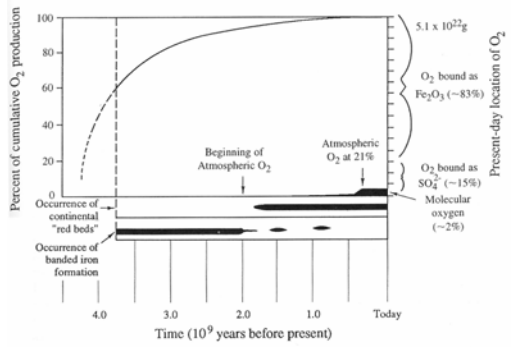
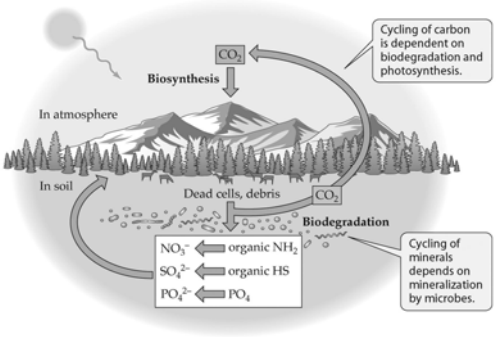


Figure 2.7 Cumulative history of O_2 released by photosynthesis through geologic time. Of more than 5.1×10^{22} g of O_2 released, about 98% is contained in seawater and sedimentary rocks, beginning with the occurrence of Banded Iron Formations at least 3.5 billion years ago (bya). Although O_2 was released to the atmosphere beginning about 2.0 bya, it was consumed in terrestrial weathering processes to form Red Beds, so that the accumulation of O_2 to present levels in the atmosphere was delayed to 400 mya. Modified from Schidlowski (1980).

Figure 11.7 Banded iron formations. An exposed cliff about 10 m in height containing layers of iron oxides interspersed with layers containing iron silicates and other silica materials. Brockman Iron Formation, Hammersley Basin, Western Australia. The iron oxides contain iron in the ferric (Fe^{3+}) form produced from ferrous iron (Fe^{2+}) primarily by the oxygen released by cyanobacterial photosynthesis.

Balance between biosynthesis and biodegradation



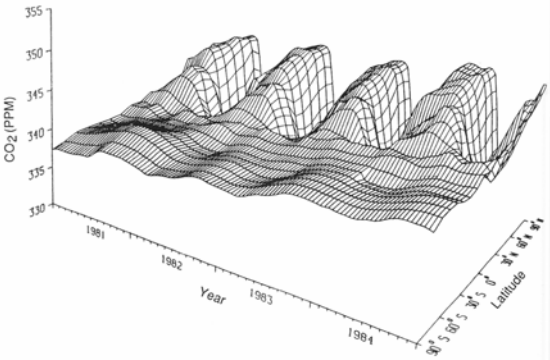
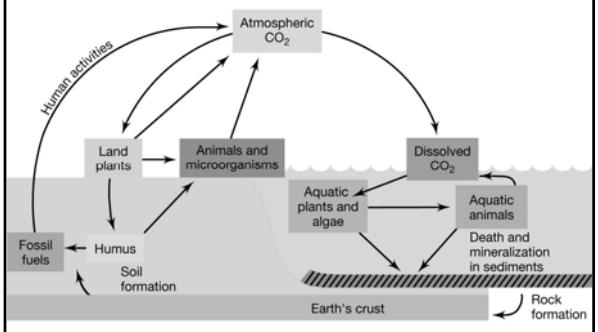
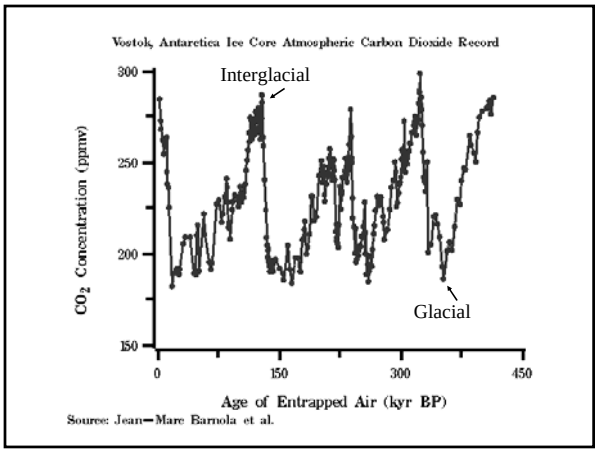


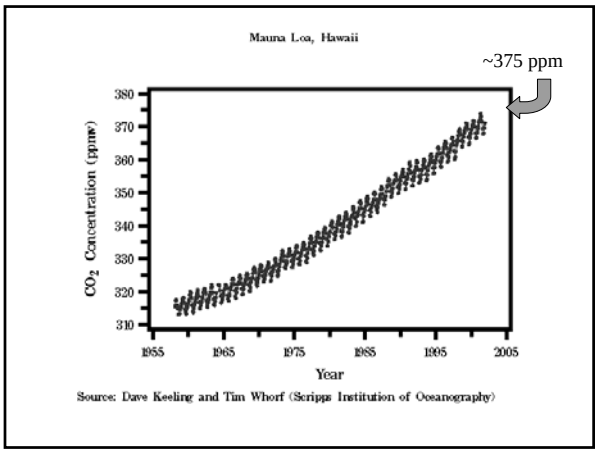
Figure 3.6 Seasonal fluctuations in the concentration of atmospheric CO_2 (1981–1984), shown as a function of 10° latitudinal belts (Conway et al. 1988). Note the smaller amplitude of the fluctuations in the southern hemisphere, reaching peak concentrations during northern hemisphere minima.

