Announcements

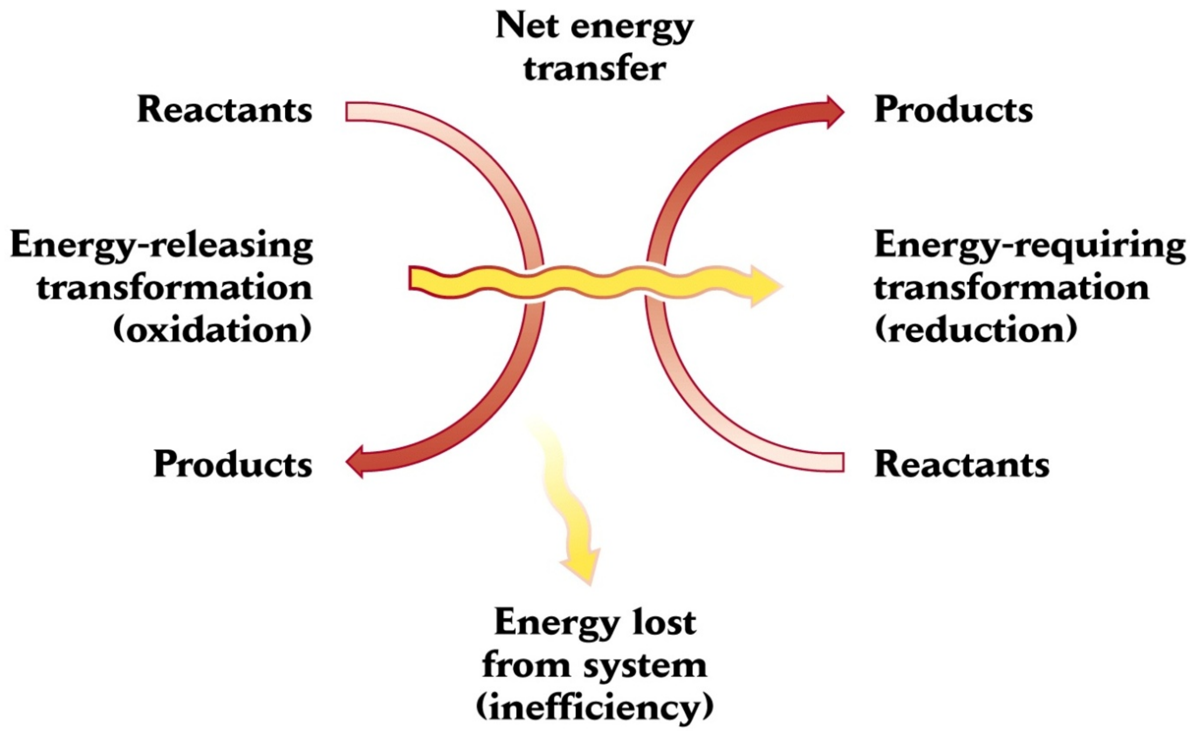
- Graphical Analysis
  - due at the beginning of the last lecture (Nov 28th)
- Guest lecture (Nico Muñoz) next Tues. (Nov. 19)
- In-class Exercise #4 next Thurs. (Nov. 21)

Outline:

- Global cycles (Water, C, N, P)
- Limiting nutrients
- Comparing productivity of ecosystems

Energy transformations in ecosystems

Energy transformations in ecosystems

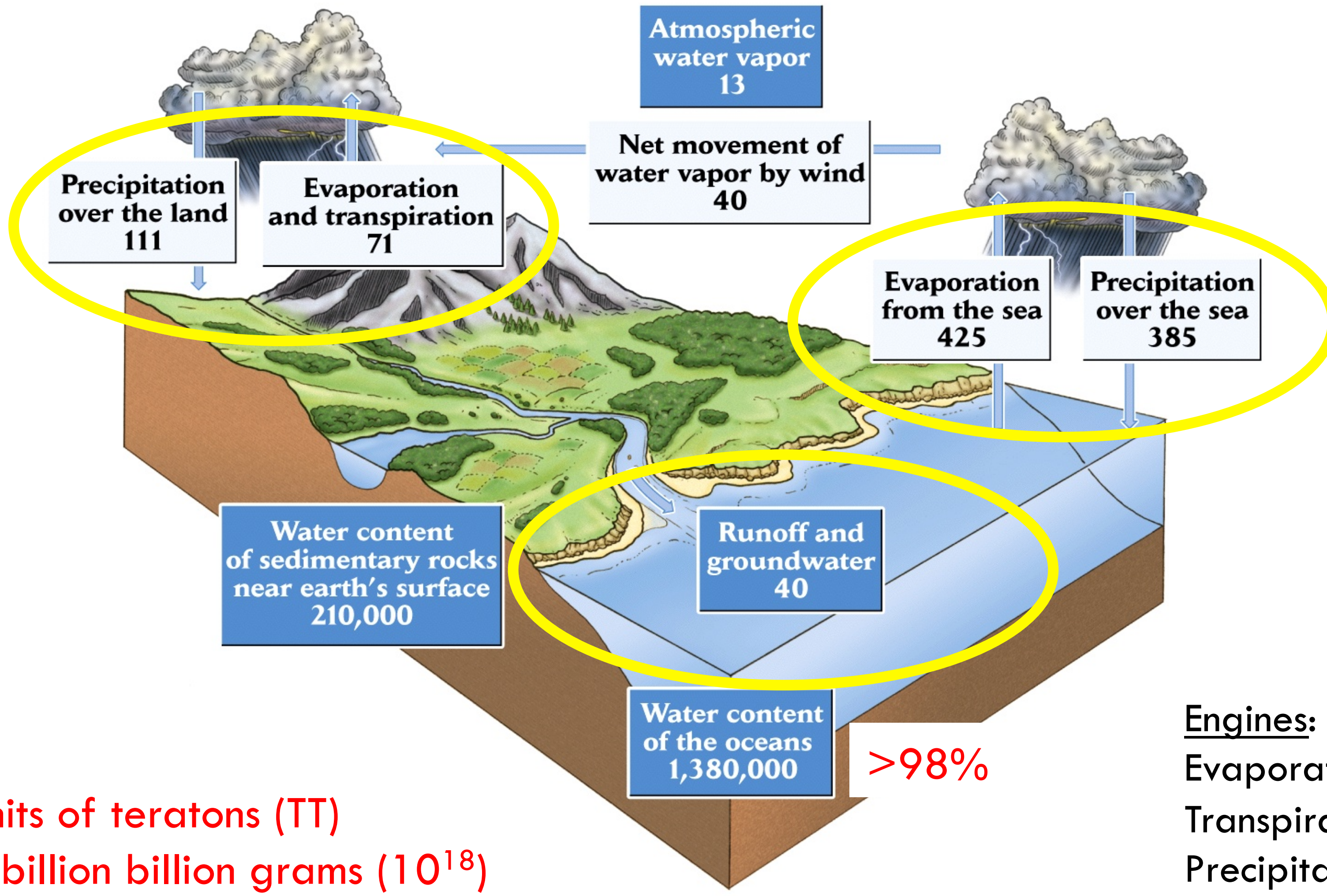


Most involve REDOX reactions (esp. Carbon)

Photosynthesis *reduces* C (light & dark reactions) to store energy

Respiration *oxidizes* C (Krebs cycle) to power cells

The global hydrologic cycle



>98%

In units of teratons (TT)

....a billion billion grams (10^{18})

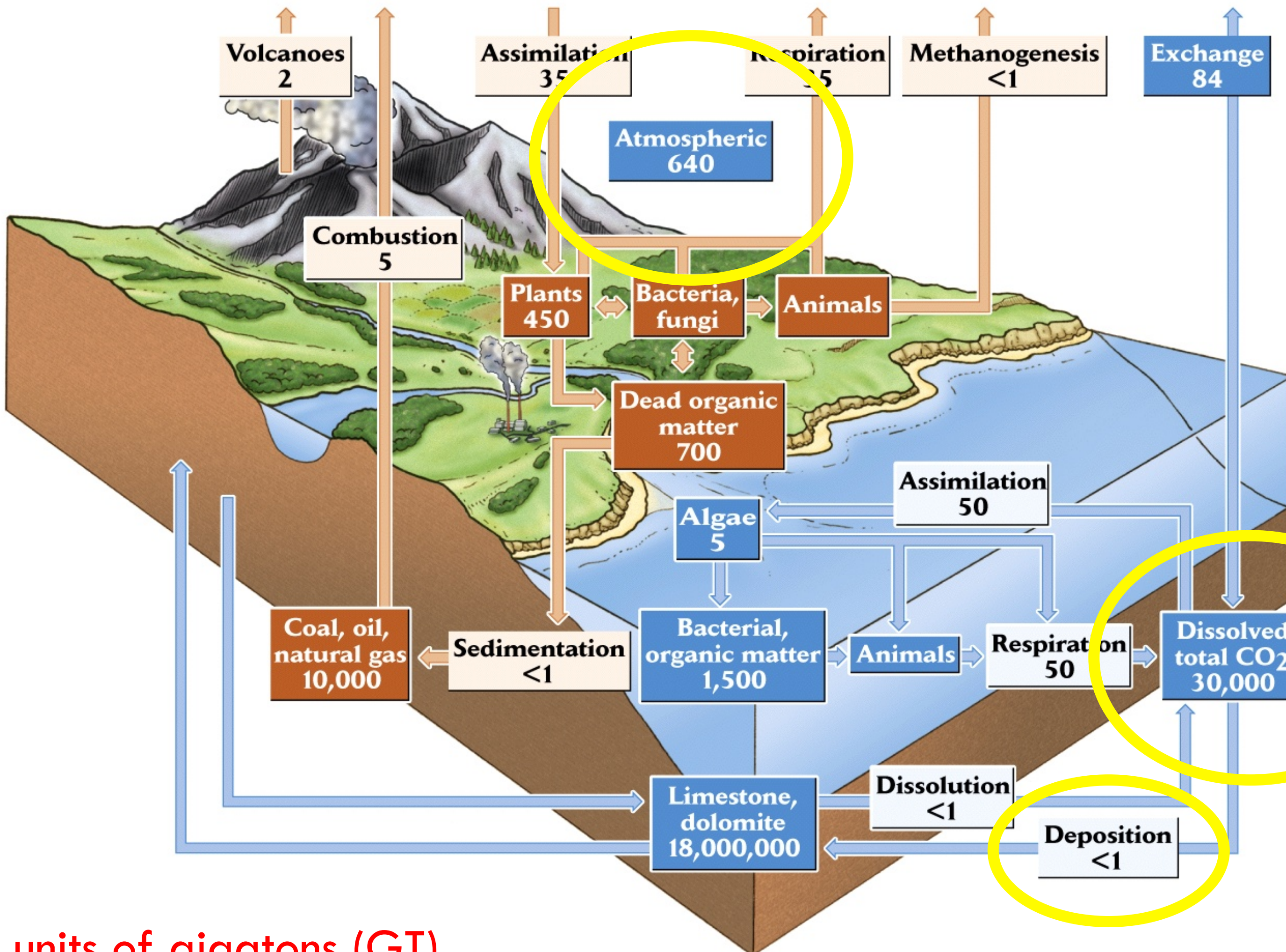
<u>Engines</u>:

