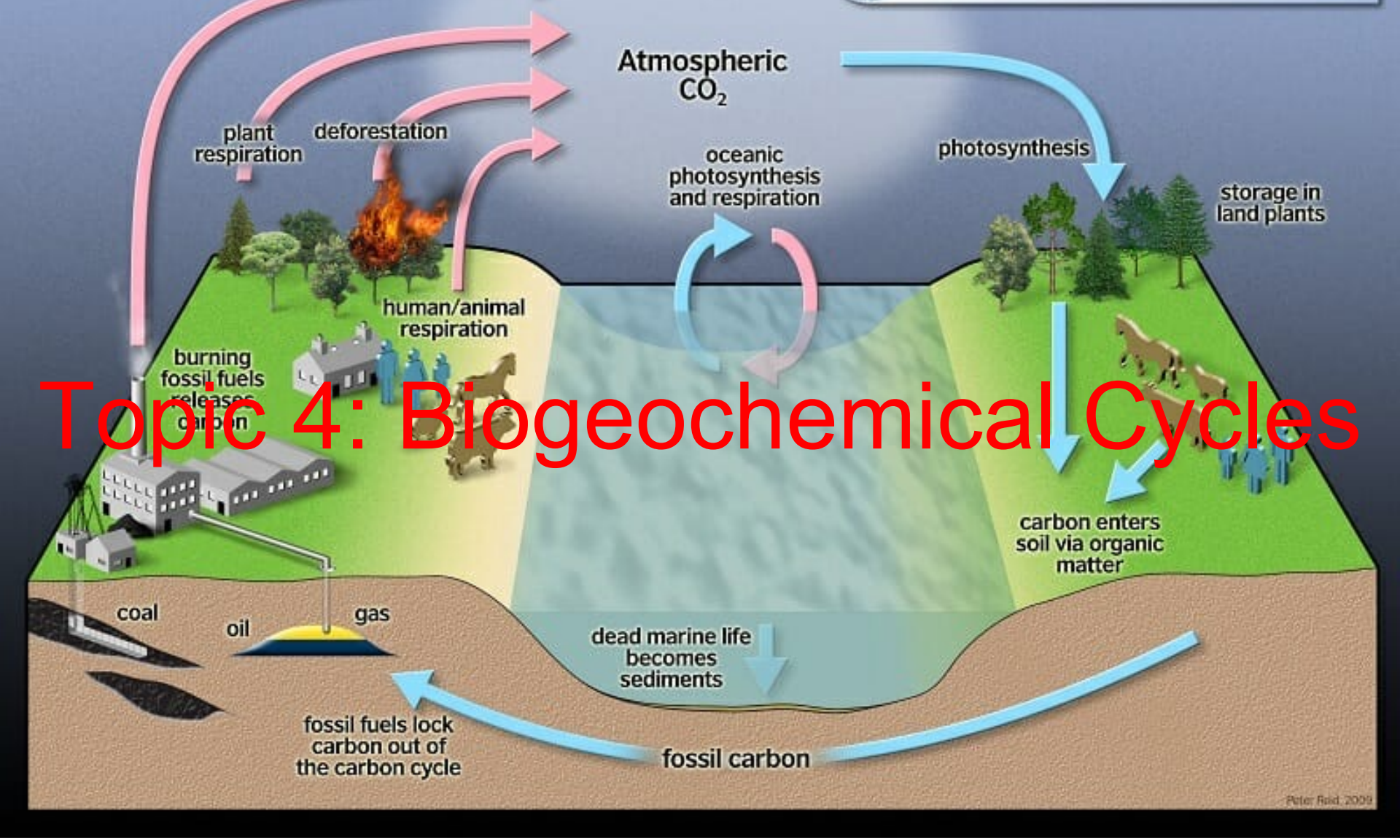


Topic 4: Biogeochemical Cycles

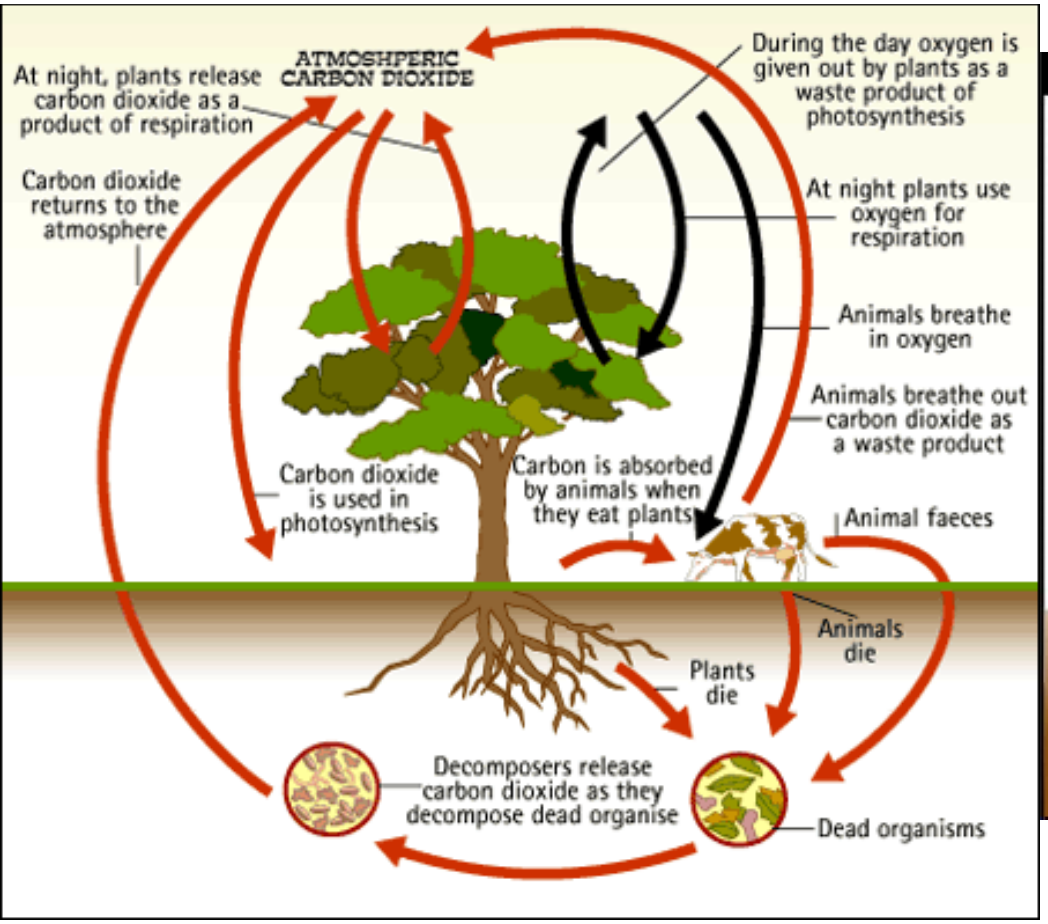
Learning Objectives:

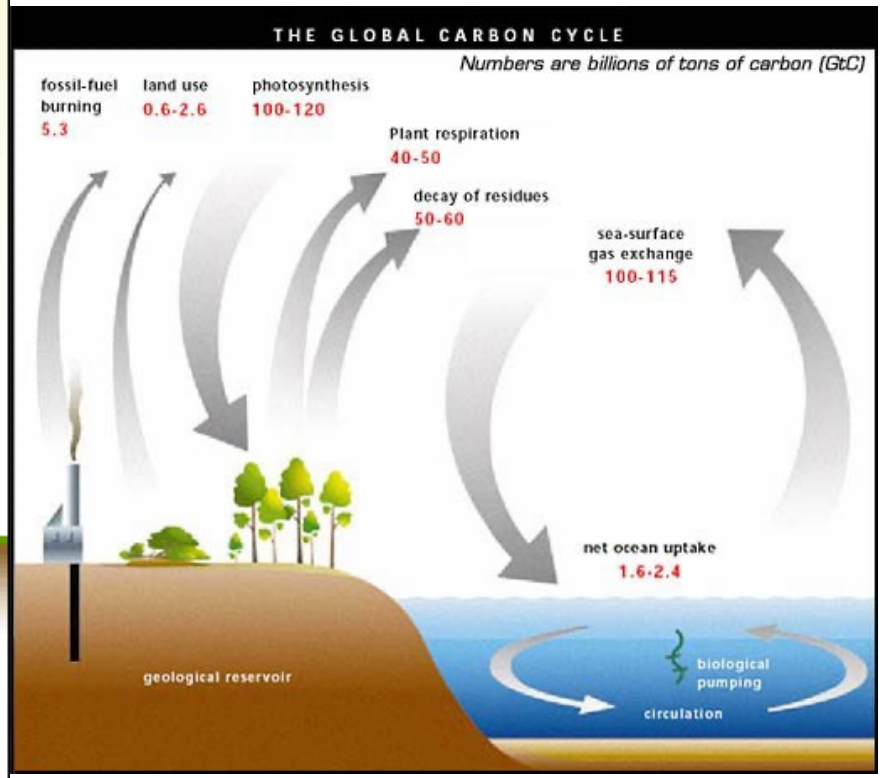
- Understand the concept of biogeochemical cycles.
- Identify the different types of biogeochemical cycles.
- Explain the uptakes and cycles of nutrients in the ecosystem.

NUTRIENT CYCLES

- **Biogeochemical cycle**
  - path atoms take from the living (biotic) to the non-living (abiotic) world and back again

NUTRIENT CYCLES: ECOSYSTEM TO ECOSPHERE

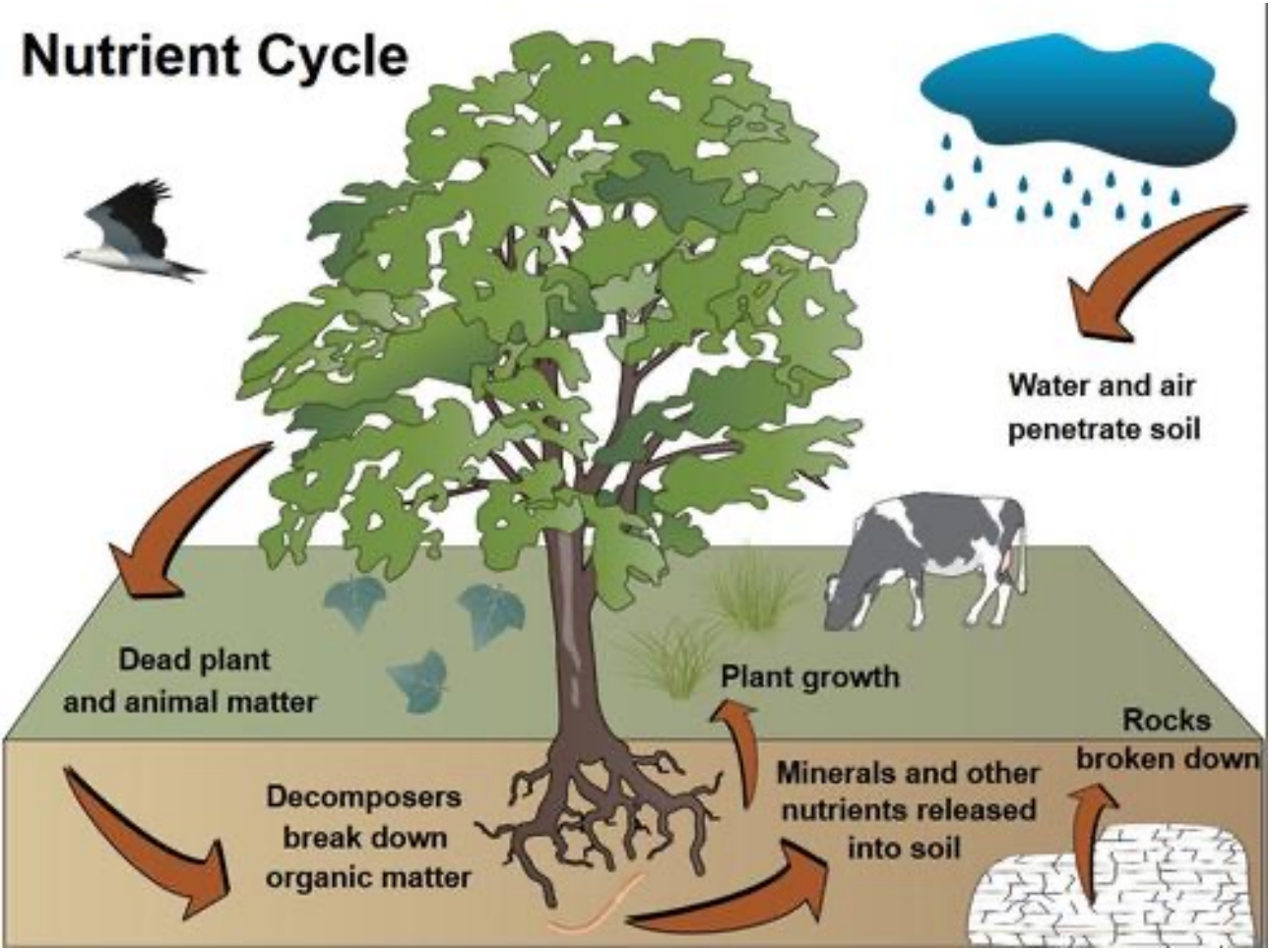


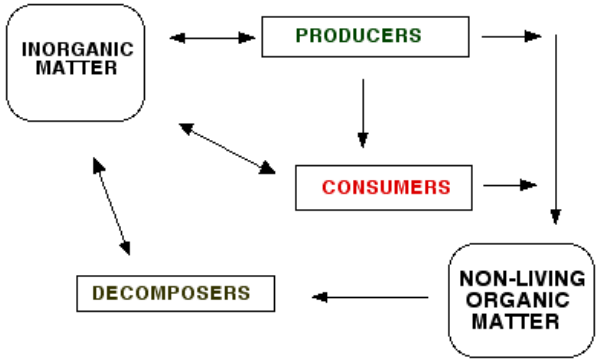


Nutrients: The Elements of Life

O OXYGEN	**K** POTASSIUM	**P** PHOSPHORUS
C CARBON	**Si** SILICON	**Cl** CHLORINE
H HYDROGEN	**Mg** MAGNESIUM	**Fe** IRON
N NITROGEN	**S** SULFUR	**Mn** MANGANESE
Ca CALCIUM	**Al** ALUMINUM	**Na** SODIUM

