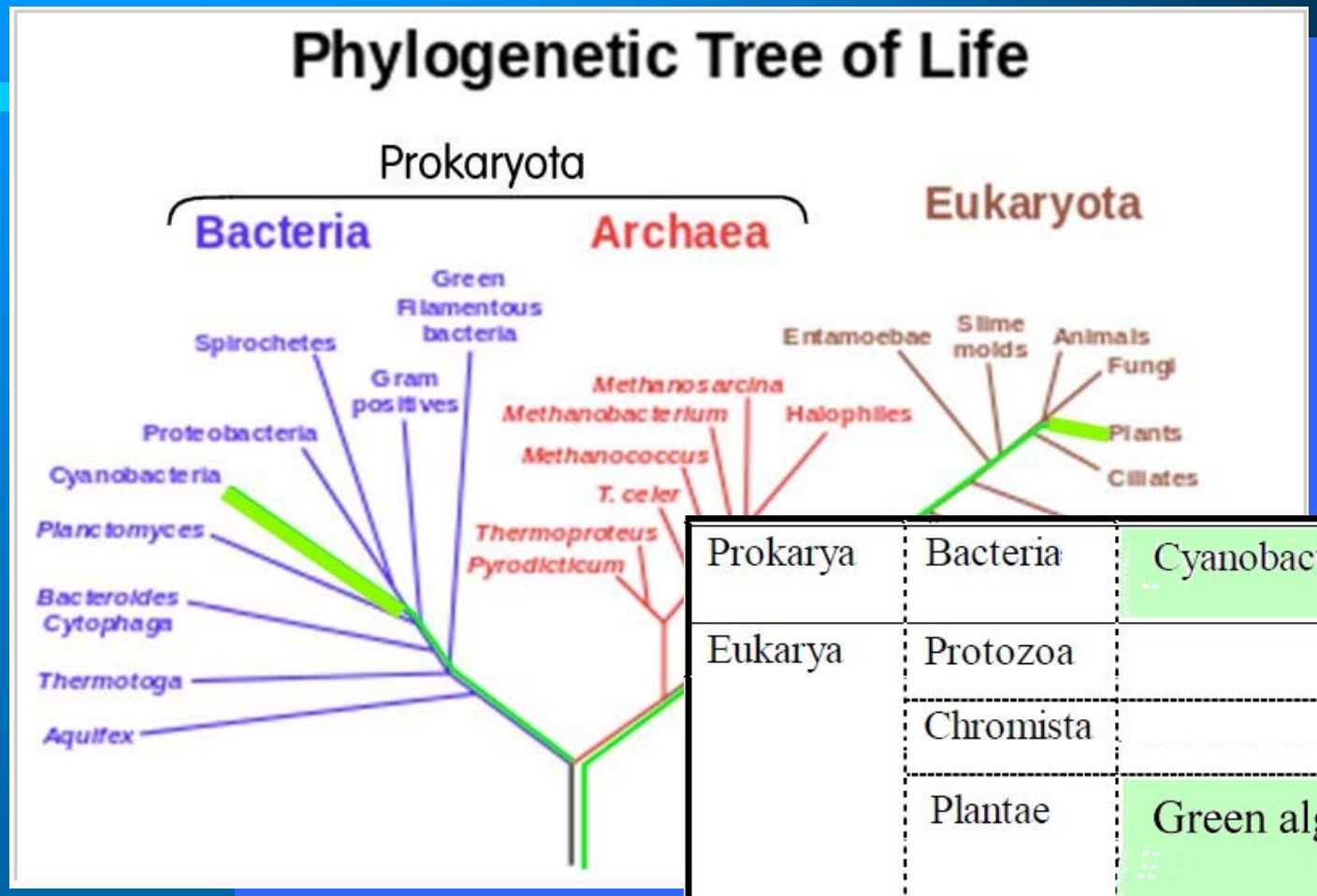
Short harvesting cycle ... mass doubling time of the order of hours
(Dunaliea salina: 3.5 hours)





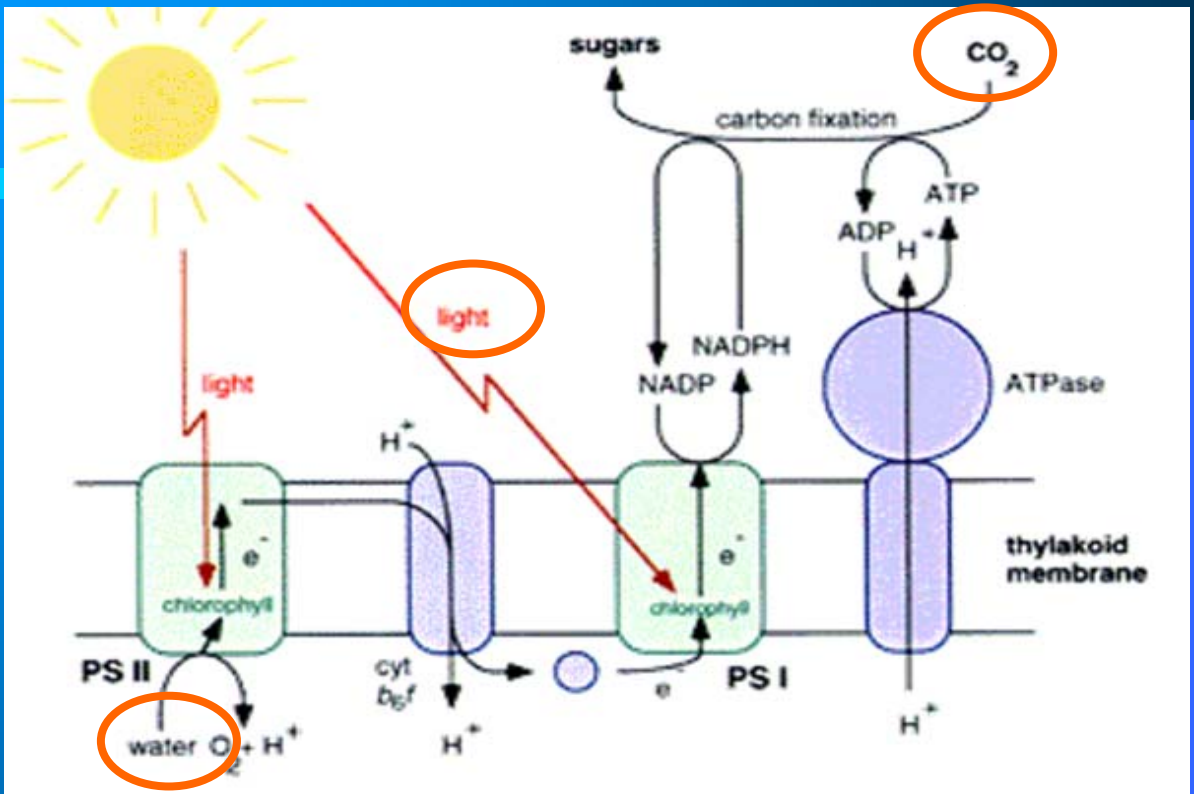
Can accumulate oils and starch

Photosynthesis: in plants + cyanobacteria



Prokarya	Bacteria	Cyanobacteria
Eukarya	Protozoa	
	Chromista	
	Plantae	Green algae (Chlorophyta)