Evaporation

Transpiration

Precipitation

The global carbon cycle

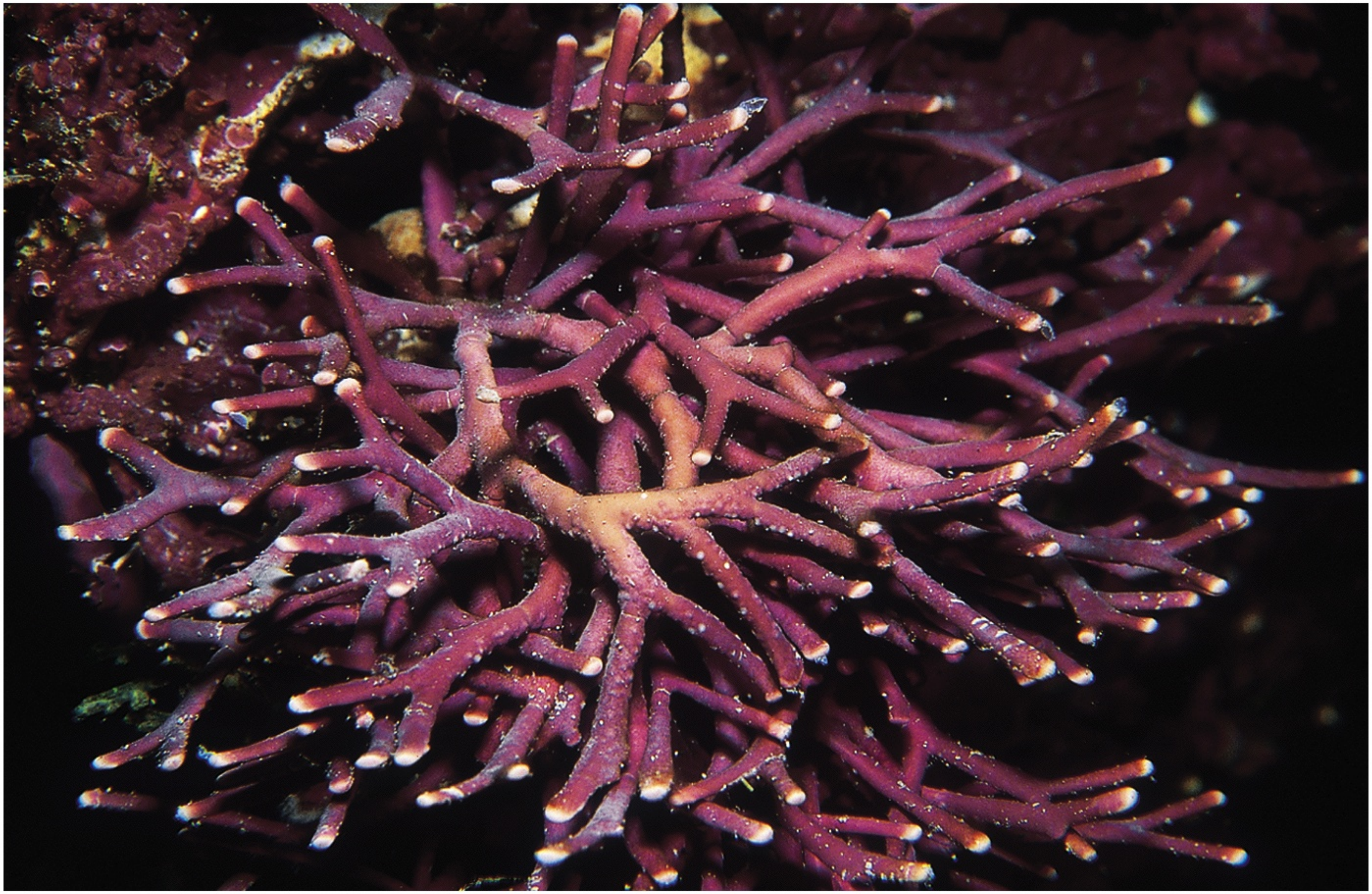


50x

In units of gigatons (GT)

.... billion metric tons (10^{15})

Effects of the oceans on global C

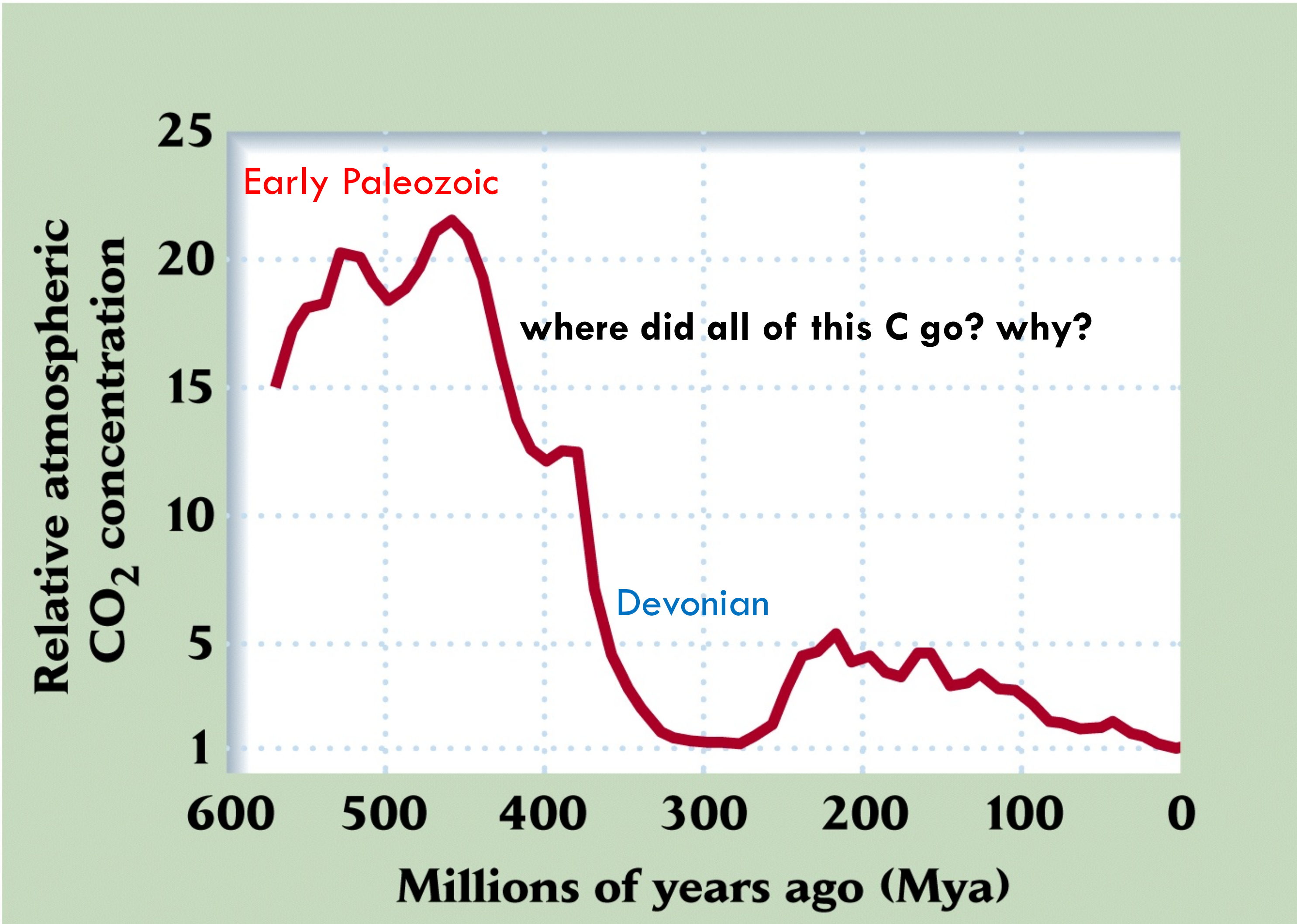


Effects of the oceans on global C

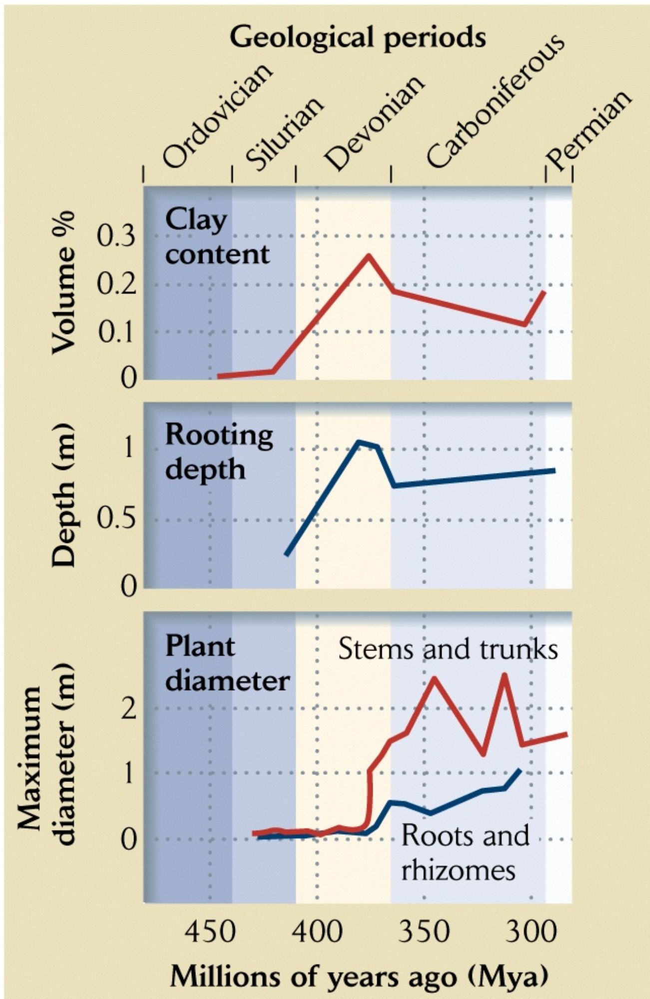
allows us to estimate past atmospheric CO_2 concentrations

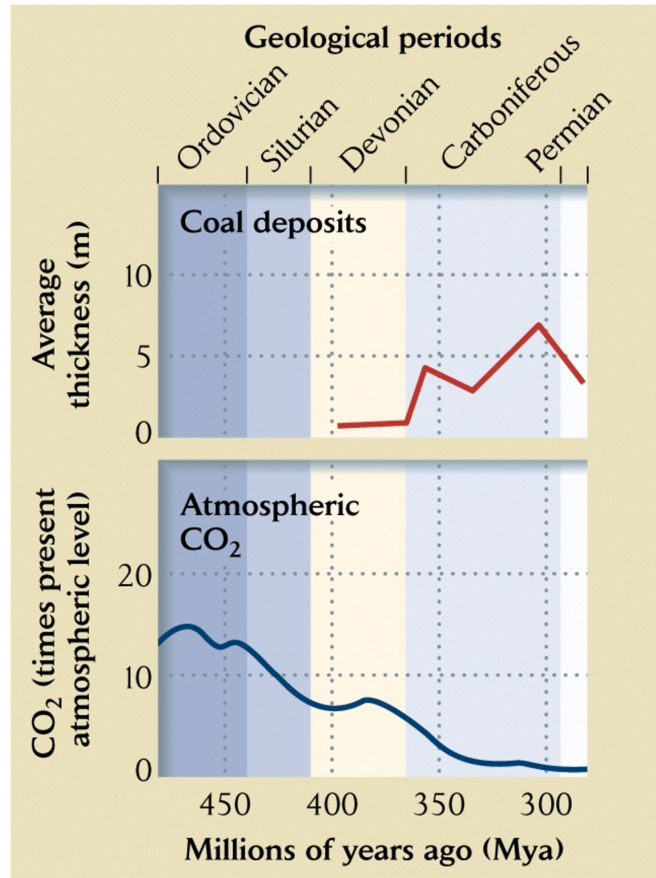
Long-term changes in global carbon cycle