NUTRIENT CYCLING IN AN ECOSYSTEM

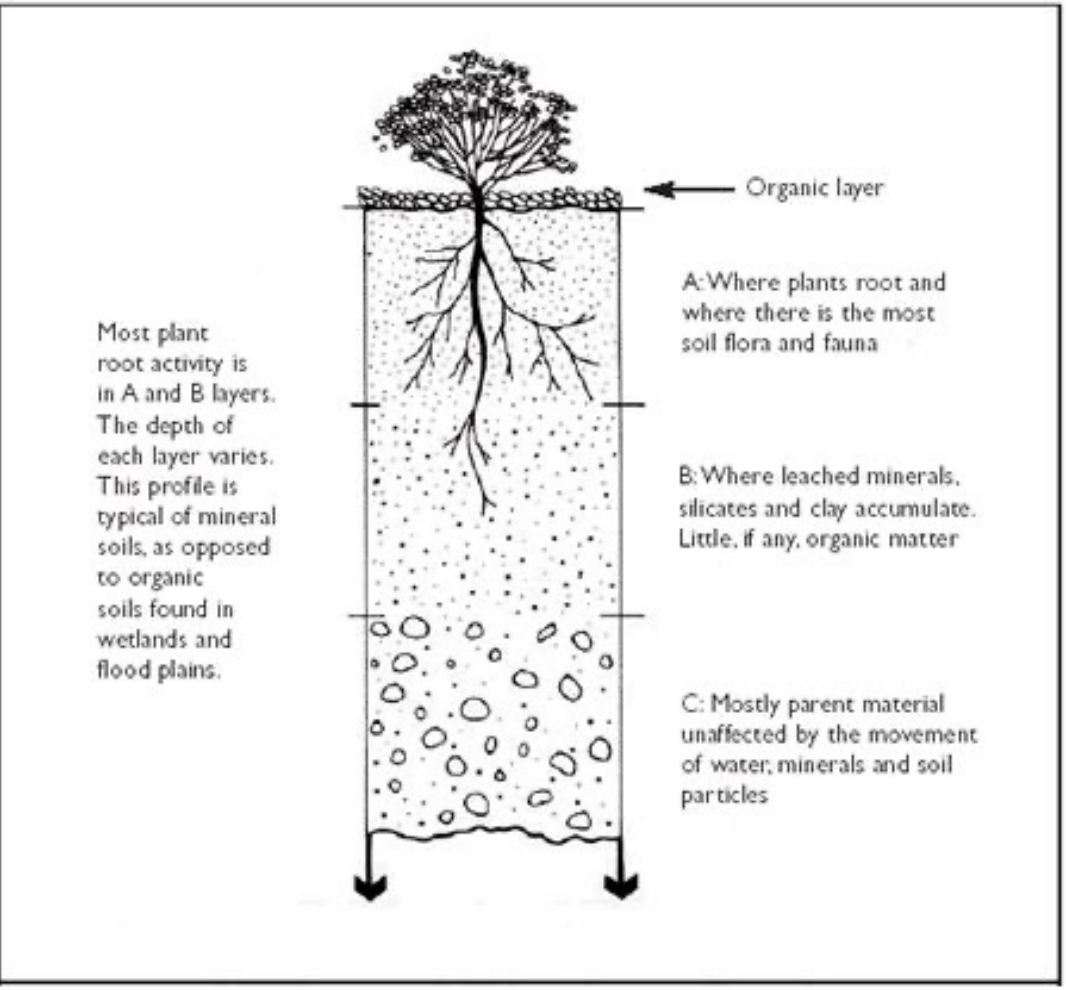


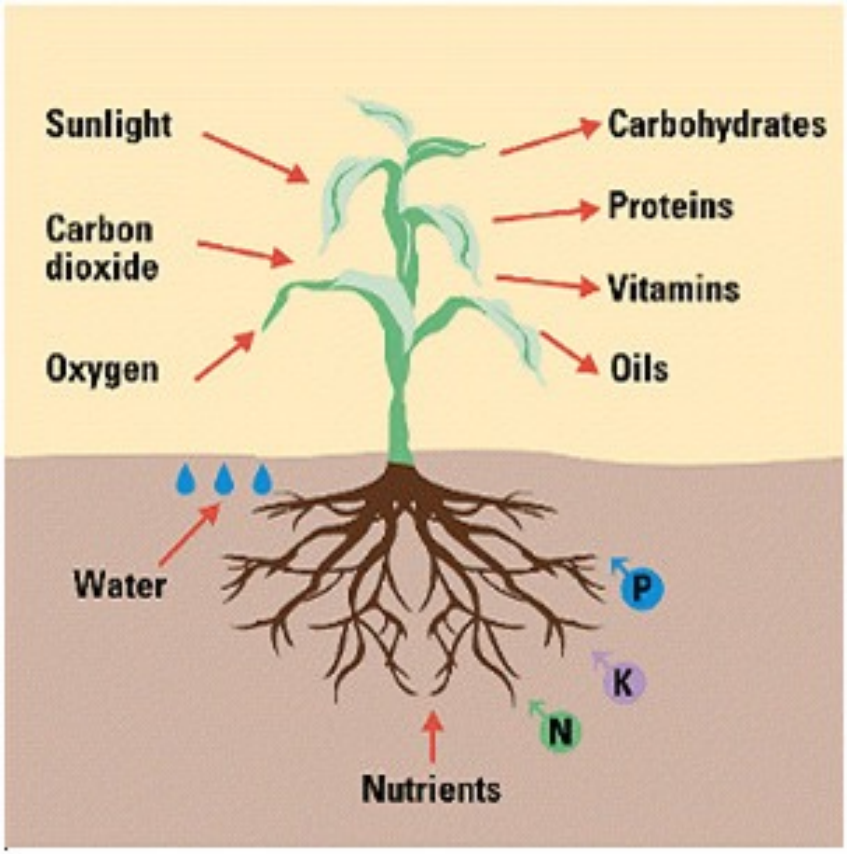


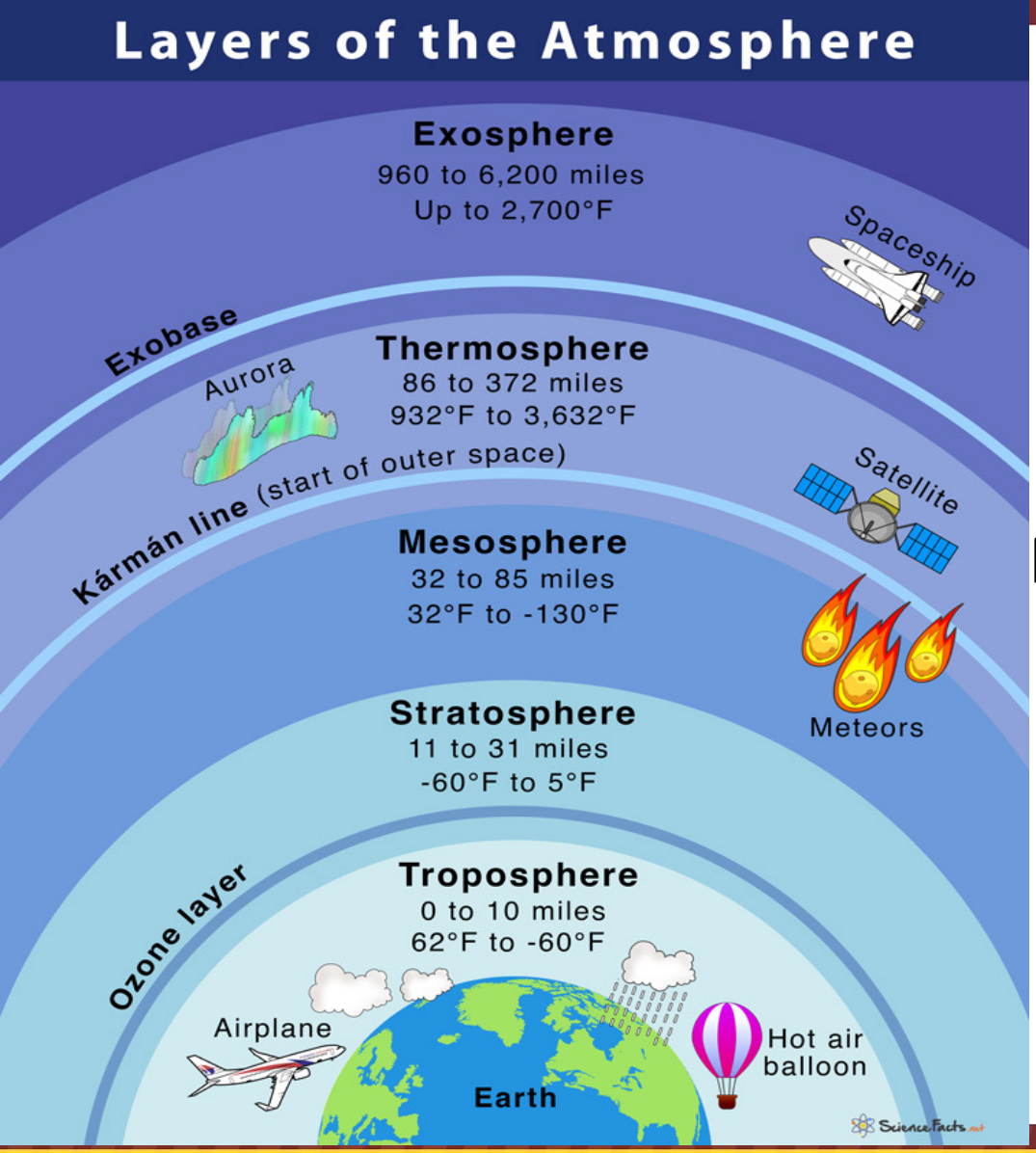
Nutrient Compartments in a Terrestrial Ecosystem

1. organic compartment consists of the living organisms and their detritus
2. available-nutrient compartment consists of nutrients held to surface of soil particles or in solution
3. nutrients held in soils or rocks that are unavailable to living organisms
4. air which can be found in the atmosphere or in the ground

Uptake of Inorganic Nutrients from the Soil





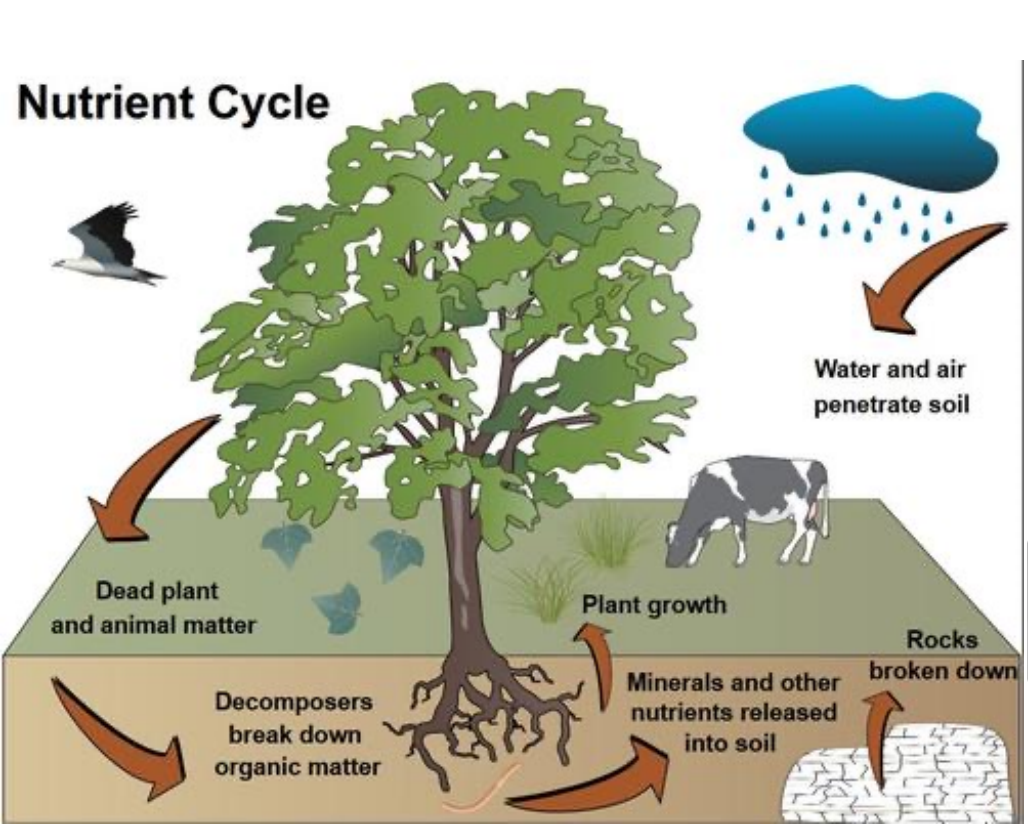


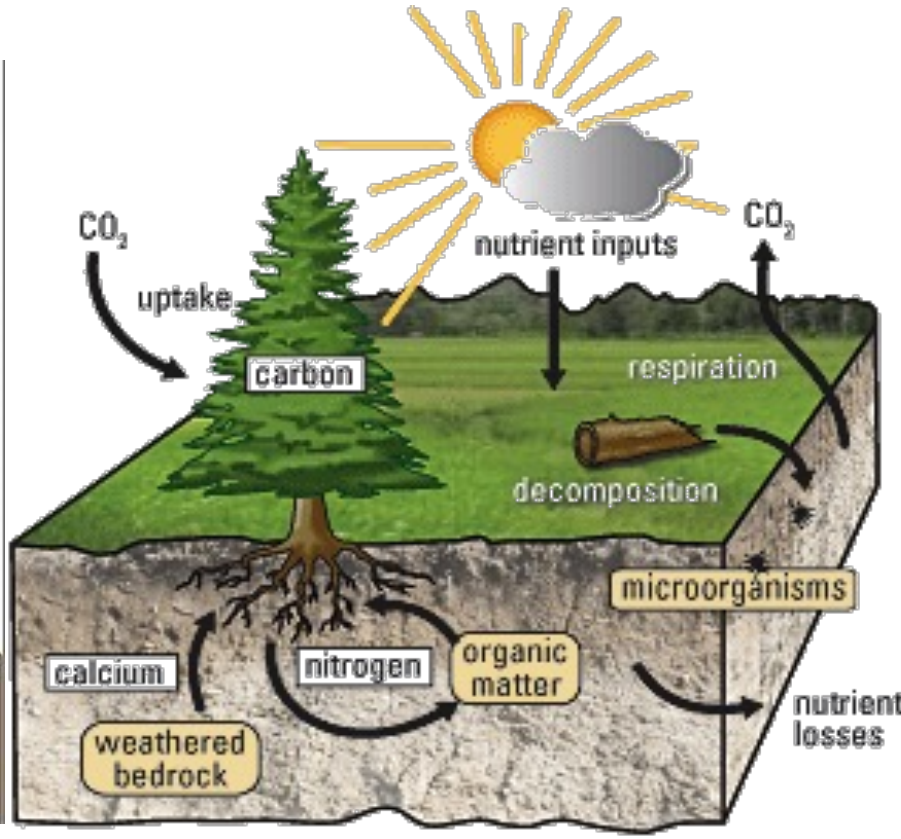
The Atmosphere Is a Source of Inorganic Nutrients

Nitrogen (N_2)

