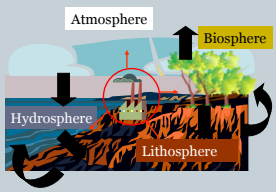
BIOGEOCHEMICAL CYCLES

BIOGEOCHEMICAL CYCLES

- A **biogeochemical cycle** or **cycling of substances** is a pathway by which a chemical element or molecule moves through both biotic and abiotic compartments of Earth. A cycle is a series of change which comes back to the starting point and which can be repeated.

The biogeochemical cycle

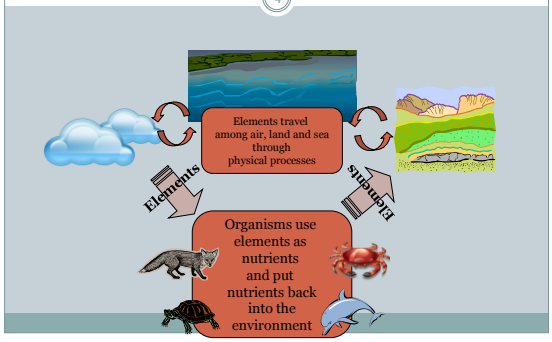


The biogeochemical cycle involves the movement of elements and compounds among the land (lithosphere), organisms, air (atmosphere) and the oceans (hydrosphere).

Human activities can affect these cycles

How do elements move through the biogeochemical cycle?

4

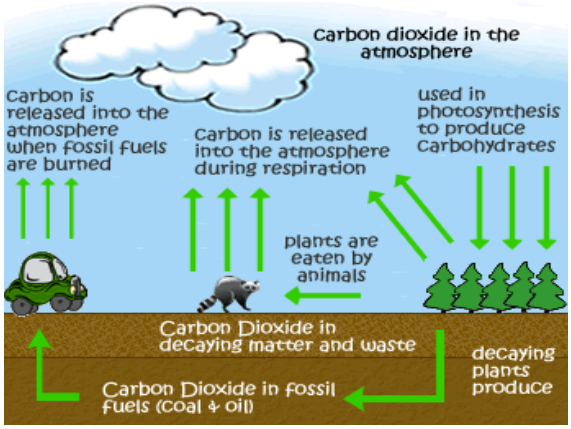


CARBON CYCLE

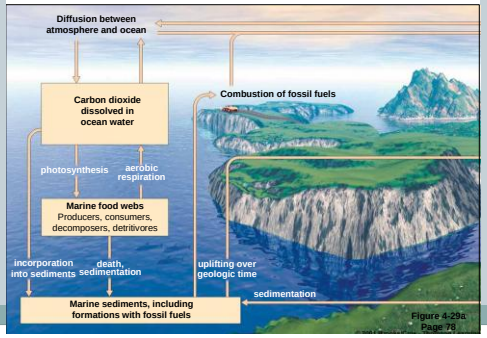
- The **carbon cycle** is the biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth. Along with the nitrogen cycle and the water cycle, the carbon cycle comprises a sequence of events that are key to making the Earth capable of sustaining life; it describes the movement of carbon as it is recycled and reused throughout the biosphere.

CARBON CYCLE

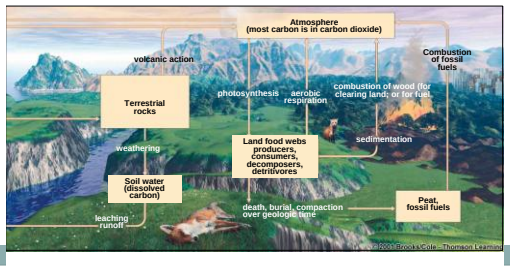
- The carbon cycle was initially discovered by Joseph Priestley and Antoine Lavoisier, and popularized by Humphry Davy.



