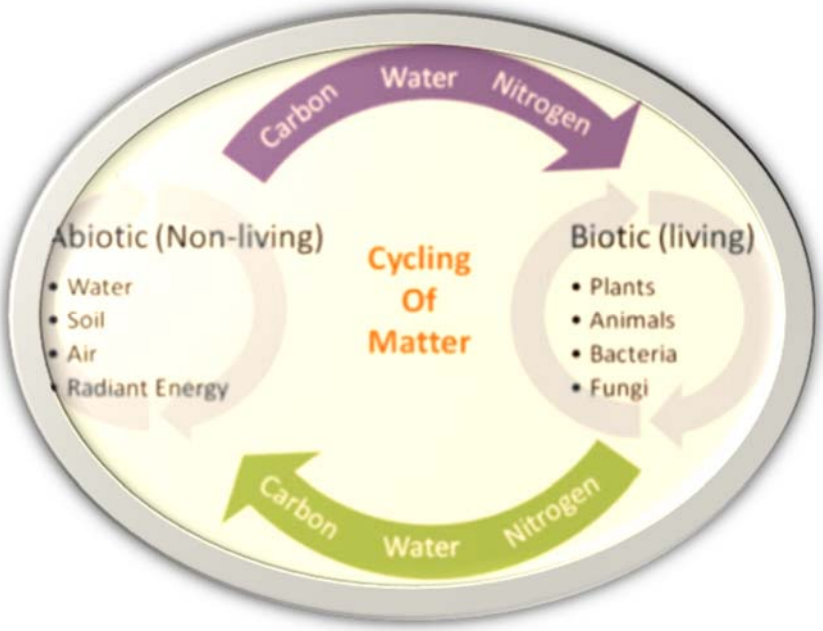
CYCLING OF MATTER



Unit Overview

In the last unit, you learned about how energy is transferred through the living (biotic) part of an ecosystem. In this unit, you will learn about how some of the most important types of matter, that are needed to support life, are recycled and reused within an ecosystem. Each substance we discuss in this unit moves from abiotic parts of an ecosystem into biotic portions of an ecosystem and back again. The types of matter that will be discussed in this unit are *water, carbon, nitrogen, and phosphorus.* Since each of these types of matter travel from nonliving parts of the environment into living parts and back again they are sometimes referred to as **biogeochemical cycles**.

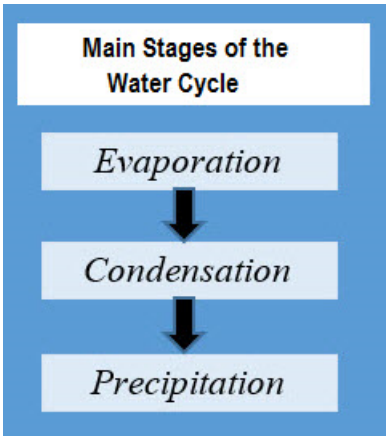
Water Cycle

Water is extremely important to all living things. Since cells are made up of about 70-90% water, and organisms need water environments for many biochemical reactions, living things could not survive without water. The availability of water is an important characteristic for a

terrestrial ecosystem and biodiversity. However, most of the water on Earth is not found in organisms, but does travel through them in the **water cycle**, also known as the hydrologic cycle.

Most of the water on Earth is found in **bodies of water**, such as oceans, lakes, rivers, streams, and ponds. Some water passes into the soil through the process of **infiltration**, which then can move down further through the soil and its layers by gravity in a process known as **percolation**. As water passes through the soil, it is then stored in underground cracks and spaces in soil, sand and rock. The water found underground is known as **groundwater.** From the Earth‘s surface, water **evaporates** into the atmosphere. The other way water can be released into the atmosphere is through the process of **transpiration**. Transpiration is a process in which the leaf of a plant releases water into the air in the form of water vapor. Animals also release water into the atmosphere as water vapor through breathing, sweating and excreting. However, animals release a much smaller amount of water vapor as compared to plants.

As water collects in the atmosphere it may begin to undergo **condensation** (forming clouds or fog). Condensation is the process of water vapor changing into liquid water droplets. The water will eventually leave the atmosphere, depending on temperature and pressure, as **precipitation**, and return to Earth’s surface. Precipitation may be in the form of rain, snow, hail, or sleet.



As precipitation reaches Earth’s surface, the water moves across the surface as **runoff**. Runoff is the flow of water over a surface of land, moving from areas of higher elevation to areas of lower elevation, eventually collecting in a body of water. As runoff occurs, some of the water will evaporate, some will seep into the ground, while the remaining runoff water collects in larger bodies of water.

