Section 5.1

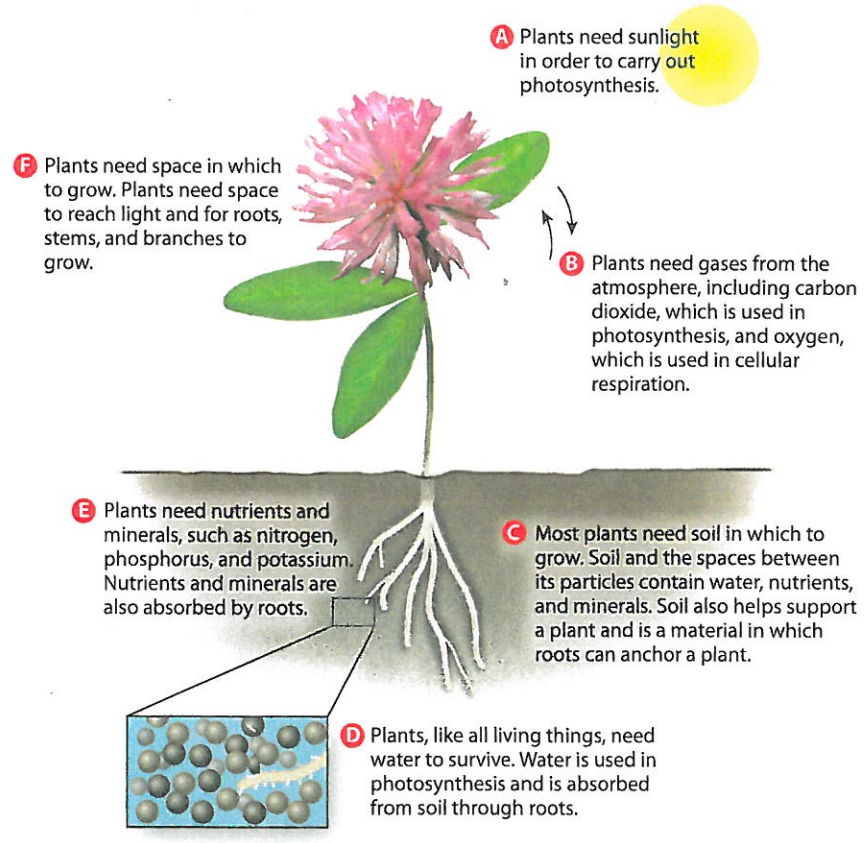
Plants and Soil

Basic Requirements of Plants

In sections 5.2 and 5.3 of this chapter, you will learn about the methods used to grow the plants we depend on for food. These include grains to make cereal, bread, and pasta; fruits and vegetables; and seeds and nuts. Before this discussion takes place, however, it is necessary to understand more about what plants need to survive, as well as the nature and properties of the life-supporting material that make it possible for plants to grow: soil.

Like all living things, plants need certain factors and conditions in order to survive in the environment where they grow and live. Figure 5.1 shows the main factors and conditions that plants need to grow, reproduce, and carry out their other life functions.

Figure 5.1 Plants need sunlight, gases from the atmosphere, water, nutrients and minerals, and space to thrive in their environment.



Pause and Reflect

1. List the factors plants need to survive.
2. Choose one of the factors you listed in question 1 and explain why it is needed for plant survival.
3. **Critical Thinking** Choose one environmental issue such as air pollution, water pollution, or global climate change and explain how it may affect a plant's ability to survive in its environment.

Components of Soil

It is common to refer casually to soil as "dirt," but this description is far from the truth. **Soil** is a loose covering of weathered (broken-down) rock particles enriched with decaying organic matter. Soil overlies the bedrock of Earth's surface. Plants anchor their roots in soil, and obtain water and nutrients from it. Soil is the product of thousands of years of activity that includes the combined action of wind, rain, the natural movements of Earth's surface, the life processes of billions of organisms that live on and in it, and the chemical compounds that result from the death and decay of those organisms. All the life-supporting regions on Earth—the forests, grasslands, and even certain parts of deserts—cannot and would not exist without soil.

soil a mixture of mineral grains, air, water, and organic material that support plant life

Soil is a mixture of four main components: mineral grains from weathered rock, air, water, and organic material. The organic material in soil includes living organisms such as worms, beetles, and bacteria, as well as the decaying remains of these and other organisms. Different soils have different proportions of the four soil components. Figure 5.2 shows the proportions of a soil that is considered to be well suited for growing agricultural crops.

