

CHAPTER 5

Nutrient Cycles & Soils

What is a nutrient cycle?

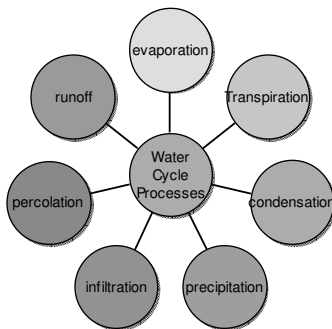
- ⇒ Flow of atoms, molecules, ions between biotic & abiotic factors in ecosystem
- ⇒ A.K.A. "biogeochemical cycle"
- ⇒ What's the role of the Law of Conservation of Matter?

Three major types of cycles:

- ⇒ **Hydrologic Cycle**
 - a.k.a. "water cycle" – done last chapter
- ⇒ **Atmospheric Cycle**
 - Gaseous element flow (O₂ for example)
 - Cycles from atmosphere → life → soil → atmosphere
- ⇒ **Sedimentary Cycle**
 - Solid, mineral form of elements
 - Crust is storehouse
 - Crust → land → seas → back to land
 - Involves major geological events in crust

5.2 Water Cycle

- Water availability = MAJOR factor in ecosystem & biome distribution for TERRESTRIAL areas
- For AQUATIC areas = "matrix"



Water cycle continued...

- **Powered by?**
 - Sun
 - Gravity
- What goes up = what comes down
- Quick terminology:
 - **Absolute Humidity**
 - Amount of vapor in a mass of air
 - **Relative humidity**
 - % of water vapor in air mass

- Condensation requires two "things":
 - Condensation nuclei – what are they?
 - Dew point – what is it?
- Rain becomes runoff → streams → rivers → eventually back to ocean
- Runoff causes:
 - Erosion
 - Weathering
- Some rain infiltrates & percolates
 - To groundwater → aquifer → seeps into streams and eventually to ocean
- Water cycle – natural purification
 - Distillation
 - Filtration

Human Impacts on Water Cycle

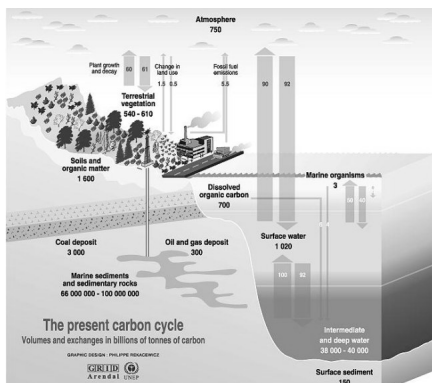
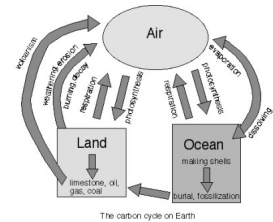
- We withdraw lots of freshwater
- Clearing
 - Increases runoff and reduces infiltration & recharge
 - Accelerates erosion
- Degrading water quality
 - Pollution
 - Cultural eutrophication
- Stop/Slow natural purification process

