

SCHOOL LAUNCH · EARTH SCIENCE K-8

GRADE 2 EARTH SCIENCE: THE EARTH'S SURFACE

A year of true stories about the ground under our feet, from Hillary and Tenzing on the top of Mount Everest and the morning Mount St. Helens blew its side away to the San Francisco earthquake, the long dark rooms of Mammoth Cave, the ice of Glacier Bay, the dinosaur bones of Utah and John Wesley Powell's boats in the Grand Canyon, each one looked at closely, measured with hands and rulers, and built again in small at the kitchen table.

First edition

“In the beginning God created the heaven and the earth.” (Genesis 1:1, KJV)

COURSE GUIDE

This course walks a young child across the face of the earth in eight short journeys: mountains, volcanoes, earthquakes, caves, glaciers and ice, oceans and shores, dinosaur lands, and the Grand Canyon. Each unit begins with a real place and a real day: Edmund Hillary and Tenzing Norgay standing on top of Mount Everest on May 29, 1953; Mount St. Helens erupting on May 18, 1980; the San Francisco earthquake of 1906; the winding halls of Mammoth Cave in Kentucky; the blue ice of Glacier Bay in Alaska; dinosaur bones in the rock wall at Dinosaur National Monument; footprints in the riverbed at Glen Rose, Texas; and John Wesley Powell's little wooden boats on the Colorado River in 1869.

Every lesson follows the same simple path. First comes **the story**, read aloud. Then we **look**: a picture to study, a rock to hold, a puddle or a hill to visit. Then we **measure**: count, compare bigger and smaller, or use hands and a ruler. Last, the child **makes and does**: folds a towel into mountains, shakes a table of blocks, grows crystals on a string, lets an ice cube scrape across clay, or pours water down a sand tray to carve a little canyon. Each lesson ends with a drawing in the field notebook.

One thread runs through the whole year: **the earth's surface is always being shaped**. Mountains are pushed up, water and ice wear them down, waves move the sand, and rivers cut deep into the rock. Some of this happens slowly and some of it happens very fast, as the children see at Mount St. Helens. The year ends with an optional **Field Lab** that takes the same questions outdoors: a landform hike, a stream table in the yard, a shake test day and a visit to a creek or shore.

Above all, the course teaches that the hills and the seas have a Maker. The very first verse of the Bible says, "In the beginning God created the heaven and the earth." (Genesis 1:1) The child learns to look at a mountain and say with the psalmist, "I will lift up mine eyes unto the hills" (Psalm 121:1), to stand at the edge of the sea and remember that God set its bounds (Job 38:11), and to hear in the Bible's stories of Mount Ararat, the cave of Adullam and the earthquake at Philippi that God is at work in the real places of the real world.

WHO IT IS FOR

Written for children in grade 2 (about ages 7-8), and gentle enough for a younger brother or sister to join in, about ages 5-8 in all. A parent reads every lesson aloud, leads the looking and measuring, and helps with each make-and-do project. The child does not need to read or write well yet: answers are given out loud, by pointing, drawing, sorting and counting. Nothing needs to be bought beyond ordinary household things such as clay or play dough, a ruler, a baking pan, sand, ice cubes, baking soda, vinegar and a notebook.

HOW TO USE THIS COURSE

The weekly rhythm. The year has 32 lessons, one a week, in eight units of four, plus the optional Field Lab. Each lesson takes two sessions of 30-40 minutes. Session 1 is the warm-up, the story and the picture study. Session 2 is the make-and-do project and the field

notebook page. Lessons marked ★ form a **quarter path** of 10 lessons, at least one from every unit, for families who want a one-quarter version of the course.

The field notebook. Use one sketchbook or primary-ruled journal for the whole year. After each project, the child draws what was seen and the parent writes one or two sentences the child says out loud. Date every page. Drawings do not need to be pretty; they need to show what the child noticed: the lines in a rock, how far the water ran, how many blocks fell down.

Experiments and safety. A parent leads every experiment. Hot water for the crystal project is poured by an adult. Baking soda and vinegar stay away from eyes. Rocks are held, not thrown, and nothing goes in the mouth. On the Field Lab hikes, stay on trails, keep well back from steep edges, and never wade into moving water or go inside a cave. Real caves, cliffs and shorelines are for looking at with a grown-up close by.

Worked example and practice. Each lesson has one very simple worked example, such as counting layers, comparing a tall mountain with a short one, reading a picture chart or measuring with hands or a ruler, and five short practice items. Most practice is oral: point, tell, sort, match, draw or count, with numbers under 100. Answers are given for the parent at the end of each lesson.