Did You Know?

"The soil is the great connector of our lives, the source and destination of all."

— Wendell Berry (b. 1934) American novelist, poet, and essayist

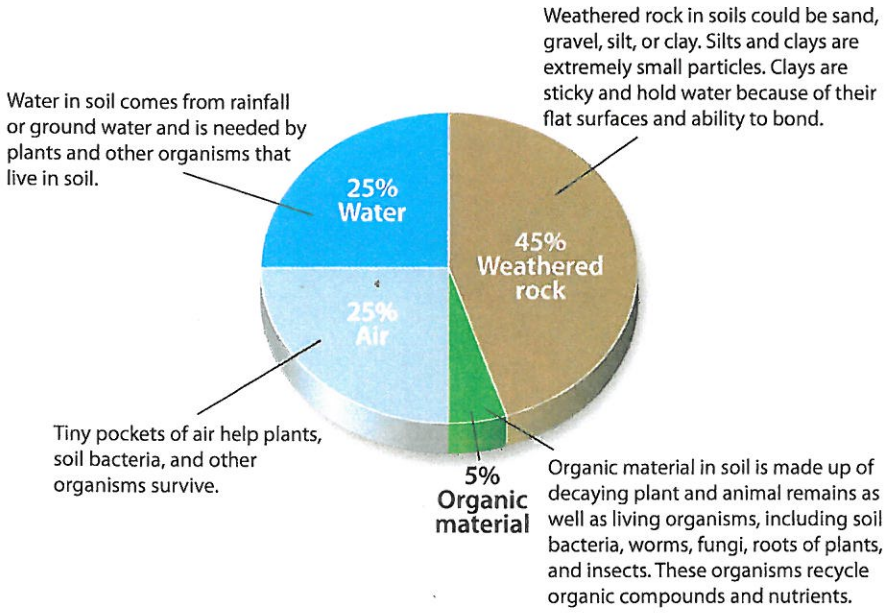


Figure 5.2 The four main components of soil are weathered rock, water, air, and organic material.

Inferring *Where do you think the air spaces in soil come from?*

Mini-Activity 5-1 Modelling the Plant-supporting Soil Layer

Carry out the following thought experiment. Your teacher might also demonstrate it for you.

- Imagine Earth as an apple cut into four equal wedges. One of these wedges represents all the land on Earth. What do the other three wedges represent?
- If you cut the land wedge in half, one of the pieces represents the part of Earth where everyone lives. What could the other piece represent?
- If you cut the land wedge into four smaller segments, one of these represents all the land on Earth that can be used to grow crops. What could the others represent?
- Suppose you peeled off the thin layer of skin on this last, tiny piece. This thin, fragile layer of skin represents the part of the soil in which all plants grow and which supplies all our food.

Why would a farmer want to understand the composition and properties of soil? Why might someone who lives in an urban (city) environment benefit from understanding soil?

Layers of Soil

soil profile the series of horizontal layers in soil

topsoil an upper layer of soil that contains nutrients and organic material

A **soil profile** is a series of horizontal layers in soil that differ in chemical make-up, physical properties, particle size, and amount of organic matter. Figure 5.3 shows a typical soil profile. Notice that just below the layer of surface litter is a layer of topsoil. **Topsoil** is an upper layer of soil that contains nutrients and organic material; this is the layer of soil in which plants have most of their roots.

