Laurea / B.A.
in Global Governance

The photosynthesis

2023/2024

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1

The laws of physics and chemistry apply to ecosystems

- The law of conservation of energy applies to ecosystems.
  - We can potentially trace all the energy from its solar input to its release as heat by organisms.
- The second law of thermodynamics allows us to measure the efficiency of the energy conversions.

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ecological resilience

- the ability of an ecosystem to maintain its normal patterns of nutrient cycling and biomass production after being subjected to damage caused by an ecological disturbance. The term *resilience* is a term that is sometimes used interchangeably with *robustness* to describe the ability of a system to continue functioning amid and recover from a disturbance

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photosynthesis

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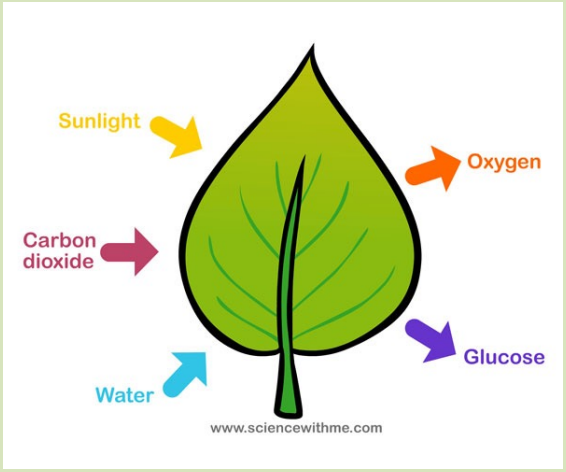

Carbon dioxide + water ⟶ glucose + oxygen

$CO_2 + H_2O \longrightarrow C_6H_{12}O_6 + O_2$

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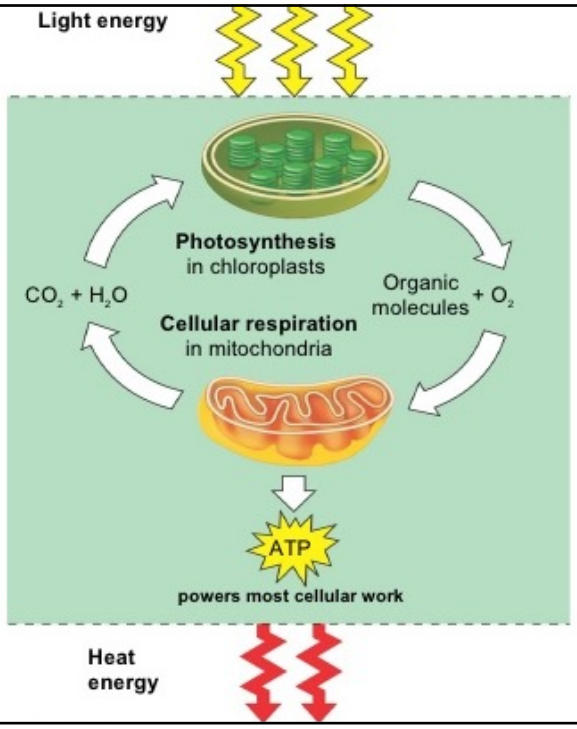

