

## Cycling of Matter in Ecosystems

Like humans, all life on Earth requires water and nutrients. Water provides the liquid component that makes up cells. Nutrients are a source of the building materials and chemical energy. Water and nutrients are composed of physical matter. You obtain matter from the food you eat, the water you drink, and the air you breathe (Figure 1). However, the particles of matter do not stay in your body forever. Every part of every cell in your body is replaced over time. Approximately 2 million of your red blood cells are replaced every second of every day. Scientists estimate that, on average, every particle in a human body is replaced at least once every 7 years! You and everyone you know are living recycling machines (Figure 2).



**Figure 1** Nutrients from food are used to repair and gradually renew every part of our body.



**Figure 2** This woman appears much older than the child, yet almost every particle in her body has been replaced within the last seven years.

### Biogeochemical Cycles

The particles that make up matter cannot be created or destroyed. This fact is significant for all life. It means that all water and nutrients must be produced or obtained from chemicals that already exist in the environment. This happens in a series of cycles in which chemicals are continuously consumed, rearranged, stored, and used. Because these cycles involve living (bio) organisms and occur as Earth (geo) processes, they are called **biogeochemical cycles**. Every particle in an organism is part of a biogeochemical cycle.

### The Water Cycle

The most obvious of the biogeochemical cycles is the **water cycle** (Figure 3, next page). Liquid water evaporates, forming water vapour that moves through the atmosphere. The vapour eventually condenses, forming liquid water or ice crystals, and returns to Earth as rain, hail, or snow. Water falling on land may enter the soil and groundwater or move across the surface entering lakes, rivers, and oceans. Water that is taken in by plant roots may be released from leaves in a process called transpiration. Most of the water that is present in the water cycle is in the abiotic environment. 🌍

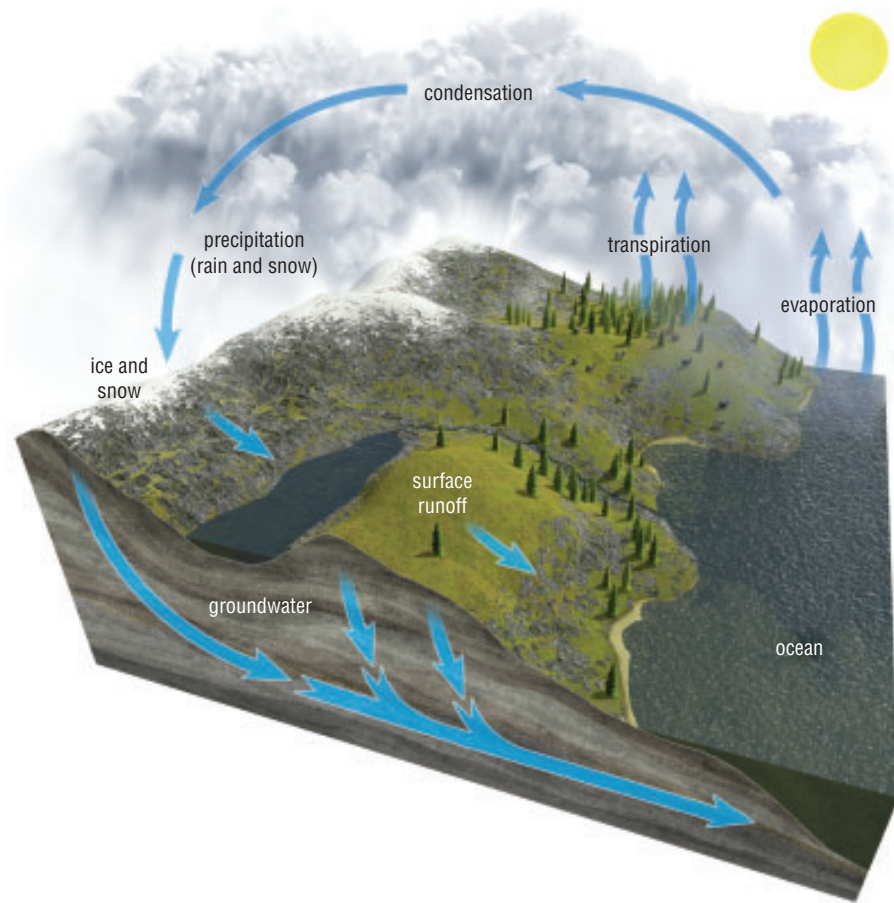
**biogeochemical cycle** the movement of matter through the biotic and abiotic environment

