Chapter 8

Weathering and Soil

North Carolina Essential Standards

6.E.2.3 Explain how the formation of soil is related to the parent rock type and the environment in which it develops.

6.E.2.4 Conclude that the good health of humans requires: monitoring the lithosphere, maintaining soil quality and stewardship.

Weathering and Soil

Weathering

Before You Read

What do you think? Read the three statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	1. Any two rocks weather at the same rate.	
	2. Humans are the main cause of weathering.	
	3. Plants can break rocks into smaller pieces.	

Read to Learn

Weathering and Its Effects

Everything around you changes over time. Brightly painted walls slowly fade. Shiny cars become rusty. Things made of wood dry out and change color. These changes are some examples of weathering. *The mechanical and chemical processes that change objects on Earth's surface over time are called* **weathering.**

Weathering also changes Earth's surface. Earth's surface in the past was different from what it is today and what it will be in the future. Weathering processes break, wear, abrade, and chemically alter rocks and rock surfaces.

Over thousands of years, weathering can break rock into smaller and smaller pieces. These pieces, also known as sediment, are called sand, silt, and clay. Sand grains are the largest soil pieces. The smallest pieces are clay. Weathering also can change the chemical makeup of rock. Chemical changes can make a rock easier to break down.

Mechanical Weathering

Mechanical weathering *occurs when physical processes naturally break rocks into smaller pieces.* Mechanical weathering does not change the chemical makeup of a rock. When granite is broken up by mechanical weathering, the smaller pieces that result are still granite.

Key Concepts

- How does weathering break down or change rock?
- How do mechanical processes break rocks into smaller pieces?
- How do chemical processes change rocks?

Study Coach

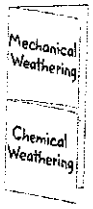
Identify Main Ideas Work with a partner. Read a paragraph to yourselves. Then discuss what you learned in the paragraph. Continue until you and your partner understand the main ideas of this lesson.

Key Concept Check

1. Describe How does weathering break down or change rock?

FOLDABLES

Make a two-tab book to organize your notes about how mechanical and chemical weathering affect rocks.



Key Concept Check

2. Summarize What is the result of a rock undergoing mechanical weathering?

Math Skills

The area (A) of a rectangular surface is the product of its length and its width.

$$A = l \times w$$

Area has square units, such as square centimeters (cm^2).

The surface area (SA) of a rectangular solid is the sum of the areas of all of its sides.

3. Use Geometry A rock sample is a cube and measures 3 cm on each side.

a. What is the surface area of the rock?

b. If you break the sample into two equal parts, what is the total surface area now?

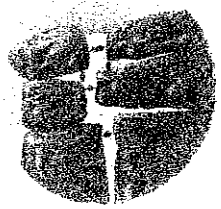
Examples of Mechanical Weathering

Mechanical weathering occurs when the high temperatures that result from a forest fire cause nearby rocks to expand and crack. The table below describes other examples and causes of mechanical weathering.

Causes of Mechanical Weathering

Ice Wedging

Ice wedging is also called frost wedging. Water enters cracks in rocks. When the temperature reaches 0°C, the water freezes. As shown in the illustration, water expands as it freezes and widens the crack. Repeated freezing and thawing can break rocks apart.



Abrasion

Abrasion grinds away rock by friction or impact. For example, a strong current in a stream can carry loose fragments of rock downstream. The rock fragments tumble and grind against one another. Eventually, the fragments grind themselves into smaller and smaller pieces. Glaciers, wind, and waves along ocean or lake shores can also cause abrasion.

Plants

Imagine a plant growing into the crack in a rock. As the plant grows, its stem and roots get longer and wider. The growing plant pushes on the sides of the crack. Over time, the rock breaks.

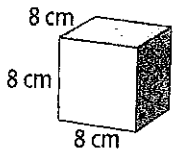
Animals

Animals that live in soil make holes in the soil. Water enters the holes and causes weathering. Animals also help break down rocks as they dig through loose rocks.

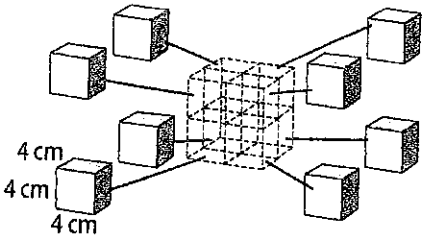
Surface Area

Surface area is the amount of space on the outside of an object. When a large rock breaks into pieces, the smaller pieces have more total surface area than the original rock did. The rate of weathering of a rock depends on the amount of surface area exposed to the environment. The cubes at the top of the next page represent rock surface area.