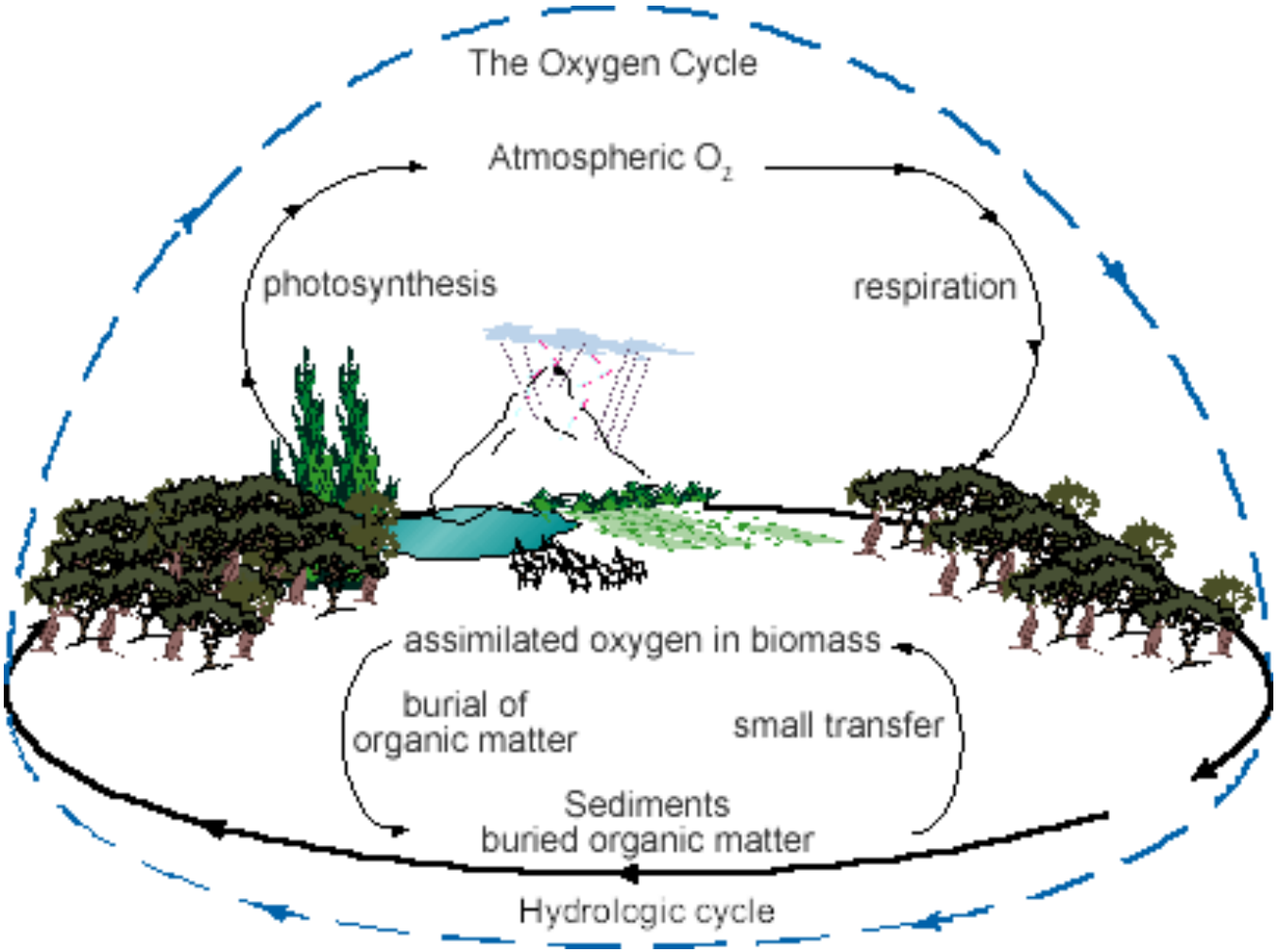
- most abundant gas in the atmosphere about 80% by volume
- entry into and exit from the biota is through bacteria.

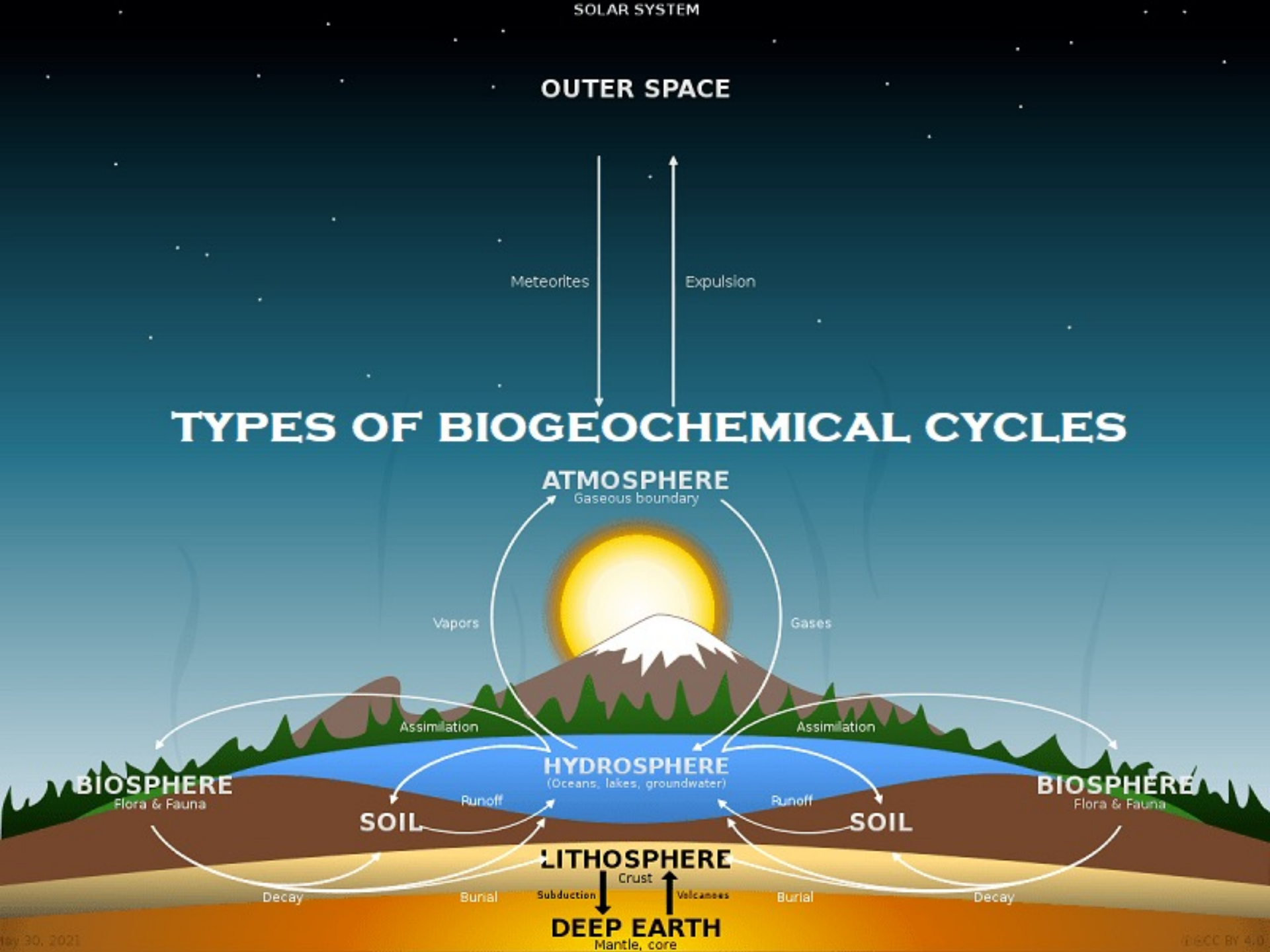
Processes Nutrients Are Recycled



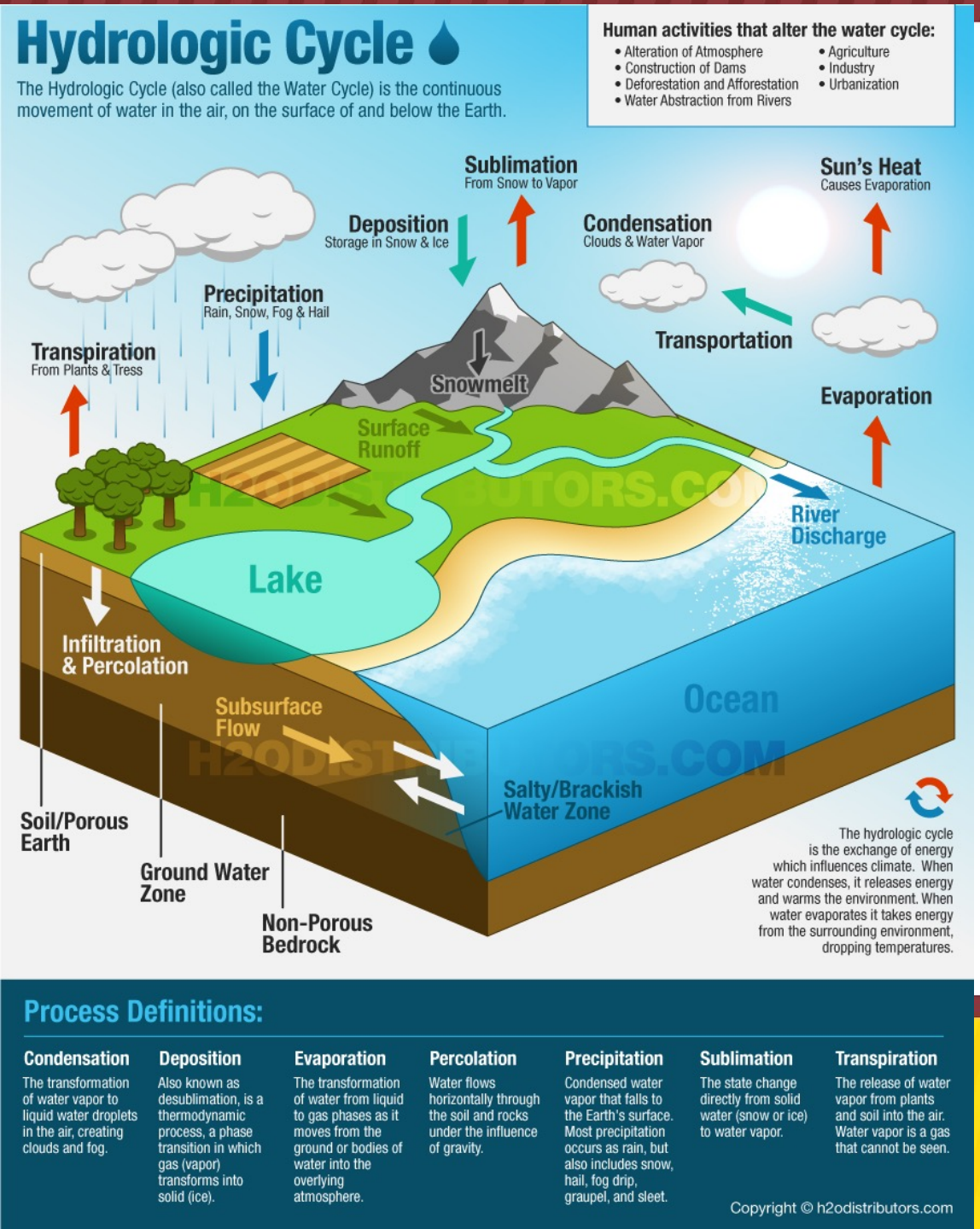


CARBON, HYDROGEN AND OXYGEN CYCLES IN ECOSYSTEMS



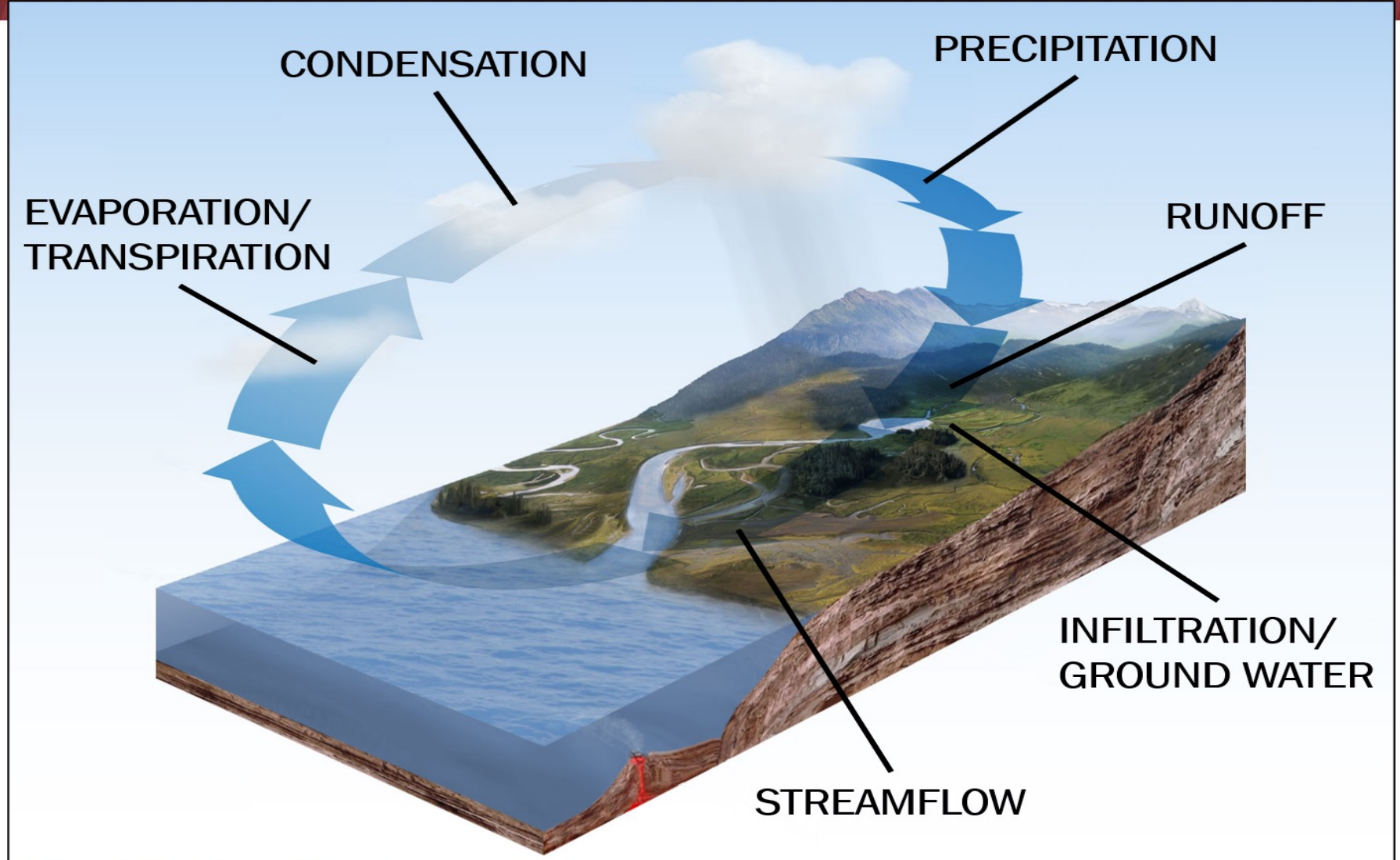

SOLAR SYSTEM
OUTER SPACE
Meteorites
Expulsion
TYPES OF BIOGEOCHEMICAL CYCLES
ATMOSPHERE
Gaseous boundary
Vapors
Gases
Assimilation
Assimilation
HYDROSPHERE
(Oceans, lakes, groundwater)
BIOSPHERE
Flora & Fauna
BIOSPHERE
Flora & Fauna
Runoff
Runoff
SOIL
SOIL
LITHOSPHERE
Crust
Decay
Burial
Subduction
Volcanoes
Burial
Decay
DEEP EARTH
Mantle, core

