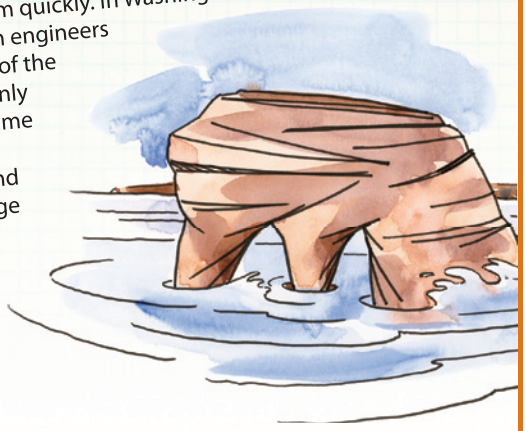
Weathering and Erosion

Many scientists once assumed that the Grand Canyon took millions of years to form. They were sure that the Colorado River could only have eroded all the layers of rock over a long period of time. However, in 1926 scientists realized that a canyon could form quickly. In Washington State an irrigation canal became blocked. When engineers rerouted the water into a ditch, the force of the water collapsed the underlying rock. In only six days, a small, 10-foot-deep ditch became the 120-foot-deep Burlingame Canyon. Creation scientists theorize that the Grand Canyon was formed in a similar way. Huge amounts of water from the Flood could have eroded layers of rock very rapidly. Through events such as the forming of the Burlingame Canyon, God has given us a glimpse of His awesome power over His creation.



25

SCIENCE BACKGROUND

Grand Canyon
This national park covers more than 277 miles of the Colorado River and adjacent uplands.

Burlingame Canyon
In 1904 near Walla Walla, Washington, irrigation canals were constructed to help with crop production. In 1926 one of the canals became clogged. Engineers changed the course of the water supply, sending it into a nearby irrigation ditch. This ditch was six feet wide and ten feet deep at its largest point. However, after just six days of this excessive water flow, the irrigation ditch "became a miniature Grand Canyon." Today the canyon measures 1500 feet long, 120 feet deep, and 120 feet wide!

(Student Text and Teacher's Edition information on Burlingame Canyon adapted from "How Long Does It Take for a Canyon to Form?" by Dr. John D. Morris of the Institute for Creation Research.)

TEACHER HELPS

Chapter preview
Other preview and prereading activities may include using a K-W-L chart, a probe, or an anticipation guide.

Chapter photo
The photo at the top of the page shows the Grand Canyon just after sunset.

Student Text diagrams
Diagrams from the Student Text are included on the Teacher's Toolkit CD.

Objectives

- Recognize that scientific inferences are not always accurate
- Preview the chapter content

Materials

- pictures of the Grand Canyon

Introduction

Display the pictures of the Grand Canyon. Allow students who have visited the Grand Canyon to share their experiences.

The Grand Canyon is one of the best-known examples of erosion. However, scientists disagree on how the canyon was formed. Some scientists, such as those that hold to the biblical view of a worldwide flood, believe that the canyon formed from the flow of a lot of water in a short period of time. Other scientists believe this extensive erosion was caused by a little water flowing for a very long period of time.

Teach for Understanding

Provide time for the student to complete Looking Ahead, Activity Manual page 21. For part B, encourage the student to think of things he would like to learn about chemical weathering and erosion. He should write his answers in question form, such as, "What does chemical weathering do to rocks?"

Provide the answers for part A and allow the student to check his work. After the chapter is finished, you may choose to have him look back at this page and check his understanding of the ones he missed.

As time allows, discuss student questions from part B about chemical weathering and erosion. You may choose to provide trade books or other resources to help answer questions that are beyond the scope of this chapter.

Activity Manual

Preview, page 21

The Looking Ahead page is intended to assess the student's prior knowledge before beginning the chapter.

Lesson 17

Student Text pages 26–29
Activity Manual page 22

Objectives
- Identify the three types of rocks and explain how they are formed
- Differentiate between mechanical and chemical weathering
- Define and give examples of mechanical weathering

Materials
- 2 small plastic containers with lids
- water
- 2 resealable plastic bags
- a freezer

Vocabulary
sedimentary
igneous
metamorphic
rock cycle
weathering
mechanical weathering
chemical weathering

Introduction

Prepare materials ahead. Water will probably need to freeze overnight.

Fill one film container to the top with water. Place lids on both film containers. Place each container in a plastic bag. Place in freezer.

Remove containers from the freezer and plastic bags.

What effect did the freezer have on the containers? The empty container stayed the same. The lid came off the container filled with water.

What can we say about the way cold affects water? Elicit that water expands when it freezes.

Today we will learn about some ways water and temperature affect rocks.

Teach for Understanding

Purpose for reading

Are rocks still being formed today?

What are some natural causes of weathering?

Discussion

Man uses rocks in many ways. What are some examples of how rocks are used? Possible answers: construction, landscaping, art sculptures, sandpaper

What are three classifications of rocks? sedimentary, igneous, metamorphic

What term do scientists use to describe how rock changes from one kind to another? the rock cycle

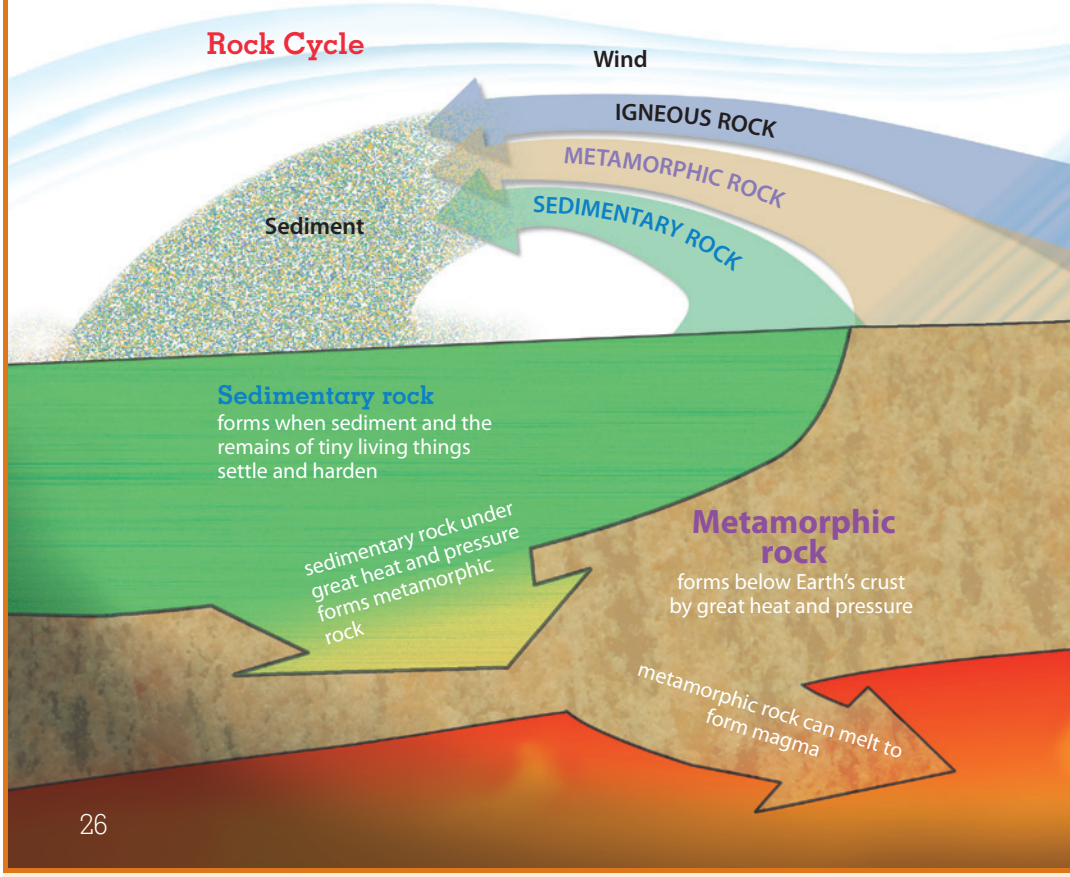
What is a cycle? Elicit that a cycle is something that occurs over and over.

From huge granite mountains to tiny particles of sand, rocks are all around us. We use them for building, for industry, for technology, and even for pleasure. They form the foundation of the earth. But rocks are also constantly moving and changing. Forces such as earthquakes grind and shift rocks, while volcanoes spew out lava that forms new rocks. Heat and pressure deep within the earth form and transform rocks while, on the surface, wind and water break down and move rocks. All of these natural processes are continuously changing the surface of God's earth.

Weathering

Rock Cycle

Though rocks vary greatly, geologists classify them into three categories: **sedimentary**, **igneous**, and **metamorphic**. Scientists call the changing of rock the **rock cycle**. They use a diagram to show what they think happens to the rock.



TEACHER HELPS

Containers
For the introduction, use any identical containers that have snap-on lids. The lid should pop off as the water freezes and expands.

SCIENCE BACKGROUND

Rock cycle
The rock cycle is an attempt to explain how rocks are formed. Some of the processes occur where they cannot be observed and are, therefore, hypothetical. Secular scientists believe that the earth is ancient and that some atoms of matter have moved completely through all of the stages of the cycle. They believe all rock started out as igneous and over billions of years has cycled through the other types. This is in conflict with a biblical, young-Earth worldview.

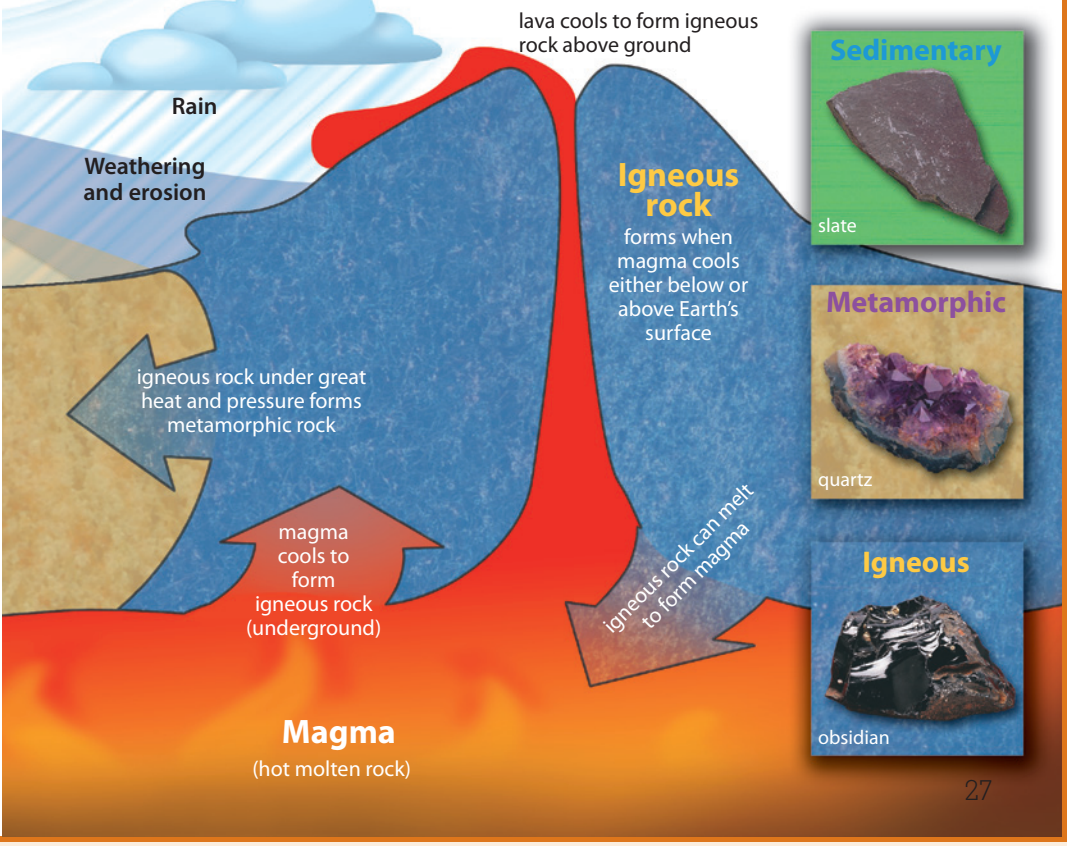
Rock formation and the Flood
Some Creation scientists believe that most sedimentary rock was formed during the Flood. The erosion caused by so much water would have moved great amounts of sediment. Pressure from the water, tectonic activity, or both at the time of the Flood may have formed the sedimentary rock. Creation scientists think it unlikely that significant amounts of sedimentary rock are still being formed today.

Uniformitarianism
People who hold to uniformitarianism believe that the forces that have shaped the earth in the past are the same forces we see today. Uniformitarianism says that the slow processes we see today are the same processes that shaped the earth and at the same rate. However, this assumption contradicts God's Word because it leaves no

Many scientists think the earth is ancient and some of the earth's materials have moved completely through this cycle. Creationists believe that the earth is much too young for this to have happened. Although each of these rock changes is occurring today, massive amounts of new rock types are not being formed.

Most kinds of rock are very hard. But even the hardest rock can be broken down into gravel and pebbles, sand, silt, or powdery clay. This process of breaking down rocks is called **weathering**.

We usually divide weathering into two distinct processes: mechanical weathering and chemical weathering. **Mechanical weathering** breaks rocks into smaller and smaller pieces. **Chemical weathering** transforms rocks into new substances. Both kinds of weathering take place at or near the earth's surface and are greatly affected by temperature and moisture. The process of weathering usually takes years or even centuries. But slowly, little by little, big rocks are worn away into smaller pieces.



room for biblical Creation or the Flood, a cataclysmic event that covered the entire earth (Gen. 6–8) and would have formed many geological formations very rapidly.

SCIENCE MISCONCEPTIONS

Weathering and erosion do not actually produce sedimentary rock. Rather, they produce the small particles that press together and harden to form sedimentary rock.

LANGUAGE

Cycle

The word *cycle* comes from the Greek word *kuklos*, which means "circle."

DIRECT A DEMONSTRATION

Demonstrate rock changes

Material: *Rock Changes* (IA)

Use the instructions on *Rock Changes* to demonstrate how igneous rocks, sedimentary rocks, and metamorphic rocks form.