Sand and clay are both the result of mechanical weathering. If you pour water on sand, some of the water sticks to the surface. Clay particles are smaller than sand particles. If you pour the same amount of water on an equal volume of clay, more water sticks to its surfaces. More surface area means that weathering will have a greater effect on soil with smaller particles.



Surface area of cube = 6 equal squares
Surface area = 6 squares × 64 cm^2 square
Surface area = 384 cm^2



Surface area of 8 cubes = 48 equal squares
Surface area = 48 squares × 16 cm^2 square
Surface area = 768 cm^2

Chemical Weathering

Chemical weathering *changes the materials that are part of a rock into new materials.* A chemically weathered piece of granite is no longer granite.

Water and Chemical Weathering

Water is important in chemical weathering because most substances dissolve in water. The minerals that make up most rocks dissolve very slowly in water. Over several years, the mineral might not show any signs of dissolving.

When a rock dissolves, its minerals break up into smaller parts in solution. For example, table salt is sodium chloride. When table salt dissolves in water, the salt breaks into sodium ions and chlorine ions. Ions are atoms that have electrical charges.

Dissolving by Acids

Acids cause chemical weathering to occur at a faster rate than rain or water does. Acids attract atoms away from rock minerals and dissolve them in the acid.

Scientists use pH, a property of solutions, to classify chemical liquids as acidic, basic, or neutral. They measure the pH of a solution on a scale from 0 to 14. The pH of an acid is between 0 and 7. The pH of vinegar is 2 to 3, so it is an acid.

Carbon dioxide in the air forms a weak acid when it reacts with rainwater. Acid rain, which has a pH of 4.5 or less, dissolves rocks.

Acid-forming chemicals enter the air from natural sources such as volcanoes. Polluting chemicals also enter the air. For example, burning coal releases sulfur oxides into the atmosphere. Sulfur oxides dissolve in rain and produce acid rain. Acid rain is more acidic than normal rainwater. It has a pH of 4.5 or less. It can cause more chemical weathering than normal rain causes.

Visual Check

4. Generalize When mechanical weathering breaks a rock into smaller pieces, which will have the most total surface area: the whole rock or its smaller pieces?

_____

Reading Check

5. Contrast How does chemical weathering differ from mechanical weathering?

_____

_____

_____

_____

_____

Reading Check

6. Interpret How can pollutants create acid rain?

_____

_____

_____

Oxidation

Oxidation is another process that causes chemical weathering. **Oxidation** *combines the element oxygen with other elements or molecules.* Most of the oxygen needed for oxidation comes from the air.

Adding oxygen to a substance produces an oxide. Iron oxide is a common oxide of Earth materials. The useful ore hematite is also an oxide of iron.

The outside of a rock has the most contact with oxygen in the air. Therefore, the outer part oxidizes the most. When a rock that contains iron oxidizes, a layer of red iron oxide forms on the gray, outside surface of the rock. The oxidized minerals in the outer layer are different from the minerals in the center of the rock.

Key Concept Check

7. Explain How does chemical weathering change rock?

What affects weathering rates?

Similar rocks can weather at different rates. The environment in which weathering occurs helps determine the rate of weathering.

ACADEMIC VOCABULARY
environment
(noun) the physical, chemical, and biotic factors acting in a community

Both types of weathering depend on water and temperature. Mechanical weathering requires repeating cycles of wetting and drying or freezing and thawing. As a result, mechanical weathering occurs most rapidly in locations that have frequent temperature changes. Chemical weathering occurs most rapidly in warm, wet places, such as regions near the equator.

Reading Check

8. Analyze Why is weathering slow in cold, dry places?

The type of rock being weathered also affects the rate of weathering and the kinds of products that result. Rocks can be made of one mineral or many minerals. The most easily weathered mineral determines the rate at which the entire rock weathers.

For example, mechanical weathering occurs more easily on rocks that contain minerals with low hardness. The mechanical weathering exposes more surface area, which helps chemical weathering occur more easily. The size and number of holes in a rock also affect the rate at which a rock weathers.