15-20x present



Long-term changes in global carbon cycle



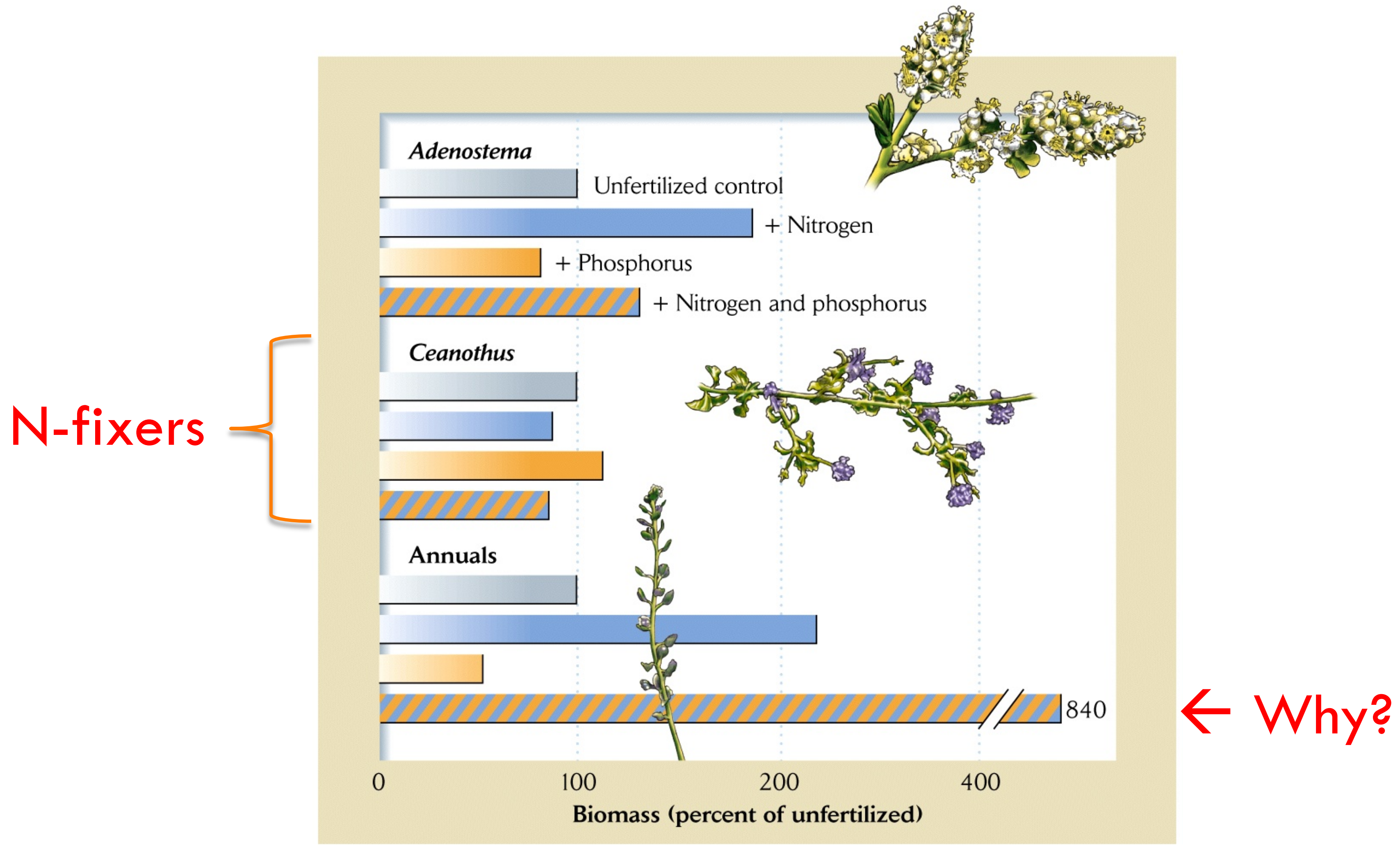


Productivity and the role of limiting elements (nutrients)

Odum's mass-balance approach champions the importance of ENERGY as the key currency

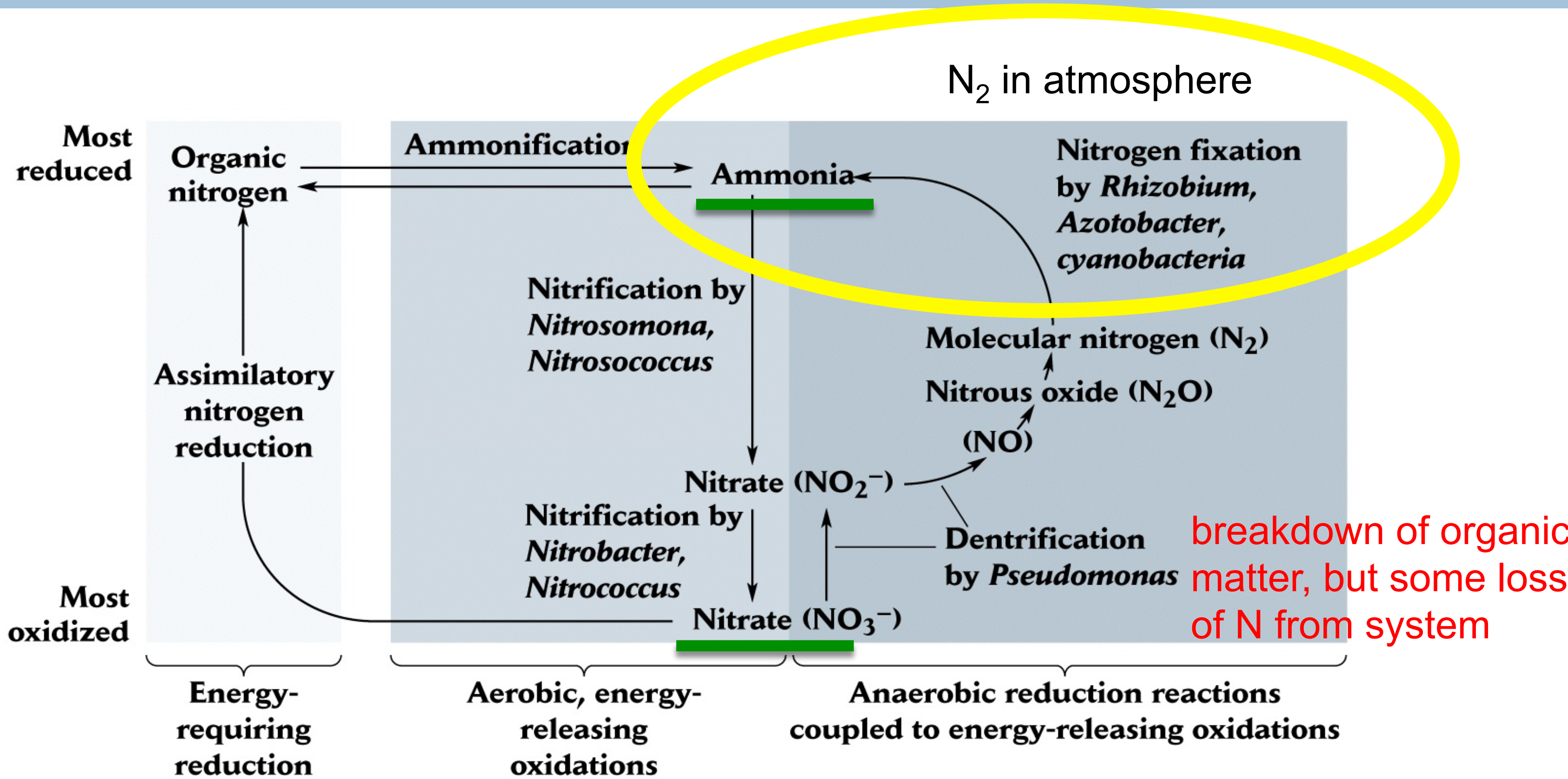
…but we know that things other than energy can limit metabolism & growth → NUTRIENTS

Productivity and the role of limiting elements (nutrients)



The nitrogen cycle

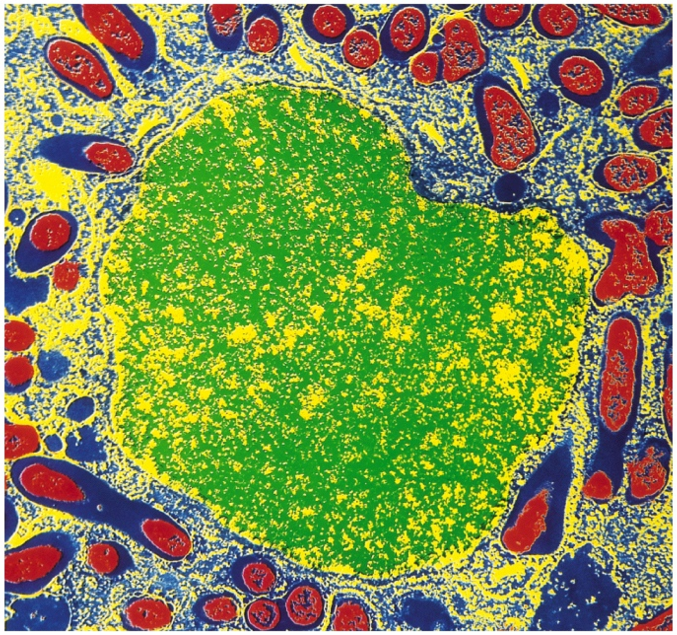
Green = forms taken up by producers



* many reduced and oxidized forms of N complicate cycle (you don't need to know all these details)

N fixers move N_2 out of the atmosphere and into the biosphere in forms that are biologically available (NH_3)

N-fixing bacteria inside

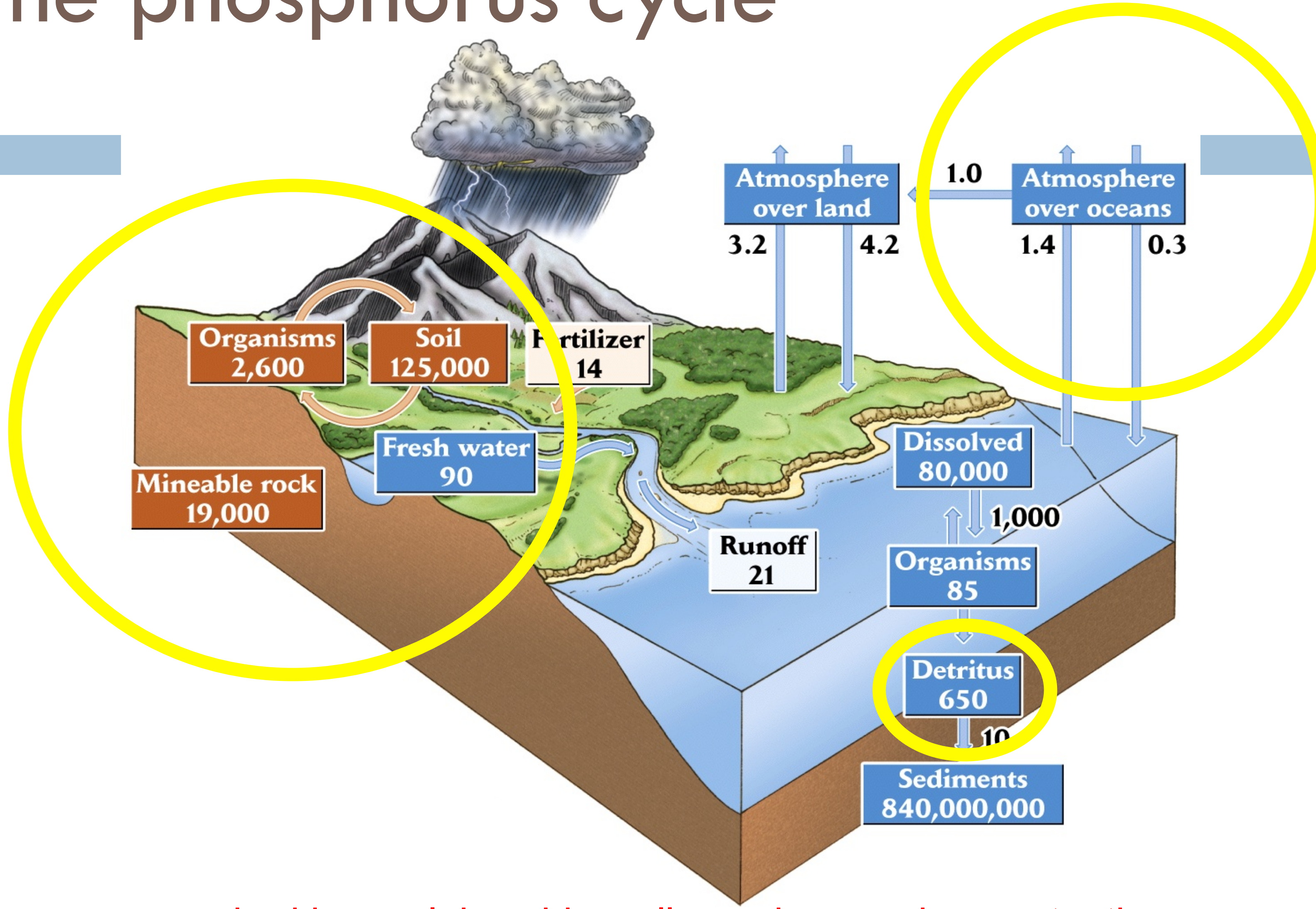


require anoxic conditions for efficient conversion via (interior of plant roots) and sugars (malate) from plants

reduction requires energy… (~2% globally of N cycle)

Nitrogen fixers (alder, lupine) often critically important to succession following disturbance (glacial retreat, Mt. St. Helens)

The phosphorus cycle



required by nucleic acids, cell membranes, bones, teeth

no atmospheric forms (dust), no REDOX transformations

marine and freshwater sediments = large P sink (O_2)

Nutrient cycling (and recycling)

Nutrient recycling in terrestrial systems

How do living plants affect nutrient cycling in ecosystems?

