Name Date

Section 2.2 Summary

Nutrient Cycles in Ecosystems

Textbook pages 68–91

Before You Read

Like other organisms, your body relies on nutrients to stay healthy. Based on your current understanding, create a definition of what you think a nutrient is. Write your definition in the lines below.

_____

_____

Mark the Text

Check for Understanding
As you read this section, be sure to reread any parts you do not understand. Highlight any sentences that help you improve your understanding.

Reading Check

1. Name the three main nutrient cycles.

_____

_____

_____

How are nutrients cycled in the biosphere?

Nutrients are chemicals required for plant and animal growth and other life processes. They are constantly recycled within Earth's biosphere. Nutrients spend different amounts of time in **stores** within the atmosphere, oceans, and land. Nutrients are stored for short periods of time in short-term stores, such as living organisms and the atmosphere. Nutrients can also be incorporated into longer-term stores, such as Earth's crust. **Nutrient cycles** describe the flow of nutrients in and out of stores as a result of biotic and abiotic processes. Without human interference, nutrient cycles are almost perfectly balanced. There are three main cycles that move nutrients through terrestrial and aquatic ecosystems:

1. the **carbon cycle**
2. the **nitrogen cycle**
3. the **phosphorus cycle** ✔

How does the carbon cycle work?

Carbon is an essential component of cells and life-sustaining chemical reactions. Carbon is cycled through living and decaying organisms, the atmosphere, bodies of water, and soil and rock. Carbon moves between stores via six main processes:

1. Photosynthesis: **Photosynthesis** is a chemical reaction that converts solar energy and atmospheric carbon dioxide gas (CO_2) into chemical energy.
2. Cellular respiration: During **cellular respiration**, plants and animals obtain energy by converting carbohydrates and oxygen (O_2) into carbon dioxide and water.

3. Decomposition: Decomposers release carbon dioxide into the atmosphere through the **decomposition** of carbon-rich organic matter in soil.
4. Ocean processes: Dissolved carbon dioxide is stored in oceans. Marine organisms store carbon-rich **carbonate** (CO_3^{2-}) in their shells, which eventually form sedimentary rock.
5. Volcanic eruptions
6. Forest fires

How do human activities affect the carbon cycle?

Human activities, such as fossil fuel combustion and land clearance, quickly introduce carbon into the atmosphere from longer-term stores. These actions increase the levels of carbon dioxide, a greenhouse gas that contributes to global climate change.

How does the nitrogen cycle work?

Nitrogen is an important component of DNA and proteins. Most nitrogen is stored in the atmosphere, where it exists as nitrogen gas (N_2). It is also stored in bodies of water, living organisms, and decaying organic matter. Most organisms cannot use atmospheric nitrogen gas. The nitrogen cycle involves four processes, three of which make nitrogen available to plants and animals.

1. **Nitrogen fixation:** Nitrogen gas is converted into nitrate (NO_3^-) and ammonium (NH_4^+), compounds that are usable by plants. Nitrogen fixation occurs mainly through nitrogen-fixing bacteria, and when lightning strikes in the atmosphere.
2. **Nitrification:** Ammonium is converted into nitrate and nitrite (NO_2^-) through the work of **nitrifying bacteria**.
3. **Uptake**: Useable forms of nitrogen are taken up by plant roots and incorporated into plant proteins. When herbivores and omnivores eat plants, they incorporate nitrogen into their own tissues.
4. **Denitrification: Denitrifying bacteria** convert nitrate back into atmospheric nitrogen.

How do human activities affect the nitrogen cycle?

Fossil fuel combustion and burning organic matter release nitrogen into the atmosphere, where it forms acid rain. Chemical fertilizers also contain nitrogen, which escapes into the atmosphere or **leaches** into lakes and streams. High levels of nitrogen cause **eutrophication** (too many nutrients) and increased algal growth in aquatic ecosystems, depriving aquatic organisms of sunlight and oxygen.

How does the phosphorus cycle work?

