

## SUMMARY OF BIOGEOCHEMICAL CYCLES

### CARBON CYCLE

- Is an atmospheric cycle.
- Carbon is required for formation of organic compounds in living things.
- C in carbon dioxide in atmosphere and in water is moved to C in glucose by photosynthesis by producers.
- C in glucose is moved to C in carbon dioxide by cellular respiration.
- C in glucose is moved to C in organic molecules by synthesis reactions in living things.
- C in organic molecules is moved to C in carbon dioxide by combustion.
- C in organic molecules in organisms is moved to C in fossil fuels over millions of years by pressure, heat, and bacterial action.
- C in limestone ( $\text{CaCO}_3$ ) is released slowly to C in carbon dioxide when exposed to oxygen and/or water.
- Largest reservoir of carbon - sedimentary rocks (limestone)  
Second largest reservoir of carbon - ocean (dissolved carbon dioxide), living things in ocean.
- In water:  
$$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{HCO}_3^- \text{ (bicarbonate ions)} + \text{CO}_3^{2-} \text{ (carbonate ions)}$$
$$\text{Ca}^{2+} + \text{CO}_3^{2-} \rightarrow \text{CaCO}_3 \text{ (calcium carbonate) in shells/skeletons of aquatic organisms}$$
$$\text{CaCO}_3 \rightarrow \text{buried, long period of time, pressure} \rightarrow \text{limestone}$$
- Human Impact:
  - Removal of vegetation reduces absorption of carbon dioxide for photosynthesis from atmosphere. Increases atmospheric  $\text{CO}_2$ .
  - Burning of fossil fuels increases atmospheric  $\text{CO}_2$ .
  - Increase in atmospheric  $\text{CO}_2$  leads to increased Greenhouse Effect  $\rightarrow$  Global Warming.

### NITROGEN CYCLE

- Is an atmospheric cycle.
- Plants and animals cannot use free nitrogen gas in the atmosphere. They must have nitrogen in "fixed" form. Nitrogen is required for proteins, nucleic acids in living things.
- Free  $\text{N}_2$  in atmosphere is "fixed" by nitrogen-fixing bacteria to  $\text{NH}_3$  (ammonia):
$$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$$
- Nitrogen fixing bacteria live in nodules on the roots of leguminous plants (soybeans, peas, clover, and alfalfa.)
- Water in the soil reacts with ammonia to form  $\text{NH}_4^+$  (ammonium ion)
- Another species of bacteria can perform nitrification once ammonium has formed:
$$\text{NH}_4^+ \rightarrow \text{NO}_2^- \text{ (nitrite; toxic)} \rightarrow \text{NO}_3^- \text{ (nitrate; plant nutrient)}$$
- Assimilation - absorption of ammonia, ammonium ion, nitrate for use by plants to make nucleic acids, proteins
- Animals get fixed nitrogen by eating plants or other animals.
- Plants and animals are broken down by still other bacteria that convert nitrogen-containing organic molecules in organisms to an inorganic form of nitrogen (ammonia or ammonium ion) = ammonification
- Once this ammonia has formed, still another group of bacteria can perform denitrification:
$$\text{NH}_3 \text{ or } \text{NH}_4^+ \rightarrow \text{NO}_2^- \text{ and/or } \text{NO}_3^- \rightarrow \text{N}_2 \text{ and } \text{N}_2\text{O (nitrous oxide)}$$

- Nitrogen is often limiting factor in plant growth because ammonia, ammonium ion, nitrate are water-soluble: can be leached from soil.
- Human Intervention:
  - In the atmosphere:
    - $N_2 + O_2 \rightarrow 2NO$  (nitric oxide) produced when burning fuel or forests.  
(Heat combines  $N_2$  and  $O_2$  present in atmosphere)
    - $NO + O_2 \rightarrow NO_2$  (nitrogen dioxide gas)
    - $NO_2 + H_2O \rightarrow HNO_3$  (nitric acid - dissolved in water causes acid deposition)
  - $N_2O$  (nitrous oxide) released from decomposition of fertilizer and waste.
  - Excess nitrogen added to aquatic systems by runoff of artificial fertilizer, farm waste, discharge of sewage. This stimulates growth of algae. Breakdown of algae by aerobic decomposers depletes water of oxygen.

## PHOSPHORUS CYCLE

- Phosphorus is required in the form of phosphate ions for nucleic acids, ATP, phospholipids in cell membranes, bones, teeth, shells of animals.
- $PO_4^{3-}$  = Phosphate
- Is a sedimentary cycle - does not include the atmosphere.
- Phosphate on land and in ocean sediment released by weathering into water and taken up by plants. Can be limiting factor for plant growth - is present in artificial fertilizer.
- Animals get phosphorus by eating plants or other animals.
- Decomposition changes organic molecules with phosphorus back into phosphate which dissolves in water which returns the phosphorus to ocean sediment or deposited as rocks.
- Human intervention:
  - Mining of phosphate for fertilizers and soap causes disruption to ecosystems.
  - Removal of phosphorus from ecosystems by cutting down of vegetation. Most of phosphorus is taken up as biomass.
  - Excessive phosphate in runoff from fertilizer, discharge of sewage, farm waste causes growth of algae, etc. (same problem as nitrogen).

## SULFUR CYCLE

- Is an atmospheric cycle.
- $H_2S$  (hydrogen sulfide) and  $SO_2$  (sulfur dioxide) released into atmosphere from natural (volcanoes) and non-natural sources.
  - $H_2S + O_2 \rightarrow SO_2$
  - $SO_2 + O_2 \rightarrow SO_3$  (sulfur trioxide) or
  - $SO_2 + H_2O \rightarrow H_2SO_4$  (sulfuric acid) ----> acid deposition, sulfur returned to water and soil, taken up by plants, animals.
- Human intervention:
  - Sulfur-containing coal, when burned, releases  $SO_2$ .
  - Other industrial processes.

## WATER CYCLE

Important terms:

absolute humidity	dew point	relative humidity
aquifer	evaporation	runoff
condensation	infiltration	transpiration
condensation	percolation	water table
nuclei	precipitation	