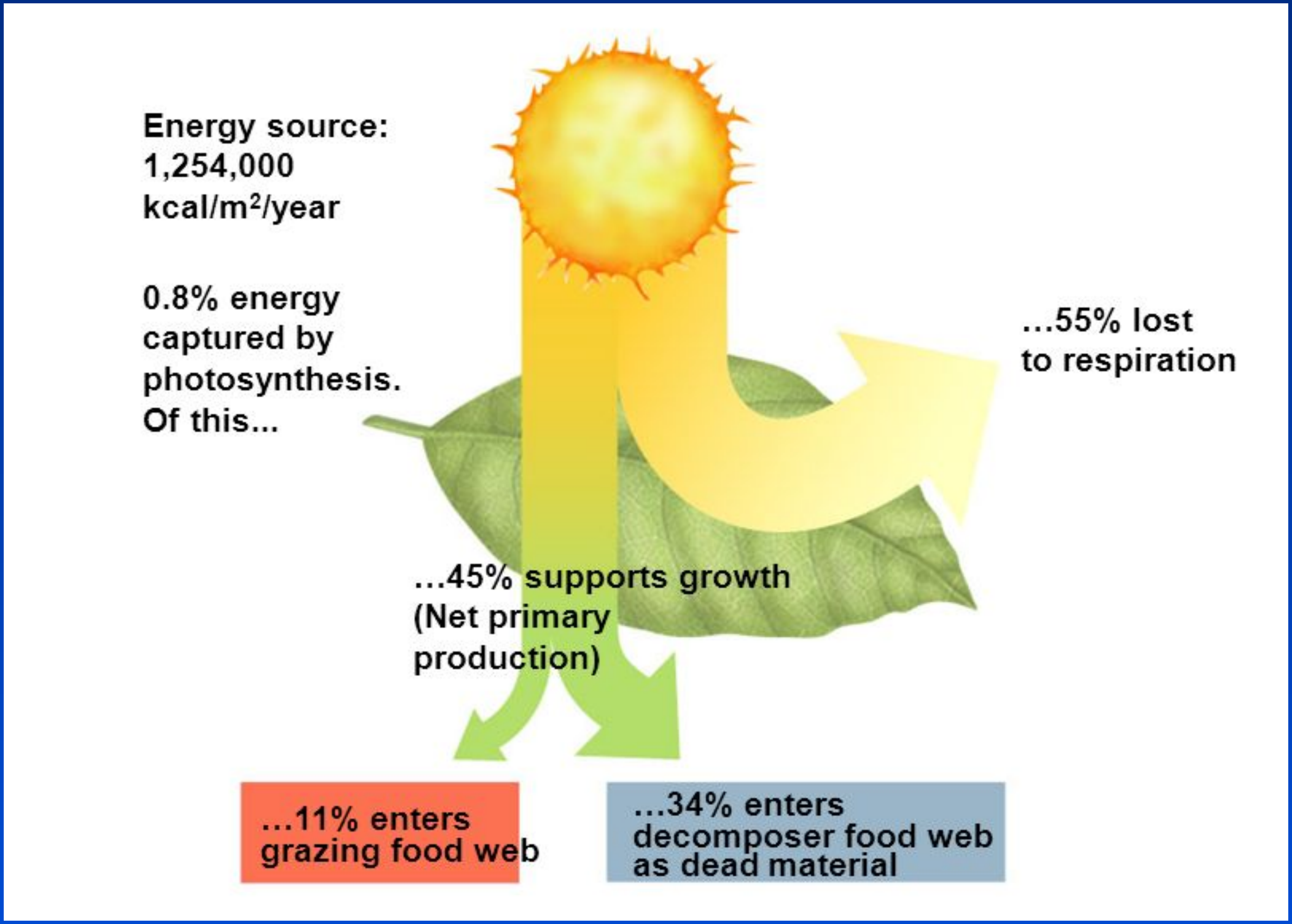
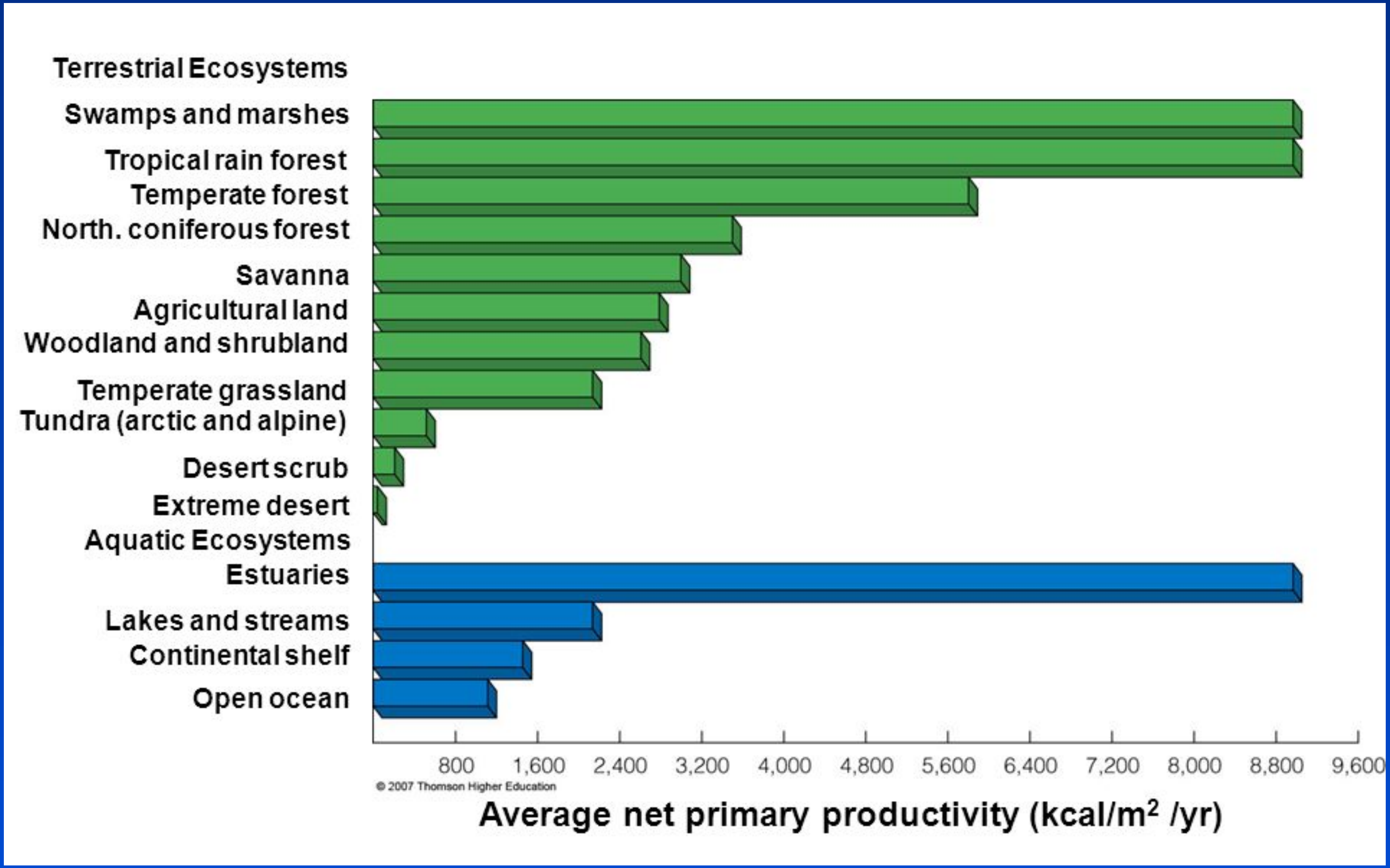
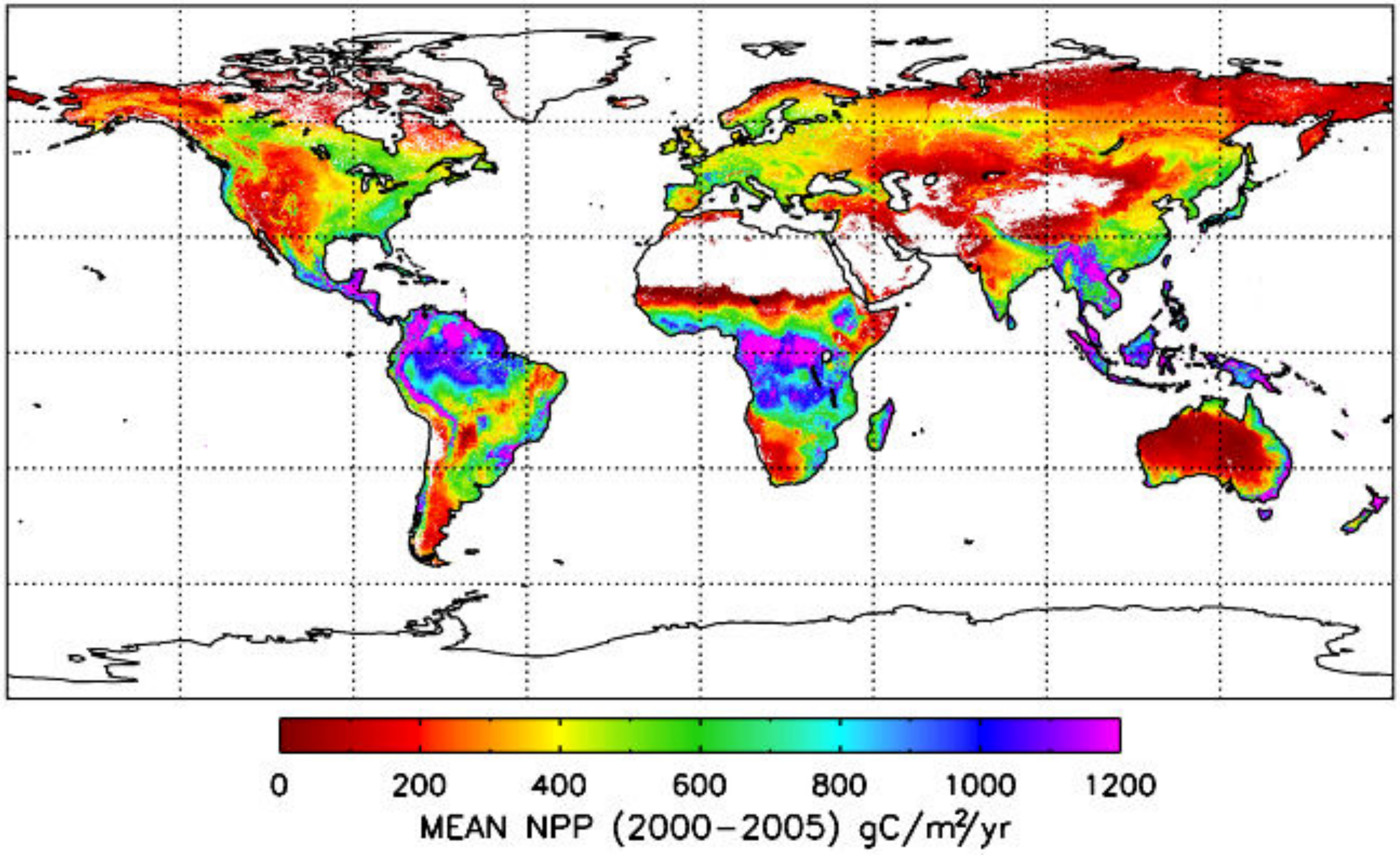
Net vs Gross Primary production



Net primary productivity
Terrestrial vs marine ecosystems



Net primary productivity (annual average)
Terrestrial systems



Primary production in terrestrial systems

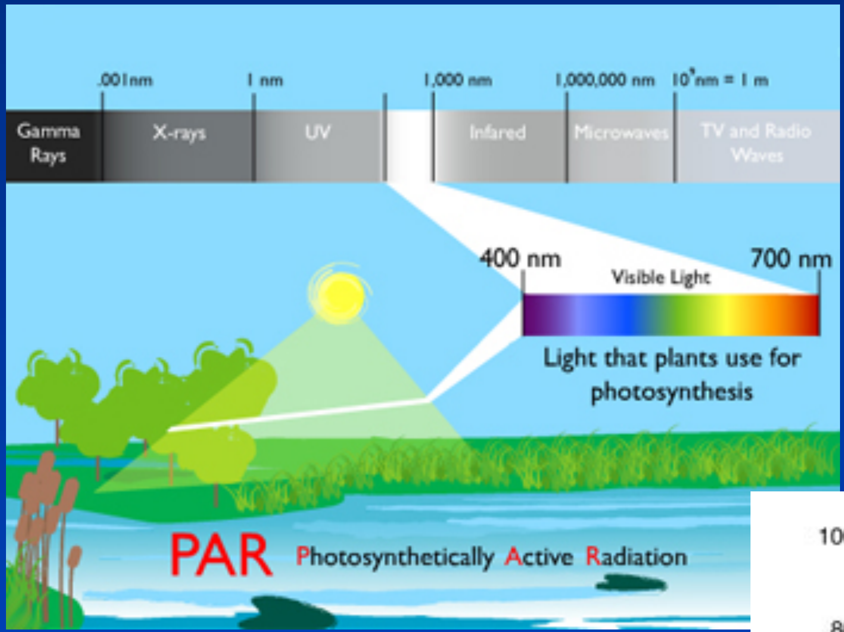
PP in terrestrial ecosystems is performed by autotrophic plants through photosynthetic processes

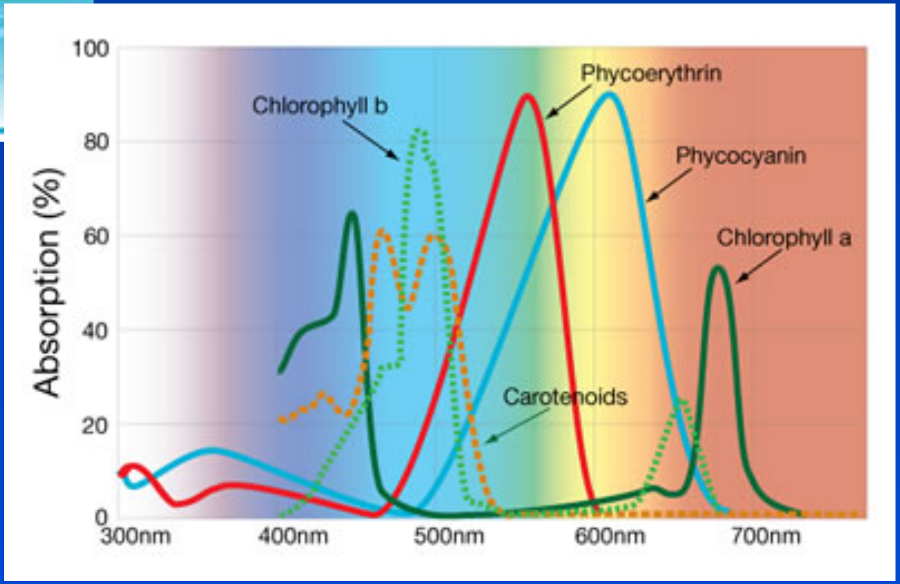
C3, C4, CAM etc.