What are two different viewpoints about the rock cycle? Many scientists think that some rocks have moved completely through the cycle because the earth is so ancient. Creationists believe that the earth is younger and that a rock would not have moved through the entire cycle, but that rock changes like these are occurring today.

Why is the rock cycle only a theory of how rocks change? Elicit that scientists cannot actually observe most of the processes that they think occur.

Discuss the *Rock Cycle*.

Sediment from which types of rock can form sedimentary rock? all kinds—igneous, metamorphic, sedimentary

How does sedimentary rock form? Sediment and remains of tiny living things settle and harden.

How is magma involved in the process of making rocks? Metamorphic rock can become so hot that it turns into magma, which becomes igneous rock when it cools again.

What happens to an igneous rock to change it into a metamorphic rock? It is heated and put under pressure.

What is weathering? the process of breaking down rocks; the processes that cause rocks to break into smaller pieces or change through chemical activity

What are two kinds of weathering? mechanical and chemical

What affects weathering? temperature and moisture

Does weathering usually occur quickly or slowly? slowly

Discussion

What is another name for mechanical weathering? physical weathering

How do rocks change when they are weathered mechanically? They are broken down. They become smaller.

Which rock would probably physically weather more—a rock that is above the surface of the ground or a rock that is underground? a rock above the surface of the ground **Why?** because more of the rock's surface is exposed

What are four main causes of mechanical weathering? Possible answers: water, wind, plants, and animals

What happens when water gets into a crack in a rock and freezes? Water expands when it freezes, and it can break the rock apart. **What is this process called?** frost wedging

What happens when water gets under a rock and freezes? The frozen water pushes the rock farther out of the ground. **What is this process called?** frost heaving

Discuss changes in the series of frost-heaving illustrations.

Who do you think has more of a problem with rocks "growing" in his fields—a farmer in Alabama or a farmer in Minnesota? a farmer in Minnesota **Why?** Water in the ground freezes more often in the North, thus pushing the rocks up.

When does pressure release occur? When the pressure on a rock is reduced, the rock can expand rapidly, causing it to crack and break.

What term describes the process of rock peeling away in sheets? exfoliation

What might cause a shift in the earth's surface and produce weathering by pressure release? Possible answers: earthquake, volcano, construction

What kinds of forces weather material by abrasion? water and wind

What is characteristic of a rock that has been weathered by water for a long time? It has round, smooth edges.

What types of machinery that you know of use abrasion? Possible answers: sand blaster, pressure washer

Mechanical Weathering

Mechanical, or physical, weathering is the process of breaking down rocks into smaller pieces. If more of a rock's surface is exposed, a greater amount of weathering will occur. Temperature, water, wind, and plant and animal life all contribute to mechanical weathering.

Though rocks appear solid, most actually have many small holes and cracks in them that allow water to get inside. Unlike most substances that contract as they freeze, water expands. So as the water in the rock freezes and expands during the winter, it acts like a wedge and forces the rock apart. In fact, this process is called *frost wedging*. Usually the process starts with small breaks, but as the cracks widen, they fill with more water, which causes larger breaks.

Another similar process, *frost heaving*, occurs when water gets underneath a rock. As the water freezes and expands, it pushes the rock farther out of the ground. At one time farmers in cold weather areas believed that rocks grew in their fields because each spring there seemed to be new rocks that had to be cleared from their fields.

If you take a damp sponge and squeeze it in your hand, you put the sponge under pressure. When you open your hand, the sponge will expand.

exfoliation

Some rocks are also under great pressure. A shift in the ground around them can reduce the pressure and cause the rocks to expand rapidly. This kind of mechanical weathering, called *pressure release,* creates cracks and breaks in the rocks. Often these cracks result in *exfoliation,* in which sheets of rock peel away like layers of an onion.

Abrasion is mechanical weathering that occurs when rocks rub against each other. It can be caused by water and by wind. As rivers and streams roll boulders and pebbles along their beds, the rocks gradually wear each other away. Rocks that have been abraded for a long time are rounded and have smooth edges.

abrasion

frost heaving

SCIENCE BACKGROUND

Pressure release and exfoliation
Sometimes pressure release weathering and exfoliation are treated as two different weathering processes. Though exfoliation can occur because of other types of mechanical weathering, it seems to be most closely associated with rocks expanding due to pressure release.

Biological weathering
Mechanical weathering caused by plants and burrowing animals is also called biological weathering.

Burrowing animals
Not only do burrowing animals move rocks, but they also can open passages deep into soil which allows water and natural acids to penetrate bedrock. This process aids chemical weathering.

LANGUAGE

Abrasion
The word *abrasion* comes from the Latin word *abrasus*, meaning "to scrape off."

What are some other ways that we use the word *abrasion*? Possible answers: A minor cut or scrape is an abrasion. Common household cleaners are categorized as abrasive and nonabrasive.

How is an abrasion that you might get by sliding into home plate similar to an abrasion caused by wind and water? In both cases something is scraped off. In one case it is the rock being scraped off; in the other case, it is your skin.

A strong wind can also abrade rocks when it picks up particles of sand and dust and blows them against the rocks. If this abrasion continues day after day, the rock will be worn away. Man has taken a lesson from nature and uses machines called sandblasters to remove grime and paint from old buildings and rust from metal by abrading the surfaces.

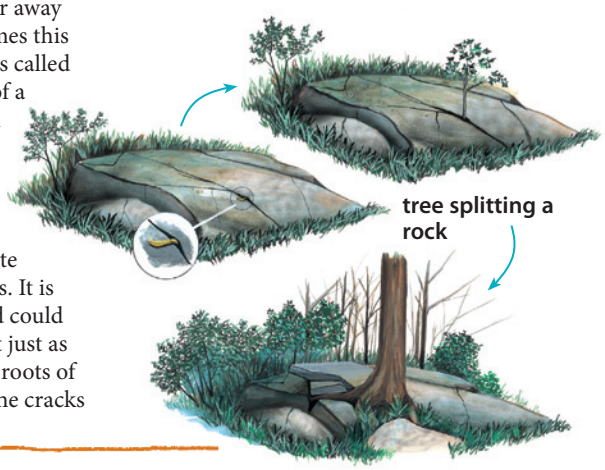
Abrasion does not affect all types of rocks equally. Soft rocks wear away faster than hard rocks. Sometimes this creates unusual rock formations called hoodoos. The rock on the top of a hoodoo is harder than the rock on the bottom, so the rock below abrades much faster, often leaving a vertical supporting column.

Plants and animals contribute to the weathering of some rocks. It is hard to imagine that a tiny seed could cause a rock to break apart. But just as ice expands to break rocks, the roots of a sprouting seed may grow in the cracks of a rock, causing it to break apart as the plant grows. Like frost heaving, huge tree roots can lift rocks out of the ground. Burrowing animals can also move rocks and expose them to additional weathering.

Fires, floods, and other catastrophic events can be causes of mechanical weathering. In fact, anything that breaks rock into smaller pieces is physically weathering that rock. You can find examples of mechanical weathering all over the world. From cold northern climates to dry, sandy deserts, rock is constantly being broken down into smaller and smaller pieces.

QUICK CHECK

1. What are the three types of rock?
2. What is mechanical weathering?
3. What are three examples of mechanical weathering?



DIRECT AN ACTIVITY

Demonstrate how sedimentary rocks can be changed by heat and pressure

Materials: butter, marshmallows, crispy rice cereal, large pan, spoon, hot plate, cooking spray, plastic sandwich bags, goggles

Melt the butter and marshmallows in the large pan, stirring constantly. The cereal represents a type of rock that has been weathered into small grains. Stir the cereal into the marshmallow mixture gradually. Give each student a spoonful of the crispy rice mixture in a plastic sandwich bag.

What do you need to do to make this a solid ball? squeeze it; shape it with your hands

The process of changing the grains of cereal into a solid ball involves applying heat and pressure, just as the application of heat and pressure changes sedimentary rocks.

Discussion

Why do rocks not weather evenly? Rocks have different hardness, and soft rock weathers faster than hard rock.

What causes a hoodoo? The rock of the lower part of a hoodoo is softer and abrades faster than the harder rock above.

How is weathering because of plants similar to weathering by ice? Roots growing in cracks act as wedges and may lift rocks out of the ground. In frost heaving, ice does the same thing.

How do burrowing animals contribute to mechanical weathering? They move rocks and expose more of the rock.

Although asphalt and concrete are manmade substances, they weather much the same way as rock. Frost wedging, frost heaving, extreme temperature changes, and plants all cause these substances to crack and deteriorate.

What are some ways asphalt and concrete weather? Possible answers: tree roots rising out of roads and sidewalks; frost wedging

Why do you think upkeep on the roads in northern states is more difficult than it is in southern states? Accept any answer, but elicit that extreme temperature changes, frequent freezing, and frequent snowplow use cause more abrasion of the road surfaces.

Answers

1. sedimentary, igneous, and metamorphic
2. the process of breaking rocks into smaller pieces
3. Possible answers: frost heaving; frost wedging; abrasion; pressure release; rocks weathered by plants, animals, fires, floods, or other catastrophic events

Activity Manual

Reinforcement, page 22

Complete parts A and B with Lesson 17 and part C with Lesson 18.

Objectives
- Define and give examples of chemical weathering
- Describe how acid rain forms
- Summarize how chemical weathering forms limestone caves

Vocabulary
carbonic acid
stalactite
stalagmite

Introduction
Have you ever visited an old cemetery?

Did you notice that the statues and headstones are often worn down or crumbling?

Allow students to share experiences they have had visiting old cemeteries.

Teach for Understanding
Purpose for reading
How does man affect the amount of chemical weathering that occurs?

What are some features of caves and caverns?

Discussion
How does chemical weathering differ from mechanical weathering? Chemical weathering actually changes the rock into a different substance. Mechanical weathering changes only the size and shape of the rock.

How are chemical and mechanical weathering alike? Both break down rock in some way.

What are the most common types of chemical weathering? oxidation and reaction of acids

What is a common form of oxidation? rust

Why don't all metal products rust away quickly? Most manufactured metals have protective coatings.

Can rocks rust? yes **Why?** Some rocks contain metal ores that can rust.

Chemical Weathering

Unlike mechanical weathering, which changes only the size and shape of a rock, chemical weathering changes the rock into a different substance. The most common types of chemical weathering are *oxidation* (ок sih DAY shun) and *reaction of acids* with minerals in the rocks. Most of us have seen oxidation. Perhaps you have noticed garden tools that have been destroyed by rust. When oxygen in the air combines with iron, iron oxide (rust) forms. In a similar way, oxygen from the air combines with what a rock is made of to form new compounds that can weaken the rock. The difference in color between the inside of a newly broken rock and its outside surface is usually from oxidation.

Another type of chemical weathering occurs when rain carries chemicals from the air onto surfaces below. Earth's atmosphere contains both water and carbon dioxide. When the carbon dioxide dissolves in the water, a weak acid called **carbonic acid** forms. Though carbonic acid is relatively weak, over long periods of time rain containing the acid can dissolve certain kinds of rock. You can see the effects of carbonic acid in old graveyards. Carbonic acid gradually wears away the limestone gravestones until the engravings are unreadable.

Carbonic acid by itself is not harmful to plant or animal life. However, man has introduced additional chemicals to the atmosphere by burning fossil fuels such as oil and coal. One of the most common chemical compounds produced by fossil fuels is sulfur dioxide. Sulfur dioxide in smoke combined with water in the atmosphere produces sulfuric acid. Rain containing sulfuric acid, carbonic acid, and other


weathered gravestones

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SCIENCE BACKGROUND

Oxidation
Oxidation is a process that occurs whenever a substance combines with oxygen to form a new substance. Iron is not the only element that can oxidize.

Carbonic acid
This weak acid gives soft drinks their "bite."

Acid rain
Acid rain is usually less acidic than lemon juice and vinegar. However, the harm it causes to ecosystems comes from long-term, repeated exposure.

BIBLE **Good stewardship**
Guide a discussion about stewardship.

When chemicals are added to the atmosphere, they are carried by the wind and can cause acid rain to fall in places away from where the chemicals originated. Does this mean that people should never use cars or should not use coal or oil? Answers will vary, but elicit the idea that man has a responsibility to manage the earth and use its resources wisely. The key is not avoiding the use of resources but learning how to use them wisely (Gen. 1:28).

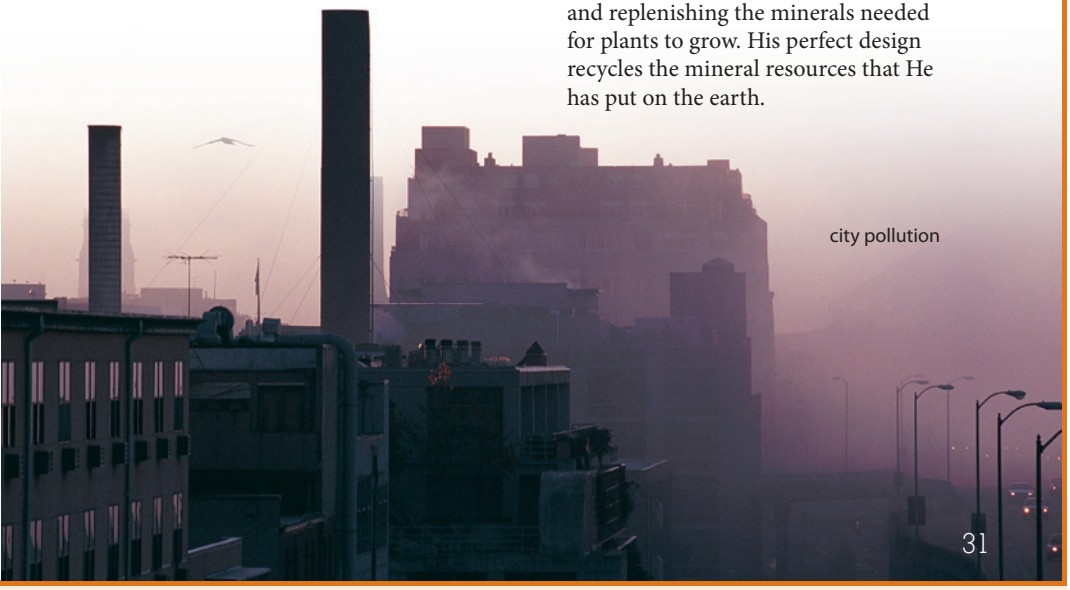
trees affected by acid rain

chemicals is stronger and weathers rocks much more quickly than rain containing carbonic acid alone. This stronger acid solution is called *acid rain*. Due to industrial smoke and the exhaust from cars, cities are more likely to have this kind of chemical weathering. However, upper-level winds can spread acid rain for hundreds of miles, causing damage to trees and wildlife far away from cities.