Phosphorus carries energy to cells. It is found in phosphate (PO_4^{3-}) rock and sediments on the ocean floor. **Weathering**—through **chemical** or **physical** means—breaks down rock, releasing phosphate into the soil from longer-term stores. Organisms take up phosphorus. When they die, decomposers return phosphorus to the soil. Excess phosphorus settles on floors of lakes and oceans, eventually forming sedimentary rock. It remains trapped for millions of years until it is exposed through **geologic uplift** or mountain building.

How do human activities affect the phosphorus cycle?

Commercial fertilizers and phosphate-containing detergents enter waterways and contribute additional phosphate to the phosphorus cycle. Slash-and-burn forest clearance reduces phosphate levels, as phosphate in trees enters soil as ash. It leaches out of the soil and settles on lake and ocean bottoms, unavailable to organisms. ✔

✔ ***Reading Check***

1. List a human activity that can cause changes to a nutrient cycle.

_____

_____

_____

Use with textbook pages 68–87.

Nutrient cycles

Answer the questions below.

1. Where are nutrients accumulated or stored for short or long periods?

_____

2. Name a biotic process and an abiotic process that allow nutrients to flow in and out of stores.

_____

_____

3. Photosynthesis is an important process in which carbon and oxygen are cycled through ecosystems. Describe this process.

_____

_____

_____

4. Cellular respiration is the process in which plants and animals make use of stored energy and release carbon dioxide back into the atmosphere. Describe this process.

_____

_____

5. How is decomposition related to the carbon cycle?

_____

_____

6. What is nitrogen fixation?

_____

7. What is denitrification?

_____

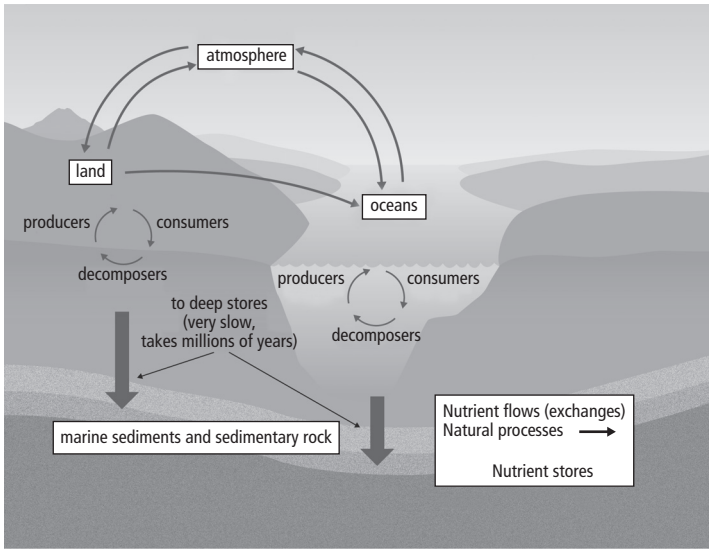
8. What is eutrophication?

_____

Use with textbook pages 69–70, 86–87.

The cycling of nutrients in the biosphere

Use the general model of a nutrient cycle to answer the questions below.



1. This diagram illustrates the general model of a nutrient cycle. What types of human activities can affect a nutrient cycle?

