Biogeochemical Cycles and Book

• You will use information from chapter 47 Starr text, notes and your own research to complete the Biogeochemical cycle book.

Biogeochemical Cycles

• The flow of a nutrient through the environment- flowing from living- biotic organisms and back to the abiotic portions of the environment

• In most organisms 95% of the body is made up of just four elements.
  – Oxygen
  – Carbon
  – Hydrogen
  – Nitrogen

Water Cycle

• Water occurs in 3 states (determined by temperature)
  – Solid
  – Liquid
  – Gas

• Over 70% of the Earth’s surface is covered by oceans and water is constantly being cycled between the hydrosphere (water), atmosphere (air) and lithosphere (land).

EVAPORATION

• The sun’s energy causes the bonds between water molecules to break and evaporate into water vapor (Liquid → gas)

• Impurities are left behind (ex: salt)
  – This is important because about 97% of water on Earth is salt water and only 3% is freshwater.

Condensation

• When atmospheric temp decreases, water vapor (gas) changes back into a liquid

• Small water droplets are formed
  – clouds
  – Fog
  – Drops on plants or on the outside of your cup
Precipitation

- Tiny water droplets bounce around in a cloud as they hit each other, stick together and become larger. As they get heavier eventually they fall back to Earth
  - Rain, freezing rain, sleet, snow, hail

Surface Runoff

- About 1/3 of water that returns to Earth as precipitation runs off the surface of the land, down hill into streams, rivers, lakes and oceans.

Infiltration/percolation

- Water that soaks into the ground (downward movement)
- This water can replenish aquifers, which store large amounts of freshwater.

Transpiration

- Water is absorbed by plant roots, travels up through the plant and then is evaporated back into the atmosphere from the plant leaves.
- Water is returned to the atmosphere by plants

Sublimation

- Conversion of solid water into gaseous form (no liquid form in between)
- When ice and snow change into water vapor

WATERSHED EXPERIMENT

- WATERSHED- any region where precipitation flows into a single stream/river
- A watershed in the Hubbard Brook Valley of New Hampshire was experimentally stripped of vegetation
- All surface water and materials within draining from watershed was measured
- Removal of vegetation caused a six-fold increase in the calcium content of the runoff water
Hubbard Brook Experiment

Before After

Hubbard Brook Experiment

Water Use and Scarcity

- Groundwater is naturally stored in soils and aquifers
  - Aquifers are used as source of drinking water in US
  - Can be contaminated by
    - Landfill chemicals, Hazardous waste / sewage / pesticides, Underground tanks (that leak)

Aquifer Problems

Meeting Water needs?

- HOW CAN WE FIX THE PROBLEM?
  - Desalinization- the removal of salt from seawater
    - is expensive and requires large energy inputs
    - requires fossil fuels

- Discuss with a neighbor… how can we meet our water needs?

DISCUSS WITH A PARTNER

- In what ways could the deforestation affect the ecology of the area?
Carbon Cycle
- Carbon moves through the atmosphere and food webs on its way to and from the ocean, sediments, and rocks
- All living things contain carbon.
  - Calcium carbonate (CaCO₃) is an important component of animal skeletons, and is found in several kinds of rocks.
  - Carbon dioxide (CO₂) is an important part of the atmosphere.
- [https://www.youtube.com/watch?v=FgEZpX3n5mo](https://www.youtube.com/watch?v=FgEZpX3n5mo)

Short Term Cycling of Carbon
- Let's start with Carbon Dioxide = Found in the atmosphere.
- PHOTOSYNTHESIS:
  - Plants and algae use CO₂ along with water and solar energy to produce their own food
  - Take the inorganic carbon and convert it into a molecule of carbon containing glucose (organic)
  - \[6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy from sunlight} \rightarrow C_6\text{H}_{12}\text{O}_6 + 6\text{O}_2\]
  - Now the Carbon is available for all other organisms to use as a food source

<table>
<thead>
<tr>
<th>Chemical Reaction</th>
<th>Equations</th>
</tr>
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<tbody>
<tr>
<td>Photosynthesis</td>
<td>[6\text{CO}_2 + 6\text{H}<em>2\text{O} + \text{energy} \rightarrow C_6\text{H}</em>{12}\text{O}_6 + 6\text{O}_2]</td>
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Short Term Cycling of Carbon
- CELLULAR RESPIRATION
  - Consumers eat the plants (including the glucose) and continue the cycle of carbon.
  - Now the Carbon is broken down
    - The Carbon can be built into structures like skin, muscles, bones, bark, cell membrane labels
    - OR is released as CO₂ back into the atmosphere.
  \[C_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy}\]

Long Term Cycling
- Other glucose molecules are built into the structures of the organism. They remain there until the organism dies.
- The animal must decay before carbon is released back into the environment.
- CARBON IN FOSSIL FUELS
  - When the organism is buried and transformed over millions of year into coal, oil or natural gas

Long Term Cycling
- CARBON IN ROCKS ETC
  - Carbon is also used by ocean dwelling organisms (Calcium Carbonate CaCO₃) to make their shells or reef
  - This material can be broken down after organism dies and ends up as sediment which forms into rock. SEDIMENTATION
  - Carbon in rock isn’t released until organisms break down the rock, or natural disasters break down the rock.