Another kind of chemical weathering can be seen in a forest. Lichens and mosses are often found growing on rocks in the woods. Because these organisms do not have true roots, they can survive on the little water and soil they find on some rocks. While attached to the rocks, these organisms secrete mild acids that dissolve the rocks and further break down the rocks into soil.

lichens

Whether by wind, weather, acids, or living organisms, God uses both mechanical and chemical weathering to break down rocks, forming soil and replenishing the minerals needed for plants to grow. His perfect design recycles the mineral resources that He has put on the earth.



city pollution

What forms when water and carbon dioxide mix? carbonic acid

How does the slight acidity of ordinary rain differ from acid rain? The carbonic acid in ordinary rain is not as strong as the sulfuric acid in acid rain.

Why is acid rain more likely to occur in industrialized areas? The conditions, such as smoke and exhaust, that contribute to acid rain occur more frequently in industrialized areas.

What kinds of activities or events increase the amount of chemicals in the atmosphere? Possible answers: burning fossil fuels such as coal and oil, volcanic gases, smoke from factories, car exhaust

Why is acid rain harmful? It can damage trees and wildlife.

How do living organisms contribute to chemical weathering? Some organisms secrete mild acids that break down rocks.

What are two important functions of weathering? forms soil and replenishes minerals for plant growth

Weathering is an example of how God cares for His world through natural processes.

HISTORY

Pollution

Acid rain is not a new problem. In the mid-1800s industrial smoke around London combined with the infamous London fog and caused acid fog.

Today most developed countries have pollution controls that reduce emission of pollutants that contribute to acid rain. However, developing countries often industrialize without such pollution controls.

Why could a developing country's pollution affect other countries? Winds and water may carry the pollution across the countries' borders.

Pollution is a difficult economic and environmental problem to handle. For a country to modernize, it must develop industry. Yet the negative effects of industrialization may harm the environment and citizens of the country as well as affect relationships with neighboring countries.

TEACHER HELPS

Acidity of rainwater

Pure water has a pH of 7, being neutral. Unpolluted rainwater is usually slightly acidic, ranking about 5.6 on the pH scale. Chapter 7 discusses acids, bases, and the pH scale. After teaching that chapter, you may want to refer back to this lesson and allow the student to test the acidity of local rainwater with either a pH meter or a purple cabbage juice solution.

Discussion

What are some ways that mechanical weathering can form caves? Possible answers: wind, waves, running water

What kind of weathering forms a limestone cave? chemical weathering

The terms *cave* and *cavern* can be used interchangeably.

How does a limestone cave form? Acidic water seeps into cracks in limestone, dissolving calcite in the limestone, which causes cavities to form.

What is the general name for the calcite formations in caves and caverns? speleothems

How are the speleothems formed? The calcite dissolved from the limestone is deposited out of the water.

What does "deposited out of the water" mean? The water, in which the calcite is dissolved, evaporates, leaving the calcite to harden.

Which kind of speleothem hangs from the ceiling? stalactite

Which kind of speleothem builds up from the ground? stalagmite

What do we call people who explore caves and caverns? spelunkers

Why do spelunkers have to carry mountain-climbing equipment? Some of the features in caves include walls of rocks or chasms like you would find while climbing a mountain.

Discuss *Fantastic Facts.*

What huge cavern system did Jim White discover? Carlsbad Caverns

What caused him to investigate? seeing hundreds of thousands of bats coming out of a hole

What response did White get from others when he told of his discovery? People laughed and did not believe that he found anything special.

Christians sometimes experience similar responses when they try to tell others about Christ or strive to live godly lives. The responses of others should not keep a Christian from saying and doing what is right. [BATs: 2c Faithfulness; 2e Work]

What finally caused people to want to visit Carlsbad Caverns? seeing black-and-white photos

FANTASTIC FACTS

In 1901 a cowboy named Jim White discovered one of the greatest cave systems in the United States. As White was riding home one evening, he saw what looked like dark-gray smoke rising from the ground. He rode nearer and discovered that the "smoke" was hundreds of thousands of bats coming out of a hole in the ground. Later, White went back to explore the hole, which he named Bat Cave. What he found amazed him. He had discovered a gigantic cave. When White told his friends what he had found, they laughed. No one believed he had found anything special. White continued to explore and tell others about his discoveries.

Finally, in 1922 a photographer took some black-and-white photographs of the caverns. Suddenly, people wanted to tour the caverns and see their wonders. On October 25, 1923, New Mexico's Carlsbad Caverns was made a national monument. In 1930 it was made a national park that now covers more than seventy-three square miles.

Caves

Weathering forms many kinds of caves. Crashing waves, wind, and running water can all form caves by mechanical weathering. However, it is chemical weathering that forms limestone caves, or caverns. As water passes through the atmosphere and the ground, it combines with other substances to form acids. As this acidic water seeps into cracks in limestone, it dissolves calcite in the limestone, leaving behind large underground cavities.

Speleothems, beautiful formations in caverns, form as the dissolved calcite is deposited out of the water. Some of the most common structures in caves are stalactites (stuh LAK tytes) and stalagmites (stuh LAG mytes). **Stalactites** hang from the ceiling and look like stone icicles. **Stalagmites** "grow" up from the ground as a result of the dripping of dissolved calcite.

People who enjoy exploring caves are called *spelunkers* (spih LUNG kurz). These explorers must take their own lights with them into the caves. Since many caves have huge chasms that must be crossed or walls of rock that must be climbed, spelunkers often use mountain-climbing equipment.

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DIRECT A DEMONSTRATION

Demonstrate how caverns are formed as limestone dissolves

Materials: clear plastic bottle with small opening (i.e., soda bottle), piece of aluminum foil, rubber band, jar, sand, sugar, 250 mL of warm water

Cut off the top 15 cm of the plastic bottle. Remove the bottle cap. Cover the neck opening with foil. Secure the foil with a rubber band. With the tip of a pencil, poke three or four small holes in the foil.

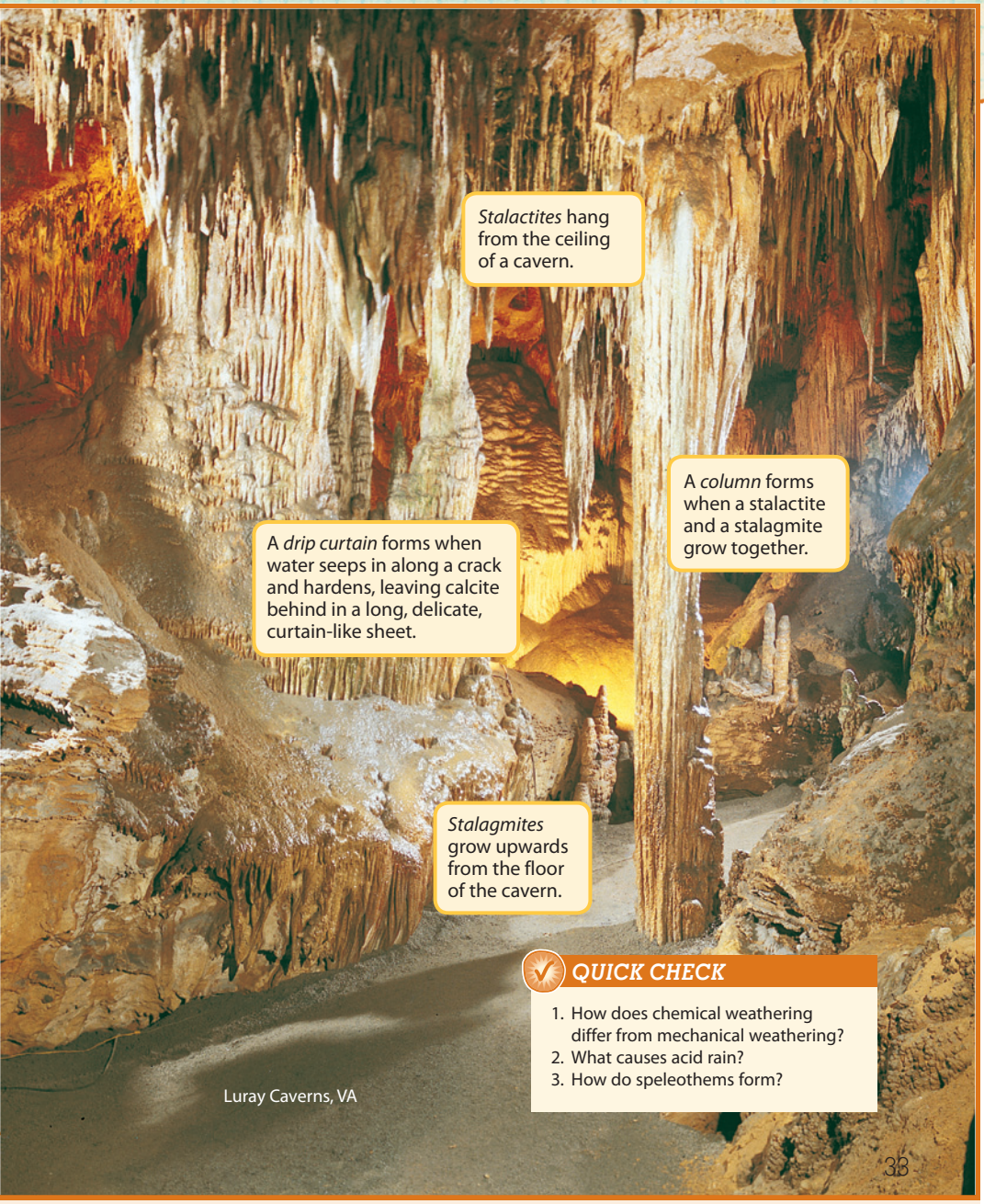
Place the foil end of the bottle top into the opening of the jar. Do not let the foil touch the bottom of the jar.

Gently press a 5 cm layer of sand into the prepared bottle top. Spread a 2.5 cm layer of sugar on top of the sand. Add another 5 cm layer of sand and press it down gently.

This model demonstrates layers of the earth that have limestone deposits.

Pour 125 mL of warm water into the bottle. After the water is absorbed, pour another 125 mL of warm water into the bottle.

After two or three hours, the sugar should dissolve and leave behind air pockets and gaps in the sand. This demonstrates how caverns form when limestone dissolves.



TEACHER HELPS

Study aid

One way to differentiate between stalactites and stalagmites is to remember that stalactite has a "c" in it, as in *ceiling*, and stalagmite has a "g" in it, as in *ground*.

LANGUAGE

Speleothem

The word *speleothem* comes from the Greek words *speleo*, meaning "cave," and *thema*, meaning "deposit."

Spelunker

The word *spelunker* comes from the Latin word *spelunca*, meaning "cave" or "grotto."

WRITING

Research cave formations

The student can research other ways that caves are formed. Caves can be formed by wind and sand, by ocean waves, and by glaciers. The student may describe the process of cave formation, show pictures of different types of caves, and report any historical significance of the caves he researched (i.e., if people lived in them or hid in them).

Encourage the student to do additional research about the use of caves either historically or currently. Possible topics may include ancient wall paintings in Lascaux Cave in France; the Anasazi Indians in the southwestern United States; the caves where the Dead Sea Scrolls were found; or modern uses for caves, such as for growing mushrooms.

Discussion

What cavern is pictured on Student Text page 33? Luray Caverns in Virginia

Point out and discuss the different speleothems in the photo.

What is a drip curtain? a speleothem that forms when seeping water hardens along a crack, forming a thin, curtain-like sheet

What causes a column? A stalactite and a stalagmite growing together.

Discuss a biblical worldview of geology.

Suppose you are visiting Luray Caverns. Your guide takes you to see a huge column that is 60 feet tall. He tells you that it takes speleothems 120 years to grow just one inch. Then he says, "So we know that this column has been forming here in this cave for about 86,400 years." What is wrong with what the guide has said? Answers should include the following: The Bible teaches that the earth is about 7,000 years old and that the Flood changed the surface of the earth rapidly. Because of the Flood, caves and what is in them would have formed rapidly.

Answers

1. In chemical weathering, the chemical makeup of the rock is changed, while mechanical weathering changes only the size and shape of the rock.
2. Pollutants in the air (from burning fossil fuels) combine with moisture in the atmosphere to create highly acidic rain.
3. Acidic water seeps through the soil and into cracks in limestone, dissolves the limestone, and leaves behind formations in caverns.

Activity Manual

Reinforcement, page 22

Part C corresponds with this lesson.

Review, pages 23–24

These pages review Lessons 17 and 18.

Assessment

Quiz 2-A

The quiz may be given any time after completion of this lesson.

Objectives

- Measure length to the nearest millimeter
- Measure mass to the nearest gram
- Measure volume to the nearest milliliter

Materials

- assortment of 8 cm × 17 cm or smaller rocks; at least one per student
- meter stick
- centimeter ruler for each student
- balance
- metric beakers or measuring cups large enough to hold one rock
- water

Introduction

This lesson is meant for practicing and reinforcing measurement skills and concepts learned in *Science 6*.

Imagine you are a geologist who has been called to an earthquake disaster site to analyze rock samples. Your job is to measure each rock taken from the site.

The data you collect may help other scientists draw conclusions about the nature of the earthquake.

Accuracy is important when taking measurements, especially in science. Without being careful and truthful, scientists will form wrong conclusions. Also, God condemns people who falsify measurements (Prov. 11:1).

Teach for Understanding

Linear Measurement

What metric tools are used to measure length? meter stick, centimeter ruler

Display the meter stick and centimeter ruler.

Which tool would be the most appropriate for measuring the distance a rock tumbles down a slope? meter stick

Which tool would be most appropriate for measuring your rock? centimeter ruler

Demonstrate marking the width and length of a rock. Place the rock on a sheet of paper. With a pencil held perpendicular to the paper, make two dots showing the width and two dots showing the length of the rock. Remove the rock from the paper. Demonstrate measuring the width and length between the dots.