Visit the link below for an interactive diagram of the water cycle:

http://water.usgs.gov/edu/watercycle-kids-adv.html

Complete the “water cycle worksheet” by clicking on the link below.

Water Cycle Worksheet

Carbon Cycle

Carbon and oxygen are very important for all life on Earth. If you recall, you learned about photosynthesis (unit 9) and cellular respiration (unit 10). Both processes required and utilized oxygen and carbon. The cycles of carbon and oxygen are also closely related such that they use the same cycle. The Carbon Cycle is sometimes referred to as the Carbon and Oxygen Cycle.

Carbon Cycle and Oxygen Cycle Relationship			
Photosynthesis		***Cellular Respiration***	
Carbon Cycle Summary			
Removes carbon dioxide (CO_2) from the atmosphere.	Produces the sugar – glucose ($C_6H_{12}O_6$)	Consumes the sugar - glucose ($C_6H_{12}O_6$) to make ATP	Produces carbon dioxide (CO_2) and releases it into the atmosphere
Oxygen Cycle Summary			
Produces oxygen (O_2) by way of splitting water and releases the oxygen into the atmosphere.		Removes oxygen (O_2) from the atmosphere to make ATP.	

Photosynthesis and cellular respiration exchanging oxygen and carbon dioxide between organisms and the environment is known as *respiration*.

There are other ways that carbon dioxide can be introduced to the atmosphere. **Combustion** is another way of releasing carbon dioxide into the atmosphere. Combustion is the burning of a substance that is living or was living. Cutting a tree down and burning it is an example of combustion of a living organism. Burning a fossil fuel (remains of dead plants and animals), as in a car engine or industrial factory, is another example of combustion, but of burning organism remains. Both methods of combustion release carbon dioxide into the atmosphere. Another way of releasing carbon dioxide is in **death and decomposition**. As decomposers break down dead organisms carbon dioxide is released in the process.

As you should notice, there are three ways of introducing carbon dioxide into the atmosphere, but only one way of removing carbon dioxide from the atmosphere.

This accumulation of carbon dioxide in the atmosphere is believed to have an effect on global temperature. Carbon dioxide, as a “greenhouse gas”, has the ability to trap heat, therefore, as carbon dioxide builds in the atmosphere, the temperature of the atmosphere begins to increase. Many use this idea to support the idea of global warning.

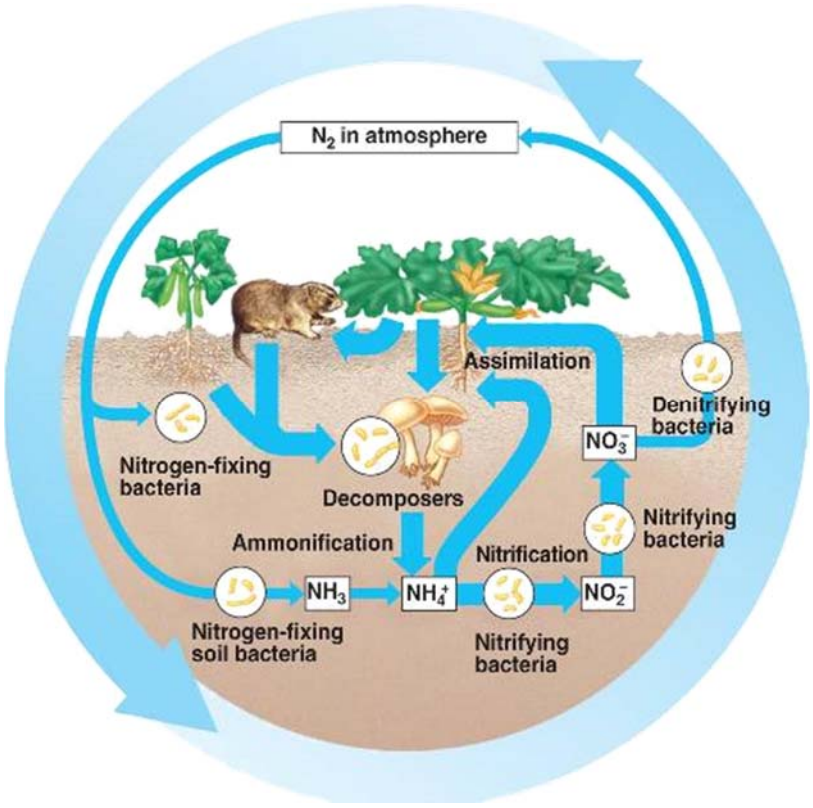
Visit the link below for a video about the carbon cycle and the effects of carbon dioxide:

http://www.epa.gov/climatechange/kids/basics/today/carbon-dioxide.html

Complete the “carbon cycle worksheet” by clicking on the link below.