_____

_____

2. How do these human activities affect a nutrient cycle?

_____

_____

3. On the diagram above, add terms and arrows that could represent the effects of human activity on a nutrient cycle.

4. How do changes in nutrient cycles affect biodiversity?

_____

_____

5. Reflect on your local community. Discuss a human activity that is affecting your local ecosystem.

_____

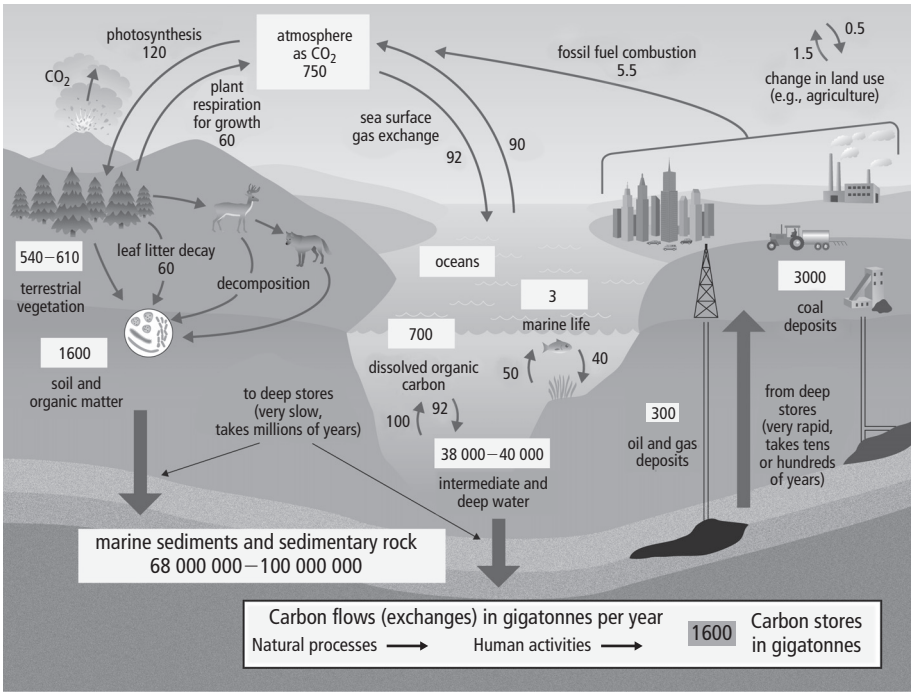
_____

Use with textbook pages 71–87.

The carbon, nitrogen, and phosphorus cycles

The carbon cycle

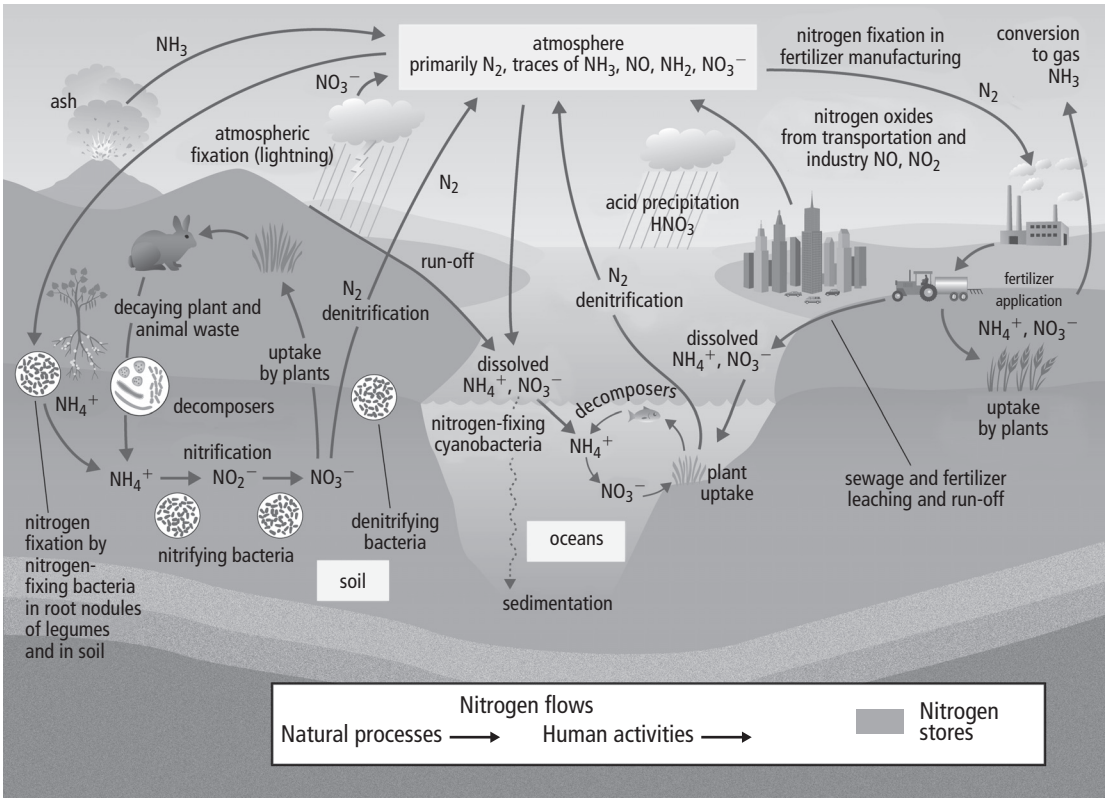
Use the nutrient cycle below to answer the questions in the chart that follows.