Unit reviews and unit projects. Each unit ends with a short oral review of 6–8 questions the parent asks aloud, worth 20 points as a simple guide, and a unit project that gathers the four lessons together: a salt-dough mountain with a snow line, a block tower that survives the shake table, a shoebox cave, a sand-tray shore or a layered canyon diorama. Keep the unit projects, or photos of them, with the field notebook as the record of the year.

A word about time. This course is written from a Christian view of creation, “In the beginning God created the heaven and the earth” (Genesis 1:1), and of the great Flood in the days of Noah (Genesis 6–9). Children will meet museum words like “Jurassic” or “Ice Age” on park signs and in library books, so the course teaches them as names, so that students can read any sign or textbook. Wherever they come up, a 🕒 **Thinking About Time** box sets out, in very simple sentences, what the sign says, what we can see for ourselves, and how Christians read it. No lesson gives a number of years for the age of anything.

SCOPE AND SEQUENCE

Unit 1: Mountains (1–4)

Hillary and Tenzing on Mount Everest; how folded rock makes mountains; the mountains of the Bible; and why trees stop and snow begins as you climb.

Unit 2: Volcanoes (5–8)

The morning Mount St. Helens erupted; what a baking-soda volcano shows and what it gets wrong; pumice and obsidian; and the volcanoes that built Hawaii.

Unit 3: Earthquakes (9–12)

The San Francisco earthquake of 1906; a shake table made of blocks; why some buildings fall and others stand; and the earthquake that opened the prison doors at Philippi.

Unit 4: Caves (13-16)

The long dark rooms of Mammoth Cave; growing stalactites on a string; the bats that live in caves; and David hiding in the cave of Adullam.

Unit 5: Glaciers and Ice (17-20)

The rivers of ice at Glacier Bay; how ice scrapes and carves the land; why most of an iceberg hides under the water; and the brave explorers of the cold poles.

Unit 6: Oceans and Shores (21-24)

The tides that come in and go out; how waves shape beaches; sand made from shells and rock; and God setting the bounds of the sea.

Unit 7: Dinosaur Lands 🦖 (25-28)

The wall of bones at Dinosaur National Monument; footprints in the rock at Glen Rose, Texas; plant eaters and meat eaters; and what Genesis says about every creeping thing.

Unit 8: The Grand Canyon (29-32)

John Wesley Powell's boat trip down the Colorado River in 1869; rock layers stacked like a cake; the little canyon carved by mud at Mount St. Helens in 1982; and a canyon diorama to end the year.

Unit 9: Field Lab (optional) (Any time)

The year's questions taken outdoors: finding landforms on a walk, carving a stream table in the yard, a family shake test, and a visit to a creek or shore.

MATERIALS

- **Field notebook (a sketchbook or primary-ruled journal):** One for the whole year, for drawings, counts and the sentences the child tells you.
- **Crayons or colored pencils, a pencil and a ruler:** Used in nearly every lesson for drawing and measuring. A cloth tape measure is helpful too.
- **Modeling clay or salt dough (flour, salt and water):** For mountains, volcanoes, a cave, the ice-carving project and the canyon diorama.
- **A baking pan or plastic tub, sand or soil, and a cup for pouring water:** Becomes the stream table, the beach for the wave lessons and the little canyon.
- **Building blocks and a tray or small board:** For the shake table and the lesson on why buildings fall or stand.
- **Kitchen supplies: baking soda, vinegar, dish soap, Epsom salt, yarn or string, ice cubes:** For the volcano, the stalactite crystals and the ice lessons. An adult handles

the hot water.

- **A magnifying glass and a few rocks, shells and sand:** Gather them on walks through the year. A piece of pumice is easy to find at a drugstore.
- **Old towels, a shoebox and colored paper:** For folded mountains, a shoebox cave and dioramas.
- **Optional: a picture book, field guide or park map from a unit's list:** Never required. See the list in each unit.

GRADING

There are no letter grades in grade 2. Learning shows up in what the child can tell back, point to, draw and make. The parent keeps a simple checklist for each lesson and listens to an oral narration at the end of each unit.

- Oral narration (the child tells the story and the big idea back in his or her own words): 40%
- Make-and-do projects (tried with care, and the child can say what happened): 30%
- Field notebook (a dated drawing for each lesson): 15%
- Unit reviews and unit projects (oral, 20 points each as a guide): 15%

No letter grades. Mark each checklist item “Got it,” “Growing” or “Let’s try again.” The percents above only show where to spend your attention.

- A good narration names the place, tells what happened and says one thing the child noticed. Write down a sentence or two of it in the field notebook.
- Count a project as done when the child tried it, watched closely and can tell you what happened, even if the volcano fizzled or the tower fell.
- Unit reviews are asked aloud. If an answer is missed, look back at the picture or the project together and ask again another day.
- Keep the field notebook and photos of the unit projects together. They are the record of the year.

