

SCIENCE 809

BALANCE IN NATURE

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II. NATURAL CYCLES

The existence of life on this planet depends on the constant recycling of many important elements. Nitrogen, carbon, oxygen, and water all have their own intricately balanced cycles. The process of decay contributes to each of these cycles and rids the earth of excessive organic matter.

SECTION OBJECTIVES

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

7. To describe the relationship between *Rhizobium* bacteria, legume plants, and soil fertility.
8. To name the two important groups of decomposers and tell two values of decay.
9. To describe how water is recycled through precipitation, ground water, and transpiration.
10. To describe how the carbon dioxide of animal respiration and the oxygen of photosynthesis are involved in a cycle.

VOCABULARY

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

bacteria (bak tir' ē u). Tiny single-celled organisms.

decomposition (dē kom pu zish' un). To decay, or rot.

fungi (fun' jī). Members of the plant kingdom without chlorophyll.

legume (leg' yüm). A group of plants that form root nodules.

nodule (noj' ül). The enlargement on the root of a legume.

Rhizobium (rī zō' bē um). The group of bacteria found in legume nodules.



THE NITROGEN CYCLE

Nitrogen is one of the major elements needed for plant growth. The atmosphere is a vast storehouse of nitrogen, but in its free state nitrogen is not available for plant use. A special relationship between **bacteria** and **legumes** is responsible for converting nitrogen into a usable form. **Fungi** and several other bacterial groups recycle the nitrogen found in plants and animals when the organism dies.

Nitrogen from the atmosphere. Since the atmosphere is 78 percent nitrogen, plants would seem to have an abundant supply. Unfortunately the nitrogen in the air is not in a form that the plant can absorb and use. A small amount of usable compounds is formed during thunderstorms when heat produced by lightning combines nitrogen and oxygen. Rain then washes these compounds into the soil. Gardeners claim

plants experience a burst of growth after a thundershower due to these nitrogen compounds.

Most available nitrogen in the soil comes from the action of nitrifying, or nitrogen-fixing, bacteria. The bacteria are named **Rhizobium** after the two Greek words *rhizo*, meaning *root*, and *bio*, meaning *life*. *Rhizobium* bacteria have a special relationship with legumes. Common legumes include clover, beans, peas, alfalfa, and peanuts. The bacteria are found in the soil and burrow into the root of a legume. The plant responds by forming a growth called a **nodule** in that area of the root. The bacteria live in the nodule and consume sugar and starches stored there. The bacteria are able to convert nitrogen found between particles of soil into nitrogen compounds the plant can use. Legume plants use all the nitrogen they need; the remainder is released from the nodule and enters the surrounding soil. An estimated 45

kilograms per acre of nitrogen can be produced in a growing season. About two-thirds of the world's required nitrogen fertilizer is a result of these bacteria.

Nitrogen from organic material. The cycle of nitrogen use continues when an animal consumes a plant. Proteins of the plant are broken down during digestion, and new proteins are formed that are characteristic of that particular animal. Any protein surplus is excreted as *urea*. When the urea reaches the soil, several other bacterial groups decompose it back into usable molecules and the plants begin the cycle again. In some areas the waste products of birds and bats (guano) have formed thick layers where the birds and bats roost. Guano is rich in nitrates and is mined and used as fertilizer.

Until the animal or plant dies, some nitrogen is tied up in the form of protein. Upon death the nitrogen is again returned to the soil by the process of decay.