Weathering
- Break down of rocks, soils and minerals through contact with earth’s atmosphere, biota and waters.
  - Occurs by wind, water and living things interacting with the rocks and soils!
    - Mechanical weathering- erosion
    - Chemical weathering- oxidation
    - Biological weathering- lichens
Combustion
- When any organic material is burned releasing the Carbon back into the environment (usually as Carbon Dioxide)
  - Fossil fuels, wood, paper, plastics, and cloth (pollutants are often included in the burning of those listed above)

Carbon in the Oceans
- Most carbon in the ocean is dissolved carbonate and bicarbonate
- Ocean currents carry dissolved carbon

Greenhouse Effect
- The sun’s rays (both solar wavelengths and heat waves) penetrate the atmosphere
  - Those waves are both absorbed and reflected.
- Some of the heat escapes back into space but much of it is trapped by the greenhouse gases and water vapor
- These actions allow for life on earth.

Greenhouse Gases
- Greenhouse gases including carbon dioxide, methane, nitrous oxide, water vapor and ozone impede the escape of heat from Earth’s surface. As a bonus Ozone also blocks much of the harmful UV radiation from the sun!

Global Warming
Long-term increase in the amount of these gases correlates with the increasing temperature in Earth’s lower atmosphere.

Carbon Dioxide Increase
- Carbon dioxide levels fluctuate seasonally
- The average level is steadily increasing
- Burning of fossil fuels and deforestation (as well as human activity) are contributing to the increase
Other Greenhouse Gases
- CFCs - synthetic gases used in plastics and in refrigeration
- Methane - produced by termites and bacteria
- Nitrous oxide - released by bacteria, fertilizers, and animal wastes

Nitrogen Cycle
- Nitrogen is used by living organisms to produce amino acids and nucleic acids
- Main reservoir is nitrogen gas (N\textsubscript{2}) in the atmosphere= 78% Nitrogen (N\textsubscript{2} is not in a usable form for most organisms)

Nitrogen Fixation
- Plants cannot use nitrogen gas (N\textsubscript{2})
- Nitrogen-fixing bacteria convert nitrogen gas into ammonia (NH\textsubscript{3}) and ammonium (NH\textsubscript{4}+)

Ammonification
- Bacteria and fungi carry out ammonification
  - conversion of nitrogenous wastes/decay to ammonia (NH\textsubscript{3})
  - Ammonia and ammonium can be assimilated by plants!
  - Consumers eat plant and get Nitrogen 😊
Nitrification

- **Nitrifying bacteria** convert ammonium (NH₄⁺) to nitrites (NO₂⁻) and nitrates (NO₃⁻) which are usable by plants
- Lightening also converts

DENITRIFICATION

- A different type of bacteria (**denitrifying bacteria**) convert nitrogen compounds back into gaseous Nitrogen (N₂)

Human Effects

- Humans increase rate of nitrogen loss by clearing forests and grasslands
- Humans increase nitrogen in water and air by using fertilizers and by burning fossil fuels
  - This can lead to global warming and acid rain
- Too much or too little nitrogen can compromise plant health
- Acts as a limiting factor in an ecosystem

Leaching

- Removal of materials from rock or soil by moving ground water, run off, etc.
- Nitrogen is lost from soils via leaching and runoff

SEDIMENTARY CYCLES:

PHOSPHORUS CYCLE

- Phosphorous is essential to living organisms because it forms part of important life
  - Incorporated into molecules such as DNA and RNA.
  - Cell membrane and bone formation.
  - Metabolic processes involving ATP.
- Phosphorous is not very common in the biosphere, but is found in ROCK and sediment!

PHOSPHORUS CYCLE

- Short term cycling- phosphorus passes through food webs (bacteria, fungus, plants and animals) quickly.
  - Plants synthesize dissolved phosphates from soil water → animals eat the plants → Animals loose phosphates through urine and feces → Bacterial/fungus release phosphate from organic waste → return to plants
SEDIMENTARY CYCLES: PHOSPHORUS CYCLE

- Long term cycling - phosphorus in rock and sediment on land and in the ocean pass very slowly
  - Rock formations are slowly broken down by weathering and erosion which deliver ions to streams and rivers and sea.
  - Here they form the continental shelves (Earth’s crust) which over millions of years may be uplifted to land again

https://www.youtube.com/watch?v=wdAzQSuypCk

SEDIMENTARY CYCLES: PHOSPHORUS CYCLE

- Eutrophication - nutrient enrichment of any ecosystem that is otherwise low in nutrients
  - Can occur with any nutrient, but main culprits are nitrogen and phosphorus
  - Cause an algal bloom - which kills the other natural wildlife in the area:
    - Algae/bacteria use up the dissolved oxygen in the water,
    - Produce toxins that kill the wildlife
    - Blocks the sunlight

https://www.youtube.com/watch?v=AviqZgYbT4