QUIZ – Questions & Answers – Biogeochemical Cycles

Explain the role each plays for life on Earth, and list the steps:

1) Water (hydrologic) Cycle

2) Oxygen Cycle

3) Carbon Cycle

4) Nitrogen Cycle

5) Phosphorus Cycle

6) Sulfur Cycle

1) <u>Water (Hydrologic) Cycle</u>: What are the key processes involved in the water (hydrologic) cycle, and how do they interact to sustain the movement of water on Earth?

The water cycle begins with **evaporation**, where solar energy heats bodies of water like oceans, lakes, and rivers, causing water to change from liquid to vapor. This water vapor rises into the atmosphere, where it cools and condenses into clouds during the process of **condensation**. Precipitation, in the form of rain, snow, or sleet, follows as these clouds release moisture when they reach saturation.

Once precipitation reaches the Earth's surface, it either becomes **surface runoff**, where it flows into rivers, lakes, and oceans, or it infiltrates the ground to recharge aquifers as **groundwater**. Some of this water may be taken up by plants and later released back into the atmosphere through **transpiration**, which is the movement of water from plant surfaces. This combination of evaporation and transpiration is collectively known as **evapotranspiration**.

The cycle is essential for distributing fresh water across ecosystems and human societies, maintaining weather patterns, and supporting the life processes of all organisms. It is a closed system, meaning no water is gained or lost, only transformed and redistributed.

2) Oxygen Cycle: Describe the processes involved in the oxygen cycle and how it supports life on Earth.

The oxygen cycle primarily involves the interactions between the atmosphere, biosphere, and lithosphere. The cycle begins with **photosynthesis**, where plants, algae, and certain bacteria use sunlight to convert carbon dioxide and water into glucose and oxygen. This oxygen is released into the atmosphere, making up about 21% of the air we breathe.

Respiration is the complementary process, where organisms (including humans) consume oxygen to break down food molecules, releasing carbon dioxide and water as byproducts. Oxygen is also involved in the **decomposition** of dead organic matter. Decomposers like bacteria and fungi break down complex organic compounds, returning carbon dioxide to the atmosphere and cycling oxygen within ecosystems.

In addition to biological processes, oxygen cycles through geological processes like the **weathering of rocks**, where oxygen reacts with minerals. Oxygen also interacts with the ozone layer, where ultraviolet radiation converts oxygen (O2) into ozone (O3), helping protect life by filtering harmful UV rays.

3) <u>Carbon Cycle</u>: How does the carbon cycle maintain the balance of carbon in the environment, and what are the key processes involved?

The carbon cycle begins with the process of **photosynthesis**, where plants, algae, and phytoplankton take in carbon dioxide (CO_2) from the atmosphere and convert it into organic matter (glucose). This carbon is then passed through the food chain as organisms consume plants and are in turn consumed by other animals.

Through **respiration**, both plants and animals release carbon dioxide back into the atmosphere. When organisms die, **decomposition** breaks down their bodies, releasing carbon into the soil or atmosphere. Some carbon, under pressure and over long periods, can become fossil fuels (coal, oil, natural gas), which store carbon until they are extracted and burned by humans, releasing large amounts of CO_2 back into the atmosphere via **combustion**.

The oceans play a significant role in the carbon cycle as well, absorbing CO_2 from the atmosphere and storing it in marine organisms or sediments. This balance of carbon between the atmosphere, land, and oceans is critical for maintaining the Earth's temperature and supporting life through climate regulation.

4) <u>Nitrogen Cycle</u>: Explain the steps involved in the nitrogen cycle and how nitrogen is made available to living organisms.

The nitrogen cycle begins with **nitrogen fixation**, where certain bacteria in the soil or in the root nodules of legumes convert atmospheric nitrogen (N_2), which most organisms cannot use, into ammonia (NH_3) or related compounds that plants can absorb. This process can also occur through lightning or industrial processes.

Once nitrogen is fixed, **nitrification** occurs, where specialized bacteria convert ammonia into nitrites (NO_2^-) and then into nitrates (NO_3^-), which are usable by plants. Plants take up these nitrates through their roots, incorporating them into amino acids and other organic molecules that form the basis of proteins. Animals then obtain nitrogen by eating plants or other animals.

After plants and animals die, **decomposers** break down their organic matter, releasing nitrogen back into the soil as ammonia in a process known as **ammonification**. **Denitrification** by other bacteria in the soil converts nitrates back into nitrogen gas, which is released into the atmosphere, completing the cycle.

5) <u>Phosphorus Cycle</u>: How does the phosphorus cycle differ from other biogeochemical cycles, and what are the major steps involved?

Unlike the carbon, nitrogen, and oxygen cycles, the phosphorus cycle does not have a significant atmospheric component. Phosphorus is primarily found in **rocks** and is released into the soil through **weathering**. As rocks break down, phosphate ions ($PO4^{3-}$) are released and can be absorbed by plants.

Plants incorporate phosphorus into their tissues, and animals obtain it by eating plants or other animals. Phosphorus is crucial for forming DNA, RNA, and ATP, which are vital for energy transfer in cells. After plants and animals die, **decomposition** returns phosphorus to the soil.

Some phosphorus can be washed into water bodies, where it can settle into sediments, eventually becoming rock again through the process of **sedimentation**. The long-term cycling of phosphorus is thus much slower than cycles like nitrogen or carbon because it largely depends on geological processes.

6) <u>Sulfur Cycle</u>: Describe the key processes in the sulfur cycle and its significance to living organisms.

The sulfur cycle begins with the **weathering of rocks**, which releases sulfur into the soil as sulfate ions ($SO4^{2-}$). Plants take up these ions and incorporate them into proteins. Animals then consume the sulfur by eating plants or other animals, using it to build important amino acids like cysteine and methionine.

Sulfur is returned to the soil when organisms die, as **decomposers** break down their bodies, releasing sulfur into the environment. In certain environments, bacteria play a role in **sulfur reduction**, converting sulfate back into hydrogen sulfide (H2S) in oxygen-deprived environments.

Volcanic activity, as well as industrial processes such as burning fossil fuels, release sulfur dioxide (SO2) into the atmosphere, where it can combine with water vapor to form sulfuric acid, contributing to **acid rain**. This acid rain deposits sulfur back into the soil and water, continuing the cycle. Sulfur is crucial for maintaining protein structure and enzyme function in living organisms.