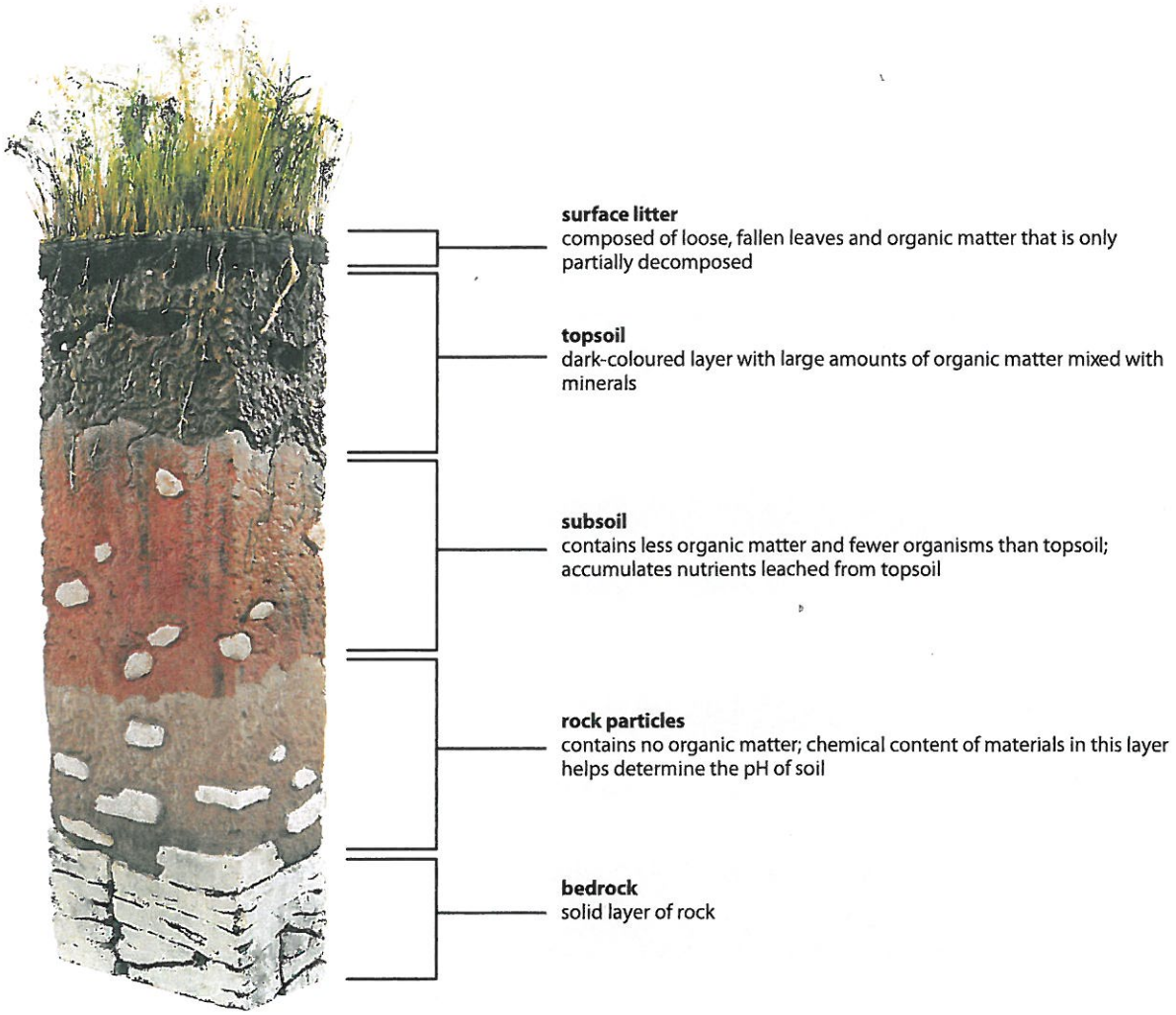


Figure 5.3 Soil has layers that differ physically, chemically, and biologically.