Which measurement is more accurate? millimeters **Why?** Since millimeters are smaller than centimeters, the measurement will be more accurate.

Measuring Rocks

Name _____

ACTIVITY

A. Follow these steps to measure the length and width of your rock. Then answer the question.

1. **Place your rock in the space provided below.**
2. **Mark the width of your rock by holding the pencil perpendicular to the paper and making one dot on each side of the rock at the widest place.**
3. **Follow the same procedure to mark the length of your rock.**
4. **Remove your rock from the paper.**
5. **Measure and record the rock's width and length in centimeters and millimeters.**

1. width _____ cm _____ mm
   length _____ cm _____ mm
2. Which unit of measurement is more accurate—centimeters or millimeters? _____

B. Circle the correct letter to answer the question. Then measure and record the mass of your rock.

1. What is the mass of an object?
   A. height and width of the object B. quantity of matter in the object
2. The mass of my rock is _____ grams.

C. Circle the correct letter to answer the question. Then measure and record the volume of your rock.

1. What is the volume of an object?
   A. the amount of space an object takes up B. the weight of an object
2. The volume of my rock is _____ milliliters.

Mass Measurement

What is meant when we talk about the *mass* of an object? Mass is the quantity of matter in an object.

Although the size, shape, or state of an object may change, its mass does not change unless some of the matter is removed or more is added. Mass is measured using a balance to compare the mass of the object to be measured with the known mass of the weights.

What unit is used to measure mass? grams

Demonstrate the use of the balance by measuring a rock.

Guide the student in completing part B.

DIRECT A DEMONSTRATION

Demonstrate conservation of mass

Use a container, ice, and a balance to demonstrate the conservation of mass. Place the ice into the container and measure the mass. Record the measurement. Let the ice melt, measure the mass of the water, and compare the measurements. The mass of the ice did not change even though its shape, or state, changed. Remove some of the water and measure the mass. Since the amount of matter changed, the mass changed.

D. Follow the steps.

1. **Trade rocks with someone else.**
2. **Measure the width, length, mass, and volume of the rock.**
3. **Record your measurements below.**
4. **Answer the question.**

1. width _____ length _____ mass _____ volume _____
2. Why is it important for scientists to measure things more than once? _____

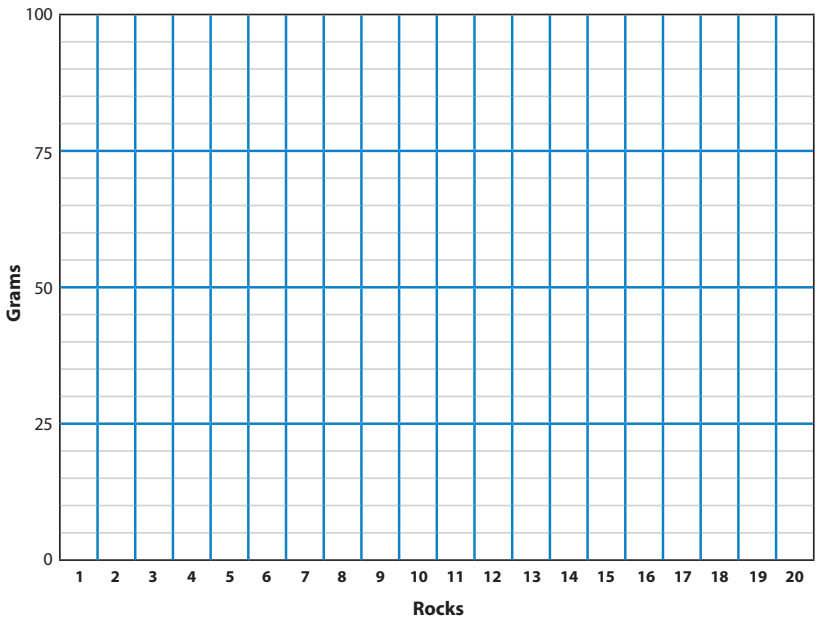
_____

_____

E. Follow the directions.

1. **Make a bar graph depicting the mass of each rock measured.**
2. **Answer the question.**

Rock Mass Bar Graph



What is the average mass of the rocks measured? _____

SCIENCE BACKGROUND

Meniscus

The curve of the surface of a liquid in a container is called a *meniscus*. Look at the bottom of the meniscus to read the volume of a liquid.

BIBLE

Measuring

Assign each of the verses to a group of students (Lev. 19:36; Deut. 25:13; Prov. 16:11; Prov. 10:23; Mal. 6:11). Provide Bible dictionaries and other study tools for the students to use to look up and write an explanation of what their verse says about measuring. Provide time for each group to share their verse and what they have written.

SCIENCE MISCONCEPTIONS

Mass and weight

The words *mass* and *weight* are often confused. Mass is measured by comparing the amount of matter in an object to the amount of known matter in an object, such as a lead weight. Balances are used to measure mass in grams or pounds. Weight is the measurement of the force of gravity on an object. If the gravity changes, the weight changes. Spring scales are used to measure weight in newtons (1 newton = 0.225 lb).

Volume Measurement

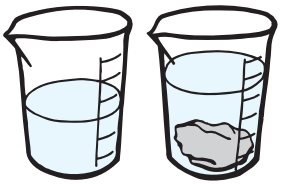
What is the volume of an object? Volume is the amount of space that an object takes up.

What are some measuring tools used to measure volume? Possible answers: measuring cups, measuring spoons, beakers, graduated cylinders

The unit of measure for volume is the liter. A graduated cylinder or metric beaker can be used. Always read the markings at eye level.

Since your rock has an irregular shape, how can you use water and a beaker (measuring cup) to measure the volume of your rock? Drop the rock into a measured amount of water and calculate the difference between the amounts of water to determine the number of milliliters the rock takes up.

Demonstrate measuring the volume of a rock with water in a beaker.



Guide the student in completing part C.

Volume can also be measured in cubic units. You can find the volume of a box by multiplying the measurements of its length, width, and height.

Why did we use water to calculate the rock's volume in milliliters rather than measuring in centimeters and then calculating from a formula? Draw the conclusion that because the rock has an irregular shape, taking accurate linear measurements and finding a formula to apply them to would be difficult.

One milliliter is equal to one cubic centimeter. Because the measurements have this relationship, they can often be used interchangeably. You may want to calculate the volume of your rock in cubic centimeters.

Direct the student to complete part D.

Were your measurements the same as the other measurements for the same rock? Why? Answers will vary.

Discuss the importance of measuring accurately and the need for scientists to repeat experiments many times, comparing their measurements and findings to verify their results.

Number all the rocks used. Guide the student in completing part E with the mass measurements for several rocks.

Activity Manual

Activity, pages 25–26

Lesson 20

Student Text pages 34–36
Activity Manual pages 27–28

Objectives
- Compare the different kinds of soil and their relative sizes
- Describe the factors that determine the composition of soil
- Describe the five soil horizons
- Interpret a texture triangle diagram

Materials
- potting soil
- centimeter ruler

Vocabulary

soil	texture
humus	loam
pedologist	horizon
sand	topsoil
clay	subsoil
silt	bedrock

Introduction

Display a handful of potting soil.

What do we use potting soil for? planting

Is this the same kind of soil you would find at a beach? no What kind of soil is at a beach? sand

How is sand different from this potting soil? Possible answers: Dry sand does not stick together, has a lighter color, and feels different.

Teach for Understanding

Purpose for reading

How do different soil particles affect the texture of the soil?

Which soil horizons contain nutrients from decayed materials?

Discussion

What is soil? the loose material at the surface of the earth

What materials are found in soil? weathered particles of rocks and minerals, decayed organic material, humus, air, and water

What is a pedologist? a scientist who studies soil

What are the three kinds of weathered particles that make up soil? sand, clay, and silt

Soil

Soil is the loose material at the surface of the earth. Weathering produces small particles of rocks and minerals. These small particles, along with water, air, and decayed organic material called **humus** (HYOOM us), make up the soil.

Soil particles

Though weathered particles greatly range in size, **pedologists** (pih DOLL uh jists), scientists who study soil, generally separate soil particles into three basic sizes.

Sand is the largest kind of particle. Some sand particles are big enough to see without a magnifying glass. Even so, they are very tiny, ranging in size from 0.06 mm to 2 mm. Sand particles are rough, causing sandy soil to have a grainy feel. Sand particles do not fit together tightly. Water can easily get between the particles, allowing the soil to drain quickly. However, sometimes soil drains so quickly that it does not retain the water necessary for certain kinds of plants to grow in it.

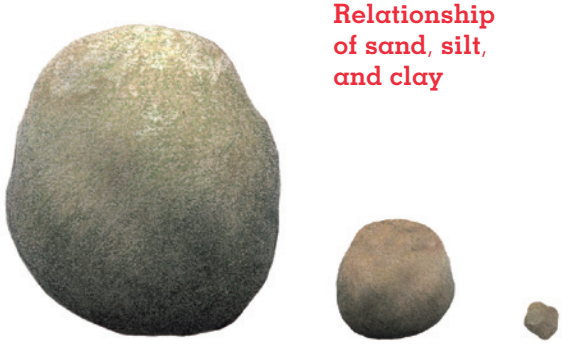
The smallest kind of particle is **clay.** It would take approximately 100,000 particles of clay to make one particle of sand. When dry, clay has a smooth texture, but it is sticky when wet. Clay holds nutrients and water well, but its particles are so close that little air can get between them. Without air, plants may rot in the moist soil.

Silt is the third kind of particle. Its particles are very tiny, yet they are actually larger than clay. Dry silt feels powdery like flour. Silt allows water and air to mix in the soil.

Soil texture and formation

Most soil is a mixture of the three different kinds of soil particles. When scientists discuss the **texture** of a soil, they are referring to the amount of each kind of particle in the soil sample. For example, a sandy soil texture would contain a large amount of sand. When equal parts of sand and silt are combined with about half as much clay, the soil is called **loam** (LOME). In loam the properties of all three kinds of particles combine to form an especially fertile soil.

Relationship of sand, silt, and clay



34

SCIENCE BACKGROUND

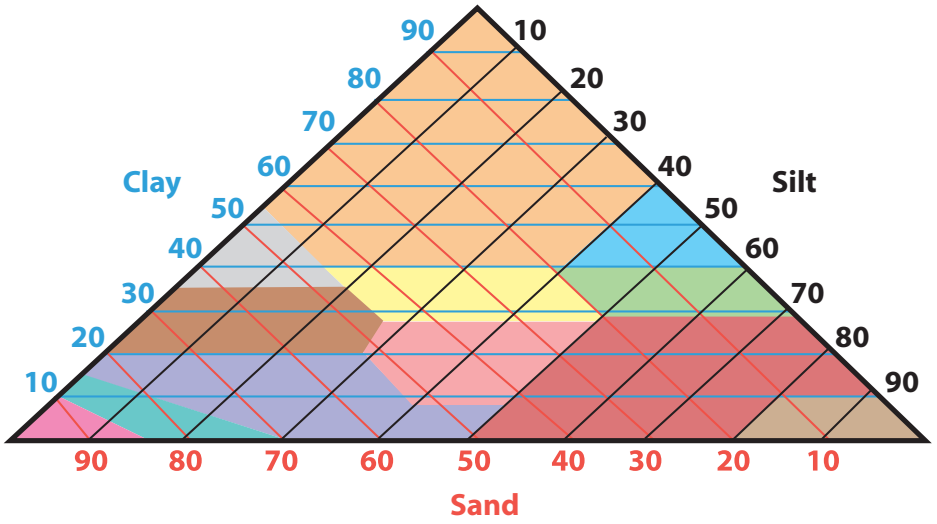
Potting soil
Most commercial potting soils are a mixture of soil, humus, sand, clay, and other materials.

LANGUAGE

Organic
Organic means material from living things, such as plants and animals. Decayed organic material is composed of living things that have died. The word *organic* is derived from the Latin word *organicus*, meaning "instrument," and has the idea of being from organized living beings.

Humus
The word *humus* is derived from the Latin word meaning "soil."

Texture Triangle



Soil texture is very important to farming. Most plants grow best in a specific kind of soil suited to the plants' design. For example, potatoes do not grow well in hard, sticky, clay soil.

The composition and fertility of soil depend on the climate, kinds of weathered rock, and types of vegetation in the area. Climate affects the rate and kind of weathering that occurs. For example, moist climates usually experience more chemical weathering than dry climates. Different rocks weather to produce different kinds of soil particles. When plants and other organic materials decay, they form humus and add nutrients to the soil.

Key

- sandy clay
- sandy clay loam
- sandy loam
- loamy sand
- sand
- clay
- clay loam
- loam
- silty clay
- silty clay loam
- silt loam
- silt

35

Discussion

Look at the marking for 2 mm on the ruler. Would you consider two millimeters to be very large? no

Look at the picture of the soil particles on Student Text page 34. A particle of sand can be two millimeters or smaller. Imagine how small the other particles are if the sand particle is two millimeters.

Point out that the particles are greatly magnified.

What are some characteristics of sand particles? Water drains through them quickly; they have a rough, grainy feel; they are very tiny.

How many clay particles would it take to make one particle of sand? about 100,000

Why does clay not make very good soil for gardening? There is not enough space for air between the particles. Plant roots will rot without enough air.

Why might silt be a better soil than sand for growing plants? Silt allows both water and air to mix in the soil.

What do we mean by the *texture* of a soil? the amount of each kind of particle found in the soil

What is loam? a soil consisting of equal parts of sand and silt combined with about half as much clay

Which kind of soil particle is the largest? sand

Why is the texture of soil important to farming? Certain crops grow best in certain soil textures.

What determines the composition and fertility of soil? kinds of weathered rock, climate, vegetation

What kind of climates are more likely to experience chemical weathering? moist climates

Discuss the *Texture Triangle* on Student Text page 35. Point out the heading and percentages along each side.

Find the red line marked 40 for sand. Trace it up to the black line marked 40 for silt. Which blue line is marked for clay at this point? 20 **What soil texture is 40% sand, 40% silt, and 20% clay?** loam

Practice locating other soil textures as time allows.