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autotrophos
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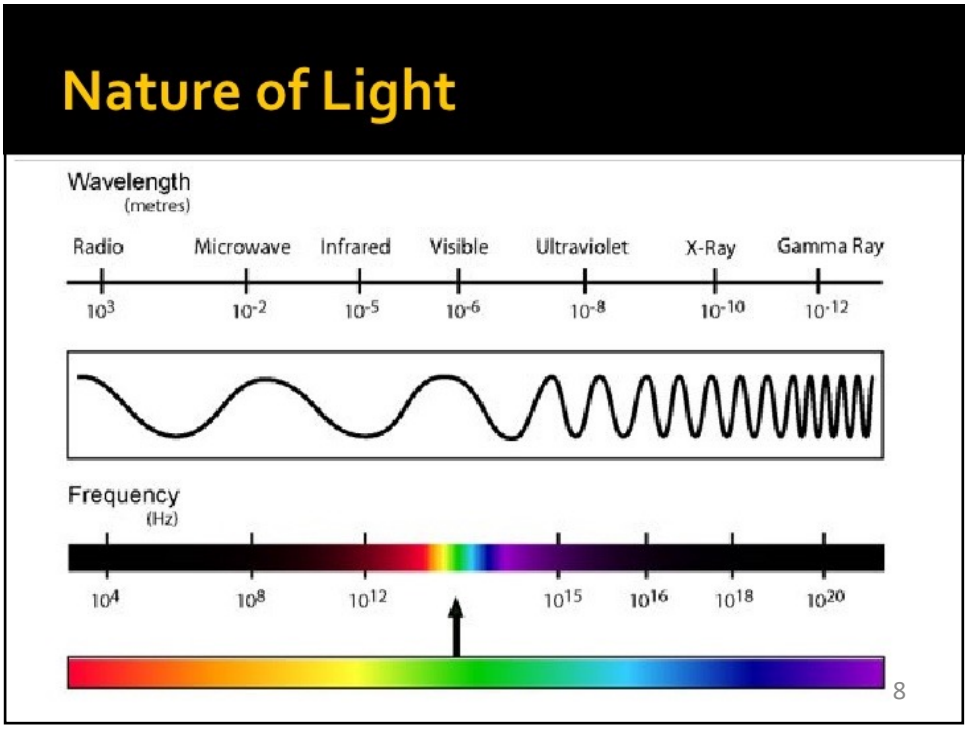
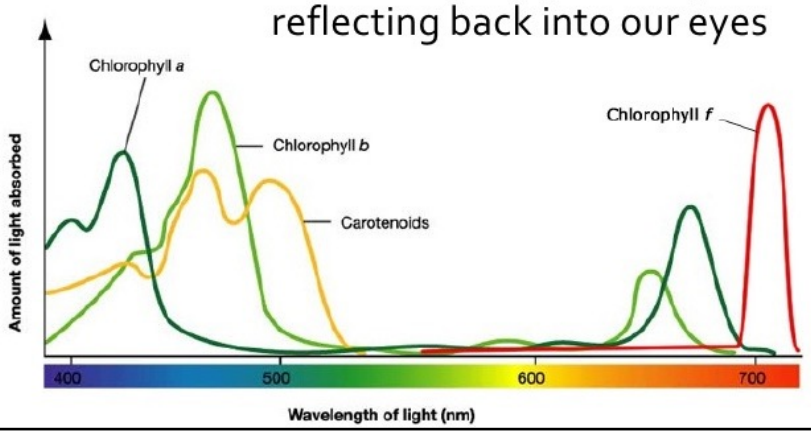

Nature of Light
Wavelength
(metres)
Radio
Microwave
Infrared
Visible
Ultraviolet
X-Ray
Gamma Ray
10^3
10^-2
10^-5
10^-6
10^-8
10^-10
10^-12
Frequency
(Hz)
10^4
10^8
10^12
10^15
10^16
10^18
10^20
8

8

Absorption Spectrum

- The colour of the pigments is due to wavelengths of light reflecting back into our eyes



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9

Production: Formation of Organic Matter

- Autotrophic Organisms
  (Plants, algae and some bacteria)
  - Photosynthesis
  - Chemosynthesis

  CO_2 + Electron Donor + **energy** → CH_2O + other

- Heterotrophic Organisms
  (most bacteria and animals)

RESPIRATION (Autotrophs & Heterotrophs)

$CH_2O + O_2 \rightarrow CO_2 + H_2O$ + Energy (ATP)

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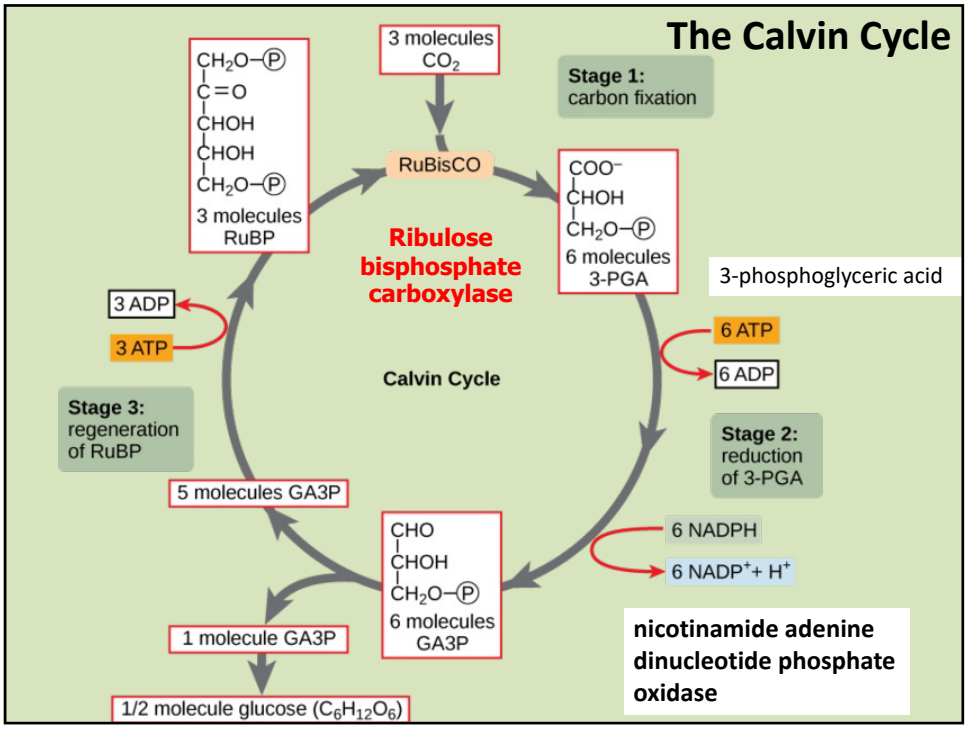
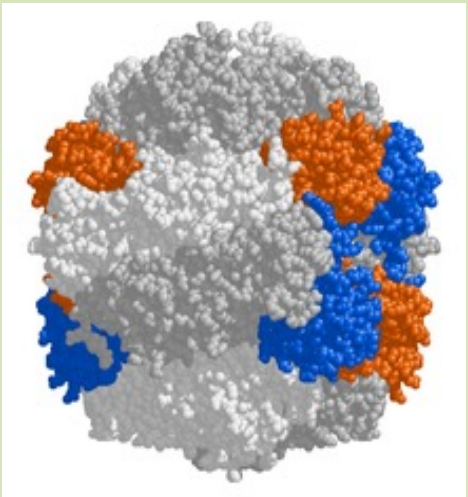


