

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.

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.

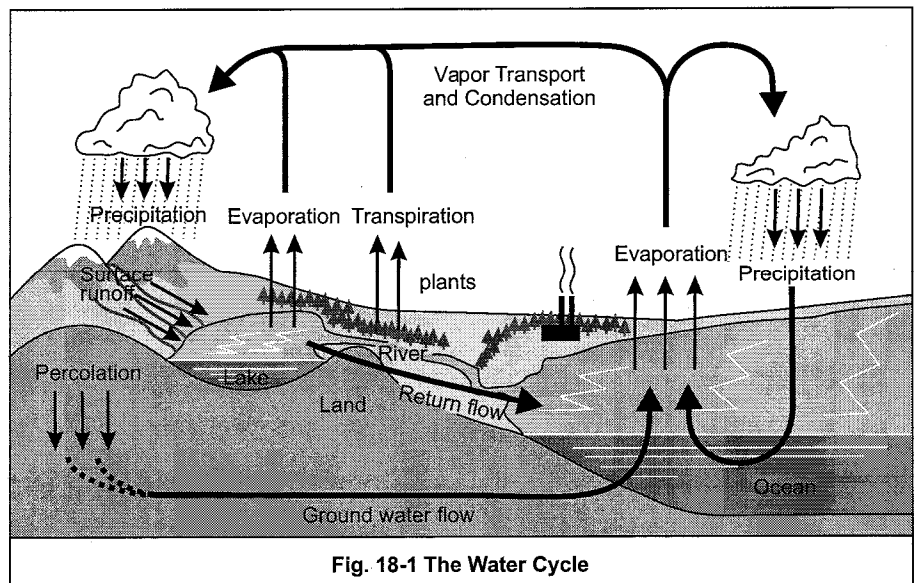


Fig. 18-1 The Water Cycle

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.

Section 18.1, continued

The Water Cycle

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.

Practice 1

Match the terms below with their correct definition or description.

- | | |
|--------------------------------|--|
| _____ 1. biosphere | A. the movement of water through an ecosystem |
| _____ 2. biogeochemical cycles | B. the part of the earth where living organisms can be found |
| _____ 3. water cycle | C. the movement of water from bodies of water to the atmosphere |
| _____ 4. precipitation | D. the process through which water vapor becomes clouds |
| _____ 5. evaporation | E. the loss of water from plants to the atmosphere |
| _____ 6. transpiration | F. the movement of water from the atmosphere to the ground |
| _____ 7. condensation | G. water that travels from ground surfaces to lakes, rivers, or oceans |
| _____ 8. run-off | H. the movement of elements and compounds through an ecosystem |

Practice 2

Answer the following questions on the water cycle.

- (A) (B) (C) (D) 1. To ensure that living organisms have the elements that they need, the elements move in which type of cycles?
- A. chemical cycles
B. energy cycles
C. biological cycles
D. biogeochemical cycles
- (A) (B) (C) (D) 2. Plants release water back into the atmosphere through which process?
- A. transpiration
B. percolation
C. precipitation
D. condensation
- (A) (B) (C) (D) 3. Rain, sleet, and snow are examples of what?
- A. energy
B. precipitation
C. organic matter
D. water vapor
- (A) (B) (C) (D) 4. The water that is not absorbed into the ground and that may end up in lakes, rivers, and streams is called what?
- A. precipitation
B. water vapor
C. run-off
D. transpiration
- (A) (B) (C) (D) 5. What is the water called that sinks into the soil beneath the earth's surface?
- A. run-off
B. water vapor
C. condensation
D. groundwater
- (A) (B) (C) (D) 6. Which of the following processes must occur before precipitation can occur?
- A. condensation
B. evaporation
C. transpiration
D. run-off

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.