BIBLE

Soil

God has made the earth to be an inhabitable place for man to live (Is. 45:18). Part of the success of that habitation depends on the plants that are growing around us. They provide food, oxygen, energy, and many other essentials for survival. God has promised to care for us just as He has cared for the plants by giving them what they need to survive (Luke 12:28). This includes giving them the correct type of soil for their survival. [Bible Promise: H. God as Father; I. God as Master]

TEACHER HELPS

Soil samples

Lesson 21 requires the student to evaluate two soil samples. You may want to have the soil samples ready before beginning that lesson.

Percentages

You may choose to review the mathematical basics of percentages. Relating percentages to cent values may help some students understand.

Discussion

What do we call the layers of soil? horizons

What is the O horizon made of? leaf litter and humus

What is humus? decayed organic material

In which horizon do plants grow? topsoil, or A horizon

What makes up topsoil? minerals from weathered rock and humus

What is another name for the B horizon? subsoil

How does the B horizon benefit from the layers of soil both above it and below it? From above, it gets nutrients from the humus. From below, it gets minerals.

Why do you think the weathered fragments in the C horizon are larger than the weathered materials in the layers above? Possible answer: The C horizon has less exposure to weathering.

What is bedrock? unweathered parent material

Why do you think bedrock is called "parent material"? Possible answer: Minerals and rock in other layers come from the bedrock.

What is another name for bedrock? R horizon, regolith

What influences the texture of the upper layers of soil? the bedrock

Why is it difficult for most vegetation to grow where there is little topsoil and humus? Possible answers: Plants get nutrients from decayed material. Most plants germinate and grow in topsoil.

Answers

1. weathered particles, water, air, and humus
2. sand, silt, clay
3. the different layers of soil

Activity Manual

Expansion, page 27

You may have the students use different colored pencils to trace along the lines for each soil sample.

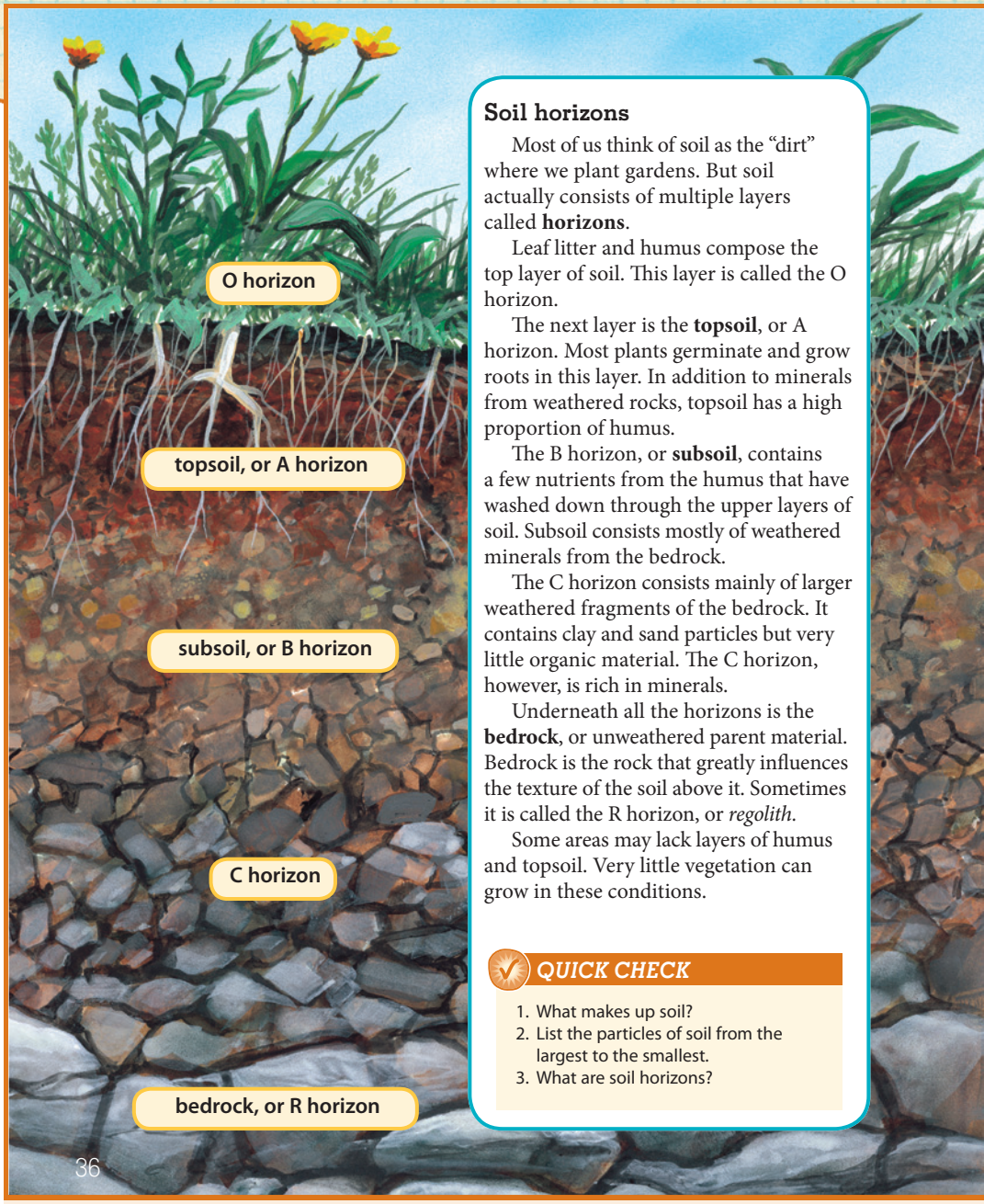
Review, page 28

This page reviews Lesson 20.

Assessment

Quiz 2-B

The quiz may be given any time after completion of this lesson.



Soil horizons

Most of us think of soil as the "dirt" where we plant gardens. But soil actually consists of multiple layers called **horizons**.

Leaf litter and humus compose the top layer of soil. This layer is called the O horizon.

The next layer is the **topsoil**, or A horizon. Most plants germinate and grow roots in this layer. In addition to minerals from weathered rocks, topsoil has a high proportion of humus.

The B horizon, or **subsoil**, contains a few nutrients from the humus that have washed down through the upper layers of soil. Subsoil consists mostly of weathered minerals from the bedrock.

The C horizon consists mainly of larger weathered fragments of the bedrock. It contains clay and sand particles but very little organic material. The C horizon, however, is rich in minerals.

Underneath all the horizons is the **bedrock**, or unweathered parent material. Bedrock is the rock that greatly influences the texture of the soil above it. Sometimes it is called the R horizon, or *regolith*.

Some areas may lack layers of humus and topsoil. Very little vegetation can grow in these conditions.

QUICK CHECK

1. What makes up soil?
2. List the particles of soil from the largest to the smallest.
3. What are soil horizons?

SCIENCE BACKGROUND

Horizons

Horizons may be described in different ways. However, the basic structure of the layers is usually the same regardless of the ways the layers are named.

Compost piles

Some people collect dead leaves, grass clippings, and other organic materials to form compost piles. The decaying material forms humus. Composting is simply an effort to speed up the process of producing humus to enrich the soil.

Soil Detective

EXPLORATION

Pedologists, or soil scientists, use many scientific instruments and methods to determine the exact texture of soil. However, when they work outside of the laboratory, they often use the "feel method" to determine the texture of soil. By following a step-by-step process, pedologists can closely approximate the texture of soil simply by feeling it.

One way of showing a step-by-step process is by using a flow chart. A flow chart is a graphic representation of a procedure. It uses symbols and arrows to show what steps to take to complete a process from start to finish.

Using a flow chart you can learn to determine the texture of soil and become a "soil detective."

What to do

1. Collect a sample of soil from the ground around your school or home.
2. Use the flow chart in your Activity Manual to analyze the soil sample.
3. Record your information.
4. Repeat with soil from another location.
5. Compare your findings.

TEACHER HELPS

Soil samples
Each student will need 2 soil samples (about the size of 2 T) from different locations. To help vary the locations, you could have each student bring in a larger soil sample so that the extra samples can be exchanged among students.

You may want to have the soil samples brought in before this lesson.

Flow charts
A flow chart is useful for teaching step-by-step directions. It can help a student analyze and evaluate each step taken as he progresses through an activity.

The appearance of the flow charts in the Activity Manual may confuse some students. To help the students focus, cover most of the chart and expose only one or two steps at a time.

Objectives
- Interpret the procedure of a flow chart
- Analyze a soil sample

Materials
- 2 soil samples per student
- water
- *How to Read a Flow Chart* (IA), for display

Introduction

Display *How to Read a Flow Chart*.

A flow chart is one way to show a process that requires multiple steps.

Follow the chart step by step. Be especially alert to places where decisions are made.

Pedologists use the feel of a soil sample to place it on a texture triangle, such as the one on Student Text page 35.

Pedologists follow a systematic method to analyze soil samples.

Teach for Understanding

Purpose for reading

What are you trying to accomplish in this experiment?

The student should read all the pages before beginning the activity.

Procedure

Show the student the approximate size of a soil sample. Explain how the samples should be collected and what kind of containers you want the samples to be in. Label the samples according to their location (for example, John's back yard or Naomi's flower garden).

Instruct the student to use one flowchart for each sample. Tell him to circle the decision that he makes each time. Compare findings with other students as time allows.

Activity Manual

Exploration, pages 29–30

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Objectives
- Record observations
- Analyze experiment results
- Predict the amount of particles needed for a specific soil sample

Materials
- several seed packets or seed catalogs that tell in what kind of soil (well-drained, dry, moist, etc.) the plant grows best
- See Student Text page
- buckets or large containers to collect used soils and water

Introduction

Two lesson days are allotted for this activity. You may choose to do Part 1 on the first day and Part 2 on the second day.

Distribute the seed packets. Direct the student to read the packets to find the kind of soil recommended. Allow several students to choose plants from the seed catalog.

Suppose you want to grow a plant that needs well-drained soil, but your soil is clay and does not drain well. What could you do to change the texture of your soil so that the soil would drain better? Answers will vary, but elicit that the soil needs some sand, silt, or both to loosen it up and allow better drainage.

Suppose your soil is sandy. What could you do to the soil to help it retain water better? Answers will vary, but elicit that adding some clay, silt, or both would help the soil retain water better.

Teach for Understanding

Purpose for reading

The student should read all the pages before beginning the activity.

ACTIVITY

Retaining the Right Amount

Process skills
- Hypothesizing
- Measuring
- Experimenting
- Observing
- Identifying variables
- Recording data

The amount of water that different types of soil can hold is one of the factors that determines how well crops can grow in that soil.

Problem

How can I mix clay, sand, and potting soil to obtain a soil sample that will retain 50% of the water it receives after 2 minutes?

Procedure—Part 1

Materials
small nail
4 foam cups, 12 or 16 oz
metric measuring cups
dry clay or clay cat litter (crushed)
sand
potting soil
4 clear plastic cups, 9 oz
water
stopwatch
Activity Manual

1. Use the nail to punch 10 tiny holes in the bottom of each foam cup. (Set one foam cup aside for Part 2.)
2. Measure 250 mL of clay. Put the clay in one of the foam cups.
3. Follow the same procedure with the sand and the potting soil.
4. Place each foam cup in a smaller plastic cup. The water that seeps through the holes will collect in the plastic cup.
5. Pour 160 mL of water over the clay in the foam cup.
6. Let the water drain into the plastic cup for 2 minutes. (You may need to periodically pull the foam cup out of the plastic cup to ensure that a vacuum has not occurred. A vacuum will prevent the water from draining into the plastic cup.)
7. After 2 minutes, remove the foam cup from the plastic cup. Measure the water that drained into the plastic cup.
8. Record your observations and measurements in the chart in your Activity Manual. (For the soil to have retained 50%, the water seepage will have to measure 80 mL.)
9. Repeat steps 5–8 with the sand and the potting soil.

Conclusions—Part 1

- Which kind of soil allowed the most water to run through?
- Which soil allowed the least water to run through?

TEACHER HELPS

Metric measuring cups
For elementary science activities, beakers, graduated cylinders, or kitchen measuring cups that are marked with metric units could be used. If a set of metric measuring cups for each group is unavailable, prepare clear plastic cups to use instead. Pour measured water into a cup and use a permanent marker to mark the water level. Repeat until all needed measurements are marked on the cup.

Cup holes
Make sure the holes in the foam cups are open. You may need to unclog the holes in the cup of sand while it is draining. If the holes are clogged, the results will be inaccurate.

Preparing the work area
- Provide large containers of water for students to measure from.
- Cover the work surface with newspaper or plastic.
- Provide buckets or containers to collect used water and soil.
- Provide a place to set the wet cups.
- Have paper or cloth towels on hand for spills.

Extending the activity
Direct the student to determine the percentage of each type of soil he used in Part 2 and to refer to the *Texture Triangle* on Student Text page 35 to identify the texture of his soil mixture.

Procedure—Part 2

1. Write your hypothesis based on your previous observations. Be sure your hypothesis identifies the amount of each kind of soil you will use in your mixture. The amounts need to total 250 mL.
2. Fill in the chart with the amount of each kind of soil you will mix together.
3. Measure your own combination of the three soils as stated in your hypothesis. Mix the soils and put the mixture in the fourth foam cup. Place the cup in a plastic cup.
4. Pour 160 mL of water over your soil mixture and time the drainage for 2 minutes.
5. Measure the amount of water in the plastic cup.
6. Record your information in your Activity Manual.
7. If your soil mixture did not retain 50% of the water after 2 minutes, then repeat steps 2–6 as needed.

Conclusions—Part 2

- What mixture of soil had a water retention equal to or closest to 50%?
- If you had a plant that needed only 20% water retention, which type of soil would you use the most of?

Follow-up

- How would you set up the experiment to see whether the temperature of the water affects the soil's retention level?

SCIENCE PROCESS SKILLS

Predicting

Predictions are made based on experience, study, or knowledge. Careful observations are a key to good predictions. In the first part of this activity, the student observes the relationships between the kinds of soil and the amounts of water they can hold. The student then uses this information to predict the results of his soil mixture.

How did your observations and results of the first part of the activity influence your predictions for the second part? Answers will vary.