- **Hydrologic cycle or water cycle**
- **Gaseous cycle:**
  - Oxygen cycle
  - Carbon cycle
  - Nitrogen cycle
- **Sedimentary cycle:**
  - Sulfur cycle
  - Phosphorous cycle



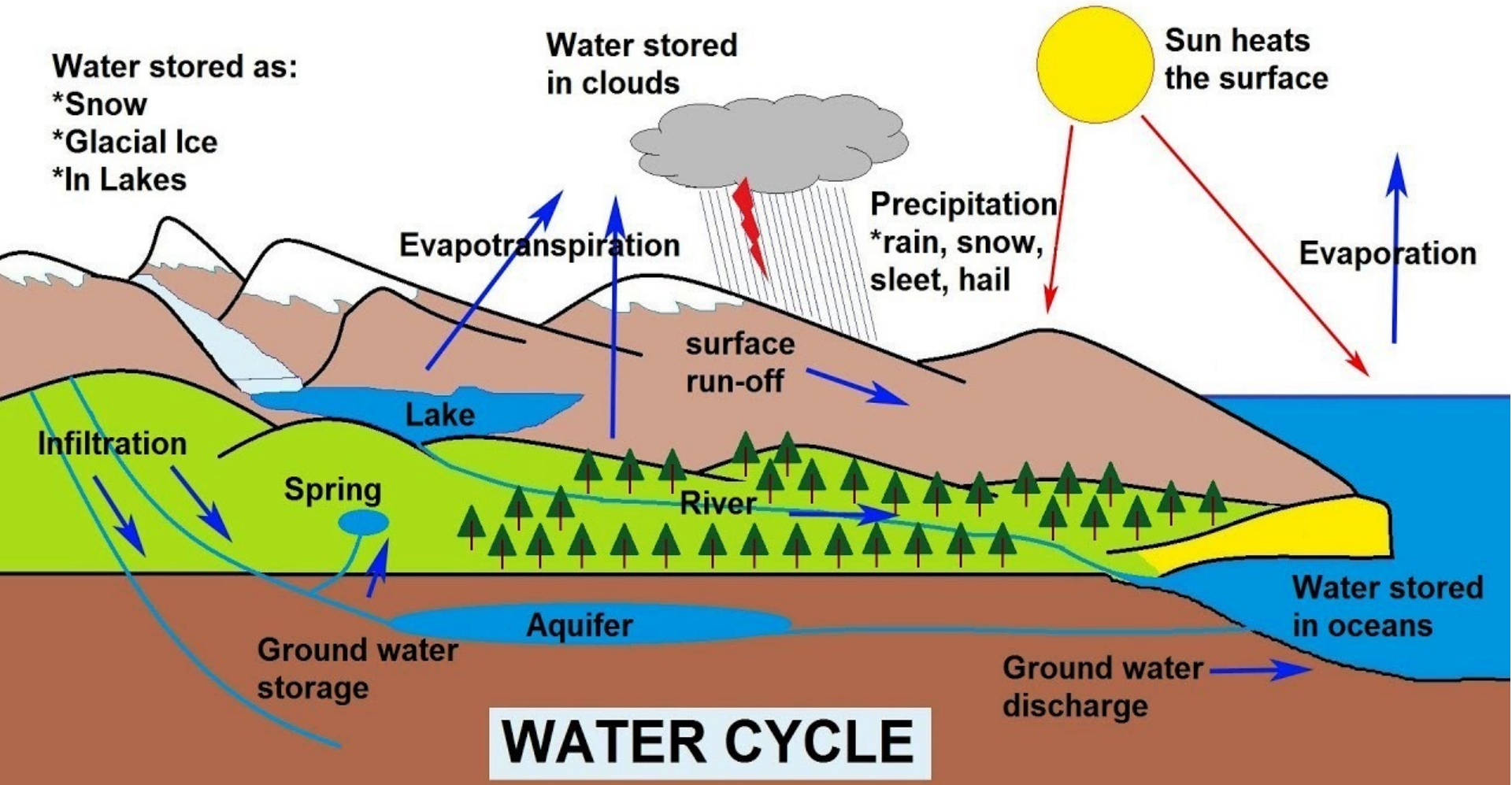
Hydrologic Cycle

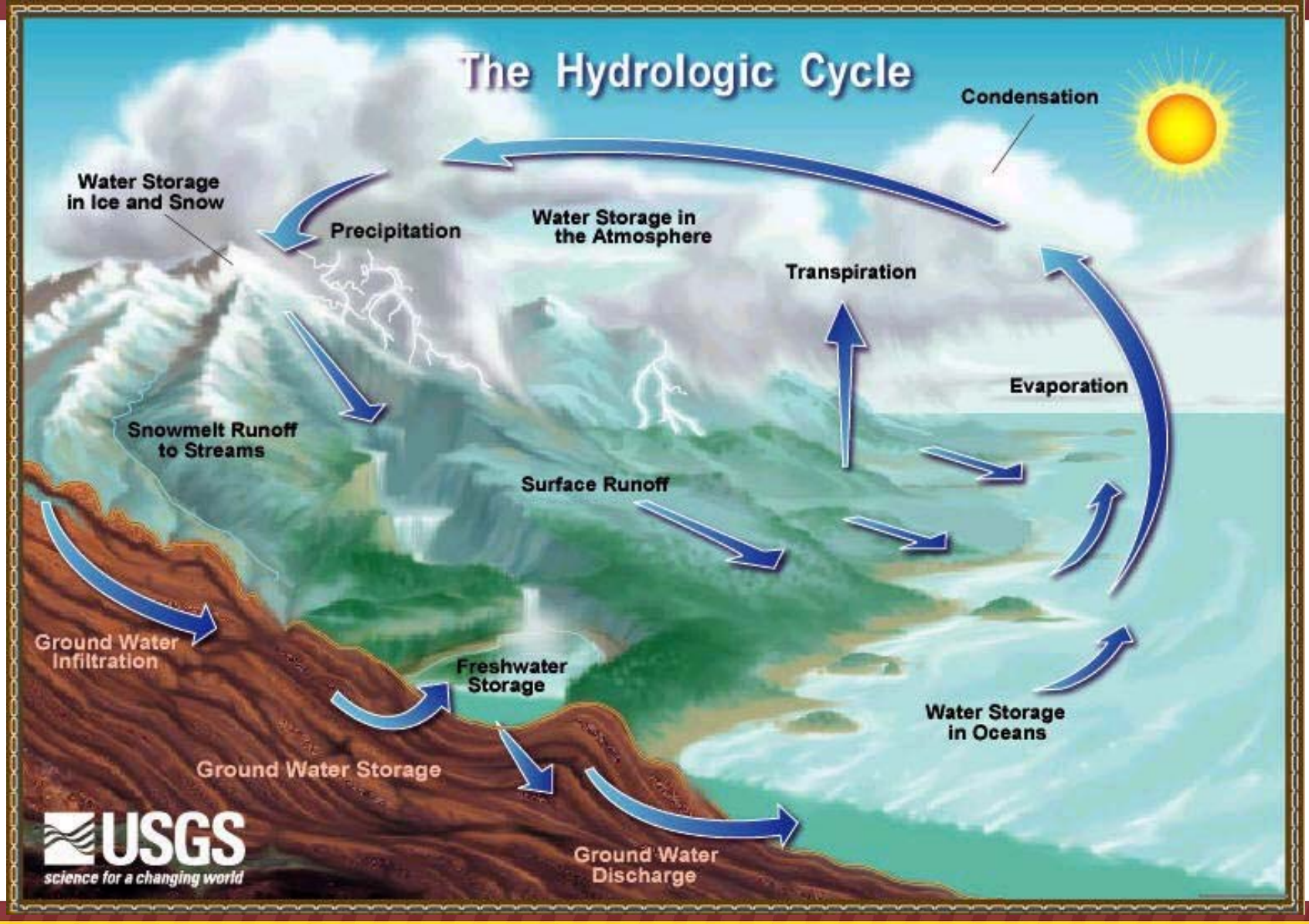
- water cycle shapes the land by transporting materials and is essential to most life on Earth.
- water cycle components
  - Evaporation;
  - Transpiration;
  - Condensation;
  - Precipitation and;
  - Runoff

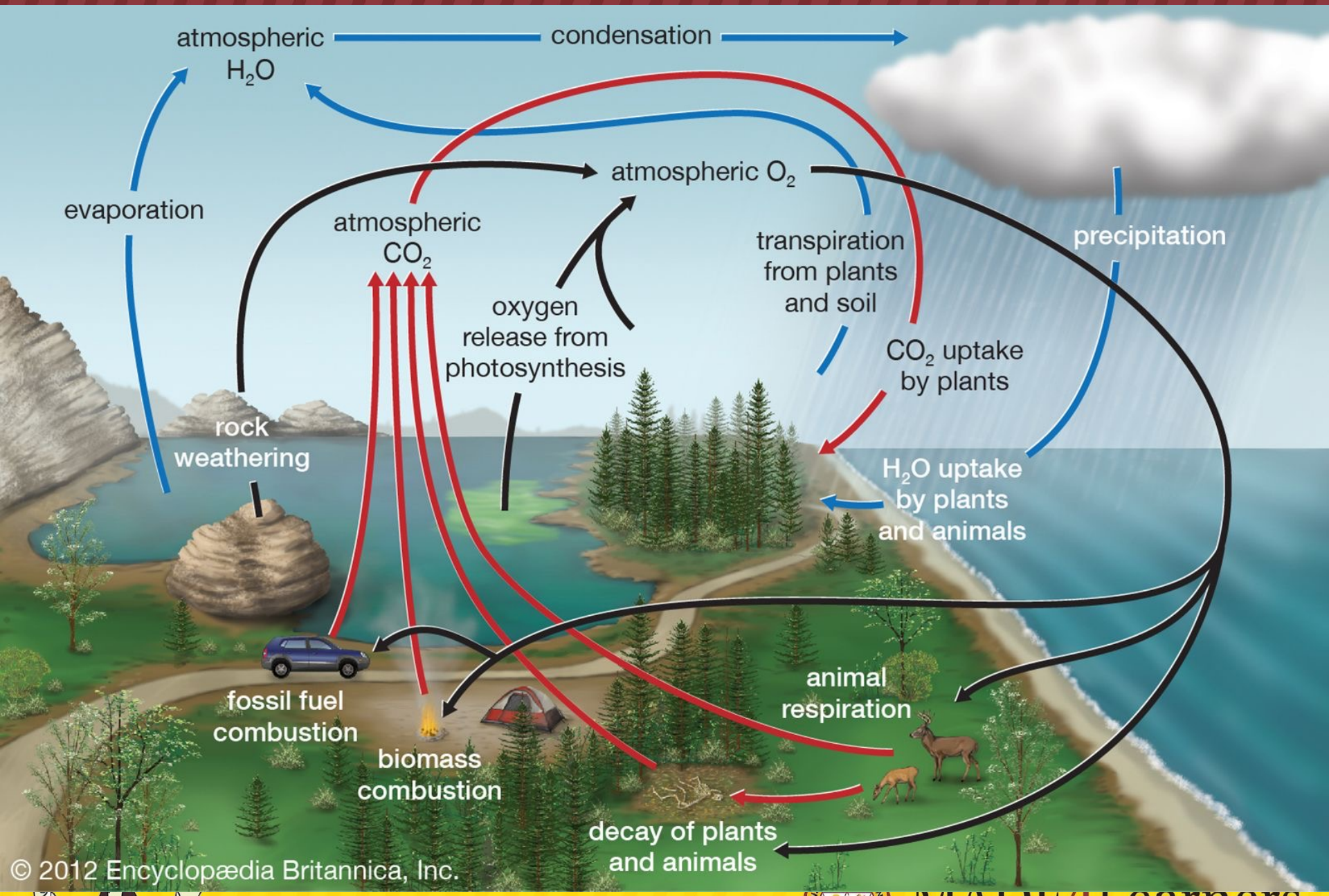


The Water Cycle

Adapted from Wikipedia/Ehud Tal

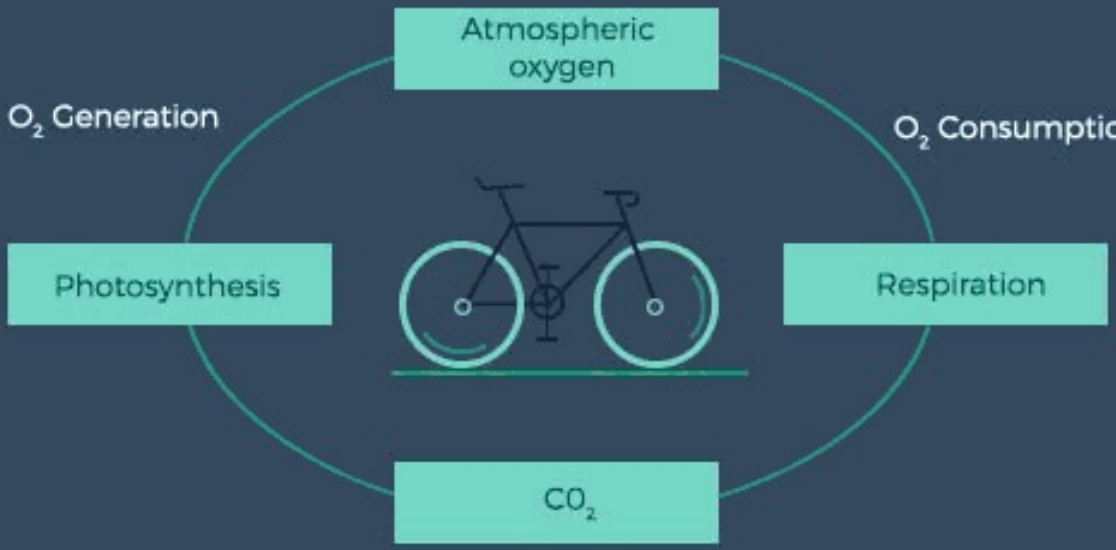






THE OXYGEN CYCLE

Oxygen is constantly used and created by different processes on planet Earth.

