Biogeochemical Cycles

Section 18.1
The Water Cycle

Pre-View 18.1

- **Biosphere** – the part of the earth where living organisms are found
- **Biogeochemical cycles** – the cycles that move water, carbon, oxygen, and nitrogen through living and nonliving parts of the ecosystem
- **Precipitation** – water that travels from the atmosphere to the ground
- **Transpiration** – the evaporation of water from the leaves of plants

Introduction to Biogeochemical Cycles

Since the four elements of carbon, hydrogen, oxygen, and nitrogen are found in all living organisms, they must be fairly common, right? These elements are found in the **biosphere**, which is the part of the earth where living organisms are found (land, air, and water). Organisms must have these elements in a form that cells can use. These elements move through the biosphere in four main cycles: the water cycle, the carbon cycle, the oxygen cycle, and the nitrogen cycle. These cycles are called **biogeochemical cycles** because the chemical elements and compounds move through both living (biological) and nonliving (geological) parts of the ecosystem. In a way, it is the ultimate recycling feat. Every molecule and atom is passed from one ecosystem to the next and changes from one form to another.

First, let's review how water is recycled in the water cycle.

The Water Cycle

Look at the diagram of the water cycle shown in figure 18-1. The water cycle shows how water moves from the atmosphere to the ground, and then back into the atmosphere again, over and over. Since it is a cycle, we can start anywhere in the cycle. Let's start with precipitation.

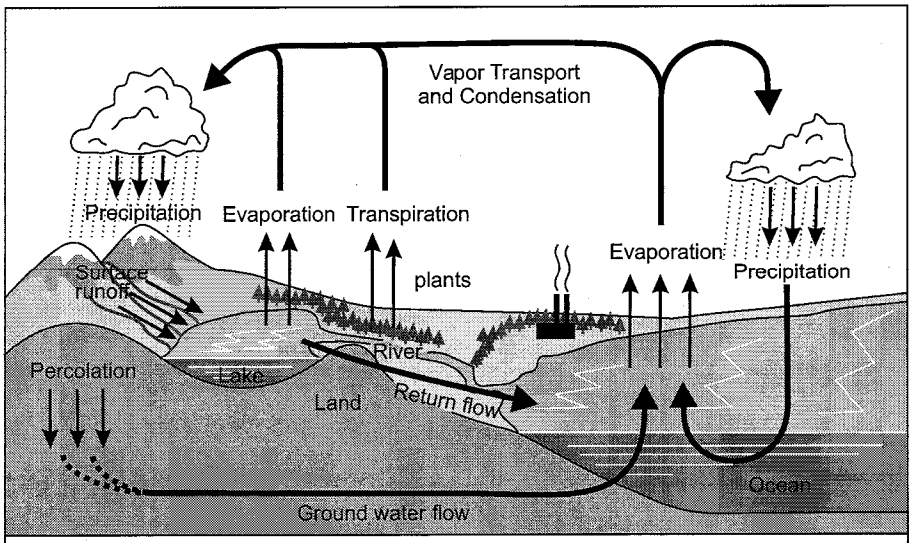

Fig. 18-1 The Water Cycle

Precipitation is how water gets from the atmosphere to the ground. It includes rain, snow, sleet, or any form of water going from the atmosphere to the ground. Once the water gets to the ground, some of it runs off into lakes, rivers, streams, and other bodies of water. From there, some of it evaporates and becomes water vapor in the air.

Some of the precipitation is taken in and used by plants and animals. Plants also give off water through a process called **transpiration**, which puts water back into the atmosphere. Some of the precipitation sinks into the ground and becomes groundwater beneath the earth's surface. Eventually, it may flow into lakes and oceans where some is evaporated into the atmosphere.

When conditions are right, the water vapor in the atmosphere will condense and form clouds. Whenever the clouds get too heavy to hold any more water vapor, precipitation occurs. Once again, water returns to the earth for organisms to use in a natural cycle.

