Carbon and Nitrogen Cycling

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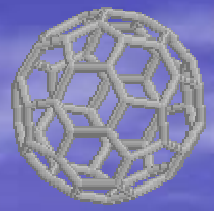
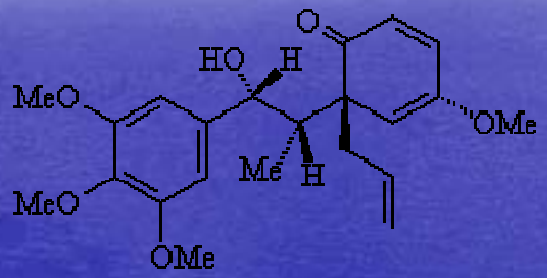
Carbon

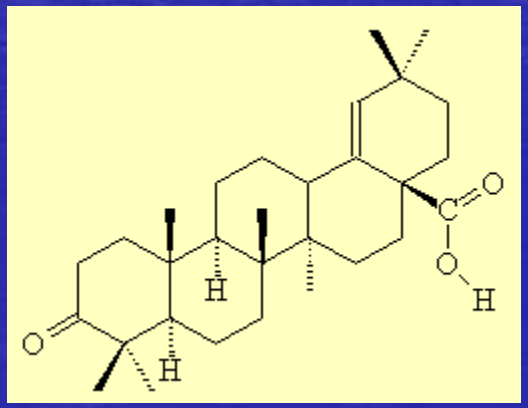


Buckminster Fullerene

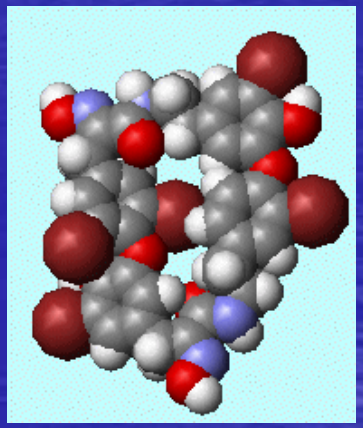
- Fourth most abundant element in the universe
- Basis for life
- 4 bonds
- Forms complex molecules
- Gaseous form



