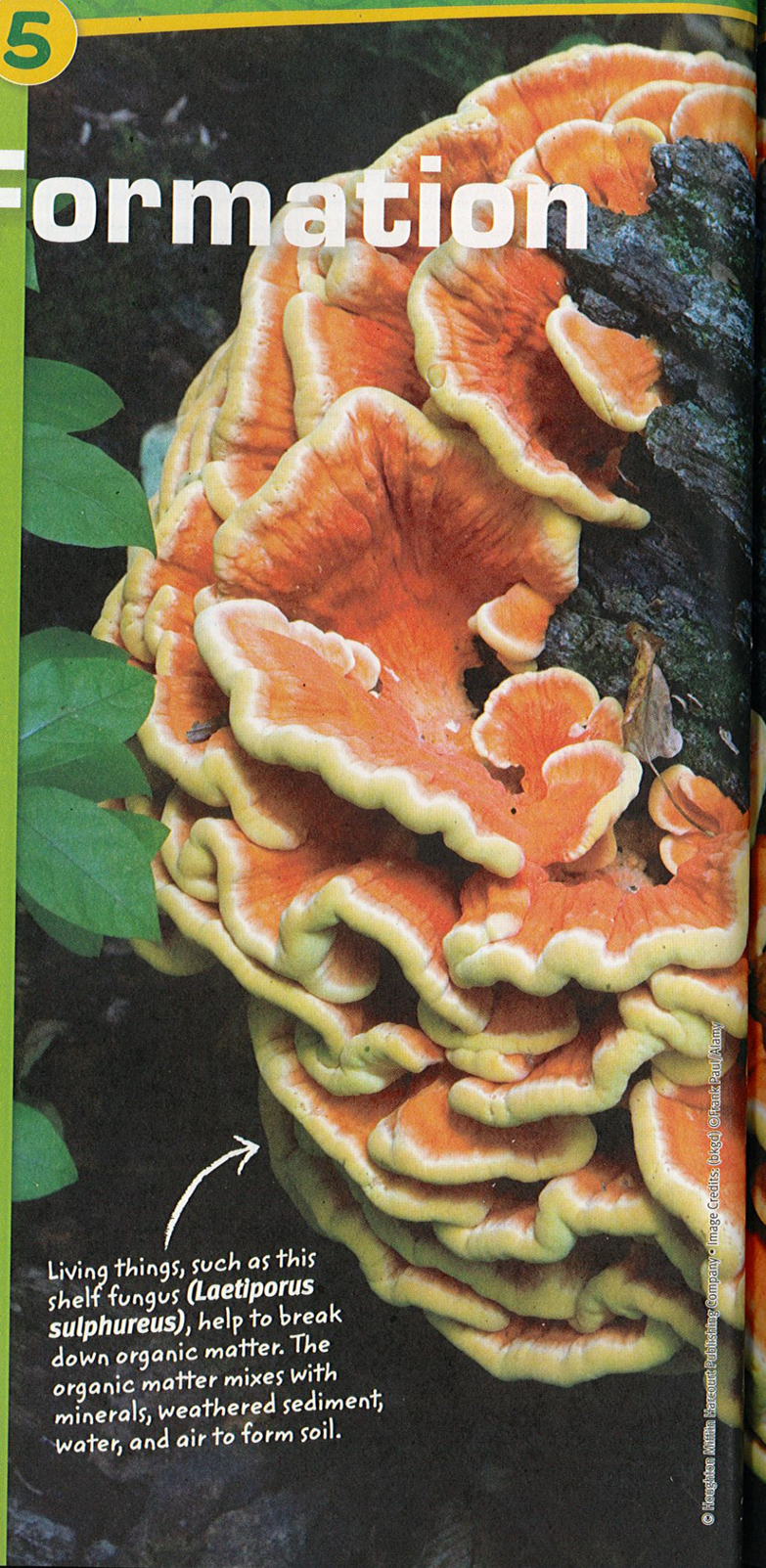
Lesson 5

Soil Formation

ESSENTIAL QUESTION

How does soil form?

By the end of this lesson, you should be able to describe the physical and chemical characteristics of soil layers and identify the factors that affect soil formation, including the action of living things.



Living things, such as this shelf fungus (***Laetiporus sulphureus***), help to break down organic matter. The organic matter mixes with minerals, weathered sediment, water, and air to form soil.