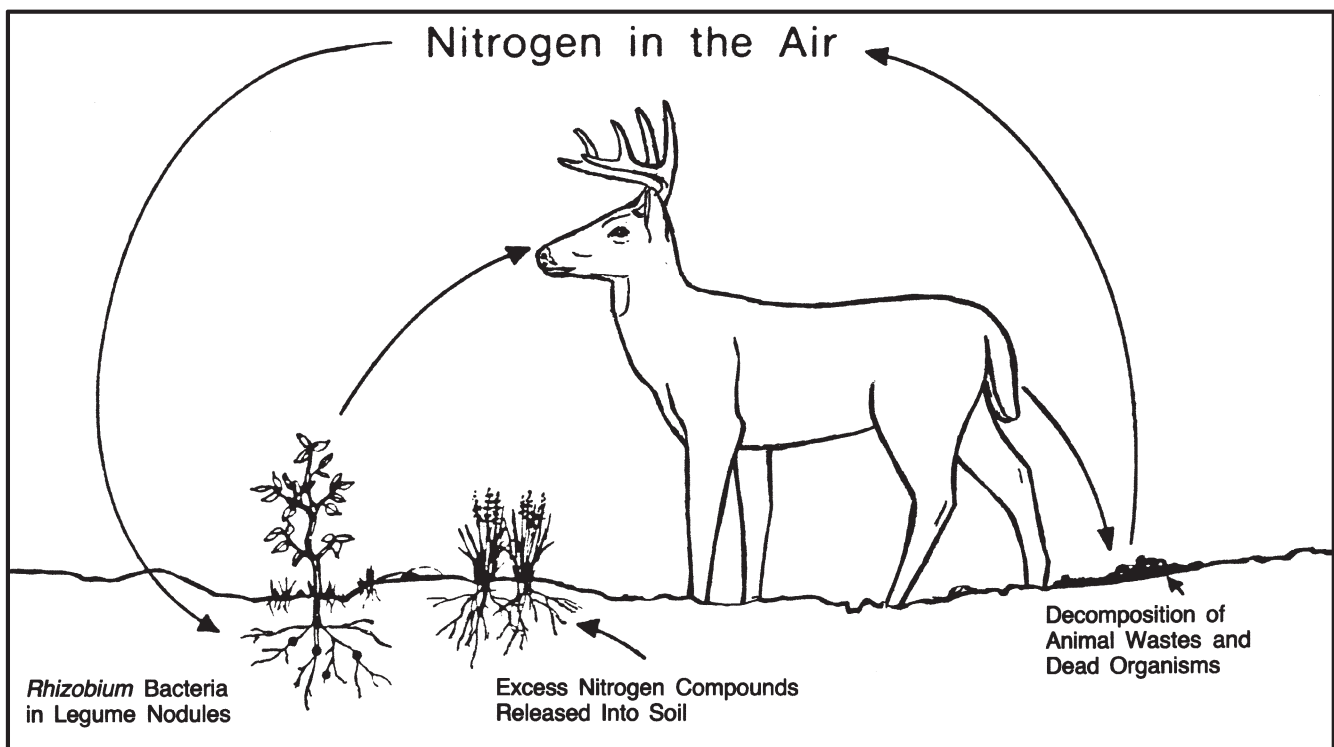


Figure 6: The Nitrogen Cycle

Thomas Jefferson suggested that farmers alternate their crops between different fields each year. Many crops are heavy users of nitrogen. If a legume is planted on the soil every few years the fertility of the soil is greatly increased by the action of the nitrogen-fixing bacteria. Crop rotation is now a common practice used to increase yields on farms. In an effort to get the most benefit possible from legume crops, many farmers will plow the legume into the soil. It decays and enriches the soil even more. Since this practice is a way of fertilizing the

land using green plants, the practice came to be known as *green manure*.

When legumes are planted on poor soil enough of the *Rhizobium* bacteria may not be available to form sufficient nodules. Powders containing millions of these bacteria can be purchased and added during planting to insure a sufficient bacterial population. Some home gardeners regularly sprinkle this powder in the row when they plant pea and bean seeds. The bacterial action insures a better crop and enriches the garden soil for the next season.



Answer these questions.

- 2.1 Why are plants unable to use nitrogen from the air? _____
- 2.2 What do *Rhizobium* bacteria do for legumes? _____
- 2.3 What do legumes provide for *Rhizobium* bacteria? _____
- 2.4 Where do nitrogen-fixing bacteria obtain nitrogen? _____
- 2.5 What happens to the excess nitrogen compounds the legumes do not need? _____
- 2.6 How much of the required world supply of nitrogen fertilizer is manufactured by *Rhizobium* bacteria? _____
- 2.7 What does an animal do with plant proteins? _____
- 2.8 Who advocated crop rotation? a. _____. Why is this practice important? b. _____.
- 2.9 What is green manure? _____



Complete this activity.