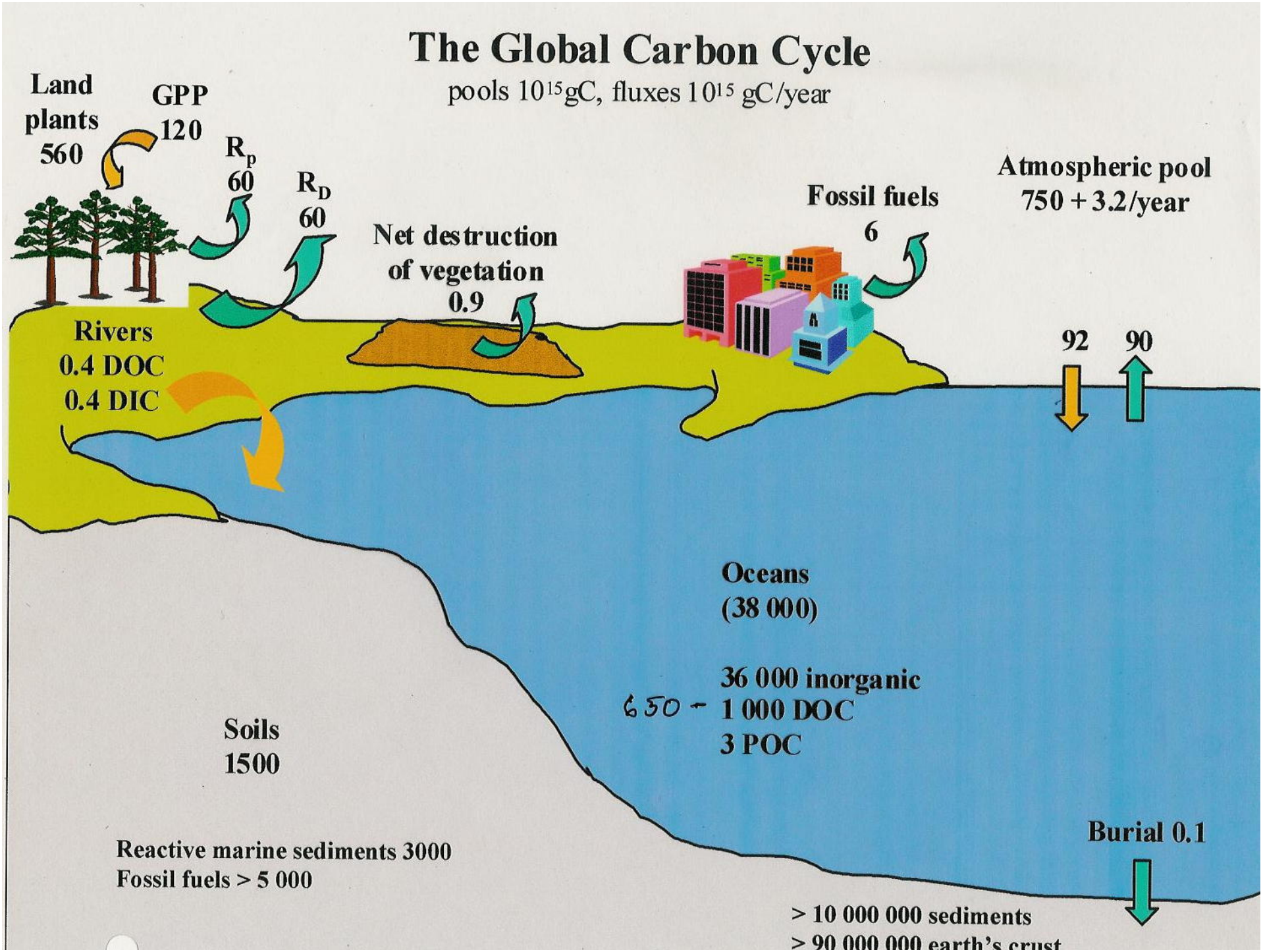
Megaphone



Moronic Acid

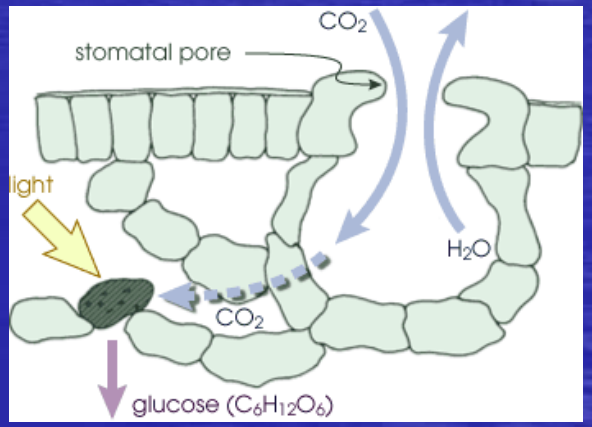


Bastadin-5

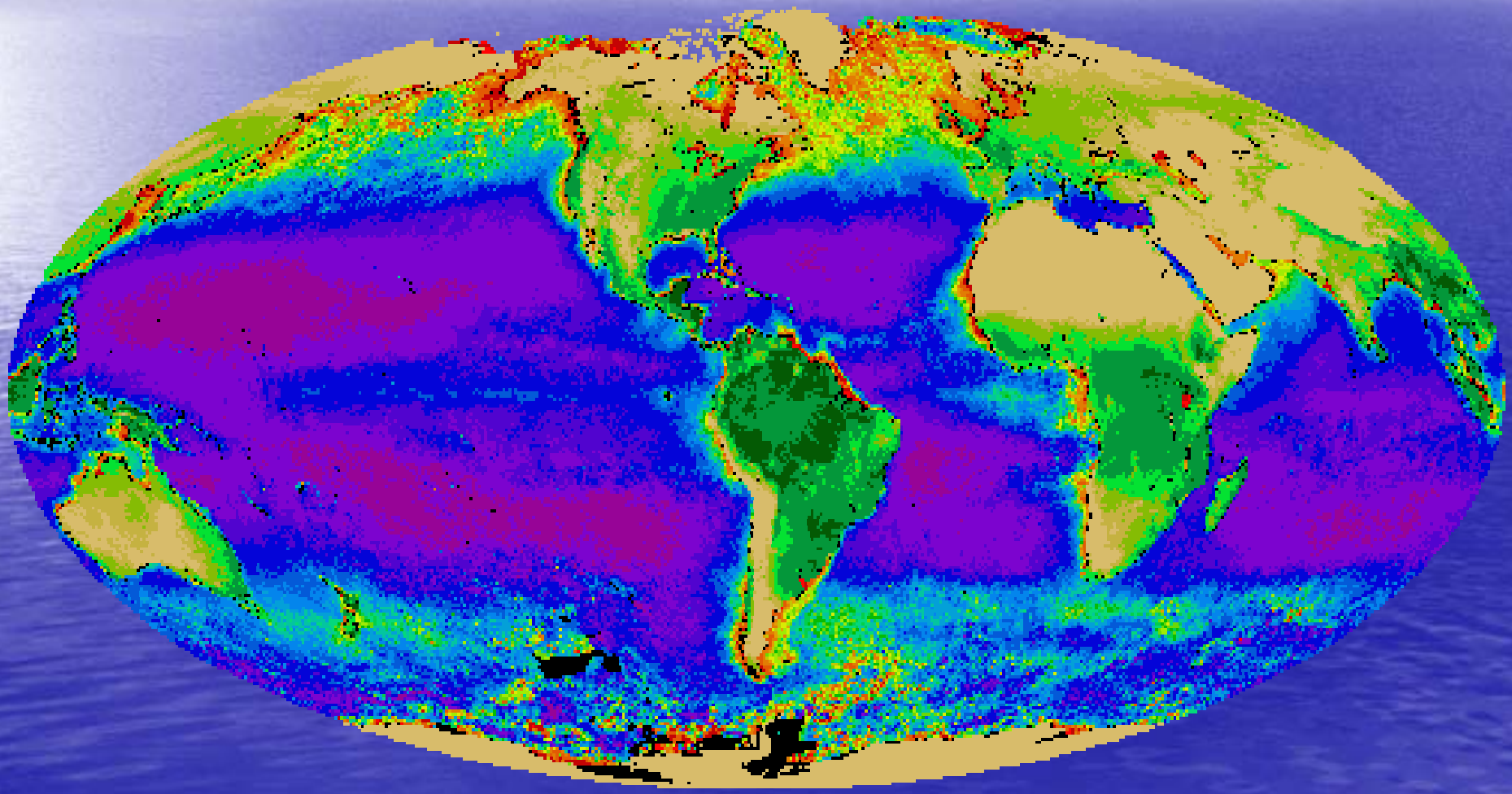

The Global Carbon Cycle
pools 10^{15}gC, fluxes 10^{15} gC/year
Land plants 560
GPP 120
R_p 60
R_D 60
Net destruction of vegetation 0.9
Fossil fuels 6
Atmospheric pool 750 + 3.2/year
Rivers 0.4 DOC 0.4 DIC
92
90
Oceans (38 000)
36 000 inorganic
650 - 1 000 DOC
3 POC
Soils 1500
Burial 0.1
Reactive marine sediments 3000
Fossil fuels > 5 000
> 10 000 000 sediments
> 90 000 000 earth's crust