Lesson Labs

Quick Labs
- Observing Life in Soil
- Modeling a Soil Profile
- Observing the Impact of Earthworms on Soil

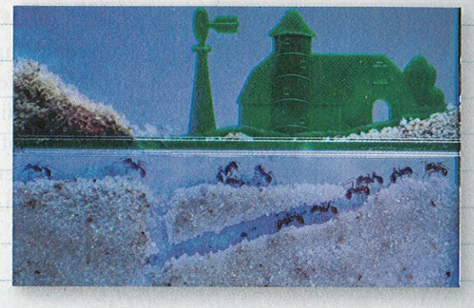
Field Lab
- Comparing Soil Characteristics

Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false.

T	F	
☐	☐	Soil contains air and water.
☐	☐	Soil does not contain living things.
☐	☐	Soils are the same from place to place.
☐	☐	Climate can affect how fertile soils are.

2 Explain How might the burrows formed by ants affect the soil?



Active Reading

3 Apply Many scientific words, such as *weather*, have more than one meaning. Use context clues to write your own definition for each meaning of the word *weather*.

Example sentence
The weather outside is nice.

weather:

Example sentence
Wind, water, and plant roots weather rock into sediment.

weather:

Vocabulary Terms

- **soil**
- **soil profile**
- **humus**
- **soil horizon**

4 Apply As you learn the definition of each vocabulary term in this lesson, write your own definition or sketch to help you remember the meaning of the term.

The Dirt on Soil

What causes soil to form?

Active Reading

5 Identify As you read, underline the different substances that make up soil.

Soil is important to your life. You walk on grass that is rooted in soil. You eat foods that need soil in order to grow. But what exactly is soil? Where does it come from? How does it form?

A scientist might define **soil** as a loose mixture of small rock fragments, organic matter, water, and air that can support the growth of vegetation. The very first step in soil formation is the weathering of *parent rock*. Parent rock is the source of inorganic soil particles. Soil forms directly above the parent rock. Soil either develops here, or it is eroded and transported to another location.

Weathering of Parent Rock

Weathering breaks down parent rock into smaller and smaller pieces. These pieces of rock eventually become very small particles that are mixed in with organic matter to form soil. The process of soil formation can take a very long time. The amount of time it takes depends on many factors that you will learn about later in this lesson.

Soil formation begins when parent rock weathers into small fragments.

Plant roots grow and can break down sediment even further.

Burrowing animals increase the rate of weathering. They mix the soil, allowing more air to enter. They bring sediment to the surface where it is weathered more quickly by water, wind, and organisms.

Decomposition and Mixing by Living Things

Some microorganisms, such as bacteria and fungi, are decomposers that live in soil. These tiny decomposers perform the important task of breaking down the remains of plants and animals. These remains are decayed organic matter called **humus**. Humus is found in the top layer of soils. It is important because it contains nutrients that plants need to grow. Plants take up these nutrients through their roots. When plants or animals die, they are broken down by decomposers, and the nutrients are returned to the soil.

Larger animals, such as earthworms and moles, also live in soil. They loosen and mix the soil as they burrow through it. The mixing increases the amount of air in soil and improves the ability of soil to drain water.

6 Apply How might a fallen leaf eventually become part of soil?

7 Summarize How do decomposers and plants cycle nutrients in soil?

At least a million microorganisms can fit into one spoonful of soil! These tiny organisms have the big job of decomposing plant and animal remains.

Thick Tops, Rocky Bottoms

What factors determine how long it takes for soils to form?

Soil formation and development are processes that take place over a very long period of time. There are four main factors in determining exactly how long these processes take. They include the parent rock type, climate, topography, and plants and animals.

- Rock type: Certain rock types weather at different rates and in different ways. The rate of weathering depends on the structure of the rock and minerals that make up the rock.
- Climate: Soil usually develops more quickly in warm, wet areas than in cold, dry areas.
- Topography: Sediments on steep slopes are often eroded. Soils usually develop faster in flatter areas where sediments are not easily eroded.
- Plants and animals: Plant roots hold sediments in place, allowing soil to develop quickly. Areas teeming with life have higher rates of decomposition and mixing. Soils tend to develop more quickly in these areas. Without a lot of plants and animals, soil tends to develop slowly.

Active Reading

8 Identify As you read, underline the factors that affect how long it takes for soils to form and develop.

9 Compare List some possible characteristics of an area where soils would develop quickly. Then do the same for an area where soils would develop slowly.

Area where Soils Develop Quickly	Area where Soils Develop Slowly

What are the main soil horizons?