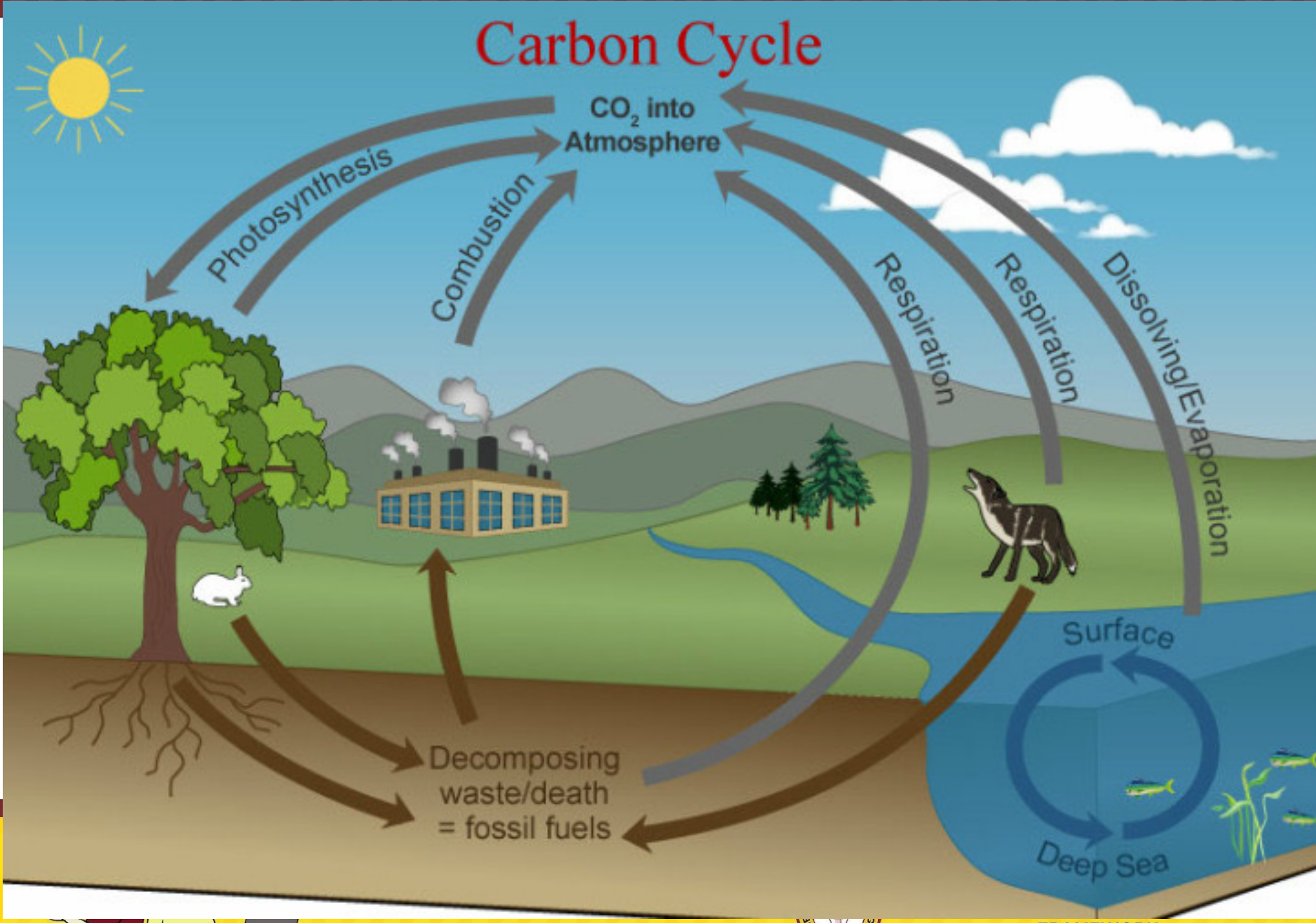


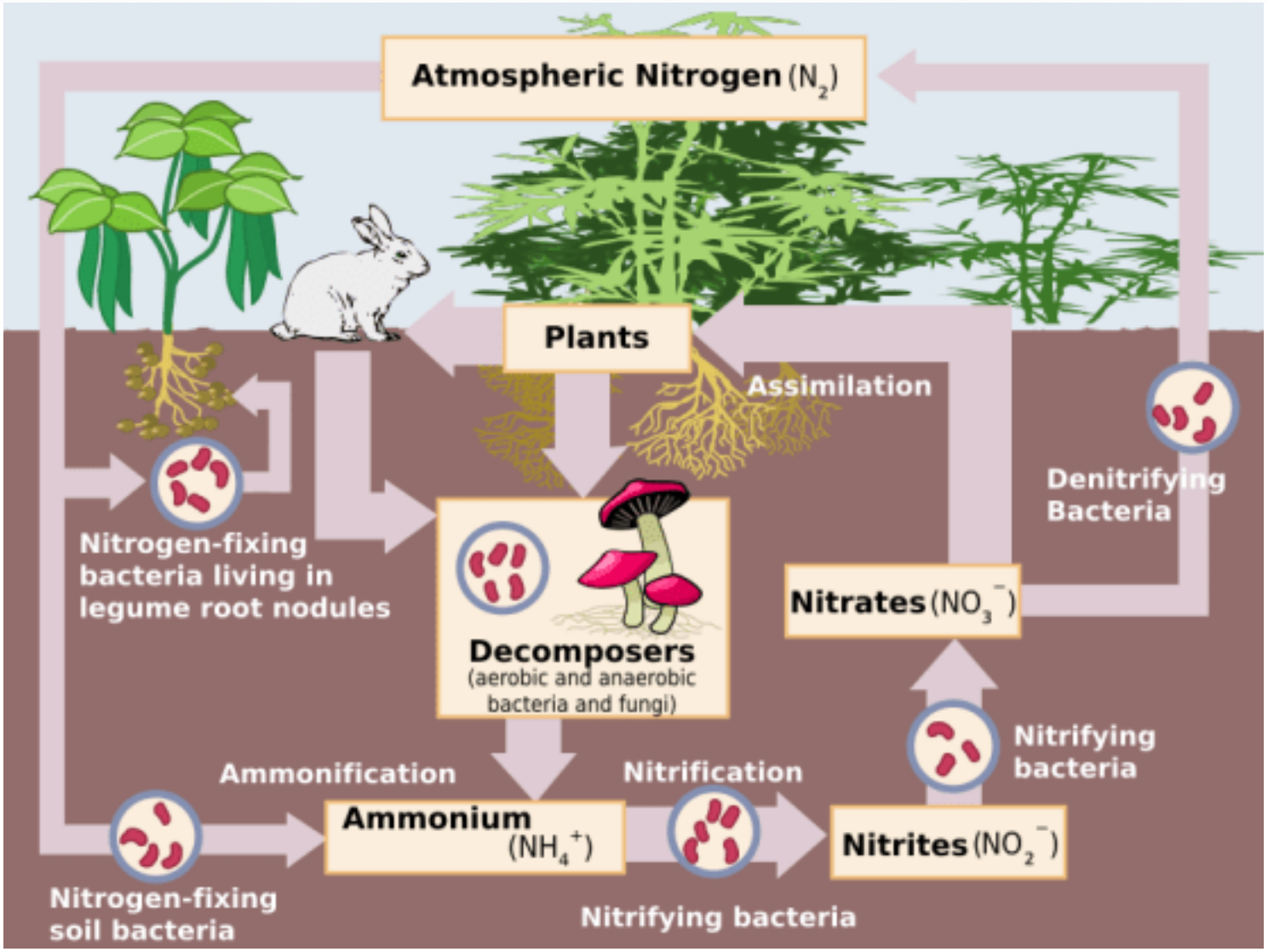
Oxygen Generation

- Plants - via photosynthesis
- Sunlight - via reaction with water vapour

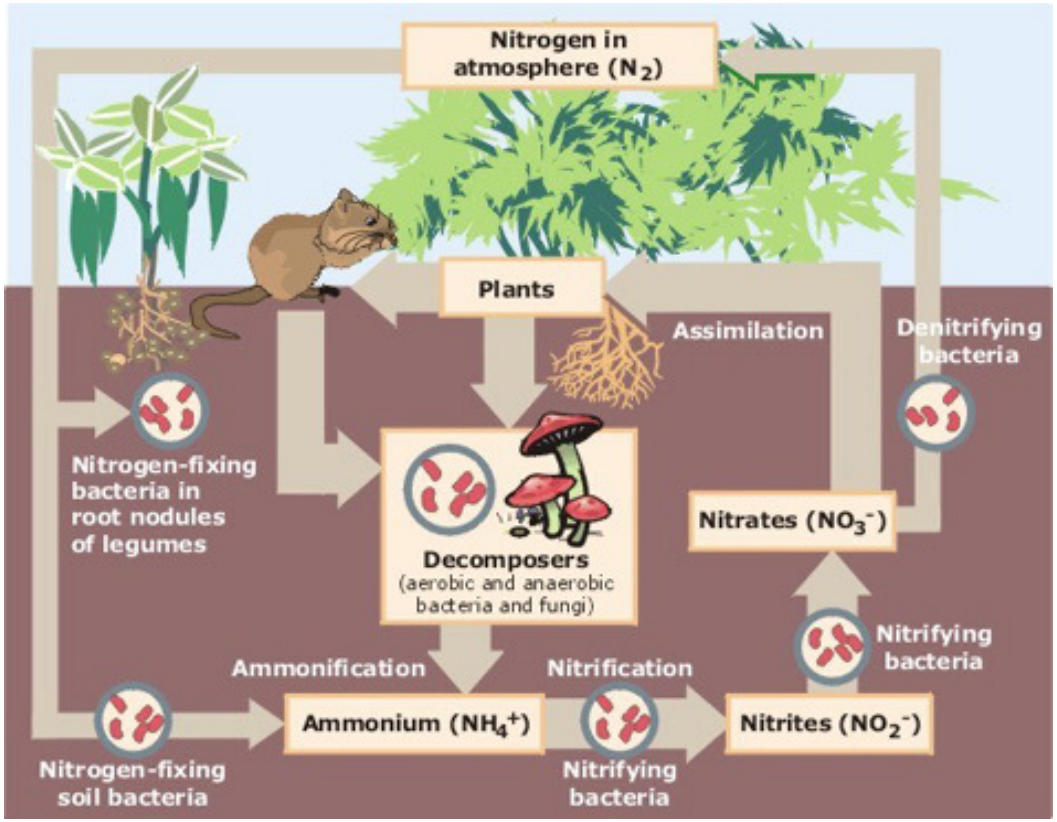
Oxygen Consumption

- Respiration
- Decomposition
- Rusting
- Combustion

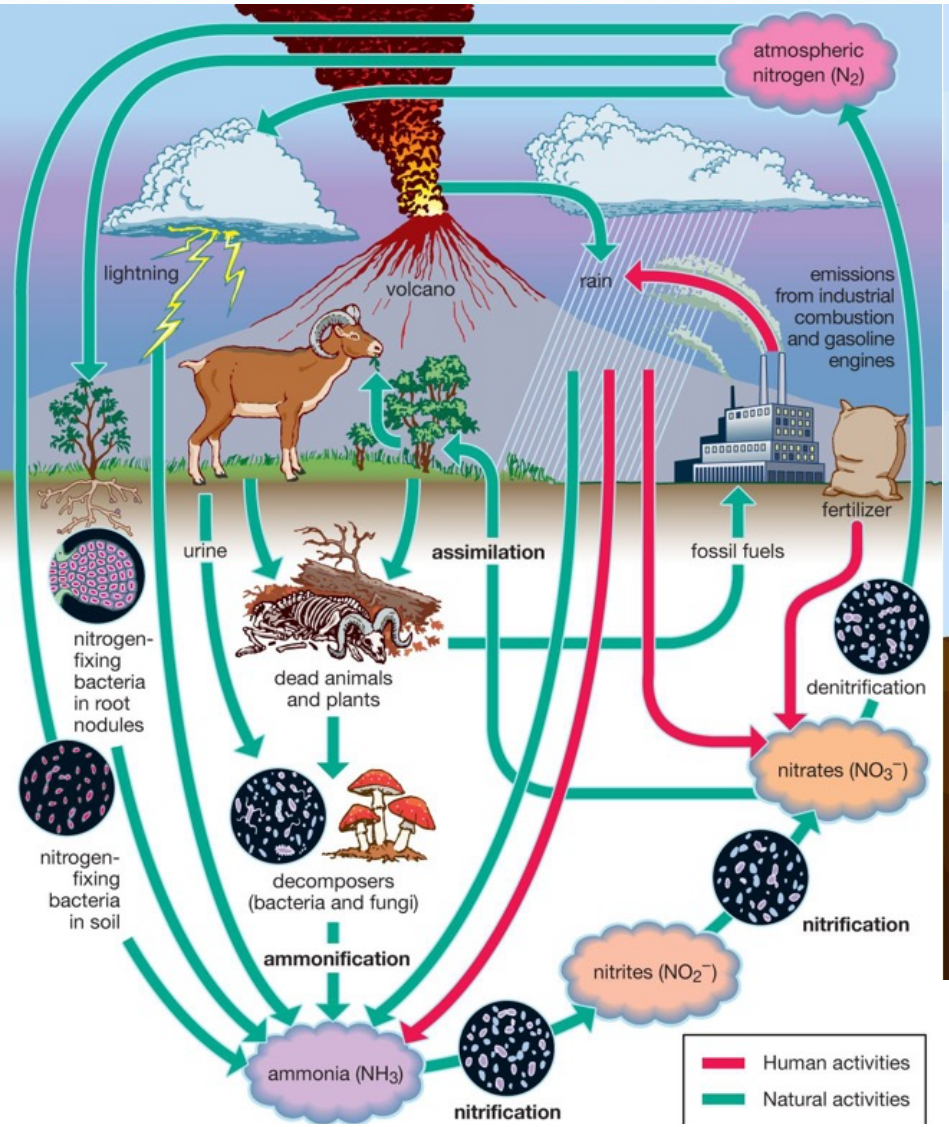

Carbon Cycle
CO_2 into Atmosphere
Photosynthesis
Combustion
Respiration
Respiration
Dissolving/Evaporation
Surface
Deep Sea
Decomposing waste/death = fossil fuels