Photosynthesis:



Overview of photosynthetic processes

$$6\,CO_2 + 12\,H_2O + \text{Light} + \textbf{Algae} \Rightarrow 6\,O_2 + 6\,H_2O + C_6H_{12}O_6$$

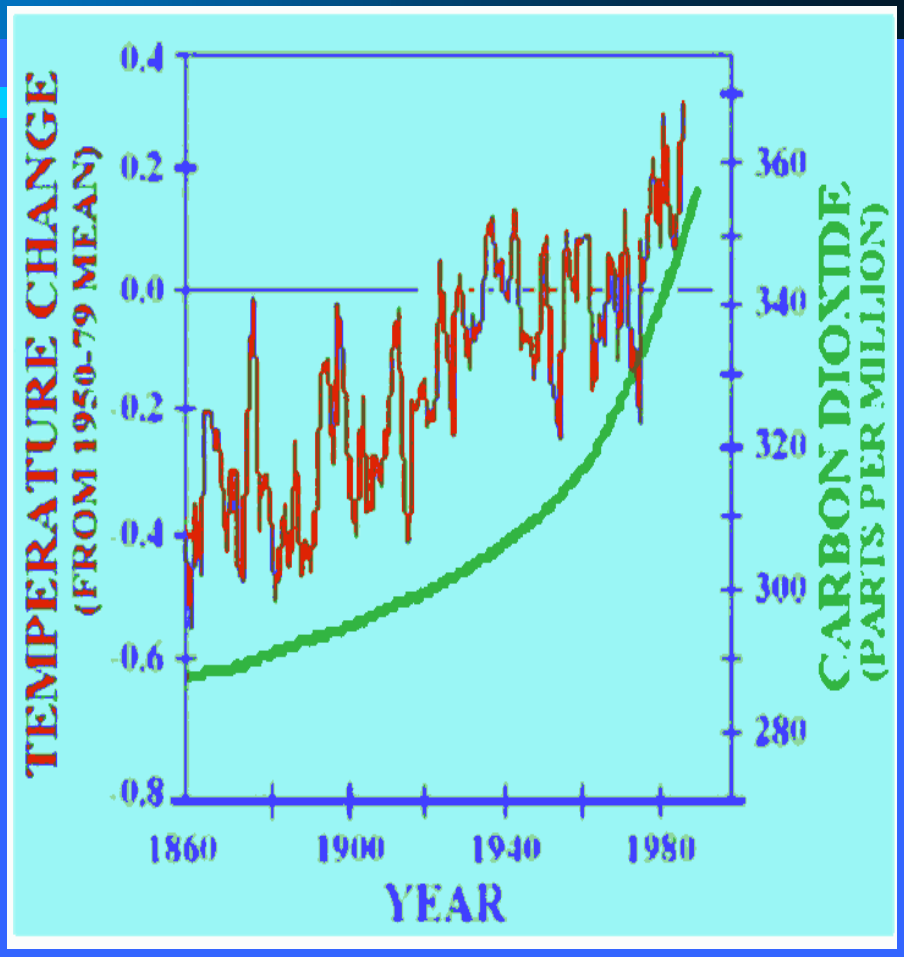
Glucose

There is also another problem to solve:

Global warming:

- the "greenhouse" effect, attributable to elevated emissions of CO_2

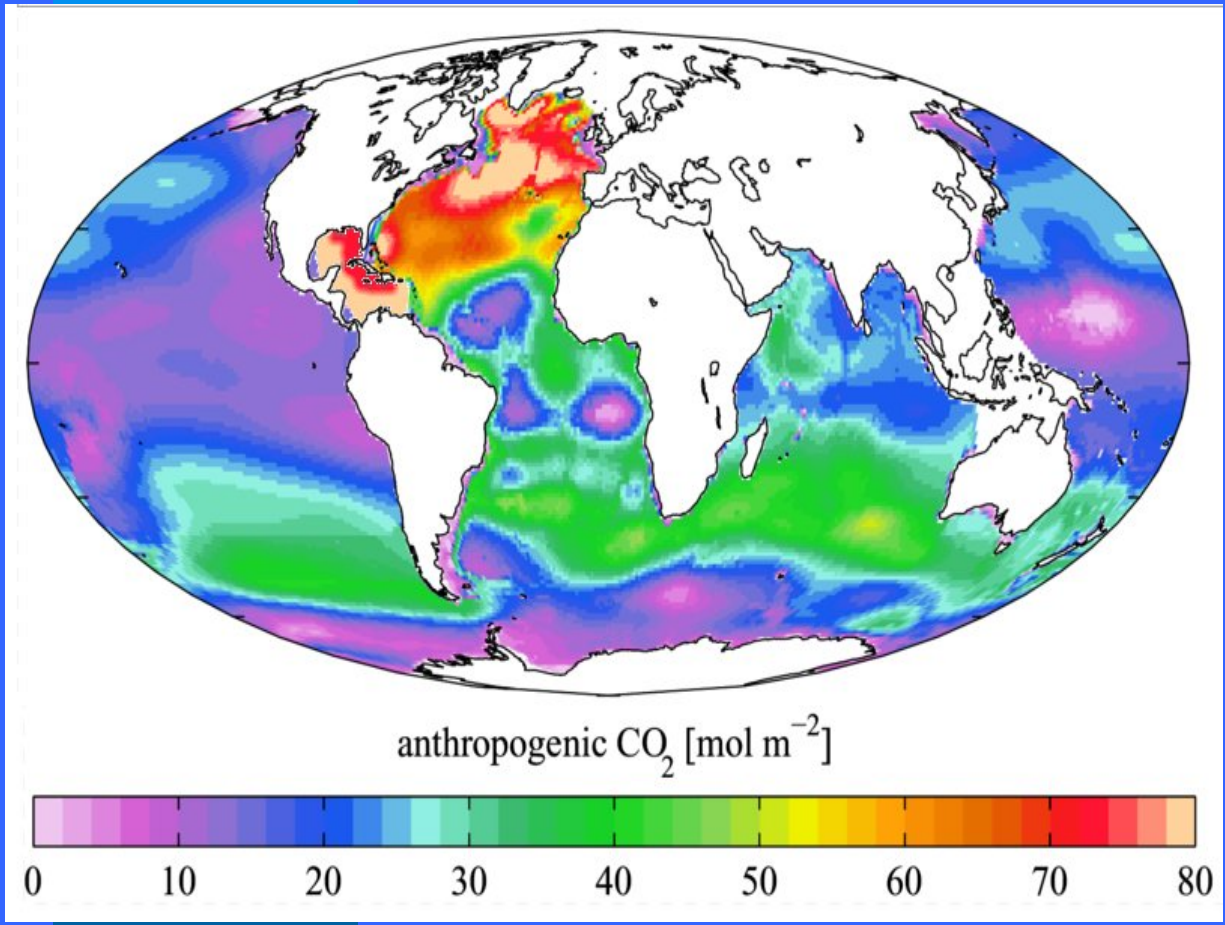
Probably due to human activity
- carbon fuel combustion
- destruction of rain forests

