egenis

Climate Change from a Microbial Point of View

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John Dupré and Maureen O'Malley
Egenis,
University of Exeter

ESRC genomics network

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Overview

- The general neglect of microbes
- Inadequacies of climate change models that do not factor in microbial activities
- Microbial interventions for the amelioration of climate change
  - Direct biogeochemical intervention
  - Genetically enhanced bioremediation
  - Microbial technologies with indirect impact, esp. alternative fuel production
- Communication strategies & public engagement

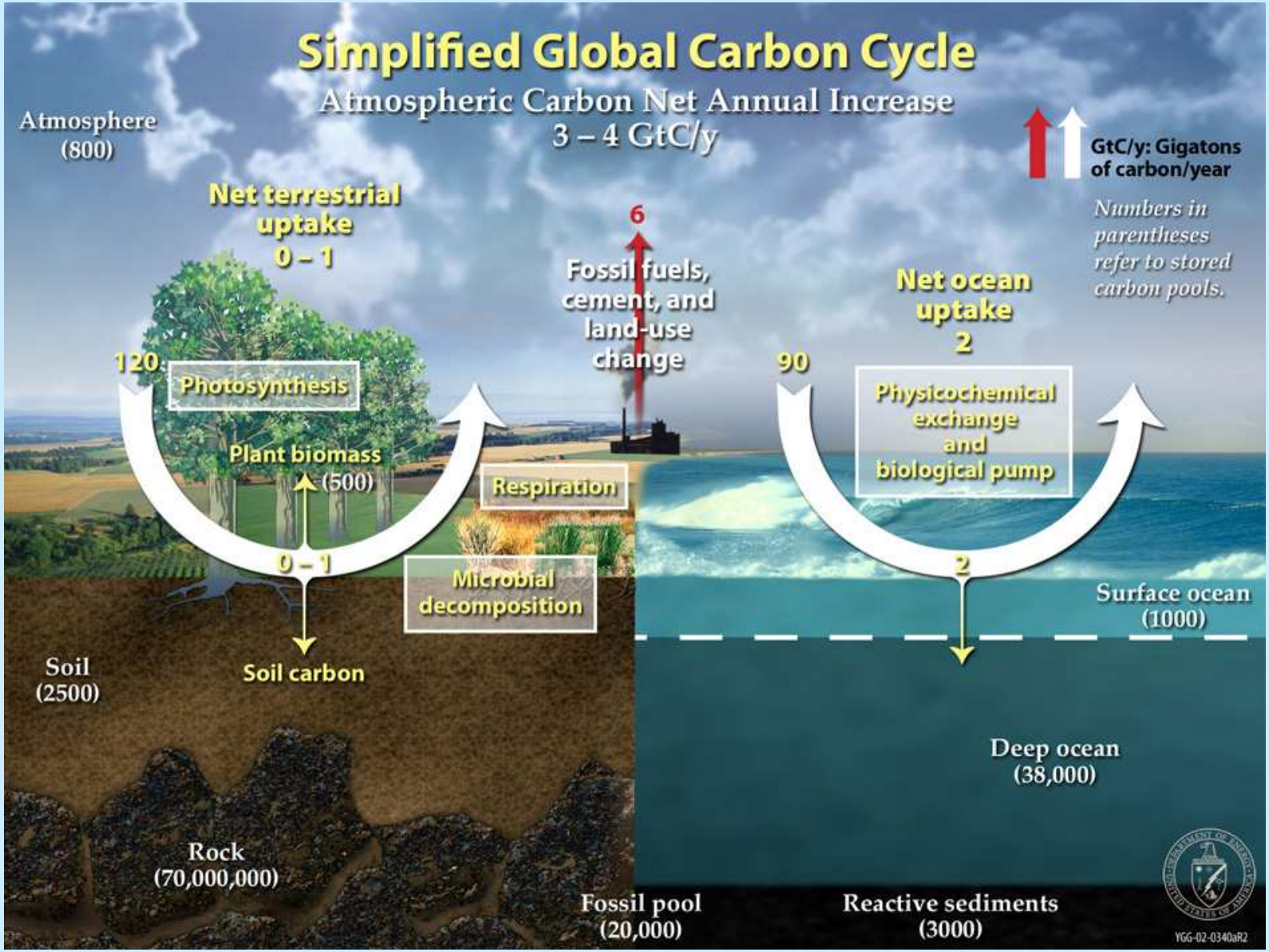
Microbial processes and their climate implications