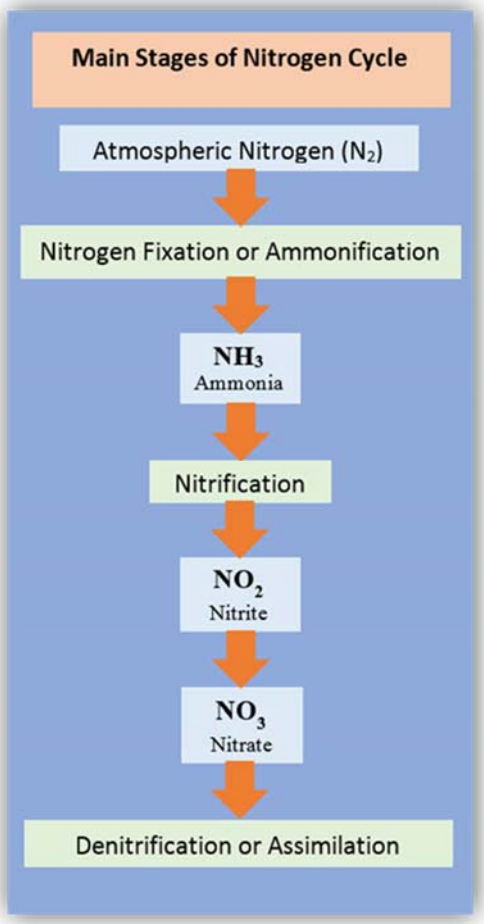
Carbon Cycle Worksheet

Nitrogen Cycle



Sometimes students can easily understand why we need water, oxygen, and carbon dioxide to cycle. Most of us can see the importance of those substances in our existence. Interestingly, all living organisms need nitrogen also. All living organism, including us, need nitrogen to make proteins and nucleic acids. Remember how proteins are made of amino acids and nucleic acids are made of nucleotides. The twenty different amino acids require nitrogen as one of their atoms, as well as the nitrogenous bases of the nucleotides, therefore we need nitrogen to cycle. Another interesting idea is that the atmosphere is made of about 78% nitrogen gas (N_2). The problem is that most organisms cannot use nitrogen in that form, most organisms need it changed into a different form.

The process of converting nitrogen gas (N_2) into the usable form nitrate is called **nitrogen fixation**. Organisms require bacteria found in the soil to convert nitrogen gas into a usable form.



Nitrogen-fixing bacteria live in the soil and in the roots of some plants. The types of plants that some of these bacteria live in are known as *legumes*, such as beans, peas, and clover. The roots of the legumes will have small swellings containing bacteria on their roots, the swellings are called **root nodules**. The legumes and bacteria that live with them have developed a *mutualistic relationship* in which both organisms benefit. The bacteria supply the plant with usable nitrogen and the plant provides the bacteria with an airtight place to live while supplying the bacteria with carbohydrates (sugar from photosynthesis). Any extra nitrogen produced is released into the soil. Nitrogen may also be fixed by lightning, but more nitrogen happens to be fixed by bacteria. Nitrogen may also be fixed by burning fuels.