Picture the rich, dark soil in a garden. Now imagine what the soil looks like as you dig deeper beneath the surface. Does the soil look and feel the same as you dig deeper? A vertical section of soil that shows all of the different layers is a **soil profile**. Each layer in the soil profile that has different physical properties is called a **soil horizon**. The main horizons include the A horizon, B horizon, and C horizon. There are many other horizons as well.

A Horizon

The A horizon is at the top of the soil profile. It is often referred to as *topsoil*. Decomposers live in this horizon, so it has the most decayed organic matter. This humus gives it a dark color. Plant roots break up fragments and animals burrow and mix the the soil. These processes increase the rate of weathering, so the A horizon is usually the most developed. As you'll learn later in this lesson, rich soils generally have high amounts of humus. Dead leaves, branches, and other organic matter may cover the surface of the A horizon.

B Horizon

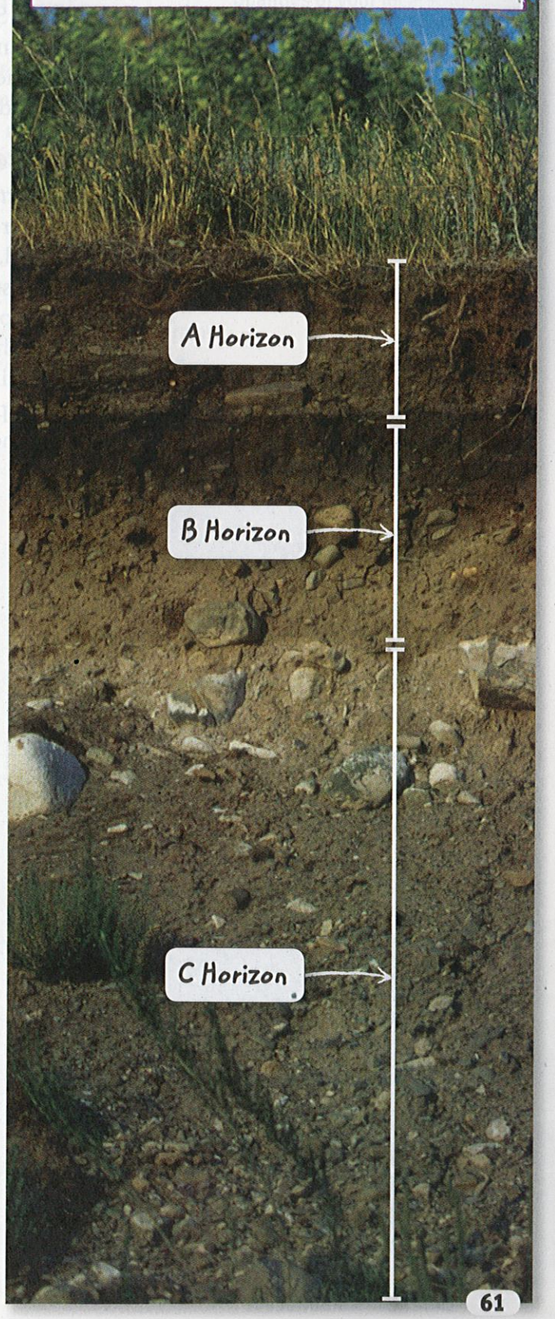
The B horizon lies below the A horizon. It is not as developed as the A horizon and has less humus. Following precipitation events, water seeps down through the A horizon. Water carries material, such as iron minerals and clay, from the A horizon down to the B horizon. This is known as *leaching*. The leached materials commonly give the B horizon a reddish or brownish color.

C Horizon

The C horizon lies below the B horizon. It is the least-developed soil horizon. It contains the largest rock fragments and usually has no organic matter. The C horizon lies directly above the parent rock. Recall that this is the weathered rock from which the soil was formed.

Visualize It!

10 Analyze Which soil horizon contains the largest rocks?



All About Soil

What are some properties of soil?

Plants grow well in some soils and poorly in others. Soils look and feel different. They also contain different minerals and particles. Soil properties are used to classify different soils. These properties include soil texture, color, chemistry, pore space, and fertility.

