Figure 19–6 **Bacteria help to break down the nutrients in this tree, allowing other organisms to use the nutrients.** In this way, bacteria help maintain equilibrium in the environment.

Importance of Bacteria

You probably remember the principal actors in the last film you saw. You might even recall some of the supporting actors. Have you ever thought that there would be no film at all without the hundreds of workers who are never seen on screen? Bacteria are just like those unseen workers. **Bacteria are vital to maintaining the living world. Some are producers that capture energy by photosynthesis. Others are decomposers that break down the nutrients in dead matter and the atmosphere. Still other bacteria have human uses.**

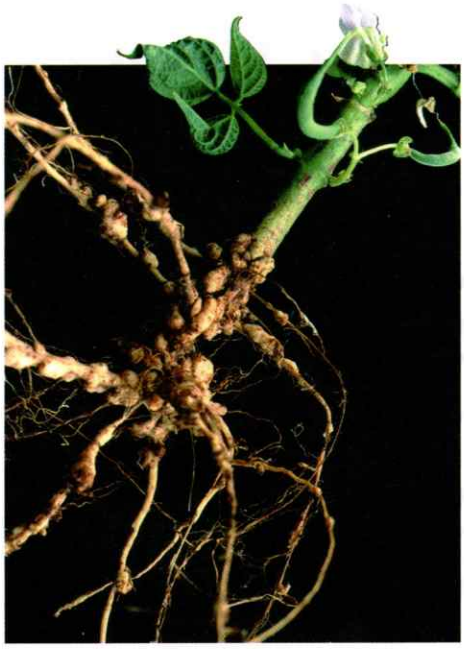
Decomposers Every living thing depends directly or indirectly on a supply of raw materials. If these materials were lost when an organism died, life could not continue. Before long, plants would drain the soil of minerals and die, and animals that depend on plants for food would starve. As decomposers, bacteria help the ecosystem recycle nutrients, therefore maintaining equilibrium in the environment. When a tree dies, such as the one in **Figure 19–6**, armies of bacteria attack and digest the dead tissue, breaking it down into simpler materials, which are released into the soil. Other organisms, including insects and fungi, also play important roles in breaking down dead matter.

Bacteria also help in sewage treatment. Sewage contains human waste, discarded food, and chemical waste. Bacteria break down complex compounds in the sewage into simpler ones. This process produces purified water, nitrogen and carbon dioxide gases, and leftover products that can be used as fertilizers.

Nitrogen Fixers Plants and animals depend on bacteria for nitrogen. You may recall that plants need nitrogen to make amino acids, the building blocks of proteins. Nitrogen gas (N_2) makes up approximately 80 percent of Earth's atmosphere.

However, plants cannot use nitrogen gas directly. Nitrogen must first be changed chemically to ammonia (NH_3) or other nitrogen compounds. Expensive synthetic fertilizers contain these nitrogen compounds, but certain bacteria in the soil produce them naturally. The process of converting nitrogen gas into a form plants can use is known as **nitrogen fixation.** Nitrogen fixation allows nitrogen atoms to continually cycle through the biosphere.

Many plants have symbiotic relationships with nitrogen-fixing bacteria. For example, soybeans and other legumes host the bacterium *Rhizobium*. *Rhizobium* grows in nodules, or knobs, on the roots of the soybean plant, as shown in **Figure 19–7.** The plant provides a source of nutrients for *Rhizobium*, which converts nitrogen in the air into ammonia, helping the plant. Thus, soybeans have their own fertilizer factories in their roots!



▲ **Figure 19–7** The knoblike structures on the roots of this soybean plant are called nodules. Within these nodules are populations of the nitrogen-fixing bacteria *Rhizobium*. **Applying Concepts** ***What is the name of the relationship between* Rhizobium *and soybean plants?***

Human Uses of Bacteria Many of the remarkable properties of bacteria provide us with products we depend on every day. For example, bacteria are used in the production of a wide variety of foods and beverages. Bacteria can also be used in industry. One type of bacteria can digest petroleum, making it very helpful in cleaning up small oil spills. Some bacteria remove waste products and poisons from water. Others can even help to mine minerals from the ground. Still others are used to synthesize drugs and chemicals through the techniques of genetic engineering.