Why is the carbon cycle important?	_____ _____
How is carbon stored?	_____ _____
How is carbon cycled?	_____ _____
Name several human activities that affect the carbon cycle.	_____ _____

The nitrogen cycle

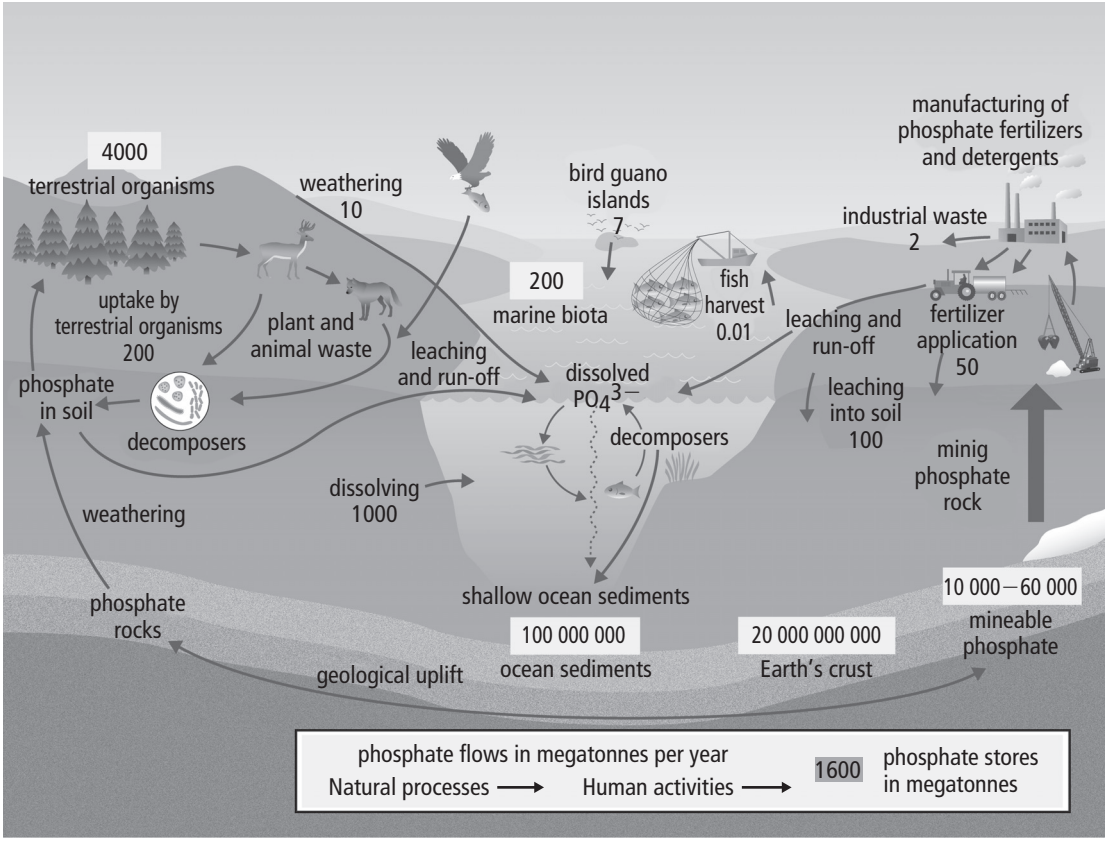
Use the nutrient cycle below to answer the questions that follow.



Why is the nitrogen cycle important?	_____ _____
How is nitrogen stored?	_____ _____
How is nitrogen cycled?	_____ _____
Name several human activities that affect the nitrogen cycle.	_____ _____

The phosphorus cycle

Use the nutrient cycle below to answer the questions that follow.



Why is the phosphorus cycle important?	_____ _____
How is phosphorus stored?	_____ _____
How is phosphorus cycled?	_____ _____
Name several human activities that affect the phosphorus cycle.	_____ _____

Nutrient cycles in ecosystems

Use with textbook pages 68–87.