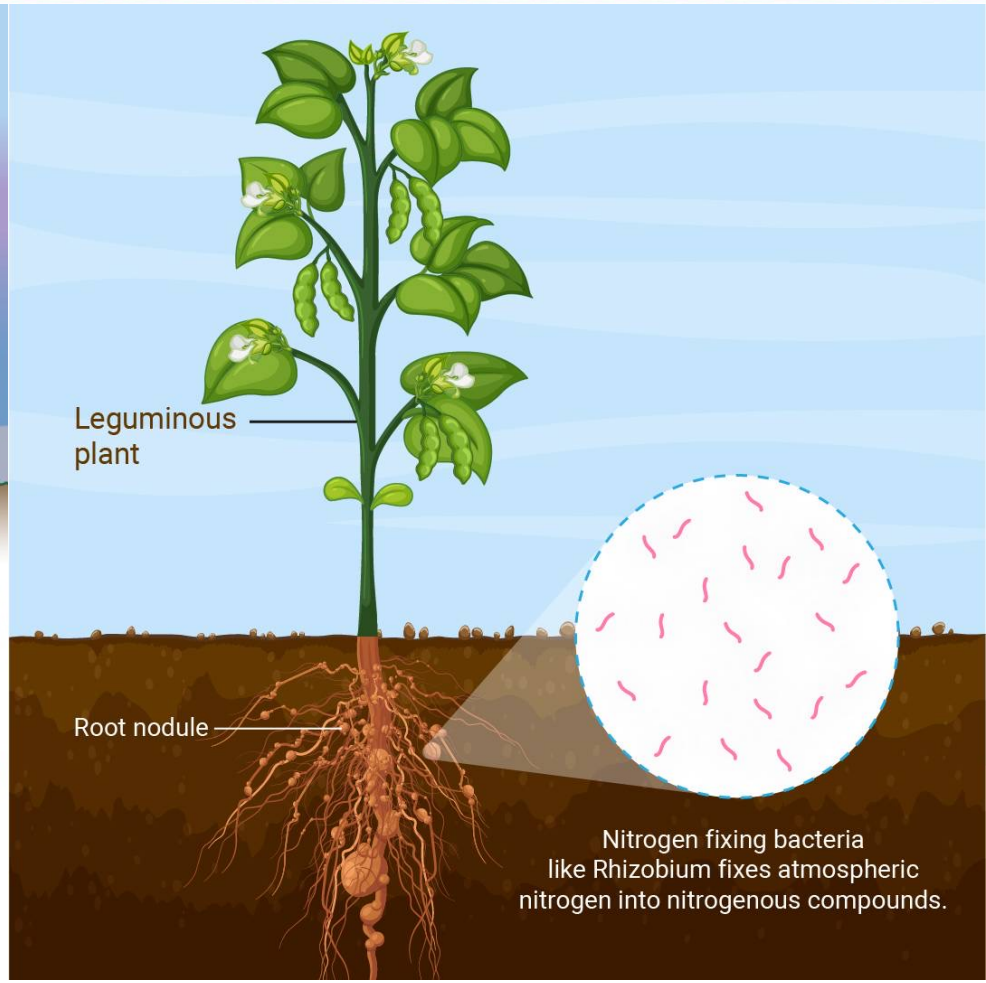


NITROGEN CYCLE IN ECOSYSTEMS

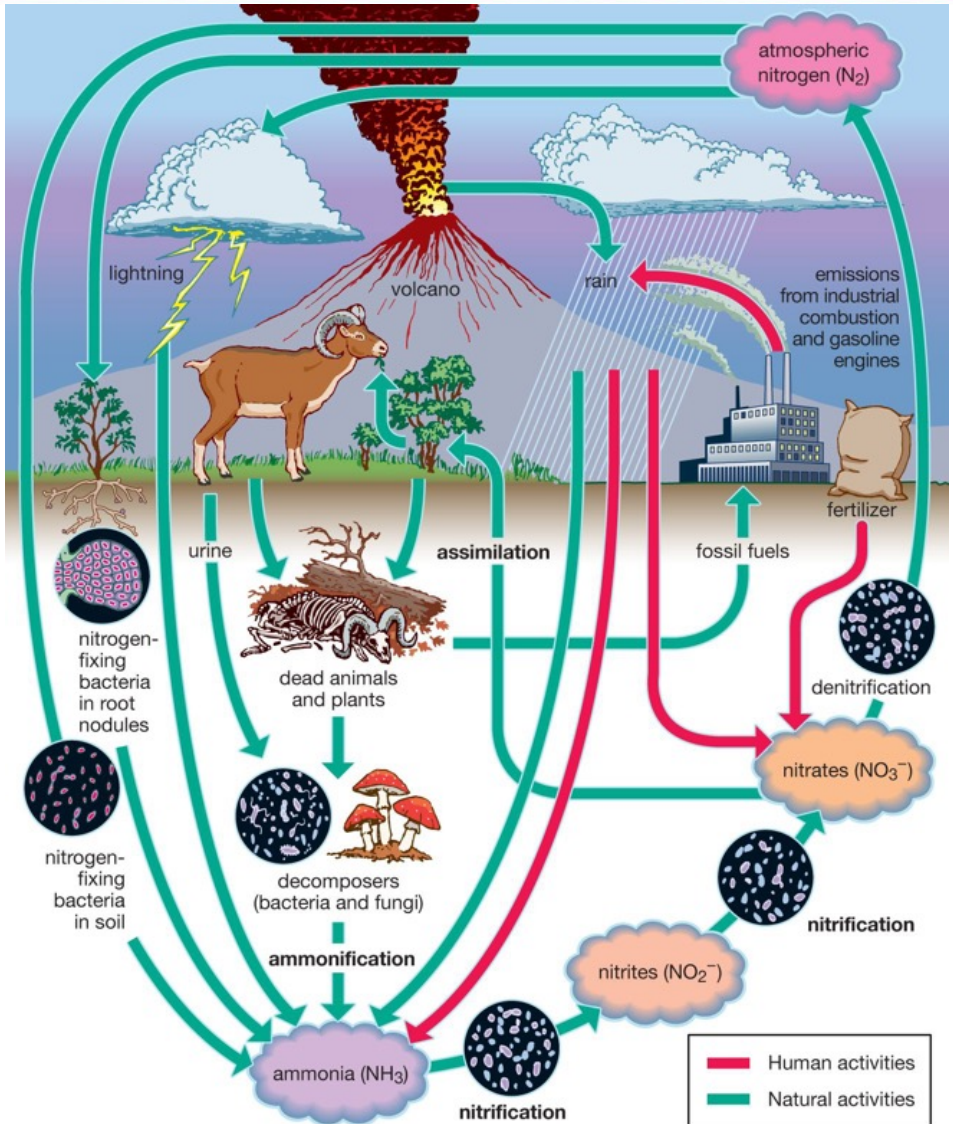


Nitrogen (N_2) makes up 78% of the atmosphere.





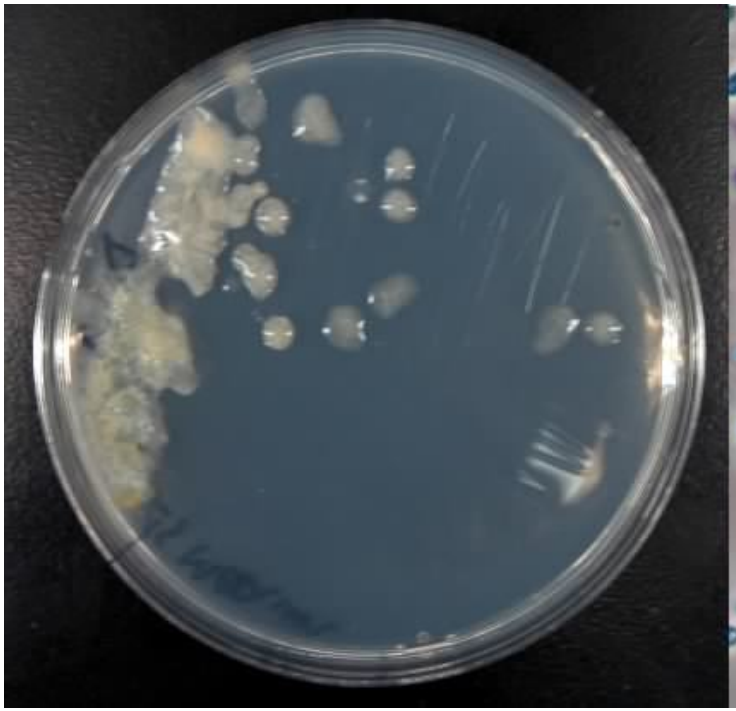
Rhizobium is a genus of Gram-negative soil bacteria that fix nitrogen.

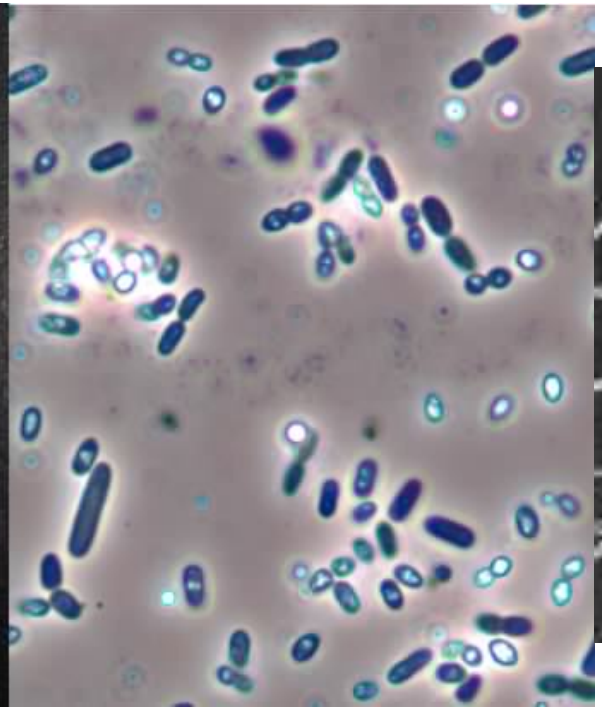


5 Steps:

1. **Nitrogen fixation** (N_2 to NH_3/ NH_4+ or NO_3-)
2. **Nitrification** (NH_3 to NO_{3-})
3. **Assimilation** (Incorporation of NH_3 and NO_3- into biological tissues)
4. **Ammonification** (organic nitrogen compounds to NH_3)
5. **Denitrification**(NO_3- to N_2)

Biological Nitrogen Fixation





Free-living soil bacteria and cyanobacteria (blue-green “algae”) are capable of converting N_2 into ammonia (NH_3) and ammonium (NH_4^+).

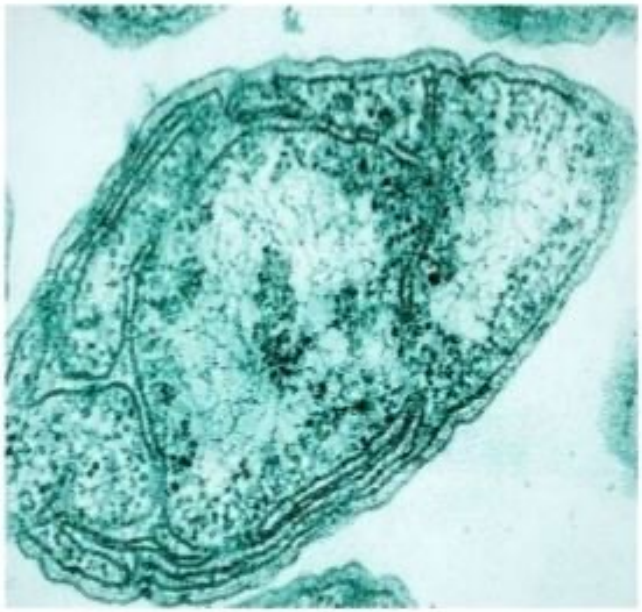
Learning Activity Assignment:

- Explain the difference between gaseous and sedimentary biogeochemical cycles.
- Enumerate at least 3 examples on each classification of biogeochemical cycles.
- Explain how phytoplankton controls the CO_2 emission.