Photosynthesis

- Where does the mass of a tree come from?
- $CO_2 + H_2O \rightarrow CH_2O + O_2$



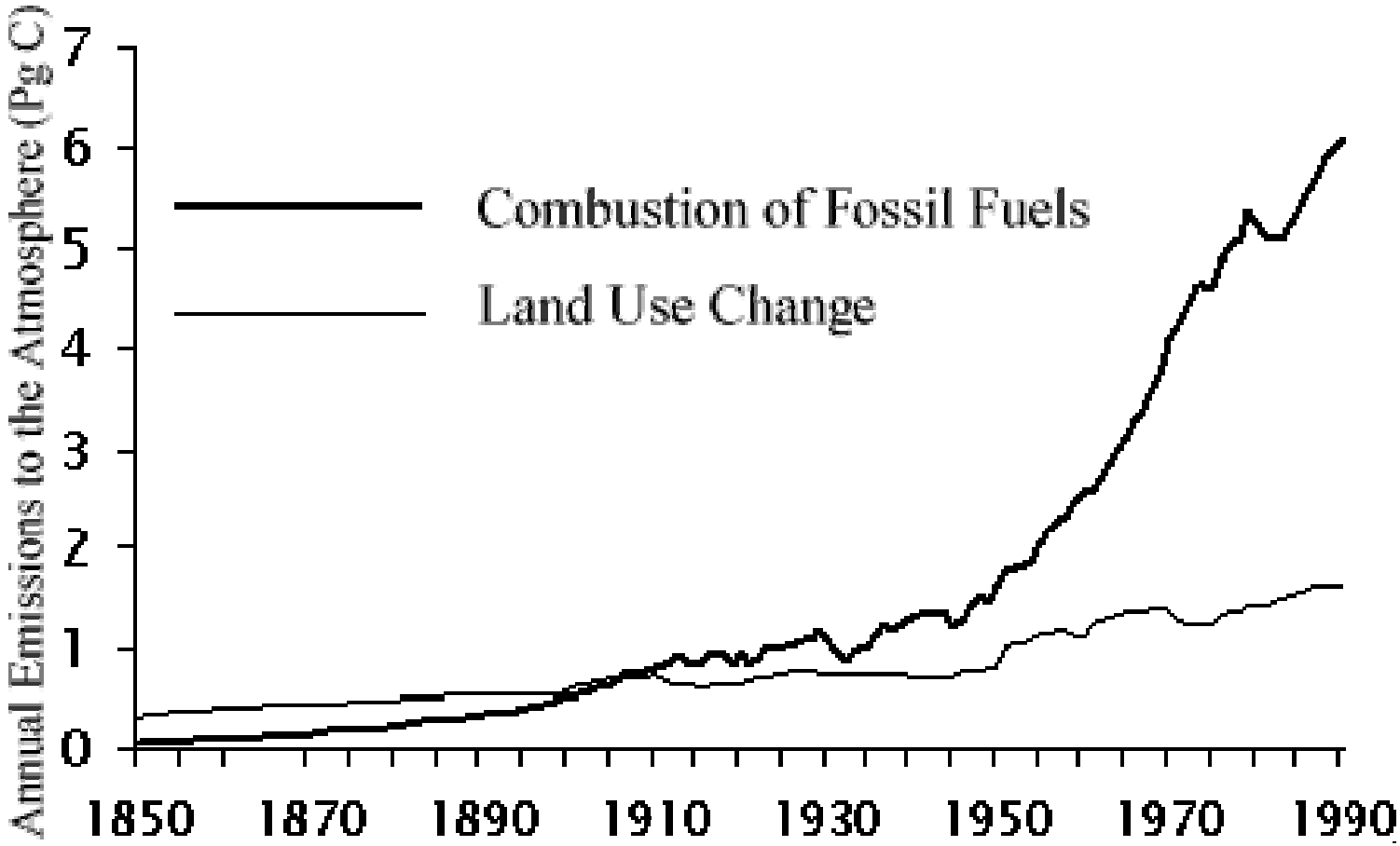
Global Productivity



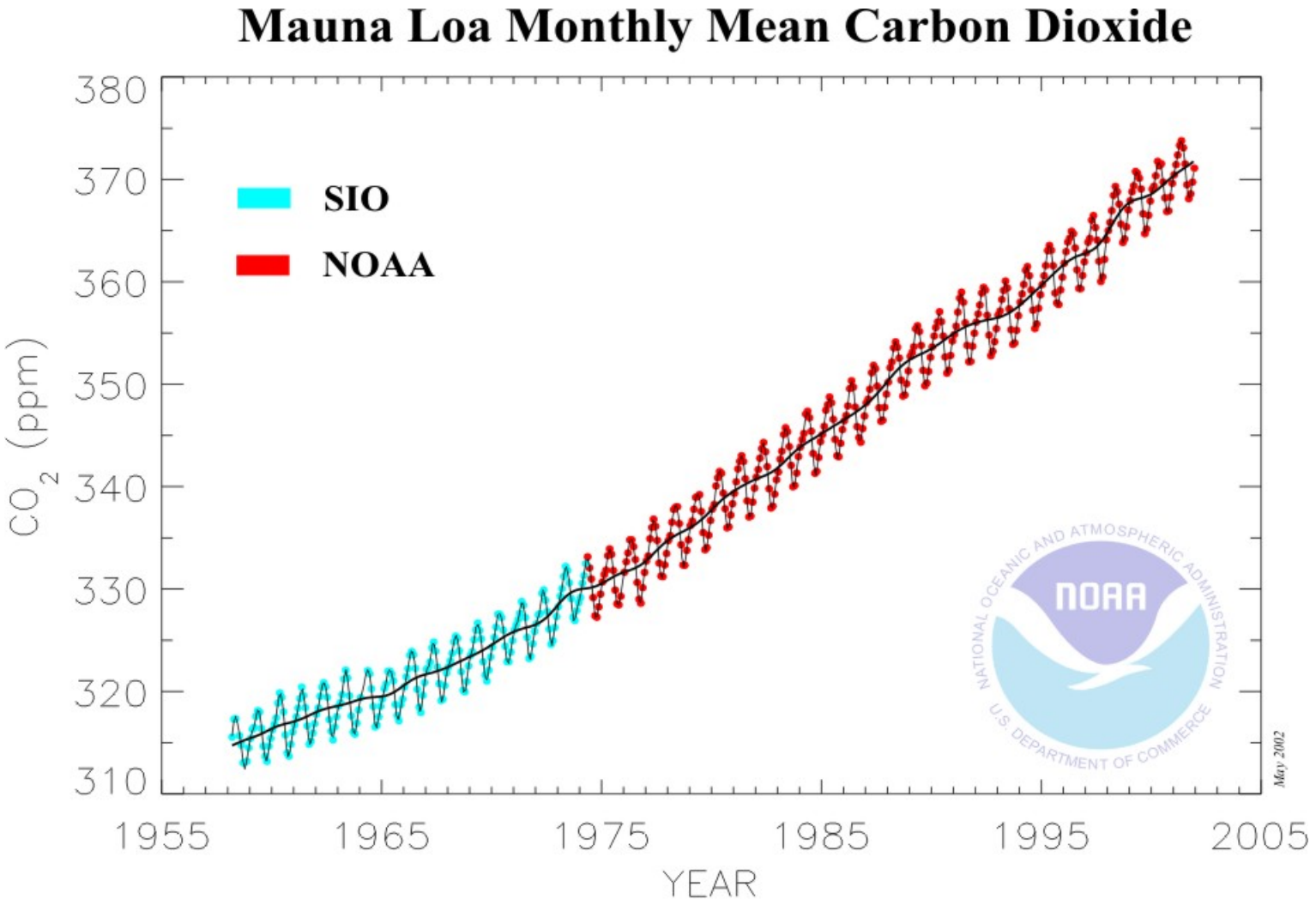
Respiration

- Mitochondria, bacteria, fires, combustion engines
- $O_2 + CH_2O \rightarrow CO_2 + H_2O$
- In earth system, the energy budget is balanced, chemical energy is temporary storage
- In ocean or land, 99.9% carbon is recycled
- Fossil Fuels burned at 20,000 times natural rates of oxidation