Match each Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Term	Descriptor
1. _____ cellular respiration **2.** _____ denitrification **3.** _____ nitrification **4.** _____ nutrients **5.** _____ photosynthesis **6.** _____ sedimentation **7.** _____ weathering	**A.** the process in which nitrogen is released into the atmosphere **B.** substances, such as nitrogen and phosphorus, that are required by plants and animals for energy, growth, development, repair, and maintenance **C.** the process in which rock is broken into smaller fragments **D.** a process in which carbon dioxide enters plants and reacts with water in the presence of sunlight to produce carbohydrates and oxygen **E.** the process in which ammonium is converted into nitrate **F.** the process in which plants and animals release carbon dioxide back into the atmosphere by converting carbohydrates and oxygen into carbon dioxide and water. **G.** the process in which soil particles and decaying organic matter accumulate in layer on the ground or at the bottom of large bodies of water

Circle the letter of the best answer.

8. In the carbon cycle, where are the highest stores of carbon found?

A. terrestrial vegetation

B. marine sediments and sedimentary rocks

C. oil and gas deposits

D. soil and organic matter

9. Calcium carbonate is a structural component of:

A. marine organisms

B. terrestrial organisms

C. algae

D. volcanic ash

10. Which of the following is not stored in the atmosphere as a gas?

A. carbon

B. oxygen

C. nitrogen

D. phosphorus

11. Nitrogen fixation results in:

A. ammonium being converted into nitrates

B. nitrates being consumed by bacteria

C. nitrogen gas being converted into nitrate or ammonium

D. ammonia being converted into carbohydrates

12. Lightning provides energy that:

A. absorbs energy into land masses

B. fixes nitrogen in the atmosphere

C. fixes carbon dioxide in the atmosphere

D. releases nitrogen into the soil

2. third trophic level
3. secondary consumers
4. primary consumer
5. secondary or tertiary consumer
6. earthworms, beetles, small insects, bacteria, fungi
7. a model that shows the loss of energy from one trophic level to another
8. producers, such as plants
9. carnivores, such as great horned owls

Illustrating Concepts

Modelling a local ecosystem
Page 19

1. Student should include 12 organisms and cover all four trophic levels.
2. Food chain: student should include four trophic levels: primary producers, primary consumers, secondary consumers, and tertiary consumers.
3. Food web: student should include interconnecting arrows between various organisms to demonstrate the feeding relationships.
4. Food pyramid: student should show a series of boxes decreasing in size from bottom to top. The pyramid should include producers, herbivores, carnivores, and top carnivores.

Assessment

Energy flow in ecosystems
Page 20

1. C **2.** F **3.** H **4.** A **5.** E **6.** G **7.** B **8.** D **9.** D **10.** A **11.** B **12.** C **13.** D **14.** D

Section 2.2 Nutrient Cycles in Ecosystems

Comprehension

Nutrient cycles
Page 24

1. Nutrients are stored in Earth's atmosphere, oceans, and land masses.
2. Biotic processes, such as decomposition, and abiotic processes, such as river run-off, can cause nutrients to flow in and out of stores.
3. Photosynthesis converts solar energy into chemical energy. Carbon, in the form of carbon dioxide, enters through the leaves of plants and, in the presence of sunlight, reacts with water to produce carbohydrates and oxygen.
4. Cellular respiration involves carbohydrates reacting with oxygen to form carbon dioxide, water, and energy.
5. Decomposers, such as bacteria and fungi, convert organic molecules, such as cellulose, back into carbon dioxide, which is then released into the atmosphere.
6. Nitrogen fixation is the process in which nitrogen gas is converted into compounds that contain nitrate or ammonium.
7. Denitrification is a process by which denitrifying bacteria, using a series of chemical reactions, convert nitrate back into nitrogen gas.
8. Eutrophication is the process by which excess nutrients result in increased plant production and decay in aquatic ecosystems.