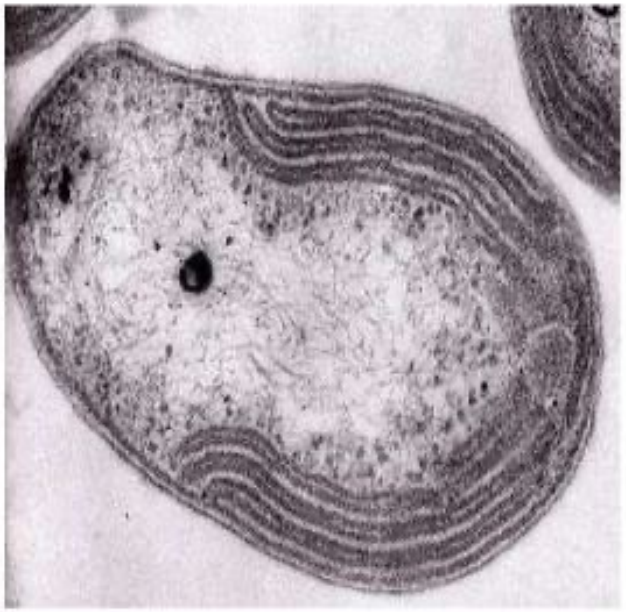
Nitrification

Nitrifying bacteria

13

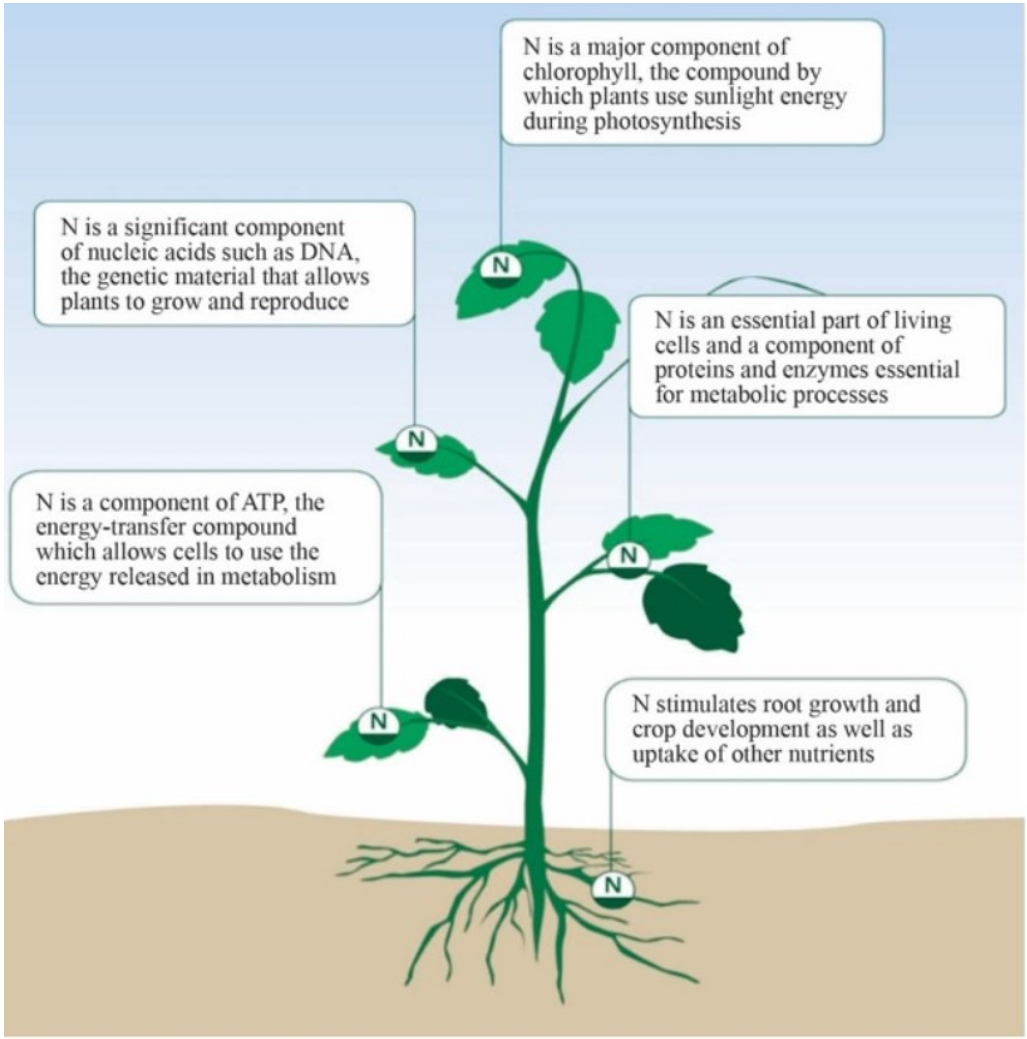


Nitrosomonas

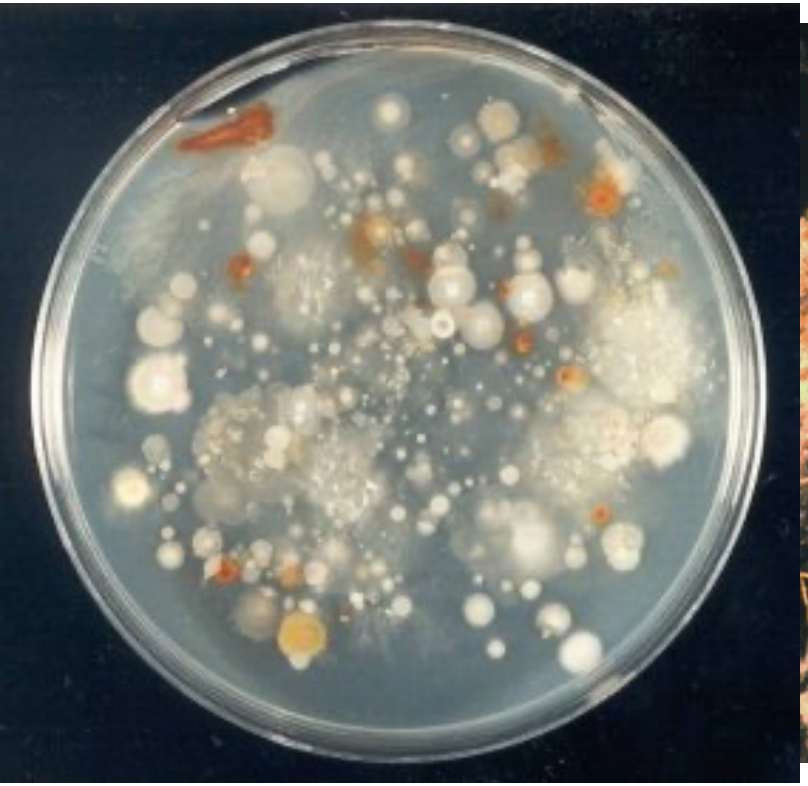


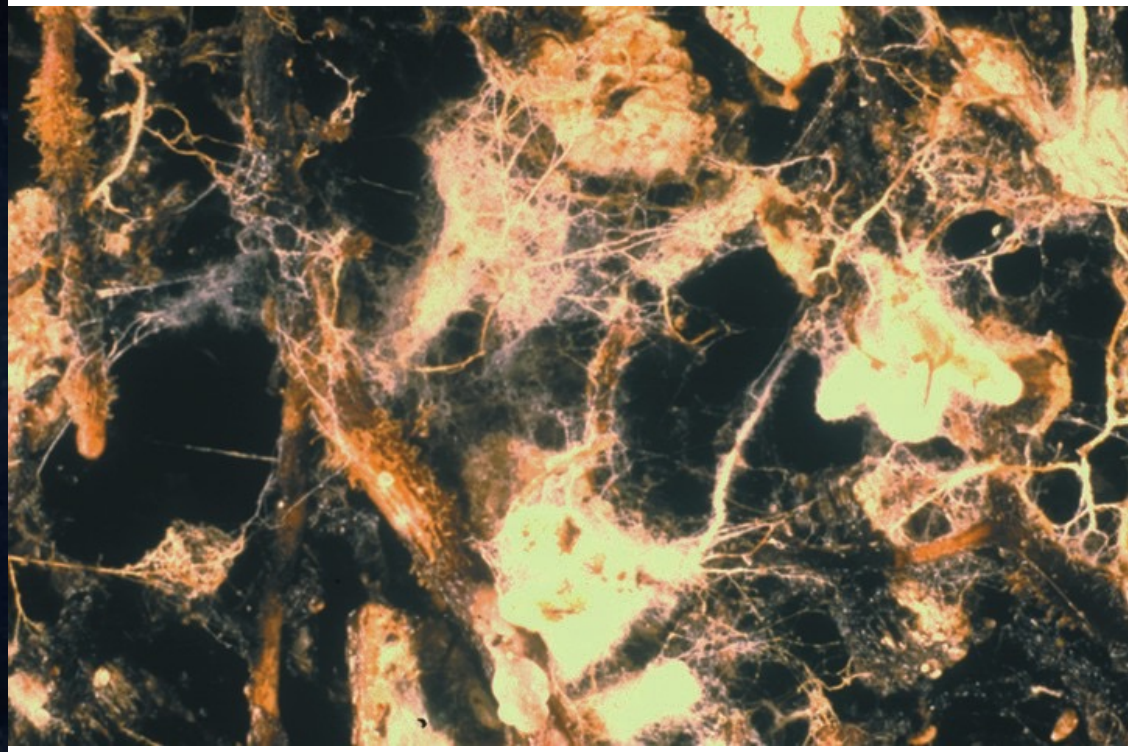
Nitrobacter

Uptake of Nitrogen by Plants

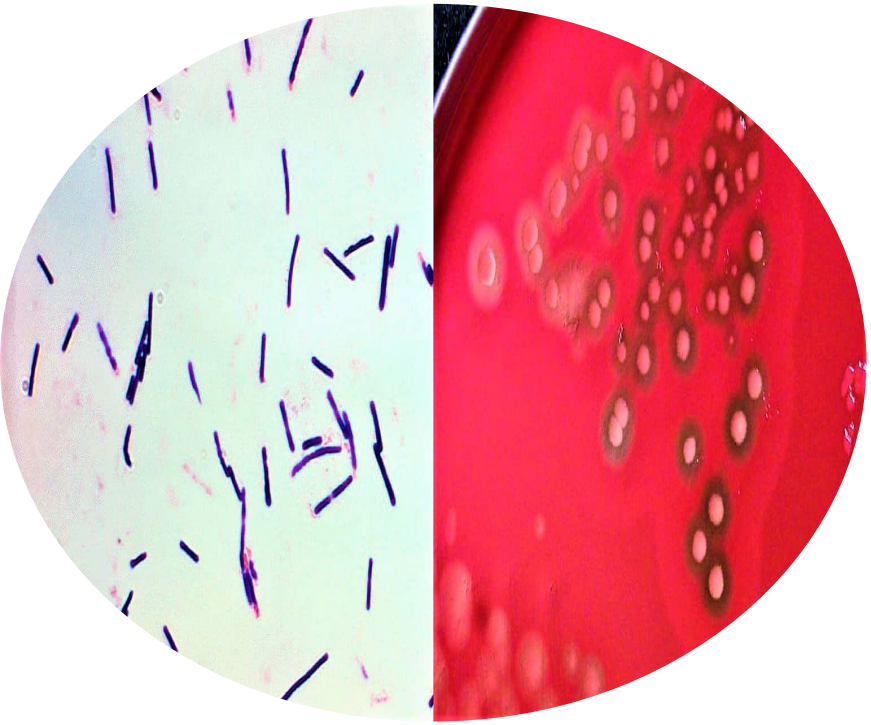


Ammonification

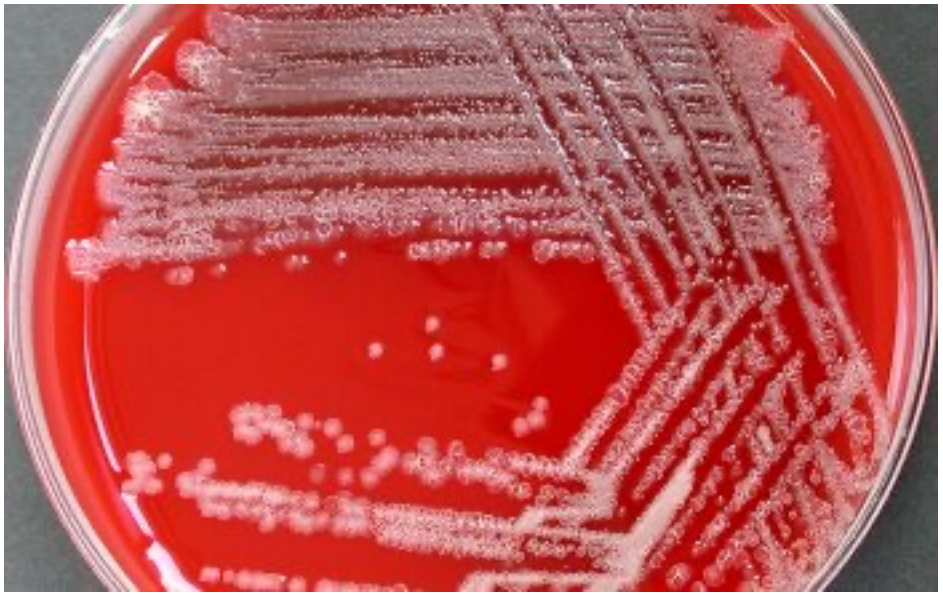




Denitrification



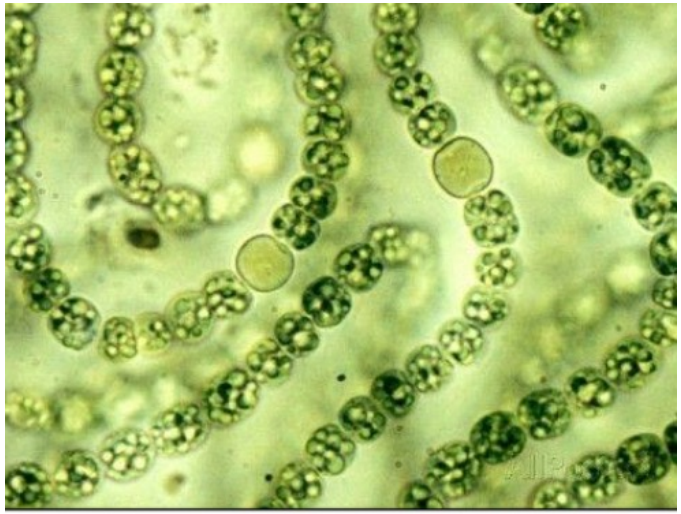
Clostridium sp.