**water cycle** the series of processes that cycle water through the environment

Hydrologists are interested in the movement of water through the environment. To learn more about becoming a hydrologist,



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### DID YOU KNOW?

#### You Are Who You Eat!

Over time, the water in our bodies moves through the biosphere. For this reason, scientists believe that we all contain at least one water particle that was once in the body of Julius Caesar and another from every *Tyrannosaurus rex* that ever lived!

**Figure 3** The water cycle

## The Carbon Cycle

Carbon moves between the abiotic and biotic parts of an ecosystem in the **carbon cycle**. Most of this exchange occurs between carbon dioxide (either in the atmosphere or dissolved in water) and photosynthesizing plants and micro-organisms.

### CARBON DEPOSITS

While large quantities of carbon cycle through photosynthesis and cellular respiration, most of Earth's carbon is not cycled. Instead, it is stored in carbon-rich deposits. Fossil fuels, such as coal, oil, and natural gas, are the most valuable carbon deposits. They form when decomposed organisms are compressed over millions of years. Carbon is also stored for millions of years as limestone formed from dead marine organisms.

Large quantities of carbon are also contained in plant tissue and as dissolved carbon dioxide in the world's oceans. These locations are referred to as carbon sinks because carbon can enter or leave them over relatively short times.

### HUMAN ACTIVITIES CHANGE THE CARBON CYCLE

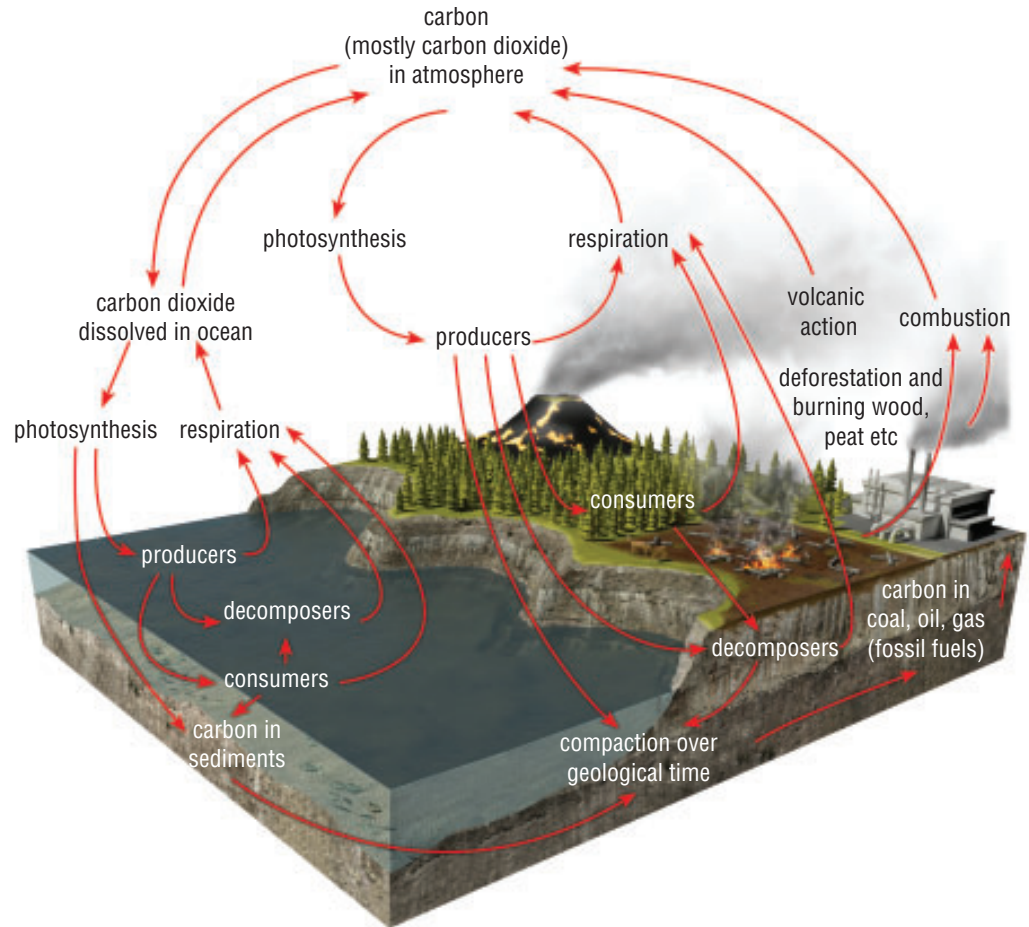
Human activities have dramatic effects on the carbon cycle (Figure 4). By burning fossil fuels, humans release the stored carbon into the atmosphere. The concentration of carbon dioxide in the atmosphere is now higher than it has been in at least the past 800 000 years. This change is causing global climatic change. Climate change has the potential to alter the most critical abiotic factors in the ecosystems: temperature and water availability. The increase in the average temperature of our atmosphere is melting ice caps and glaciers, causing sea levels to rise, and disrupting ecosystems.