Soil Texture

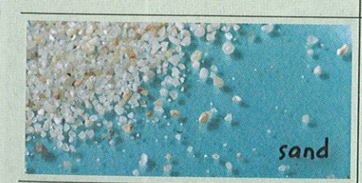
Active Reading

11 Identify As you read, underline the three kinds of soil particles.

The term *soil texture* is a property that describes the relative amounts of differently sized soil particles. Soil particles are classified as sand, silt, or clay. Most soils are a mixture of all three. Sand is the largest particle, ranging from 0.05 mm to 2 mm. Soils containing a lot of sand feel coarse. Silt particles are smaller than sand particles. They range from 0.002 mm to 0.05 mm. Silty soils have a smooth, silky feel. At less than 0.002 mm, clay particles are the smallest soil particles. Clayey soils feel very smooth and are usually sticky when they are wet.

Visualize It!

12 Distinguish The last space in each row contains three circles. Fill in the circle that shows the correct relative size of the particle shown in that row.

Particle	Size Range	Relative Size
 sand	0.05 mm–2 mm	
 silt	0.002 mm–0.05 mm	
 clay	less than 0.002 mm	

Soil Color

Soils can be black, brown, red, orange, yellow, gray, and even white. Soil color is a clue to the types and amounts of minerals and organic matter in the soil. Iron minerals make soil orange or reddish. Soils that contain a lot of humus are black or brown. Color can also be a clue about the environmental conditions. Gray soil can indicate that an area is often wet and has poor drainage.

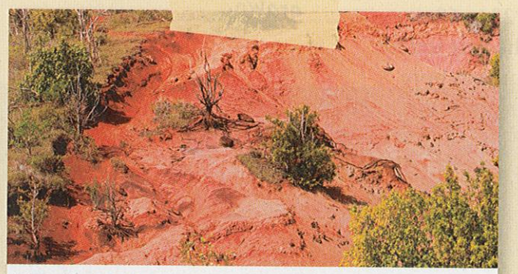
Soils are usually a mixture of colors, such as reddish brown. Scientists use the Munsell System of Color Notation to describe soil colors. The system uses a book of color chips, much like the paint chips found in a paint store. Scientists compare a soil to the color chips in the book to classify soils.

Think Outside the Book

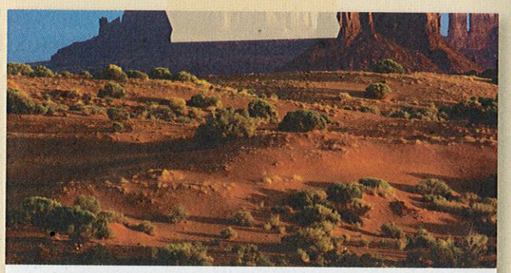
13 Apply Find out about the qualities of your local soil. Describe its texture, color, chemistry, pore space, and fertility. Choose one of these activities to present your description: draw a poster or diagram, create a brochure, or write a poem.

Soil and Climate

Climate can affect how soil forms in different regions on Earth. Warm, rainy regions produce tropical soils and temperate soils. Dry regions produce desert soils and arctic soils.



Tropical Soils form in warm, wet regions. Heavy rains wash away and leach soils, leaving only a thin layer of humus. Soil development is fast in these regions. They are not suitable for growing most crops.



Desert Soils form in dry regions. These soils are shallow and contain little organic matter. Because of the low rainfall, chemical weathering and soil development is slow in desert regions.

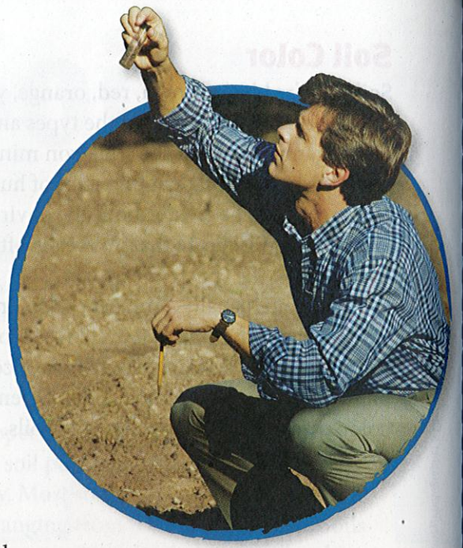
Temperate Soils form in regions with moderate rainfall and temperatures. Some temperate soils are dark-colored, rich in organic matter and minerals, and good for growing crops.

Arctic Soils form in cold, dry regions where chemical weathering is slow. They typically do not have well-developed horizons. Arctic soils may contain many rock fragments.