Biogeochemical Cycles

Section 18.2
The Carbon Cycle

Pre-View 18.2

- **Photosynthesis** – a plant process that uses energy from the sun to convert carbon dioxide into carbohydrates
- **Carbon fixation** – converting inorganic carbon, as in carbon dioxide, to organic carbon, as in sugar
- **Carbohydrates** – different types of sugars made by plants
- **Cellular respiration** – process used by all living organisms that uses energy from carbohydrates and releases carbon dioxide back into the atmosphere
- **Combustion** – the burning of fuels that releases carbon dioxide into the atmosphere

Carbon is called the building block of organic molecules. Remember that organic molecules are the ones that make up living organisms. Carbon is found in fats, proteins, and carbohydrates. Let's see how carbon moves through an ecosystem in the carbon cycle, which is shown in figure 18-2.

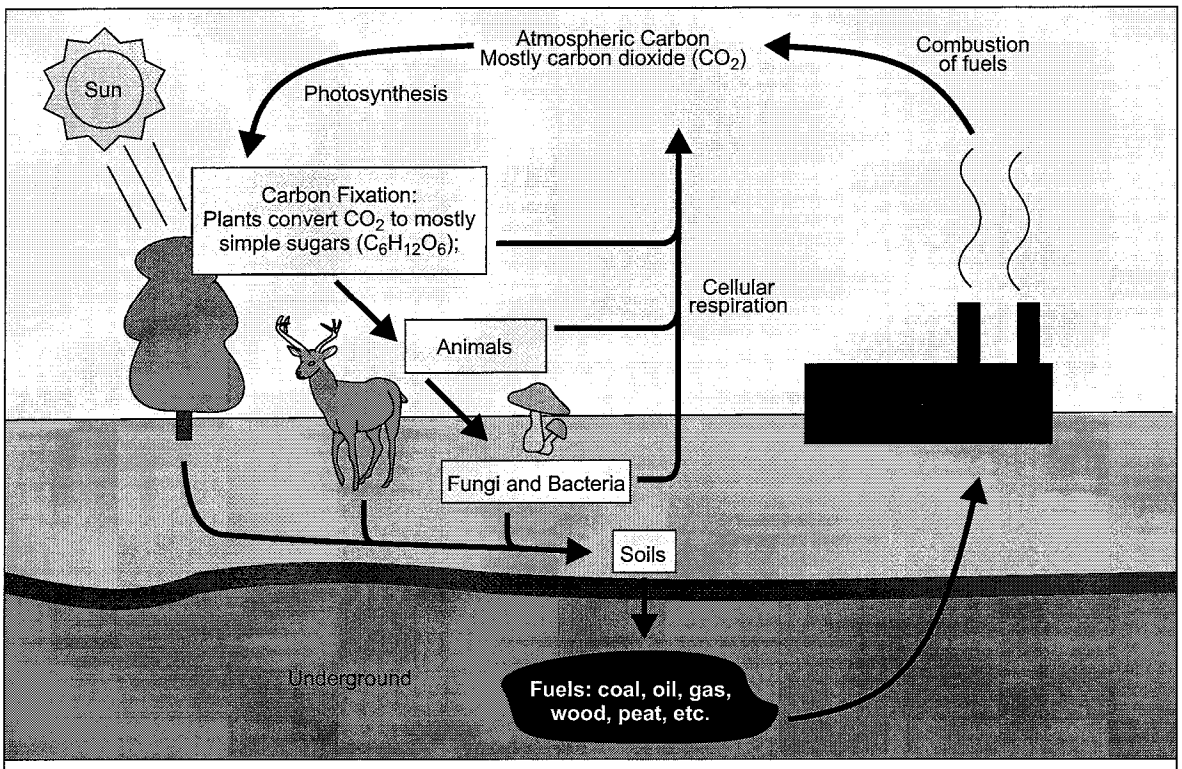

Fig. 18-2 The Carbon Cycle

Most carbon in the atmosphere is in the form of carbon dioxide (CO_2). When plants go through **photosynthesis**, they use the energy in sunlight to change carbon dioxide gas into sugar molecules that contain energy. Converting non-organic carbon in carbon dioxide to organic carbon in sugar molecules is called **carbon fixation**. These sugar molecules are called **carbohydrates**. The plants use some of the carbohydrates for the energy to grow and carry out their life processes. When animals eat the plants (or other animals), they also use the carbohydrates for energy. To get energy from the carbohydrates, living organisms use a process called **cellular respiration**, which releases carbon dioxide back into the atmosphere. When the living organisms die, other organisms, like bacteria and fungi, break down the organic carbon molecules and release more carbon dioxide into the atmosphere.