Mini Glossary

chemical weathering: the chemical processes that change the materials that are part of a rock into new materials

mechanical weathering: the physical processes that naturally break rocks into smaller pieces

oxidation: the chemical process that combines the element oxygen with other elements or molecules

weathering: the mechanical and chemical processes that change objects on Earth's surface over time

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that explains how acids and chemical weathering are related.

_____

_____

2. Fill in the table below to distinguish between mechanical and chemical weathering. Use these phrases:
   - Breaks up rocks
   - Fastest in warm, wet places
   - Fastest where temperature changes a lot
   - Changes rock materials into new materials

Mechanical Weathering	Chemical Weathering
• _____	• _____
_____	_____
• _____	• _____
_____	_____

3. Which idea that you and your partner discussed was hardest to understand? How did discussing the idea with a partner help you better understand it?

_____

_____

_____

What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

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Log on to ConnectED.mcgraw-hill.com and access your textbook to find this lesson's resources.

Name _____ Date _____

Weathering and Soil

What natural processes break down rocks and begin soil formation?

Before You Read

Before you read the chapter, think about what you know about weathering and soil formation. Record your thoughts in the first column. Pair with a partner, and discuss his or her thoughts. Write those thoughts in the second column. Then record what you both would like to share with the class in the third column.

Think	Pair	Share

Chapter Vocabulary

Lesson 1	Lesson 2
NEW weathering mechanical weathering chemical weathering oxidation **ACADEMIC** environment	**NEW** soil organic matter pore decomposition parent material climate topography biota horizon **REVIEW** sediment

Lesson 1 Weathering

Scan *Lesson 1. Read the lesson titles and bold words. Look at the pictures. Identify three facts that you discovered about weathering. Write your facts in your Science Journal.*

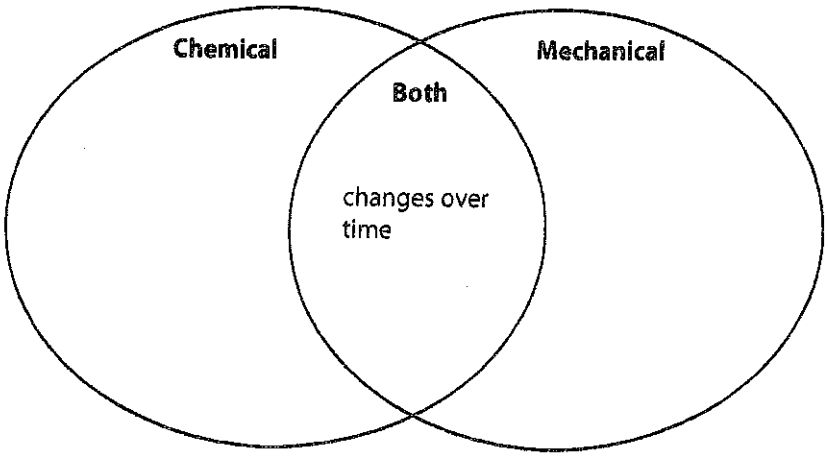
Main Idea

Weathering and Its Effects

I found this on page _____.

Details

Compare and contrast *information about* weathering.



Mechanical Weathering

I found this on page _____.

Analyze *information about* mechanical weathering. *Complete the cause-and-effect chart.*

Cause →	Effect
_____	Water collects in the cracks of a rock and freezes. The frozen water widens the cracks. Repeated thawing and freezing breaks the rock apart.
Abrasion	_____ Examples: _____ _____
Plants	_____ _____ _____
Animals	_____ _____ _____ _____

I found this on page _____.

I found this on page _____.

I found this on page _____.

Main Idea

I found this on page _____.

Details

Sequence *the process of* mechanical weathering.

Mechanical weathering breaks _____ rocks into _____ ones.

↓

The smaller rocks have _____ than the one large rock.

↓

Rock material with _____ can hold more _____ for plants.

Chemical Weathering

I found this on page _____.

Organize *information about* chemical weathering.

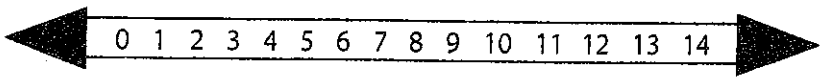
Chemical Weathering

Water _____ minerals in rock.

- **Normal Rain**
  - pH: _____
  - causes some _____ _____
- **Acid Rain**
  - pH: _____ _____
  - caused by _____ in air reacting with rain water
  - causes much more chemical weathering than _____

I found this on page _____.