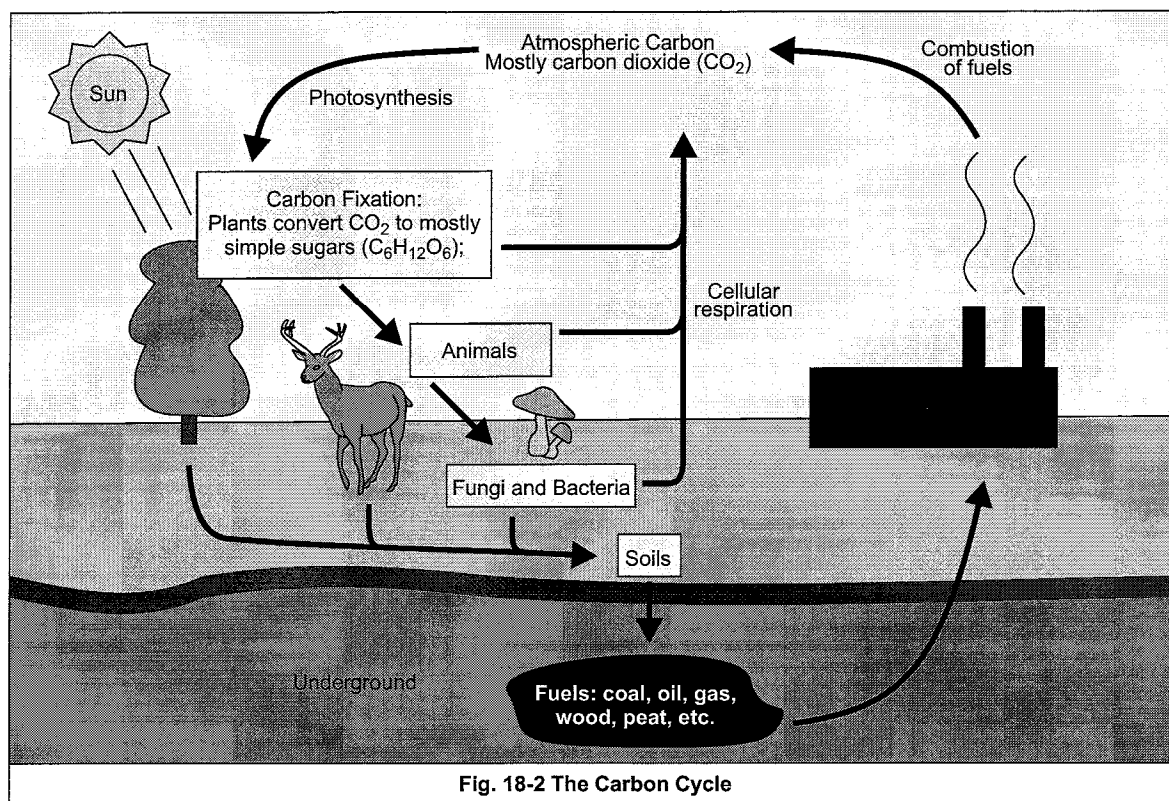


Fig. 18-2 The Carbon Cycle

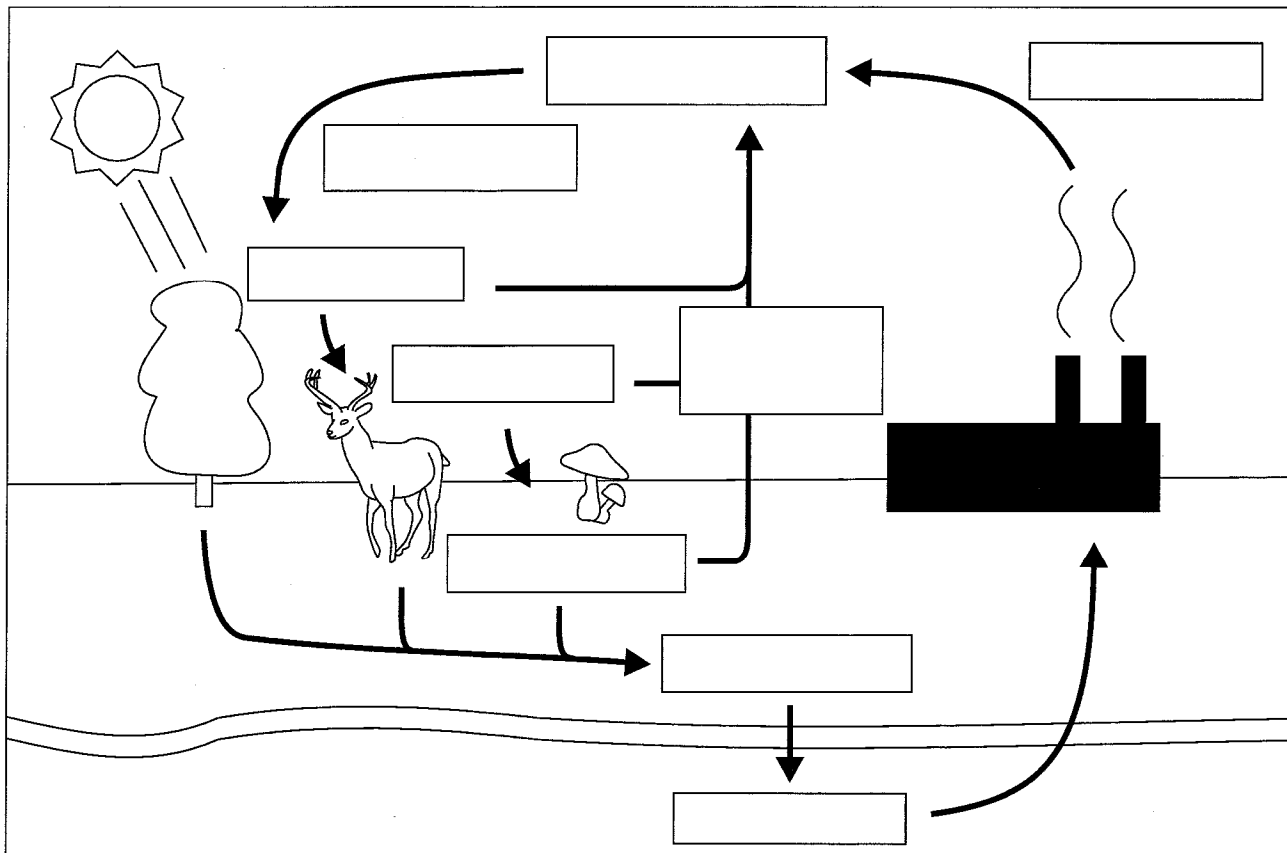
Most carbon in the atmosphere is in the form of carbon dioxide (CO_2). When plants go through **photosynthesis**, they use the energy in sunlight to change carbon dioxide gas into sugar molecules that contain energy. Converting non-organic carbon in carbon dioxide to organic carbon in sugar molecules 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.

Section 18.2, continued
The Carbon Cycle

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.

Practice 1

Fill in the blanks on the carbon cycle below. Use the following terms: animals, bacteria/fungi, carbon dioxide, cellular respiration, combustion, fuels, photosynthesis, plants, soil.



Practice 2

Match the terms below with their correct definition or description.

- | | |
|-------------------------------|--|
| _____ 1. photosynthesis | A. the process of burning fuels that releases carbon dioxide into the atmosphere |
| _____ 2. carbon fixation | B. converting inorganic carbon into organic carbon |
| _____ 3. carbohydrates | C. process of living organisms that uses carbohydrates and releases carbon dioxide |
| _____ 4. cellular respiration | D. sugars made by plants |
| _____ 5. combustion | E. plant process that converts carbon dioxide into carbohydrates |

Section 18.2, continued
The Carbon Cycle

Practice 3

Answer the following questions on the carbon cycle.

- (A) (B) (C) (D) 1. Which of the following is the MOST important reason that the recycling of carbon is so important to living organisms?
- A. Carbon is needed in the soil.
 - B. Carbon is needed for fuel combustion.
 - C. Carbon is needed to make organic molecules.
 - D. Carbon is needed to make coal.