Hubbard Brook ecosystem experiment (p. 510-511)

In-class exercise#4 → will used this dataset!

Distribution of nutrients in plants and soil in different ecosystems

Table 8.1 **Distribution of mineral nutrients in the soil and living biomass of a temperate and a tropical forest ecosystem**

		Nutrients (kg per ha)		
Forest (Locality)	Biomass (T per ha)*	Potassium	Phosphorus	Nitrogen
Ash and oak (Belgium)	380			
Living vegetation		624	95	1,260
Soil		767	2,200	14,000
Ratio of soil to biomass		1.2	23.1	11.1
Tropical deciduous (Ghana)	333			
Living vegetation		808	124	1,794
Soil		649	13	4,587
Ratio of soil to biomass		0.8	0.1	2.0

**T = metric tons.*

Source: *P. Duvigneaud and S. Denayer-de-Smet, in D. E. Reichle (ed.),* Analysis of Tropical Forest Ecosystems, *Springer-Verlag, New York (1970), pp. 199–225; D. J. Greenland and J. M. Kowal,* Plant Soil *12:154–174 (1960); J. D. Ovington,* Biol. Rev. *40:295–336 (1965).*

<u>Remember:</u> Detritus accumulation in temperate vs. tropical forests

Residence time of litter : Tropics = 1-2 yrs.
Temperate N. Am = 4-16 yrs
Mountain & Boreal = 100's to 1000's of years

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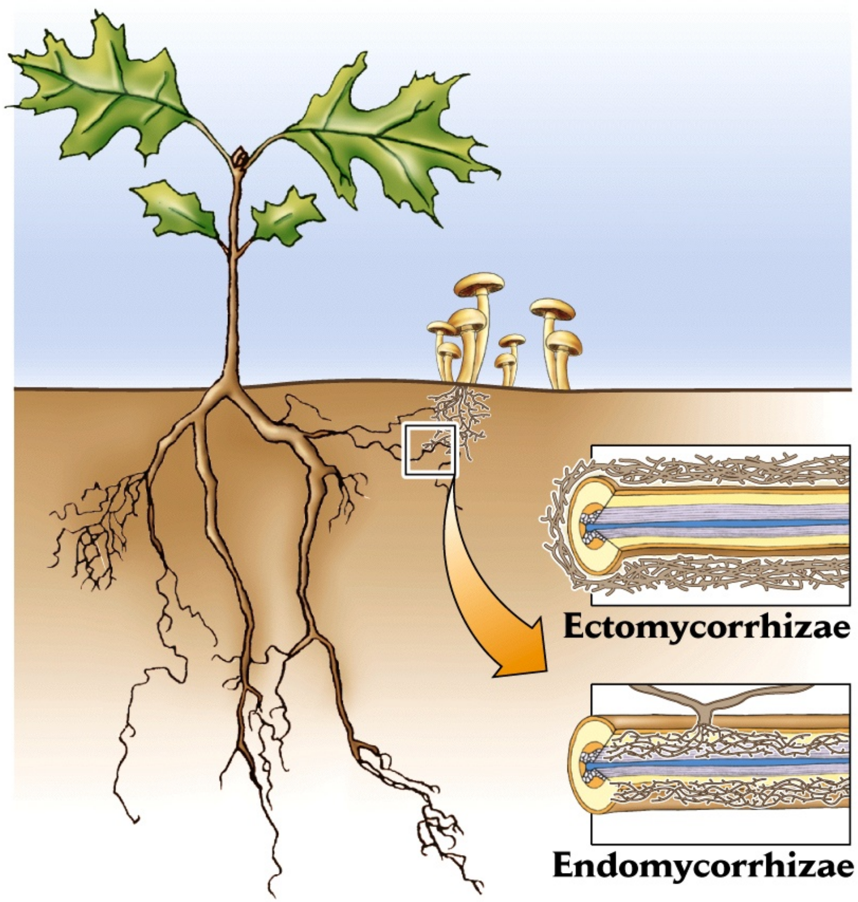
Decomposition releases nutrients from organisms

…so does excretion and egestion

The role of decomposers is therefore critical to maintaining productive ecosystems

Remember ecosystem differences in decomposition rates (and why)!

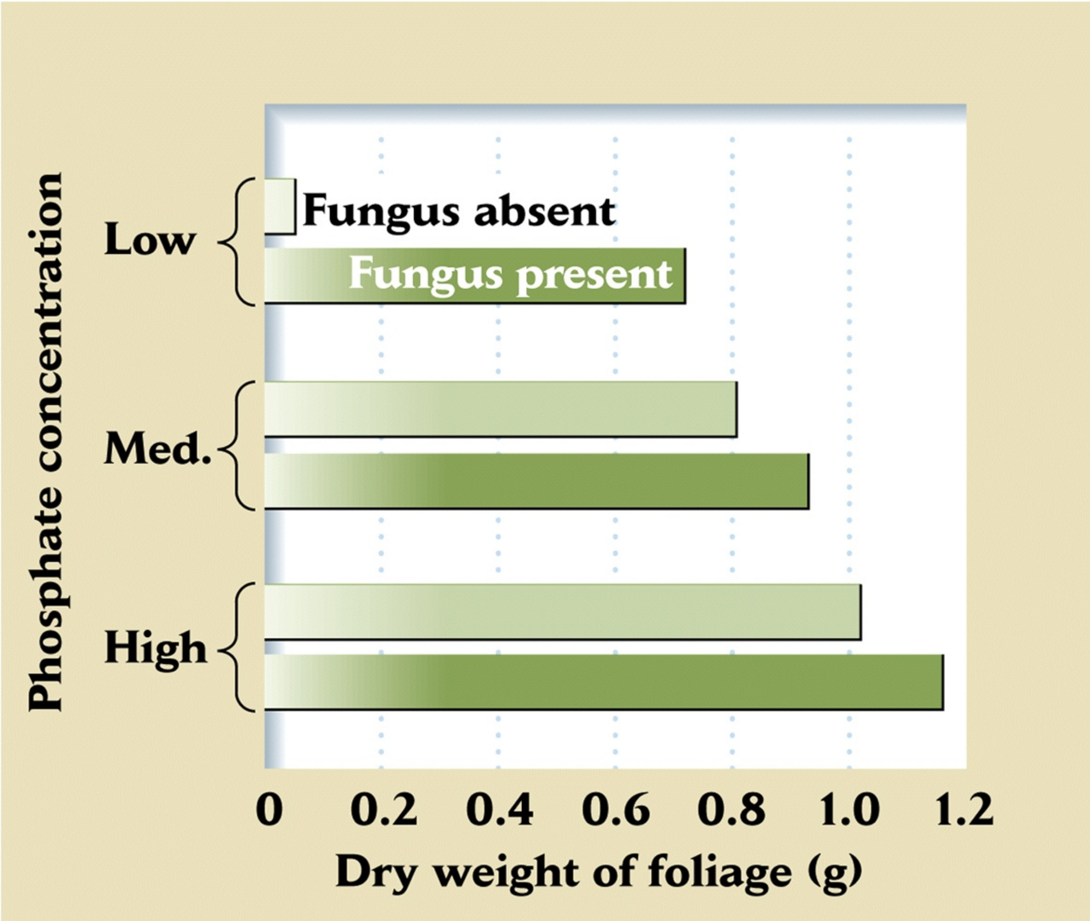
Mycorrhizal associations with plants enhances their abilities to extract nutrients from the environment



- Mycorrhyzae secrete enzymes into surrounding soil (and acids) mobilizing mineral nutrients
- Extend the volume of soil from which nutrients can be ‘extracted’ (higher surface area)
- Make sure you understand differences between N-fixing bacteria & mycorrhyzae

Mycorrhyzae interact with soil nutrients to affect plant growth

Fertilizer applied



What do you conclude from this experiment?

Mycorrhyzae most important in nutrient-limited environments

How do human alterations to the landscape affect nutrient cycling and retention in terrestrial ecosystems?

Tropical forests have nutrients in living biomass not soils

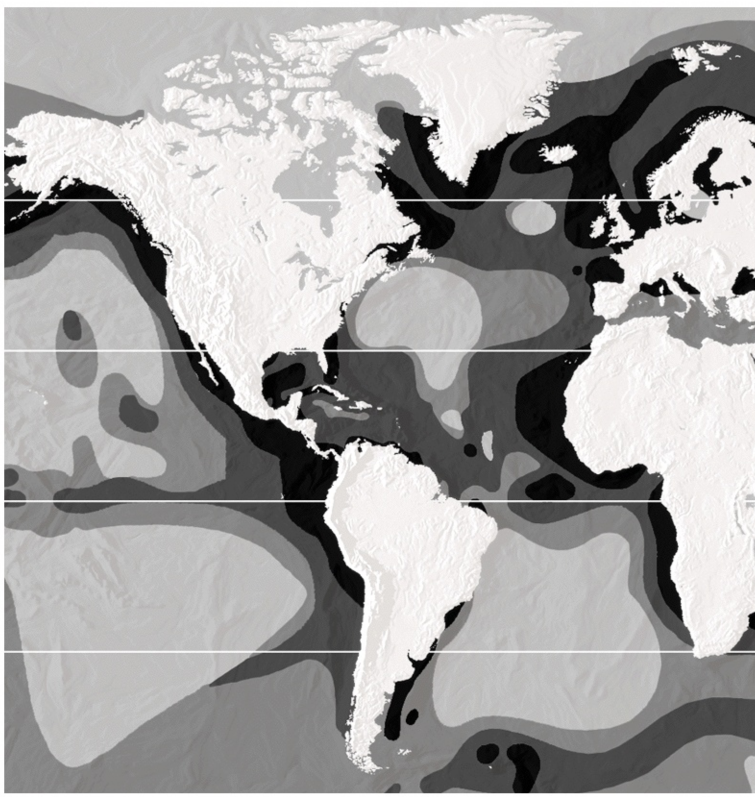
How do human alterations to the landscape affect nutrient cycling and retention in terrestrial ecosystems?

… the ecosystem becomes ‘leaky’ (esp. net loss of N). Implications for aquatic ecosystems downstream.

20% of total biomass in detritus (1-2% in tropics)

Nutrient recycling in the oceans derives mostly from:

1. Regeneration from sediments and deep water layers
2. Consumer-based recycling (zooplankton)



Productivity in the oceans (mg C fixed/m^2/day)

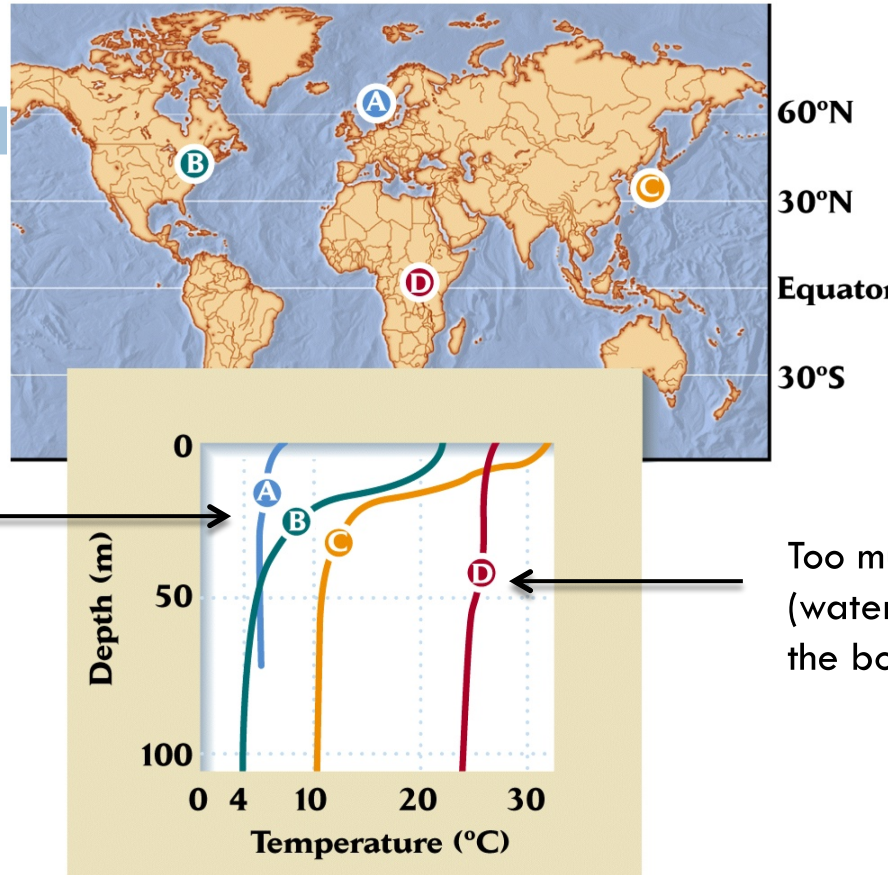
What controls nutrient recycling in lakes?