11

Ribulose bisphosphate carboxylase

Ribulose bisphosphate CarbOxylase

RuBisCO



Most common protein in the world

12

The Calvin Cycle:

The Calvin cycle has three stages.

1. the enzyme RuBisCO incorporates carbon dioxide into an organic molecule, 3-PGA. (3-phosphoglyceric acid)
2. the organic molecule is reduced using electrons supplied by NADPH. nicotinamide adenine dinucleotide phosphate oxidase
3. RuBP, the molecule that starts the cycle, is regenerated so that the cycle can continue. Only one carbon dioxide molecule is incorporated at a time, so the cycle must be completed three times to produce a single three-carbon GA3P molecule, and six times to produce a six-carbon glucose molecule.

13

RUBISCO enzyma adds CO_2 to RuBP (RibuloseBiphosphate), but at low concentration of CO_2 in the atmosphere it can add also O_2.

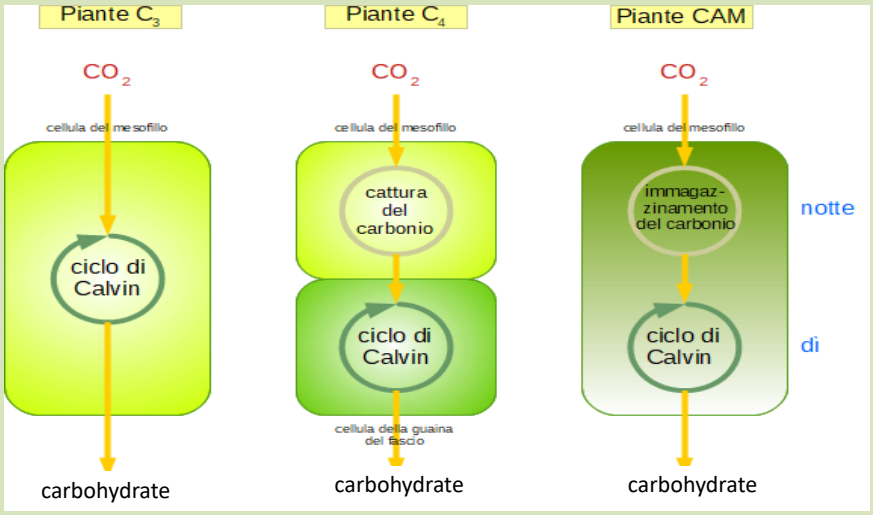
So the reaction is less productive and the growth of plants is influenced.

Nowaday we have two types of plants, called C3 and C4, and CAM.

14

C3, C4 and CAM plants

Crassulacean Acid **Metabolism**



15

When CO_2 concentration is low photosynthesis C3 has low efficency When CO_2 increases also efficency increases.

Level of CO2 in atnosphere	Incresae of photosynthesis in C3 plant	Incresae of photosynthesis in C4 plant
180 [1]	**100**	**100**
200	108	104
220	116	108
240	123	112
260	129	115
280 [2]	**135**	**118**
300	141	120
320	146	123
340	151	125
360	155	128
380	160	130
400 [3]	**164**	**132**
420	168	134
440	172	136
460	175	138
480	178	139
500	182	141
520	185	142
540	188	144
560 [4]	**191**	**145**

16

- (1) 180 ppmv CO_2 al last ICE ERA;
- (2) 280 ppmv CO_2 pre-industrial age (up to 1750);
- (3) 400 ppmv CO_2 current level;
- (4) 560 Double level compared to pre-industrial, doubling that with the current growth rates is expected around 2080 while models based on global economic growth anticipate to 2050.