Microbes are historically the most effective geoengineers and biogeochemists

- Great Oxidation Event (c. 2.4bya) and Oxygen cycle
- Nitrogen cycle
- Carbon cycle

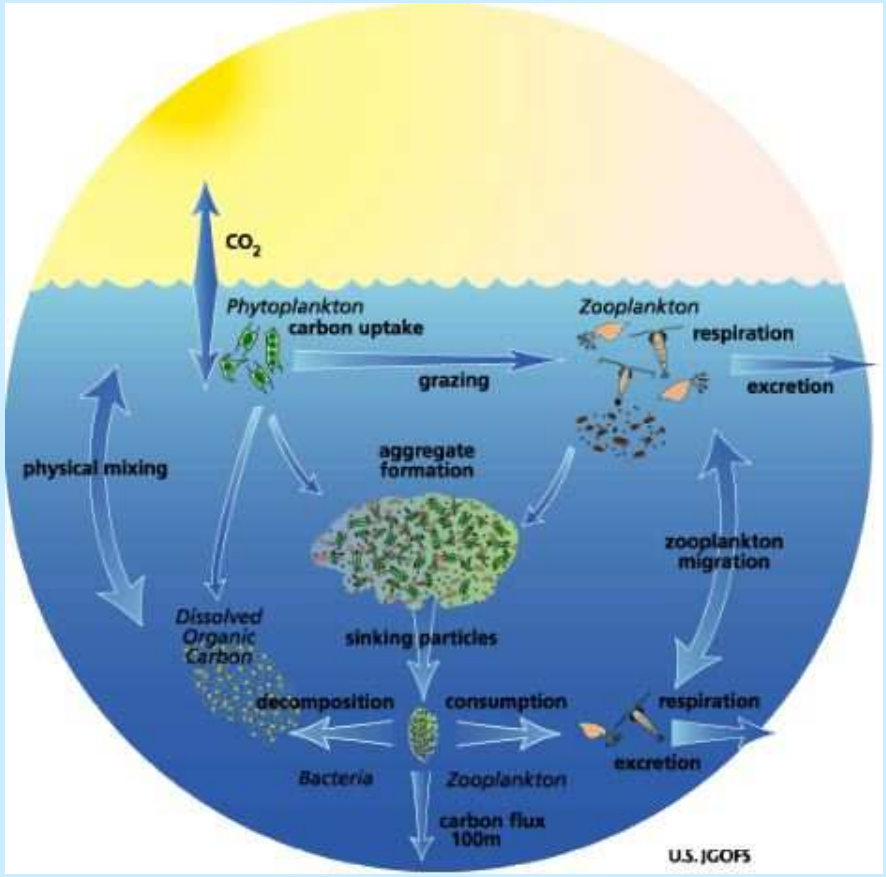
Possibilities of major microbial positive and negative feedback responses to temperature change, and interactions, are inadequately understood

Warwick Hillier, www.photosynthesisresearch.org



US Department of Energy, Office of Science (Genomics: Genomes to Life)