Procedure—Part 1

The student will use his results from Part 1 to help him develop his hypothesis during Part 2.

Remind the student about the importance of accuracy in measuring. Demonstrate how to adjust the foam cup inside the plastic cup to prevent a vacuum from forming.

Which soil do you expect to drain the fastest? Answers will vary; sand

Which soil will likely drain the slowest? Answers will vary; clay

Guide the student in measuring the drainage for each type of soil. Remind him to complete the chart in his Activity Manual for each soil.

Conclusions—Part 1

Guide the student as he uses his measurements to answer the questions.

Procedure—Part 2

Using your observations and results from Part 1 to form your hypothesis is called predicting. Scientists make predictions about further study based on previously gained knowledge and experiences.

The student's hypothesis should include the amount of each kind of soil that he intends to use.

Repeat trials as time permits until 50% of the water is retained in the mixture.

Conclusions—Part 2

Provide time for the student to evaluate his hypothesis and answer the questions.

What mixture of soil had a water retention of 50%? Answers will vary.

If you had a plant that needed only 20% water retention, which type of soil would you use the most of? probably sand

Use the question in the Science Process Skills to discuss predicting.

Activity Manual

Activity, pages 31–32

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Objectives
- Differentiate between erosion and weathering
- Identify kinds of mass wasting
- Describe how sediment is carried and deposited by a stream

Materials
- world map

Vocabulary
sediment	mass movement
erosion	load
deposition	delta

Introduction
Have you ever seen fences, netting, or other barriers between the side of a road and the base of a rocky hillside?

Why do you think highway engineers use these barriers? Possible answer: to prevent any loose or falling rock from going on the road

Do you think these barriers work? Possible answer: The barriers could work for individual rocks, but are probably not effective to catch debris from larger mass movements.

Teach for Understanding
Purpose for reading
What do we call erosion caused by gravity?

How can flooded streams help farmers but harm people living in towns?

Discussion
What is sediment? small, weathered particles

What is the difference between weathering and erosion? Weathering breaks down rock, and erosion moves the weathered rock from one place to another.

What is the primary force in erosion? gravity

What are some agents of erosion? water, wind, and ice

Who controls agents of erosion, such as water, wind, and ice? God [Bible Promise: I. God as Master]

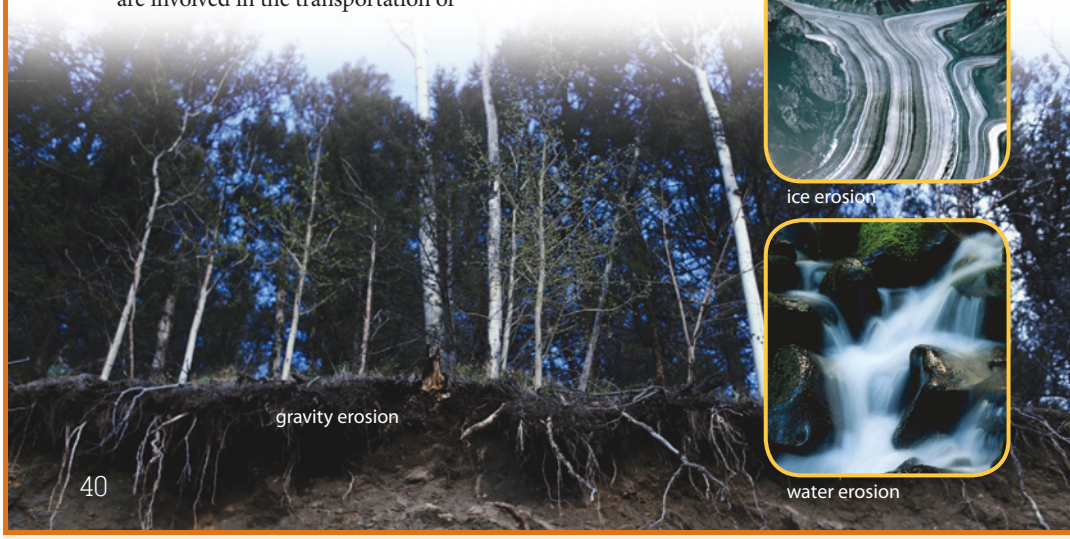
What term refers to the dropping of sediment in a new location? deposition

Why do depositions often have a layered look? Sediment drops according to weight, so the heaviest portions drop first, and the lighter ones drop on top of them.

Erosion
Agents of Erosion
Weathering produces small particles called **sediment**. Some of this sediment combines with decayed organic materials (humus), air, and water to form soil. Other sediment lies loosely on the weathered rock. But sediment seldom stays in the same location for long. When weathered material moves from one location to another, **erosion** takes place. Weathering and erosion often occur together, but they are not exactly the same. Weathering breaks down rocks, but erosion moves the broken-down material from one place to another.

The primary force behind erosion is gravity. Sometimes gravity pulls weathered material from a higher location to a lower location without the aid of other factors. However, other factors, called agents of erosion, often are involved in the transportation of weathered material. These agents include water, wind, and ice. Sometimes these agents work together to erode the earth's surface. Though forces like water, wind, and ice may seem to work on their own, God is their Master. Psalm 147:17–18 reminds us that the ice, the wind, and the water belong to God. He controls them and uses them to provide for the earth.

Weathered material that moves from one location to another must eventually stop. **Deposition** occurs when wind, water, or ice drops sediment and rocks in a new location. Usually sediment drops according to its weight. The heaviest sediment drops first, and the lightest drops last. As a result, depositions often have a layered look.




wind erosion

ice erosion

water erosion

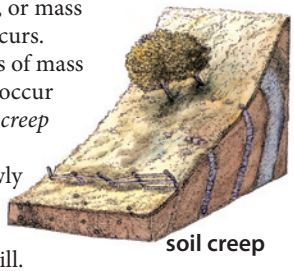
Deposition
The word *deposition* can be related to the more common form, *deposit*. Examples: One may deposit money in a bank (it is carried and left there). One may deposit his books on the floor. The idea is the same, in that something is carried and then left behind.

SCIENCE BACKGROUND

mudflow—also called *mudslide*
earth flow—also called *landslide*

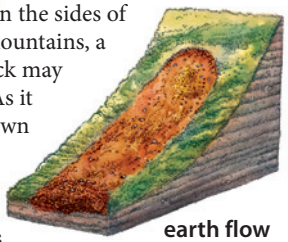
Mass Movements

When gravity is the primary force that moves rocks and sediment, **mass movement**, or mass wasting, occurs. Some forms of mass movement occur slowly. *Soil creep* happens as gravity slowly pulls soil down the slope of a hill. Sometimes this causes trees and fences on the hillside to lean at awkward angles.



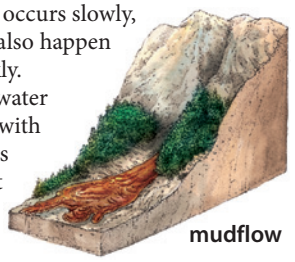
soil creep

Another mass movement is an *earth flow.* As gravity pulls at rocks and sediment on the sides of hills and mountains, a piece of rock may break off. As it tumbles down the hill, this rock dislodges other rocks and sediment, which in turn dislodge other material. The result is a pile of soil and rocks at the bottom of an incline. Sometimes an earth flow occurs slowly, but it can also happen very quickly.



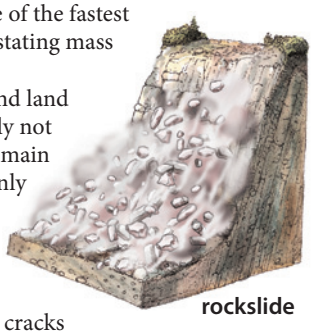
earth flow

When water combines with soil, a mass movement called a *mudflow* can occur. The combination of soil and water produces an extremely heavy and unstable area. The greater the mass of material at the top of the hill the greater the chance that gravity will start it moving downhill. A mudflow is one of the fastest and most devastating mass movements.



mudflow

Soil creep and land flows are usually not very deep. The main movement is only at the surface. In *rockslides*, however, huge slabs of rock break off along cracks and faults. Sometimes an entire side of a mountain is part of a rockslide. You have probably seen examples of smaller rockslides where roads have been built through mountains. Often large rocks lie along the sides of roads where they have broken off from the slope.



rockslide

Another kind of mass movement is an *avalanche.* An avalanche occurs when a mass of snow along the side of a mountain becomes unstable. The pull of gravity starts the snow moving. Suddenly, huge amounts of snow rumble down the mountain, burying everything in their paths.

avalanche

What is mass movement? erosion that is primarily caused by gravity

What are five kinds of mass movements? soil creep, earth flow, mudflow, rockslide, avalanche

What kind of mass movement might cause the trees or poles on a hillside to lean at an angle? soil creep

What happens during an earth flow? Tumbling rock loosens other rocks, resulting in a pile of soil and rocks at the bottom of an incline.

Why do you think a mudflow is such a devastating mass movement? Possible answer: Since the mud flows like water, it can fill spaces that dry rocks and soil would not fill.

How is a rockslide different from an earth flow? A rockslide is the movement of many large slabs of rock rather than of a few rocks and soil, as in an earth flow.

What causes an avalanche? Gravity pulls an unstable mass of snow down a mountain.

What tectonic forces can start a sudden mass movement? earthquakes, volcanoes

How does erosion show God's preservation of the earth? Possible answer: Erosion can move minerals and nutrients to less fertile land.

TECHNOLOGY

Avalanche technology

Although man cannot stop avalanches, he has developed technology to help detect and channel the path of an avalanche. Scientists use temperature, weather conditions, land terrain, and snowfall to help predict areas likely to have avalanches. Based on their predictions, steps can be taken to prevent serious damage or danger.

Ski rangers and snow patrols constantly test and monitor snow over acres of land looking for potential problems. Sometimes they use huge guns to cause small controlled avalanches in order to break up larger, more dangerous masses of snow.

Discussion

What term describes the sediment carried in moving water? load

Can you see the dissolved load in a stream? no **Why?** It is dissolved; its particles have mixed with the liquid water.

How is a suspended load different from a dissolved load? The sediment of a suspended load is not dissolved.

How can the suspended load cause more mechanical weathering than water alone causes? The sediment abrades rocks along the sides and bottom of the stream channel.

What determines how large a load a stream can carry? Possible answer: the speed and volume of the water flow

Why is it not safe to cross through a flooded stream? The increased volume and speed of the water can move large objects, including cars and people.

Why do fast streams cause deeper and wider channels than slow streams? The load the stream carries acts as an abrasive force, eroding more and more of the channel as the water flows faster.

What happens when a stream slows down? It starts to deposit its sediment.

Which sediment drops first? the heaviest

What is this process called? deposition

How does the deposition affect the stream? It causes the stream to become shallower.

What are some places where a stream might deposit its sediment? in the streambed; in the flooded countryside; in flooded buildings

When is sediment welcome? when it fertilizes farmland **When is it unwelcome?** when it is deposited in homes and other buildings

Use the map to locate the Dead Sea in Israel and the Great Salt Lake in Utah.

How do these lakes get so salty? Dissolved minerals and salts flow into, but not out of, the lakes. As water evaporates, the dissolved materials become more concentrated

Where do most dissolved minerals and salts eventually end up? in oceans and seas

SCIENCE & HISTORY

In the 1960s the Aswan High Dam was built on the Nile River. The dam controls floods, produces hydroelectricity, and stores water. Though the Egyptian people enjoy the benefits of the dam, it has also caused problems. The Nile used to flood annually. Without the sediment deposited by the Nile, farmers have more difficulty maintaining the fertility of their soil.

As the dam prevents new sediment from reaching the Mediterranean Sea, the delta, Egypt's most fertile farmland, is being eaten away by the sea waves. In an effort to keep the force of the waves from carrying away this precious land, the Egyptian government has built several protective barriers offshore.

Where is all the sediment that once formed the delta? It collects behind the dam. This sediment must be removed constantly so that it will not get into the generating equipment.

Aswan High Dam

Stream Erosion

Moving water transports huge amounts of sediment from one location to another. Even the tiniest raindrop moves loose material a little. As the rain washes across the surface of the earth, it carries sediment into streams. The sediment that a stream carries is called its **load**.

Some sediment, such as minerals, dissolves in the stream and is transported to larger bodies of water. This is called the stream's *dissolved load*. Most streams eventually flow to the ocean, but a few flow into large inland lakes or seas. The dissolved minerals make these bodies of water so salty that few things can live in them. The Dead Sea in Israel and the Great Salt Lake in the United States are examples of such bodies of water.

Other sediment particles cannot dissolve in water. Any sediment that is carried by a stream but is not dissolved is the stream's *suspended load*. The faster a stream flows, the more sediment it can pick up and carry along. The sediment acts as an abrasive substance, weathering and eroding additional rock along the sides and bottom of the stream channel. A rapidly flowing stream rolls larger particles along its streambed, further

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SCIENCE BACKGROUND

Stream

In the context of this lesson, the term *stream* means any form of water moving as a result of gravity. It might be a small creek or an enormous river.

eroding and deepening its channel. During a flash flood, when the volume and speed of a stream are unusually great, rushing water can move large boulders. This is why it is never safe to cross a flooded stream. Just as the water can move boulders, it can also pick up cars and people and sweep them away.

When a stream slows down, it begins to drop its sediment. The heaviest sediment is dropped first. This deposition may be in the streambed. Instead of deepening a channel as before, the sediment fills it, causing the stream to be shallower. If the stream floods outside its normal channel, the sediment may be deposited in homes and buildings in the surrounding countryside.

Not all deposited sediment is destructive, however. Farmers in many places depend on the yearly flooding of their land to improve its productivity. An area that commonly floods is called a *floodplain.* Some sediment is deposited in the floodplain, and some is carried to the mouth of the river. So much sediment can deposit at a river's mouth that a new area of land forms. The new land is rich in nutrients and is often used for farming. An area of sediment at the mouth of a river is called a **delta**. Deltas were named after the triangular shape that is formed where the Nile River flows into the Mediterranean Sea. The area looks like the Greek letter *delta* (Δ).