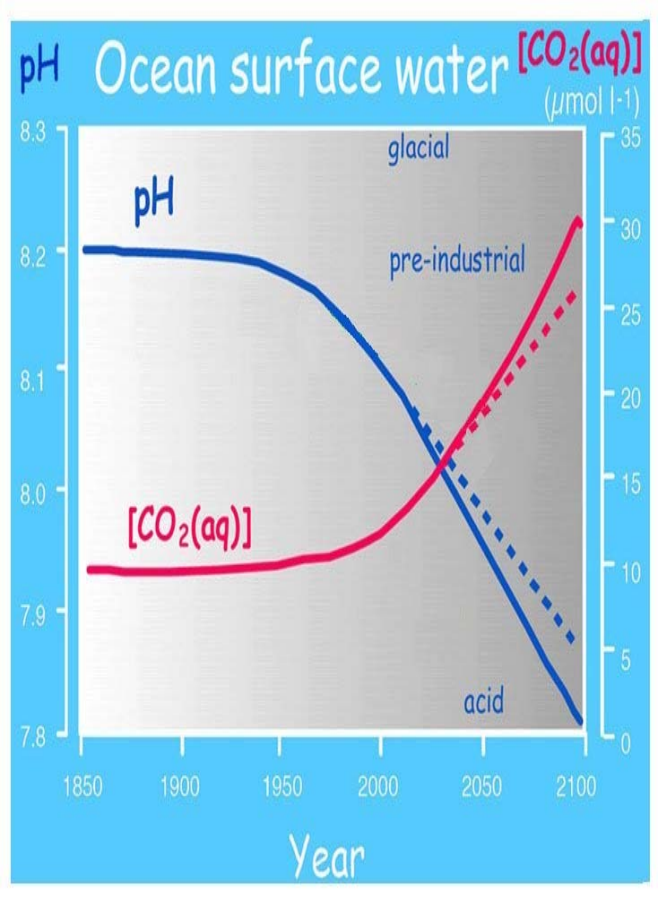


Kyoto Protocol

- Promoted by United Nations in1997
- Objective: reducing greenhouse gases by 5.2% on the basis of the emission in 1990,
  - more than 187 countries have ratified, but mostly failed to show real reductions
- The non-Economies-in-Transition countries show emissions 5% higher than 1990. Emissions in the US have increased 16% since 1990.
- Crash of the Copenhagen Climate Summit