- 2.10 List the names of four legumes. a. _____ b. _____
c. _____ d. _____



Complete this activity.

- 2.11 Find a farmer who can show you a legume root with nodules. Draw it and bring a sample to class. If this activity is not possible, consult an encyclopedia and write one paragraph about legume plants.



Give your paper to your teacher.

THE DECAY CYCLE

Decay is caused by a variety of organisms. At times decay is very damaging to food crops and wood but is necessary to keep the amount of organic matter on the earth at a manageable level.

The agents of decay. Eventually all plants and animals die and decay. A number of organisms are involved in the decay process, but most are either bacteria or fungi. Bacteria are single-celled organisms so small they can be seen only through a high-powered microscope. They cannot manufacture their own food and must obtain it from organic matter.

Fungi are simple members of the plant kingdom even though they do not have chlorophyll. They range from single cells up to large organisms measuring 50 centimeters or more. Since fungi have no chlorophyll they, too, need to obtain their food from other plant or animal material. Fungi can be of a wide variety of shapes and sizes.

Yeasts are one-celled fungi; certain strains are used in bread-making and fermentation. Another type of fungi are molds. The growths found on old bread and rotten fruit are common molds. Particular types give cheeses their distinctive flavors; one fungus is the source of penicillin. Mushrooms and puffballs are large fungi and usually obtain their nourishment from organic matter in the soil of moist areas. Bracket, or shelf, fungi are found on old stumps and logs.

Both bacteria and fungi are agents of decay and are found almost everywhere. When an animal or plant dies, **decomposition** begins. Decomposers use the nutrients in dead material as food for their own growth and reproduction. In the process they break down molecules into simpler units.

The value of decay. A vast amount of elements such as nitrogen, carbon, and trace minerals are tied up in living animals and plants. These elements are not released into the environment until after death and decomposition. Without this decay and

release of valuable nutrients, life would eventually end. Plant growth would continue until the soil was depleted of its nutrients and then all growth would cease. Animals depend on plants for food and would continue eating until all the plants were gone. Soon the animals would starve. The cycle of life would end without the action of bacteria and fungi to release the critical elements back into the environment.

Besides recycling important nutrients, bacteria and fungi reduce the volume of organic matter produced each year. If leaves never decayed, the trees in a forest would soon be choked by their own leaves. If blades of grass did not decay, a lawn would smother itself. Many gardeners take organic material such as leaves, grass clippings, and vegetable peelings and put them in an area of their property to make a *compost* pile. If the pile is kept moist, the material decomposes. Compost makes a valuable addition to the garden soil. The nitrogen, carbon, and other elements tied up in the compost are released and put back into the soil to start the cycle again.

The problem of decay. All decay is not economically valuable. Tons of fruits, vegetables, and grains decay each year before they can be sold or consumed. Wooden homes and fences in moist climates rot and must be replaced. Once animals are slaughtered the meat is good only for a short time.

Methods had to be found to preserve organic material from decomposition. Ancient people dried berries and meat. Even cooking is a form of preservation although it extends the edible life only a few days. Salting was another easy ancient method of preservation. Salt was so important in food preservation that people were paid wages in salt. This practice gave rise to the saying that a worker was "worth his salt."

Christians are also called "the salt of the earth," or the preservers of God's world. Read what Jesus said in Matthew 5:13 about Christians being the salt of the earth.

Refrigeration and freezing slow down the growth of bacteria and fungi so that food can be stored for a longer period before spoiling. In canning, the food and container are heated to such high temperatures that the bacteria and fungi are killed. The food will stay free from

decomposition as long as the seal is not broken. Nutritional values of canned foods decline with time but the food remains edible. A meat roast canned in 1824 was opened 114 years later in 1938. The meat was fed to rats for ten days as an experiment. The rats remained alive and well.