MARINE CARBON CYCLE

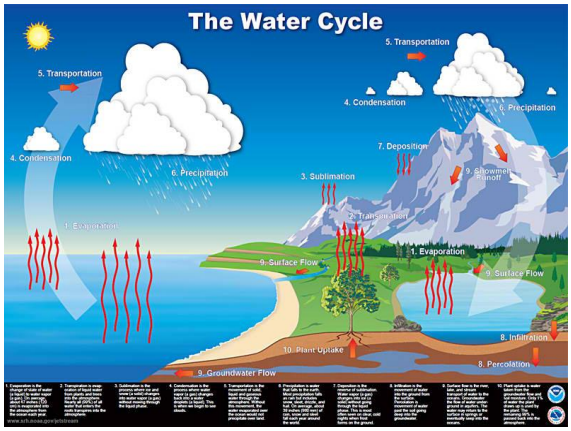


TERRESTRIAL CARBON CYCLE

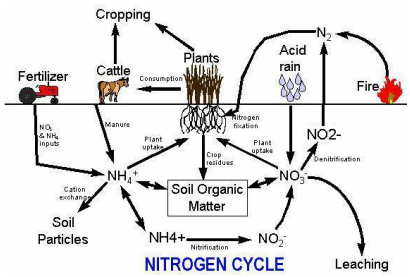


HYDRGOLOGIC CYCLE (WATER CYCLE)

The **water cycle**, also known as the **hydrologic cycle** or the **H_2O cycle**, describes the continuous movement of water on, above and below the surface of the Earth. The mass water on Earth remains fairly constant over time but the partitioning of the water into the major reservoirs of ice, fresh water, saline water and atmospheric water is variable depending on a wide range of climatic variables. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. In so doing, the water goes through different phases: liquid, solid (ice), and gas (vapor).



The Nitrogen Cycle



Forms of Nitrogen

- Urea → $CO(NH_2)_2$
- Ammonia → NH_3 (gaseous)
- Ammonium → NH_4
- Nitrate → NO_3
- Nitrite → NO_2
- Atmospheric Dinitrogen → N_2
- Organic N

Global Nitrogen Reservoirs

Nitrogen Reservoir	Metric tons nitrogen	Actively cycled
Atmosphere	$3.9*10^{15}$	No
Ocean → soluble salts **Biomass**	$6.9*10^{11}$ $5.2*10^{8}$	Yes Yes
Land → organic matter **→ Biota**	$1.1*10^{11}$ $2.5*10^{10}$	Slow Yes

Roles of Nitrogen

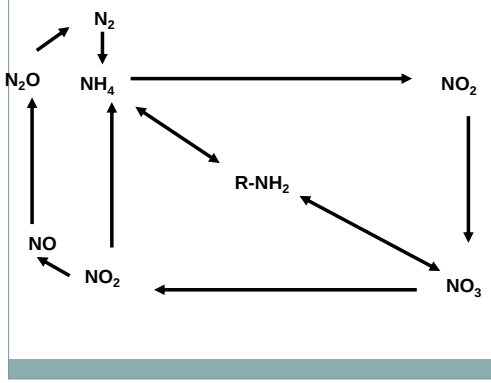
- Plants and bacteria use nitrogen in the form of NH_4^+ or NO_3^-
- It serves as an electron acceptor in anaerobic environment
- Nitrogen is often the most limiting nutrient in soil and water.

Nitrogen is a key element for

- amino acids
- nucleic acids (purine, pyrimidine)
- cell wall components of bacteria (NAM).

Nitrogen Cycles

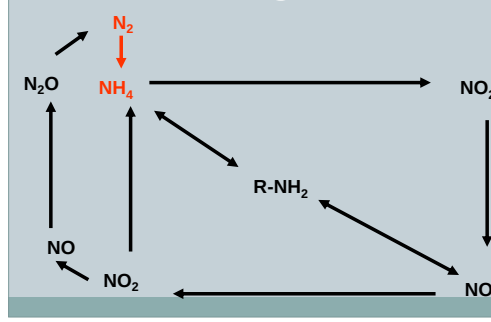
- Ammonification/mineralization
- Immobilization
- Nitrogen Fixation
- Nitrification
- Denitrification



Immobilization

- The opposite of mineralization
- Happens when nitrogen is limiting in the environment
- Nitrogen limitation is governed by C/N ratio
- C/N typical for soil microbial biomass is 20
- C/N < 20 →Mineralization
- C/N > 20 →Immobilization