A NOTE TO PARENTS

You do not need to be a geologist to teach this course. Read the story aloud, look at the picture together, and then get your hands a little muddy. Ask “What do you see?”, “Which is bigger?” and “What do you think will happen?” Those three questions are most of what a good science teacher does with a young child.

The course teaches what can be seen and measured, and it also teaches that the world was made. When a park sign or a library book uses a word like “Jurassic” or “Ice Age,” the  Thinking About Time boxes help you talk about it calmly and simply, so your child can read the sign, know what it means, and know what Christians believe about creation and the Flood.

Above all, the course hopes to raise a child who looks closely, wonders often and gives thanks. A mountain, a cave, a wave on the sand and a canyon wall are all invitations to say, with the psalmist, "O LORD, how manifold are thy works! in wisdom hast thou made them all" (Psalm 104:24).

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Unit 1: Mountains

- 1.1 Mount Everest Climbed (May 29, 1953) ★
- 1.2 Folded Towel Mountains
- 1.3 Mountains of the Bible (Sinai, Zion, Ararat)
- 1.4 Tree Line and Snow Line

Unit 2: Volcanoes

- 2.1 Mount St. Helens (May 18, 1980) ★
- 2.2 Baking-Soda Volcano and What It Gets Wrong
- 2.3 Lava Rocks: Pumice and Obsidian
- 2.4 Hawaii's Volcanoes

Unit 3: Earthquakes

- 3.1 San Francisco, 1906 ★
- 3.2 Shake Table with Blocks ★
- 3.3 Why Buildings Fall or Stand
- 3.4 The Earthquake at Philippi (Acts 16:26)

Unit 4: Caves

- 4.1 Mammoth Cave ★
- 4.2 Stalactites from String and Epsom Salt
- 4.3 Bats in Caves
- 4.4 David in the Cave of Adullam (1 Samuel 22)

Unit 5: Glaciers and Ice

- 5.1 Glacier Bay ★
- 5.2 Ice That Carves (Ice Cube on Clay) ★
- 5.3 Icebergs Float, Mostly Under Water
- 5.4 Polar Explorers

Unit 6: Oceans and Shores

- 6.1 Tides ★
- 6.2 Waves shape beaches
- 6.3 Sand from shells
- 6.4 "Hitherto shalt thou come" (Job 38:11)

Unit 7: Dinosaur Lands

- 7.1 Dinosaur National Monument ★
- 7.2 Footprints in Rock (Glen Rose, Texas)
- 7.3 Plant Eaters and Meat Eaters
- 7.4 Dinosaurs on the Ark? What Genesis Says About "Every Creeping Thing"

Unit 8: The Grand Canyon

- 8.1 John Wesley Powell's Voyage (1869) ★
- 8.2 Layers Like a Cake
- 8.3 How Fast Can Water Carve? Mount St. Helens' Little Canyon (1982)
- 8.4 A Canyon Diorama

Unit 9: Bonus: Field Lab (optional)

9.1 Landform Hike

9.2 Yard Stream Table

9.3 Shake Test Day

9.4 Creek or Shore Visit

★ quarter path ·  Thinking About Time box

MOUNTAINS

“I will lift up mine eyes unto the hills” (Psalm 121:1). Mountains are some of the biggest things God has made that we can see with our own eyes. In this unit your child will climb Mount Everest with Edmund Hillary and Tenzing Norgay on May 29, 1953, build a mountain range out of folded towels, visit three mountains where great things happened in the Bible, and find out why trees stop growing and snow stays all year high on a mountain.

Every lesson starts with something real: a real climb, a real stack of towels, a real place you can find on a map, a real mountain photographed long ago. Your child will count camps, measure with hand spans, compare heights, sort things into zones and build models with their own hands. Along the way they will learn the words **summit**, **layer**, **fold**, **mountain range**, **tree line** and **snow line**, and they will see that the God who made heaven and earth also set the mountains in their places.

BEFORE YOU BEGIN

- Can count to 20 and add and take away small numbers
- Can tell which of two things is bigger or taller
- Can listen to a short story and tell it back
- Knows the stories of Noah and Moses in simple form (helpful, not required)

MASTERY CHECKLIST

- I can tell the story of Hillary and Tenzing climbing Mount Everest in 1953.
- I can point to the summit of a mountain and name the highest mountain on earth.
- I can show with towels how layers pushed from the sides fold up into mountains.
- I can name Ararat, Sinai and Zion and tell what happened on each one.
- I can point to the tree line and the snow line on a mountain picture.
- I can explain that the air gets colder as you climb higher.