Principal factors affecting terrestrial PP are:

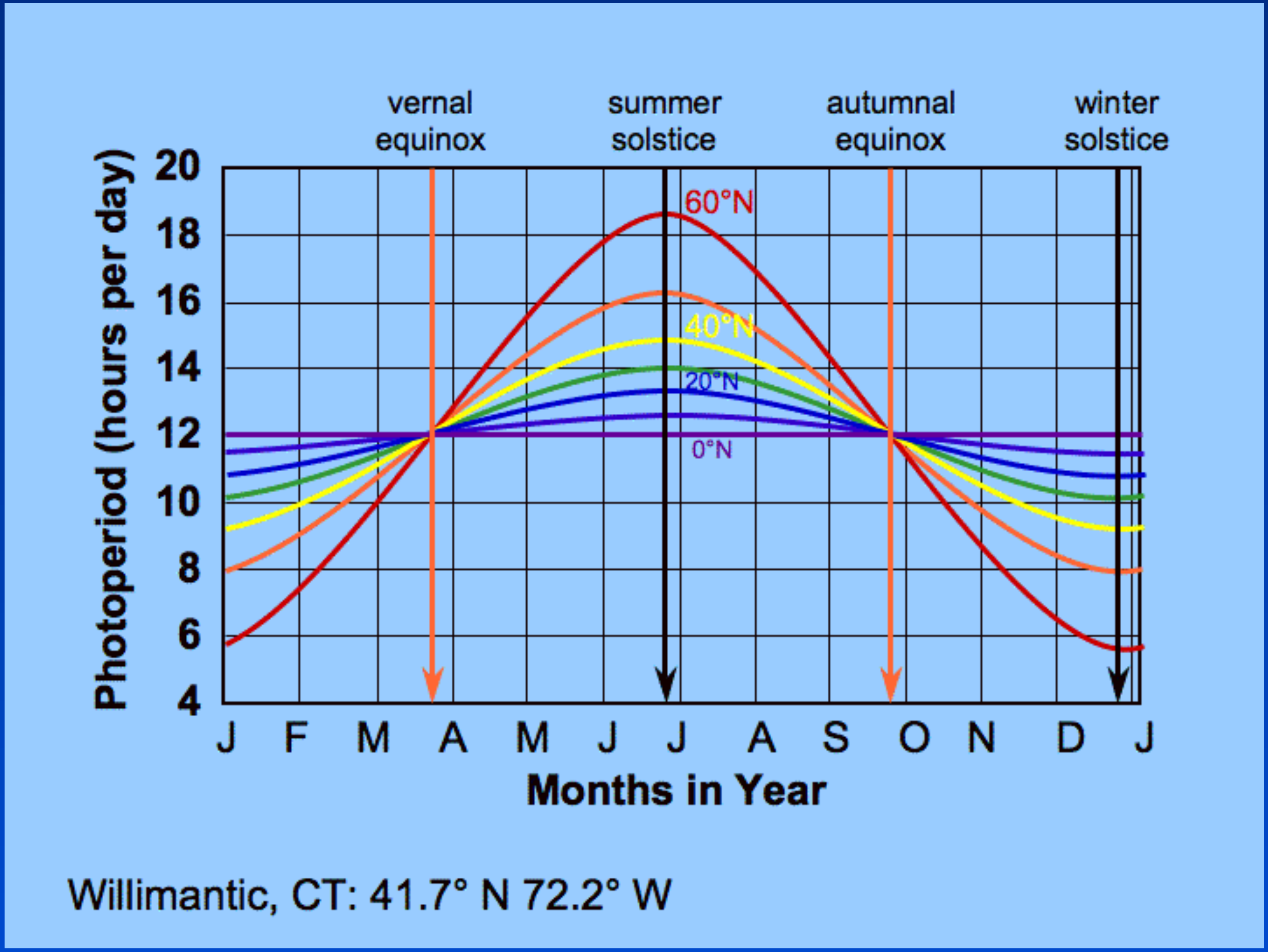
- ✓ Light availability (season/latitude)
- ✓ Nutrient availability (soil composition, recycling)
- ✓ Water availability (precipitation, soil physical characteristics)
- ✓ Disturb such as fire, grazing (natural and anthropogenic)

Photosynthetically Active Radiation





Photoperiod length



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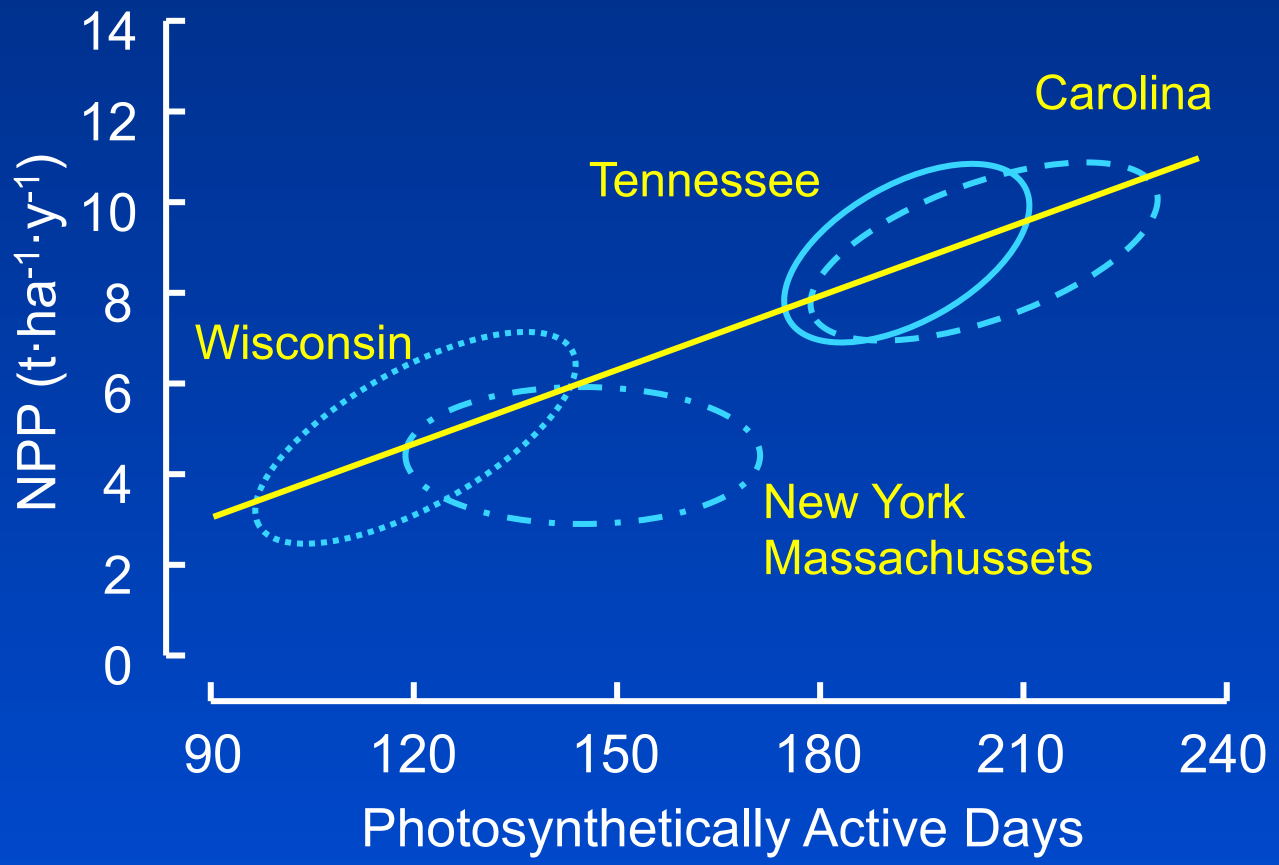
Net Primary Productivity in temperate forests

Central-East USA



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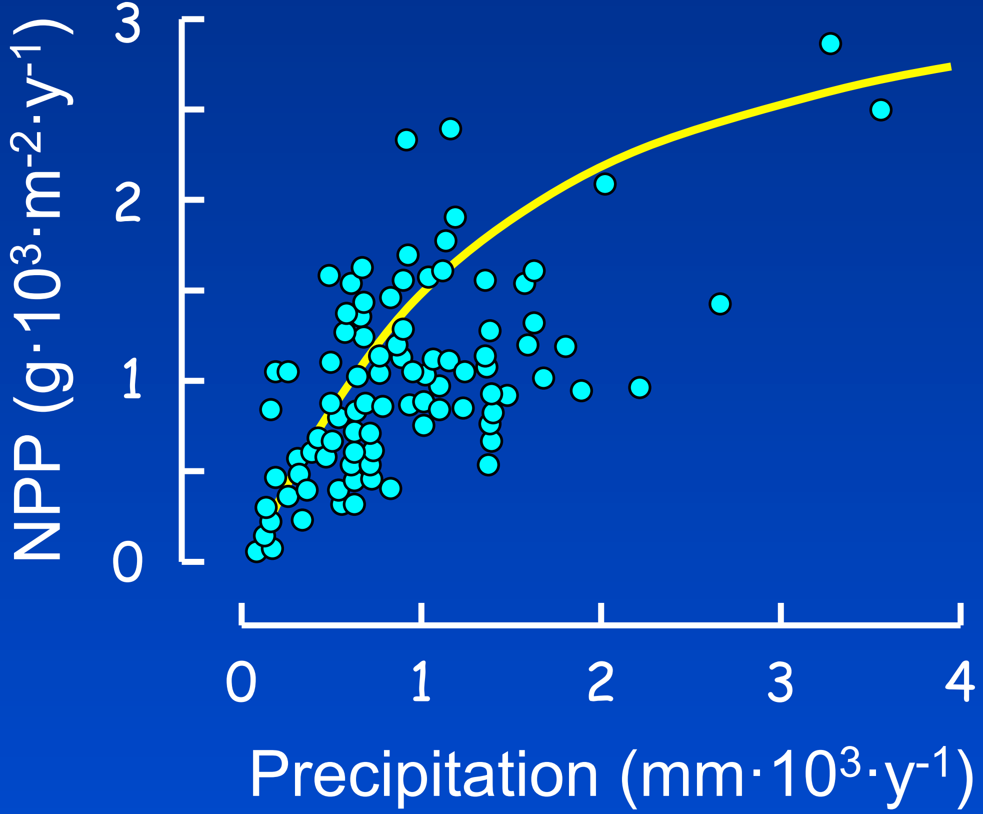
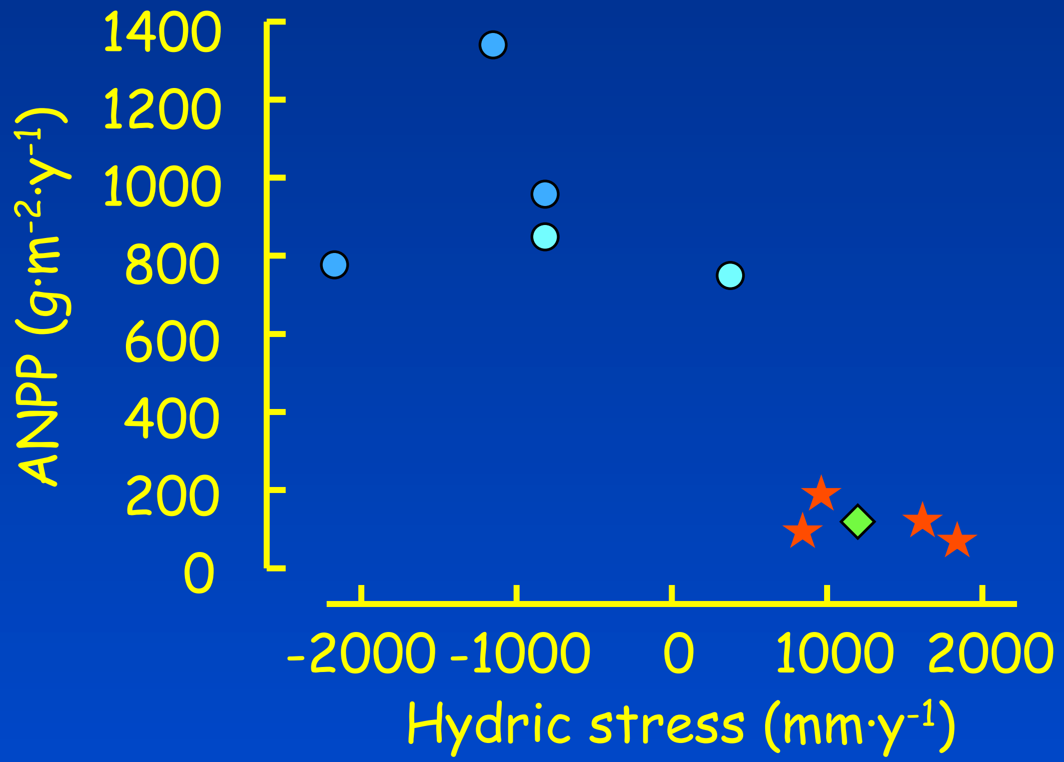
NPP relationship with precipitations