Identify pH *ranges. Color the* pH *range for normal rain blue, and color the* pH *range for the acid rain red.*

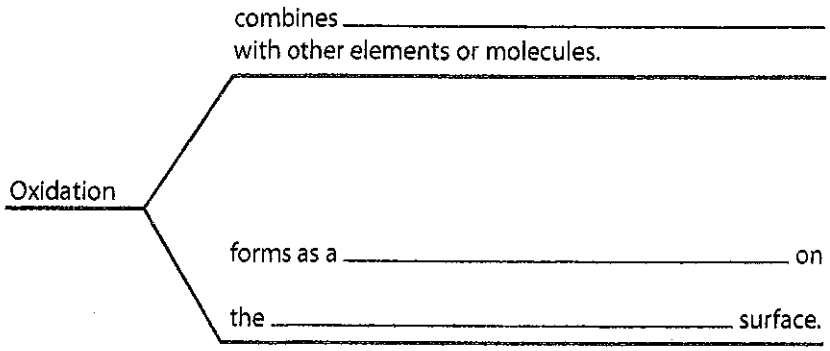


Main Idea

I found this on page _____.

Details

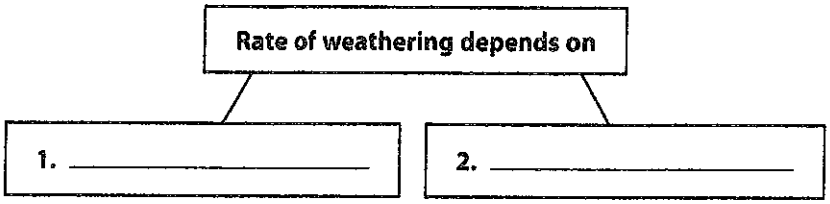
Analyze oxidation *using the graphic organizer.*



What affects weathering rates?

I found this on page _____.

Identify *the factors that affect the rate of* weathering. *Complete the sentences explaining how each factor affects* mechanical *and* chemical weathering.



1. Mechanical weathering requires _____ _____. Chemical weathering occurs more rapidly in _____ climates.
2. _____ are weathered more easily by mechanical and chemical weathering than _____.

Connect It The granite statue of a hero in the local park is discolored. Your friend suggests that rain will clean the statue. Do you agree with your friend? Explain your response.

_____

_____

_____

_____

_____

_____

CHAPTER 8
LESSON 2

Weathering and Soil

Soil

Key Concepts

- How is soil created?
- What are soil horizons?
- Which soil properties can be observed and measured?
- How are soils and soil conditions related to life?

Before You Read

What do you think? Read the three statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	4. Air and water are present in soil.	
	5. Soil that is 1,000 years old is young soil.	
	6. Soil is the same in all locations.	

Study Coach

Make an Outline Create an outline of the lesson, using the headings as your main outline items. Add main ideas below the headings. Use the outline to review what you read in this lesson.

Read to Learn

What is soil?

Soil *is a mixture of weathered rock, rock fragments, decayed organic matter, water, and air.* About half the volume of soil is solid materials. The other half is liquids and gases. Weathering breaks rocks into smaller pieces. These fragments, however, do not become good soil until plants and animals live in them. Plants and animals add organic matter to rock fragments. **Organic matter** *is the remains of something that was once alive.*

Soil contains varying amounts of water and air in the *small holes and spaces in soil called* **pores.** Soil pores are important because water flows in and through them. The movement of water through the pores is known as porosity.

The Organic Part of Soil

Organic matter in soil includes leaves, dead insects, and waste products of animals. As living things die and fall to the ground, organisms that live in the soil decompose these materials for food. **Decomposition** *is the process of changing once-living material into dark-colored organic matter.*

Organic matter affects soil properties. Dark soil absorbs sunlight, while organic matter holds water and provides plant nutrients. Organic material holds minerals in clusters. This helps keep pores open for water and air to move in soil.

Reading Check

1. Describe How is decomposition related to organic matter?

The Inorganic Part of Soil

The term *inorganic* describes materials that have never been alive. Mechanical and chemical weathering of rocks into fragments forms inorganic matter in soil. Scientists classify the soil fragments according to their sizes. Rock fragments can be boulders, cobbles, gravel, sand, silt, or clay. Larger particles have larger pores between them. Sand particles are larger than silt, so sand drains more easily than silt because sand has larger pores. The smaller particles in silt store more water in the soil.