CO2 Emissions



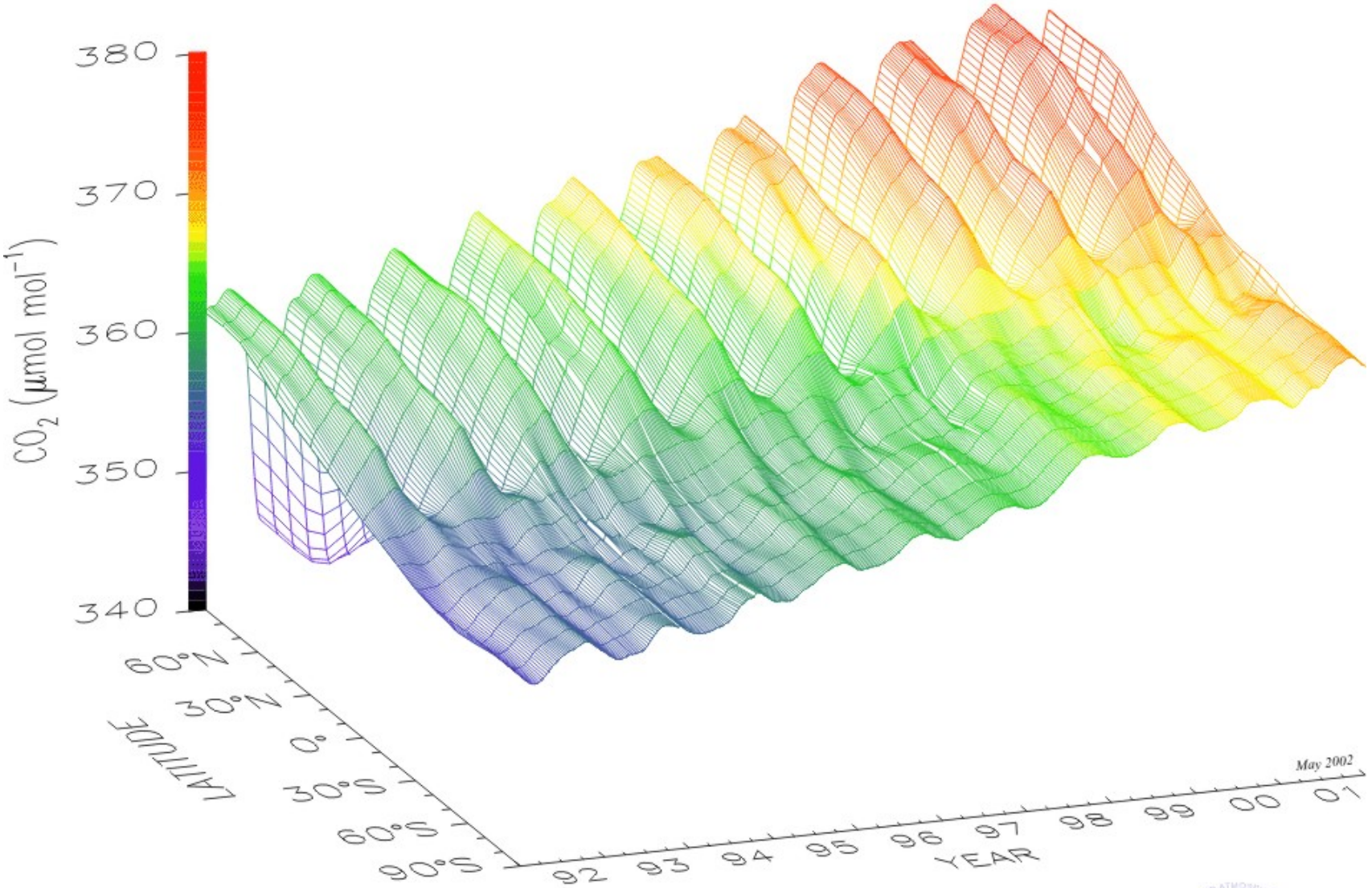
Atmospheric Measurements



Atmospheric carbon dioxide monthly mean mixing ratios. Data prior to May 1974 are from the Scripps Institution of Oceanography (SIO, blue), data since May 1974 are from the National Oceanic and Atmospheric Administration (NOAA, red). A long-term trend curve is fitted to the monthly mean values. Principal investigators: Dr. Pieter Tans, NOAA CMDL Carbon Cycle Greenhouse Gases, Boulder, Colorado, (303) 497-6678, ptans@cmdl.noaa.gov, and Dr. Charles D. Keeling, SIO, La Jolla, California, (616) 534-6001, cdkeeling@ucsd.edu.

Global Distribution of Atmospheric Carbon Dioxide

NOAA CMDL Carbon Cycle Greenhouse Gases



