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II. ECOSYSTEMS AND HOW THEY WORK

Ecosystem ecology involves the relationship of organisms to the abiotic component of the ecosystem. These relationships of the biotic to the abiotic are very numerous and complex. We

will begin our brief look at ecosystem ecology by looking at how certain essential chemicals—water, carbon, nitrogen, and phosphorus—are “recycled” in ecosystems.

SECTION OBJECTIVES

Read these objectives. When you have completed this section, you should be able to:

8. Explain the four main biogeochemical cycles and their importance to ecosystems.
9. Describe a food chain and a food web, and explain the difference between the two.
10. Explain the flow of energy through ecosystems and contrast that to the flow of chemicals.
11. Describe different balancing systems that work in ecosystems.

VOCABULARY

Study these words to enhance your learning success in this section.

biogeochemical cycle
chemical energy
consumers
denitrification
ecological pyramid

energy
food chain
food web
mechanical energy
nitrification

nitrogen fixation
omnivore
producer
tertiary
thermodynamics

BIOGEOCHEMICAL CYCLES

Biogeochemical sounds like a big word, but it has a simple meaning. The word breaks down to mean “life (bio) - earth (geo) - chemical.” A biogeochemical cycle is simply the cycling of certain chemicals from the biotic to the abiotic components of the ecosystem. We will briefly discuss the four main types of these cycles.

THE WATER CYCLE

The water cycle is probably the most familiar cycle to us (see Figure 16). Water exists in bodies like rivers, streams, lakes, and oceans. From there, sunlight evaporates water. As this moisture rises, it cools and condenses, forming clouds. Further condensation will cause the clouds to drop some of their moisture onto the earth in the form of rain or snow. After the water seeps through the soil and/or flows

across the land, most will collect again in streams, rivers, lakes, and oceans. From here the water may evaporate and begin the cycle all over again.

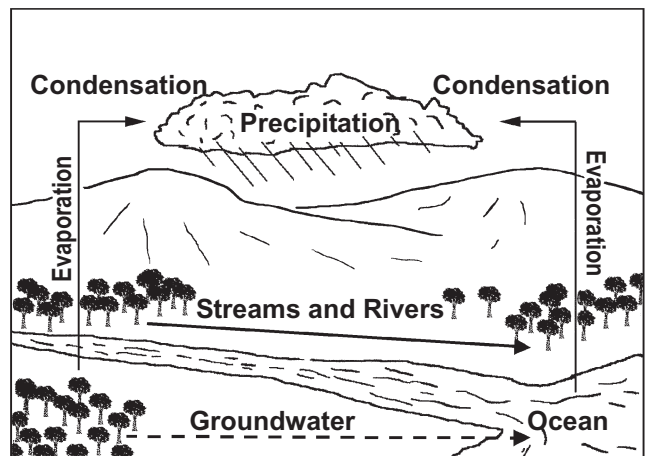


Figure 16: Water Cycle

THE CARBON CYCLE

The carbon cycle (see Figure 17) has two primary pathways—aquatic and terrestrial—both of which are based on carbon dioxide. Carbon dioxide is taken in by plants, and the carbon in it is then incorporated into the carbohydrates produced in photosynthesis. These carbohydrates are then broken down by plants as they go about respiration or later in the animals that consume the plants. When broken down, the carbon is released into the air as carbon dioxide, and the cycle repeats. Some carbon is also “locked up” in the bodies of the

organisms but will be released again to the environment when the organisms die and are decomposed by bacteria and fungi. The burning of existing fossil fuels such as coal, gas, and oil is a large source of carbon dioxide in the air.

In the aquatic portion of the carbon cycle, carbon dioxide dissolves in bodies of water to form bicarbonate. This bicarbonate is used in photosynthesis by phytoplankton (photosynthetic algae) and then released in the form of carbon dioxide when the phytoplankton (or the organisms that eat the phytoplankton) die and are decomposed.