Formation of Soil

Not all soils are the same. The five factors of soil formation determine the type of soil that forms. These five factors are parent material, climate, topography, biota, and time.

Parent Material

Parent material *is the starting material of soil.* It is the rock or sediment that weathers and forms the soil. Soil can develop from rock that weathers in the same place where the rock first formed. This rock is called bedrock. Wind and water can also carry away the rock particles and form soil in a different location. The particle size and type of parent material determine the properties of the soil that develops.

Climate

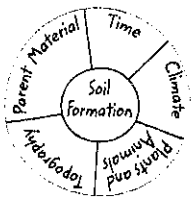
Climate *is the average weather of an area.* Some measures of climate are the amount of precipitation and the daily and average annual temperatures. Soil can form rapidly if the parent material is in a warm, wet climate. Large amounts of rain can speed up the weathering of rock. Warm temperatures speed up weathering by increasing the rate of chemical changes. Weathering rates also increase in locations where freezing and thawing occur.

Topography

Is the land where you live hilly or flat? If it is hilly, are the hills steep or gentle? **Topography** *is the shape and steepness of the landscape.* The topography of an area determines what happens to water that reaches the soil surface. For example, in flat landscapes, most of the water enters the soil. Water speeds up weathering. In steep landscapes, much of the water runs downhill. This water carries soil with it and leaves some slopes bare of soil. Rock and sediment collect at the bottom of a steep slope. There, they undergo further weathering.

FOLDABLES

Divide a circle into five parts to record information about the factors of soil formation.



Key Concept Check

2. Specify What is the role of parent material in creating soil?

_____

_____

_____

Reading Check

3. Explain Why do soils form rapidly in warm, moist climates?

_____

_____

_____

Biota

A variety of organisms, from rodents to bacteria, live in soil. **Biota** (bi OH tuh) *is all of the organisms that live in a region.* Biota in the soil help speed up soil formation. Some soil biota form passages for water to move through. Most soil organisms decompose organic matter. Mature soils form over thousands of years as plants, animals, and other processes break down bedrock and subsoil.

Key Concept Check
4. Express How does biota aid in soil formation?

Time

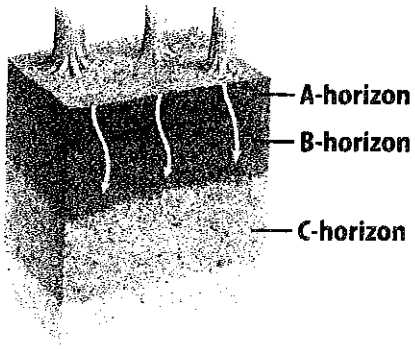
Weathering constantly acts on rock and sediment. As a result, soil forms constantly, but slowly. Soil is still young after a thousand years. Mature soils develop layers as new soil forms on top of older soil. Each layer has different characteristics as organic matter is added or as water carries elements and nutrients downward.

Horizons

Soil has layers, called horizons. **Horizons** *are layers of soil formed from the movement of the products of weathering.* The materials in a horizon determine its characteristics. Not every soil has the same horizons. The figure below shows the three horizons common to most soils: the A-horizon, B-horizon, and C-horizon. The top, organic layer is called the O-horizon. Below the C-horizon is an unweathered, bedrock layer called the R-horizon.

Key Concept Check
5. Define What are soil horizons?

A-horizon If you dig a shallow hole in soil with your fingers, you will see the A-horizon. Organic matter from the decay of roots and the action of soil organisms often make this horizon excellent for plant growth. Because it contains most of the organic matter in the soil, it is usually darker than other horizons.



Visual Check
6. Analyze One horizon contains a lot of clay, and another horizon is dark. Of these two horizons, which is on top? Explain your answer.

B-horizon Recall that weathering creates clay particles. When water from rain or snow moves through pores in the A-horizon, it carries clay particles. Water then deposits clay and other materials below the upper layer, forming the B-horizon.

C-horizon The C-horizon is the layer of weathered parent material. Parent material can be rock or sediments.

Soil Properties and Uses

Soil horizons in different locations have different properties. Properties are characteristics used to describe something. The table below describes several soil properties. The properties of a soil determine the best use of that soil. For example, plants grow well in soil that is young, deep, and has few horizons.