- (A) (B) (C) (D) 2. In what form is most carbon found in the atmosphere?
- A. CO
 - B. CO₂
 - C. H₆C₁₂O₆
 - D. H₂CO₃
- (A) (B) (C) (D) 3. How do plants use carbon dioxide in photosynthesis?
- A. It is used for cellular respiration.
 - B. It is used to produce sunlight.
 - C. It is used to produce carbohydrates.
 - D. It is released as a byproduct of photosynthesis.
- (A) (B) (C) (D) 4. Through which process do living organisms release carbon into the atmosphere?
- A. photosynthesis
 - B. cellular respiration
 - C. transpiration
 - D. combustion
- (A) (B) (C) (D) 5. Which of the following is NOT a way that carbon in dead organisms is returned to the carbon cycle?
- A. by becoming a part of a fossil fuel
 - B. through the process of combustion
 - C. through decomposition
 - D. through photosynthesis
- (A) (B) (C) (D) 6. During which process is carbon fixed?
- A. transpiration
 - B. cellular respiration
 - C. photosynthesis
 - D. combustion
- (A) (B) (C) (D) 7. Where does carbon fixation take place?
- A. in the leaves of plants
 - B. in the roots of fungi
 - C. in the lungs of animals
 - D. underground
- (A) (B) (C) (D) 8. How is cellular respiration used in the carbon cycle?
- A. It converts carbon dioxide into carbohydrates.
 - B. It converts the carbon in the soil into fossil fuels.
 - C. It passes carbon from plants to animals.
 - D. It releases carbon dioxide back into the atmosphere.
- (A) (B) (C) (D) 9. How does carbon enter the soil?
- A. through dead organisms
 - B. through photosynthesis
 - C. through cellular respiration
 - D. through combustion
- (A) (B) (C) (D) 10. How do animals obtain carbon to be used in cellular processes?
- A. by breathing in carbon dioxide
 - B. by eating plants or other animals
 - C. by photosynthesis
 - D. by carbon fixation