5.3 CARBON CYCLE

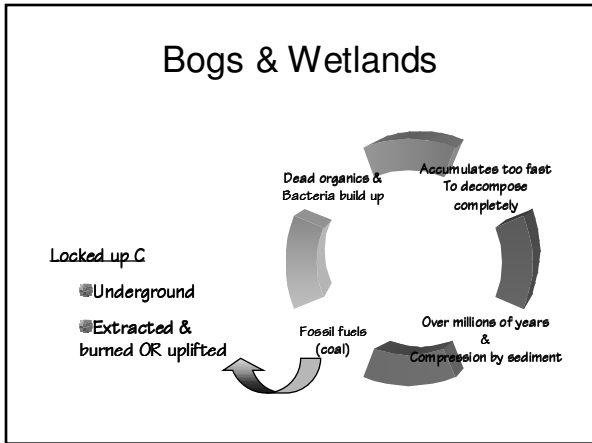
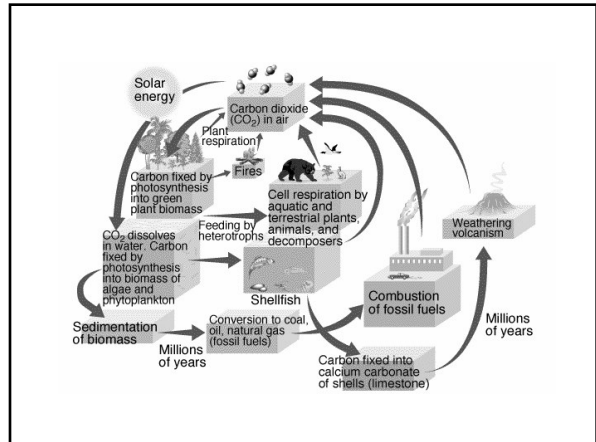
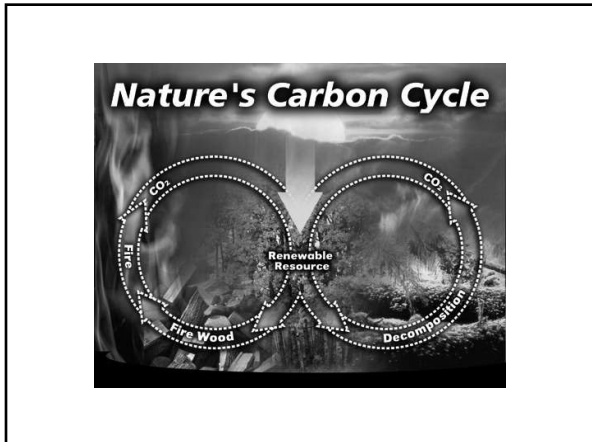
- Importance of elemental carbon:
 - Building atom of life
 - "Currency for energy exchange"
 - Component of greenhouse gasses
 - ⊕ Methane
 - ⊕ Carbon dioxide

[Run carbon cycle animation](#)

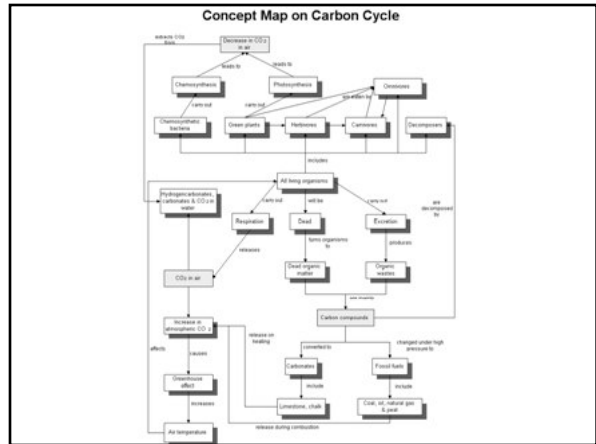
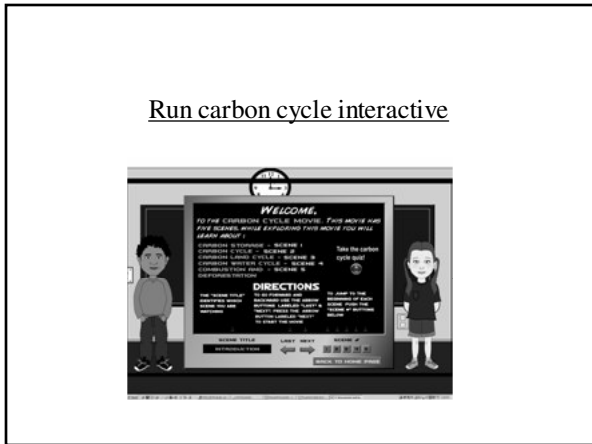
- Based on carbon dioxide
- Two main processes:
 - Photosynthesis – removes from atmosphere
 - Respiration – returns to atmosphere
- Carbon in biomass ("locked up") cycles slowly
 - Requires death & decomposition to unlock
 - Fire can speed up