Visual Check

7. Apply In the table, highlight the two properties that best describe the soil in this statement: *Rainwater seeps easily into an area's sandy soil.*

Soil Properties	
Color	Different soils have different color properties. Soil can be yellow, brown, or red. It can be light or dark. The intensity of the color can vary.
Texture	The texture of soil ranges from boulder-sized pieces to very fine clay.
Structure	Soil structure describes the shape of the soil clumps and how the particles are held together. Structure can be grainy, blocky, and even prism shaped.
Consistency	Consistency is the hardness or softness of a soil. Consistency varies with moisture. For example, some soils have a soft, slippery consistency when they are moist.
Infiltration	Infiltration describes how fast water enters a soil.
Soil moisture	The moisture content of a soil is the amount of water in its pores.
pH	Most soils have a pH between 5.5 and 8.2. Soils can be more acidic in humid environments.
Fertility	Soil fertility is a measure of a soil's ability to support plant growth. Soil fertility includes the amount of certain elements necessary for good plant growth.

Observing and Measuring Soil Properties

Scientists can determine some properties of soil by looking at and feeling the soil. This gives them an idea of the amount of sand or silt, types of horizons, and color. The color shows how much organic matter the soil contains.

Scientists measure other soil properties in a laboratory. They analyze nutrient content and soil pH to determine how well the soil will support plant growth.

Key Concept Check

8. Identify List soil properties that can be observed and measured.

_____

_____

Soil Properties That Support Life

Plants depend on the nutrients that come from organic matter and the weathering of rocks. Soil forms very slowly. It can take many human lifetimes for damaged soil to regain its nutrients.

Key Concept Check

9. Make Connections How are soil nutrients related to life?

_____

_____

Soil Types and Locations

Recall that climate influences the type of soil that forms. In cold climates of the far north and high mountains, some soils stay frozen all year. These soils are simple and have few horizons. A wide variety of soil types form in the milder mid-latitudes. In the warm, wet climate of the tropics, soils are deeply weathered. Soils that form near volcanoes are acidic and have fine ash particles from volcanic activity.

Key Concept Check

10. Consider Are soils the same everywhere?

_____

Mini Glossary

biota (bi OH tuh): all of the organisms that live in a region

climate: the average weather of an area

decomposition: the process of changing once-living material into dark-colored organic matter

horizon: a layer of soil formed from the movement of the products of weathering

organic matter: the remains of something that was once alive

parent material: the starting material of soil

pore: a small hole or space in soil

soil: a mixture of weathered rock, decayed organic matter, mineral fragments, water, and air

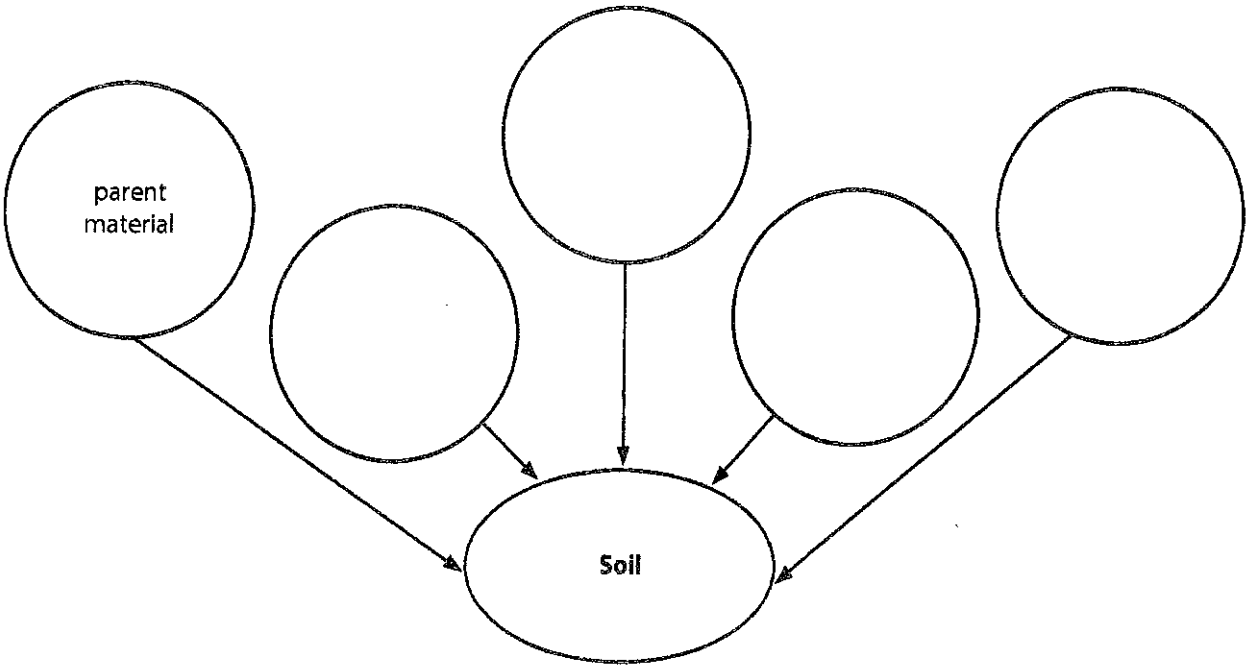
topography: the shape and steepness of the landscape