Temperate forests Europe and USA



NPP relationship with hydric stress

Temperate forests Europe and USA



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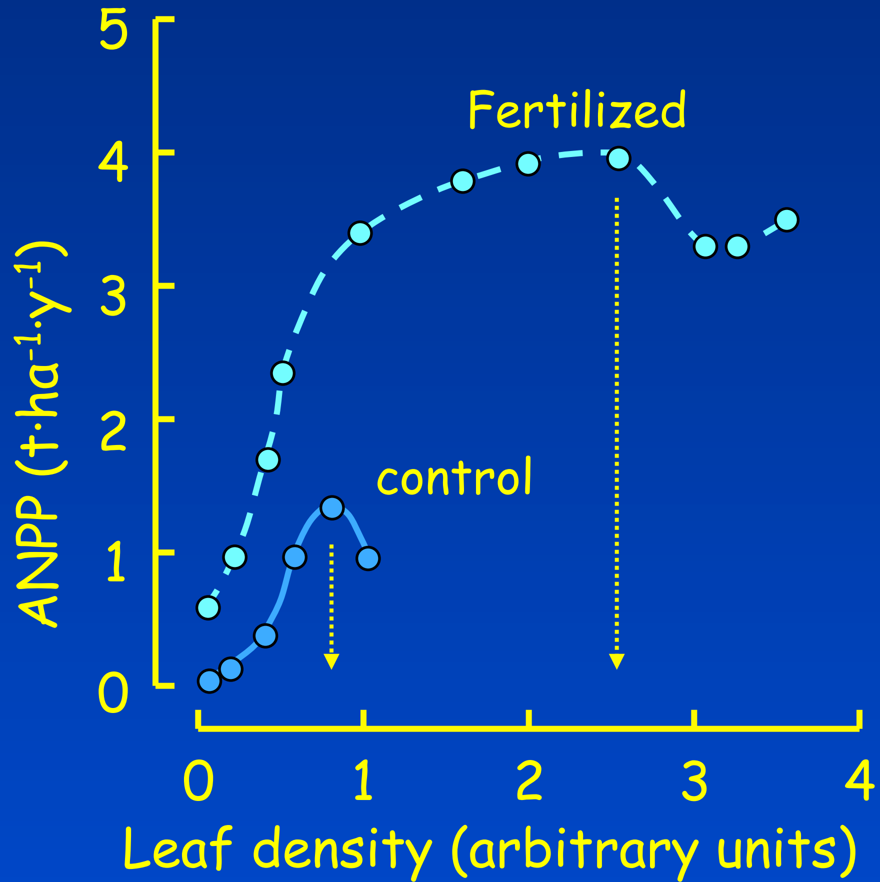
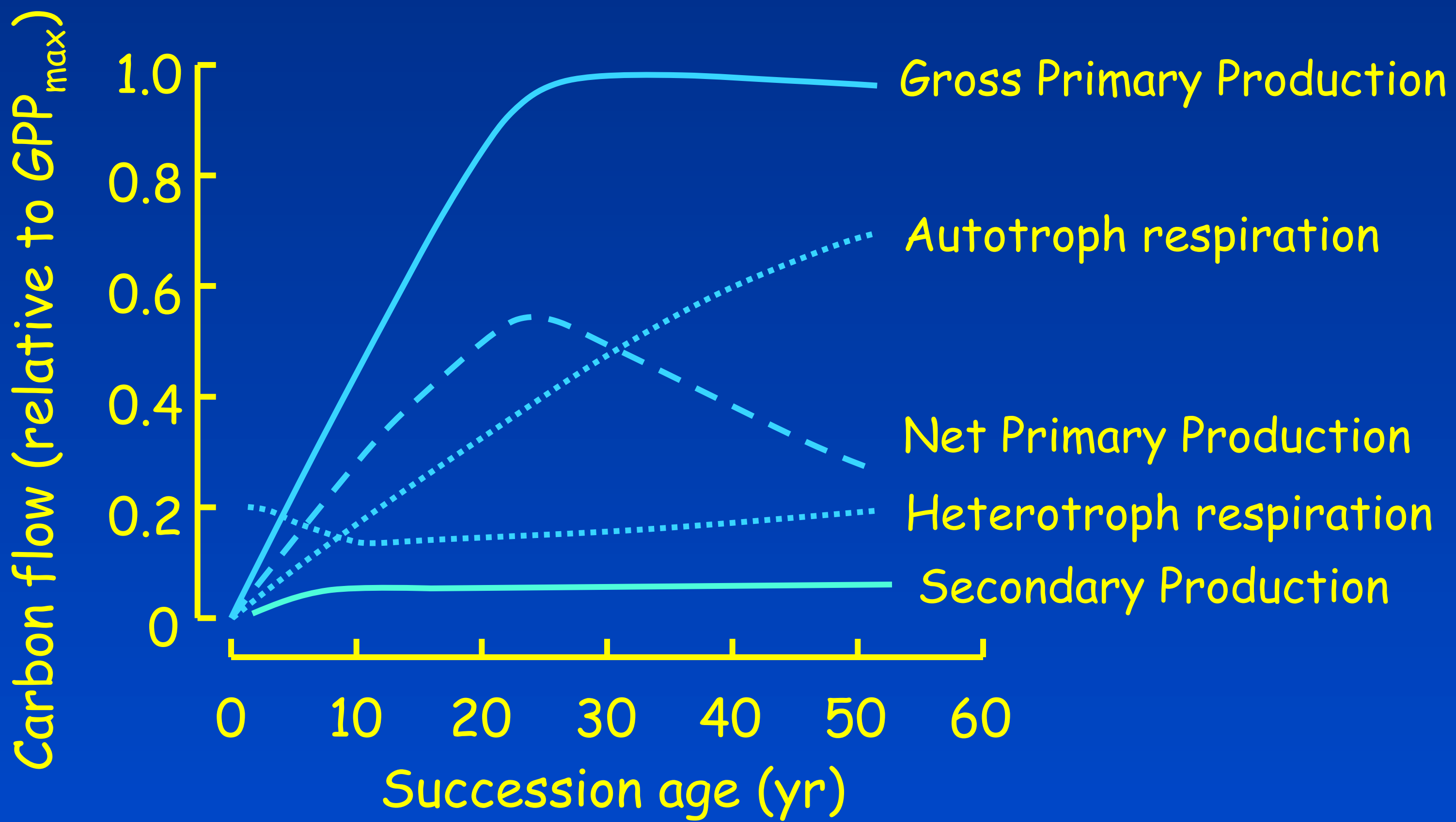
NPP increase with soil fertilization

Chestnut stand



Production and respiration along the succession

in an evergreen temperate forest (schematic)



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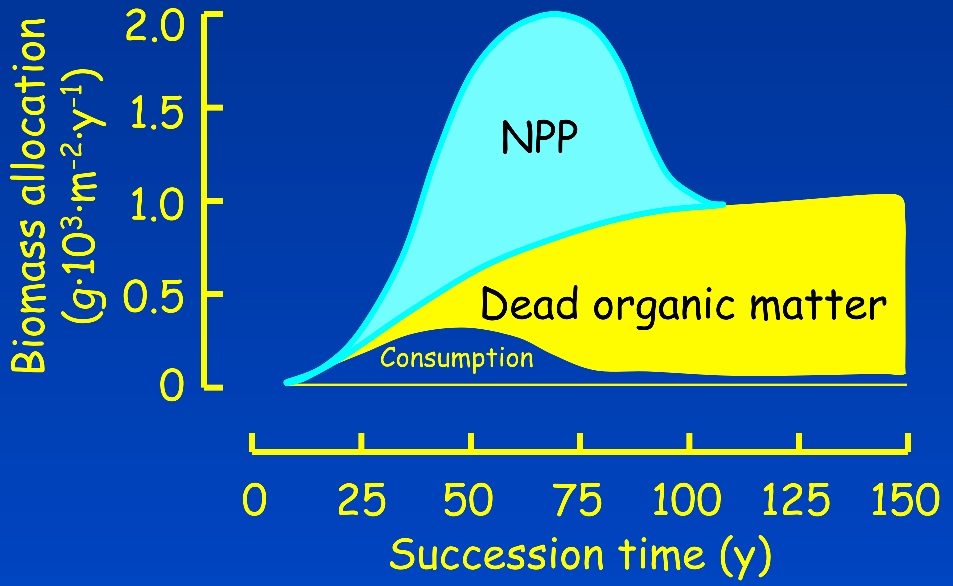
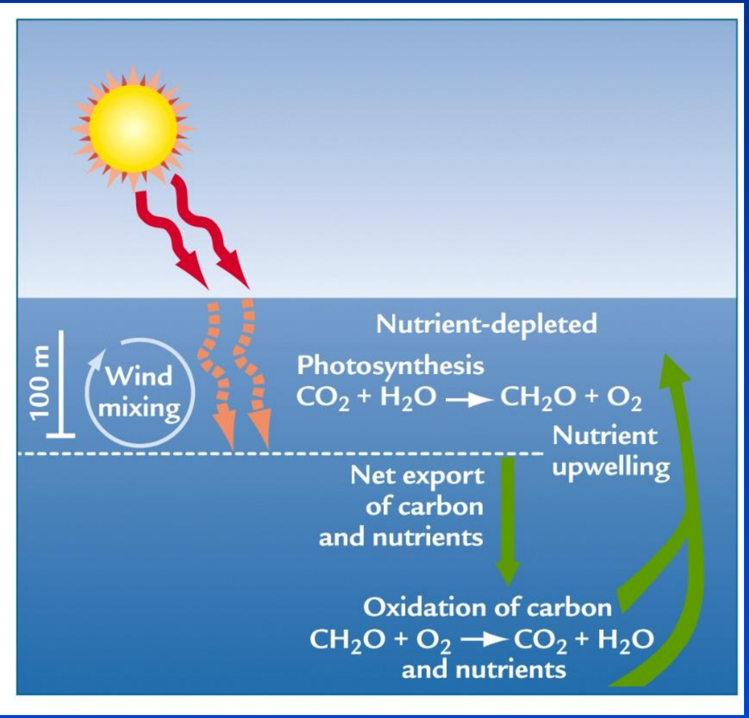
Biomass allocation along the succession

in a broadleaf temperate forest (schematic)



Primary production in oceanic systems

Most of oceanic PP is from photosynthetic phytoplancton operating at the ocean surface in the euphotic zone (ten to hundreds m depth)



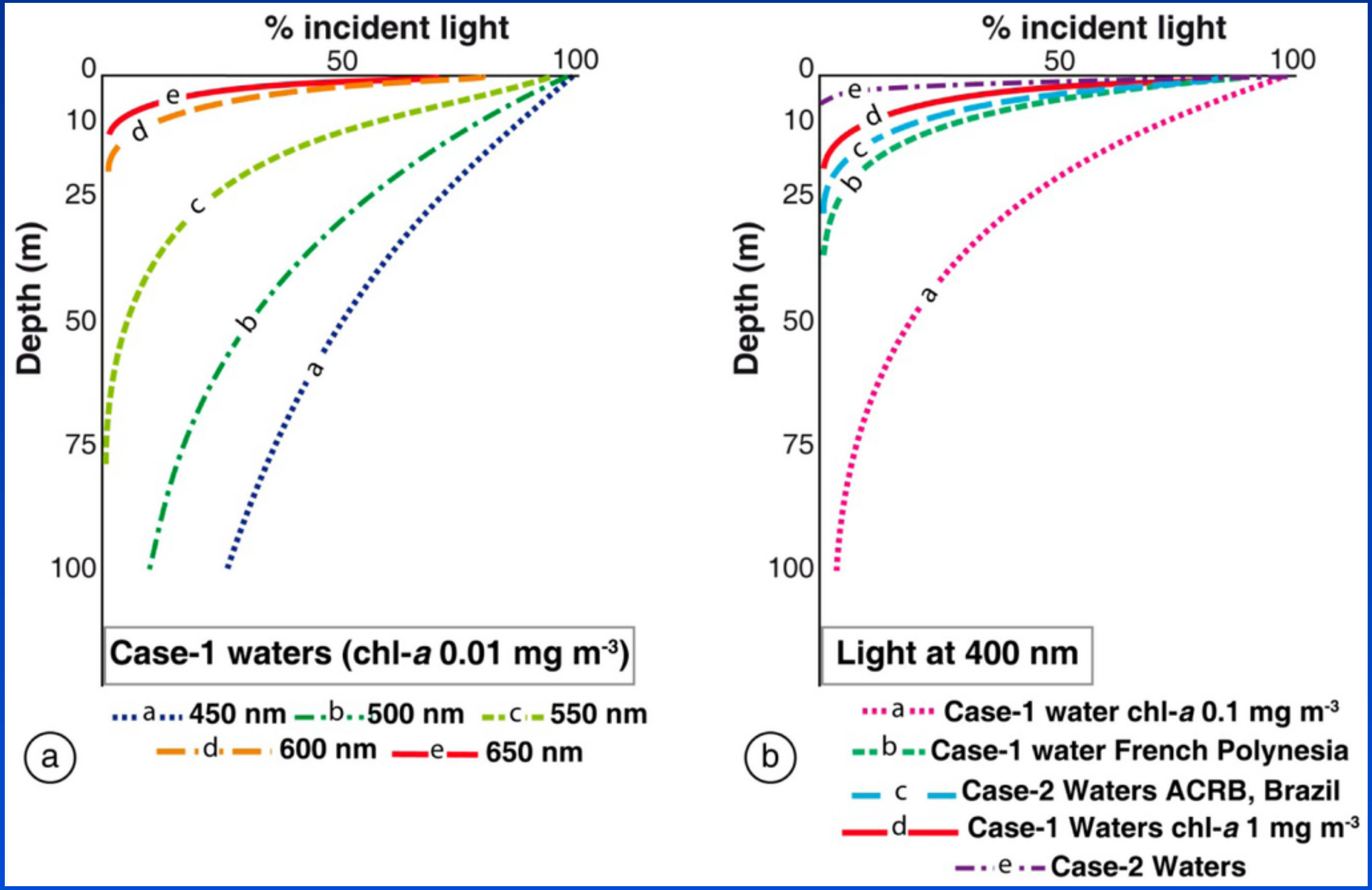
Factors affecting oceanic PP are:

- ✓ Light availability (depth)
- ✓ Nutrient availability (recycling, runoff and upwelling)
- ✓ Temperature
- ✓ Water acidity (CO_2 dissolved by antropogenic release in the atmosphere)

Light extinction with dept in water

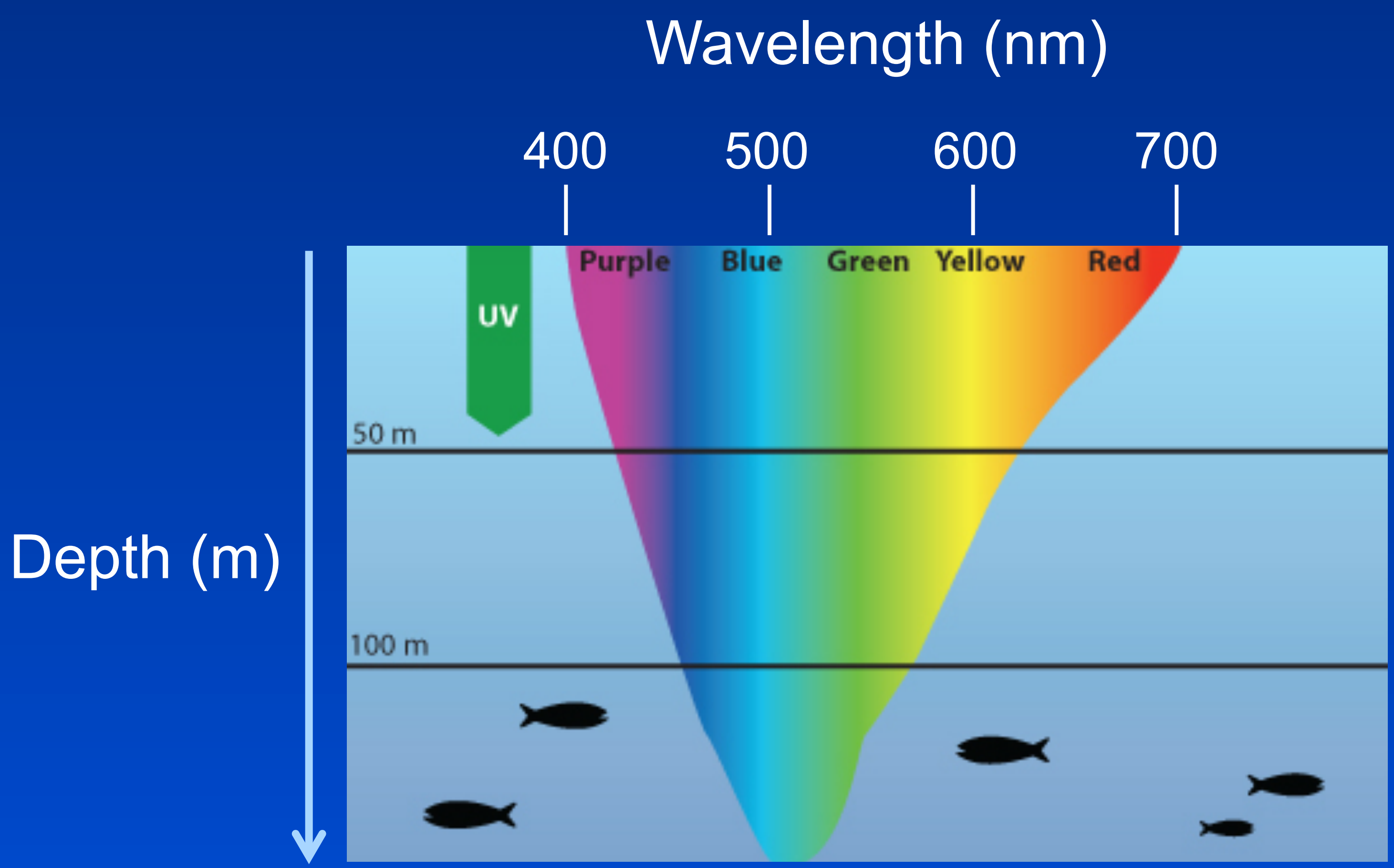
Lambert-Beer equation

$$I_z = I_0 \cdot e^{-kz}$$ (Z, extinction coefficient)