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.

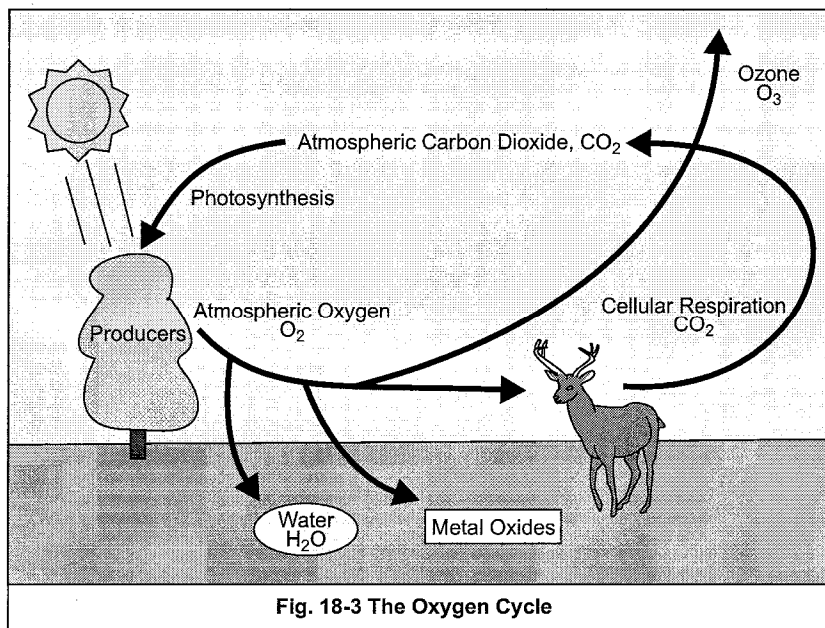


Fig. 18-3 The Oxygen Cycle

Practice

Answer the following questions on the oxygen cycle.

- (A) (B) (C) (D) 1. Which two processes are involved in both the oxygen cycle and the carbon cycle?

A. combustion and cellular respiration C. transpiration and combustion
 B. photosynthesis and transpiration D. cellular respiration and photosynthesis
- (A) (B) (C) (D) 2. Through which process is oxygen released into the atmosphere?

A. combustion B. condensation C. photosynthesis D. nitrification
- (A) (B) (C) (D) 3. Where is most of the earth's oxygen found?

A. in the earth's crust B. in the atmosphere C. in water D. in plants
- (A) (B) (C) (D) 4. How is ozone helpful?

A. It is needed for cellular respiration. C. It is used during combustion.
 B. It protects the earth from harmful radiation. D. It helps form organic molecules.
- (A) (B) (C) (D) 5. How many atoms of oxygen make up a molecule of ozone?

A. 1 B. 2 C. 3 D. 4

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.

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.

