STEMBoost Newsletter - December 2024

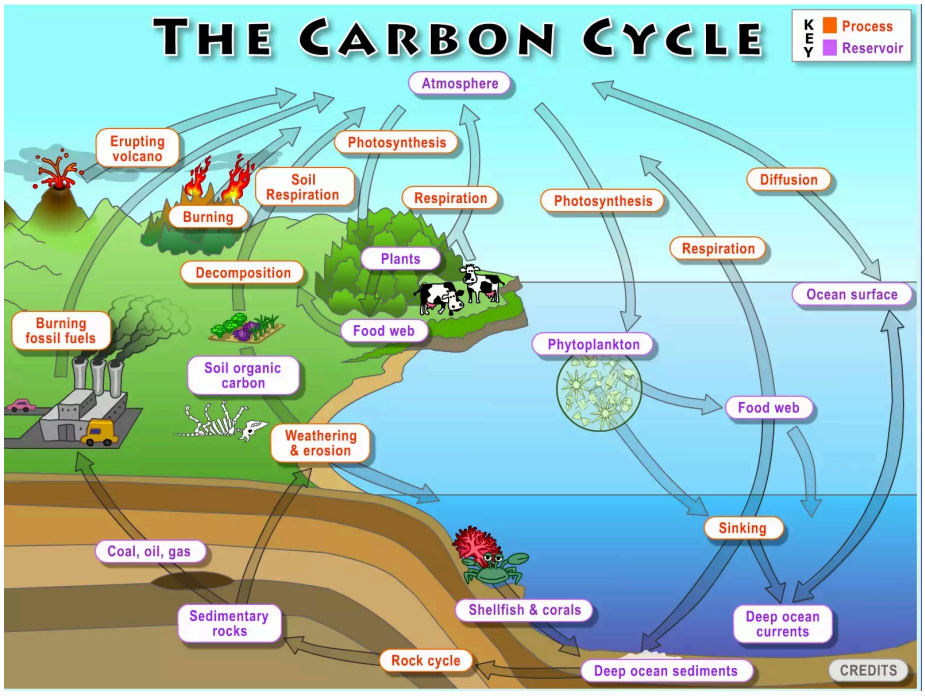
Exploring the Four Major Biogeochemical Cycles

Editorial by Shamali Rewari

Biogeochemical Cycles

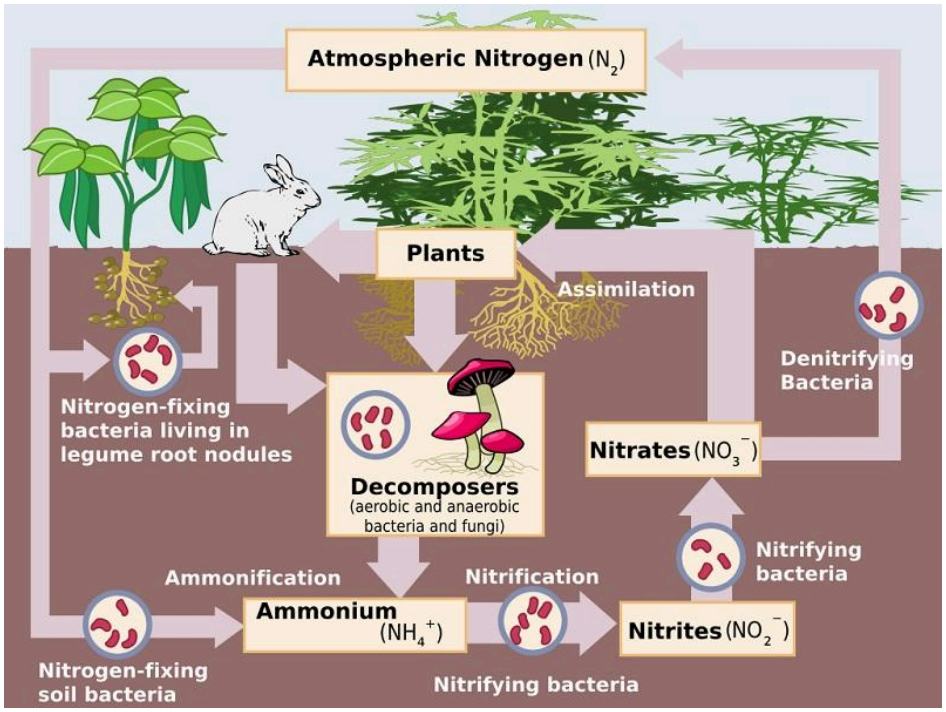
What are biogeochemical cycles? They are models of the self-regulating, naturally-occurring movement of chemical molecules through various sources and sinks (reservoirs). These cycles help stabilize and regulate the flow of matter through ecosystems, and can be disrupted by human activity.