Inferring *Why do you think topsoil is considered an important natural resource?*

Humus: The Organic Component of Soil

humus organic material resulting from the breakdown of plant and animal remains

The organic material in soil that results from the decay of plant and animal remains is **humus**. Humus is an important part of soil that builds up on the surface and eventually becomes mixed with the top layers of mineral particles. Humus contains nutrients that are taken up by plants from soil. Humus increases the water-holding ability and the acidity of soil, which makes it easier for plants to absorb the nutrients. Humus also tends to make other soil particles stick together and helps create a loose, crumbly soil that allows water to soak in and air to be incorporated. A good soil for agricultural use will crumble and has spaces for air and water.

Living Organisms in Soil

As shown in Figure 5.4, inhabitants of soil include burrowing animals such as worms and insects, soil bacteria, fungi, and the roots of plants. One of the most important burrowing animals is the earthworm. As earthworms move through soil, they mix organic and inorganic material in soil. This mixing increases the amount of nutrients available to plants. Soil drainage is also improved by the burrowing of earthworms and other soil animals, such as mites and pill bugs.

Bacteria and fungi are important in the decay and recycling of materials. Their chemical activities change complex organic materials into simpler forms that plants can use as nutrients. For example, some of these micro-organisms can change the nitrogen contained in organic matter into nitrogen compounds that can be used by plants. When the roots of plants die and break down, they release organic matter and nutrients into the soil and provide channels for water and air.

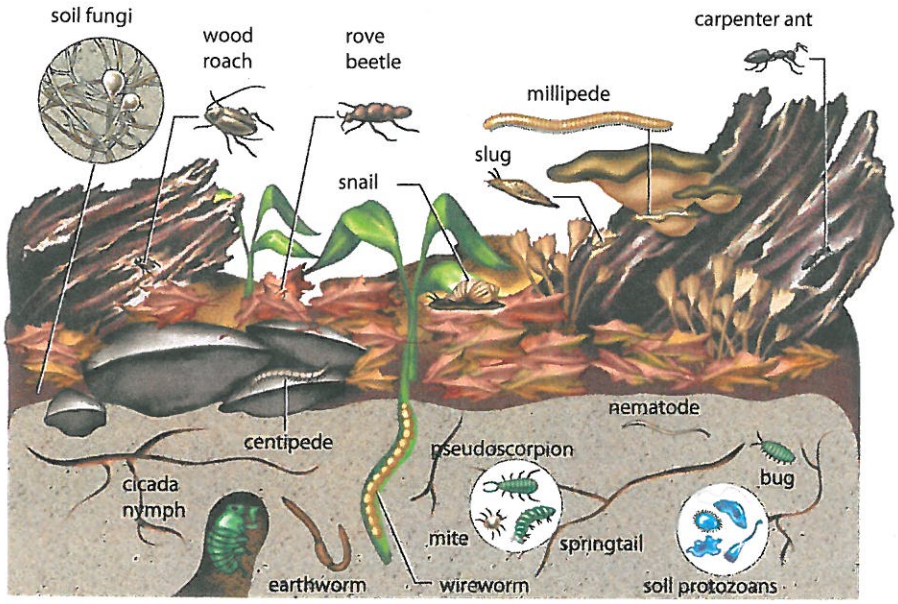


Figure 5.4 Beneath the surface of soil, countless organisms live in a sunless world. They form a network of food chains within soil and open up spaces for air and water to move through soil.

Soil Properties: Texture

Soil texture is determined by the size of the mineral particles in the soil. Particles between 0.05 and 2.0 mm in diameter are classified as sand. Silt particles range from 0.002 to 0.05 mm in diameter. The smallest particles are clay, which are less than 0.002 mm in diameter. Rarely does soil consist of a single-size particle. As shown in Figure 5.5, various particles are mixed in many different combinations, resulting in many different soil classifications. The ideal soil for agriculture is *loam*, which combines large spaces for air and water drainage with the ability of clay particles to hold nutrients and water.