Pretty much the same processes as in the ocean…

1. Regeneration from sediments and deep water layers
2. Consumer-based recycling (zooplankton)

Except…

Thermal stratification in lakes (Ch 6)



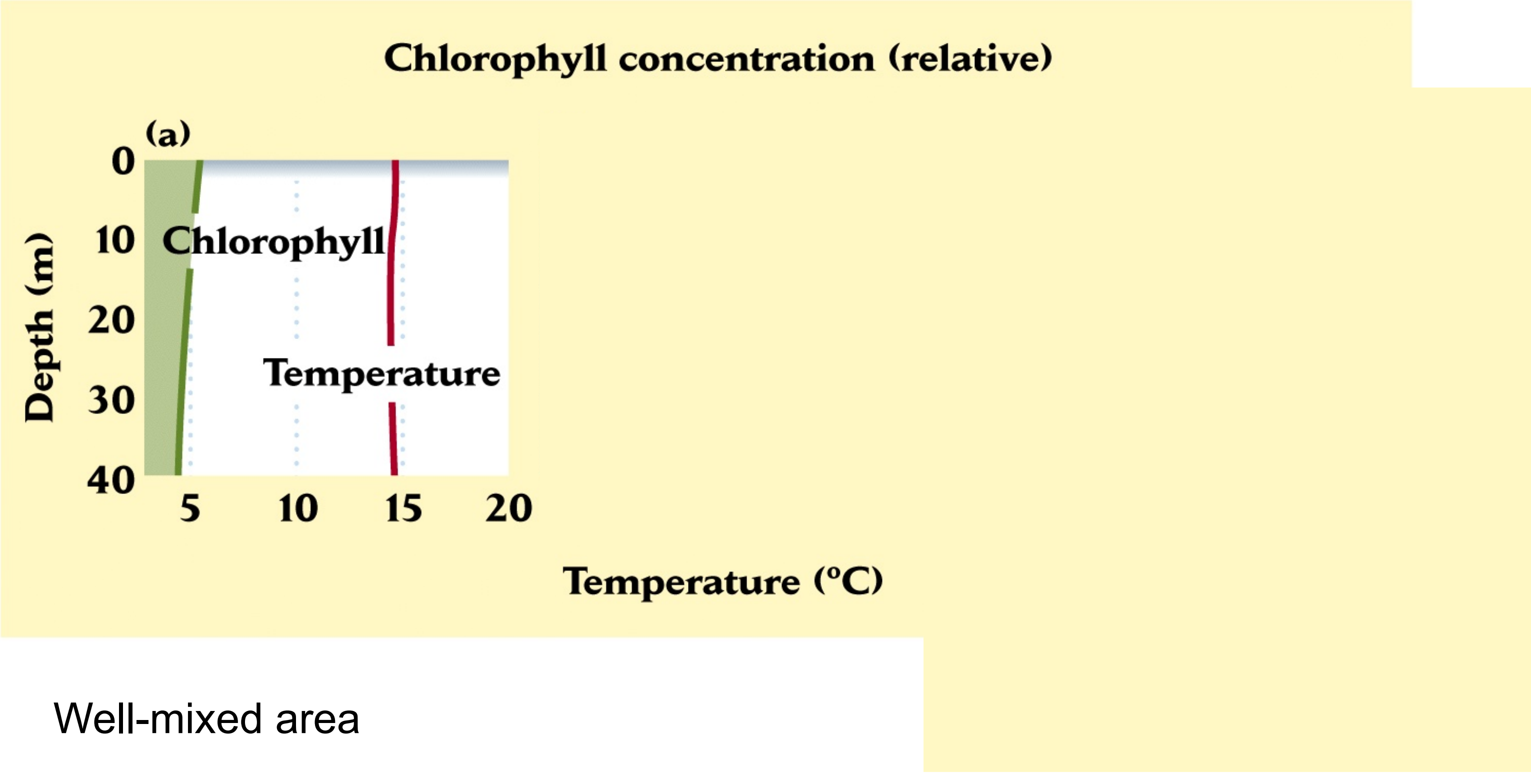
Too little heat (not enough energy to prevent mixing from wind, etc.)

Too much heat (water warmed year round to the bottom of lakes)

Vertical stratification impedes nutrient mixing from deep waters
…also prevents phytoplankton from traveling out of photic zone

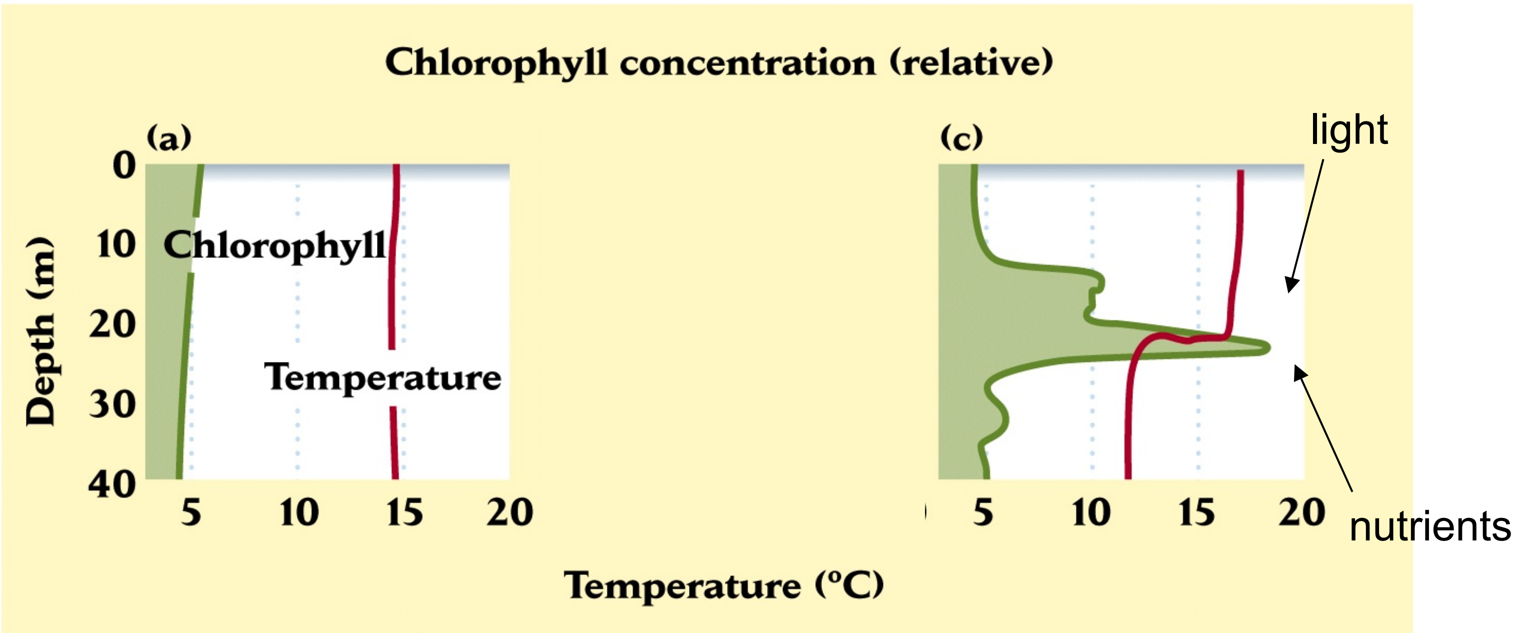
(summer stratification across latitudes)

Vertical distribution of primary producers in aquatic ecosystems depends on the balance of nutrients and light with depth



Well-mixed area

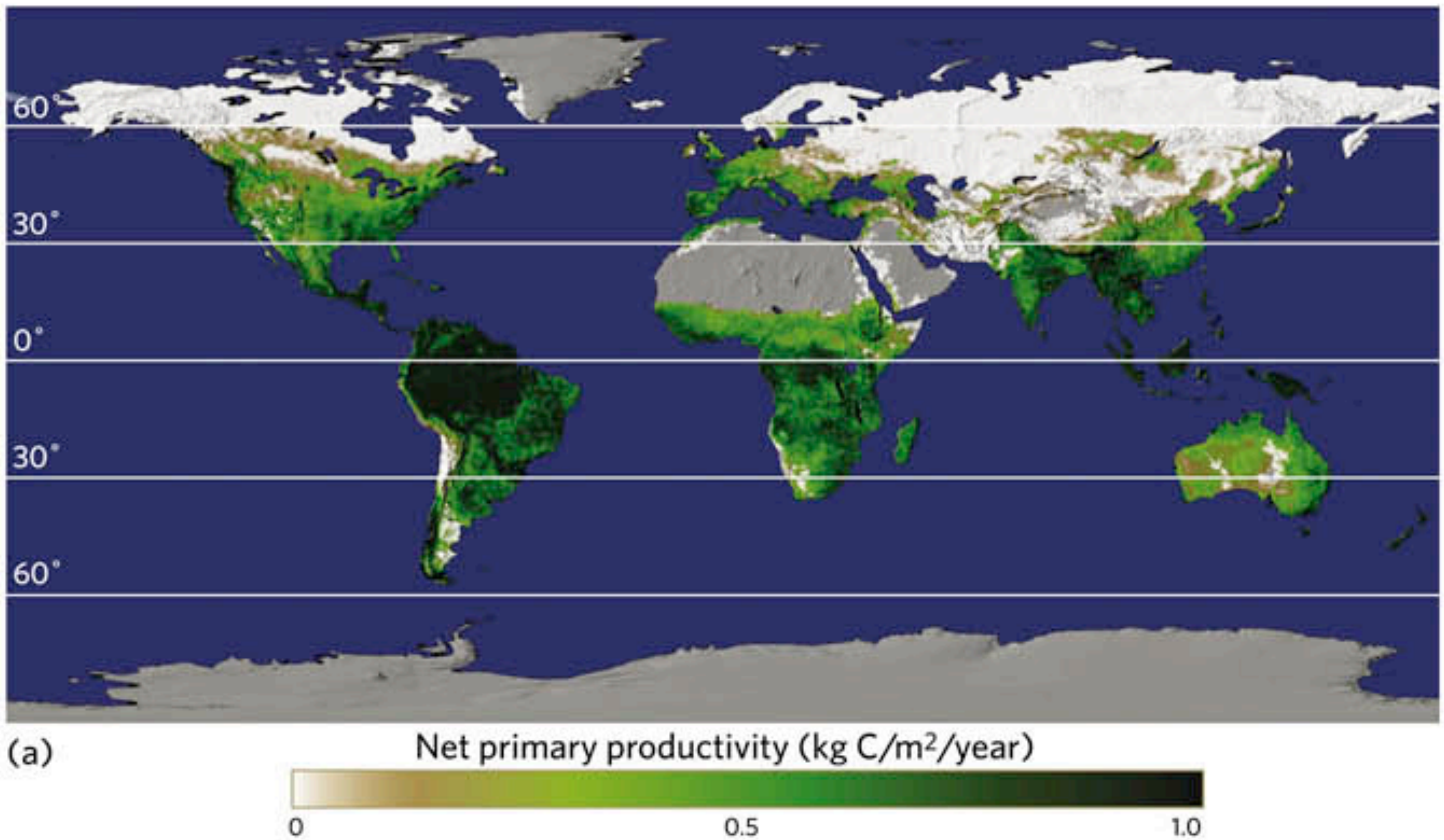
Vertical distribution of primary producers in aquatic ecosystems depends on the balance of nutrients and light with depth



Well-mixed area

Strongly stratified area

What element controls primary productivity (NPP) in terrestrial ecosystems?