Oceanic carbon cycle



US Joint Global Ocean Flux Study: http://ijgofs.whoi.edu/

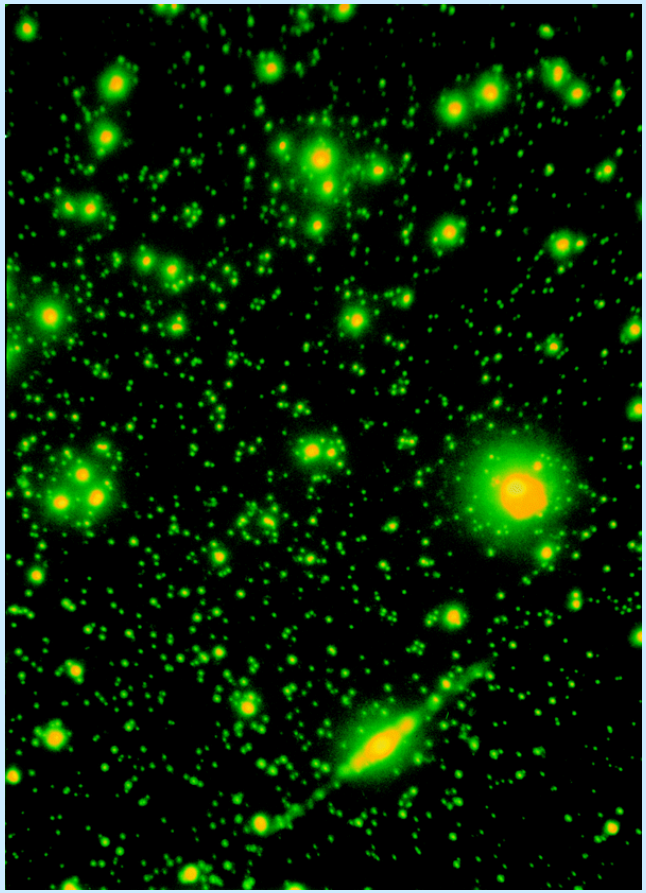
- 50 times more CO_2 in ocean than in the air
- Oceans cycle equivalent of all man-made CO_2 in less than five years.
- Carbon cycle is dominated by micro, nano, and pico plankton, including bacteria and archaea
- Microbes dominate!

(Stewart, 2003)

Marine Viruses

- ~ 4×10^{30} viruses in ocean waters
- If stretched end to end would span 10 million light years
- Each marine virus = 0.2 fg of carbon
- ~ 200 Mt of carbon total
- Viral carbon is equivalent to the carbon in 75 million blue whales (10% carbon, by weight)

(Suttle, 2005)



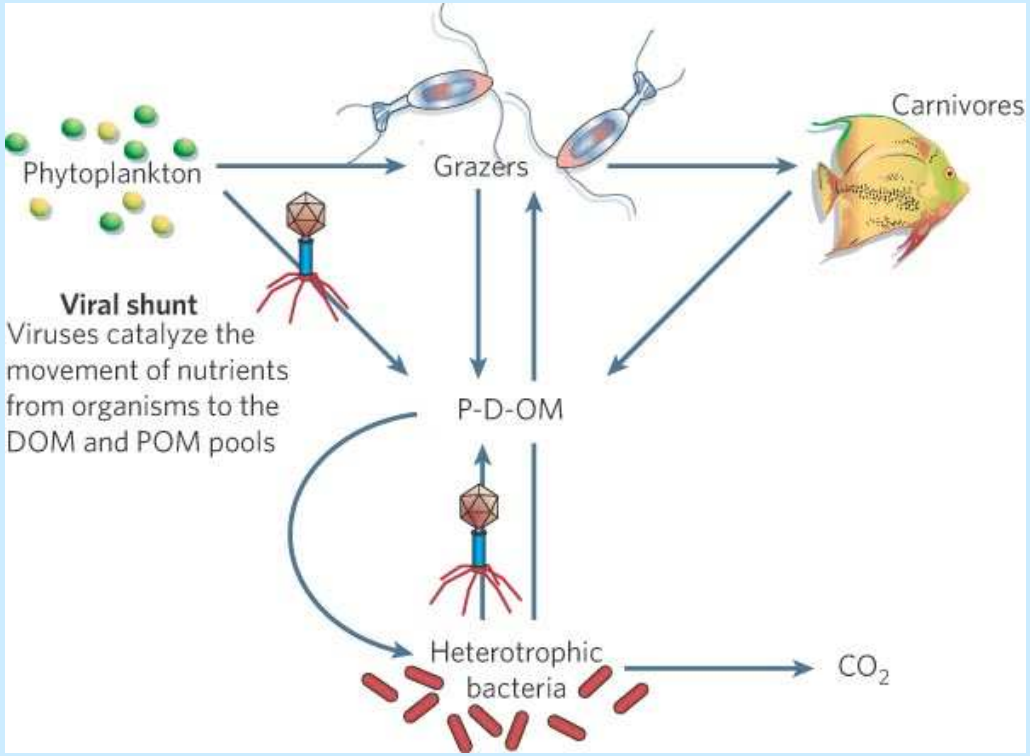
http://www.eoearth.org/image/Prokaryotes_and_viruses.jpg