<p>Largest reservoir: Rock (esp. limestone) deposits (in ocean sediment & continental)</p> <ul style="list-style-type: none"> • Limestone corals = CaCO₃ <ul style="list-style-type: none"> ▪ Acid dissolves, releasing CO₂ • Geologically uplifted deposits exposed to weathering 	<p>2nd Largest: Ocean waters</p> <ul style="list-style-type: none"> • Dissolved CO₂ <ul style="list-style-type: none"> ▪ Some stays ▪ Some used/removed by producers ▪ Reacts with water to make carbonate & bicarbonate ions ▪ As water warms, more gas released into atmosphere
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- ### Human Influences
- Adding CO₂
 - Deforestation/clearing
 - How is that "adding" carbon dioxide?
 - Burning fossil fuels
 - Increasing greenhouse effect
 - Altering climate
 - Disrupting food webs – food production



5.4 Nitrogen Cycle

- Vital to life for:
 - Amino acids
 - Proteins
 - Nucleic acids
- Limiting nutrient for plant production
- Most nitrogen is not directly usable by plants
 - 78% atmosphere is N_2
 - Plants can use NH_3 or NH_4^+
 - Prefer NO_3^{-2} [generated by nitrification]

Major Processes

- Nitrogen fixation
- Nitrification
- Assimilation
- Ammonification
- Denitrification



[Run interactive nitrogen cycle](#)

- **Nitrogen fixation**
 - $N_2 + 3H_2 \rightarrow 2NH_3$ (ammonia)
 - Cyanobacteria & *Rhizobium* in legume root nodules
- **Nitrification**
 - $NH_3 \rightarrow NO_2^-$ (nitrite, toxic to plants) $\rightarrow NO_3^{-2}$ (nitrate)
- **Ammonification**
 - Plants die \rightarrow decompose \rightarrow converted to NH_3 & NH_4^+
- **Denitrification**
 - NH_3 & $NH_4^+ \rightarrow NO_2^-$ & $NO_3^{-2} \rightarrow N_2$ & N_2O [gasses]
- **Assimilation**
 - NH_3 , NH_4^+ , NO_3^{-2} used in plant production

Human Influences - 1

- Make ammonia salts for fertilizers (Haber Process)
- Add $NO_{(g)}$ to atmosphere
 - Burning fuels
 - $NO + O_2 \rightarrow NO_2 + H_2O_{(g)} \rightarrow HNO_3$ [acid deposition]
- Emit N_2O
 - Global warming heat trapping gas
 - Depletes ozone layer
 - From animal wastes, commercial fertilizers, & bacteria

Human Influences -2

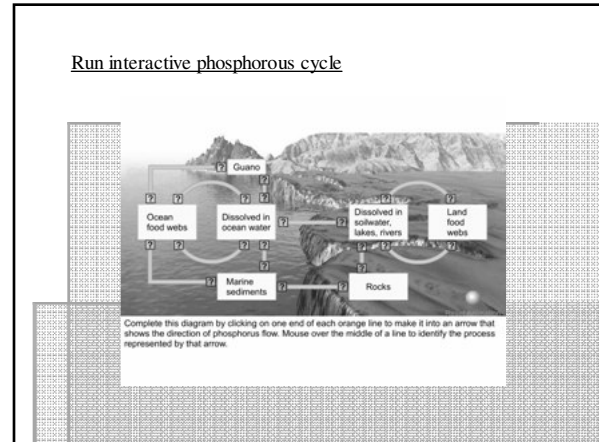
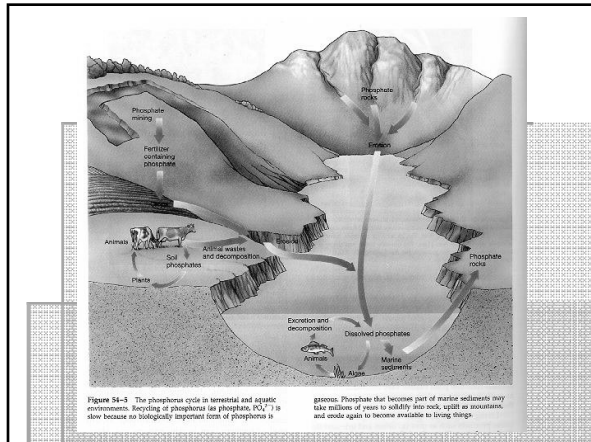
- Remove N from crust
 - Mine for fertilizer
 - Harvest N rich crops – removes N from topsoil
 - Irrigation – leaches N from topsoil
 - Burning & clearing
- Add excess N to water
 - Agricultural runoff
 - Sewage wastes
- Atmospheric deposition (solid particles)
 - N comp'ds drop from atmos onto plants/land