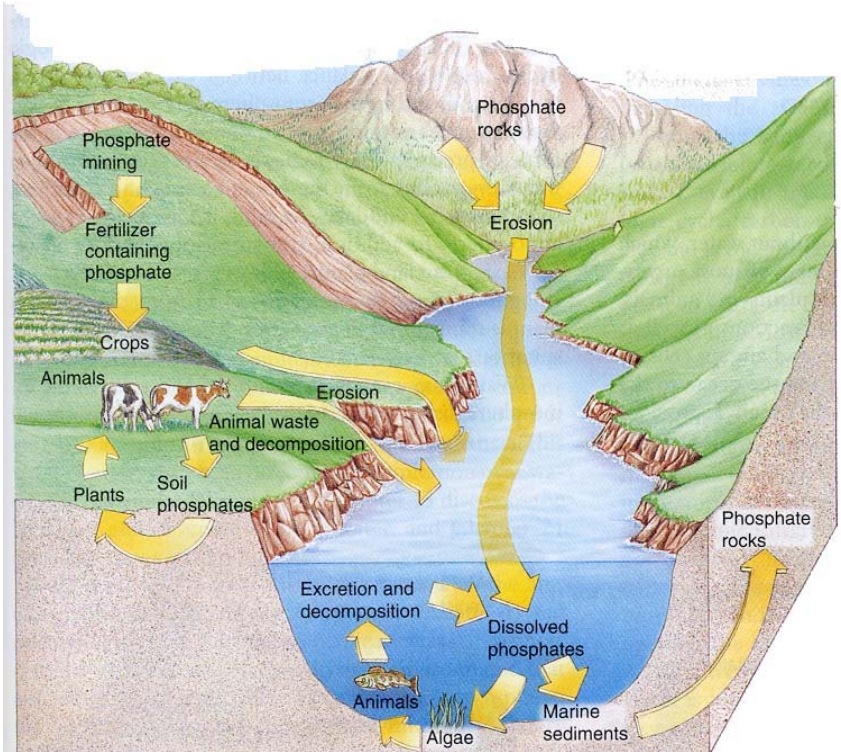
Decomposers break down dead material and release nitrogen in the form of ammonia (NH_3) in a process called **ammonification**. Ammonification provides another way of reintroducing nitrogen back into the ecosystem. A second type of nitrogen-fixing bacteria take this ammonia (NH_3) and convert it into nitrites (NO_2) and nitrates (NO_3). The process of converting ammonia into nitrites and nitrates is known as **nitrification**. After nitrification, in the effort to make nitrates (NO_3), plants now have a usable form of nitrogen. The process in which plants absorb the nitrates (NO_3) that are produced is called **assimilation**. Leftover nitrates in the soil will be broken down by a third type of bacteria in the soil, which will convert the nitrates back into nitrogen gas to be released into the atmosphere once again. The process of converting the nitrates back into nitrogen gas is called **denitrification**. Notice that animals are not mentioned in this cycle, except under decomposition. Animals acquire the nitrogen they need by consuming the plants which absorb the nitrogen from the ground.

Complete the “nitrogen cycle worksheet” by clicking on the link below:

Nitrogen Cycle Worksheet

Phosphorus Cycle

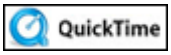
Phosphorus is another substance that needs to be cycled for all living things in an ecosystem. Phosphorus is needed by organisms for nucleic acids, cell membranes, and bones. This substance, just like the others we have already mentioned, go from the physical environment to living organisms and back to the physical environment. Phosphorus cannot be found in the air as a gas. Phosphorus is normally found in soil and rock as calcium phosphate in the form of a solid which is dissolved in water. When dissolved in water, the phosphorus can seep into the ground for plants to absorb, or it will wash into bodies of water by way of runoff. The phosphorus cycle is one cycle where the atmosphere does not play a major role in the movement of a substance.



Usable phosphate found in the ground is absorbed by plants. Animals, including us, eat the plants to obtain the phosphorus. When the animals and plants die and decompose the phosphorus returns to the ground.

The phosphorus cycle moves slowly through the physical environment (soil and oceans), but quickly through the living parts (plants and animals) of the ecosystem. The phosphorus cycle is one of the slowest biogeochemical cycles.

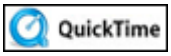
In the following video all aspects of the phosphorus cycle are described. Phosphate in fertilizer runs off into waterways, causing algal blooms or eutrophication.



Requirements for Life: Phosphorus

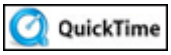
Discovery Education-Additional Resources:

The Water Cycle Skill Builder from Discovery Education presents an animation of each phase of the water cycle: evaporation, condensation, precipitation, and infiltration.



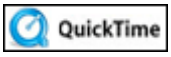
Water Cycle Skill Builder

The Carbon Cycle Skill Builder Traces the flow of carbon through the atmosphere, the biosphere, the hydrosphere, and the geosphere. Also defines such terms as photosynthesis, assimilation, respiration, diffusion, and combustion.



Carbon Cycle Skill Builder

The Nitrogen Cycle Skill Builder identifies the phases in the nitrogen cycle including assimilation, decomposition, and nitrification. Also examines the problems that occur when the cycle breaks down, like algal blooms and acid rain.



Nitrogen Cycle Skill Builder

UNIT VOCABULARY REVIEW

Click on the **Quizlet icon** below to access the quizlet.com vocabulary flash cards. Review the vocabulary before completing your assessment.

Now answer questions 1 through 20.