The Impact of Viruses

Viruses may lyse up to 50% of oceanic cyanobacteria per day

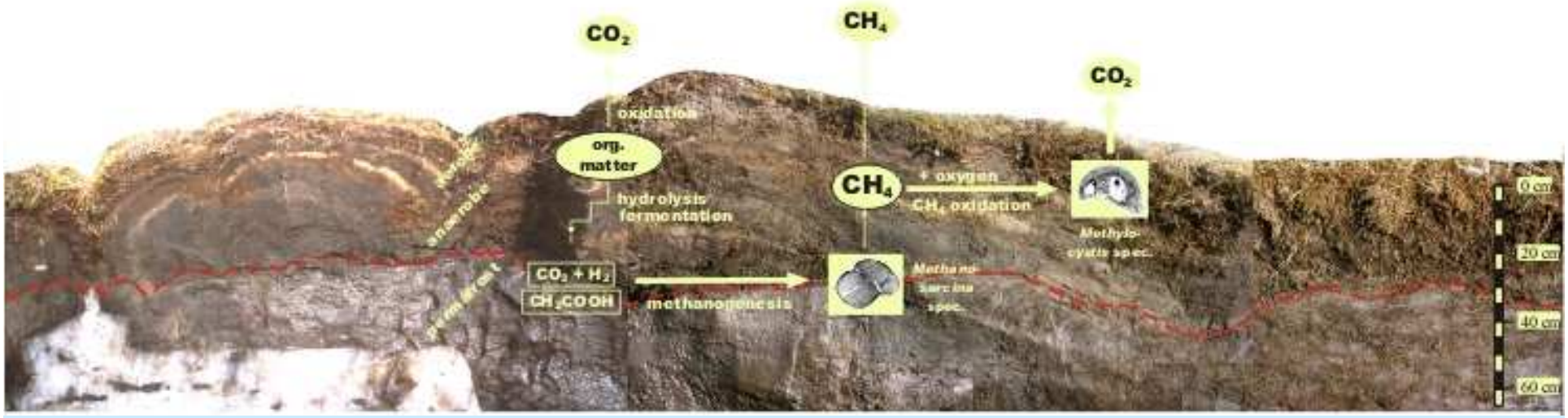
This short-circuits the flow of carbon and nutrients from phytoplankton and bacteria to higher trophic levels and shunts the flux to the pool of dissolved and particulate organic matter.

Result: more of the carbon is respired, thereby decreasing the trophic transfer efficiency of nutrients and energy through the marine foodweb
(Suttle 2005; 2007)



www.whoi.edu

Methane Production in Warming Tundra



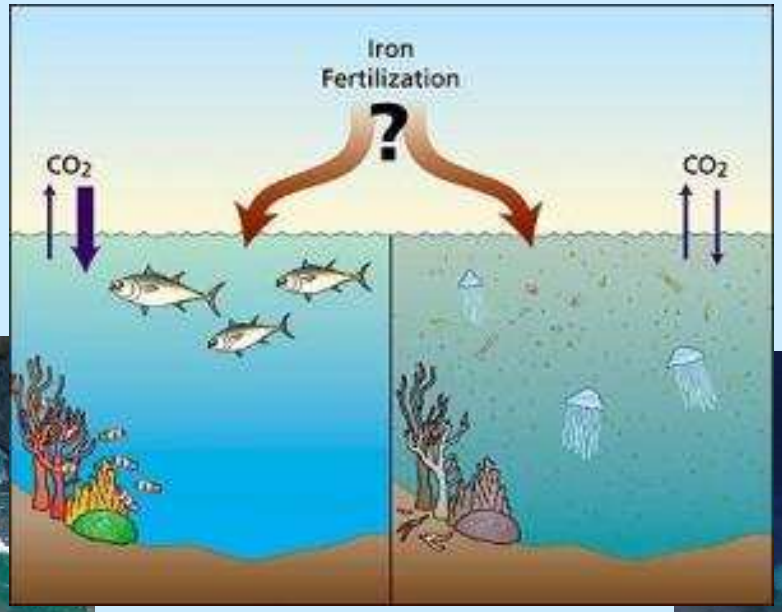
Main source of methane in permafrost soils is methanogenic archaea.
Only known terrestrial sink is methanotrophic bacteria.
Balance between these processes is poorly understood.