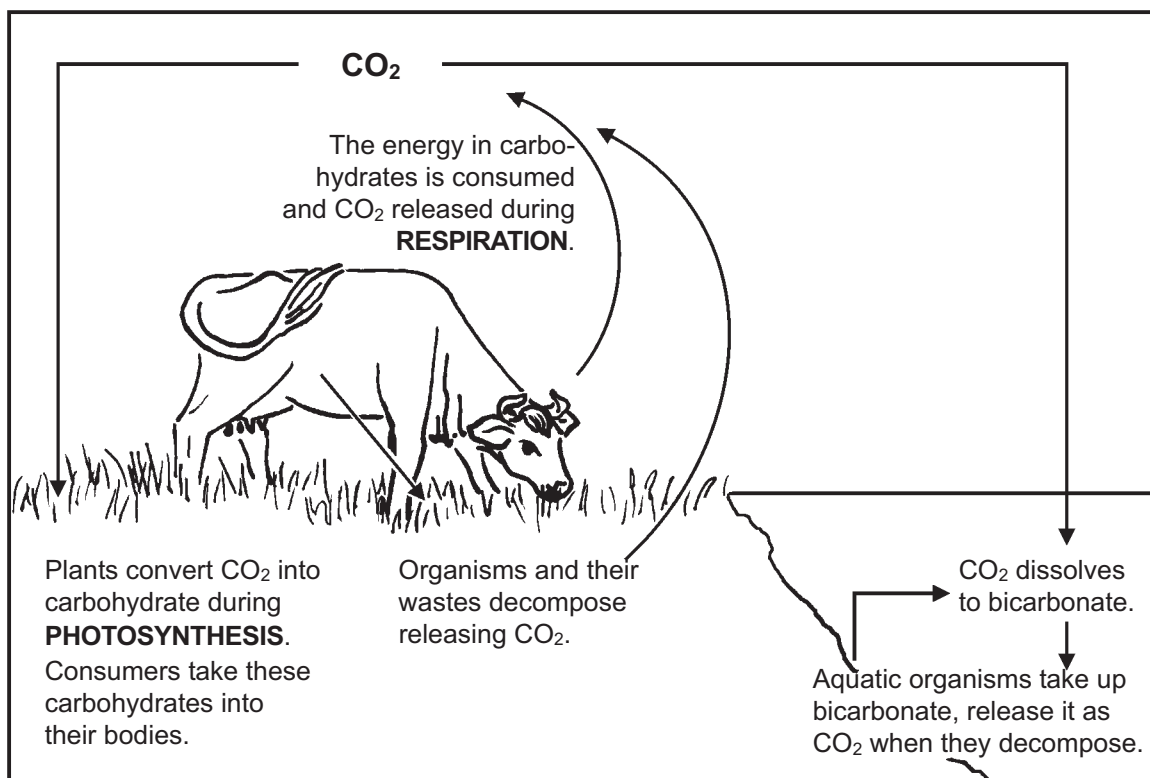


Figure 17: Carbon Cycle



Complete the following exercises.

- 2.1 Define biogeochemical cycle. _____

- 2.2 Briefly describe the water cycle. _____

- 2.3 In what form does carbon exist in the atmosphere? (a) _____
in water? (b) _____

- 2.4 What are the two pathways of the carbon cycle? _____ and _____
- 2.5 Plants incorporate carbon into carbohydrates during _____.
- 2.6 A large source of carbon dioxide in the atmosphere is the burning of _____.
- 2.7 When is the carbon that is locked up in the body of an organism released again? _____
- 2.8 The carbon in both pathways is released in the form of _____.

THE NITROGEN CYCLE

The nitrogen cycle (see Figure 18) is very important because nitrogen is an essential ingredient of all protein. One interesting aspect of the nitrogen cycle is that it is totally dependent on *bacteria*. The stages of the nitrogen cycle involve a conversion from one form of nitrogen to another—each conversion accomplished by a specific kind of bacteria.