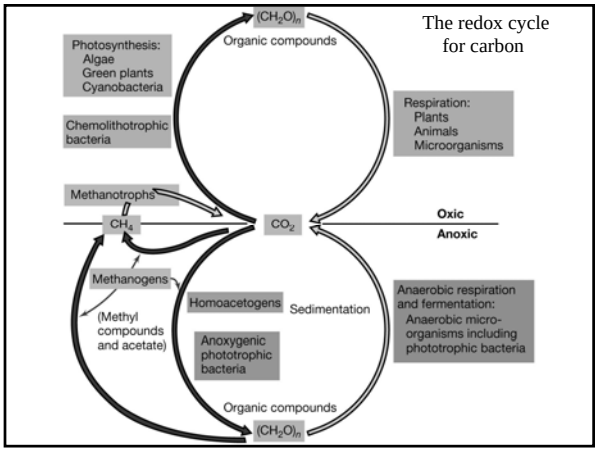
The carbon cycle, closely connected with oxygen cycle

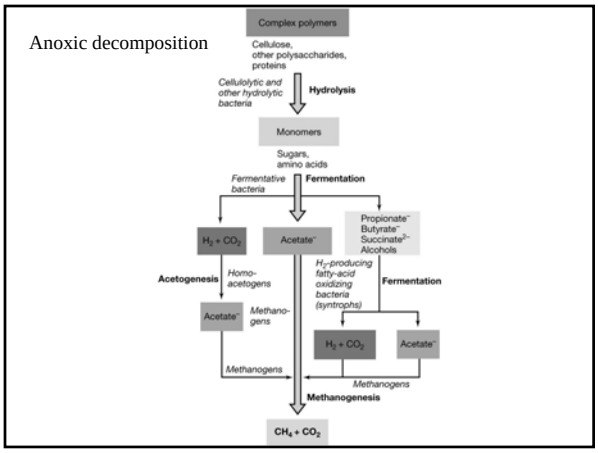


Most carbon in carbonate rocks & sediments

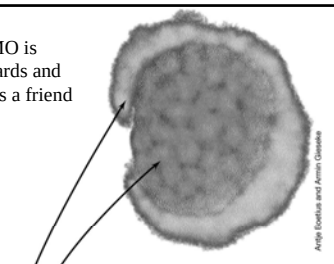



Mauna Loa, Hawaii
~375 ppm
CO_2 Concentration (ppmv)
380
370
360
350
340
330
320
310
1955
1965
1975
1985
1995
2005
Year
Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)


The redox cycle for carbon
$(CH_2O)_n$
Organic compounds
Photosynthesis:
Algae
Green plants
Cyanobacteria
Chemolithotrophic bacteria
Respiration:
Plants
Animals
Microorganisms
Methanotrophs
CH_4
CO_2
Oxic
Anoxic
Methanogens
(Methyl compounds and acetate)
Homoacetogens
Sedimentation
Anoxygenic phototrophic bacteria
Anaerobic respiration and fermentation:
Anaerobic micro-organisms including phototrophic bacteria
Organic compounds
$(CH_2O)_n$


Anoxic decomposition
Complex polymers
Cellulose, other polysaccharides, proteins
Cellulolytic and other hydrolytic bacteria
Hydrolysis
Monomers
Sugars, amino acids
Fermentative bacteria
Fermentation
$H_2 + CO_2$
Acetate⁻
Propionate⁻
Butyrate⁻
Succinate²⁻
Alcohols
Acetogenesis
Homo-acetogens
H_2-producing fatty-acid oxidizing bacteria (syntrophs)
Fermentation
Acetate⁻
Methano-gens
$H_2 + CO_2$
Acetate⁻
Methanogens
Methanogens
Methanogenesis
$CH_4 + CO_2$

AMO is backwards and requires a friend



(a)

Reaction	Organism	$\Delta G^{0'}$(kJ)
$CH_4 + 2\,H_2O \longrightarrow CO_2 + 4\,H_2$	Methanogen	+131
$SO_4^{2-} + 4\,H_2 + H^+ \longrightarrow HS^- + 4\,H_2O$	Sulfate-reducer	−156
Sum: $SO_4^{2-} + CH_4 \longrightarrow HCO_3^- + HS^- + H_2O$	Syntrophic reaction	−25

(b)

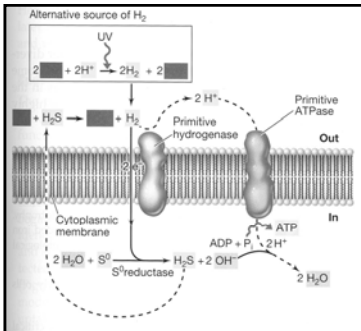


Figure 11.6 A possible energy-generating scheme for primitive cells. Formation of pyrite leads to H_2 production and S^0 reduction, which fuels a primitive ATPase. Note how H_2S plays only a catalytic role; the net substrates would be FeS and S^0. Also note how few different proteins would be required. The $\Delta G^{0'}$ of the reaction $FeS + H_2S \rightarrow FeS_2 + H_2 = -42$ kJ. An alternative source of H_2 could have been the UV-catalyzed reduction of H^+ by Fe^{2+} as shown.

Chemosynthesis or Photosynthesis???

Simple hydrogenase or simple rhodopsin???

Porphyrin ring opens many possibilities for metabolic diversity!!!

Which ones are Domain specific?

Cytochromes: Bacteria…
Chlorophyll: Bacteria…
Corrinoids: Archaea only