The Carbon Cycle



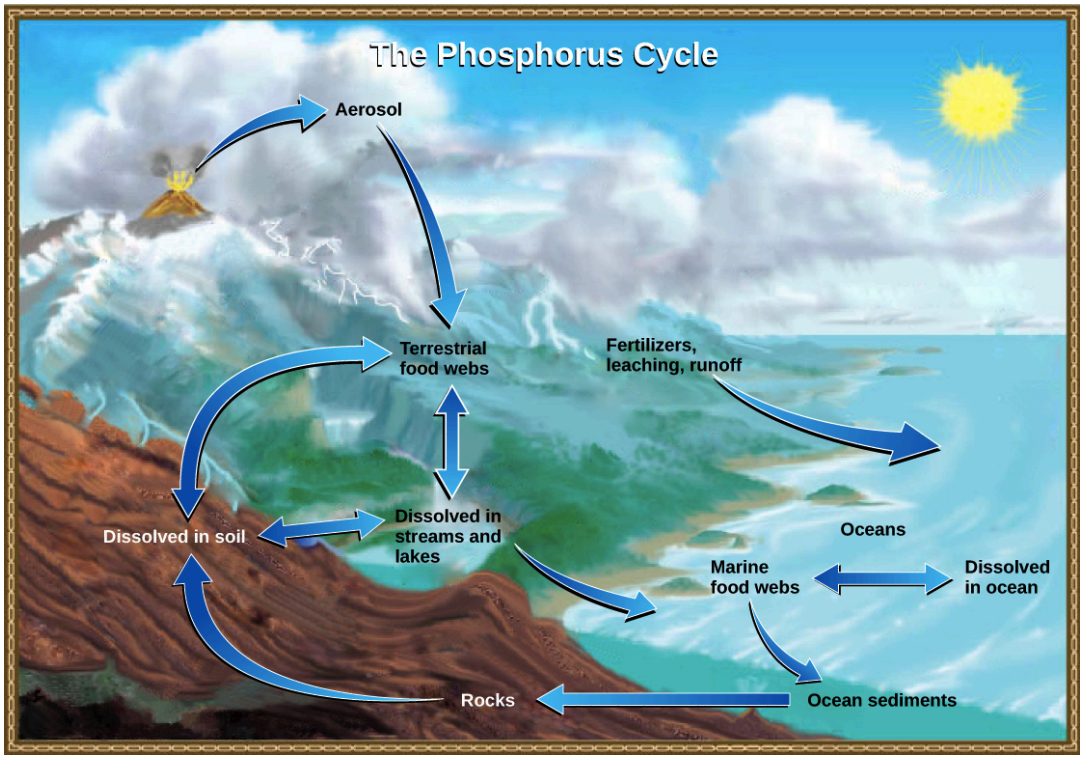
Carbon is found in the atmosphere as CO2. This is a short-term reservoir of carbon. Photosynthesis transforms the CO2 into glucose (C6H12O6). Plant and microbial respiration release CO2 back into the air, which is a rapid process. Through the process of air and sea gas exchange, CO2 dissolves in the top layers of the ocean, and the ocean outgasses CO2 at the same rate. This is a balanced, abiotic process. Decomposition releases CO2 into the atmosphere. Carbon is stored in the bodies of terrestrial and aquatic producers and consumers. As living organisms die, decomposition also releases carbon into the soil and ocean sediment. The ocean is a very large reservoir of carbon deposits. With time and pressure, the ocean sediments become stone. Limestone is formed through lithification in aquatic ecosystems but is also the bedrock for many terrestrial ecosystems. In terrestrial ecosystems, fossilized carbon is a long term reservoir. Human fossil fuel emissions can add fossil fuels to the atmosphere.