Interpreting Illustrations

The cycling of nutrients in the biosphere
Page 25

1. Human activities that can affect a nutrient cycle could include land clearing, agriculture, urban expansion, mining, industry, and motorized transportation.
2. These human activities increase the amounts of nutrients in a cycle faster than natural biotic and abiotic processes can move them back into stores.
3. Terms and arrows could be similar to Fig 2.17 on page 70. Students may also add other facts or effects that they have thought of.
4. Changes in the carbon, nitrogen, and phosphorus cycles can affect the health and variety of organisms that live in an ecosystem.
5. Answers will vary but they should include a human activity, a description of the activity, and its impact on a specific part of the local ecosystem.

Applying Knowledge

The carbon, nitrogen, and phosphorus cycles
Page 26

The carbon cycle

Why is the carbon cycle important?	cellular respiration provides energy for living things
How is carbon stored?	short term: vegetation, land and marine animals, decaying organic material, carbon dioxide in its dissolved form long term: dissolved carbon dioxide in deeper ocean waters; coal, oil, and gas deposits; marine sediments and sedimentary rock
How is carbon cycled?	photosynthesis, respiration, decomposition, ocean processes, volcanic eruptions, forest fires

Name several human activities that affect the carbon cycle.	industry, motorized transport, land clearing, agriculture, urban expansion

The nitrogen cycle

Why is the nitrogen cycle important?	component of DNA, proteins, muscle function in animals; growth of plants
How is nitrogen stored?	nitrogen gas in atmosphere, oceans, organic matter in soil
How is nitrogen cycled?	nitrogen fixation, nitrification, uptake, denitrification
Name several human activities that affect the nitrogen cycle.	fossil fuel combustion, power plants, sewage treatment, motorized forms of transport, clearing forests, grassland burning, chemical fertilizers leading to eutrophication

The phosphorus cycle

Why is the phosphorus cycle important?	carries energy to plant cells and animal cells; root development in plants; bone development
How is phosphorus stored?	phosphate rock; ocean floor sediments as PO_4^{-3}, HPO_4^{-2}, $H_2PO_4^{-}$
How is phosphorus cycled?	chemical weathering, physical weathering
Name several human activities that affect the phosphorus cycle.	commercial fertilization and detergents negatively affect species, causing fish death

Assessment

Nutrient cycles in ecosystems

Page 29

1. F **2.** A **3.** E **4.** B **5.** D **6.** G **7.** C **8.** B **9.** A **10.** D **11.** C **12.** B

Section 2.3 Effects of Bioaccumulation on Ecosystems

Cloze activity

Bioaccumulation

Page 33

1. bioaccumulation
2. keystone species
3. biomagnification
4. producers
5. PCBs
6. half-life
7. persistent organic pollutants
8. parts per million
9. heavy metals
10. lead; cadmium; mercury
11. bioremediation

Applying Knowledge

Impact of bioaccumulation on consumers

Page 34

CHEMICAL	EFFECTS ON PRODUCERS, PRIMARY CONSUMERS, AND SECONDARY CONSUMERS	EFFECTS ON HUMANS
toxic organic chemicals from red tide	Produces toxic chemicals that affect clams, mussels, and oysters. Toxins bioaccumulate in fish and mammals.	Can cause paralytic shellfish poisoning, leading to serious illness or death.
DDT	Bioaccumulates in plants and then in fatty tissue of fish, birds, and animals that eat the plants. Affects aquatic food chains.	Changed into a chemical form that is stored in fat tissue. Can cause nervous system, immune system, and reproductive disorders.
lead	In fish and birds it can cause nervous system damage, affect fertility rates, kidney failure, and impair mental development.	Harmful effects range from anemia, nervous system damage, sterility in men, low fertility rates in women, impaired mental development, and kidney failure.
cadmium	Plants take up cadmium from the soil and pass it on to the animals that eat them. Highly toxic to earthworms and other soil organisms. In fish, cadmium contributes to higher death rates, and lower reproduction and growth rates.	Accumulates in lung tissues, causing lung diseases, such as cancer. Leads to infertility and damage to central nervous system, immune system, and DNA.
mercury	Bacteria change mercury into methylmercury, a toxin that accumulates in the brain, heart, and kidneys of vertebrates. Levels of methylmercury in fish depend on how high they are on the food chain.	Methylmercury is absorbed in digestion and enters the blood and then the brain. It affects nerve cells, heart, kidney, lungs, and it suppresses the immune system.