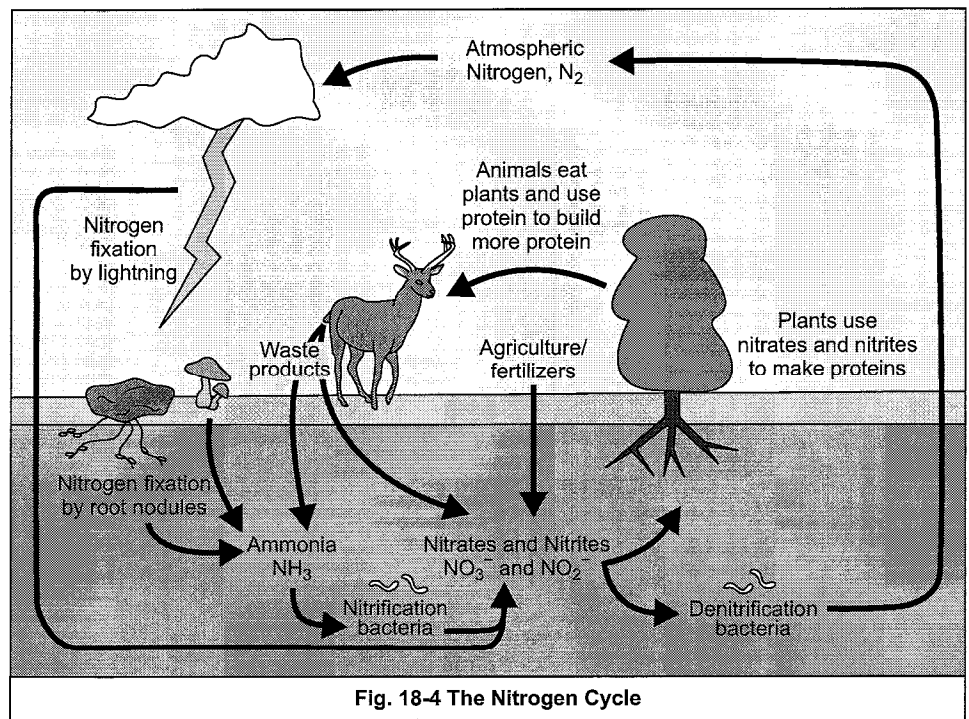


Fig. 18-4 The Nitrogen Cycle

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.

Section 18.4, continued
The Nitrogen Cycle

Practice 1

Match the terms below with their correct definition or description.

- | | | |
|-------|--------------------------|---|
| _____ | 1. nitrogen fixation | A. bacterial process that converts ammonia to nitrates and nitrites |
| _____ | 2. nitrates and nitrites | B. forms of nitrogen that can be used by plants to build protein |
| _____ | 3. denitrification | C. bacteria on the root nodules and lightning use this process to convert atmospheric nitrogen to ammonia |
| _____ | 4. ammonia | D. bacterial process that converts nitrates into nitrogen gas and returns nitrogen to the atmosphere |
| _____ | 5. nitrification | E. the result of nitrogen fixation and a component of consumer wastes |

Practice 2

Answer the following questions on the nitrogen cycle.

- Ⓐ Ⓑ Ⓒ Ⓓ 1. Why is nitrogen important to living organisms?
- A. It is used to make proteins.
B. It is needed for photosynthesis.
C. It is found in all organic molecules.
D. It is needed for cellular respiration.
- Ⓐ Ⓑ Ⓒ Ⓓ 2. Which process converts nitrogen gas into ammonia?
- A. denitrification
B. nitrogen fixation
C. nitrogen conversion
D. ammonia synthesis
- Ⓐ Ⓑ Ⓒ Ⓓ 3. Why must nitrogen gas be converted to another form in the soil?
- A. so it can produce lightning
B. so it can be harvested by humans
C. so it can be used by plants
D. so it can kill bacteria in the soil
- Ⓐ Ⓑ Ⓒ Ⓓ 4. What organisms are involved in nitrogen fixation?
- A. bacteria in the soil
B. some types of plants
C. parasites in the soil
D. autotrophs
- Ⓐ Ⓑ Ⓒ Ⓓ 5. Before plants can use the nitrogen in ammonia, it must be changed into which form(s)?
- A. nitrogen gas and nitrates
B. nitrogen gas and nitrites
C. nitrates and nitrites
D. amino acids and nitrogen gas
- Ⓐ Ⓑ Ⓒ Ⓓ 6. What is the role of decomposers in the nitrogen cycle?
- A. They release nitrogen gas into the atmosphere.
B. They release nitrogen during cellular respiration.
C. They use ammonia when they break down dead organisms.
D. They release nitrogen into the soil when they break down dead organisms.