17

17

- C3 (most of the cultivated species, including wheat, barley, rye, rice, beet, potato, etc.) therefore risk "starvation» (for plant…).
- C4 (ex: corn, sorghum, sugar cane) appeared during cold period
- the increase in CO_2 should produce:
- - greater resistance to drought for the simple reason that plants will have less need to develop stomata required to acquire CO_2 from the atmosphere and therefore will have less water losses.
- - greater accumulation of dry matter in the underground parts (reserve organs such as tubers, roots, rhizomes) which is explained by the fact that the plant has less need to develop the epigeal apparatus to intercept CO_2.

18

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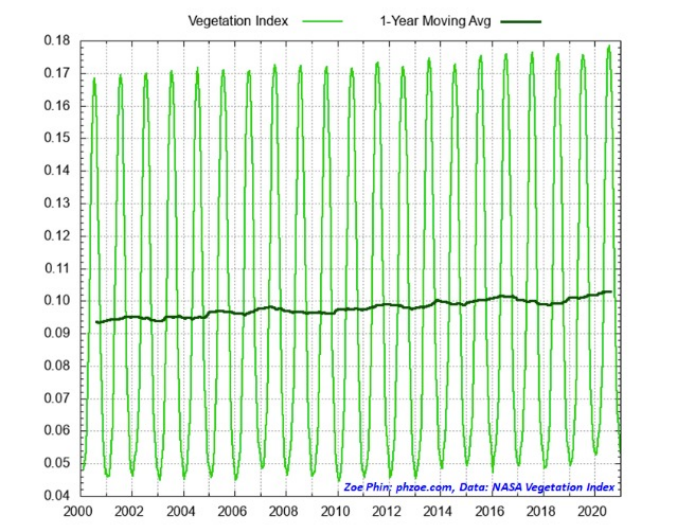
NASA Vegetation Index: Globe Continues Rapid Greening Trend, Sahara Alone Shrinks 700,000 Sq Km!



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19

the increase of CO_2 determines carbonic fertilization and explains [1] the 30% [2] increase in green mass observed by satellites. [6], [3] in Europe alone, forests increased by 90,000 km2 between 1990 and 2015! [8]

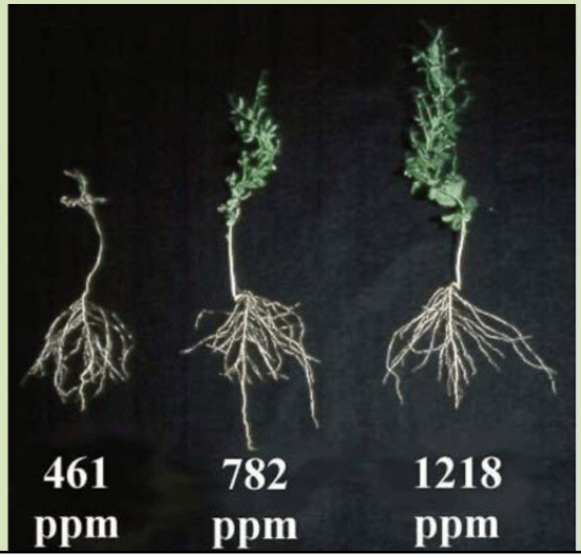
1 Zhu, 2016. Zhu, Z., Piao, S., Myneni, R. et al. Greening of the Earth and its drivers. Nature Clim Change 6, 791–795, 2016.

2 Campbell, 2017. Campbell, J., Berry, J., Seibt, U. et al. Large historical growth in global terrestrial gross primary production. Nature 544, 84–87 (2017). https://doi.org/10.1038/nature22030

3 Haverd, V; Smith, B; Canadell, J. G.; Cuntz, M; Mikaloff-Fletcher, S; Farquhar, G.; Woodgate, W; Briggs, Peter R.; Trudinger, Cathy M.: Higher than expected CO2 fertilization inferred from leaf to global observations, Global Change Biology, V 26, Innue 4 dell'Aprile 2020, p. 2390-2402