(see p. 474-476)

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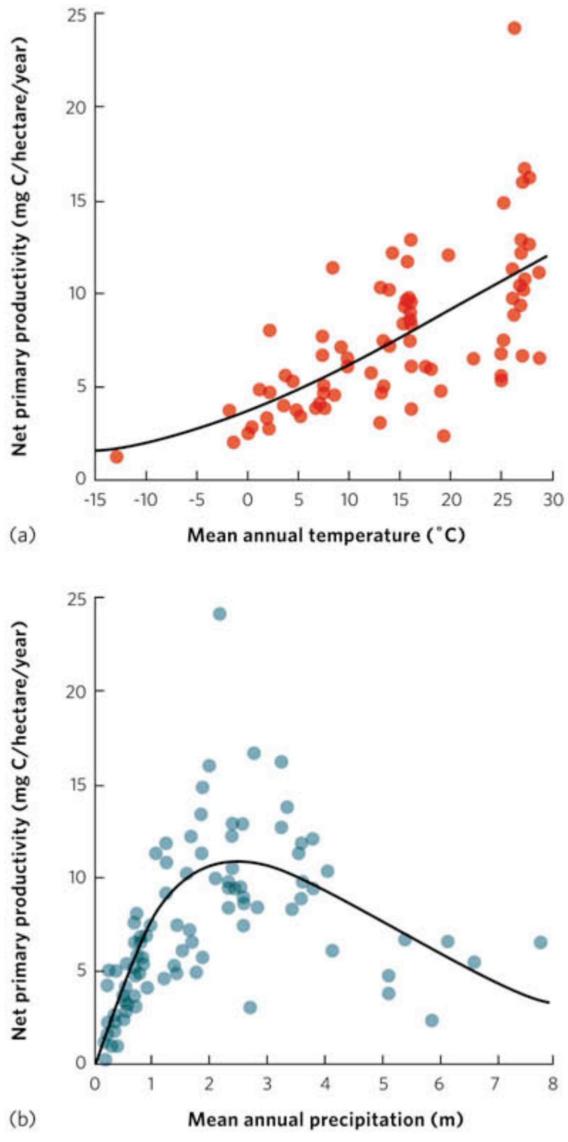

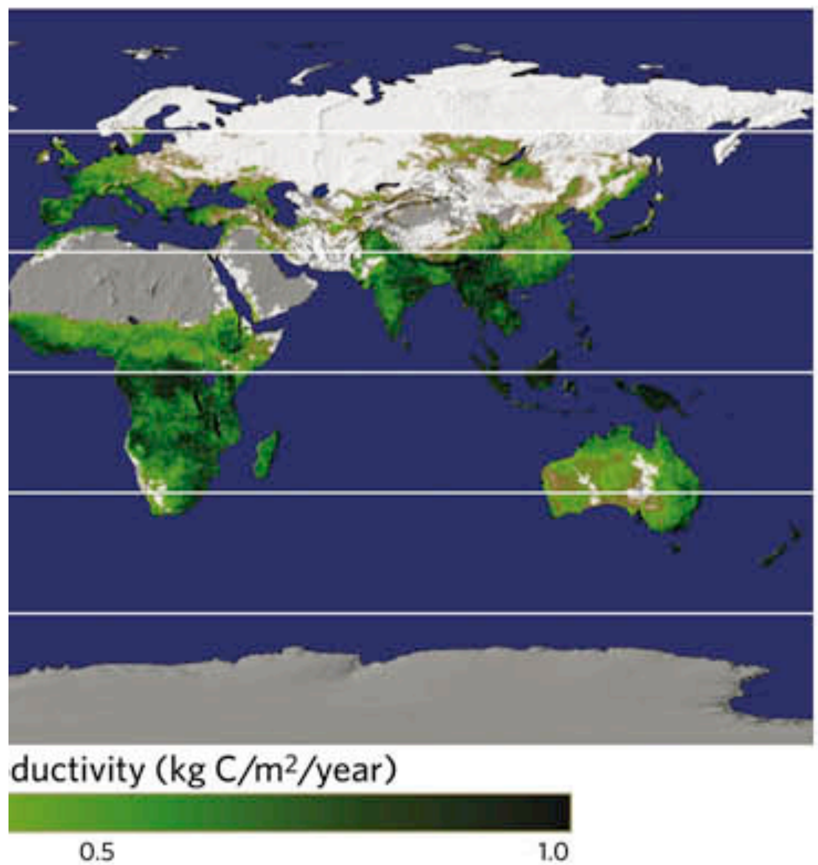

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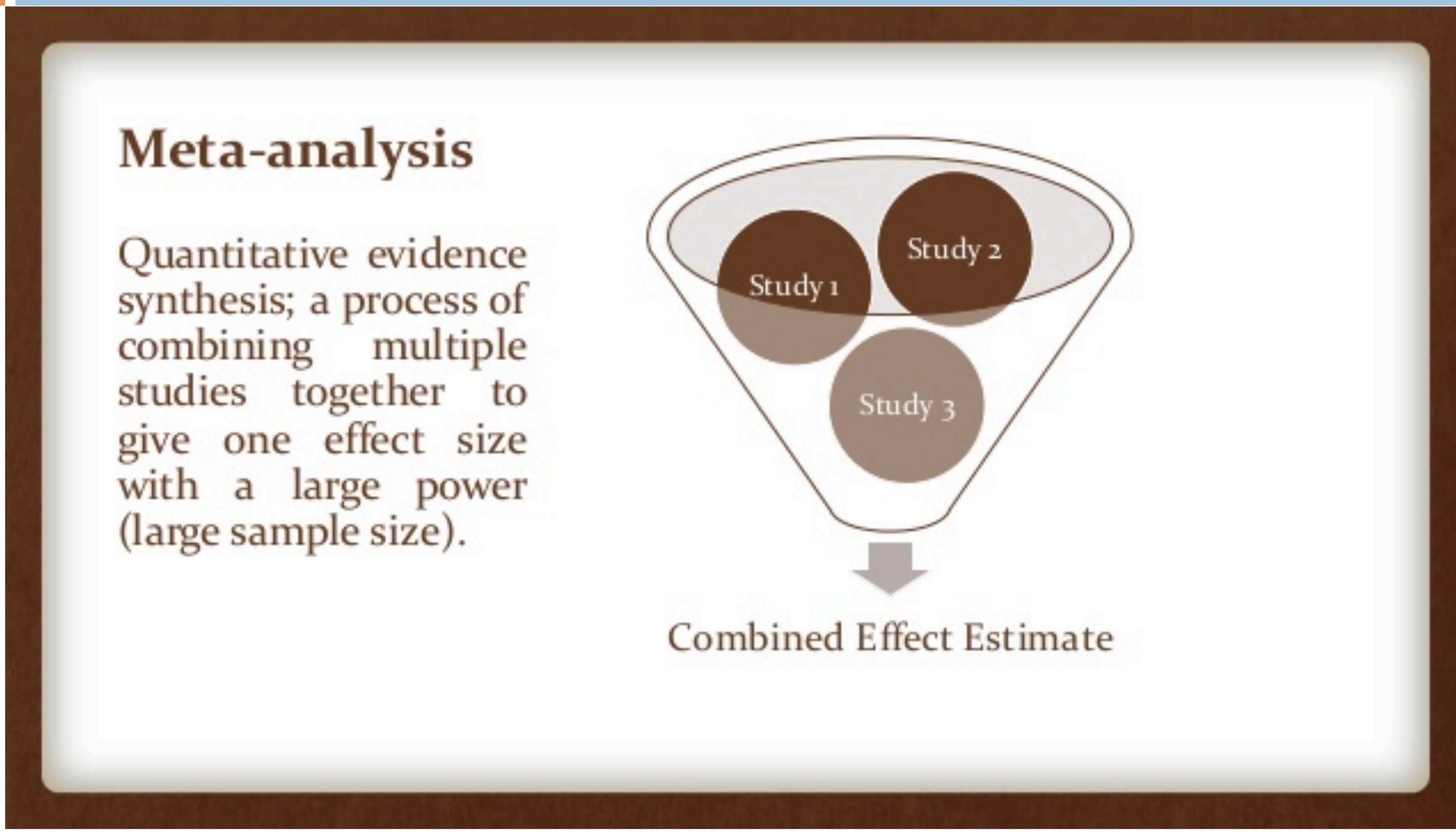