Some of the carbon in dead organisms gets trapped in the ground where it can become a fossil fuel, such as coal or oil. Whenever the fossil fuels are burned, the carbon is released back into the atmosphere. When other fuels containing organic molecules (such as wood) are burned, the process of **combustion** also releases carbon into the atmosphere as mostly carbon dioxide. The carbon dioxide is then available once again for photosynthesis, and the cycle repeats.

Biogeochemical Cycles

Section 18.3
The Oxygen Cycle

Pre-View 18.3

- **Photosynthesis** – a plant process that releases oxygen into the atmosphere as a byproduct
- **Cellular respiration** – process used by all living organisms that requires oxygen from the atmosphere

The oxygen cycle (figure 18-3) is similar to the carbon cycle in that it involves photosynthesis and cellular respiration. During **photosynthesis**, water molecules are split into hydrogen and oxygen. Plants release this oxygen into the atmosphere as a byproduct. This oxygen is used by living organisms during **cellular respiration**.

Most of the earth's oxygen is not in the air, though. Most of the oxygen is found in the earth's crust as metal oxides, and it is not usable in this form.

Some of the oxygen is found as ozone, which has three oxygen atoms. Although ozone is harmful to breathe, it is needed in the upper atmosphere to help shield the earth from the harmful ultraviolet radiation from the sun.

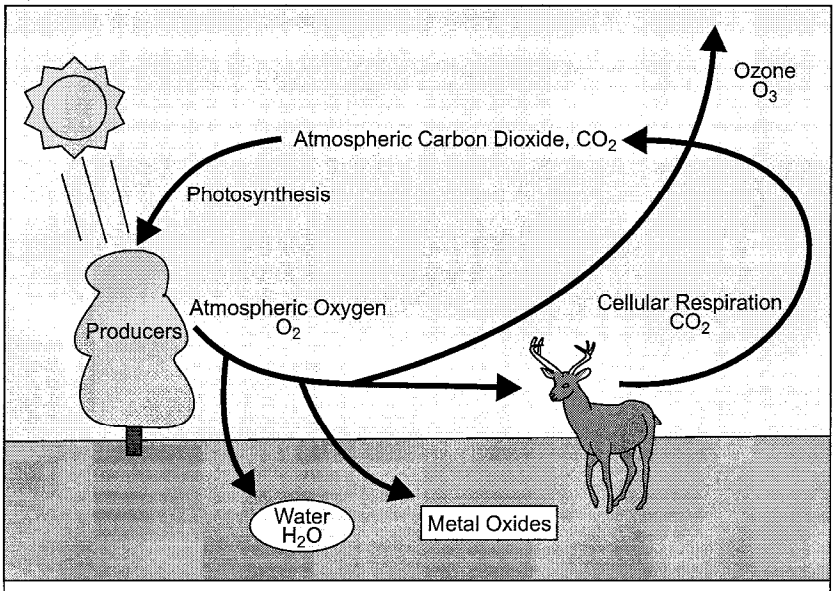

Fig. 18-3 The Oxygen Cycle

Biogeochemical Cycles

Section 18.4
The Nitrogen Cycle

Pre-View 18.4

- **Nitrogen-fixing bacteria** – a type of bacteria found living in the soil or on root nodules; convert nitrogen gas into ammonia
- **Nitrogen fixation** – a process that converts nitrogen gas into ammonia
- **Nitrification** – a process that converts ammonia into nitrates and nitrites
- **Decomposers** – organisms, such as bacteria and fungi, that break down dead organisms and put nitrogen back into the soil
- **Denitrification** – a process that converts nitrates in the soil back into atmospheric nitrogen gas

Nitrogen is important to living organisms because it is used to make amino acids, the building blocks of proteins. Although 78% of the earth's atmosphere is nitrogen gas, not many organisms can use this form of nitrogen directly. The nitrogen cycle in figure 18-4 shows how nitrogen is changed to forms that are more usable and how that nitrogen is returned to the atmosphere.