Unique bacteria called nitrogen-fixing bacteria take nitrogen out of the atmosphere and begin the process of nitrification—the process of converting nitrogen into a form that can be used by organisms. Nitrogen-fixing bacteria live in nodules (little lumps) on the roots of

many plants in the bean family, and convert the atmospheric nitrogen into ammonia in a process called **nitrogen fixation**. Then a second kind of bacteria converts the ammonia into nitrite and a third kind converts the nitrite into nitrate as the final step of nitrification. Plants can use nitrate to build protein, and this protein is then incorporated into the bodies of the animals that eat these plants. Nitrogen is then returned to the soil in the form of wastes and dead organisms. In the soil, denitrifying bacteria return the nitrogen to the atmosphere using a process called **denitrification**. This cycle keeps the amount of nitrogen in the atmosphere in a constant balance.

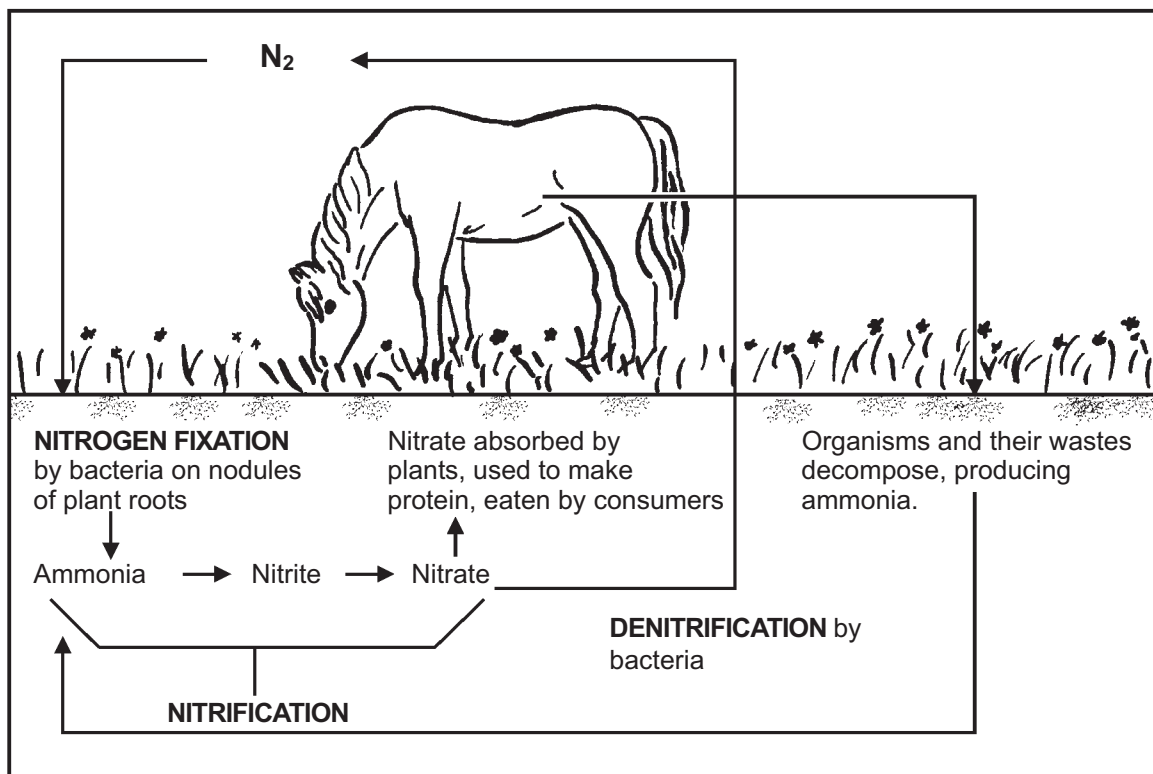


Figure 18: Nitrogen Cycle

THE PHOSPHOROUS CYCLE

The phosphorous cycle differs from the preceding three cycles in that the main reservoir (storage pool) of the nutrient exists in the mineral form, rather than in the atmosphere-like water, carbon, and nitrogen (see Figure 19). The phosphorous cycle is typical of other mineral cycles in which the reservoir of the nutrient is the mineral form. The kind of phosphorus that is usable by plants, called soluble

(dissolvable) phosphate, becomes available as phosphate-rich rocks weather. Once in the soluble form, phosphate can be incorporated into the bodies of plants and then into the bodies of plant-eating animals. Phosphate is then released back to the soil as the wastes and carcasses of these plants and animals are decomposed. Some of the soluble phosphate in soils is lost as water moves through the soil and carries it along to the oceans.