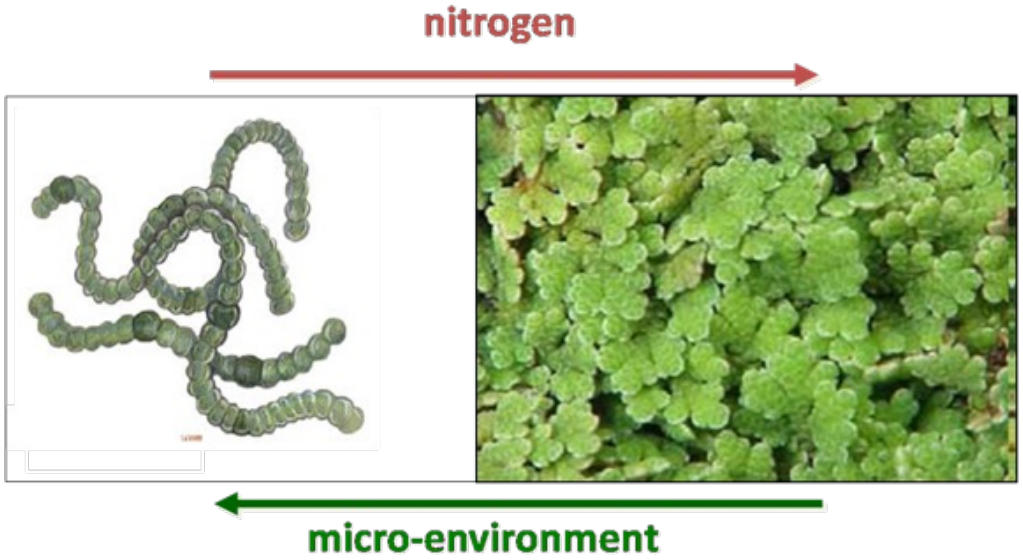
Pseudomonas stutzeri

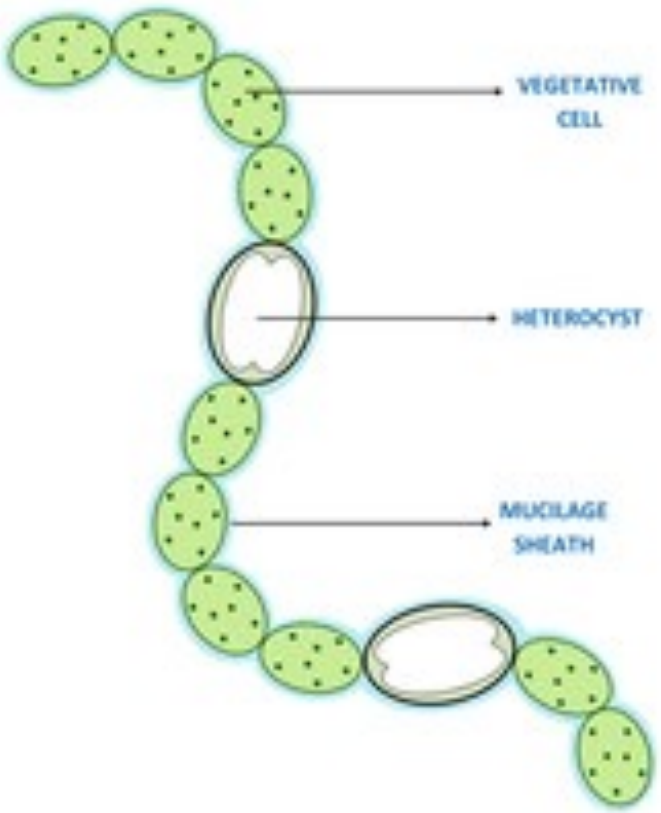
Sources of Nitrogen to the Soil

Biological Sources of Soil Nitrogen

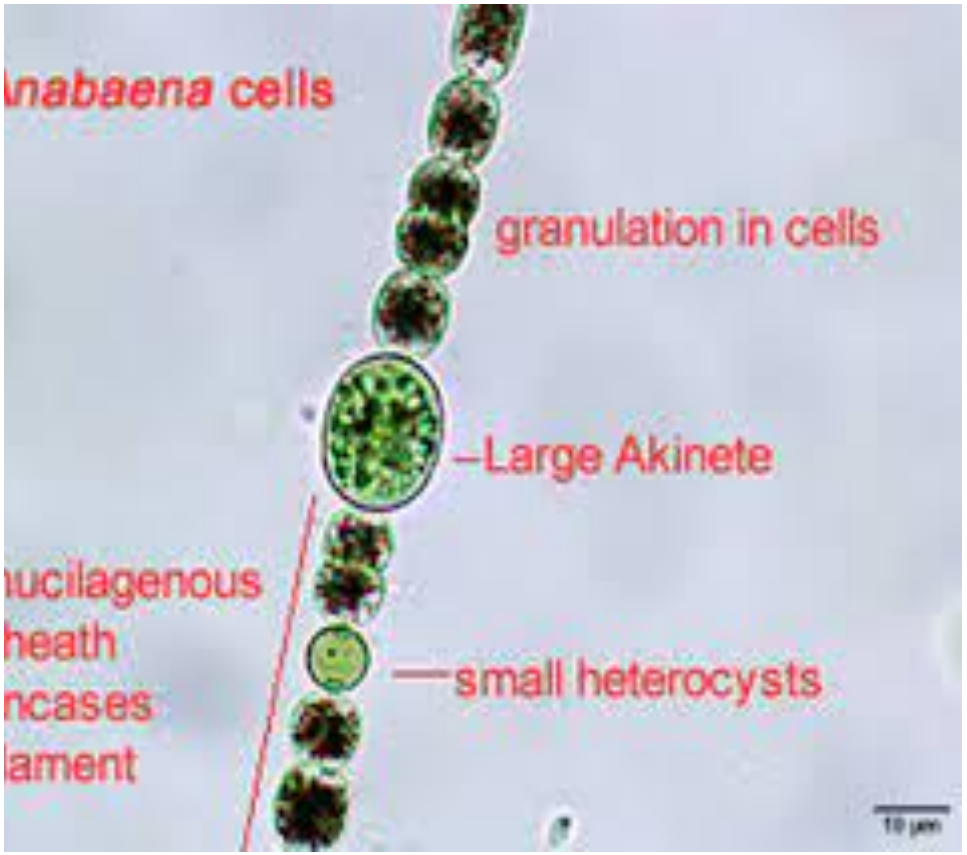


Nostoc sp. – blue - green algae





Nostoc



Mycorrhizal colonization also alter root exudation

Atmospheric Sources of Soil Nitrogen

Agricultural Supplements to Soil Nitrogen

NUTRIENT LOSS IN ECOSYSTEMS I

Experiments at Hubbard Brook

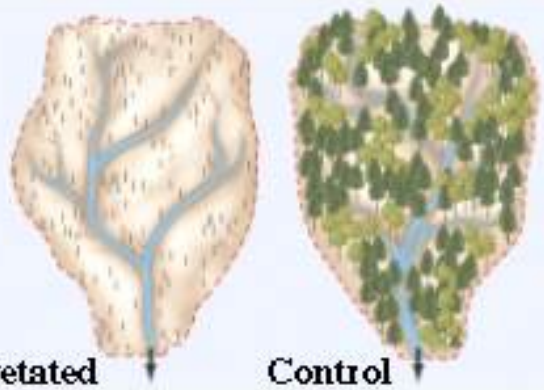
NUTRIENT LOSS IN ECOSYSTEMS II

Question: How does the presence of vegetation affect the rate of nutrient export in an ecosystem?

Hypothesis: Presence of vegetation lowers the rate of nutrient export because it increases soil stability and recycling of nutrients.

Null hypothesis: Presence of vegetation has no effect on the rate of nutrient export.

Experimental setup:



Devegetated Control

1. Choose two similar watersheds. Document nutrient levels in soil organic matter, plants, and streams.

2. Devegetate one watershed, and leave the other intact.

3. Monitor the amount of dissolved substances in streams.

Prediction: Amount of dissolved substances in stream in devegetated watershed will be much higher than amount of dissolved substances in stream in control watershed.

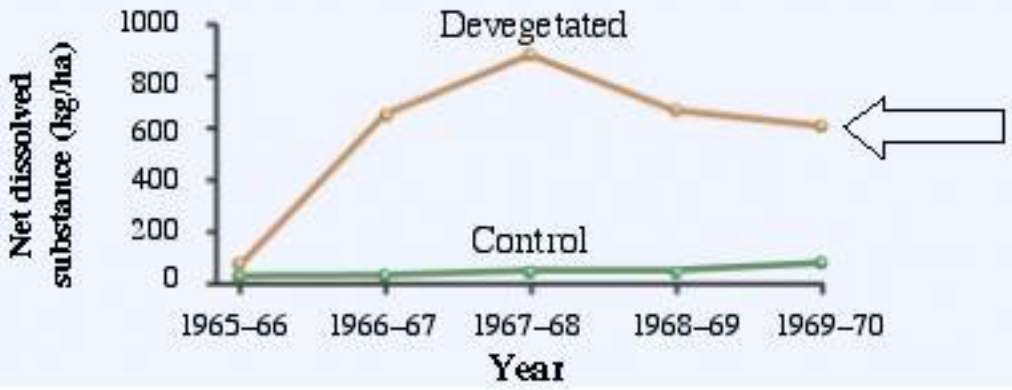
Prediction of null hypothesis: No difference will be observed in amount of dissolved substances in the two streams.

NUTRIENT LOSS IN ECOSYSTEMS III

Prediction: Amount of dissolved substances in stream in devegetated watershed will be much higher than amount of dissolved substances in stream in control watershed.

Prediction of null hypothesis: No difference will be observed in amount of dissolved substances in the two streams.

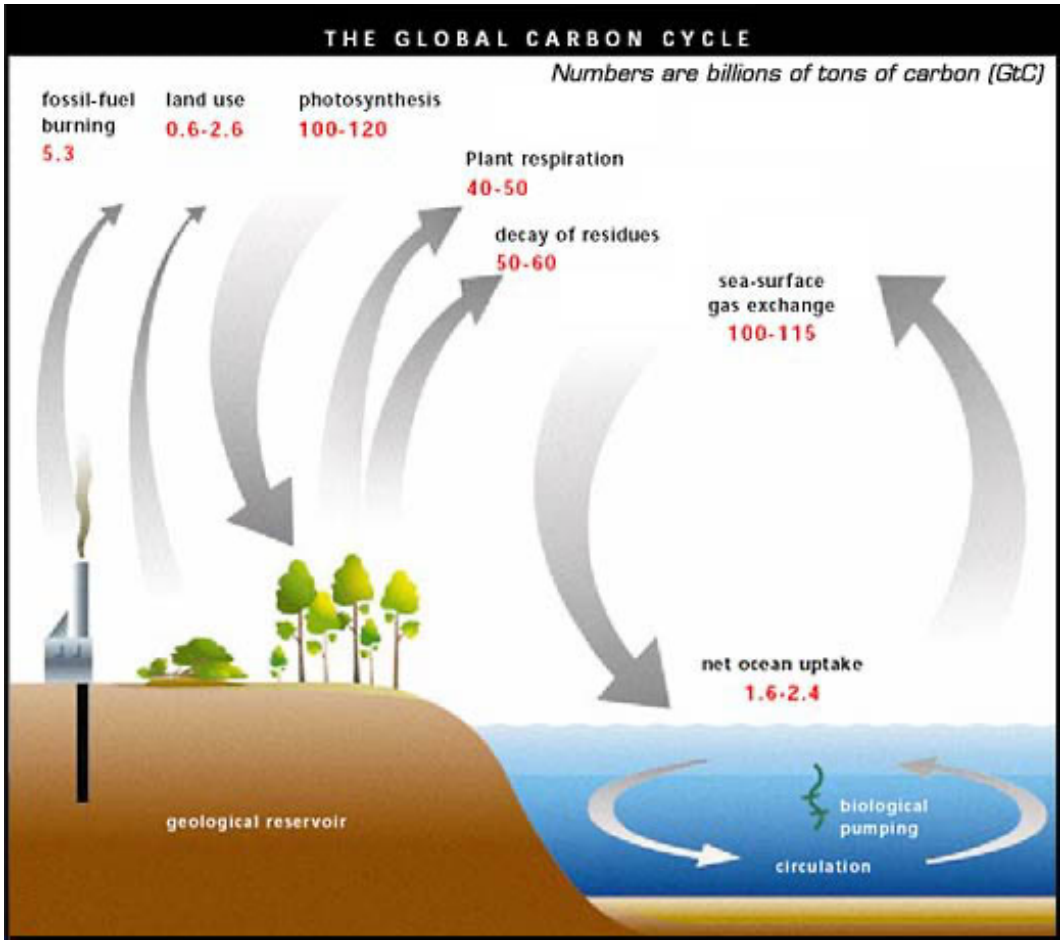
Results:



About 10 times more dissolved substances in devegetated watershed than in control watershed

Conclusion: Presence of vegetation limits nutrient loss. Removing vegetation leads to large increases in nutrient export.

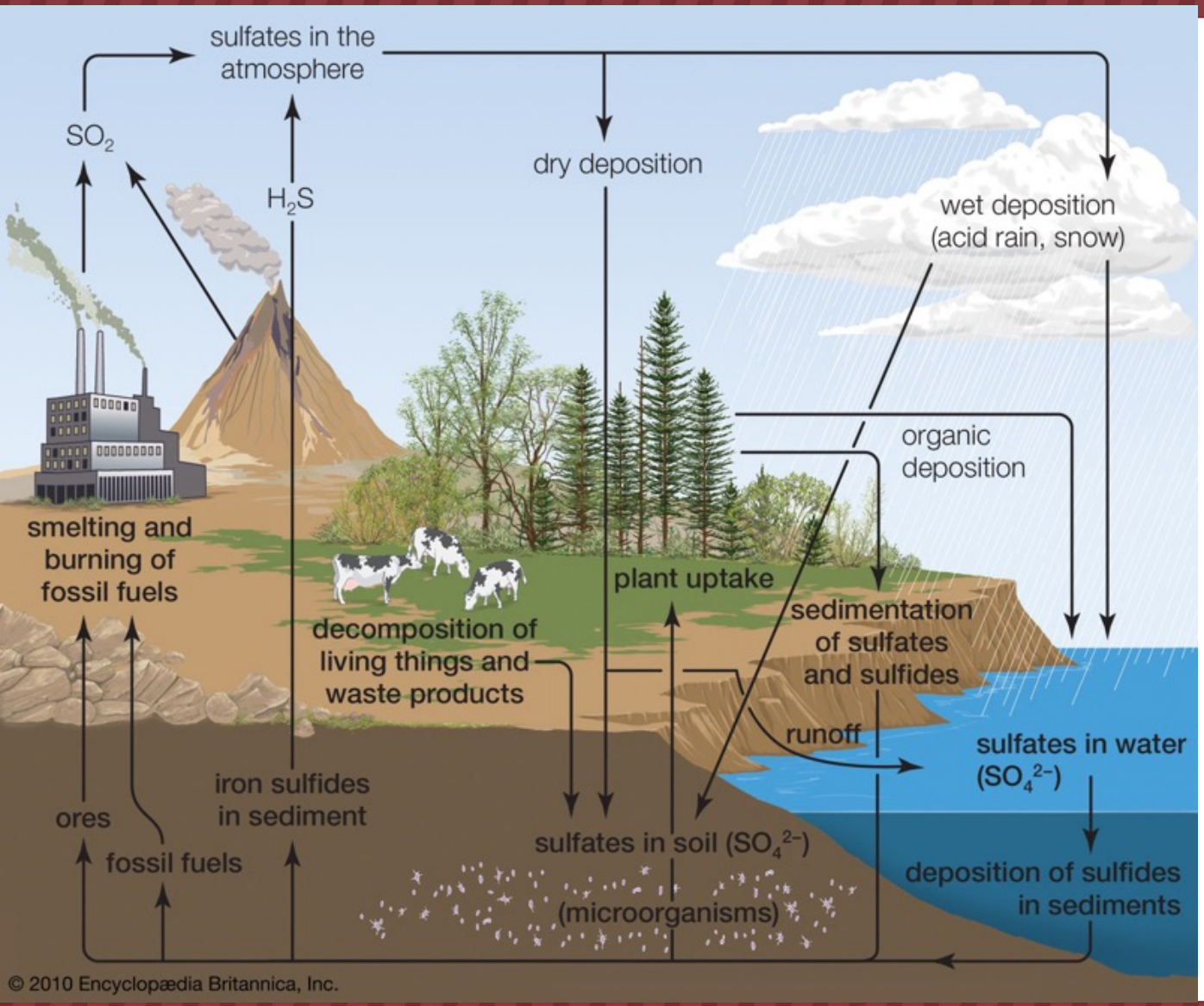
GLOBAL NUTRIENT CYCLES



Sedimentary Cycles

Sulfur Cycle

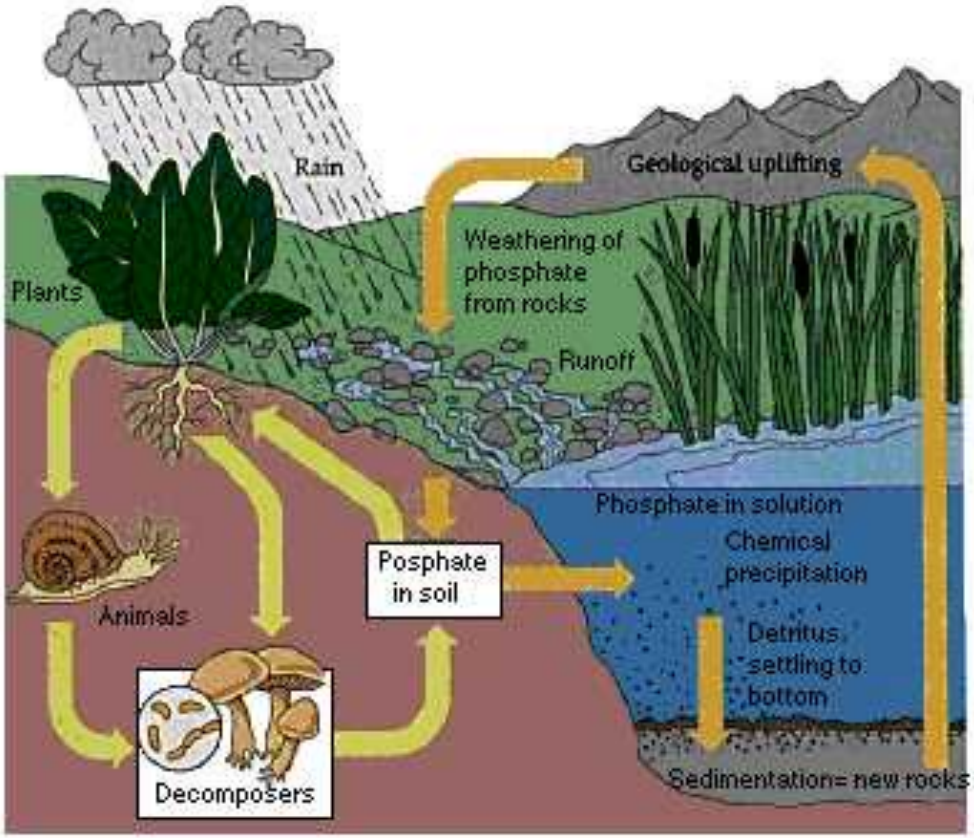
Phosphorous Cycle



Sulfur Cycle

- Sulfur is released from rocks through weathering, and then assimilated by microbes and plants.

PHOSPHOROUS CYCLE IN ECOSYSTEMS



Phosphorus, as phosphate (PO_4^{-3}), is an essential element of life.