Nitrogen Fixation



Nitrogen Fixation

- Energy intensive process :
- **N_2 + 8H+ + 8e$^-$ + 16 ATP = 2NH_3 + H_2 + 16ADP + 16 Pi**
- Performed only by selected bacteria and actinomycetes
- Performed in nitrogen fixing crops

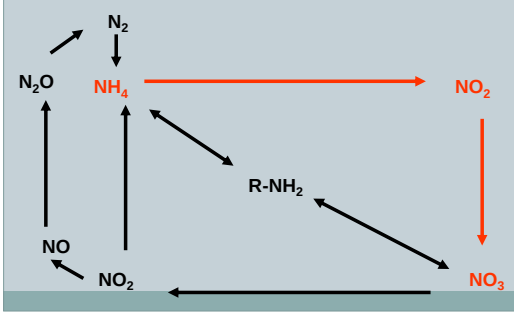
(ex: soybeans)

Microorganisms fixing

- *Azobacter*
- *Beijerinckia*
- *Azospirillum*
- *Clostridium*
- *Cyanobacteria*

- Require the enzyme nitrogenase
- Inhibited by oxygen
- Inhibited by ammonia (end product)

Nitrification



Nitrification

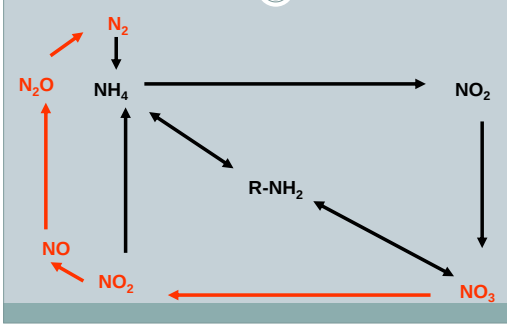
Two step reactions that occur together :

- 1rst step catalyzed by *Nitrosomonas*
  $2\ NH_4^+ + 3\ O_2 \rightarrow 2\ NO_2^- + 2\ H_2O + 4\ H^+$
- 2nd step catalyzed by *Nitrobacter*
- $2\ NO_2^- + O_2 \rightarrow 2\ NO_3^-$

- Optimal pH is between 6.6-8.0
- If pH < 6.0 → rate is slowed
- If pH < 4.5 → reaction is inhibited

In which type of wetlands do you thing Nitrification occurs?

Denitrification



Denitrification

- Removes a limiting nutrient from the environment
- $4NO_3^- + C_6H_{12}O_6 \rightarrow 2N_2 + 6\ H_20$
- Inhibited by O_2
- Not inhibited by ammonia
- Microbial reaction
- Nitrate is the terminal electron acceptor

PHOSPHOROUS CYCLE

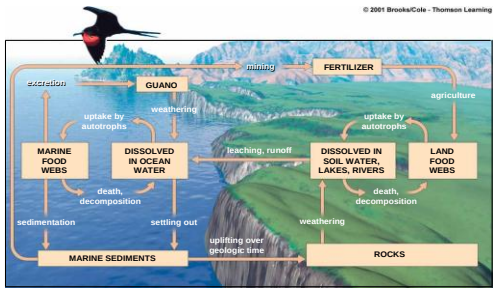
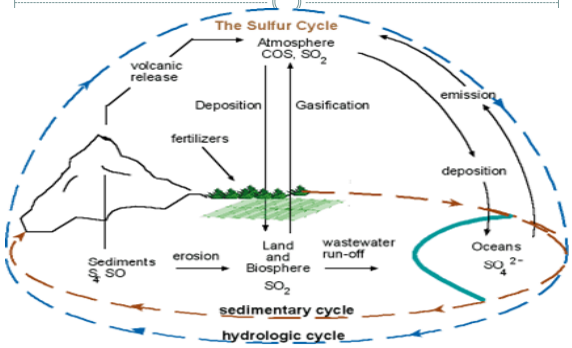


Figure 4-33
Page 82

SULFUR CYCLE

- The **sulfur cycle** is the collection of processes by which sulfur moves to and from minerals (including the waterways) and living systems. Such biogeochemical cycles are important in geology because they affect many minerals. Biogeochemical cycles are also important for life because sulfur is an essential element, being a constituent of many proteins and cofactors.

SULFUR CYCLE



SULFUR CYCLE