Soil Chemistry

Soil pH is determined by the combination of minerals, sediment, and organic matter found in soil. The pH of soil is a measure of how acidic or basic a soil is. The pH is based on a scale of 0 to 14. If pH is less than 7, the soil is acidic. If pH is above 7, the soil is basic. In the middle of the pH scale is 7, which means the soil is neither acidic nor basic; it is neutral. Scientists measure soil pH to determine whether the soil can support different plants. For example, soybeans grow best in a soil with a pH between 6.0 and 7.0. Peanuts thrive when the pH of soil is between 5.3 and 6.6.

Farmers can adjust the pH of soil to meet the needs of their plants. They can add lime to make acidic soils more basic. They can add acids to make basic soils more acidic.



The pH of a soil can be tested to make sure it will support the plants being grown.

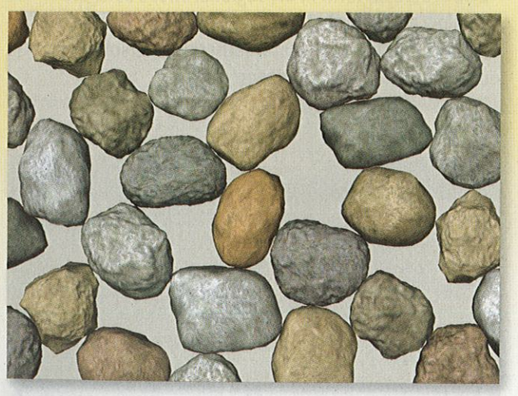
Pore Space

Pore space describes the spaces between soil particles. Water and air are found in the pore spaces of soils. Water and air move easily through soils with many well-connected pore spaces. Soils with this property are well-drained and typically good for plant growth.

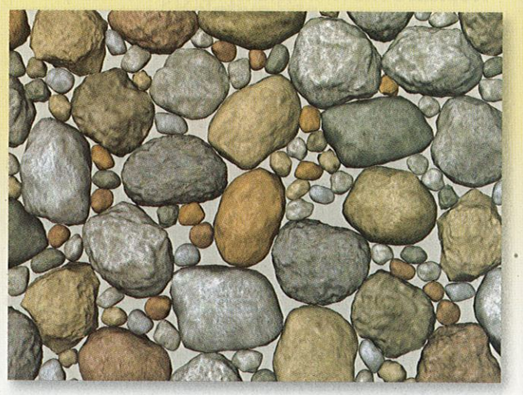
Plants need both water and air to grow. About 25 to 60 percent of the volume of most soils is pore space. The best soil for growing most plants has about 50 percent of its volume as pore space, with that volume equally divided between water and air.

Visualize It!

14 Describe Write a caption that describes the pore space for each diagram below.



A _____



B _____

Soil Fertility

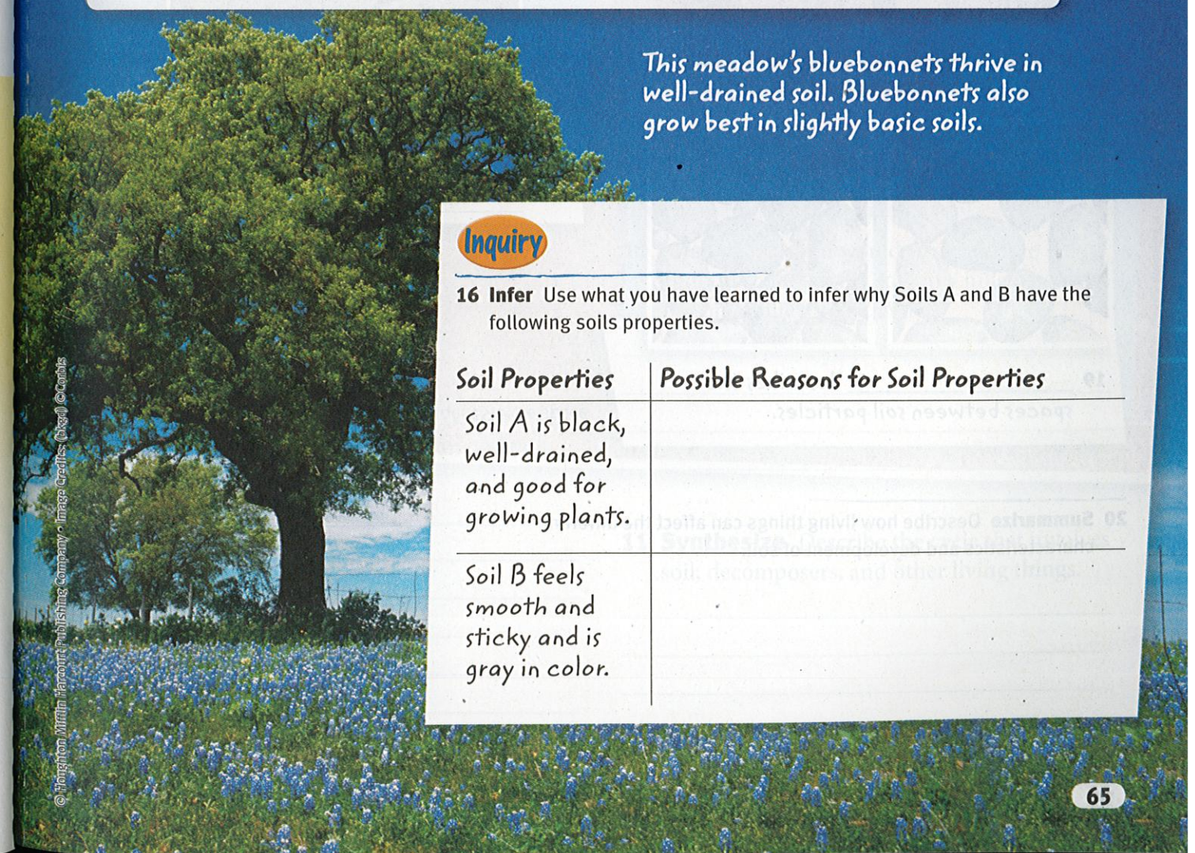
Soil fertility describes how well a soil can support plant growth. This quality is affected by factors that include the climate of the area; the amount of humus, minerals, and nutrients in the soil; and the topography of the area.