CO_2 dissolved in seas:
Acid rains
Acid ocean

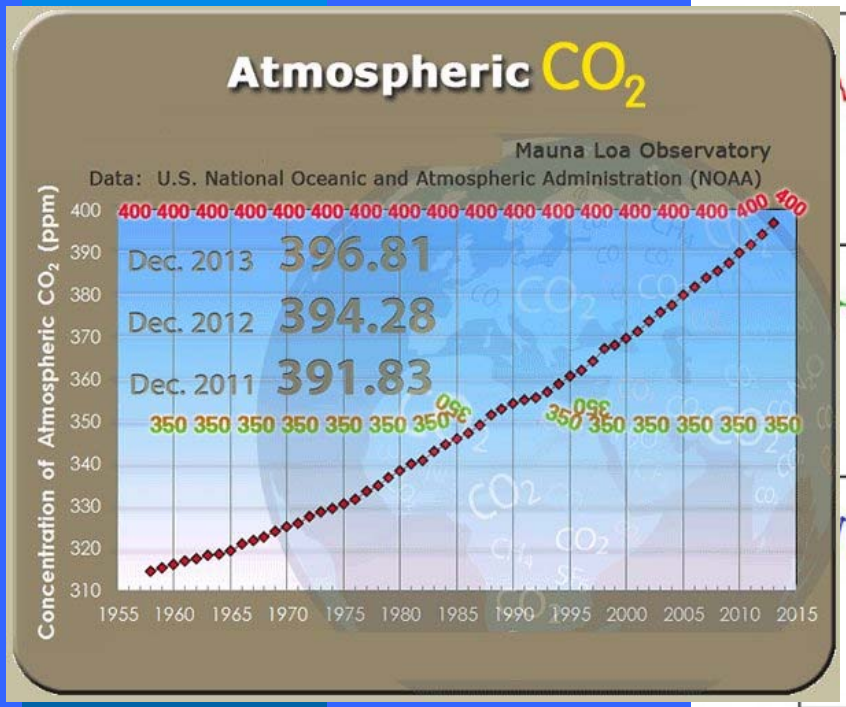


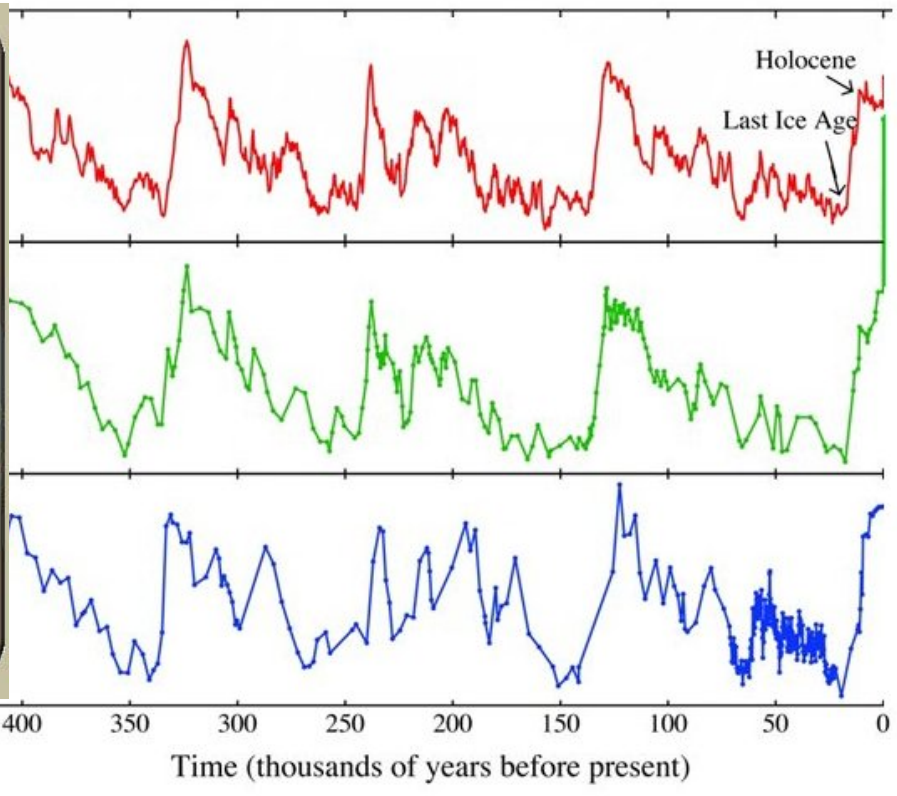


CO_2 quite probable man-made

product of fossil fuel combustion

drilling in Greenland ice shows periodic cycles – but current trend is steeper





Current generation rate: 12 tons CO_2 per person per year

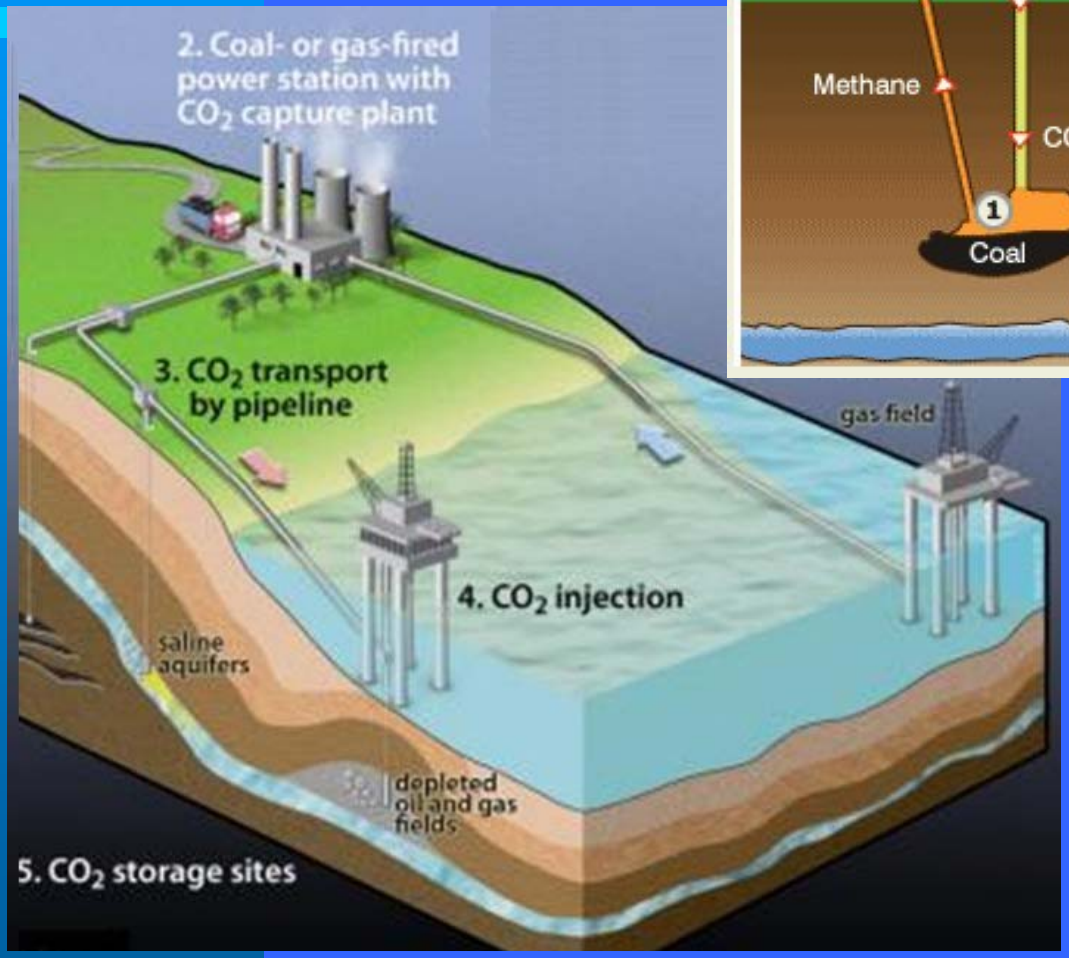
CO_2 capture by plants in agriculture contributes by only 3–6% of fossil fuel emissions

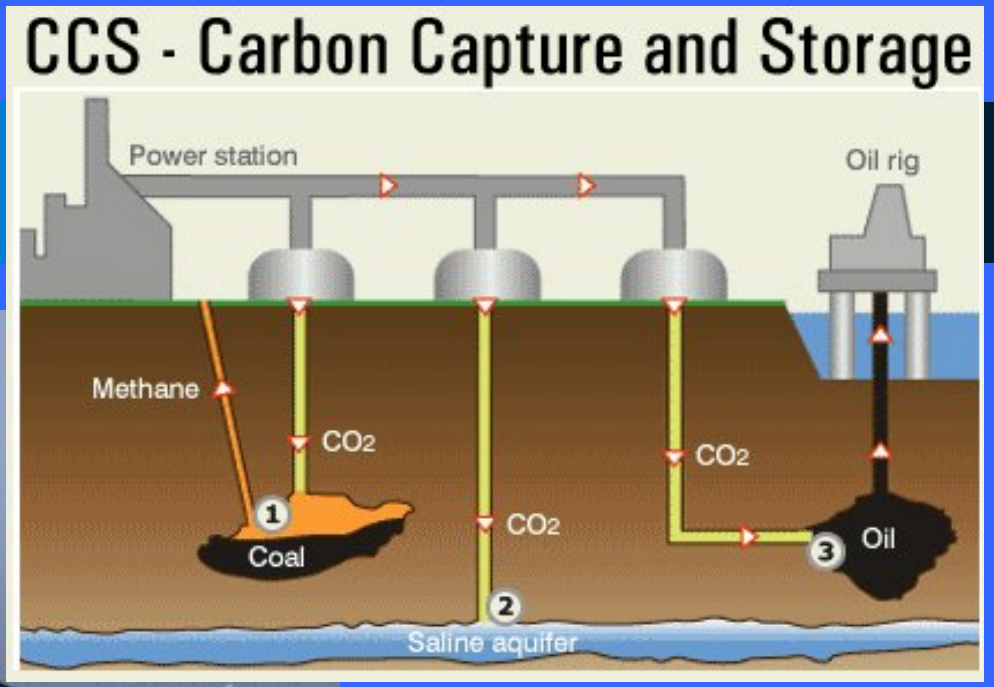
TECHNOLOGIES proposed for CO_2 mitigation
- in general costly and energy-consuming

e.g., CO_2 reacting with solid metal oxide in a carbonation reactor ...