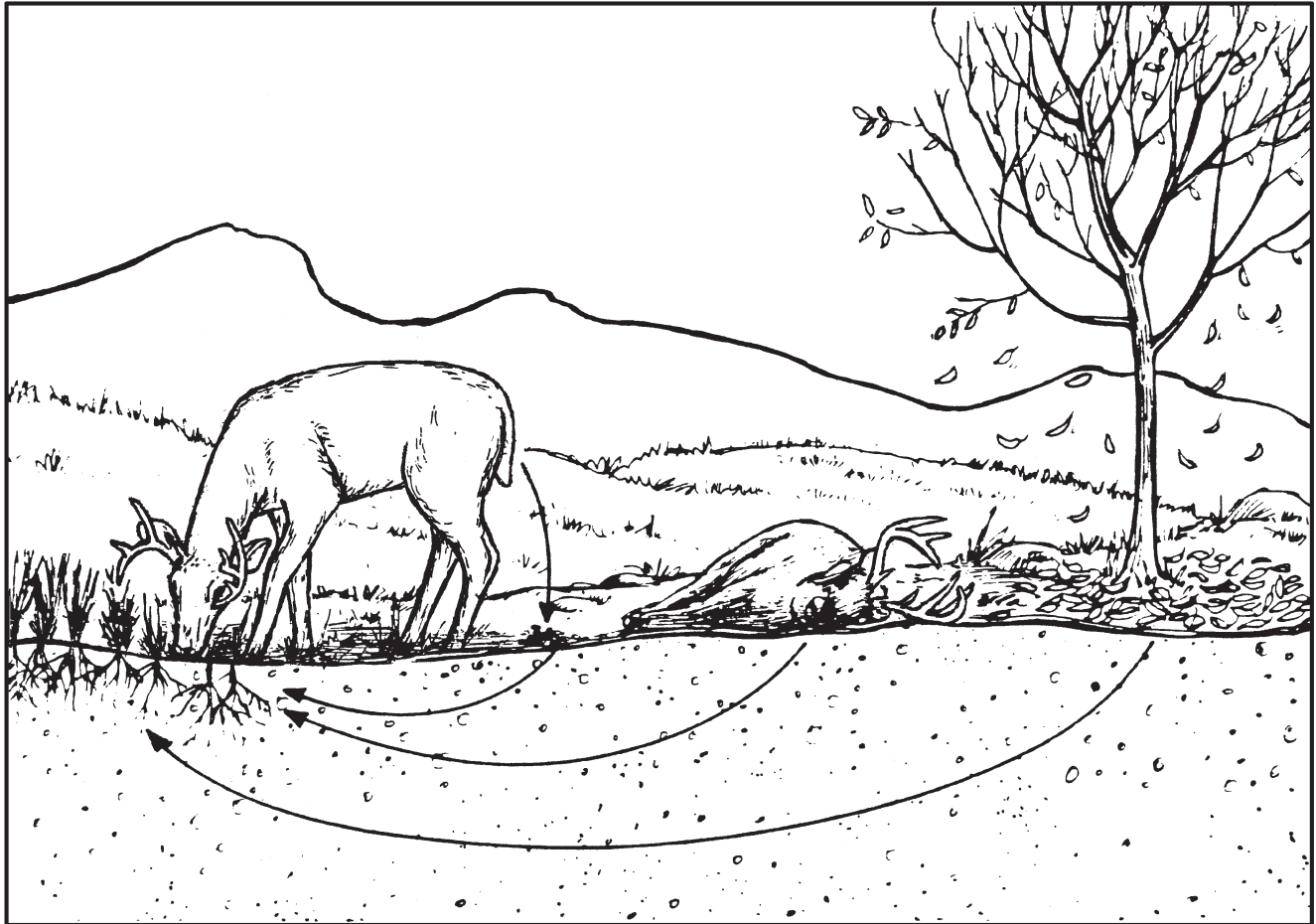


Figure 7: The Decay Cycle



Answer these questions.

- 2.12 What are the two main groups of decomposers? a. _____
b. _____
- 2.13 How do animals and plants contribute to the environment even after they die? _____
- 2.14 What would happen to life if no elements were ever recycled? _____
- 2.15 Bacteria and fungi do not make their own food. Why? _____