20

https://stoneforge.com/2017/03/22/the-benefits-of-co2/



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Kelp Forest

Fucus sp

Macroalgae: 3%
Ocean
Photosynthesis

23

Primary consumers

24

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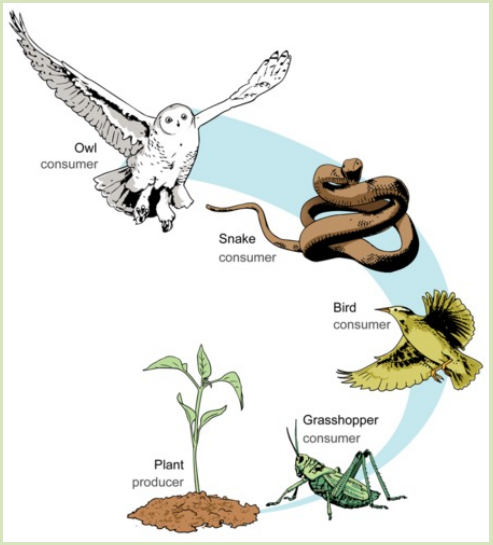
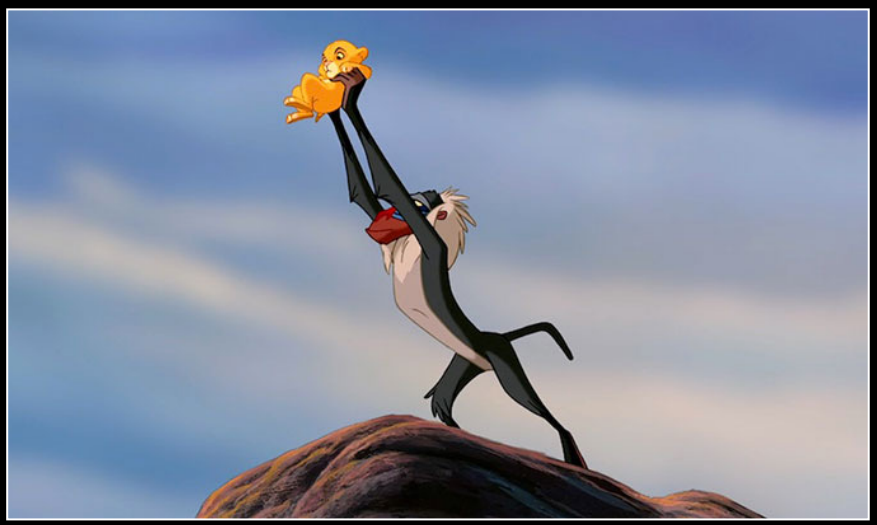

Owl
consumer
Snake
consumer
Bird
consumer
Grasshopper
consumer
Plant
producer

25

25



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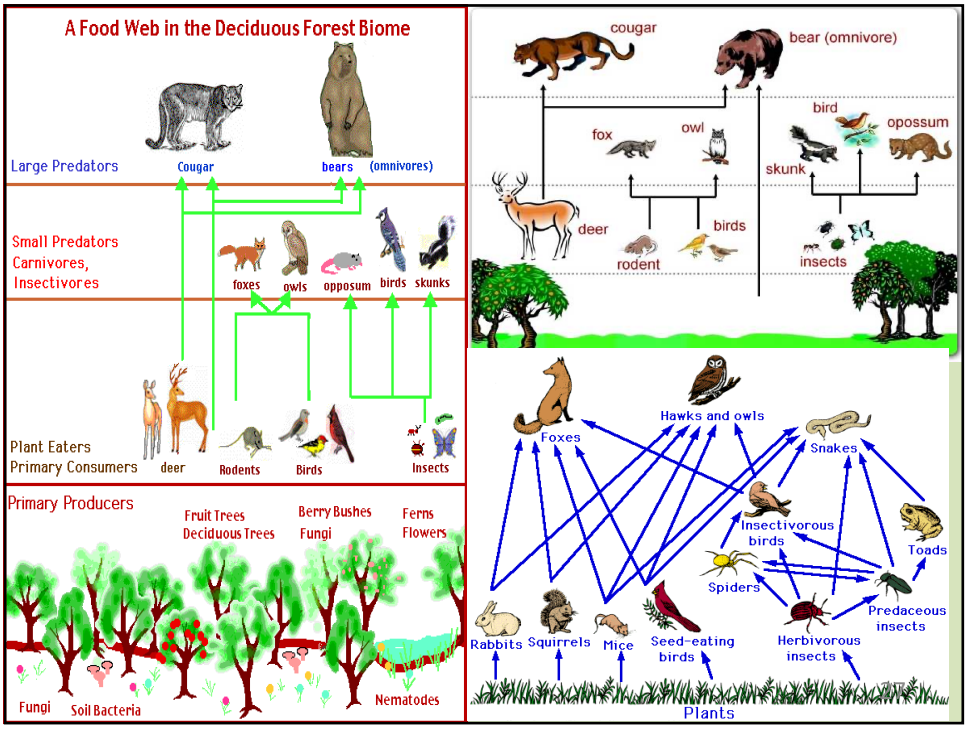


27

Detritivores

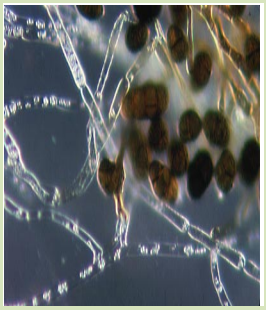
Detritivores are important because they play the key roles in a process which is vital in a biome, recycling. They recycle so that dead matter can be reentered into the ground and be useful for the new growth, mainly all the nutrients. Snail is an example of a detritivore in our biome.