The Mississippi River in the United States has a delta that extends into the Gulf of Mexico. Every year the delta gets a little bigger as more sediment is added to it. Much of this sediment is topsoil washed off farmland. Unlike the neat outline of the Nile delta, the Mississippi delta sprawls in all directions. The currents and waves of the Gulf of Mexico shape the delta differently. The shape of the Mississippi Delta is so unusual that it has been named a birdfoot delta.


Mississippi delta

QUICK CHECK

1. What is the difference between weathering and erosion?
2. What are the advantages and disadvantages of sediment deposition?
3. Why is the shape of the Mississippi Delta different from the Nile Delta?

DIRECT A DEMONSTRATION

Demonstrate stream erosion

Materials: modeling clay, water, small aluminum pan, sand, potting soil

Direct a student to cover the bottom of the aluminum pan with about 5 cm of clay. Tell him to make a channel about 2.5 cm deep and 2.5 cm across and then fill the channel with potting soil.

Pour just enough water to fill the channel to the top.

What do you think will happen when we put more water into the channel? The water will overflow.

What will happen to the sediment (soil) that is in the channel? Answers will vary.

Pour in more water until the soil floats out of the channel.

Explain that this is what happens when additional water fills a stream or river. Empty and clean out the channel. Again fill it with water.

What is another way we could get the water to overflow its banks? Answers will vary. Try some of the ideas.

If students do not come up with the idea that increased deposition might also cause a river to overflow its banks, start filling the channel with sand until the water overflows.

How does this model show what happens to a river? Elicit that as rivers drop their loads, they widen to accommodate the same amount of water.

Discussion

What is a floodplain? an area where a river or stream commonly floods

What happens when the same amount of water flows through a channel that has become shallower? Answers will vary, but elicit that the water must go somewhere, so the river or stream will probably widen as it gets shallower.

What place other than a floodplain can sediment be deposited? at the mouth of a river

What can result from sediment collecting at the mouth of a river? New land can form.

What do we call new land formed at the mouth of a river? a delta

Why is it called a delta? The land formed at the mouth of the Nile River has a triangular shape like the Greek letter *delta*.

What causes the shape of the Mississippi River delta to be different from that of the Nile River delta? The currents of the Gulf of Mexico shape the delta differently.

Discuss *Science & History.*

Why did the Egyptians build a dam across the Nile River? to control floods, produce electricity, and store water

How is the sediment carried by the Nile River beneficial to farmers? It makes the land fertile.

What problem does the sediment cause for the Aswan High Dam? The sediment collects at the dam and can damage the generating equipment.

On the map, point out where the Nile River flows into the Mediterranean Sea. Point out where the Mississippi River flows into the Gulf of Mexico.

Why is the Mississippi Delta called a birdfoot delta? The erosion has not formed a uniform triangular shape. The many channels running in different directions resemble a bird's foot.

Answers

1. Weathering is breaking down rock. Erosion is moving weathered rock.
2. When sediment is deposited, they fertilize the land. When sediment is deposited in towns and in buildings, the effects can be destructive.
3. The shape is different because the currents and waves in the Gulf of Mexico are different from those in the Mediterranean Sea.

Objectives
- Record and analyze data
- Measure volume, angles, and mass accurately
- Experiment to discover how the steepness of a slope affects erosion

Materials
- See Student Text page

Introduction
Have you ever looked at a calm stream and tried to figure out which way it was flowing?

Because of gravity, water flows from a higher elevation to a lower elevation. The steepness of the slope can affect the speed at which the water flows.

In this activity you will investigate the effects of slope on the amount of sediment that erodes.

Teach for Understanding
Purpose for reading
What are you trying to find out by doing this experiment?

The student should read all the pages before beginning the activity.

Procedure
In this activity you are using models to find the answer for Pedro's question.

What are you trying to find out by doing this experiment? how the slope of a hill affects the amount of erosion

Provide time for the student to formulate his hypothesis and record it. Discuss as needed.

Help the student prepare the aluminum pans for the experiment. Remind him to measure accurately. Demonstrate how to use the protractor and books to elevate the pans of dirt to the proper angles.

As needed, guide the student in using the balance to measure the mass of the eroded material. Remind him to record his measurements in his Activity Manual.

ACTIVITY

Stream Erosion

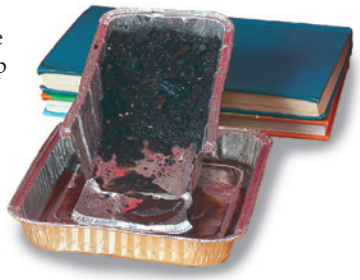
Process skills
- Hypothesizing
- Measuring
- Experimenting
- Observing
- Identifying variables
- Recording data

Pedro recently bought a new house. In one corner of the yard is a steep slope with no grass growing on it. After the first hard rain, Pedro was surprised at the erosion that occurred on the slope. He wondered if the erosion would be the same if the slope were not as steep. Investigate and measure the erosion for a 20° slope and a 45° slope. Find out if a steeper slope has more or less erosion.

Problem
How does the steepness of a slope affect the amount of erosion that is caused by a stream?

Materials
2 foil loaf pans
scissors
metric measuring cups
potting soil (dirt)
2 small rectangular baking pans
protractor
water
spray bottle
cheesecloth
2 clear plastic cups, 12 oz
balance
Activity Manual

Procedure
1. Write your hypothesis in your Activity Manual. Include the angle of the slopes in your hypothesis.
2. Prepare a foil loaf pan by cutting it at the corners of one of the smaller ends. Fold the piece down so it is even with the bottom of the pan. Repeat with the other loaf pan. (Safety tip: The cut edges of the pan may be sharp.)
3. Measure 250 mL of potting soil. Place the dirt at the uncut end of one of the foil loaf pans. Measure and add another 250 mL of soil to the other loaf pan.
4. Place the open end of each loaf pan into a larger pan. This second pan will catch the runoff water. Raise the dirt end of each loaf pan and set it on a stack of books or another raised surface.
5. Using a protractor, adjust the angle of one of the loaf pans to 45°. Add or take away books to keep the pan elevated at this angle. Follow the same procedure with the other pan of dirt, elevating it to a 20° angle.
6. Measure 120 mL of water into the spray bottle.



TEACHER HELPS

Measuring with a protractor
Rest one end of the pan on several books. Place the flat side of the protractor on the table. Align the center point of the protractor with the point at which the pan touches the table. Measure the angle formed between the pan and the table. Adjust books as needed to get the correct angle.

See Teacher Helps on page 46 for a suggested way to prepare the work area.

7. Spray the dirt in one of the pans until all the water is gone. Repeat the procedure with the other pan of dirt using the same amount of water.
8. Place a double layer of cheesecloth over a plastic cup to act as a filter. Pour the contents of the large pan from the 20° slope through the filter to remove the water. Put the eroded material in a clean plastic cup and use the balance to measure its mass. Record your measurements.
9. Repeat step 8 with the eroded material from the 45° sloped pan. Compare the measurements.

Conclusions

- Why would changing the angle of the slope affect the amount of erosion?
- How is this experiment like a real stream? How is it different?

Follow-up

- What variables could you change to find out more about stream erosion?

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SCIENCE PROCESS SKILLS

Measuring
Discuss some of the kinds of measurements used in the experiment, such as measuring the angle, measuring milliliters, and measuring milligrams.

Why is it important to measure the amount of water that we put in the spray bottle? Answers will vary, but elicit that it keeps the variable constant.

Why is it important to measure the amount of soil that erodes? Answers will vary, but elicit that without measuring we are simply guessing how much soil actually erodes.

Emphasize the importance of accurate measurement.

If we fail to measure accurately, what happens to the information that we gain from the experiment? The information becomes unreliable because it has no specific data that can be quantified.

Conclusions

Provide time for the student to evaluate his hypothesis and answer the questions.

Did your results support your hypothesis? Which pan appeared to have the most erosion? The pan with the steepest slope had the most erosion.

Why would a steeper incline cause more sediment to erode? Answers will vary, but elicit that a steeper incline causes the water to run faster because of gravity. The faster the water flows, the more it erodes.

What might happen if the water were poured rather than sprinkled? The poured water would increase the amount of eroded dirt.

Use the questions in the Science Process Skills to discuss measuring.

Activity Manual

Activity, pages 33–34

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Lesson 26

Student Text pages 46–49
Activity Manual pages 35–36

Objectives

- Demonstrate an understanding of the real-life problems of sand erosion and deposition
- Summarize how water, wind, and ice cause erosion
- Compare the effects of ice erosion with other kinds of erosion
- Describe how rocks are eroded by glaciers

Materials

- aluminum pan
- clay
- ice cubes
- sand
- world or United States map

Vocabulary

deflation
dust storm
sandstorm
glacier
plucking
moraine

Introduction

Have you ever built a sandcastle at a beach?

What happened to your sandcastle when the tide came in? Possible answers: The waves eroded the sandcastle. The waves left deposits of sand in and around the sandcastle.

Teach for Understanding

Purpose for reading

What are three causes of erosion other than stream erosion?

Which kind of erosion can move the largest rocks?

Discussion

How does wave erosion affect shorelines? It causes the shores to change constantly.

Why does a changing shoreline have a tremendous effect on commerce? Shipping lanes sometimes clog with sediment and have to be dredged in order to stay open. Sandbars create hazards for ships along the coast.

What can cause wave erosion to be greater? storms, such as hurricanes

Discuss *Science & History.*

What was the purpose of the Cape Hatteras lighthouse? to warn ships of the shallow sandbars off the coast

Why was the lighthouse in danger? The shoreline had eroded almost to the lighthouse.

What happened to the lighthouse? It was moved farther inland.

Wave Erosion

Water is also a force of erosion along shorelines. The pounding of ocean waves exerts tremendous pressure on the rocks along the coast. As the rocks weather and erode, the ocean waves move the sediment to new locations. The shoreline constantly changes as this erosion and deposition take place.

Sometimes waves carve out caves and sea arches from rocky cliffs. Places where land was once connected may be eroded to form islands. On the other hand, sand deposits may fill in channels and bays, forming new areas of land.

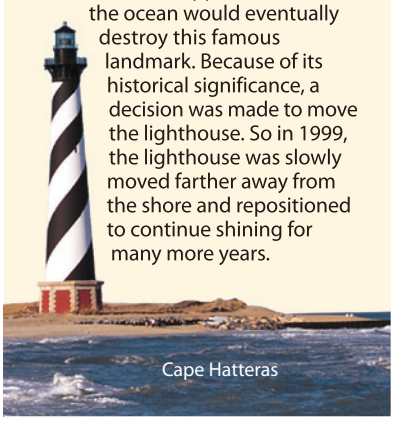
Sand deposits called sandbars may create shoals, shallow places along the coast. Shallow water can be dangerous to ships. A ship's navigator may not notice a sandbar and run aground. Sandbars constantly shift positions, which adds to the danger.

Commerce can be greatly affected when channels that are used for shipping become shallower because of sediment deposits. Often large sums of money are spent to dredge (remove sediment) in order to maintain shipping lanes.

Storms such as hurricanes increase the erosion and deposition caused by waves. High winds create bigger and more powerful waves. Those waves may erode a beach so much that buildings along the shore are destroyed.

SCIENCE & HISTORY

On Cape Hatteras, in North Carolina, a lighthouse stood for many years to warn ships of the shallow sandbars off the coast. But over time the shore at the lighthouse eroded, becoming narrower and narrower. It appeared that the ocean would eventually destroy this famous landmark. Because of its historical significance, a decision was made to move the lighthouse. So in 1999, the lighthouse was slowly moved farther away from the shore and repositioned to continue shining for many more years.


Cape Hatteras

Deflation
The word *deflation* comes from the Latin word that means "to blow away."

desert sand dunes

Wind Erosion

Wind is a powerful agent of erosion in dry areas such as deserts. It can also erode areas where land has become very dry due to a drought. When wind blows, picks up loose sediment, and carries it away, the process of **deflation** takes place. The wind cannot move large particles like water can. Nevertheless, a strong wind can carry tons of sediment at a time. **Dust storms** occur when the wind blows small, loose particles such as clay and silt. These dust storms can reach hundreds of meters into the air. However, since sand particles are heavier, **sandstorms** tend to be closer to the ground. Some of the sand moves as the wind bounces it along the ground.

Along the shore where sand dries out, wind often blows sand into piles called sand dunes. Deserts also have sand dunes caused by wind. Some of these are small. However, others are hundreds of meters tall. In a desert with few obstacles to stop the erosion, sand dunes can move as much as twenty-five meters per year. The prevailing, or most constant, wind determines the size and shape of the sand dunes.

beach sand dunes

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In what kind of climate is wind the greatest erosion agent? dry areas

Why would farmland normally not be eroded much by wind? Answers will vary, but elicit that in farming areas the soil and air are usually moist. Farmland also would usually have crops or ground cover instead of bare soil.

What weather condition can cause farmland to be more easily eroded? a drought

When does a drought happen? when an ecosystem has less than normal rainfall for an extended time

What is deflation? the process of the wind picking up loose sediment and carrying it away

Name two kinds of wind erosion. dust storms and sandstorms

As time allows, discuss the causes and effects of the Dust Bowl that occurred in the central United States during the 1930s.

Which kind of storm is closest to the ground? a sandstorm **Why?** The particles are heavier.

What determines the size and shape of sand dunes? the prevailing wind

How might waves and wind combine to change the shoreline? The waves bring sand to the beach. As the sand dries, the wind picks it up and moves it into dunes.

DIRECT A DEMONSTRATION

Demonstrate moving wet and dry particles

Materials: a pile of paper hole punches, a saltshaker filled with water, a small aluminum pan

Place the paper punches in the middle of the pan. Blow gently. Observe what happens to the paper punches. Return the paper punches to the middle of the pan. Sprinkle water on the paper punches. Blow gently. Observe the results.

How does sprinkling water on the paper punches change the effects of the wind? Possible answer: The water adds weight to the punches and causes them to stick together.

WRITING

Persuasive essay

Moving the Cape Hatteras Lighthouse was an enormous and expensive project.

Do you think moving the lighthouse was worth the time and money spent?

The student should research to find details about moving the lighthouse. Then the student should write a one-page essay for or against spending the money to move the lighthouse. The argument can include information concerning the historical value of the lighthouse, the current need for a functioning lighthouse, technology that could possibly replace the lighthouse, and the impact on nature of moving the lighthouse.