The Nitrogen Cycle



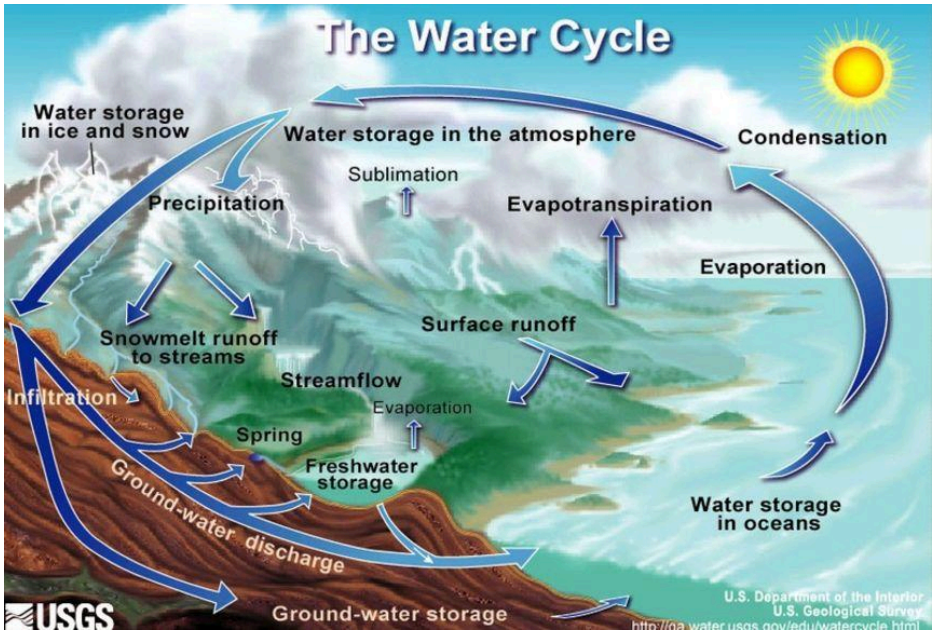
Through the process of fixation, N2 gas is fixed by lightning (abiotic) or microbes in soil and root nodules (biotic). In ammonification, NH3 (ammonia) is converted into NH4+ (ammonium ion) by soil bacteria. NH3 (ammonia) can also be added by the decay of organic material. Plants usually prefer the ammonium ion for growth. Nitrification consists of two stages. In the first stage, NH4+ is converted to NO2 (nitrites), and in the second stage, NO2 is converted to NO3- (nitrates). NO3- (nitrates) are uptaken by plants through their roots, and then are transferred to animals through feeding. This is known as assimilation. Plants prefer the nitrates for growth, incorporate them into their bodies, and then pass them on to higher trophic levels. Some plants can uptake NH3 (ammonia) and NO2- (ammonium ions) directly, but they also assimilate NO3- (nitrates). By denitrification, NO3- (nitrates) can be converted back to N2- by soil bacteria.

The Phosphorus Cycle



Sediments and rocks are a major reservoir of phosphorus. Through uplift and weathering, the phosphorus becomes dissolved in the soil. The phosphorus in soil then becomes dissolved in streams and lakes, and is assimilated into terrestrial food webs. Through runoff, phosphorus from lakes, streams, and terrestrial ecosystems will enter aquatic and marine food webs. Marine producer organisms take up the phosphorus through assimilation. Phosphorus in the runoff can also be dissolved in the ocean and become ocean sediments. Through lithification, the ocean sediments will again become rocks under time and pressure. Volcanoes can release phosphorus aerosols, but this is not gaseous.

The Water Cycle



The Sun is the driver of the water cycle. The Sun's energy causes evaporation, evapotranspiration (water released from plants), and sublimation (ice to water vapor without liquid stage). The water vapor is stored in the atmosphere. The water moves from the atmosphere and is collected on Earth through precipitation, dew, fog drip, and condensation. Once on the ground, water is stored in ice, snow, glaciers, rivers, as soil moisture, freshwater lakes, saline lakes, wetlands, and oceans. Snowmelt runoff and surface runoff help return precipitation to rivers and freshwater lakes. Runoff occurs when water falls on an impervious surface. Water in terrestrial ecosystems enters the ground through infiltration and seepage. The water can then seep back up into springs and lakes (groundwater recharge and flow) or can remain deeper underground (groundwater storage). Eventually groundwater storage will return to the ocean. Water from the ocean will evaporate and return to the atmosphere again.

References

UCAR Center for Science Education. (n.d.). *Biogeochemical cycles*. https://scied.ucar.edu/learning-zone/earth-system/biogeochemical-cycles

Ha, M., & Schleiger, S. (n.d.). *Biogeochemical cycles*. In *Environmental science*. LibreTexts. https://bio.libretexts.org/Bookshelves/Ecology/Environmental_Science_(Ha_and_Schleiger)/02%3A_Ecology/2.04%3A_Ecosystems/2.4.03%3A_Biogeochemical_Cycles