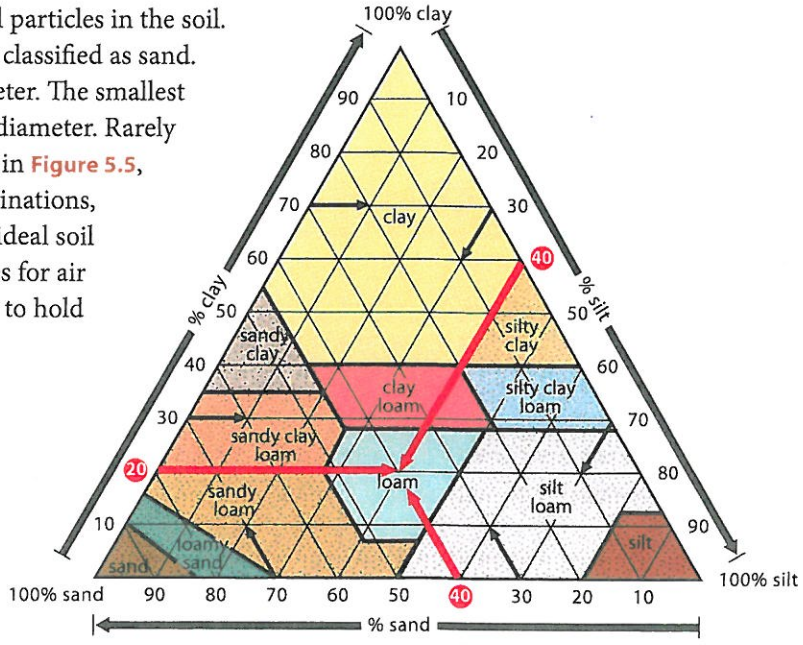


Figure 5.5 Soil texture depends on the percentage of clay, silt, and sand particles in the soil. A loam soil has the best texture for most crops.

Describing *What is the percentage of sand, silt, and clay in loam?*

Soil Properties: Porosity

The porosity of soil refers to the size and number of spaces among particles of soil. The importance of these spaces is that they allow water and air to move through soil. Different types of soil have different degrees of porosity.

Inquiry Lab 5A, Characteristics of Various Soil Samples, on page 164

As shown in Figure 5.6A, soil that is made up of particles of different sizes has spaces for both water and air. The soil in Figure 5.6B is made up of small particles that are all about the same size. This soil has less space for air. Since plant roots need both air and water, the soil in Figure 5.6A would be better able to support agricultural crops than the soil in Figure 5.6B. The amount of water and air in soil is also important for determining the numbers and kinds of organisms that live in the soil.

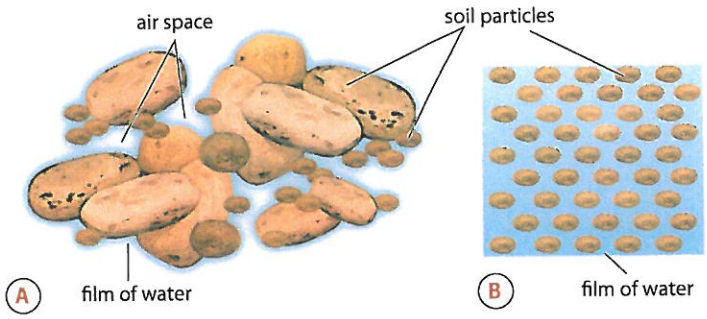


Figure 5.6 (A) The different sizes of soil particles allow air and water to move through soil. **(B)** The soil particles in this example are more uniform in size, leaving less space for air among the particles.

Explaining *Why is it important that soil contain air?*

Soil Properties: pH

pH measures how acidic or basic a substance is. A substance that has a pH of less than 7 is acidic, one that has a pH of 7 is neutral, and one that has a pH higher than 7 is basic. Most plants grow well in soil with a pH between 6 and 7, although some plants, such as blueberries and potatoes, grow well in more acidic soil.

The pH of soil depends on the amount of rainfall and the amount of organic material the soil contains. High annual rainfall makes soil more acidic. The rainwater dissolves and removes minerals such as calcium, magnesium, and potassium from soil, leaving more acidic material behind. In addition, the breakdown of organic matter tends to increase the acidity of soil.