Algal Bloom
Depletes D.O.

5.5 PHOSPHOROUS CYCLE

- Mainly PO_4^{-3} and HPO_4^{-2}
- Important for life
 - DNA
 - ATP
 - Phospholipids
 - Essential limiting nutrient for plants
- No gaseous form
- Cycle is slow – most P runs from land into the deep ocean
- Typical form – phosphate salt with PO_4^{-3} ions
 - Found in ocean sediment/rock formations

[Run P-cycle animation](#)



Human Influences

- Mining P rock deposits → fertilizers & detergents
- Deforestation → removes growth containing P
- Agricultural runoff
 - Livestock wastes
 - fertilizers

Algal Bloom
Depletes D.O.

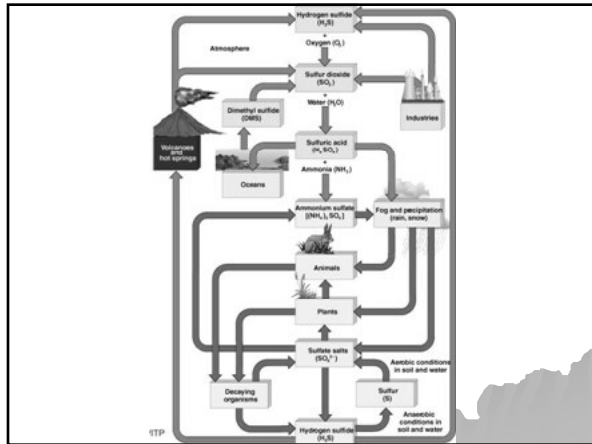
5.6 SULFUR CYCLE

- ◆ Sulfur important
 - Proteins
 - Vitamins
 - Three dimensional structure of DNA
- Run S-cycle Animation
- ◆ Mostly SO_4^{2-} dissolved in water
- ◆ Lots of S tied up in rock deposits
 - Uplifted & weathered to enter atmosphere

- ◆ Volcanoes & swamps release H_2S (g)
 - Anaerobic decomposition in swamp
 - H_2S → highly toxic, rotten egg odor
- ◆ Volcanoes also release SO_2 (g)
 - Colorless & suffocating gas
- ◆ Ocean spray
 - Sulfate salt particles (EX: ammonium sulfate)

Effects of S in atmosphere

- ◆ $2SO_2 + O_2 \rightarrow 2SO_3$
- ◆ $SO_3 + H_2O \rightarrow H_2SO_4$ (sulfuric acid)
- ◆ Leads to acid deposition



Human Influences

- ◆ Burn coal (2/3 impact)
- ◆ Refining petroleum
- ◆ Smelting ore
- ◆ Industrial processes

5.7 ROCK CYCLE

Three types of rock

- Igneous rock
 - Magma cools & solidifies
 - Bulk of crust
- Sedimentary rock
 - Sediments "cement" under pressure
 - Chemical weathering
 - Mechanical weathering – speeds up chemical
 - Frost wedging