Three dimensional representation of the latitudinal distribution of atmospheric carbon dioxide in the marine boundary layer. Data from the NOAA CMDL cooperative air sampling network were used. The surface represents data smoothed in time and latitude. Principal investigators: Pieter Tans and Thomas Conway, NOAA CMDL Carbon Cycle Greenhouse Gases, Boulder, Colorado, (303) 497-6678 (ptans@cmdl.noaa.gov, http://www.cmdl.noaa.gov/ccgg).

“Missing Sink” of Atmospheric CO2 (in Gigatons Carbon—10^{15}gmC)

- Fossil Fuel Burning =6.0+/- 0.5
- Deforestation =0.9+/-0.7

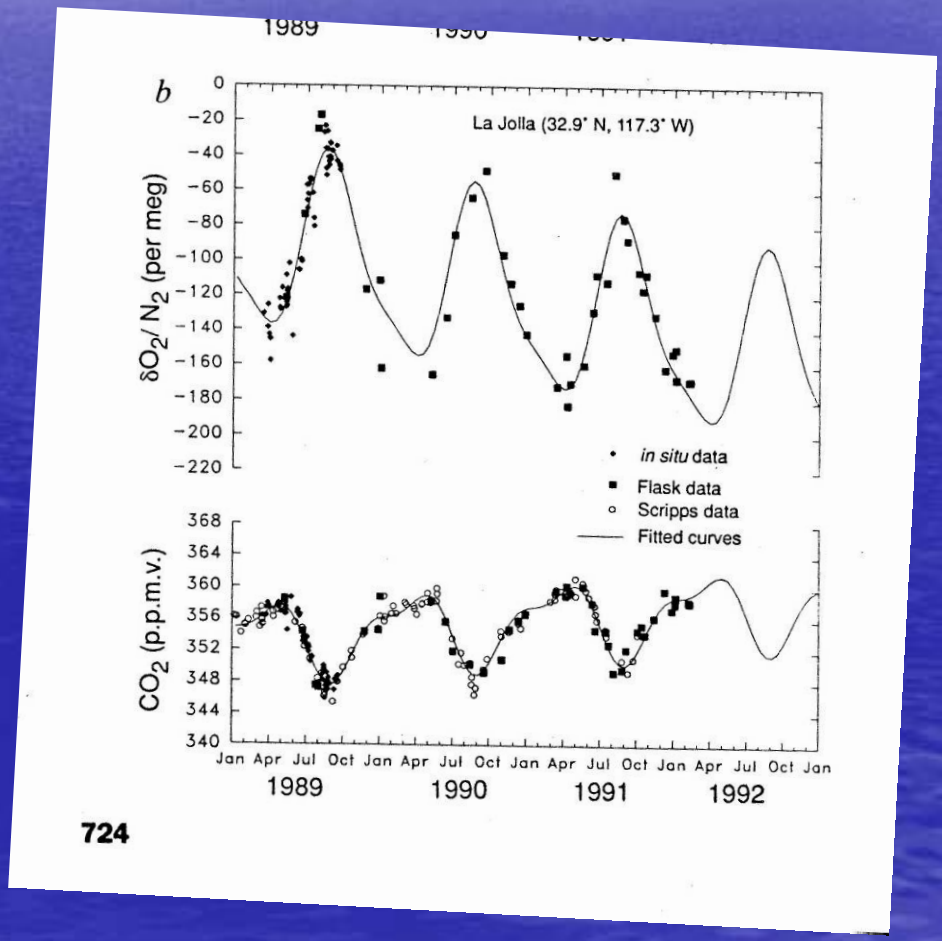
- Atmospheric Increase =3.2+/-0.1
- Oceanic Uptake =2.0 +/-0.8
- “Missing Sink” =1.7 +/1.2