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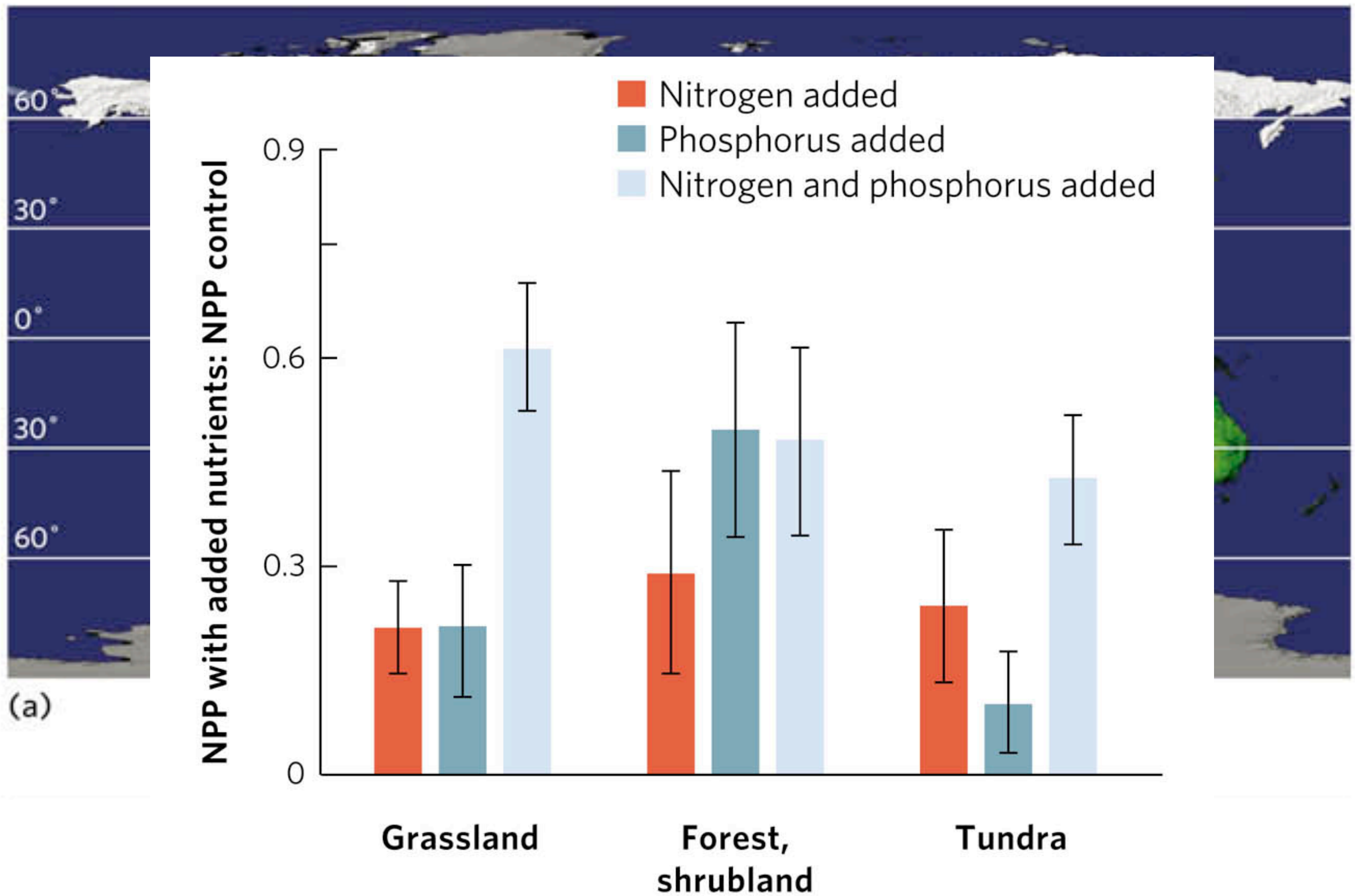
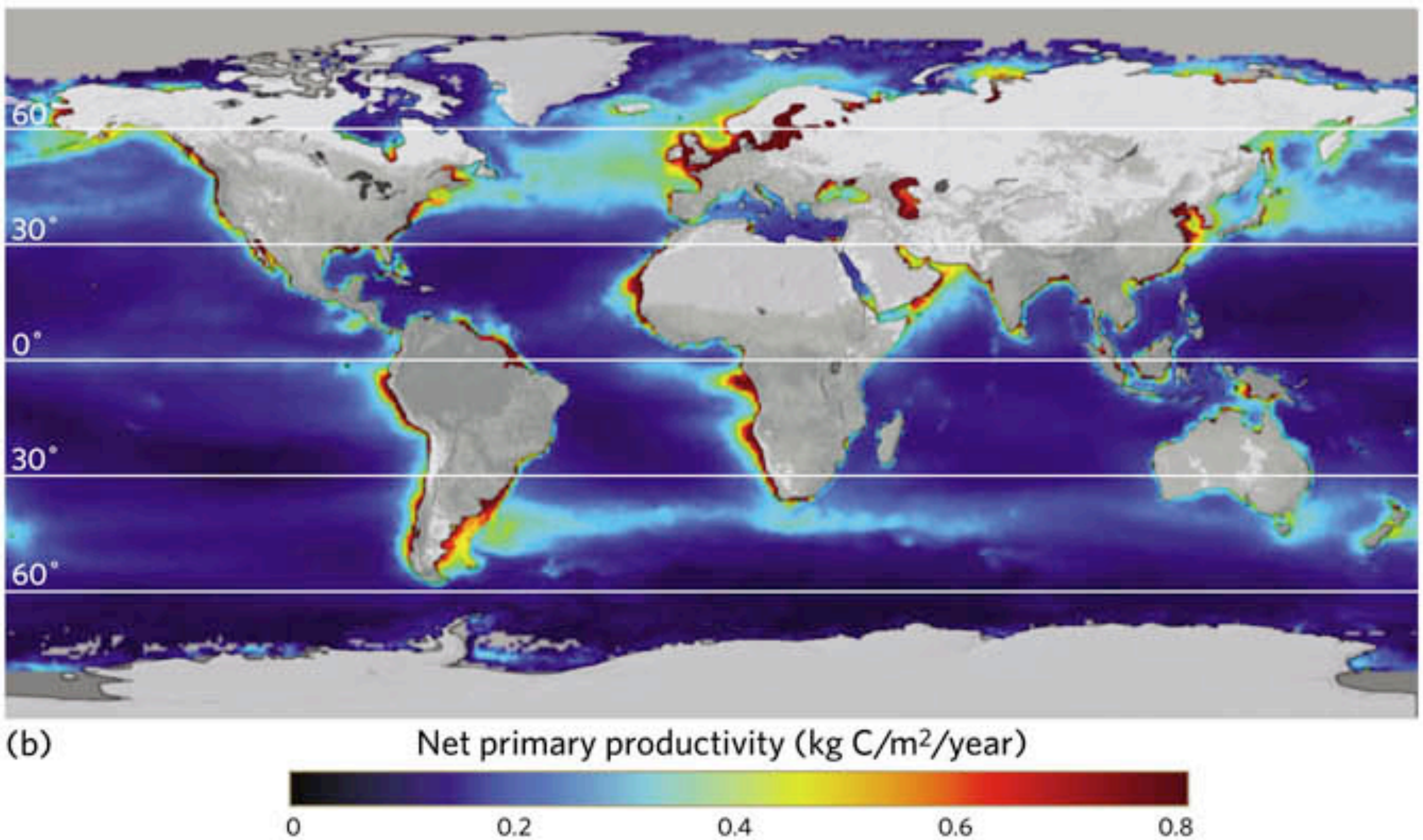


Elser et al. (2007) *Ecology Letters*

*141 Studies combined

(see p. 474-476)

What element controls algal productivity (NPP) in oceans?



(see p. 476-479)

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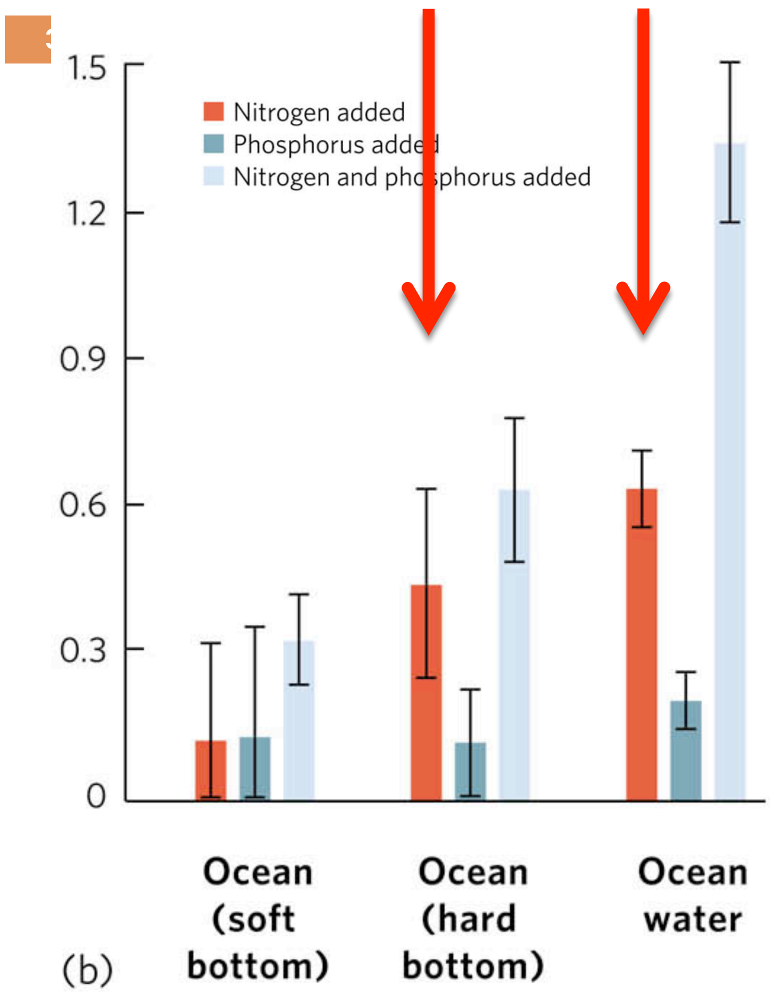
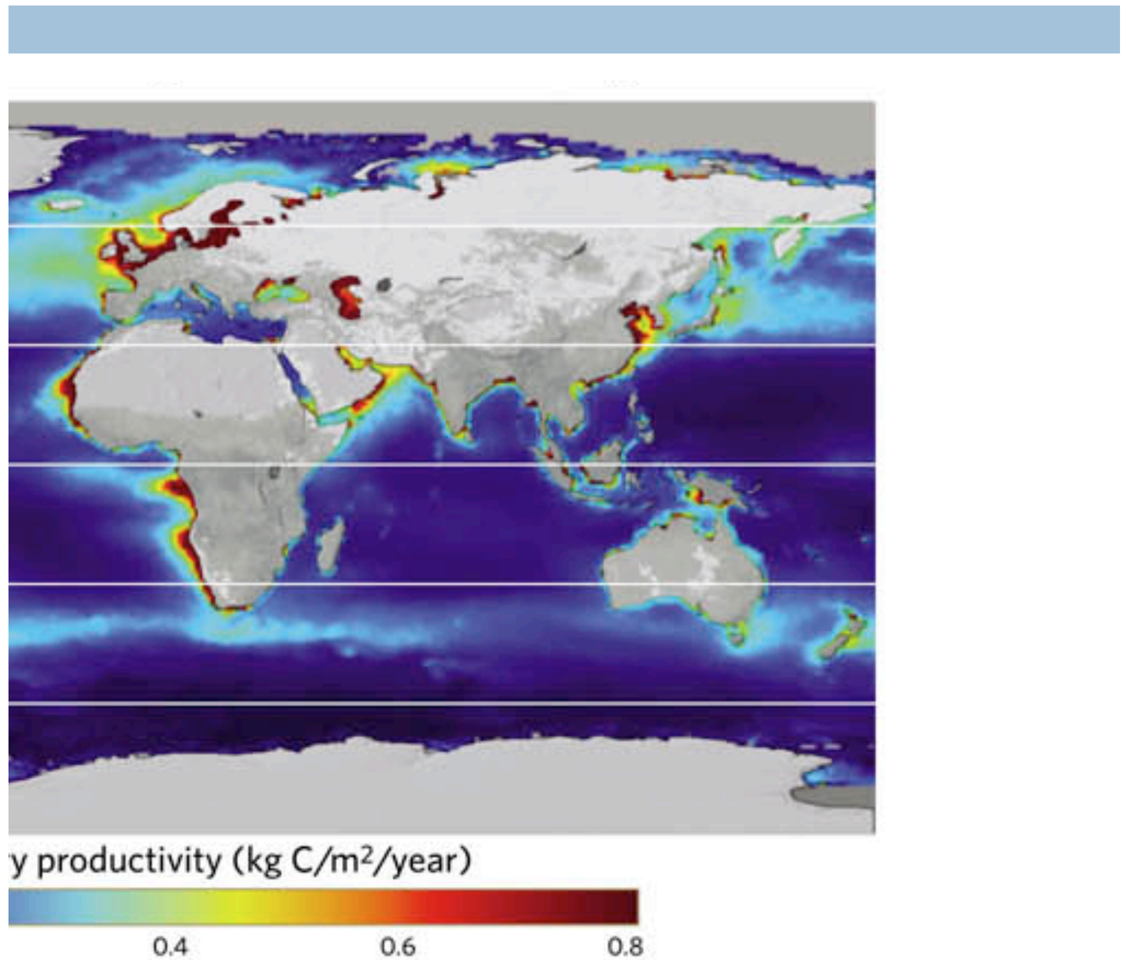