British CCS project

- storage in undergound cavities





A desperate attempt – at any rate cannot operate for long

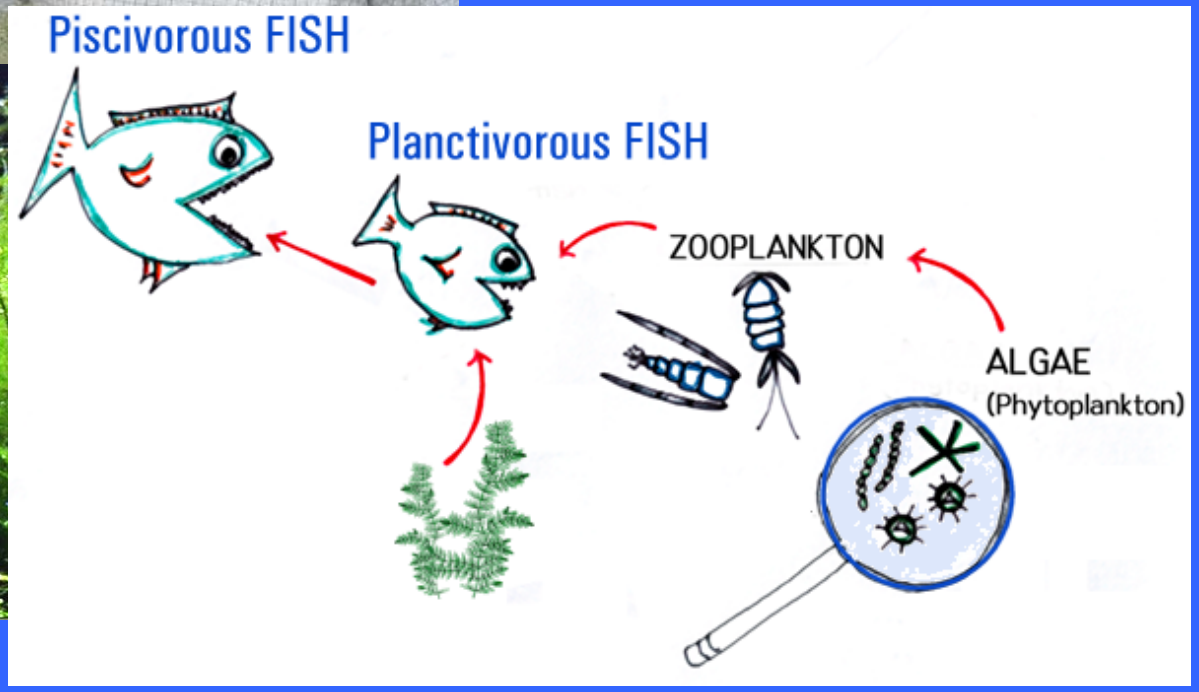
SOLUTION:

Use atmospheric CO_2 to grow ALGAE

- at the same time producing bio-petrol

and perhaps even solve the problem of food

ALGAE as the base of nutrition chain



ALGAE as source of FUEL

News report (June 2014):

China builds algae bio-fuel facility

Jun Ya Yan Technology Development Comp. Shanghai invests $40 million (US). To produce biofuel in open ponds
- also: livestock food, as remains after algae squeezing.

NAABB

US Department of Energy recently earmarked
multi-billion $ to finance consortium NAABB
(National Alliance for Advanced Biofuels and Bioproducts)

Task: bio-fuel production price decrease
to a level comparable with standard gasoline.

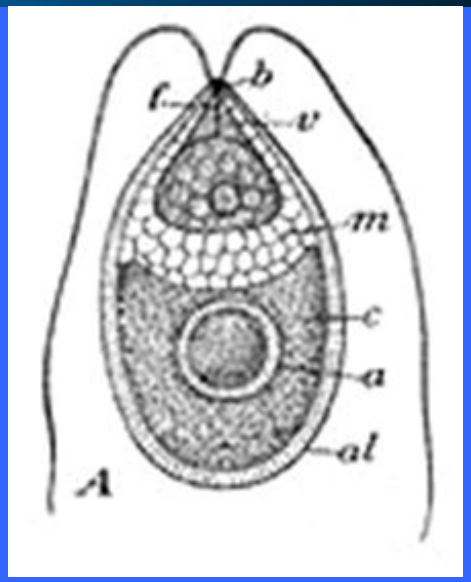
17 universities
16 industrial enterprises
5 federal laboratories

- headed by LOS ALAMOS Nat. Lab., New Mexico

BRIEF NOTES ON ALGAL BIOLOGY

Dunaliea

- *D. acidophila*
- *D. bardawil*
- *D. bioculata*
- *D. lateralis*
- *D. maritima*
- *D. minuta*
- *D. parva*
- *D. peircei*
- *D. polymorpha*
- *D. primolecta*
- *D. pseudosalina*
- *D. quartolecta*



Green halophillic alga, grows in high salinity environment, unicellular, biflagellate

BRIEF NOTES ON ALGAL BIOLOGY

Spirulina

15 species

Filamentous : in the shape of perfect spiral

- Multicellular arrangement of cylindrical cells up to 1 mm in length

Left-hand chirality !