Discussion

How is a glacier formed? A glacier forms when layers of unmelted snow compact and turn to ice.

What happens when a glacier starts moving? It slides downhill, gouging the ground underneath it.

What happens when plucking occurs? Large pieces of bedrock are pulled out of the ground and carried along the mountainside.

How is the erosion caused by a glacier similar to erosion caused by a stream? Answers will vary, but elicit that for both the sediment that is carried (suspended load) abrades the surface under it.

How is the erosion caused by a glacier different from the erosion caused by a stream? Possible answer: Glaciers can carry much larger sediments and can cause much more erosion than streams can.

Usually lower soil horizons are not exposed to extensive weathering or erosion. How is this different in areas where glaciers move? Explain. Possible answer: A glacier probably erodes all layers of soil since it can move bedrock.

Provide time for the student to complete *Try It Yourself*.

What happens to the soil and rock when a glacier begins to melt at the bottom of a mountain? The soil and rock are deposited.

What are the piles of deposited soil and rock called? moraines

What do we call rock that has been ground into fine powder by glaciers? rock flour

Why do you think it is called rock flour? Answers will vary, but elicit that it looks similar to flour used for baking.

What are receding glaciers? glaciers that melt faster than snow falls

What kind of valley does a receding glacier create? a U-shaped valley

What lakes do scientists think were caused by a receding glacier? the Great Lakes in North America

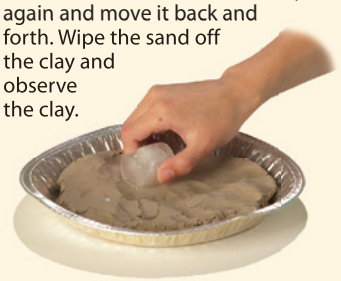
Point out on the map the Great Lakes and states discussed in the text.

TRY IT YOURSELF

You can show how a glacier erodes. Spread a layer of clay in the bottom of an aluminum pan. Press an ice cube on the clay and move it back and forth. Remove the ice cube and observe the clay.

Place a small pile of sand on the pile of clay. Place the ice cube on the pile of sand for one minute. Pick up the ice cube and observe the bottom.

Place the ice cube on the clay again and move it back and forth. Wipe the sand off the clay and observe the clay.



Ice Erosion

Ice formations called **glaciers** erode huge amounts of all kinds of sediment and rocks. Glaciers form where snow that has fallen in the winter does not completely melt in the summer. When more snow falls the next winter, that snow presses the first layer down and compacts it into ice. Eventually the mass of ice becomes so heavy that gravity causes it to begin sliding slowly downhill.

As glaciers slide down a mountain, they do not slide smoothly like an ice cube across a table. Instead, they take pieces of mountain with them. Rocks become caught in the bottom of the glacier as it slides. The rocks and rough

Sioux quartzite rock left by a glacier

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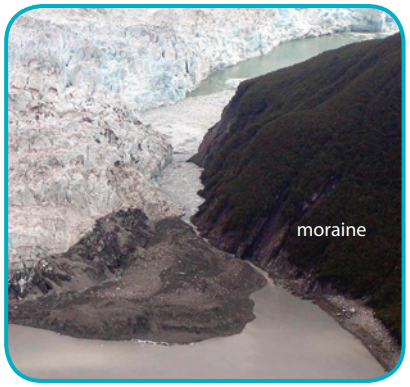
Try It Yourself

You could provide time for the student to do this activity during the teaching of the lesson. You could also assign it to be done after the lesson or just encourage the student to do it on his own. If assigned, follow up with discussion about what the student observed.

ice gouge out the ground underneath them. Where there are weaknesses in the bedrock, a glacier can pull a huge piece of bedrock loose and carry it along, a process called **plucking**. As the glacier continues to slide down the mountainside, the rock already picked up by the glacier scrapes soil and bedrock from the ground. After a while the glacier may erode the rock underneath it and form its own valley.



As long as more snow is accumulating than is melting, a glacier will continue to move downhill. Toward the bottom of the mountain, the temperature rises, and the glacier begins to melt. As the glacier melts, it deposits the soil and rock it picked up on the way down the mountain into piles called **moraines** (muh RAINS). These piles of debris can be hundreds of meters deep and hundreds of kilometers long. Moraines often consist of *rock flour*—rocks that the glacier has ground into fine powder—and huge rocks that were never broken up. They are left behind as the glacier recedes.

A glacier that melts faster than new snow falls is called a *receding glacier*. A glacier that has completely melted often leaves behind a beautiful U-shaped valley. It may also leave lakes behind.

Many large moraines exist along the southern edges of the Great Lakes. The Valparaiso Moraine wraps around the southern tip of Lake Michigan through the states of Michigan, Indiana, Illinois, and Wisconsin. The continental glacier that helped shape Lake Michigan may have left this moraine behind.

Causes of Erosion

Most erosion is part of the normal processes that God has planned for the renewing of the earth. However, people can change the surface of the earth and sometimes cause erosion that is greater than normal. As people develop land and industry, careful planning is important. By thinking ahead about erosion and other possible results of our activities, we can be wise stewards of the resources God has entrusted to our care.

QUICK CHECK

1. How can waves change a shoreline?
2. Where does most wind erosion occur?
3. What is a moraine? What causes it?

TECHNOLOGY

Controlling water runoff
In many places builders who pave large areas are required to provide a retention pond, a place where water from the paved area can run into and slow down before it flows into creeks and ditches.

How would water running off a large paved area create problems for ditches and creeks? Accept any answer, but elicit that there would be a lot of water running at a fast rate. This water would likely cause a lot of erosion.

Do you think builders should be required to have places for water to run off? Answers will vary.

Discussion

Water, wind, and ice are called agents of erosion. Do the agents of erosion actually cause the material to weather? Answers will vary, but elicit that while water may cause some materials to weather, most weathering is done by the sediment and loads carried by water, wind, and ice. The agents of erosion are mainly the means to transport weathered material.

Does all erosion occur because of natural processes? no

How does man sometimes cause greater erosion than normal? Possible answers: cutting down all vegetation in an area; cutting through rocks to make roads; paving over land so that water runs off too quickly

Why is careful planning necessary as people develop land and industry? to avoid erosion problems

Discuss man's God-given responsibility to be a wise steward. A Christian's goals should include plans to be a wise steward of the resources that God has entrusted to him. [BATs: 2c Faithfulness; 2d Goal setting]

Answers

1. They erode away the beach and deposit the sand in new places.
2. in dry areas
3. the pile of soil and rock left by a glacier as it melts and recedes

Activity Manual

Review, pages 35–36

This page reviews Lessons 24 and 26.

Assessment

Quiz 2-C

The quiz may be given any time after completion of this lesson.

Activity Manual pages 37–38

Objectives

- Use the PQ3R method to read informational text

Materials

- *Devils Postpile National Monument* (IA), for each student

Introduction

Discuss different purposes for reading.

What types of books do you read for fun?

Do you expect to learn new information as you read these books? not usually

Do you usually have to remember the information that you learn while reading for fun? no

Sometimes you must read to gain new information. What types of books might you read for this purpose? Possible answers: textbooks, encyclopedias, other reference books

When you read to gain information, such as from your Science textbook, do you always understand and remember what you read?

In this lesson the student will learn how to use a study skill called PQ3R to help him improve his ability to gain and remember important information as he reads.

Teach for Understanding

Discussion

Discuss each step of the PQ3R study skill. The discussion refers only to Activity Manual page 37 to teach each step of the PQ3R study skill. Then guide the student in using PQ3R and completing Activity Manual pages 37–38 while reading the Devil's Postpile National Monument article.

Look at the Study Skill box on Activity Manual page 17. What does each letter of PQ3R stand for? Preview, Question, Read, Recite, Review

What is a preview? Possible answers: a sample look, skimming to get a general idea

When the student reads to learn information, his first step is to Preview the entire selection to get a general idea of what it is about. In this step **the student *skims*, or takes a quick look at, the title, subheadings, illustrations, captions, chart titles, bold words, and italicized words.**

After the student previews the selection, he reads each section of the selection separately. The *Question*, *Read*, and *Recite* steps of PQ3R are repeated for each section read.

Study Skill: PQ3R

Name _____

A. Practice the PQ3R study method as you read "Devils Postpile National Monument" from the page your teacher gives you. Begin by using the *Preview* step. Check each box as you complete the step.

Study Skill

P review	Skim the text.
Q uestion	Ask questions.
R ead	Look for answers.
R ecite	Answer your questions.
R eview	Reread and think about what you have learned.

❑ **Preview (Skim)**

1. What do you look at during your preview? _____
2. What do you think this article is about? _____

B. Follow the middle three steps (*Question*, *Read*, and *Recite*) for the first section of the article.

❑ **Question**

3. Make a question from the title of the article "Devils Postpile National Monument." _____
4. Look at the first illustration. Make a question from the caption under the map. _____

❑ **Read**

5. Think about your questions as you silently read the first section of the article.

❑ **Recite**

6. Tell yourself the answers to the questions you wrote in numbers 3–4.

C. Repeat the *Question*, *Read*, and *Recite* steps for the "Volcanic Formation" part as you read the next section.

❑ **Question**

7. Make a question from the subheading "Volcanic Formation." _____
8. Make a question from the caption under the second picture. _____
9. Make a question with the word *basalt*. _____
10. Make a question with the words *columnar basalt*. _____

❑ **Read**

11. Think about your questions as you read silently.

❑ **Recite**

12. Tell yourself the answers to the questions you wrote in numbers 7–10.

D. Repeat the *Question, Read,* and *Recite* steps for the "Glacier Erosion" section.

❑ **Question**

13. Make a question from the subheading "Glacier Erosion." _____

_____

14. Make a question from the caption under the picture. _____

_____

15. Make a question with the word *striations.* _____

❑ **Read**

16. Think about your questions as you read "Glacier Erosion" silently.

❑ **Recite**

17. Tell yourself the answers to the questions you wrote in numbers 13–15.

E. Repeat the *Question, Read,* and *Recite* steps as you read the last section.

❑ **Question, Read, Recite Again**

18. On your own paper, make questions for the next section, "Rainbow Falls." Read the section and recite your answers.

F. Complete the last step in the PQ3R study method.

❑ **Review**

19. Look back at the title, subheadings, captions, bold words, and italicized words. Think about the information you have learned.

TEACHER HELPS

PQ3R

PQ3R is taught in *Reading 6*. If you are using this program, you may want to coordinate teaching the study skill.

Once PQ3R is learned, remind the student to use it as he reads *Science 6* or any other informational material.

SQ3R

SQ3R is a study method in which the first step is *Survey*. We have chosen to teach PQ3R. The *Preview* step is the same as the *Survey* step in SQ3R.

What is the second step of PQ3R? Question

In the *Question* step the student **forms questions from titles, headings, illustrations, captions, charts, bold words, italicized words, or other material he did not understand during the *Preview* step**. The questions may be written.

Look at the title of Activity Manual page 37. Titles usually tell you what information you will be reading. Make a question from the title on this page. Possible answers: What is PQ3R? What will I learn about PQ3R?

What is the third step of PQ3R? Read

After the student has formed questions about the section, he is to read the section completely. During the *Read* step **he looks for the answers to his questions**. In addition to the text, **he reads captions and examines any graphic information, such as maps and charts**. He should slow his reading or stop and reread a passage if it is especially difficult.

What is the fourth step of PQ3R? Recite

The *Recite* step immediately follows each *Read* step. In this step the student **recites, thinks about, or writes the answers to his questions**. He may also find it helpful to **summarize the section in his own words or take notes**.

What is the fifth step of PQ3R? Review

After the entire selection is read, the student reviews what he has learned. In the *Review* step the student **rereads the titles and headings, rereads captions and other graphic information, and thinks about the answers to his questions**.

Activity Manual

Expansion, pages 37–38

Guide the student as he applies the PQ3R study skill to read *Devils Postpile National Monument*.

Lesson 28

Objectives

- Recall concepts and terms from Chapter 2
- Apply knowledge to everyday situations

Introduction

Material for the Chapter 2 test will be taken from Student Text page 50 and Activity Manual pages 23–24, 28, 35–36, and 39–40. You may review any or all of the material during this lesson. Questions similar to Solve the Problem or the ones in Thinking It Through, Activity Manual pages 39–40, may appear on the test.

You may choose to review Chapter 2 by playing "To the Ocean" or a game from the Game Bank on the Teacher's Toolkit CD.

Teach for Understanding

Diving Deep into Science

Information on this page reflects the vocabulary and concepts the student should know for the test.

Solve the Problem

In order to solve the problem, the student must apply material he has learned. The student should attempt the problem independently. The answer for this Solve the Problem is based on the material on Student Text pages 34–35. Answers will vary and may be discussed.

Activity Manual

Review, pages 39–40

These pages require written responses to application questions.

Lesson 29

Objective

- Demonstrate knowledge of concepts taught in Chapter 2

Assessment

Tests, Chapter 2

DIVING DEEP INTO SCIENCE

Words to Know

weathering
carbonic acid
stalactites
stalagmites
soil
humus
pedologist
texture
loam
sediment
erosion
deposition
mass movement
load
delta
deflation
dust storms
sandstorms
glaciers
plucking
moraine

Key Ideas

Rock cycle
Types of mechanical weathering
Examples of chemical weathering
Difference between chemical and mechanical weathering
Types of soil particles
Soil horizons
Difference between weathering and erosion
Agents of erosion
Effects of gravity on erosion
Kinds of erosion

Solve the Problem

When you start to dig a flowerbed in your new yard, you find thick red clay and lots of rocks. You notice that when it rains, a small stream runs right across the area where you want to plant your flowers. Would your flowers likely grow well in this area? What could you do to the soil in the area to increase the likelihood of having a blooming garden?

Elicit that flowers would probably not grow well. You could improve the soil by adding some sand and silt to add open spaces for air and water to move through the clay soil.

50

Review Game

To the Ocean

Divide the class into two teams. Each student represents a piece of sediment. The goal is to get all of the sediment to the ocean. Each time a student correctly answers a question, he moves to the designated "ocean" spot. The first team to have all its members enter the ocean wins the game.

Variation: Set a certain number of correctly answered questions as a completed trip to the ocean. See how many trips to the ocean can be completed in a certain amount of time.