**carbon cycle** the biogeochemical cycle in which carbon is cycled through the lithosphere, atmosphere, hydrosphere, and biosphere



**Figure 4** Human activities influence the carbon cycle.

Deforestation also increases the concentration of carbon dioxide in the atmosphere (Figure 5). Large-scale reforestation and a dramatic reduction in the use of fossil fuels are needed to slow the process of climate change. As you study climate change in Grade 10, remember what you have learned about the importance of the carbon cycle and sustainable ecosystems.



**Figure 5** The carbon cycle results in the long-term and short-term storage of carbon.

## The Nitrogen Cycle

Nitrogen is extremely abundant in the atmosphere. However, it is not easy to acquire directly from the abiotic environment. Nitrogen enters and leaves the atmosphere through a complex biochemical pathway in the **nitrogen cycle** (Figure 6, next page).

**nitrogen cycle** the series of processes in which nitrogen compounds are moved through the biotic and abiotic environment

Most of the nitrogen used by living things is taken from the atmosphere by certain bacteria in a process called nitrogen fixation. These micro-organisms convert nitrogen gas into a variety of nitrogen-containing compounds including nitrates, nitrites, and ammonia. Lightning and ultraviolet light also fix small amounts of nitrogen. In addition, humans add nitrogen to the soil as fertilizer.

Once in the soil ecosystem, the nitrogen-rich compounds are available to producers. After the nitrogen is absorbed, it is passed from producer to consumer and on up the food chain. Many animals consume more nitrogen than they can use and excrete the excess in the form of urea or ammonia. A dead organism's nitrogen-rich compounds are taken in by decomposers or are released back into the environment. These compounds are either recycled again by soil micro-organisms or they are converted by denitrifying bacteria back into nitrogen gas which then re-enters the atmosphere.