Mass Balance

- Total mass is always conserved
- Each element is also conserved in a closed system
- Can you design a closed system that is sustainable indefinitely?
- Eco-sphere.com

Cycles are linked

- $CO_2 + H_2O \rightarrow CH_2O + O_2$



Biosphere 2

- http://www.b2science.org/about-mission.html
- 7 people, O2 began to drop
- Why?

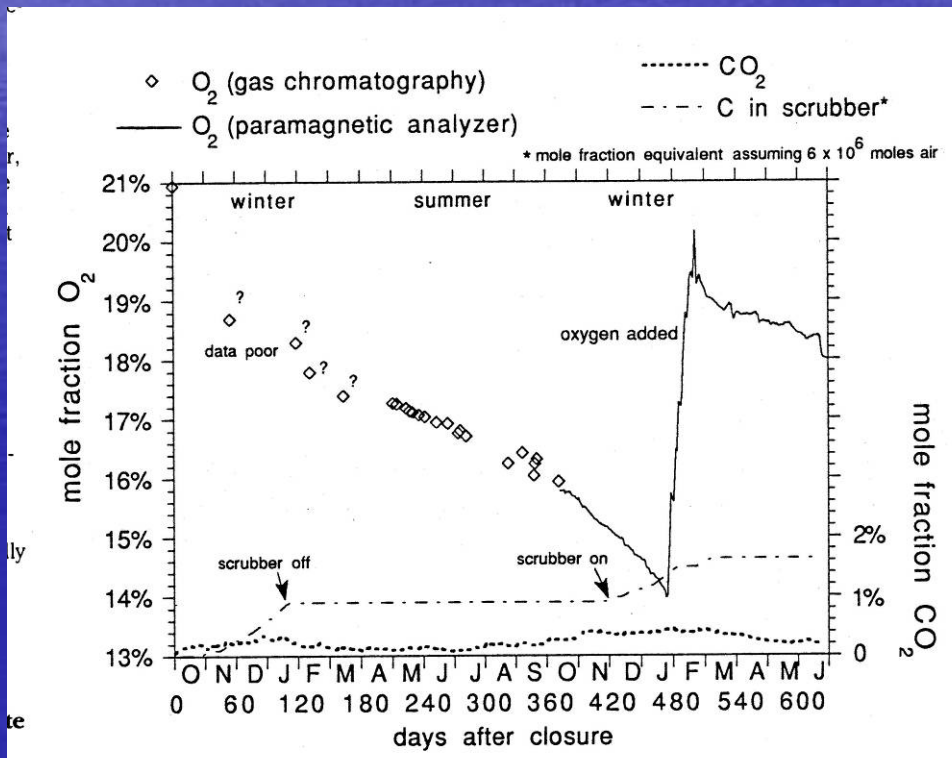
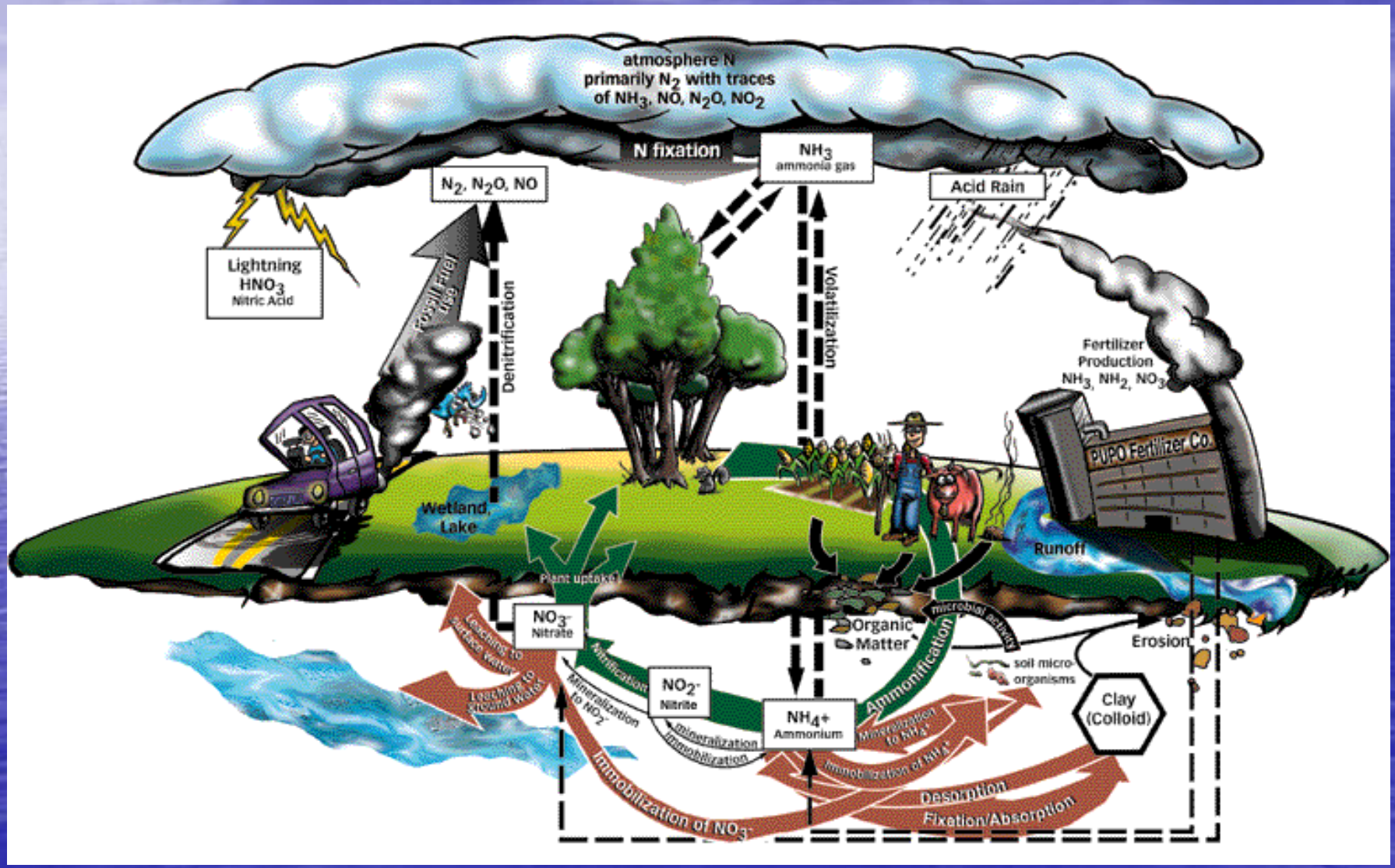