OPTIONAL BOOKS AND RESOURCES

- **Rocky Mountain National Park (National Park Service)** (<https://www.nps.gov/romo/>): Free. The park’s website has photos and pages about the forest, the tree line and the alpine tundra, and about pikas and other high-mountain animals (Lesson 1.4). If you live near any mountains, look for a road or trail that climbs above the trees.
- **U.S. Geological Survey** (<https://www.usgs.gov/>): Free. Parents can search the USGS photo library for pictures of folded rock layers and for William Henry Jackson’s photographs of the Rocky Mountains (Lessons 1.2 and 1.4).

1.1 MOUNT EVEREST CLIMBED (MAY 29, 1953) ★

OBJECTIVES

- Tell the story of Edmund Hillary and Tenzing Norgay, who reached the top of Mount Everest on May 29, 1953.
- Explain that Mount Everest is the highest mountain on earth above the level of the sea.
- Name three things climbers need on a very high mountain and tell why they need them.

Warm-up. Stand at the bottom of your stairs or a small hill in the yard. Point to the very top. Now climb it slowly, one step at a time, and count your steps out loud. At the top, wave a dish towel like a flag. How do your legs feel? Today you will hear about two men who climbed the highest mountain in the whole world.

Video. Coming soon. Mount Everest and the first climb by Hillary and Tenzing in 1953, for young children: search National Geographic Kids, SciShow Kids, Homeschool Pop (Alternate), Royal Geographical Society archive film, and Himalaya nature footage.

KEY TERMS

mountain

Land that rises high above the land around it, with steep sides and a top.

summit

The very top of a mountain.

Sherpa

A people who live high in the mountains of Nepal. Many Sherpas are strong, skilled climbers and mountain guides.

oxygen

The part of the air we need to breathe. High on a mountain the air is thin, so each breath brings in less of it.

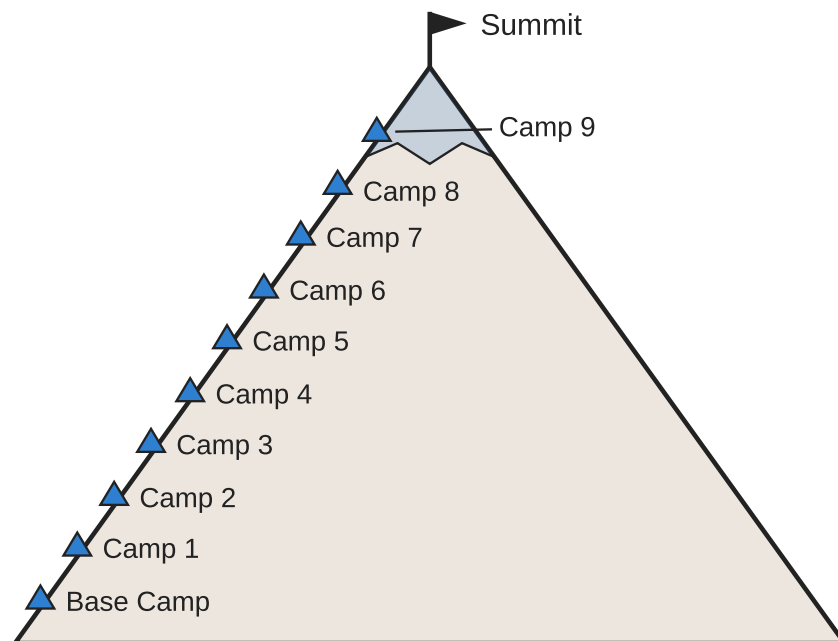
CORE IDEAS

The story. Far away in Asia, on the border of Nepal and Tibet, stands Mount Everest. It is the highest mountain on earth. For many years climbers tried to reach its top, and every one had to turn back. In the spring of 1953 a team from Britain came to try again, led by John Hunt. Two men were chosen for the last climb. One was Edmund Hillary, a tall beekeeper from New Zealand. The other was Tenzing Norgay, a Sherpa climber who had been high on Everest many times before. On the morning of May 29, 1953, they crawled out of their tiny tent and climbed, step by step, up a narrow ridge of snow. A little before noon there was no more mountain above them. They were standing on the top of the world!

How they did it. Hillary and Tenzing did not do it alone. Hundreds of helpers carried tents, food and tanks of oxygen up the mountain. The team set up camps one above another, like steps on a stair, so the climbers could rest on the way up. Near the top the air is so thin that each breath brings in less oxygen, so the two men breathed from tanks on their backs. They wore thick boots with metal spikes called crampons, and they chopped steps in the ice with their ice axes. They were tied together with a rope, so if one slipped, the other could hold him.

The big idea. A **mountain** is land that rises high above the land around it, with steep sides and a top called the **summit**. The summit of Everest is higher above the sea than any other place on earth: more than five miles straight up! Up there it is colder than a freezer, the wind blows hard, and snow and ice cover the top all year. Mountains often stand together in a long row called a range. Everest belongs to the Himalayas, the highest mountain range in the world.