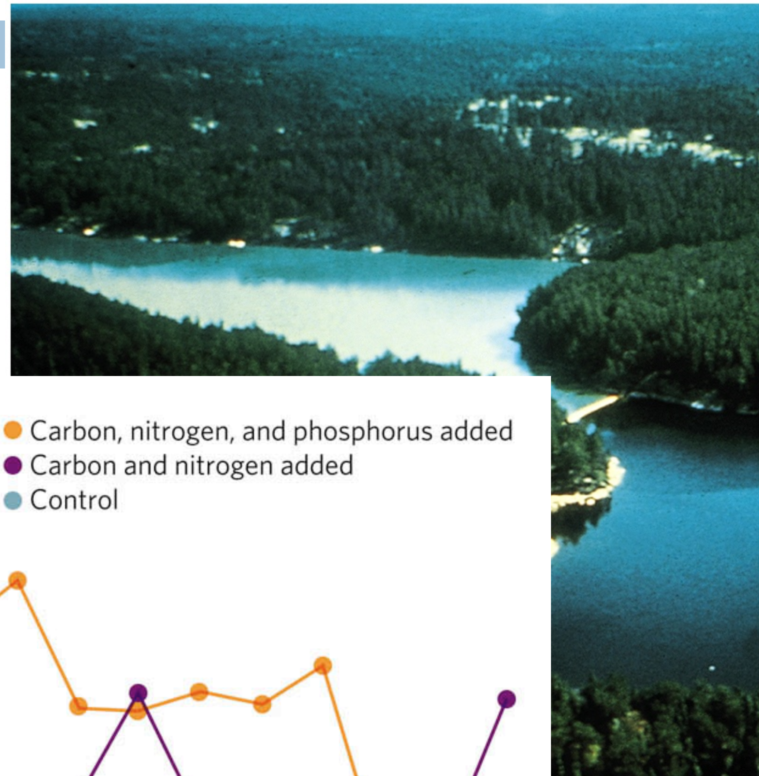
*Silicon & Iron

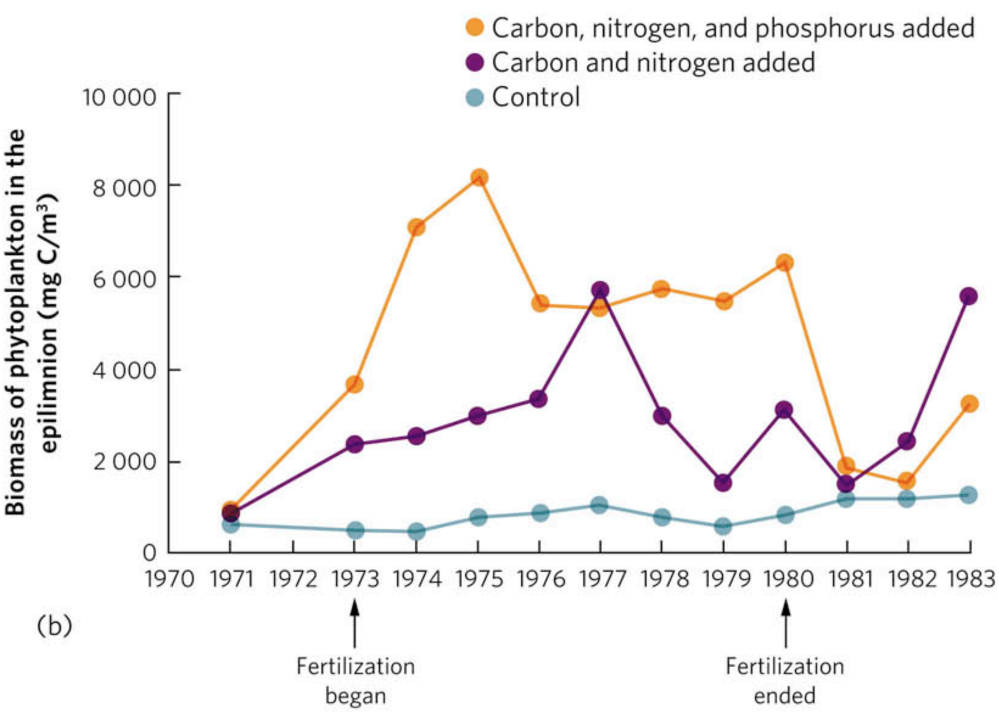
(see p. 476-479)

Elser et al. (2007) *Ecology Letters*

*928 experiments combined

What element controls algal productivity (NPP) in lakes?





ıental Lakes Area

(see p. 476-479)

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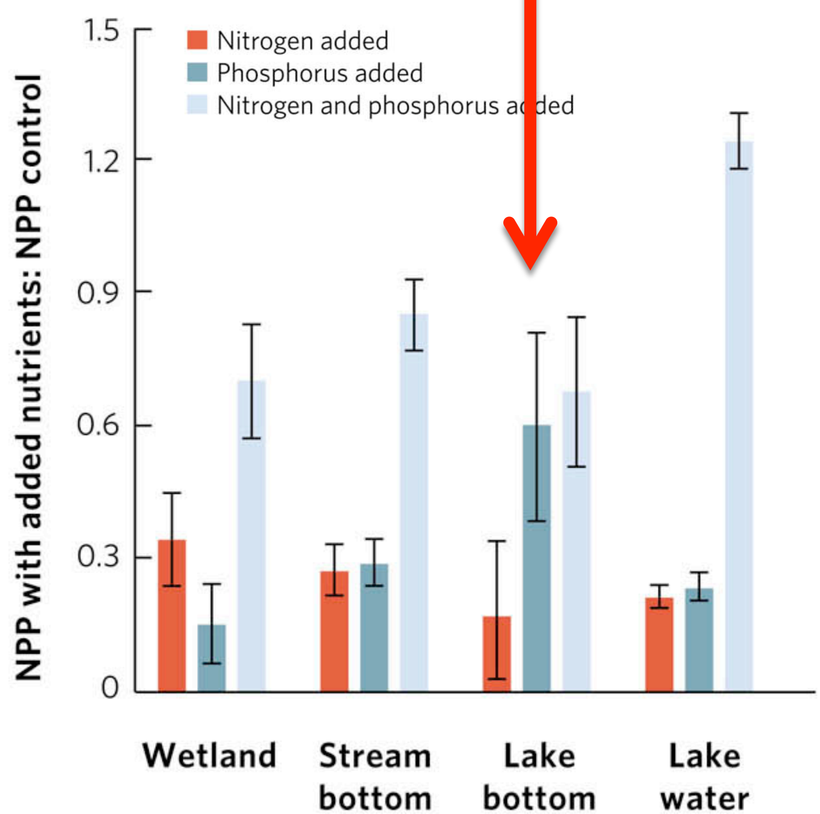

Elser et al. (2007) *Ecology Letters*

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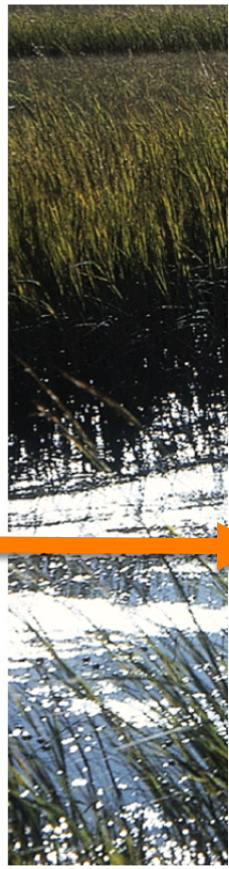
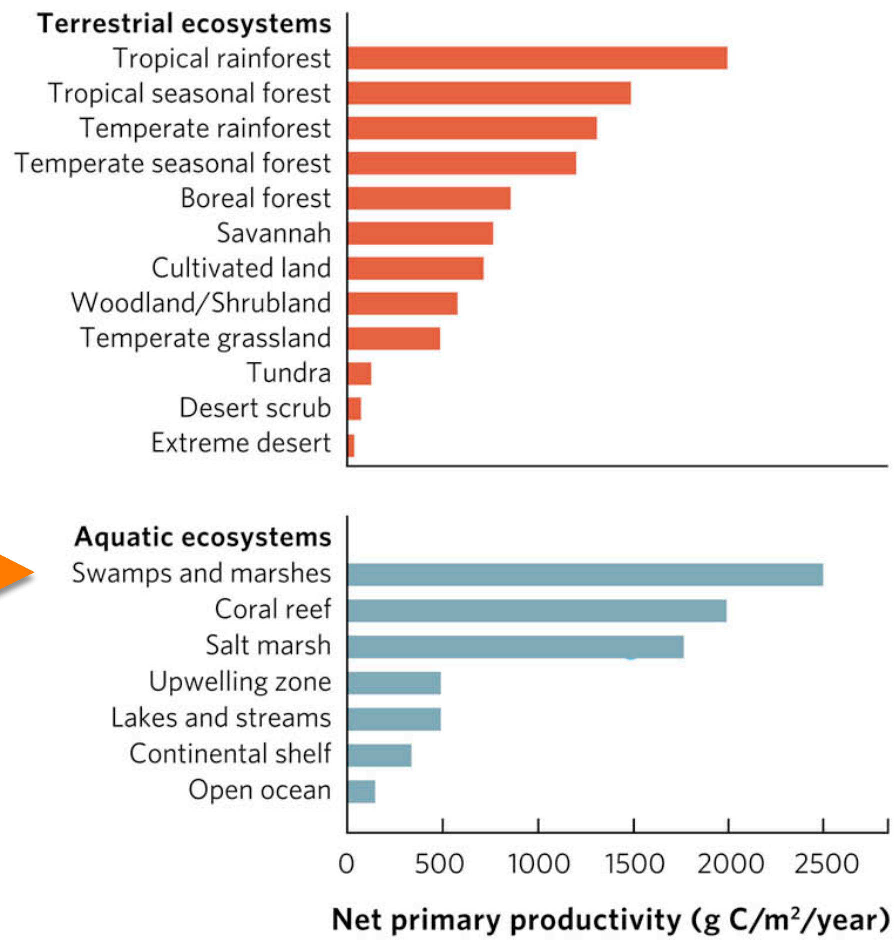
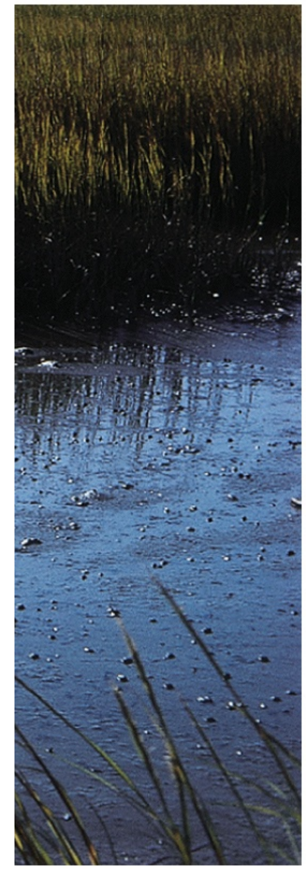
Salt marshes

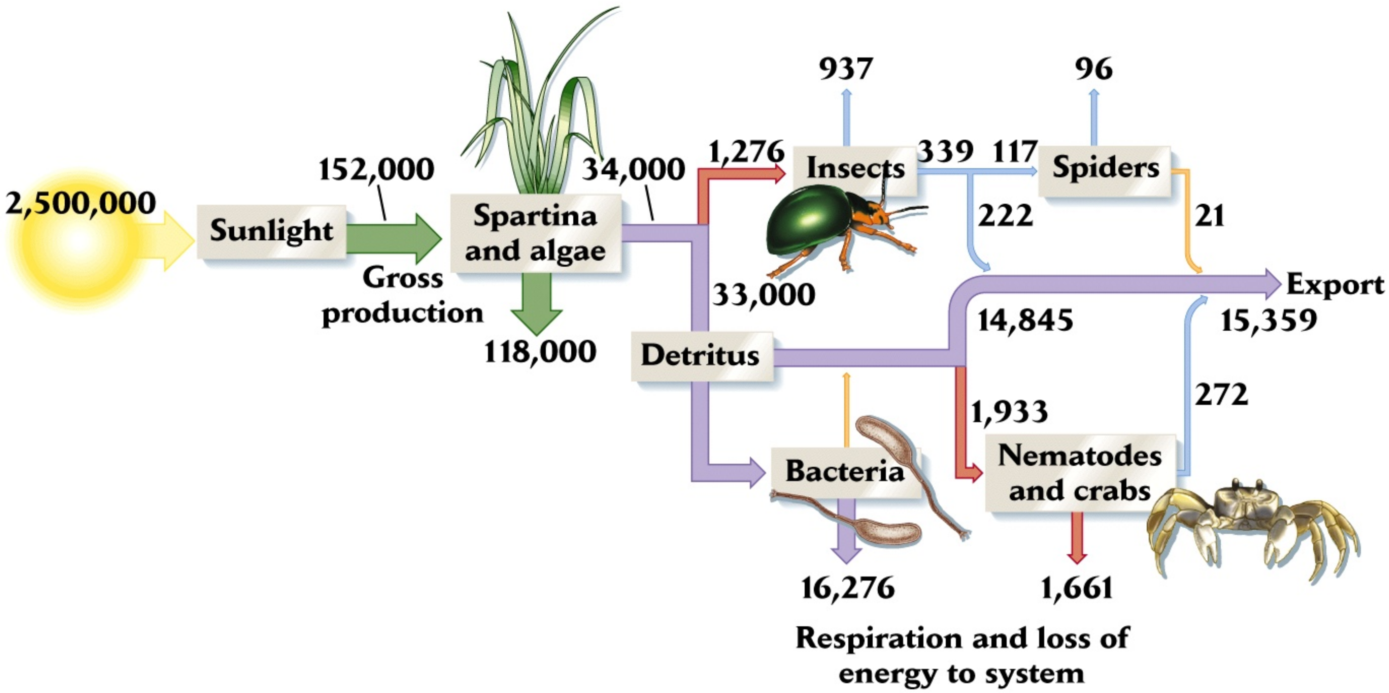




Chapter 20 Figure 20-07



Export huge amounts (~10%) of their production to adjacent ecosystems (strong local regeneration of nutrients = high prod.)



~50% of NPP exported to coastal oceans (organisms, particulate detritus, dissolved organic material, etc.) carried out by the tides