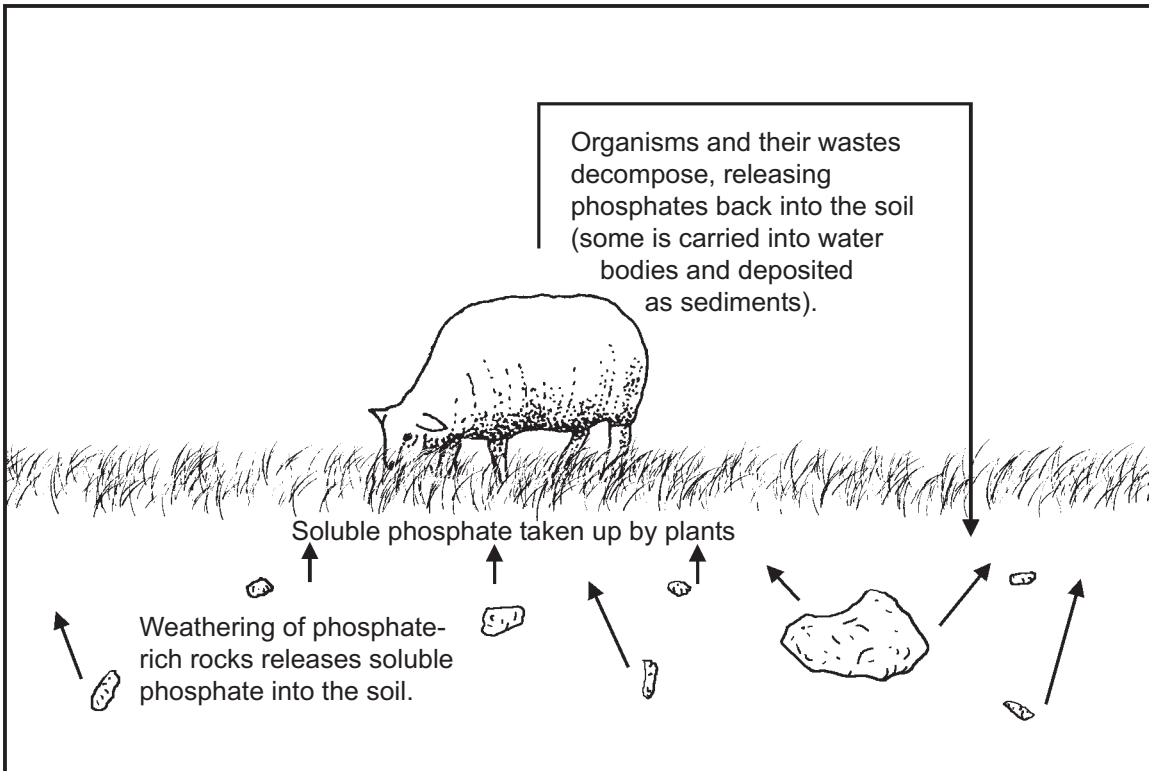


Figure 19: Phosphorous Cycle



Name the process that is described.

- 2.9 _____ The process by which the nitrogen in the atmosphere is converted into ammonia.
- 2.10 _____ The process by which nitrate is converted back to atmospheric nitrogen.
- 2.11 _____ The form of nitrogen produced by the final step of nitrification and used by plants to build protein.
- 2.12 _____ The form of nitrogen produced by nitrogen fixation.
- 2.13 _____ The process by which nitrogen is converted to a usable form.



Answer the following questions.

- 2.14 Upon what kind of organism does the nitrogen cycle depend? _____
- 2.15 The roots of many bean plants have nodules that contain _____.