Fertile soils are often found in areas with moderate rainfall and temperatures. Soils with a lot of humus and the proper proportions of minerals and nutrients have high soil fertility. Soils found in dry areas or on steep hillsides often have low fertility. Farmers can add chemical fertilizers or organic material to soils to improve soil fertility. They also can grow crops, such as legumes, to restore certain nutrients to soil or leave cropland unplanted for a season to replenish its fertility.

Active Reading **15 Apply** What could you do to improve the fertility of the soil in your garden?

_____

_____



This meadow's bluebonnets thrive in well-drained soil. Bluebonnets also grow best in slightly basic soils.

Inquiry

16 Infer Use what you have learned to infer why Soils A and B have the following soils properties.

Soil Properties	Possible Reasons for Soil Properties
Soil A is black, well-drained, and good for growing plants.	
Soil B feels smooth and sticky and is gray in color.	

Visual Summary

To complete this summary, fill in the blanks with the correct word. Then use the key below to check your answers. You can use this page to review the main concepts of the lesson.

Soil Formation

Soil formation involves weathering of rock, addition of organic material, and actions by plants and animals that live in the soil.

17 In general, soils in cold, dry areas will take _____ to develop than soils in warm, wet areas.

Characteristics of soil include texture, color, chemistry, pore space, and soil fertility.

19 _____ describes the spaces between soil particles.

A soil profile commonly has the A horizon, B horizon, and C horizon. They each have distinct physical characteristics.

18 The _____ contains the most organic matter; leaching carries minerals and humus down to the _____.

Answers: 17 longer; 18 A horizon, B horizon; 19 Pore space

20 **Summarize** Describe how living things can affect the different characteristics and development of soil.

Lesson Review

Vocabulary

Draw a line to connect the following terms to their definitions.

1 soil	A decomposed organic matter
2 humus	B layer of soil with distinct physical properties in a soil profile
3 soil profile	C vertical section showing the soil horizons
4 soil horizon	D mixture of weathered sediment, organic material, water, and air

Key Concepts

5 **Identify** What is the first step of soil formation?

6 **Explain** What are the main factors that determine how long it takes for a soil to form and develop?

7 **Describe** How would a soil that developed in a warm, wet place be different than one that developed in a hot, dry place?

8 **Compare** How might a dark colored, coarse soil differ from a reddish, smooth soil?

Critical Thinking

Use this table to answer the following question.

Climate Data for Locations A and B

	Average Yearly Temperature (°C)	Average Yearly Precipitation (cm)
Location A	27	190
Location B	3	26

9 **Analyze** In which location would soils develop faster? Explain.

10 **Infer** Which soil would you expect to be better developed: the soil on a hillside or the soil on a valley floor? Why?

11 **Synthesize** Describe the cycle that involves soil, decomposers, and other living things.