Soil pH is important because it affects how easily nutrients can be removed from soil, and this affects the kinds of plants that will grow in the soil. In turn, the kinds of plants that grow in soil affect the amount of organic matter that farmers have to add to soil. Also, since plants need the nutrients calcium, magnesium, and potassium, their loss from soil reduces the fertility of soil. Aluminum dissolves more easily in soil that is highly acidic, and soil that is high in aluminum is toxic to many plants.

Mini-Activity 5-2 Filtering Water through Soil

- Put a piece of filter paper in a funnel, and place the funnel in a beaker or flask.

Your teacher will provide each group with a different soil sample.

- Obtain a soil sample from your teacher. Place the soil in the funnel.
- Pour 100 mL of water over the soil. Time how long it takes for the water to drain through the soil. Then measure how much water drained through.
- Describe the appearance of the water that drained through the soil. Compare your observations with those of other groups. How did the texture of the soil affect the variables you measured or described? How do you think what you observed is related to the issue of nutrients, pesticides, or other chemicals in surface water run-off from farms?

Reviewing Section 5.1

Summary

- Plants need certain factors and conditions, including light, water, and soil, in order to survive in their environment.
- Soil is a thin covering over the land made up of a mixture of minerals, organic material, living organisms, air, and water that together support the growth of plant life.
- A soil profile is a series of horizontal layers in soil that differ in chemical make-up, physical properties, particle size, and the amount of organic matter they contain.
- Humus is the organic material in soil that results from the decay of plant and animal remains.
- Inhabitants of soil include burrowing animals, such as worms and insects, soil bacteria, fungi, and the roots of plants. Bacteria and fungi are important in the decay and recycling of materials.
- Soil texture is determined by the size of the mineral particles in the soil.
- The porosity of soil refers to the size and number of spaces among particles of soil. Different types of soil have different degrees of porosity.
- Soil pH affects how easily nutrients can be removed from soil, which affects the kinds of plants that will grow.

Review Questions

1. Explain why plants need space to survive. K/U

2. From which source do plants get nutrients and minerals? K/U

3. List the four components of soil. Identify the origin of each component and describe its function. K/U

4. Identify and describe the layers in a soil profile. K/U

5. Create a flowchart or concept map to show the relationships among (a) the role of humus in soil, (b) the role of soil in plant growth, and (c) the role of plants in producing humus. C

6. Identify three organisms that live in soil and what each organism does to improve the quality of soil. K/U

7. Why is loam considered a good soil texture for growing agricultural crops? K/U

8. How is the size of the particles in soil related to its porosity? K/U

9. Soils that contain a high percentage of sand drain water very quickly. Explain why sandy soil may not be a good soil in which to grow agricultural crops. T/I A

10. The quality of soil depends on many environmental conditions, including climate, topography, and the types of particles it contains. Predict how each event or condition would affect the quality of soil in which an agricultural crop is growing. T/I A

a) too much rain

b) extreme cold

c) a steep slope

11. Soil has been described as "the ultimate resource." Develop an argument to support this statement. Develop a counter-argument in favour of some other resource that could reasonably be regarded as the "ultimate" one. C T/I

12. The table below contains information about the function of certain nutrients in plants and what happens if there is not enough of the nutrient. A T/I

Nutrient	Function	Not Enough
Nitrogen	Gives plants their dark green colour	Plants have yellowing leaves and stunted growth
Phosphorus	Helps plants develop roots, buds, and seeds	Plants grow slowly; young leaves may be greyish, older leaves may be reddish
Potassium	Builds strength and disease resistance, and improves quality of plant seeds	Plants are stunted and the edges of older leaves turn brown and die
Magnesium	Needed for photosynthesis	Leaves are yellow with green veins
Calcium	Helps develop healthy cell walls	Plants may be unable to grow new leaves, stems, or roots

a) Which nutrient is the plant in the photo lacking? Explain your reasoning.

b) You are starting a garden. You notice that some plants are not able to grow new leaves, some have stunted growth, and the older leaves are turning brown and dying. Do you live in an area with high rainfall? Explain your reasoning.