28

Earthworm

centipede

ants



fungi

bacteria

29

Measuring Productivity

- **Plant Biomass**
  - **How much Plant Biomass is there**
    (mg PB/m^3) or (µg Chlorophyll/liter)
- **Productivity**
  - **A rate of how much carbon is produced per time**
    - **g Carbon / m^3 / day**
  - **GROSS Productivity = Carbon fixed through Photosynthesis per time**
  - **NET Productivity = Gross Prod - Respiration**

30

30

Phytoplankton Dominance

- **Phytoplankton**
  - **Optimize surface area/volume**
    $(^4/_3\Pi r^2) / (^4/_3\Pi r^3)$
    - **Smaller size → larger surf. area/volume**
    - **5µm = 1/5**
    - **10µm = 1/10**
  - **Small Particles sink slower**
    - **Larger surf. area/volume → Slower sinking**

31

31

- The Global Energy Budget

primary producers are capable of producing about 170 billion tons of organic material per year.

32

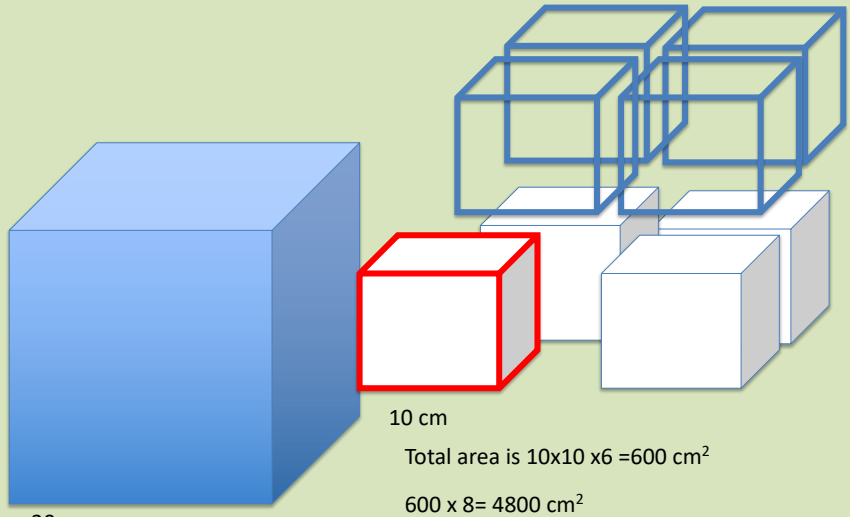
Phytoplankton

Phytoplankton: 97% Ocean Photosynthesis

33

33

34



Total area is 10x10 x6 =600 cm^2

600 x 8= 4800 cm^2

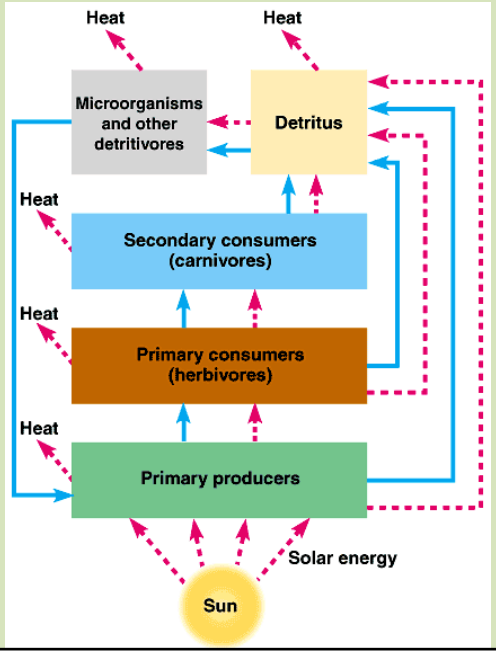
Total volume is 8000 cm^3

Total area is 20x 20 x 6=2400 cm^2

Total volume is 8000 cm^3

35

An ecosystem's energy budget depends on primary production



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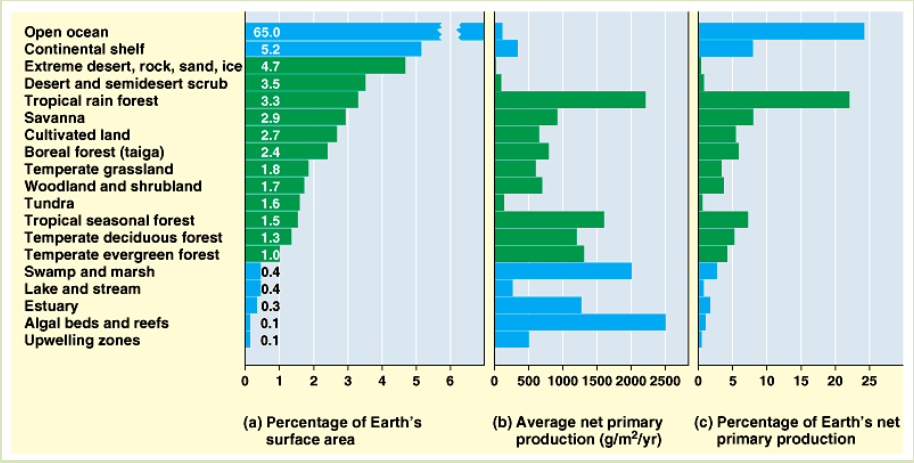
- Gross and Net Primary Production.
  - Total primary production is known as **gross primary production (GPP)**.



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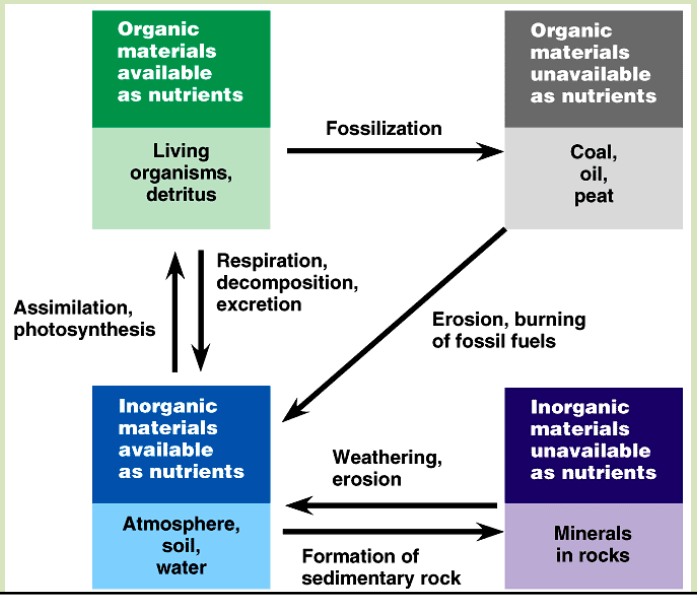
37

Biological and geologic processes move nutrients between organic and inorganic compartments



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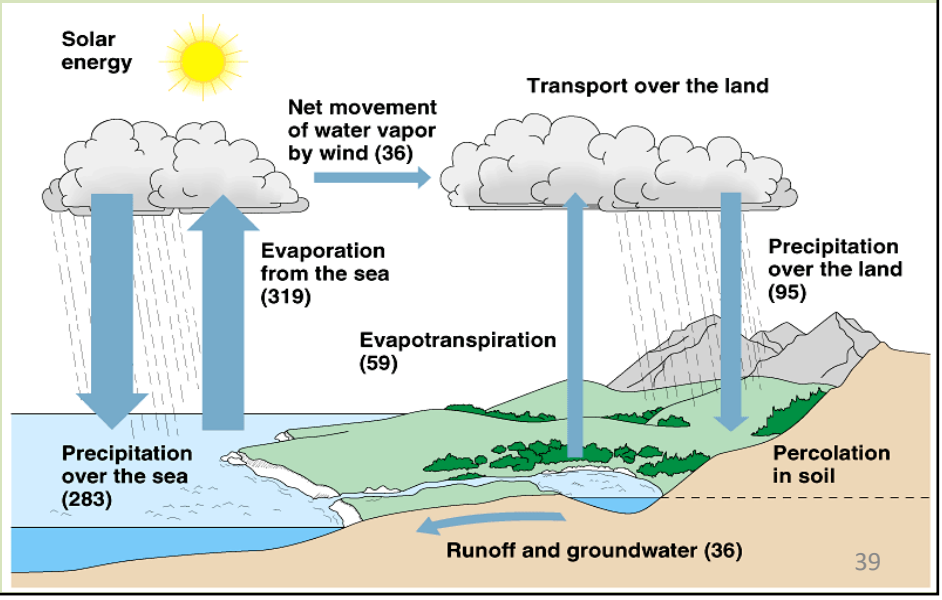
38