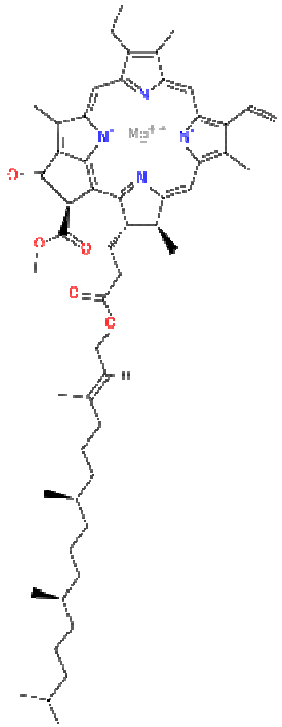
Fig. 1. Oxygen and CO_2 history in Biosphere 2. The same scale is used for O_2 and CO_2 with a 13% offset. Note that oxygen drop is much greater than CO_2 increase, even taking into account the chemical scrubber. This requires the existence of a sink of O_2 or CO_2 other than respiration or photosynthesis.

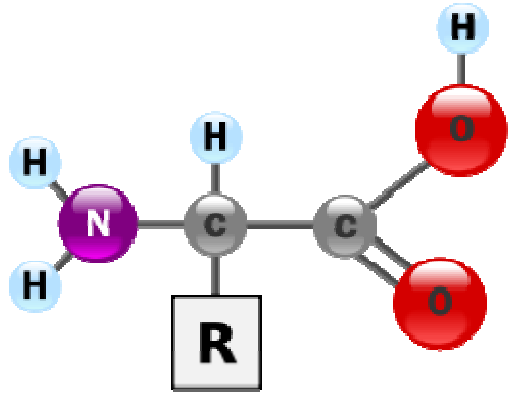
Nitrogen Cycle

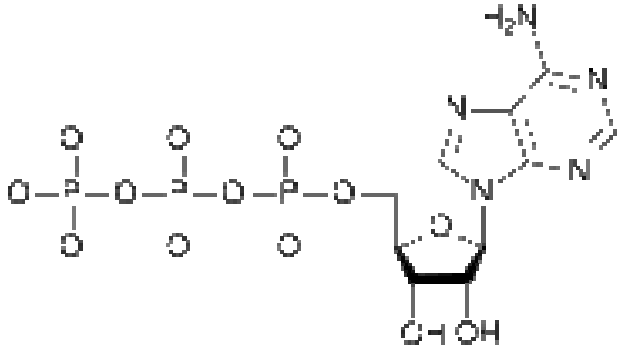


Needs

- Amino Acids→proteins
- Nucleic Acids
- Chlorophyll
- Carbon to Nitrogen ratio



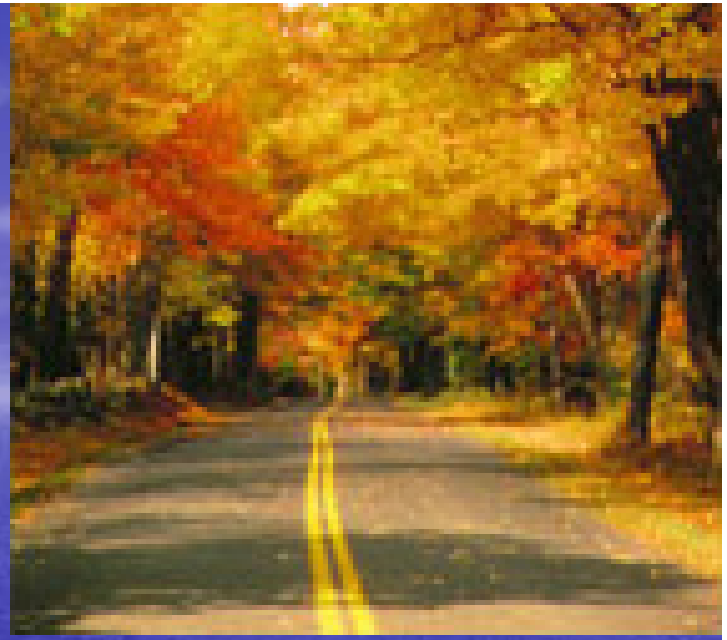




Sources

- Nitrogen Fixing bacteria
  - Legumes
  - Clover
  - Cyanobacteria
- Lightning
- Haber Process (factory fertilizer production)
- Internal combustion engines (cars)
- Mankind has doubled N-inputs to coastal areas→ eutorphication

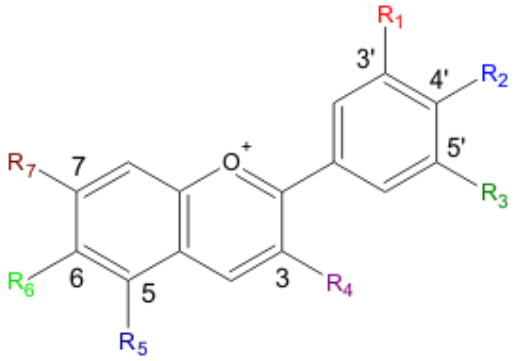
Fall Colors



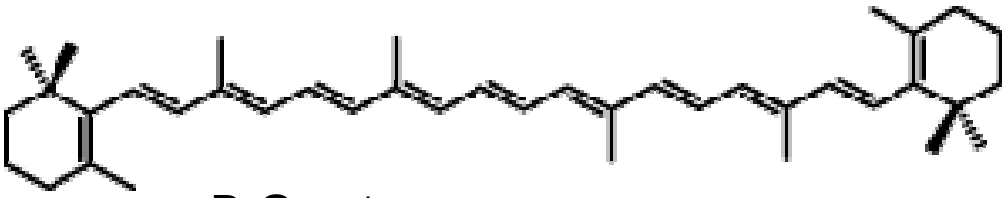
- Chlorophyll-N recalled
- Accessory pigments shown
- Huge loss of C, but not N

Why do leaves turn colors?

- Nutrients
- Pigments
- Carotenoids, Xanthophylls
- Anthocyanins

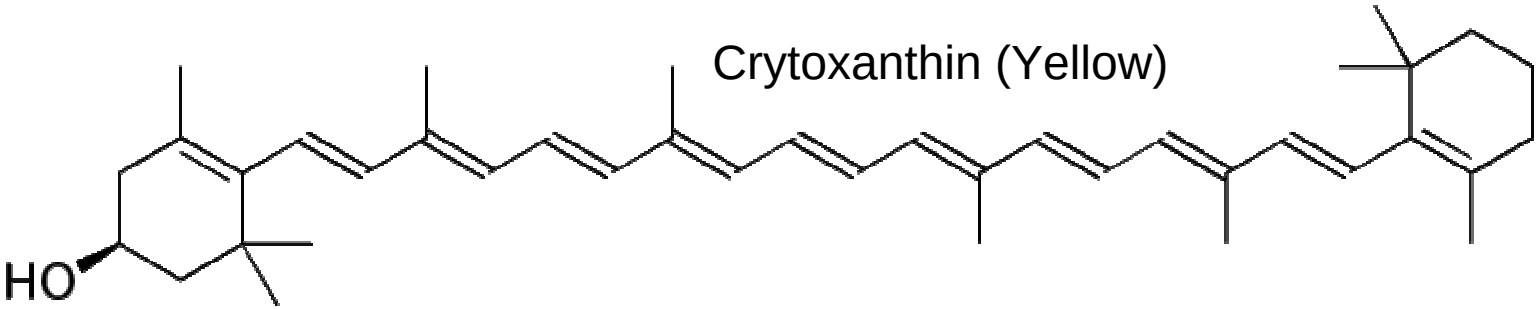


Anthocyandin (purple)



B-Carotene

Crytoxanthin (Yellow)



Lawn calculation

- If you add 1 pound of nitrogen fertilizer to your lawn, how many pounds of lawn clippings must you carry away?
- Water
- Carbon/Nitrogen ratio

Biogeochemistry

- Conservation of mass in a system
- Discover missing processes through box model budget
- Use tracers (biomarkers, elements, isotopes, radionuclides) to elucidate processes
- Variety of temporal and spatial scales