BRIEF NOTES ON ALGAL BIOLOGY

Chlorella

10 –20 distinguishable species

The first culture of microalga scientifically investigated by microbiologist M.W.Beijerinck in 1890 - it was ***Chlorella vulgaris***

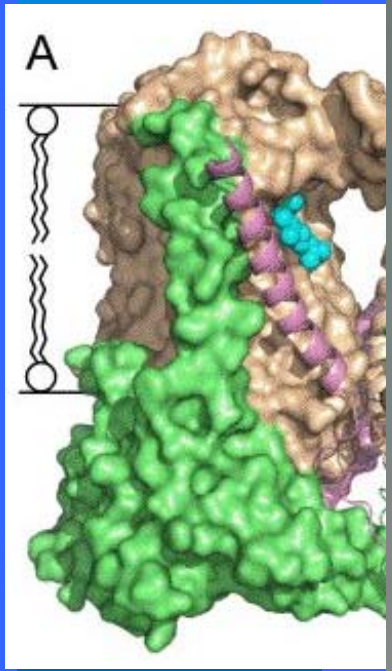
Simple, non-motile, unicellular, aquatic green algae

Size: between 5 μm and 10 μm, mostly of spherical shape

thick cell wall: 100- 200 nm ... mechanical and chemical protection,

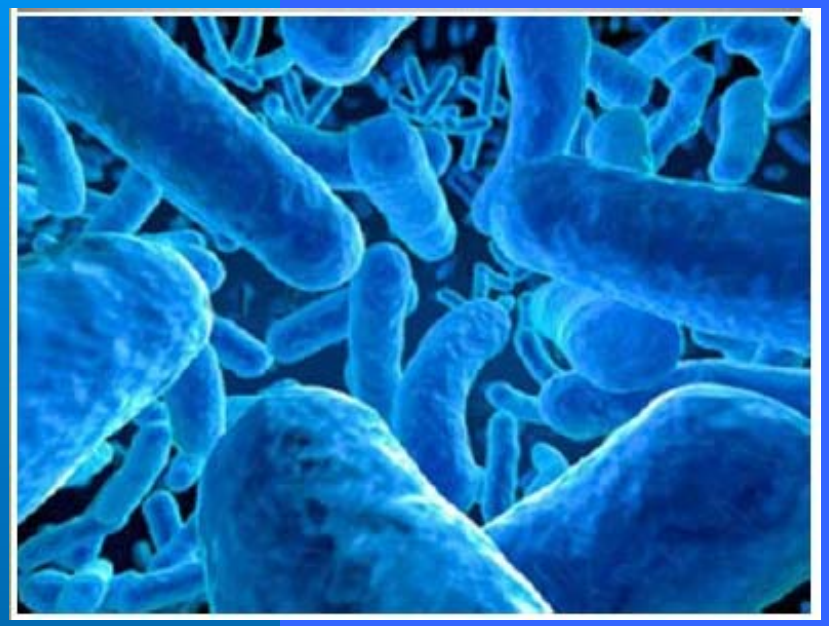
SYNTHETIC BIOLOGY

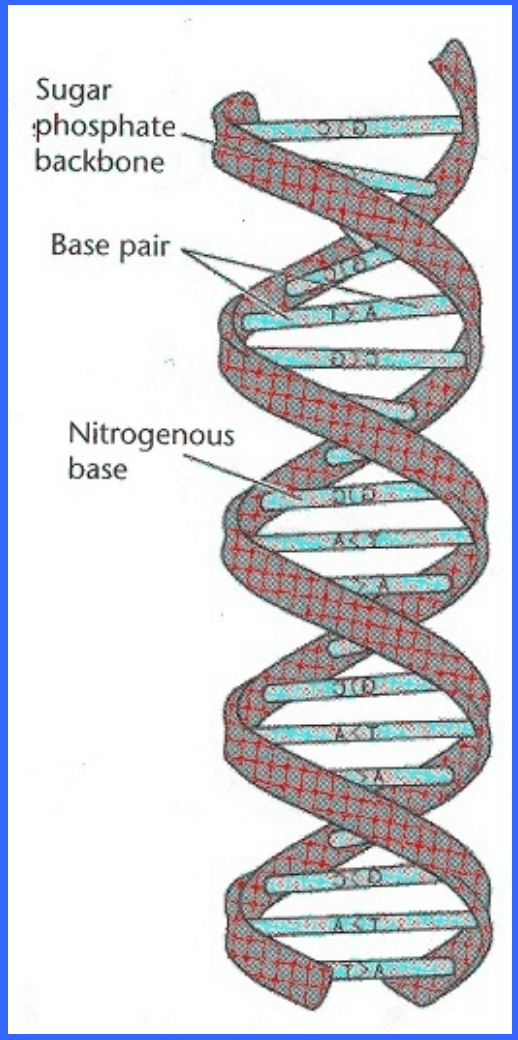
Bacteria manipulated into mutants
for performing photosynthesis