Our intestines are inhabited by large numbers of bacteria, including *E. coli*. The term *coli* was derived from the fact that these bacteria were discovered in the human colon, or large intestine. In the intestines, the bacteria are provided with a warm and safe home, plenty of food, and free transportation. These bacteria also make a number of vitamins that the body cannot produce by itself. So both we and the bacteria benefit from this symbiotic relationship.

Biologists continue to discover new uses for bacteria. For example, biotechnology companies have begun to realize that bacteria adapted to extreme environments may be a rich source of heat-stable enzymes. These enzymes can be used in medicine, food production, and industrial chemistry.

19–1 Section Assessment

1. **Key Concept** Describe the characteristics of the two kingdoms of prokaryotes.
2. **Key Concept** What factors can be used to identify prokaryotes?
3. **Key Concept** Give one example of how bacteria maintain equilibrium in the environment.
4. Identify the parts of a prokaryote.
5. What are some ways that prokaryotes obtain energy?
6. **Critical Thinking** **Inferring** Why might an infection by Gram-negative bacteria be more difficult to treat than a Gram-positive bacterial infection?

Thinking Visually

Making a Venn Diagram

Create a Venn diagram that illustrates the similarities and differences between eubacteria and archaebacteria. *Hint*: Before you start, you may want to list the similarities and differences.

19–3 Diseases Caused by Bacteria and Viruses

Have you ever heard a teacher say that when a few people misbehave, they ruin it for everybody? In a way, that saying could be applied to bacteria and viruses. Bacteria and viruses are everywhere in nature, but only a few cause disease. However, these **pathogens,** or disease-causing agents, get all the attention.

Disease can be considered a conflict between the pathogen and the host. All viruses reproduce by infecting living cells, and disease results when the infection causes harm to the host. All bacteria require nutrients and energy; however, disease results when bacteria interfere with the host's ability to obtain enough of those elements to function properly.

Bacterial Disease in Humans

Many bacteria live on and within our bodies, and some bacteria even help us to perform essential functions, such as digesting our food. The growth of pathogenic bacteria, on the other hand, disrupts the body's equilibrium by interfering with its normal activities and producing disease.

The French chemist Louis Pasteur, shown in **Figure 19–12,** was the first person to show convincingly that bacteria cause disease. Pasteur helped to establish what has become known as the germ theory of disease when he showed that bacteria were responsible for a number of human and animal diseases.

Bacteria produce disease in one of two general ways. Some bacteria damage the cells and tissues of the infected organism directly by breaking down the cells for food. Other bacteria release toxins (poisons) that travel throughout the body interfering with the normal activity of the host.

Using Cells for Food The bacterium *Mycobacterium tuberculosis*, which causes tuberculosis, is inhaled into the lungs, where it destroys the lung tissue. The bacterium also may enter a blood vessel and travel to new sites in the body where it destroys more tissue.

Releasing Toxins Bacterial toxins can travel throughout the body. For example, the *Streptococcus* bacterium that causes strep throat can release toxins into the bloodstream. These toxins can cause scarlet fever. A red rash appears on the skin of someone infected with scarlet fever. Diphtheria, another disease caused by the *Corynebacterium diphtheriae* bacterium, infects the tissues of the throat. *C. diphtheriae* releases toxins into the bloodstream, where they destroy tissues. Diphtheria can lead to breathing problems, heart failure, paralysis, and death.

Guide for Reading

Key Concepts
- How do bacteria cause disease?
- How can bacterial growth be controlled?
- How do viruses cause disease?

Vocabulary
pathogen
vaccine
antibiotic
viroid
prion

Reading Strategy: Outlining Before you read, use the headings of this section to make an outline about disease. As you read, fill in subtopics. Then, add phrases or a sentence after each to provide key information.

▲ **Figure 19–12** By testing multiple hypotheses, Louis Pasteur was able to show that bacteria cause disease.