Light extinction with dept in water

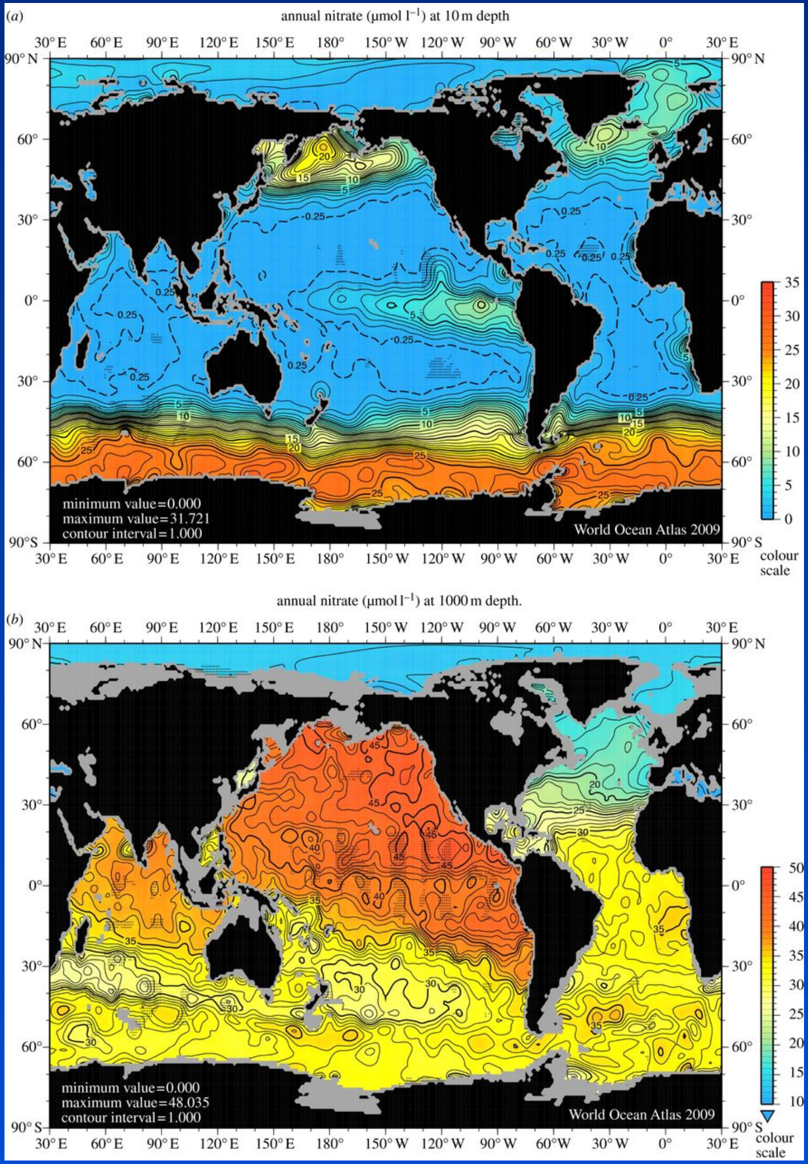
Spectral variation



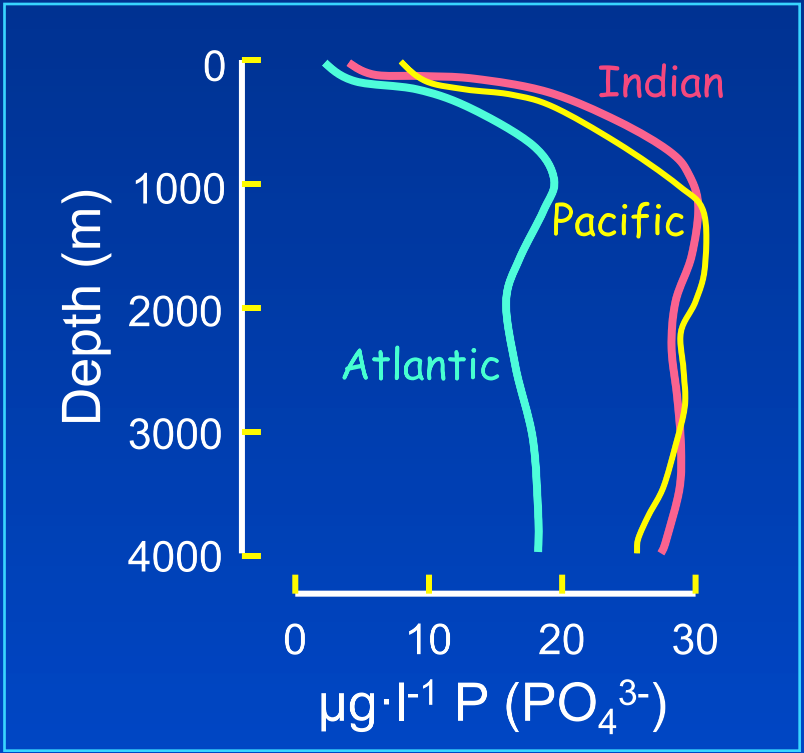
Nitrates dissolved in oceanic waters

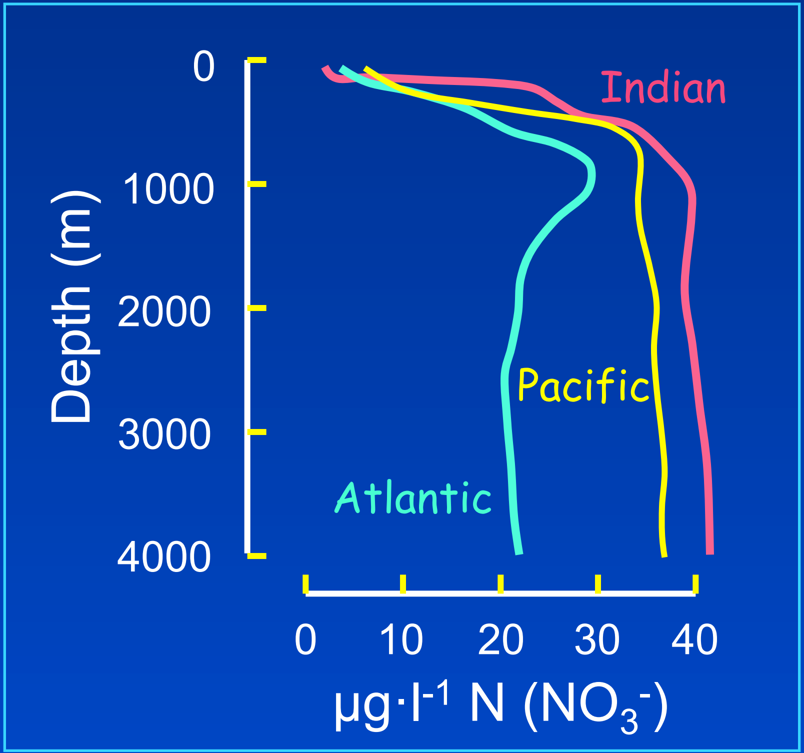
Surface

1000 m depth



Phosphates & nitrates concentration
Oceanic waters





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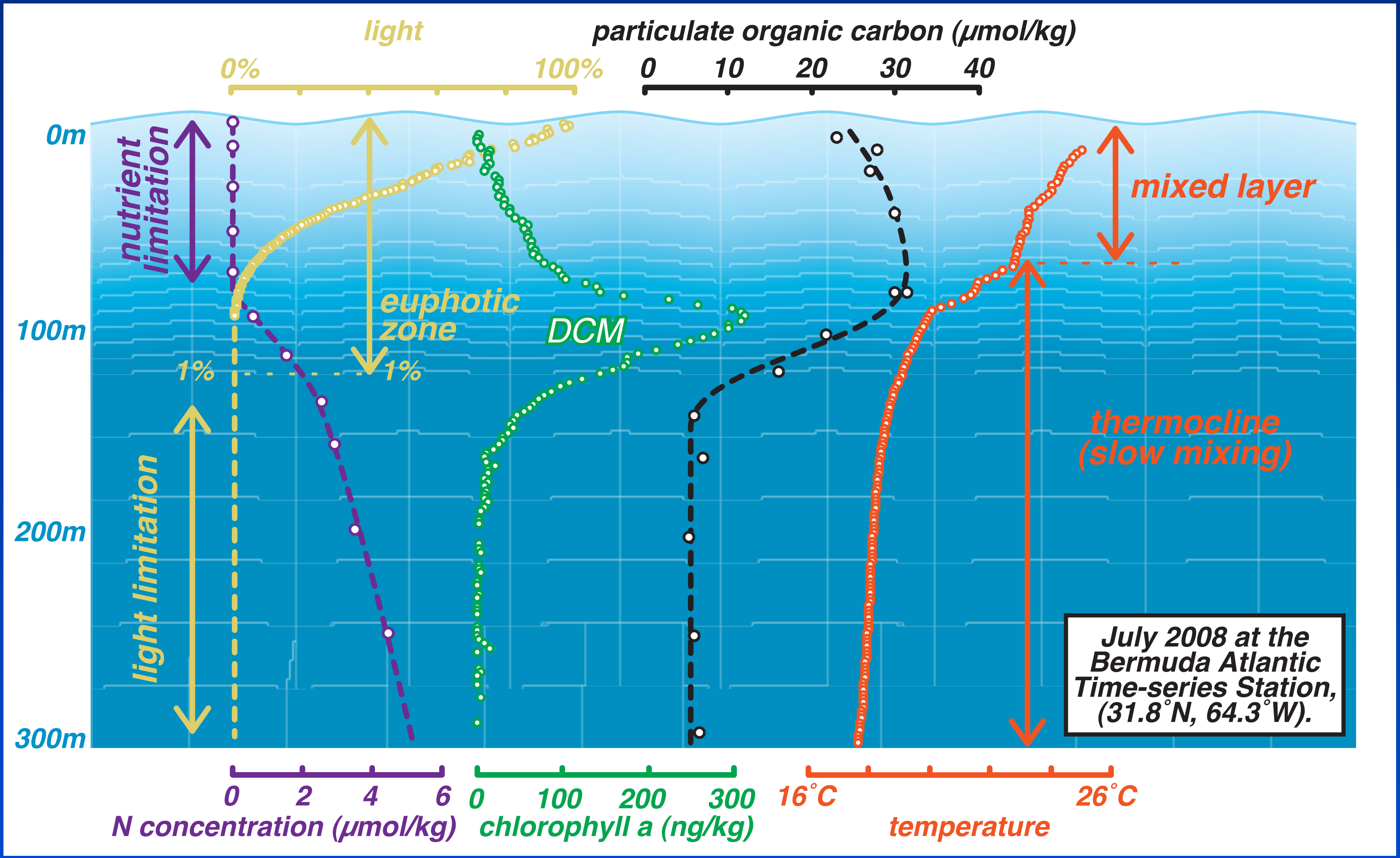
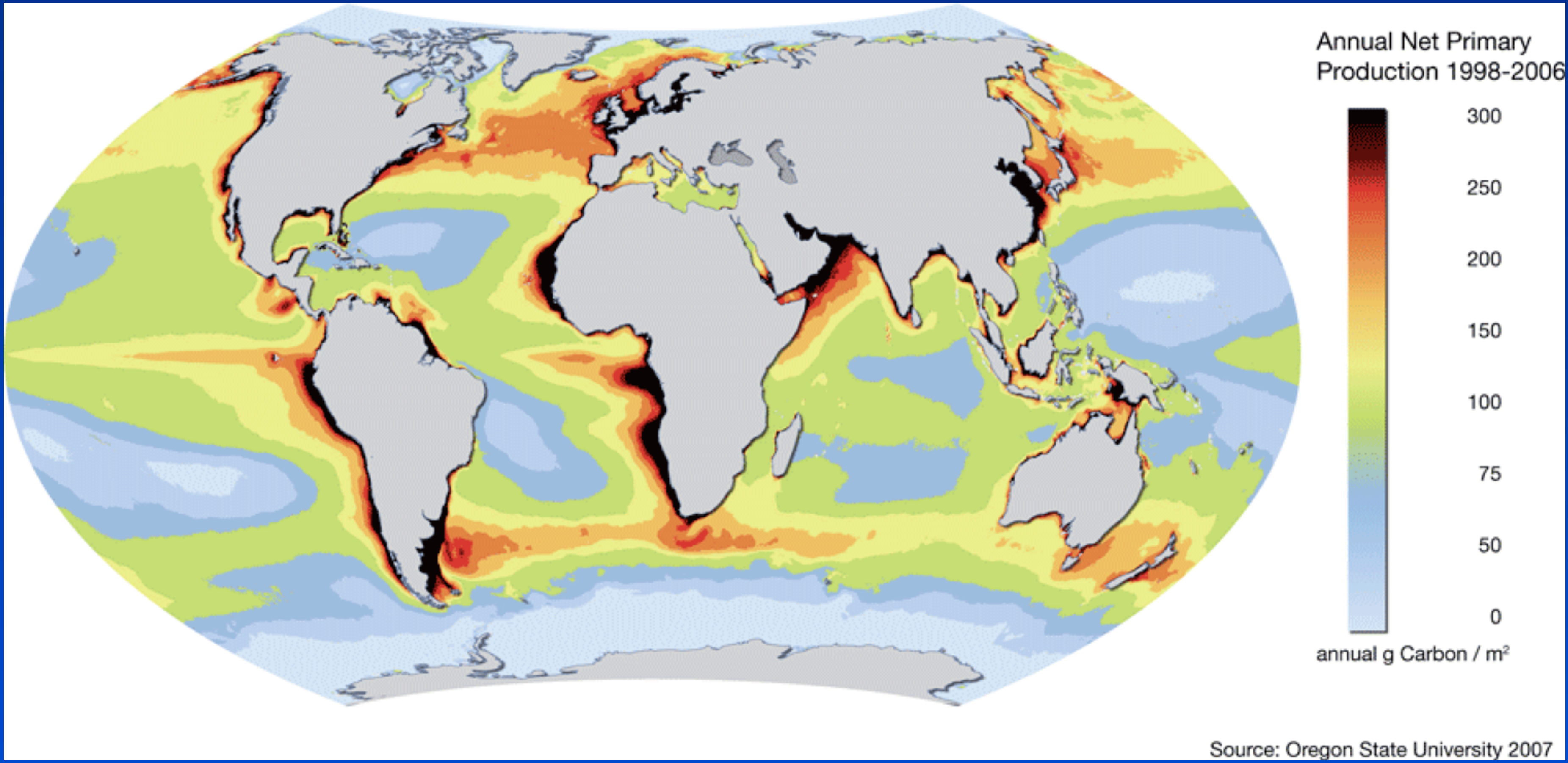
Physical/chemical gradients at ocean surface