EVEN DEEPER INROAD INTO LIFE ON EARTH

SYNTHETIC BIOLOGY



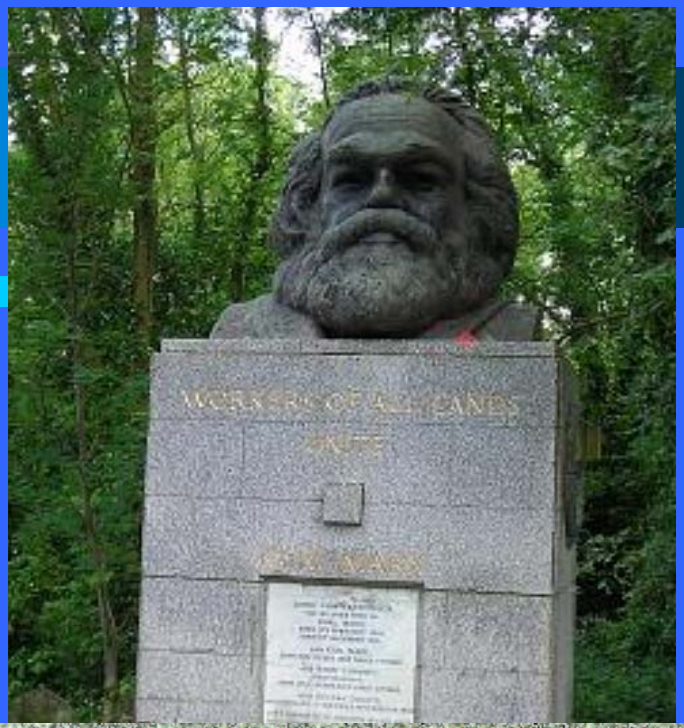


Genetic manipulation

MUTANTcreators

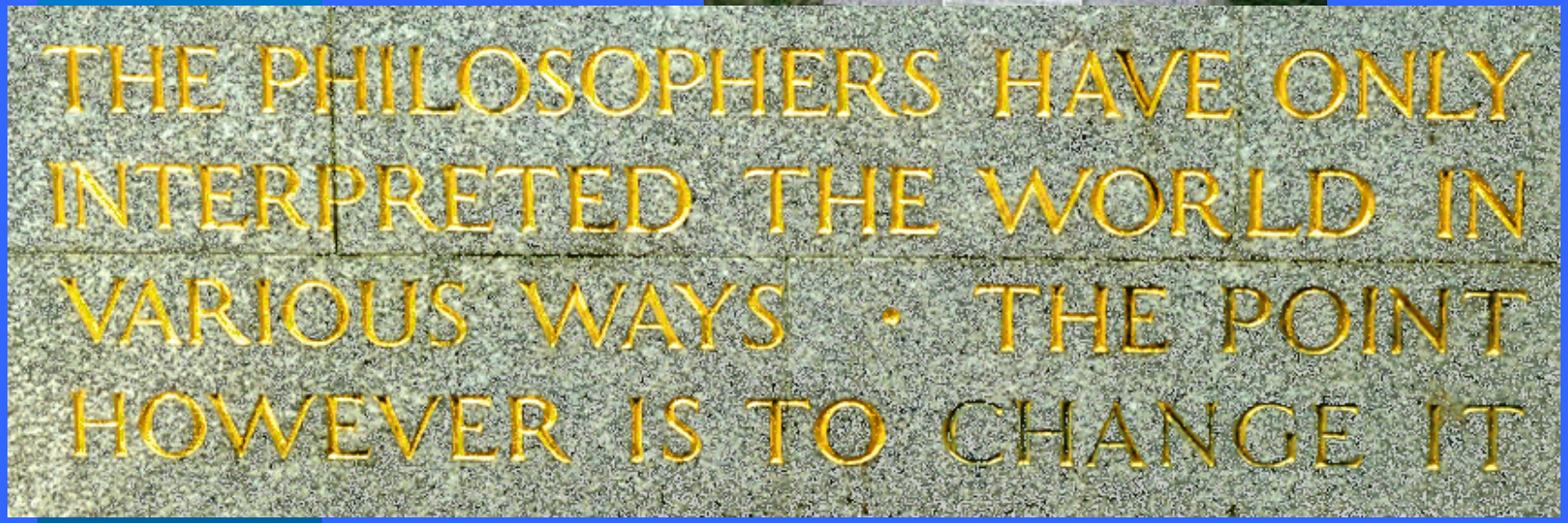
justify it

by the idea



Grave of
Karl Marx

- Hampstead,
London



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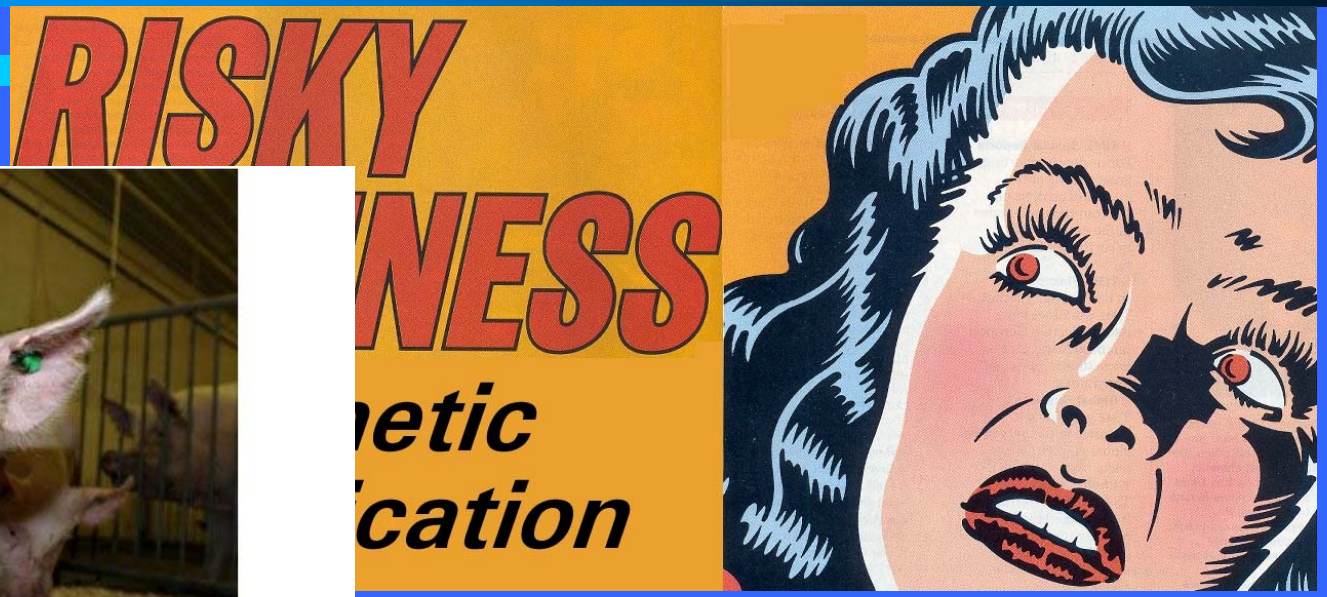
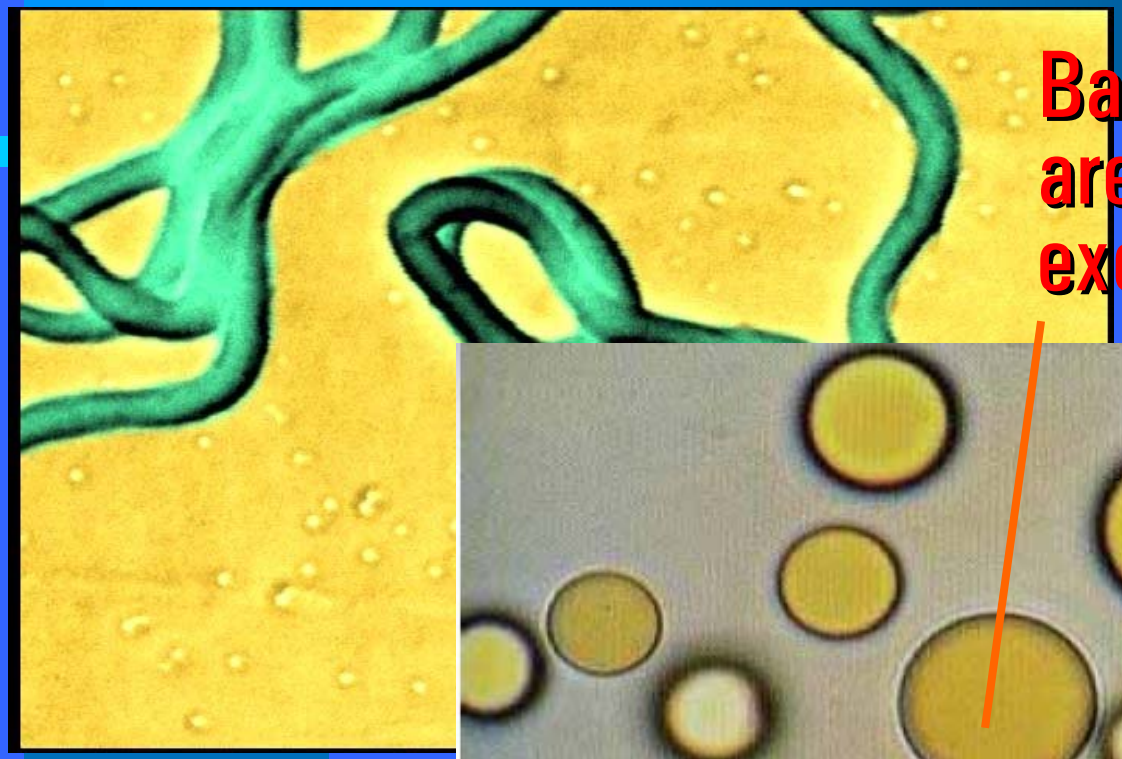