Biogeochemical Cycles

Section 18 Review

Answer the following questions on the biogeochemical cycles.

1. Which of the following moves water between the earth's surface and the atmosphere and back again?

- A the water cycle
- B the condensation cycle
- C precipitation
- D transpiration

(A) (B) (C) (D)

5. How does nitrogen get recycled back to the atmosphere?

- A decay by bacteria
- B infiltration of groundwater
- C runoff of precipitation
- D lightning in storm clouds

(A) (B) (C) (D)

2. Plants release water into the atmosphere through which process?

- F condensation
- G transpiration
- H photosynthesis
- J percolation

(F) (G) (H) (J)

6. Which process do some bacteria use to convert nitrogen gas in the air to ammonia?

- F decomposition
- G excretion
- H denitrification
- J nitrogen fixation

(F) (G) (H) (J)

3. Which of these is NOT a way that carbon cycles through the biosphere?

- A photosynthesis
- B transpiration
- C combustion of fossil fuels
- D decomposition

(A) (B) (C) (D)

7. Which type of organism carries out most nitrogen fixation?

- A insects
- B plants
- C bacteria
- D mammals

(A) (B) (C) (D)

4. How does carbon dioxide in the atmosphere enter into living organisms?

- F burning of forests
- G combustion of fossil fuels
- H photosynthesis
- J transpiration

(F) (G) (H) (J)

8. Which two biogeochemical cycles depend on photosynthesis for part of the recycling process?

- F carbon and oxygen
- G water and nitrogen
- H water and oxygen
- J carbon and nitrogen

(F) (G) (H) (J)

Section 18 Review, continued

9. Most carbon in the atmosphere occurs in what form?

- A** carbonic acid
- B** elemental carbon
- C** carbon dioxide
- D** carbohydrates

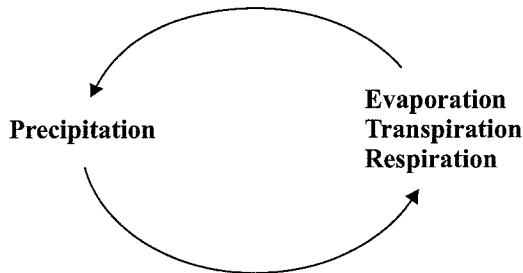
(A) (B) (C) (D)

12. What role do plants play in the nitrogen cycle?

- F** They release nitrogen into the atmosphere by decomposing nitrates and nitrites.
- G** They convert atmospheric nitrogen to ammonia.
- H** They produce and release nitrogen as a byproduct of photosynthesis.
- J** They convert nitrates and nitrites in the soil to proteins.

(F) (G) (H) (J)

10. Look at the diagram below.

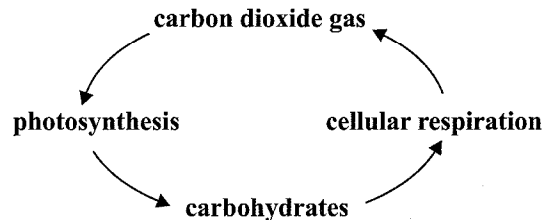


What does this diagram BEST represent?

- F** the nutrient cycles
- G** the nitrogen cycle
- H** the carbon cycle
- J** the water cycle

(F) (G) (H) (J)

13. Look at the simplified diagram of the carbon cycle shown below.



During which stage of the carbon cycle is carbon fixed?

- A** during photosynthesis
- B** during cellular respiration
- C** when carbon dioxide is in the atmosphere
- D** when carbohydrates are in plants and animals

(A) (B) (C) (D)

11. Which of the following is NOT a way that carbon is stored in the biosphere?

- A** in the atmosphere
- B** as fossil fuels underground
- C** in tissues of living organisms
- D** as ozone

(A) (B) (C) (D)

14. Which of the following describes a plant's role in the carbon cycle?

- F** It stores carbon dioxide in its leaves to be consumed by animals.
- G** It releases carbon dioxide as a byproduct of photosynthesis.
- H** It decomposes organic carbon molecules like carbohydrates into inorganic carbon compounds in the soil.
- J** It converts carbon dioxide to carbohydrates through photosynthesis.

(F) (G) (H) (J)