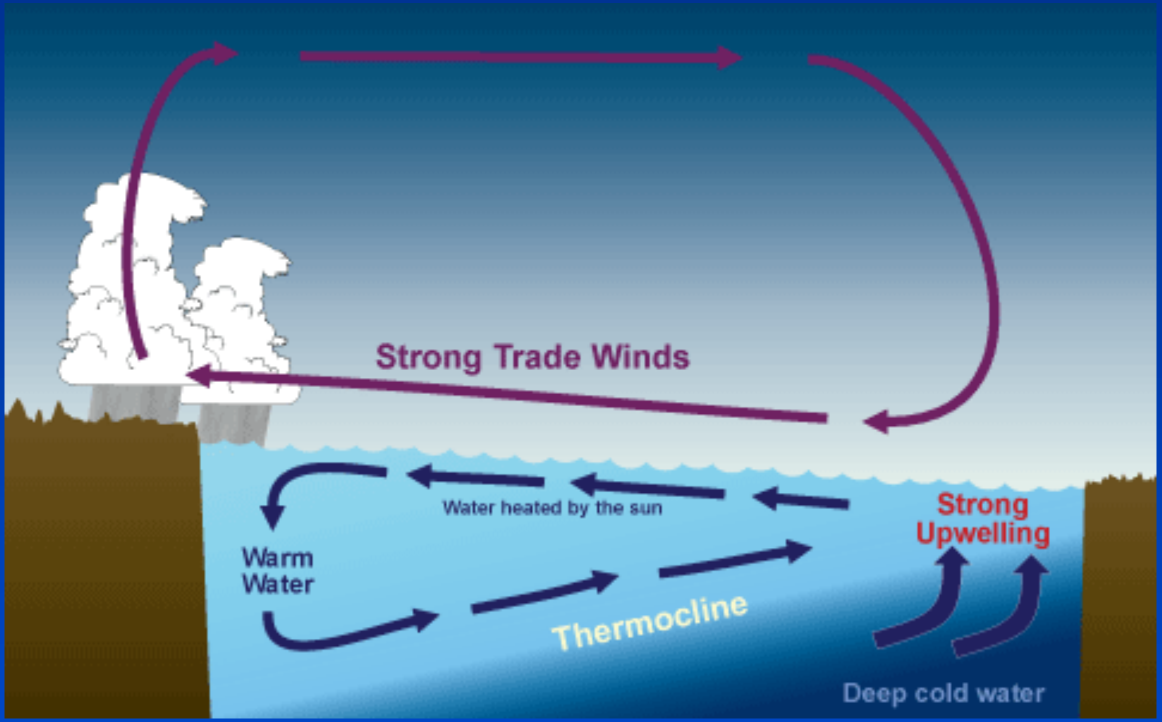
DCM deep chlorophyll maximum

Net primary productivity (annual average)
Oceanic systems



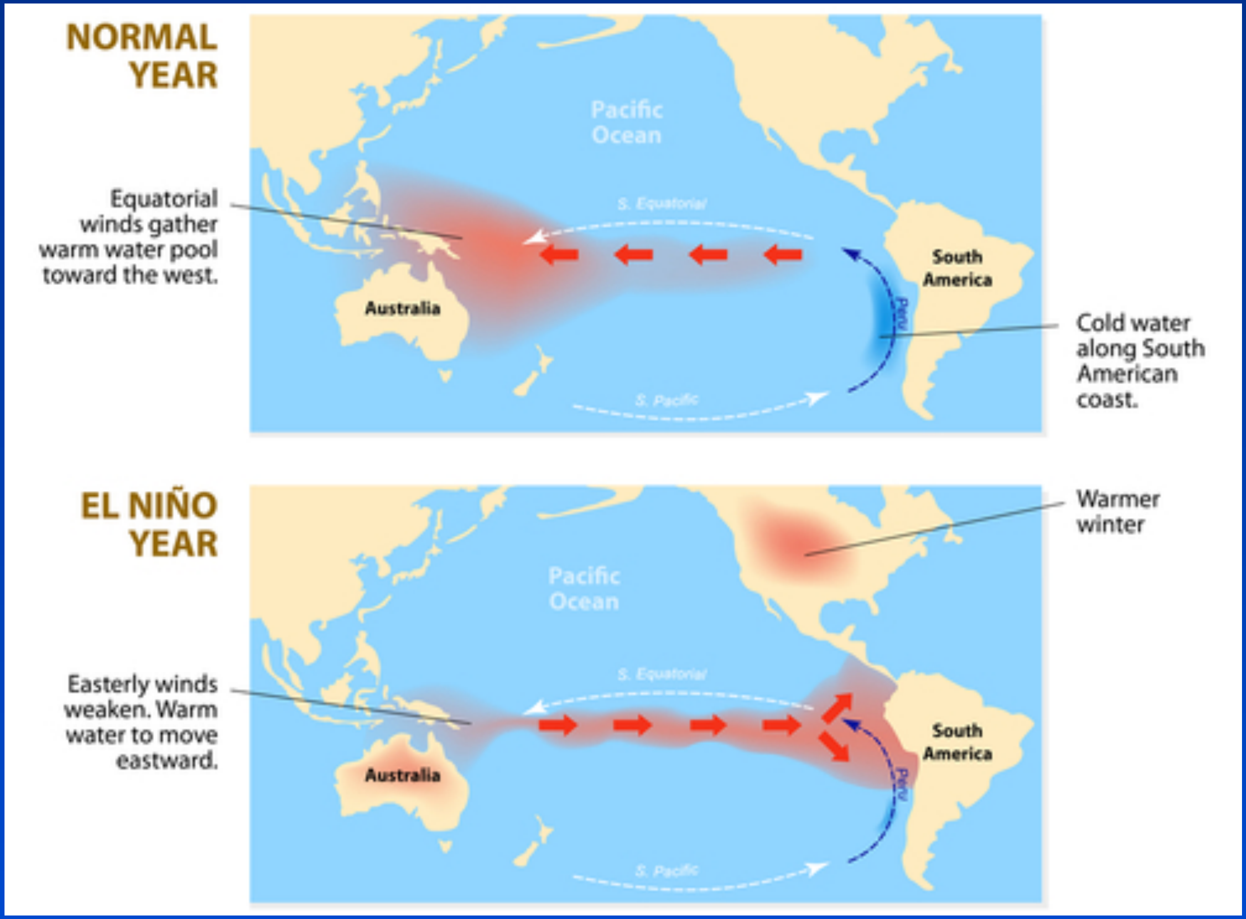
Upwelling in equatorial Pacific

Low pressure High pressure



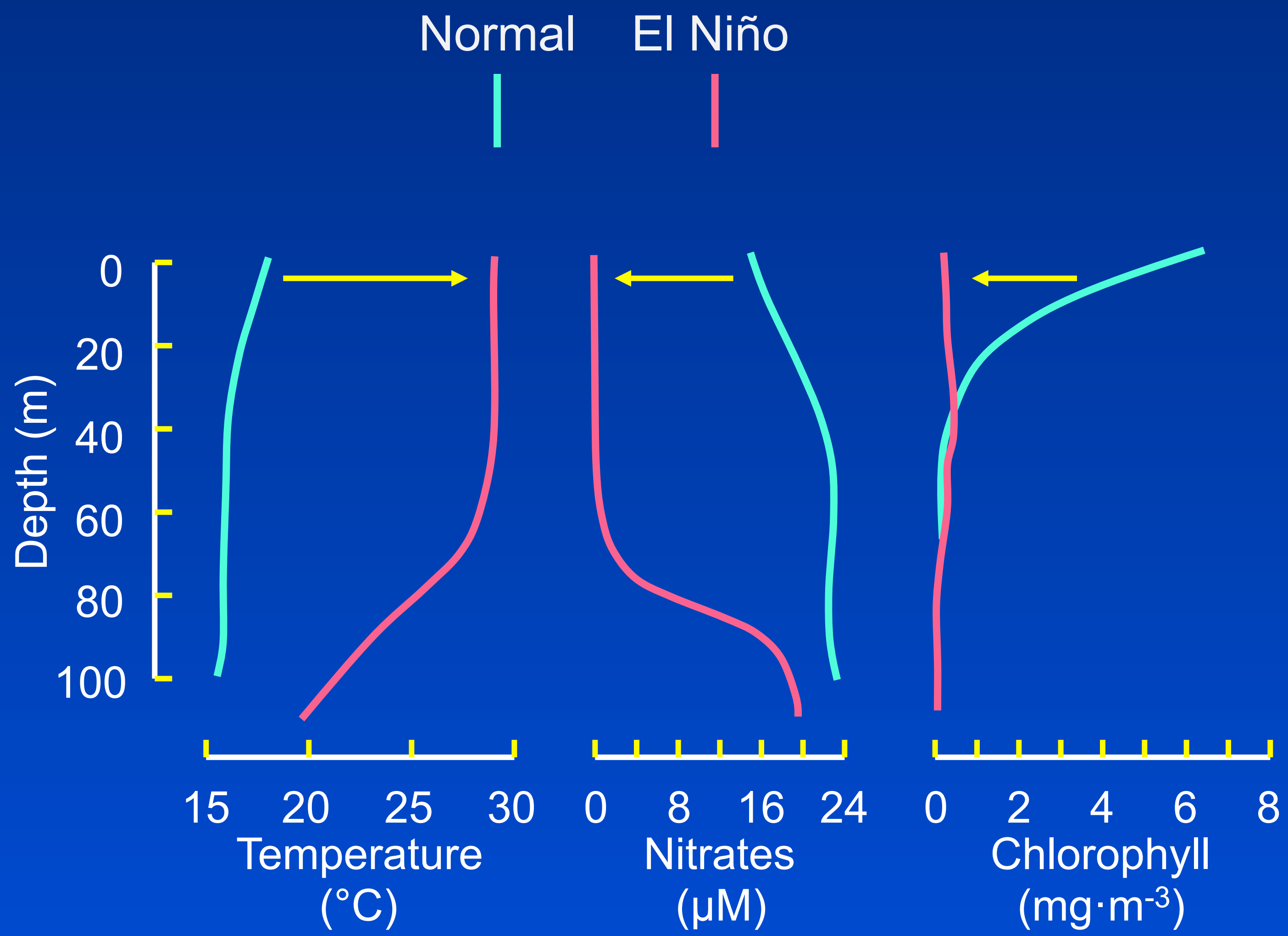
Australia Peru

El Niño Southern Oscillation

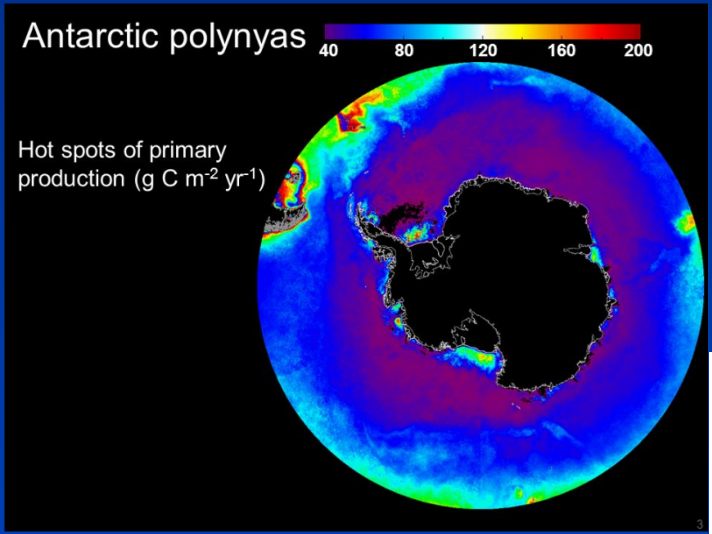


El Niño Southern Oscillation

Variations off the Peru coast

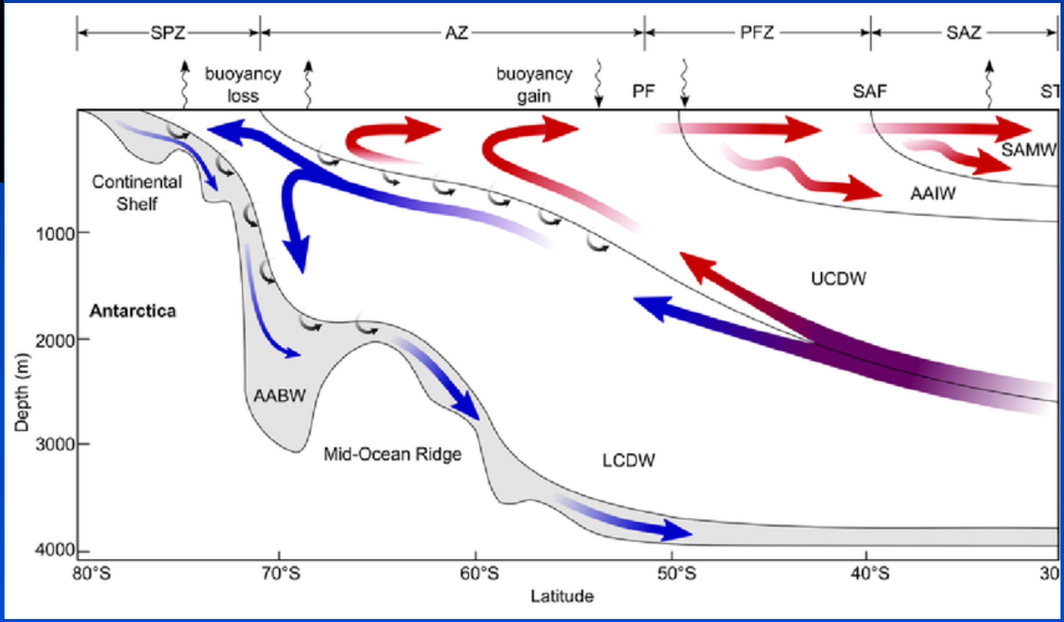


Circum-Antarctic overturning circulation



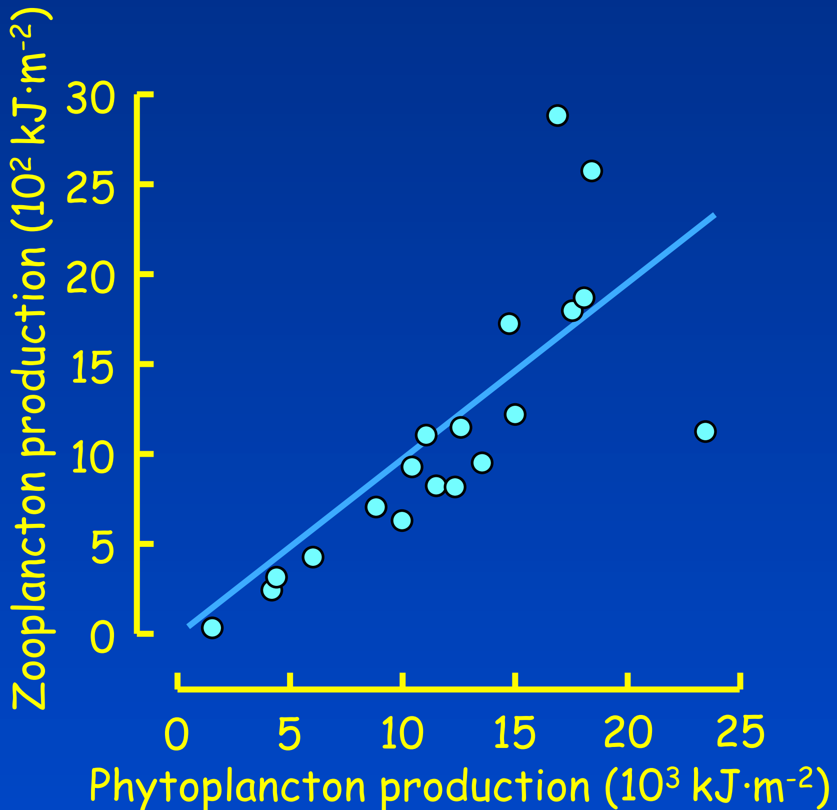
Primary productivity

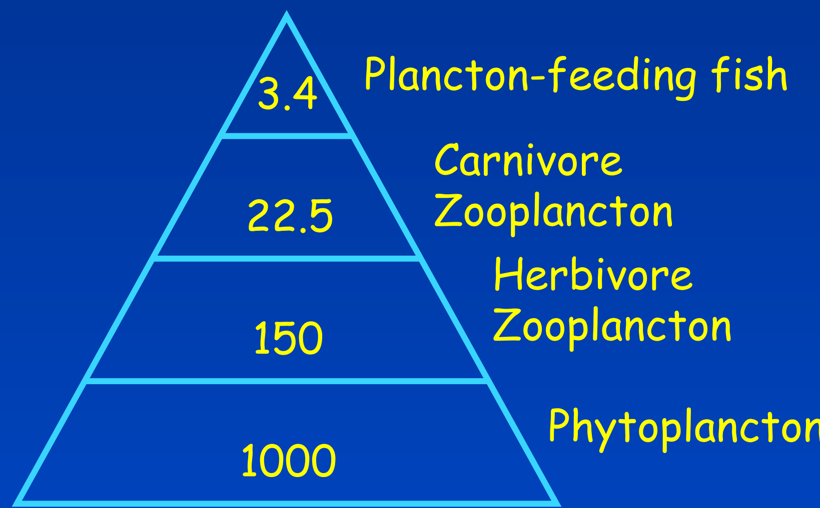
STF, Sub-Tropical Front; SAF, Sub-Antarctic Front; PF, Polar Front; SAMW, Sub-Antarctic Mode Water; AAIW, Antarctic Intermediate Water; UCDW, Upper Circumpolar Deep Water; LCDW, Lower Circumpolar Deep Water; AABW, Antarctic Bottom Water; SAZ, Sub-Antarctic Zone; PFZ, Polar Frontal Zone; AZ, Antarctic Zone; SPZ, Sub-Polar Zone.