God's handiwork. On the summit, Hillary took a picture of Tenzing holding up his ice axe with flags tied to it. Tenzing pressed a few sweets into the snow as a gift, as his people did. Hillary laid down a small cross that John Hunt had given him. They stayed only about fifteen minutes, then carefully climbed down. Mountains show us how great and strong God is. When we look up at the hills, the Bible reminds us where our help comes from: from the Lord, who made heaven and earth (Psalm 121:1-2).



The 1953 team set up camps one above another, like steps on a stair. Camp 9 was the highest. Hillary and Tenzing slept there before their climb to the summit.

PICTURE STUDY



Kangchenjunga, Vittorio Sella, 1899 · Photograph from a glass-plate negative · Fondazione Sella, Biella, Italy

Vittorio Sella was an Italian mountain climber who loved to take pictures. He carried a big, heavy camera and fragile glass plates high into the snow, where other photographers never went. In 1899 he walked all the way around Kangchenjunga, a giant mountain in the Himalayas, the same range as Everest. Kangchenjunga is the third highest mountain in the world. His pictures showed people far away what these great mountains really look like, long before anyone stood on top of Everest.

Look closely

- Find the highest point in the picture. That is the summit.
- Find the sharp edges of rock and snow that run up toward the top. Climbers call these ridges.
- Look for snow and ice. Is any part of the mountain green with trees?
- Look at the light and the shadows. Which side of the mountain is the sun shining on?

Talk about it

1. If you were a climber, which way up this mountain would you try? Why?
2. Why do you think nothing green grows near the top?
3. Why was it hard work to carry a big camera up into these mountains?

Safety first. If you use real stairs for the rope team walk, go slowly and hold the rail. Never put a rope, scarf or string around anyone's neck.

MAKE AND DO: CLIMB EVEREST AT HOME

You will make a paper Everest on the wall, set up your camps one by one, pack a climber's backpack, and walk as a rope team, just like Hillary and Tenzing.

You will need

- A large sheet of paper or a paper grocery bag cut open
- Crayons or markers, tape and scissors
- Ten small paper triangles for tents
- A small backpack
- Things to sort: warm hat, mittens, scarf, swimsuit, sunglasses, sandals, a water bottle, a toy
- A long scarf or jump rope for the rope team

Steps

1. Draw a big tall triangle on the paper and tape it to the wall. Color the top white for snow and ice. Draw a little flag at the summit.
2. Tape one tent at the bottom and write "Base Camp" on it. Then tape tents up the side of the mountain, one above another, and number them 1 to 9.
3. Make a tiny climber from paper. Each day this week, move the climber up one camp. Count how many camps are left to the summit.
4. Pack the backpack for Everest. Look at each thing and decide: does it keep me warm and safe on a cold, icy mountain? Put the "yes" things in the pack and the "no" things back.
5. Make a rope team. You and a parent each hold one end of the long scarf and walk around the house or yard together. If the leader stops, the second climber stops too. Take turns being Hillary and Tenzing.
6. At the end, stand by your paper mountain and tell the story of May 29, 1953, in your own words.

Tips

- Real climbers rest at each camp so their bodies can get used to the thin air. Going slowly is the smart way up a mountain.
- Sunglasses belong in the pack! Bright sun on snow can hurt climbers' eyes.

Check your work

- I can point to the summit of my mountain.
- I can count the camps from the bottom to the top.
- I can name three things a climber needs and tell why.

FIELD NOTEBOOK

1. Draw Mount Everest with snow on top and a flag on the summit. Label the summit.

2. Draw Hillary and Tenzing tied together with a rope. Draw their ice axes and their tanks of oxygen.
3. Draw the inside of a climber's backpack and label three things inside it.

From history. The news that Everest had been climbed reached London on June 2, 1953, the very morning Queen Elizabeth II was crowned, and people cheered in the streets. Edmund Hillary was made a knight, so people called him Sir Edmund. Tenzing Norgay was given the George Medal. Hillary never forgot the Sherpa people who helped him. For the rest of his life he raised money and worked with his own hands to build schools and hospitals in their mountain villages.

WORKED EXAMPLES

Example 1. Look at the picture of the camps on the mountain. The climbers started at Base Camp and set up Camp 1, Camp 2 and so on, all the way up to Camp 9. How many camps did they set up above Base Camp? If a climber is resting at Camp 4, how many more camps must he climb to reach Camp 9?

(Use the map or drawing "Count the camps with your finger, from the bottom to the top." shown earlier in this lesson.)

1. Put your finger on Base Camp at the bottom. Do not count it, because we want the camps *above* it.
2. Move your finger up one tent at a time and count: 1, 2, 3, 4, 5, 6, 7, 8, 9. There are 9 camps above Base Camp.
3. Now put your finger on Camp 4. Climb up and count each new camp: Camp 5 is one, Camp 6 is two, Camp 7 is three, Camp 8 is four, Camp 9 is five.
4. Check with take-away: $9 - 4 = 5$.