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that describes the connection between biota and decomposition.

_____

_____

2. Fill in the circles to identify the five factors of soil formation.



What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

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LESSON 2

Soil

Predict *three facts that will be discussed in Lesson 2 after reading the headings. Write your facts in your Science Journal.*

Main Idea

What is soil?

I found this on page _____.

I found this on page _____.

I found this on page _____.

I found this on page _____.

Details

Identify *the components of* soil.

1. _____
2. _____
3. _____
4. _____
5. _____

Identify organic *and inorganic parts of* soil. *Describe and give three examples of each part.*

Soil	
Inorganic	**Organic**
Description: _____ _____ _____	Description: _____ _____ _____
Examples: 1. _____ 2. _____ 3. _____	Examples: 1. _____ 2. _____ 3. _____

Explain *how* decomposition *affects* soil.

Decomposition _____ into dark-colored _____. This matter helps hold _____ in the soil.

Sequence *the materials that make up the inorganic part of* soil *from the smallest to the largest.*

smallest particles ⟵ ⟶ largest particles

Main Idea

Formation of Soil

I found this on page _____.

I found this on page _____.

I found this on page _____.

I found this on page _____.

I found this on page _____.

Horizons

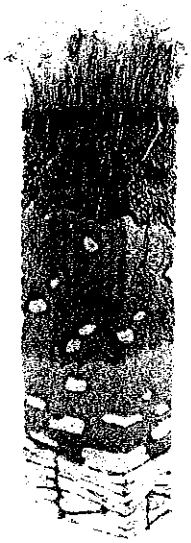
I found this on page _____.

Details

Describe *the 5 factors that affect* soil *formation by completing the chart.*

Factor	How it affects soil formation
Parent material	
Climate	
Topography	
Biota	
Time	

Label *the diagram of* soil horizons. *Describe each* horizon.



Main Idea

Soil Properties and Uses

I found this on page _____.

I found this on page _____.

I found this on page _____.

Details

Identify *8 properties of* soil. *Circle the properties that can be measured.*

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Assess *the information about* soil *properties that support life. Read each statement below. If the statement is true, write* true *on the line. If the statement is false, write* false *on the line and rewrite the underlined portion so that it is true.*

People can determine how many nutrients are in the soil by the way plants grow.

_____

It takes a few years to form soil from the parent material.

_____

After soil has been destroyed through misuse, it remains destroyed for one generation.

_____

Explain *why* soils *in different locations around the world have different properties.*

_____

_____

_____

_____

_____

Analyze It Describe the relationship between weathering and soil.

_____

_____

_____

_____

Weathering and Soil

Chapter Wrap-Up

Now that you have read the chapter, think about what you have learned.

Use this checklist to help you study.

- ❑ Complete your Foldables® Chapter Project.
- ❑ Study your *Science Notebook* on this chapter.
- ❑ Study the definitions of vocabulary words.
- ❑ Reread the chapter, and review the charts, graphs, and illustrations.
- ❑ Review the Understanding Key Concepts at the end of each lesson.
- ❑ Look over the Chapter Review at the end of the chapter.

Summarize It Reread the chapter Big Idea and the lesson Key Concepts. Trace the development of soil from parent material to organic-rich soil. Include in your description the processes that break down rock and the changes that must occur in order for soil to support life.

Challenge *Suppose that you had a large boulder in your yard that you wanted to move. How could you break the boulder into smaller pieces without using a sledgehammer?*