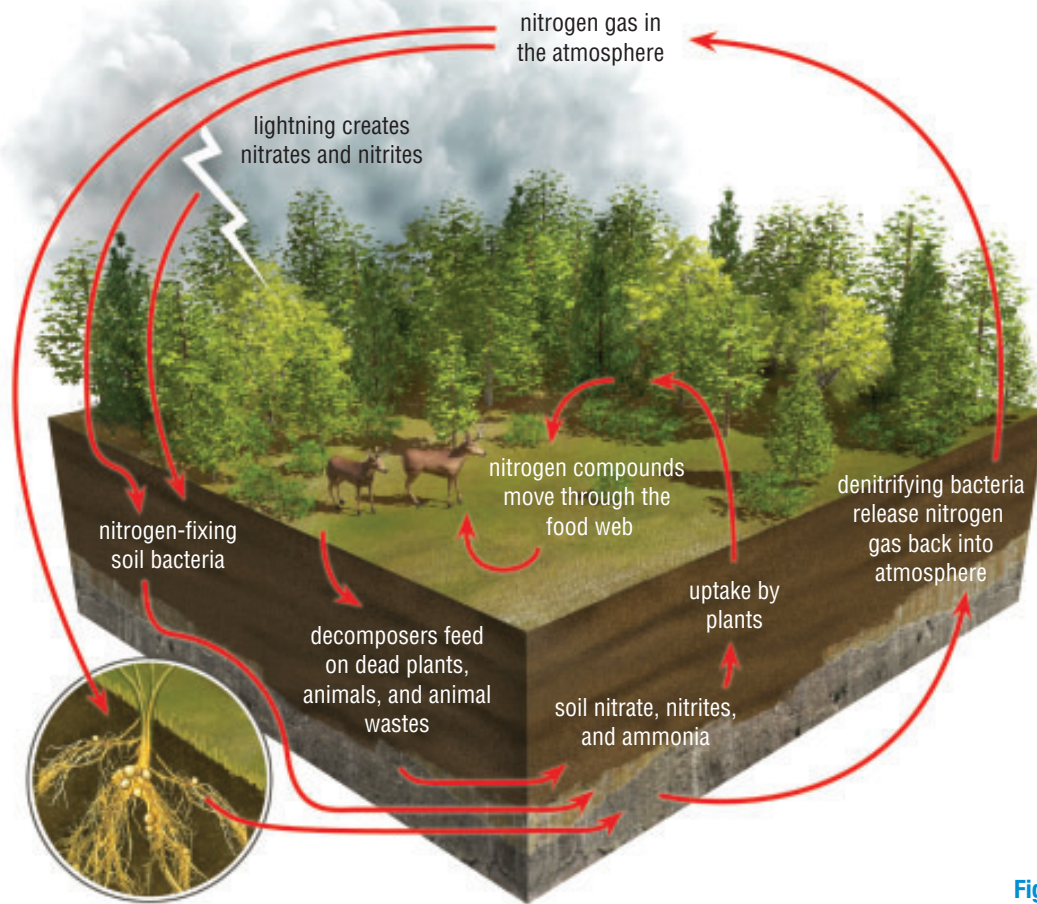


Figure 6 The nitrogen cycle

## IN SUMMARY

- Matter is cycled through ecosystems via biogeochemical cycles.
- Water can occur in all states (solid, liquid, and gas) as it moves through the water cycle.
- Carbon moves between the abiotic and biotic components of the ecosystem via photosynthesis and cellular respiration.
- Nitrogen is removed from the atmosphere by soil micro-organisms undergoing nitrogen fixation and returned to the atmosphere by denitrifying bacteria.
- Carbon, oxygen, and hydrogen are readily available to living organisms, but nitrogen is more difficult to obtain.
- Human activities disrupt biogeochemical cycles.

## ✓ CHECK YOUR LEARNING

1. Describe the main pathways of the water cycle, including how water enters and leaves the atmosphere. [K/U](#)
2. Why do you think biogeochemical cycles are considered sustainable? [T/I](#)
3. List the main sources of carbon entering the atmosphere. [K/U](#)
4. Explain how the carbon cycle is related to energy flow in ecosystems. [K/U](#)
5. In what ways do human activities influence the [K/U](#) [A](#)
  - (a) water cycle?
  - (b) carbon cycle?
  - (c) nitrogen cycle?
6. In this section, you learned that all body matter is eventually replaced. How does this influence your understanding of how your own body is involved in biogeochemical cycles? [A](#)
7. Name two human actions needed to slow climate change. [K/U](#)
8. Describe some ways that climate change might influence the water cycle. [A](#)
9. Plants need nitrogen to produce proteins and other important chemicals. Describe how nitrogen in the atmosphere makes its way into plants. [K/U](#)
10. How is the nitrogen in dead organisms released back into the soil? [K/U](#)