Answer: There are 9 camps above Base Camp. From Camp 4, the climber must climb 5 more camps to reach Camp 9.

PRACTICE

1. **EASY** Point to the summit in the picture of the camps. What does the word summit mean?
2. **EASY** Who were the two men who first stood on the top of Mount Everest? Which one was a Sherpa?
3. **MEDIUM** Sort these into two piles, "Take up Everest" and "Leave at home": warm boots, swimsuit, rope, ice axe, beach ball, tank of oxygen, mittens.
4. **MEDIUM** A rope team has 2 climbers tied together. How many climbers are in 4 rope teams? Use beans or buttons to count.
5. **HARD** Tell in your own words why Hillary and Tenzing carried tanks of oxygen on their backs.

COMMON MISTAKES

- Thinking Hillary and Tenzing did it all by themselves. Hundreds of helpers, many of them Sherpas, carried loads and set up the camps.
- Thinking Everest is the tallest mountain measured from its bottom to its top. Everest's summit is the highest place above the sea. Mauna Kea in Hawaii starts deep under the ocean, so from its bottom it is taller, but most of it is under water.
- Thinking a mountain is a big pile of dirt. Mountains are made mostly of solid rock, often covered with soil, plants, snow or ice.

Make it a game • Summit Steps. Stand at the bottom of the stairs, or make ten “camps” with pillows across the floor. Your parent asks a question from this lesson. Each right answer lets you climb one step or camp. Reach the top and plant your flag on the summit! Then switch, and you ask the questions.

Scripture. “I will lift up mine eyes unto the hills, from whence cometh my help. My help cometh from the LORD, which made heaven and earth.” (Psalm 121:1-2, KJV)

Even the highest mountain on earth is something God made. Climbers need ropes, tents and friends to help them, but our greatest help comes from the Lord who made the mountains.

Practice answers

1. The child points to the very top of the mountain, by the flag. The summit is the very top of a mountain.
2. Edmund Hillary and Tenzing Norgay. Tenzing Norgay was the Sherpa.
3. Take up Everest: warm boots, rope, ice axe, tank of oxygen, mittens. Leave at home: swimsuit, beach ball.
4. 8 climbers ($2 + 2 + 2 + 2 = 8$).
5. High on Everest the air is very thin, so each breath brings in less oxygen than at home. The tanks gave them extra oxygen to breathe so they could keep climbing.

1.2 FOLDED TOWEL MOUNTAINS

OBJECTIVES

- Show with a stack of towels how flat layers of rock can be pushed from the sides into folds and mountains.
- Use the words layer, fold and mountain range correctly.
- Tell that shells of sea animals are found high on mountains, and that many Christians see this as a sign of the Flood.

Warm-up. Lay a sheet of paper flat on the table. Put one hand on each end and slowly push your hands toward each other. Watch the middle. What happens? Did the paper get shorter or longer? Did it get taller or flatter?

Video. Coming soon. How folded mountains form, with towel, paper or clay models and real folded rock layers, for young children: search SciShow Kids, Homeschool Pop (Alternate), Science Max, USGS educational videos.

KEY TERMS

layer

A flat sheet of rock or soil lying on top of another one, like the layers of a cake.

fold

A bend in rock layers, made when they are squeezed hard from the sides.

folded mountains

Mountains made when layers of rock are pushed from the sides and bent up high.

mountain range

A long row of mountains standing together.