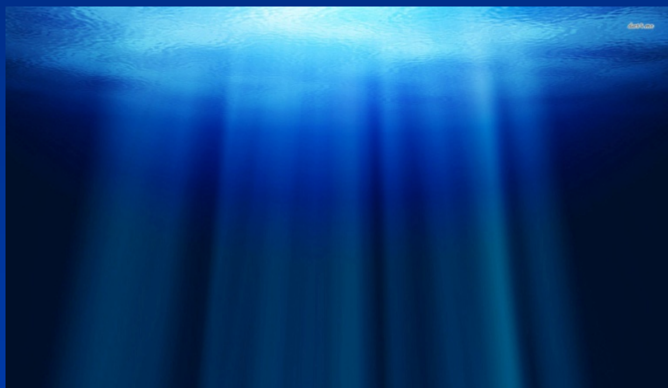
Oceanic trophic chain

Relative energy content of different trophic levels





Source-sink coupled communities



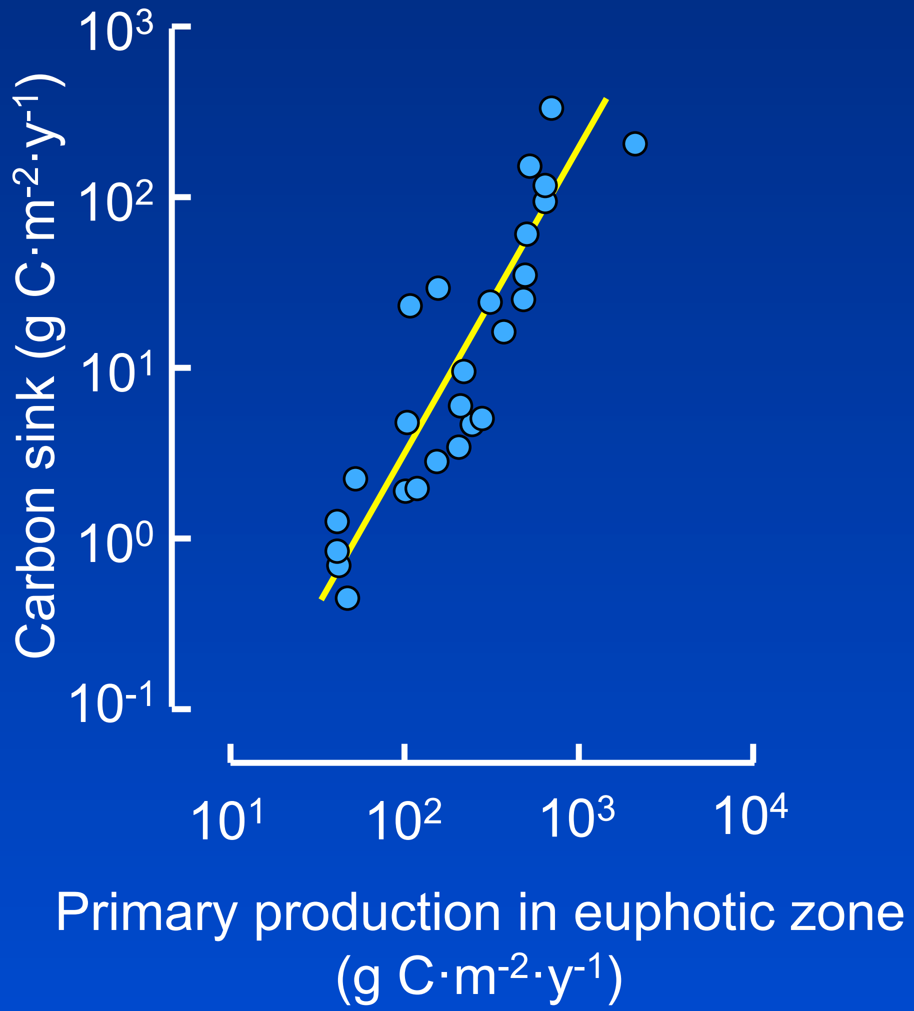
Euphotic zone

Gravity

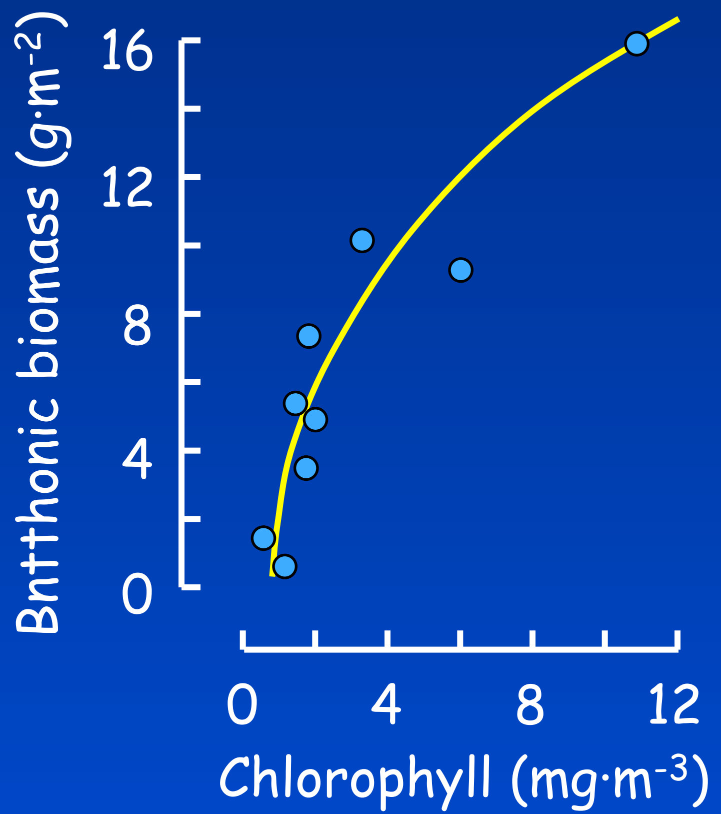
Organic carbon “snow”

Benthic zone

Carbon sink from euphotic zone



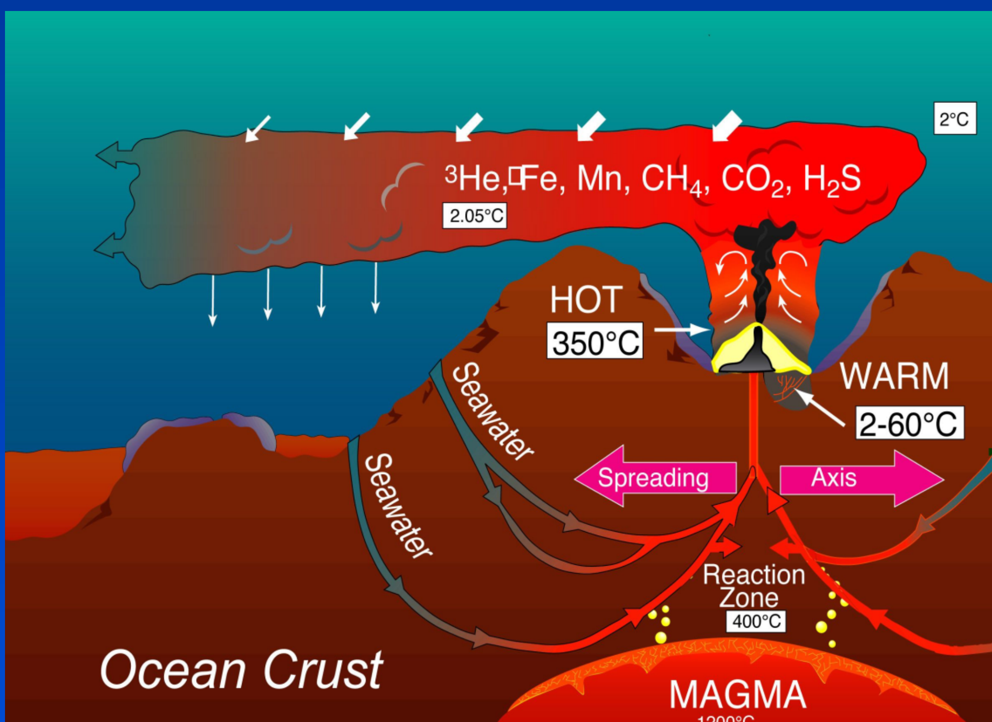
Relationship between euphotic PP and benthonic production



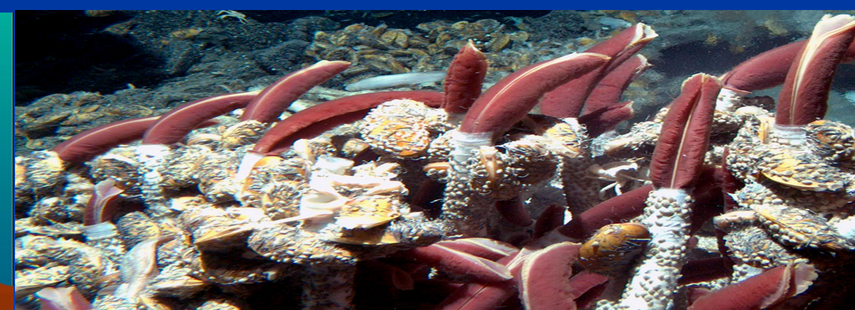
Primary production in oceanic systems

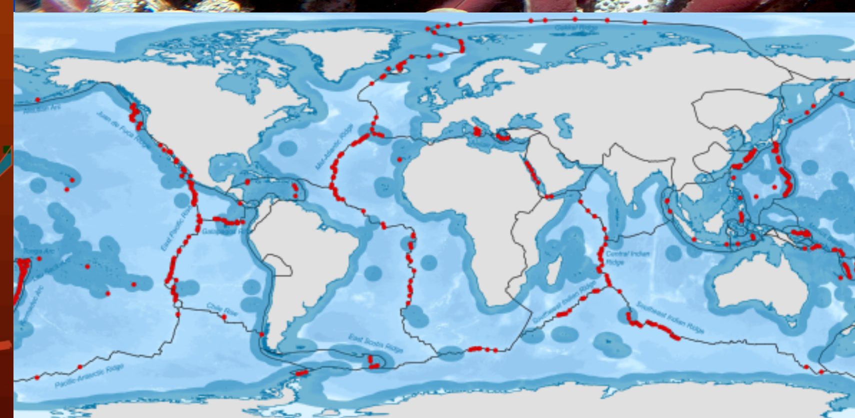
Only a minor fraction of PP in oceans is from chemosynthesis, as in the hydrothermal vents of mid-oceanic ridges, operated by chemoautotroph bacteria