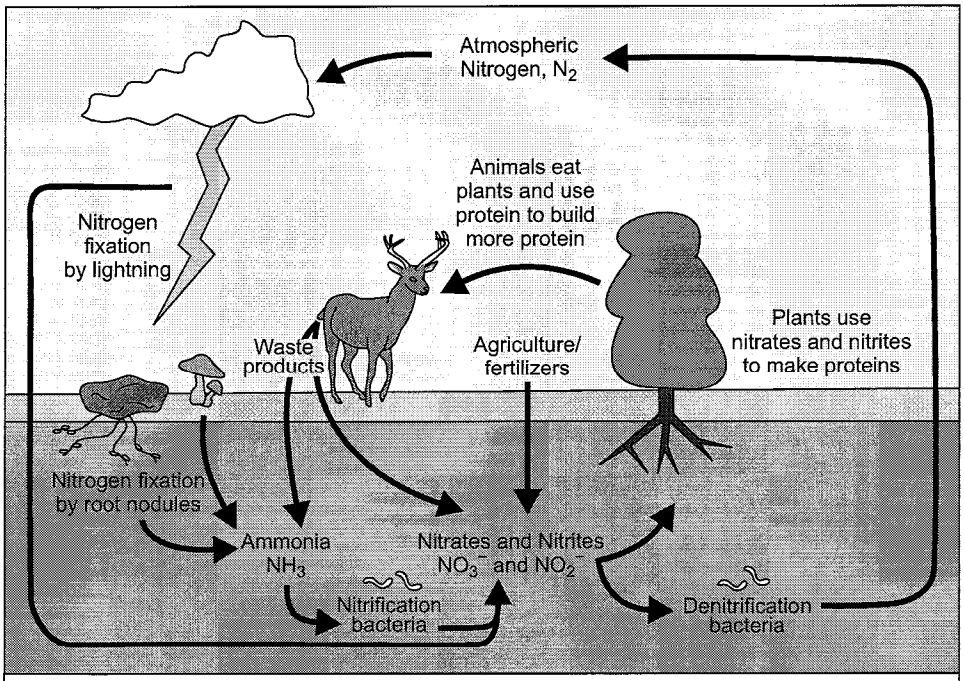

Fig. 18-4 The Nitrogen Cycle

Certain types of bacteria, called **nitrogen-fixing bacteria**, live on nodules on the roots of some plants and in the soil. This bacteria can take nitrogen gas, N_2, and convert it to ammonia (NH_3) in a process called **nitrogen fixation**. Lightning can also convert atmospheric nitrogen to ammonia.

Once the nitrogen has been "fixed," other bacteria can change the ammonia into nitrates (NO_3^-) and nitrites (NO_2^-) in a process called **nitrification**. The nitrate and nitrite forms of nitrogen are ones that plants can use to make proteins. Some human activities also add nitrates to the environment. For example, agriculture adds nitrogen to the soil through fertilizers.

Once animals eat the plants, the nitrogen is reused to make proteins for the animals.

How does the nitrogen get back into the atmosphere? The waste products produced by many organisms contain ammonia, nitrates, and nitrites. When living things die, they are broken down by a group of organisms called **decomposers**, which include bacteria and fungi. Decomposers put nitrogen back into the soil to be used again by plants. Some types of bacteria can change the nitrates in the soil back into nitrogen gas in the process of **denitrification**, which puts nitrogen back into the atmosphere again. The nitrogen found in the oceans also goes through denitrification and is returned to the atmosphere.