www.awi.de

Microbial interventions

- Geoengineering
- Genetically enhanced bioremediation
- Bioenergy production (carbon based, carbon neutral)

Ocean fertilization and algal blooms

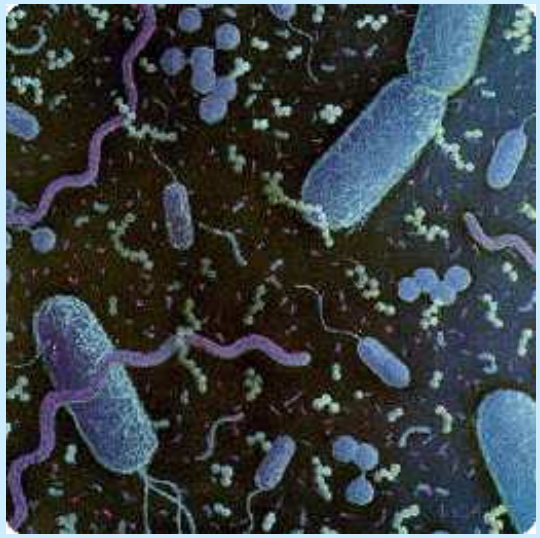


Miriam Godfrey, www.niwa.cri.nz

Jacques Descloitres, NASA/GSFC

Microbial bioremediation

- Genetically enhanced bioremediation, modifying the production of nitrogen- and carbon-based compounds



http://www.virtualviz.com/florida.htm

Microbial Biofuels

http://northbynwa.com/wp-content/uploads/2008/04/pondscum01.jpg

Pilot plant for growing algae for biofuel. Estimates of potential yields typically 30x those for crops such as soybean.