$$\mathbf{12H_2S + 6CO_2 \rightarrow C_6H_{12}O_6 + 6H_2O + 12\ S}$$



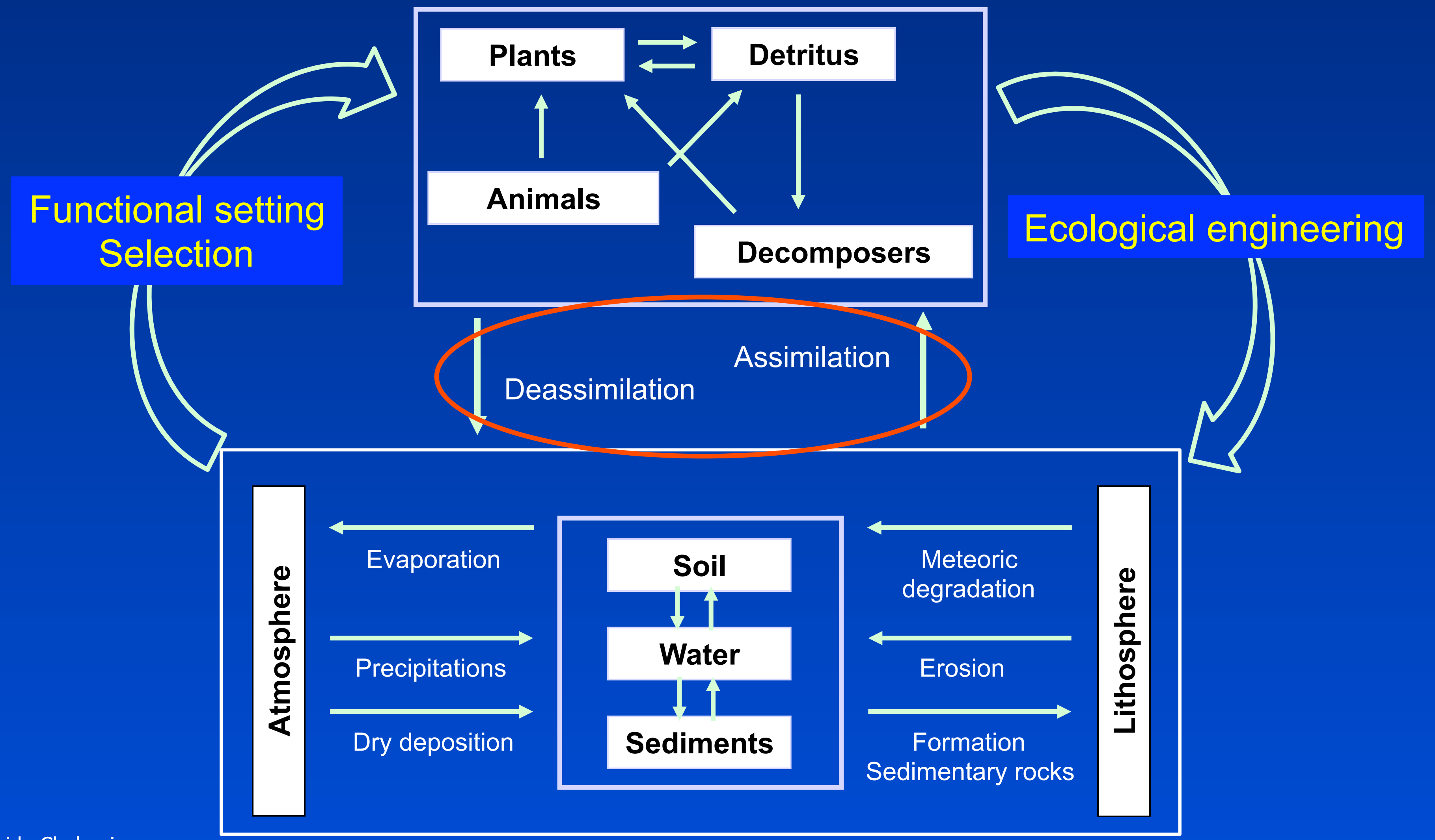
Riftia pachyptila



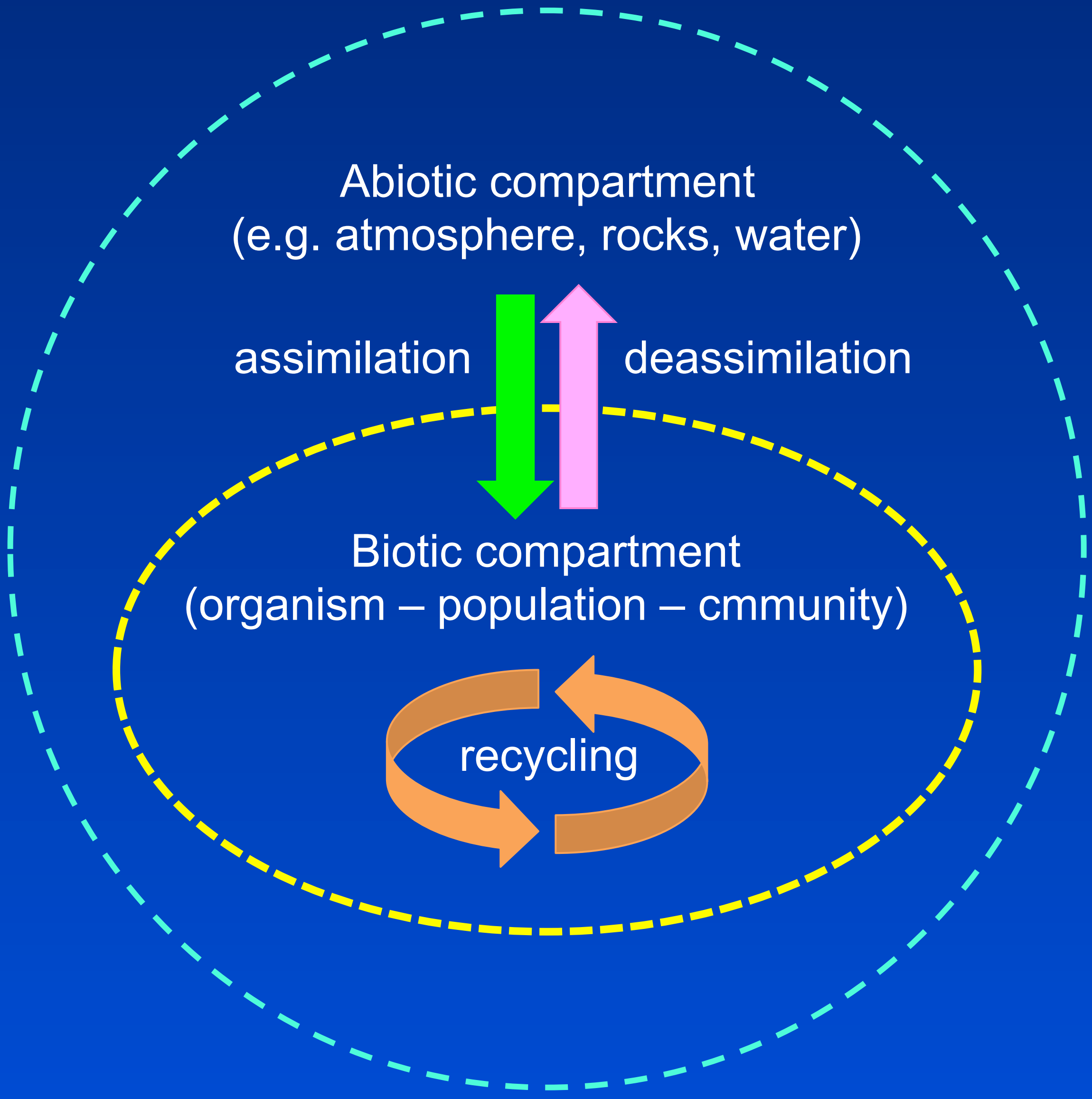


The Ecosystem

The whole set of bio-abiotic compartments and their patterns of interaction



Biogeochemical cycles



Biogeochemical cycles

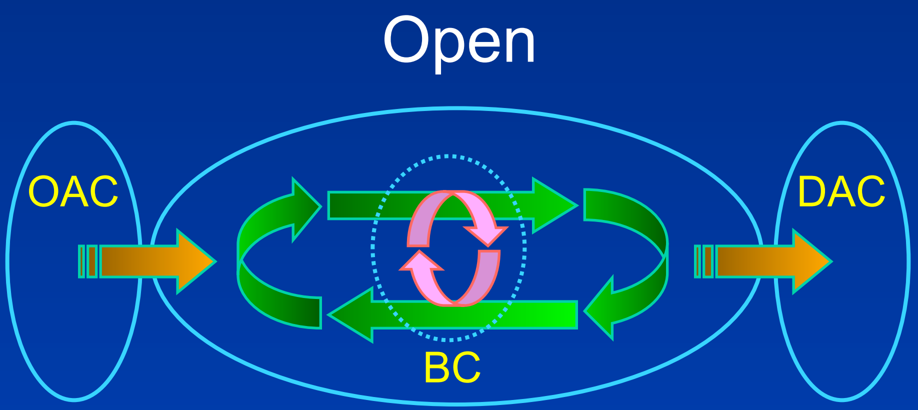
Which chemical items are subject to biogeochemical cycling

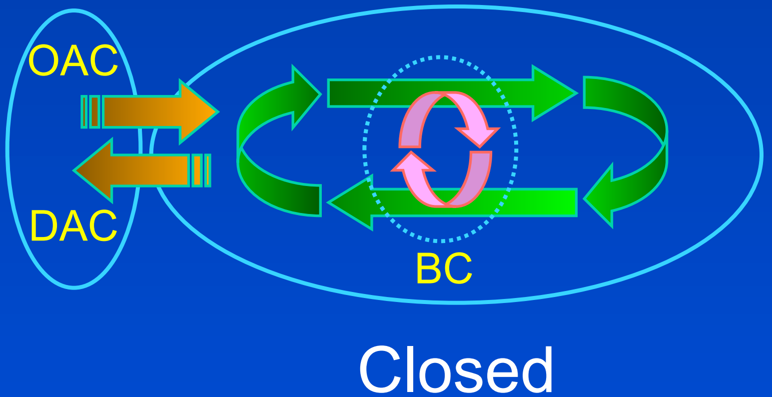
Elements
Macrocomponents (e.g. C, N, O, P, S)
Microcomponents (e.g. Mg, Mn, Fe, Cu)

Molecules
(e.g. H_2O, CH_4, O_2)

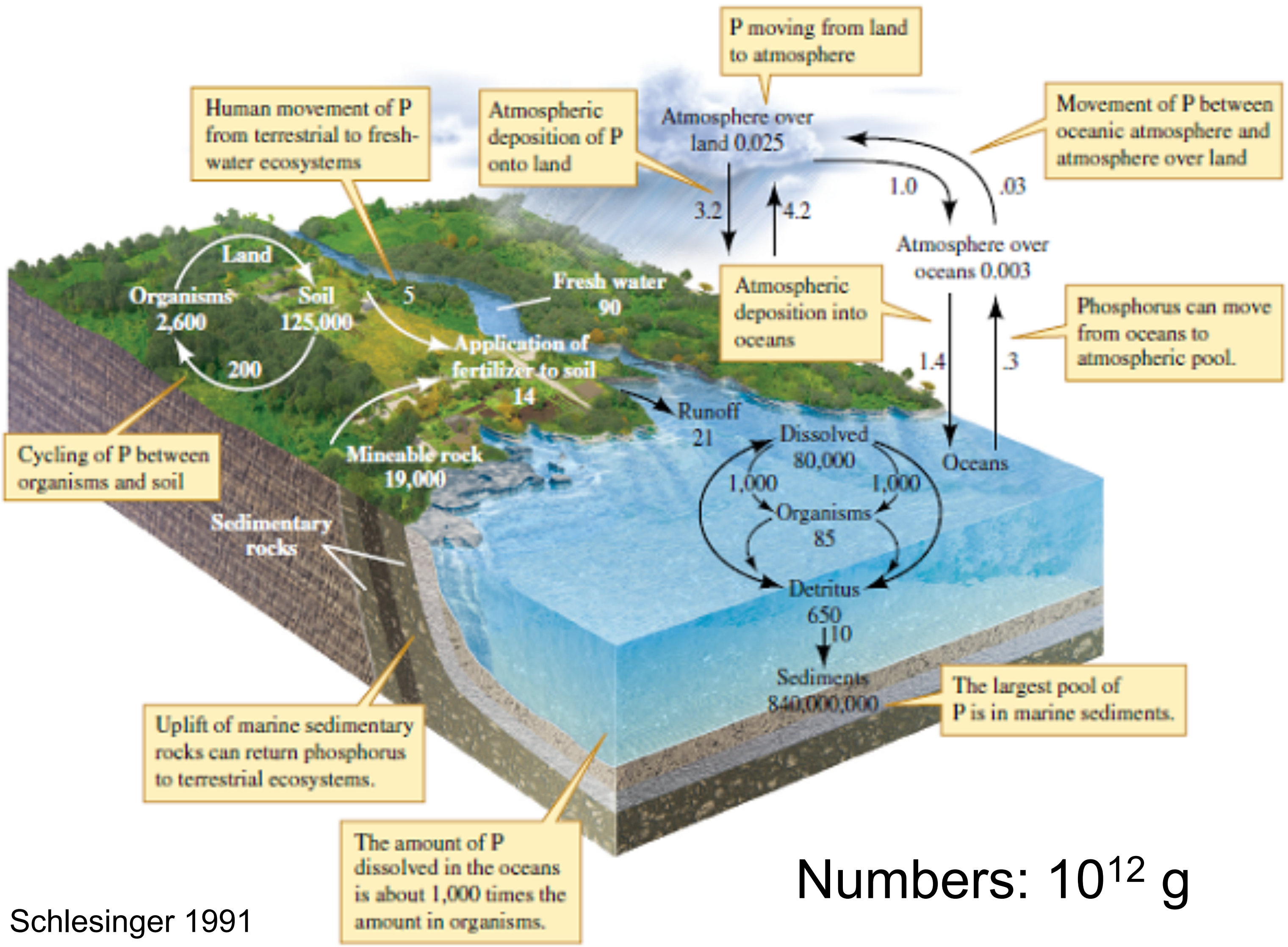
Xenobiotics
(e.g. chlorinated hydrocarbons, organometallic compounds)

Biogeochemical cycles
General schemes





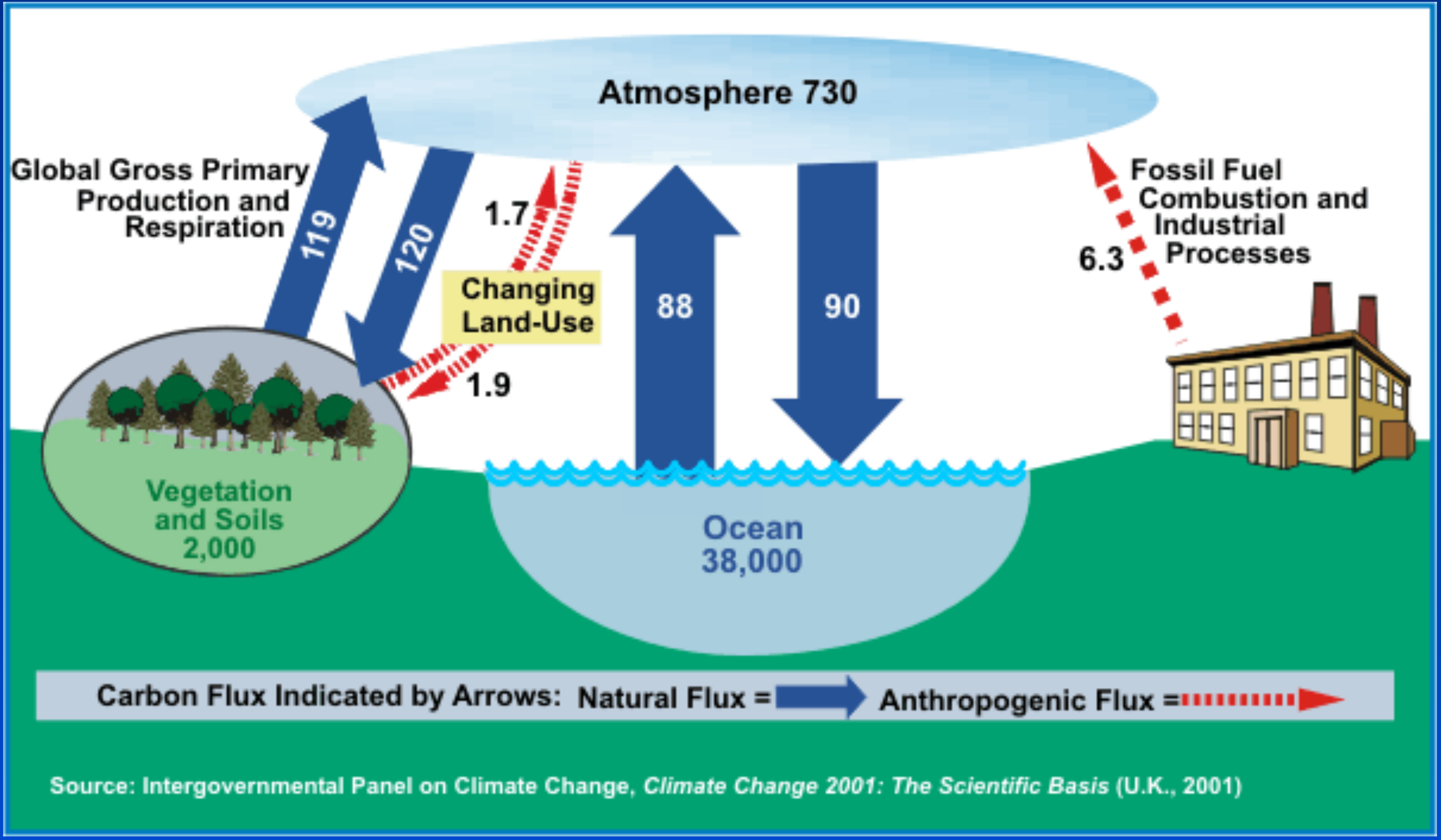
Phosphorus global cycle (quasi open cycle)