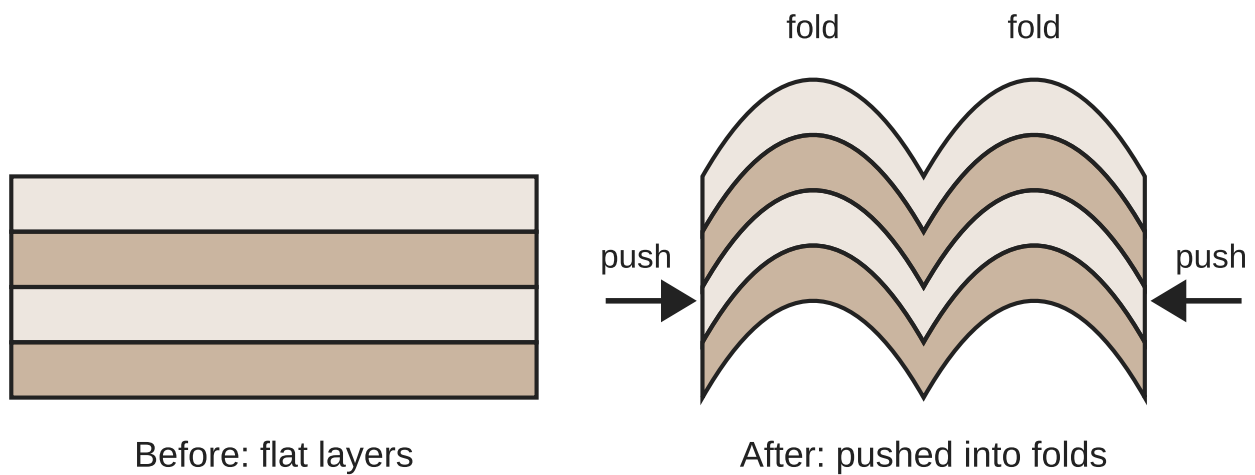
CORE IDEAS

The story. In western Maryland there is a long, high ridge called Sideling Hill. Workers once cut a deep gap right through it to make room for a highway. When the rock was opened up, people saw stripes of gray, tan and brown rock, one layer on top of another. But the stripes were not flat! They bent down in the middle into a giant U, like a big smile. Something had pushed on that rock very hard and bent it. Today families stop there to look at the bent layers.

How they figured it out. Long ago in Italy, a Christian scientist named Nicolas Steno looked closely at rock layers. He knew that water spreads mud and sand out in flat sheets, one on top of another. So he reasoned that rock **layers** start out flat. If we find layers that are bent or tipped up on end, something must have pushed them after they were laid down. Scientists still use Steno's rule today.

The big idea. Stack some towels flat on the floor. Each towel is a layer. Now push the two ends toward each other. The towels cannot go down into the floor, so they buckle up into humps and hollows. Each bend is a **fold**, and the humps are like little mountains. God's earth works in a similar way. When huge layers of rock are squeezed from the sides, they bend and wrinkle and rise up into **folded mountains**. Many folds side by side make a long row of mountains called a **mountain range**. The Appalachian Mountains, the Alps and the Himalayas all have rock layers bent into giant folds.

God's handiwork. High on Mount Everest, near the very top, climbers have found rock full of the shells and pieces of little sea animals. How did sea creatures get up there? That rock was once mud under water, and later it was pushed high into the sky. The Bible tells us about a great Flood that covered the whole earth (Genesis 7:19). Many Christian scientists think that much of the folding and pushing up of mountains happened during that Flood, as the waters ran off the land. The God who made the mountains can lift them up and set them in their places.



Before and after: flat layers squeezed from both sides bend into folds, and the folds rise up like mountains.

PICTURE STUDY



The Rocky Mountains, Lander's Peak, Albert Bierstadt, 1863 · Oil on canvas · The Metropolitan Museum of Art, New York

Albert Bierstadt was born in Germany and grew up in Massachusetts. In 1859 he traveled west with a road-building party led by Frederick Lander and made many sketches of the Rocky Mountains in what is now Wyoming. Back in his studio in New York, he painted this huge picture. He named the tall peak after Lander, who had died in the Civil War.

In front of the mountains Bierstadt painted a camp of Shoshone people, who lived in that land. The painting is so big that when people first saw it, they felt as if they were looking out a window at the real mountains.

Look closely

- Find the tallest snowy peak. That is Lander's Peak.
- Count the mountains you can see standing in a row. A row of mountains is a mountain range.
- Find the waterfall. Where does the water go?
- Find the tents, the people and the horses in the meadow. How small do they look next to the mountains?

Talk about it

1. Where is there snow in the painting, and where are there trees? Why do you think the snow is up high?
2. If you could walk into this painting, what would you do first?
3. How did the painter make the mountains look so big and far away?

MAKE AND DO: TOWEL MOUNTAINS

You will build a stack of rock “layers” from towels, squeeze them from the sides, and watch mountains rise. Then you will measure how much shorter and taller your towel land became.

You will need

- Four bath towels or hand towels, in different colors if you have them
- A smooth floor or long table
- Your hands for measuring (hand spans), or a ruler
- Play dough or clay in three or four colors (for the second session)
- A plastic knife or a piece of dental floss
- Paper and crayons

Steps

1. Lay the towels flat, one on top of another, with the ends lined up. Say the colors from the bottom layer to the top layer.
2. Measure the stack from end to end with hand spans. Write down the number.
3. Kneel at one end while a parent kneels at the other. Slowly push the two ends toward each other. Watch the humps and hollows grow. Stop when you have a little mountain range.
4. Count your mountains (the humps). Measure the stack again with hand spans. Is it shorter or longer now? Is it taller or flatter?
5. Second session: roll play dough into flat sheets of different colors and stack them like a cake. Push the ends together slowly with your palms until the layers bend.
6. Ask a parent to cut the dough mountain straight down with a plastic knife or floss. Look at the cut side. Can you see the bent layers, like the rock at Sideling Hill?
7. Draw your towel range and your cut dough mountain. Label the layers and the folds.