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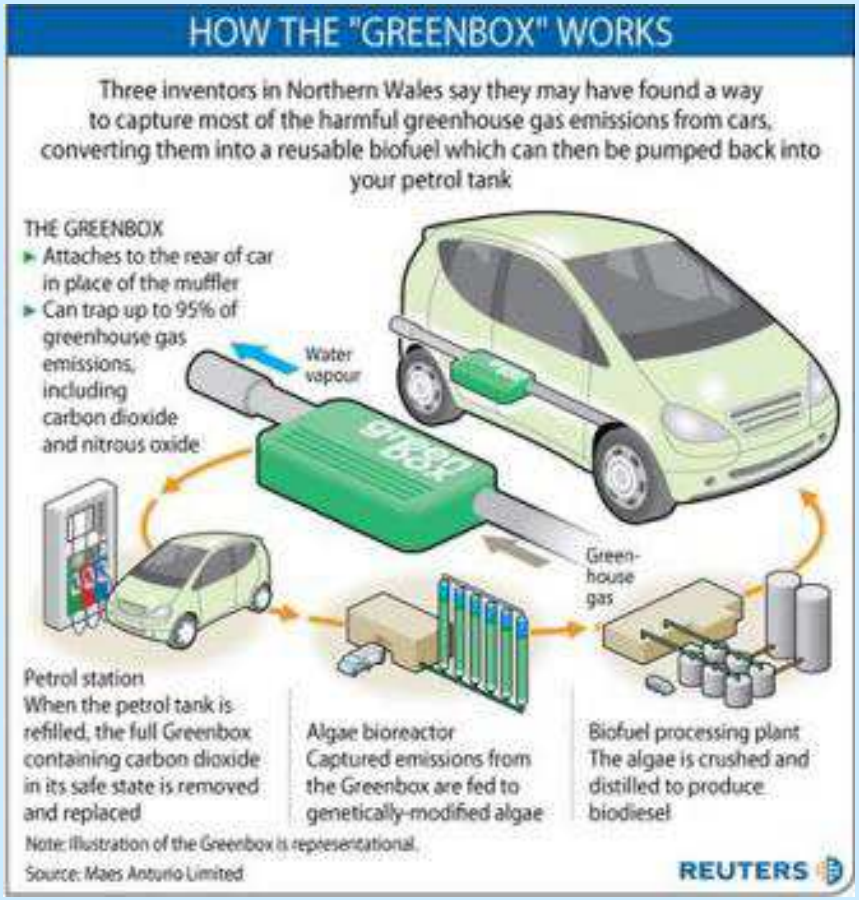
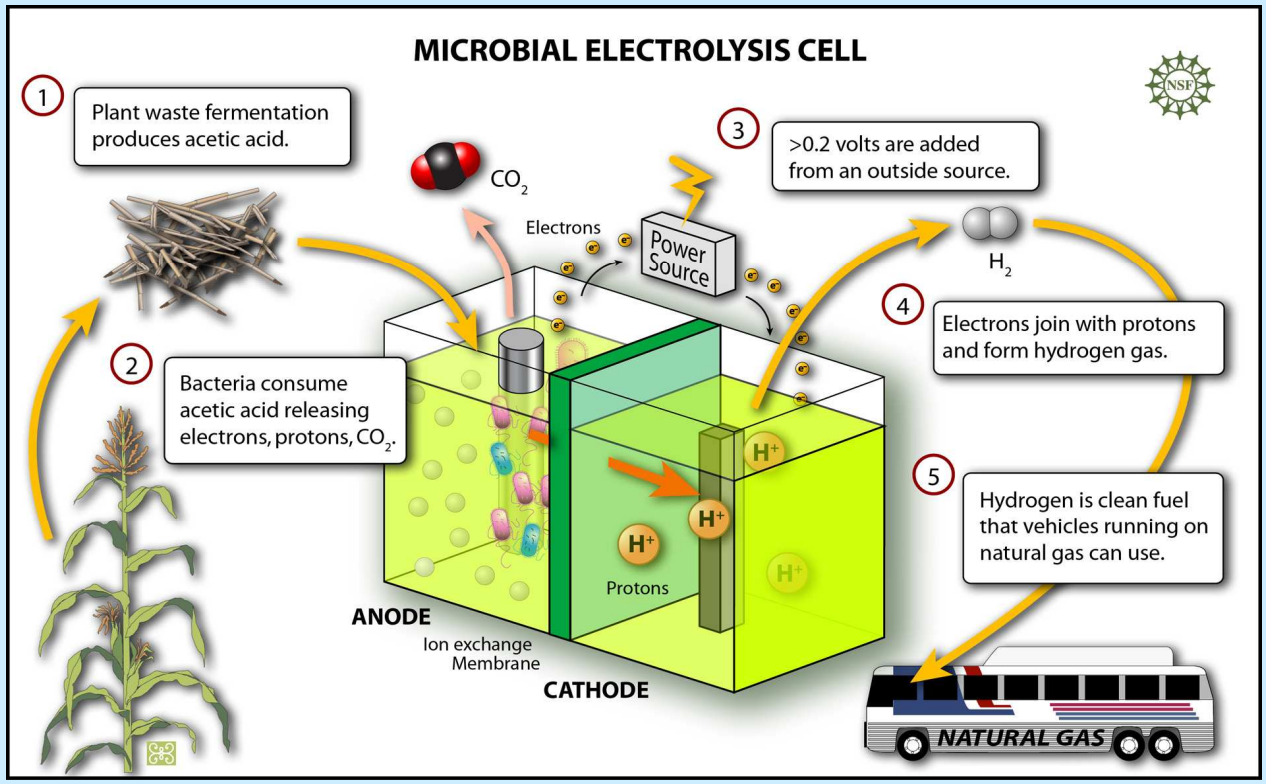


Hydrogen from Plant Waste



Credit: Zina Deretsky, National Science Foundation

It is claimed that the hydrogen energy generated by this process is 288% of the energy that is added to the process as electricity.

Public engagement issues

- What does an awareness of microbially driven climate factors mean for communication of climate change?
- Will balancing out the anthropogenic emphasis take away ‘blame’ for climate change?
- Does bringing in microbes make the message too complicated and unwieldy?
- How much of the public message about climate change is moral as opposed to scientific?

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