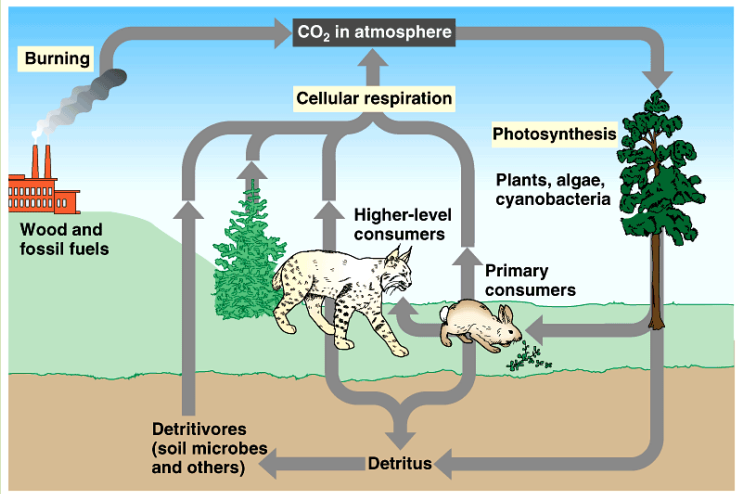
– The water cycle is more of a physical process than a chemical one.



39

39

- The carbon cycle fits the generalized scheme of biogeochemical cycles better than water.



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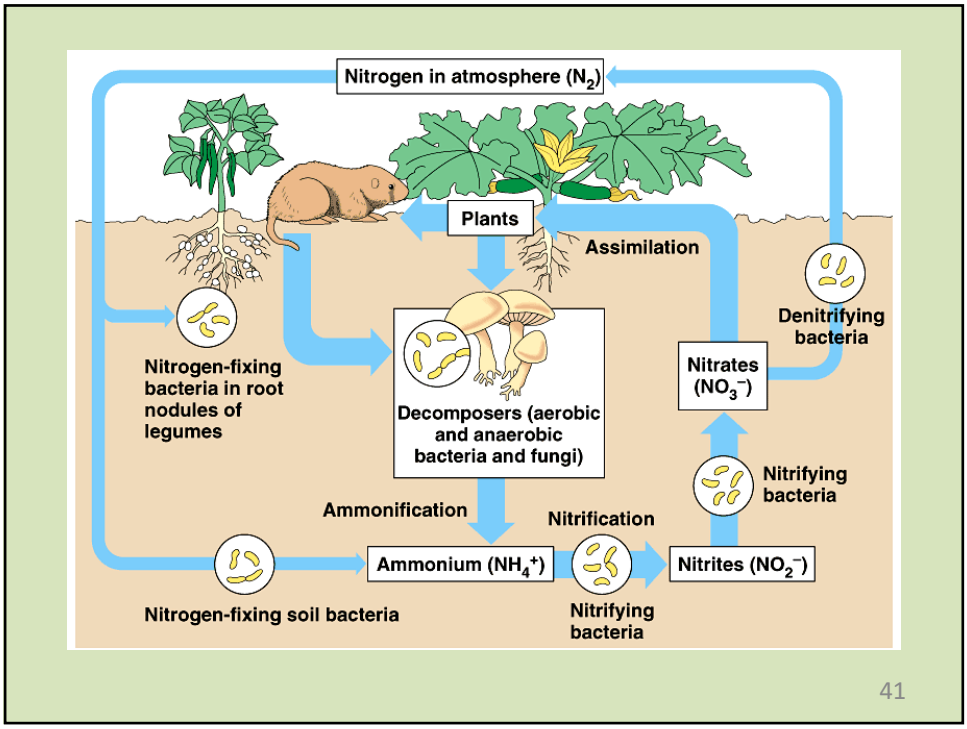

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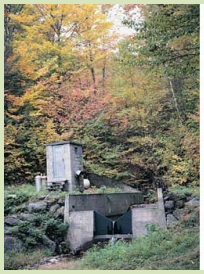
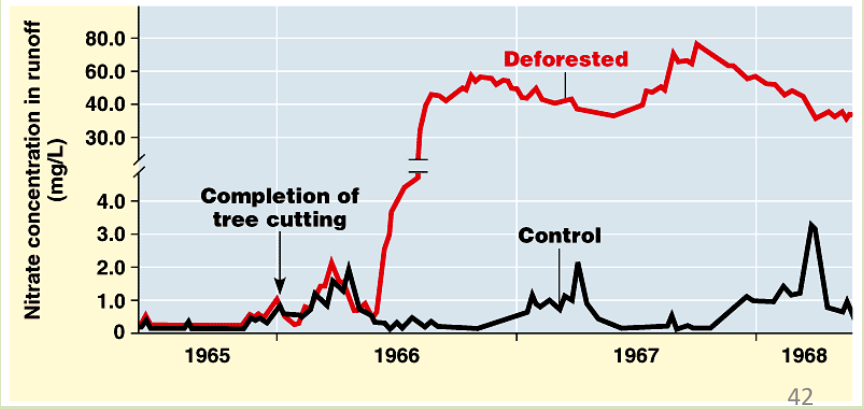
Nutrient cycling is strongly regulated by vegetation.





42