Enviropig *i.e.*, "Frankenswine"

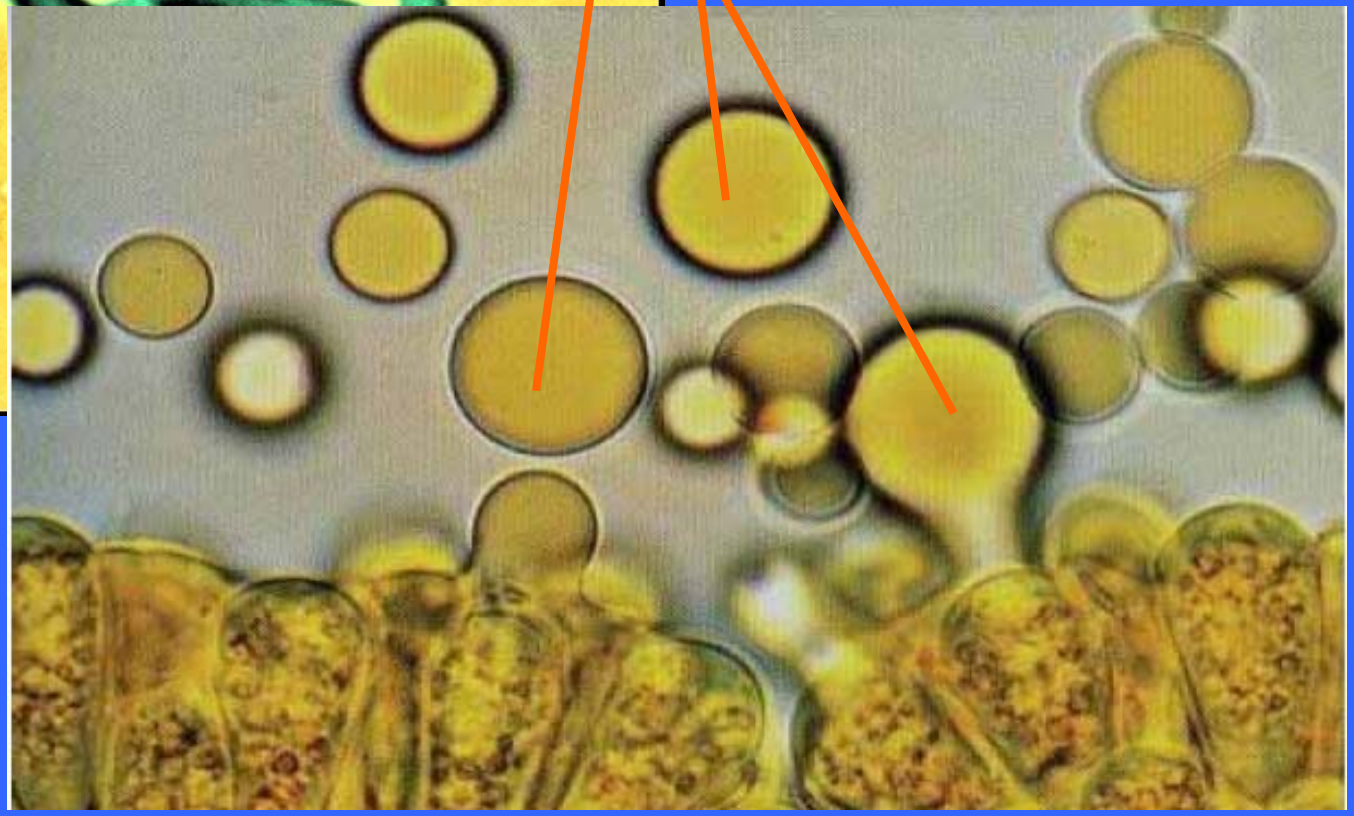
- Able to digest and process cellulose

Pig with enzymes transferred from fungi

SYNTHETIC BIOLOGY



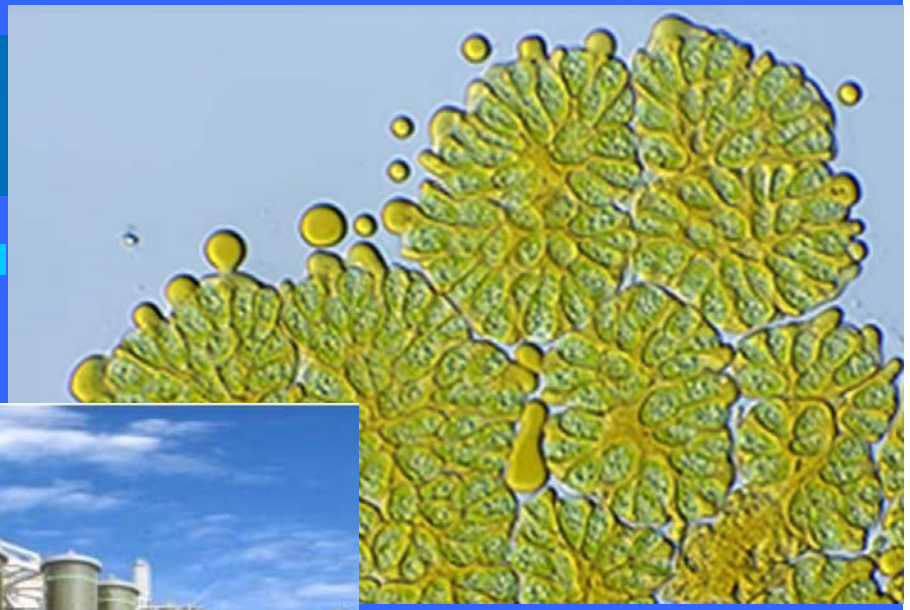
Bacteria *Escherichia coli* are manipulated to excrete diesel fuel



SYNTHETIC BIOLOGY

GM algae

Industrial-scale facility
Las Cruces, New Mexico



GM organisms must be kept enclosed

Opportunity for fluidic microbubble generators !

CONCLUSION:

(with only a small exaggeration)

Efficient and inexpensive generation of CO_2 microbubbles
may actually play a non-negligible role in the future of our civilisation