Numbers: 10^{12} g

Schlesinger 1991

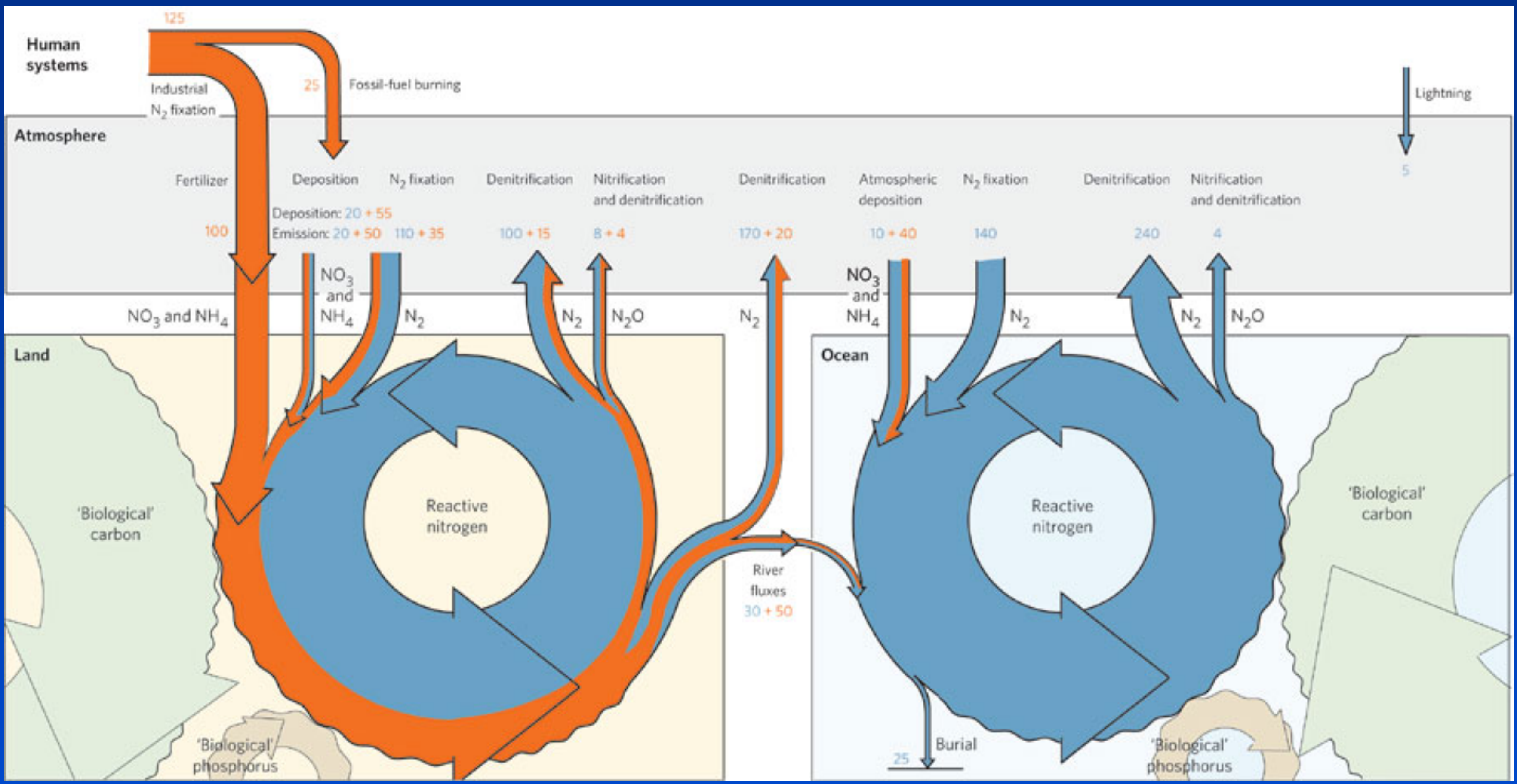
Carbon global cycle (quasi closed cycle)
IPCC 2001



Numbers: Gt Yr $^{-1}$

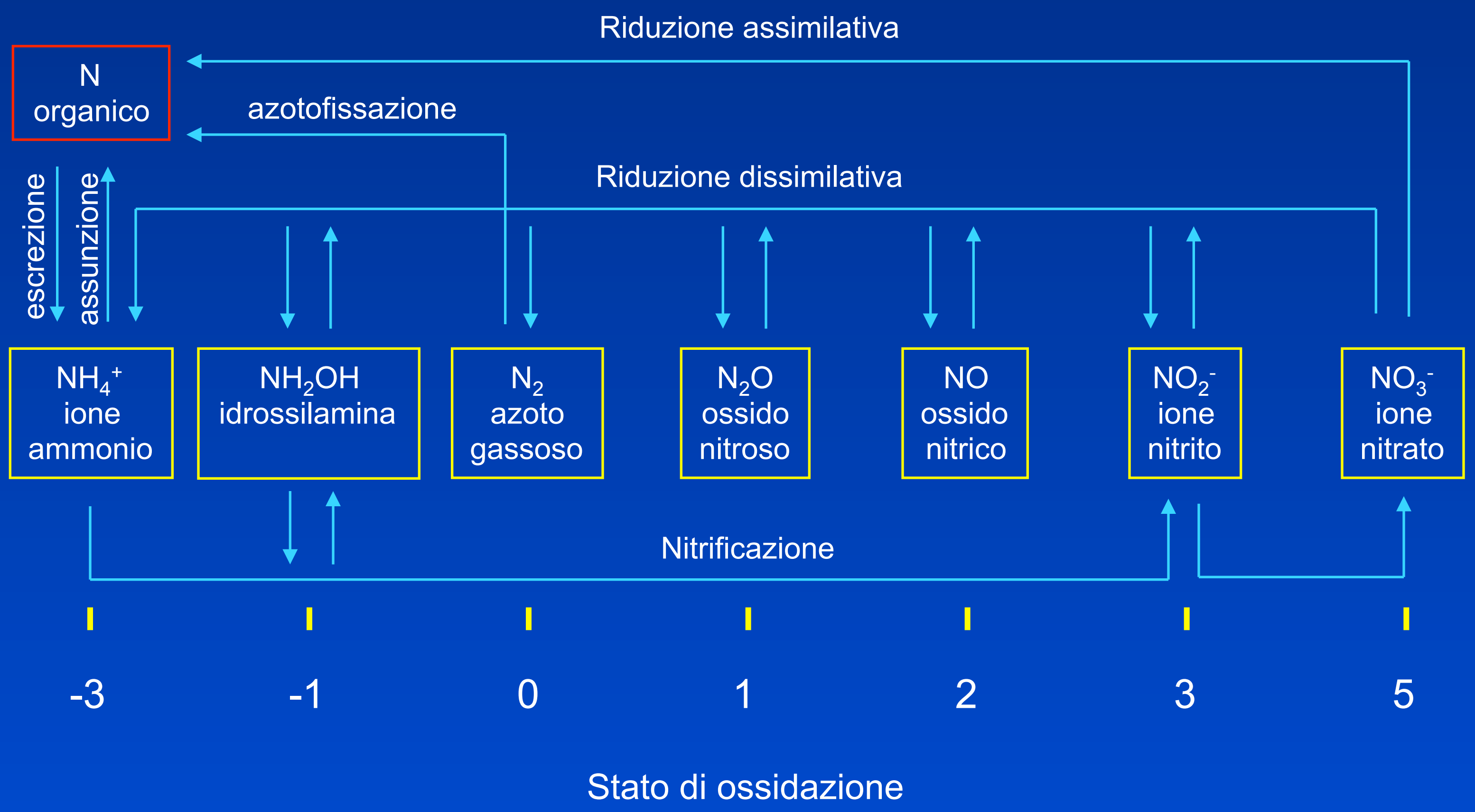
Nitrogen global cycle

Gruber & Galloway 2008 Nature



Fluxes in Tg Yr^{-1}

Redox transformationss during Nitrogen global cycle



The role of bacteria in the terrestrial Nitrogen cycle

A. Nitrogen Fixation:

Free-living (e.g. *Azotobacter*) and symbiotic (e.g. *Rhizobium*) bacteria convert atmospheric nitrogen N_2 to ammonia NH_4^+ using the energy from ATP. (In the marine environment N_2 fixation is performed by cyanobacteria).

B. Nitrification:

Several species of soil bacteria convert ammonia NH_4^+ to nitrite NO_2^+ (e.g. *Nitrosomonas*) and nitrite to nitrate NO_3^+ (*Nitrobacter*) when the soil contains high levels of oxygen.

C. Denitrification:

Several species of soil bacteria (e.g. *Pseudomonas*, *Clostridium*) convert nitrate NO_3^+ to free nitrogen N_2 when the soil is waterlogged and thus contains low levels of oxygen. Such bacteria use the nitrate as the final electron acceptor during respiration rather than oxygen. Denitrification depletes the soil of essential nitrate fertilizers.

Human effects on Nitrogen cycle

A. Increase in Nitrogen fixation by use of nitrogen-fixing plants and industrial production of ammonia (Haber-Bosch)

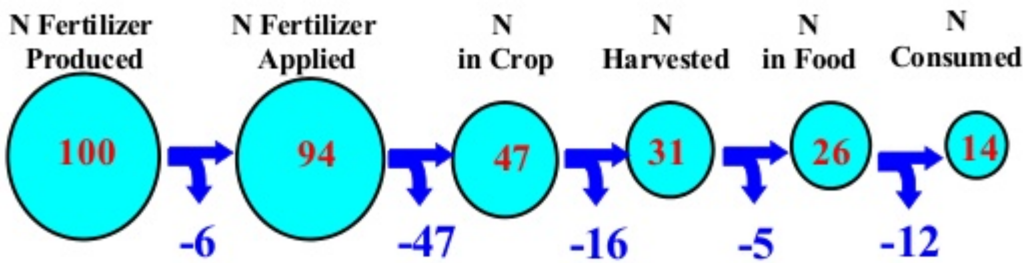
B. NOx emission into Atmosphere by civil and industrial fossil fuel burning

C. Waste water discharge from human and domestic animal populations

Main effects:

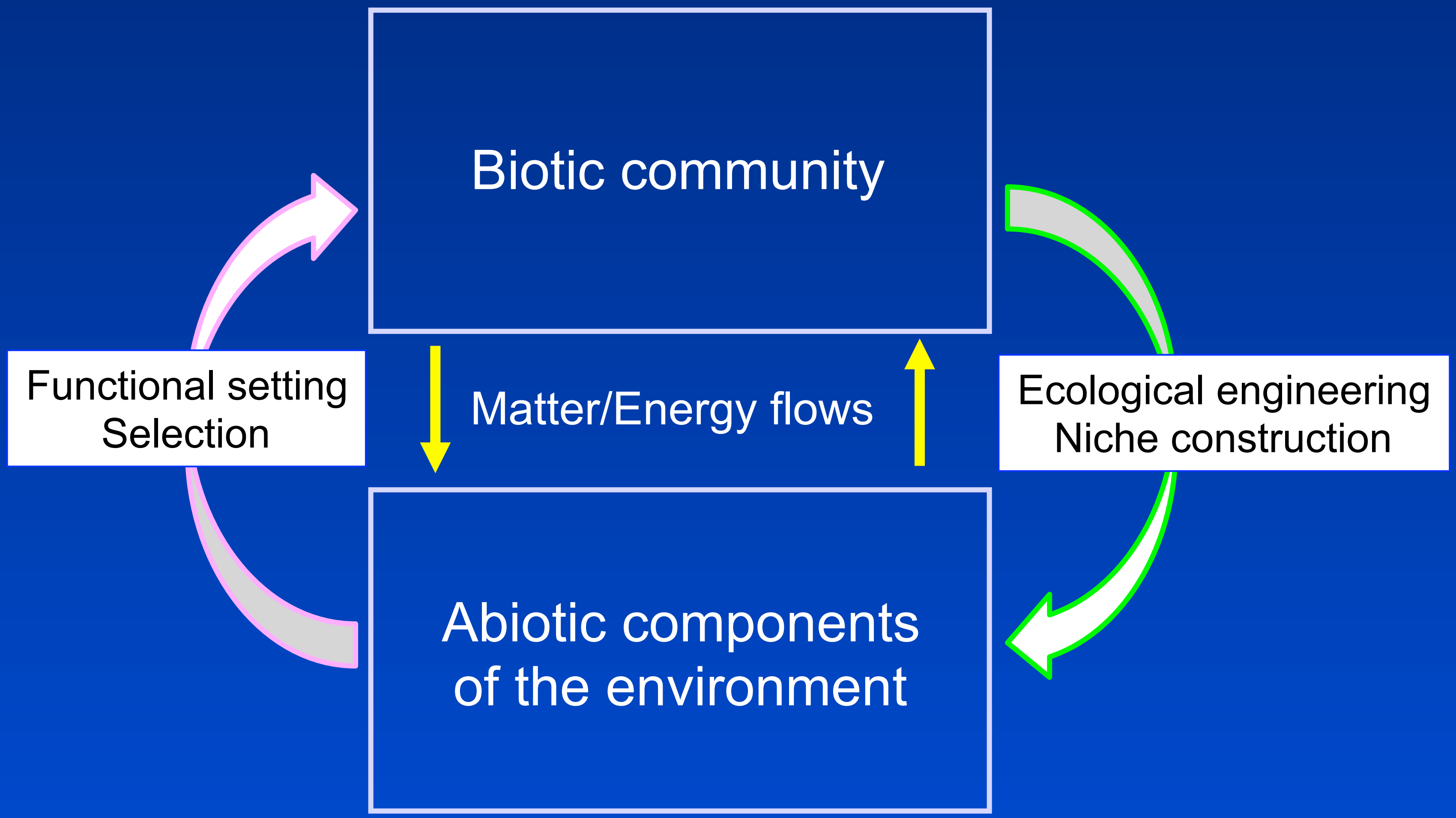
- Eutrophication
- Air, soil and water acidification
- Greenhouse effect (N_20 has a lifetime of 114–120 years, and is 300 times more effective than CO_2 as a greenhouse gas)

The Fate of Haber-Bosch Nitrogen



14% of the N produced in the Haber-Bosch process enters the human mouth……….

Ecological engineering-Niche construction



Examples of niche constructors

Cyanobacteria – Oxyatmosphere

Beaver – Dams/Lakes

Rhinos - Savannah

Scleroactinians – Coral reefs

Guido Chelazzi