Tips

- Push slowly and evenly from both sides. If you push too fast, the towels just slide.
- The bottom towel cannot go into the floor, so all the bending goes up. That is how folds make mountains.
- Try it with a heavy book lying on top of the towels. Do the folds come out different?

Check your work

- I can show how pushing from the sides makes folds.
- I can count the layers and the mountains in my model.
- I can tell whether my stack got shorter and taller after the push.

FIELD NOTEBOOK

1. Draw a stack of flat rock layers. Then draw the same layers bent into folds, with arrows showing the push from both sides.
2. Draw the giant smile of bent layers at Sideling Hill, with a road going through the middle.
3. Draw a seashell sitting on top of a tall snowy mountain. Under it, write: "Sea shells on the mountain top!"

From history. Nicolas Steno was born in Denmark and worked in Italy. In 1666 he looked at the head of a huge shark caught near the Italian coast and saw that its teeth looked just like the pointed "tongue stones" people dug out of rocks. He said the tongue stones were really shark teeth, buried in mud that later turned to rock. In 1669 he wrote down his rules for reading rock layers, including the rule that layers start out flat. Later in his life Steno became a priest and then a bishop, and he gave away much of what he had to the poor.

WORKED EXAMPLES

Example 1. Lily lays her towels flat and measures the stack. It is 8 hand spans long. She pushes from both ends until she has a little mountain range. Now the stack is 5 hand spans long. How much shorter did it get? Did it get taller?

(Use the map or drawing "The folded stack is shorter from end to end but taller in the middle." shown earlier in this lesson.)

1. Before the push, the stack was 8 hand spans long. After the push, it was 5 hand spans long.
2. To find how much shorter, start at 5 and count up to 8: 6, 7, 8. That is 3 more spans. Or take away: $8 - 5 = 3$.
3. Look at the stack from the side. The middle humped up into folds, so the towel land got taller.

Answer: The stack got 3 hand spans shorter, and it got taller where the folds rose up into mountains.

PRACTICE

1. **EASY** Look at the flat stack on the left side of the picture. Point to each layer and count them.
2. **EASY** To make your towel mountains, did you push down from the top or push in from the sides? Show me with your hands.
3. **MEDIUM** Draw a cake with flat layers. Then draw a second cake that got squeezed from both sides. What happened to the layers?

4. **MEDIUM** Your first towel range has 3 mountains. Your second towel range has 4 mountains. How many mountains did you make in all?
5. **HARD** Nicolas Steno said rock layers start out flat. So what does it tell us when we find rock layers that are bent?

COMMON MISTAKES

- Thinking rock can never bend. Real mountains show rock layers bent into big waves and U shapes.
- Thinking folded mountains are pulled up from the top, like a pinch. They are squeezed from the sides, so they buckle upward.
- Thinking every mountain is a folded mountain. Some mountains are volcanoes, and some are big blocks of rock pushed straight up. You will learn about volcanoes in the next unit.

Make it a game · Fold or Flat?. Your parent holds up a picture or object: a flat cookie, a stack of pancakes, a wrinkled rug, a folded blanket, a crumpled sock, a book. You shout “Flat layers!” or “Folded!” and push your hands together if it is folded. One point for each right answer. Then build the tallest towel mountain you can in thirty seconds.

Scripture. “They go up by the mountains; they go down by the valleys unto the place which thou hast founded for them.” (Psalm 104:8, KJV)

Psalm 104 praises God for setting the waters and the mountains in their places. Many Bible readers think this verse describes the waters running off the land as mountains rose and valleys sank, after the Flood.

Practice answers

1. 4 layers.
2. From the sides. The child pushes both hands toward each other.
3. The second drawing shows layers bent into humps and dips. The layers folded and the cake got shorter and taller.
4. 7 mountains ($3 + 4 = 7$).
5. Something pushed or squeezed the layers after they were laid down, and bent them into folds.

1.3 MOUNTAINS OF THE BIBLE (SINAI, ZION, ARARAT)

OBJECTIVES

- Tell what happened at the mountains of Ararat, at Mount Sinai and at Mount Zion in the Bible.
- Compare the three mountains and tell which is tallest and which is lowest.
- Find these real places on a map or globe.

Warm-up. Find three cups or bowls: a big one, a middle one and a small one. Turn them upside down on the table. Now you have three mountains! Line them up from tallest to shortest. Today you will meet three real mountains from the Bible, and they are not the same size either.

Video. Coming soon. Mount Ararat, Mount Sinai (Jebel Musa and Saint Catherine's Monastery) and Mount Zion in Jerusalem, for children: search travel and nature footage of each mountain, Bible-lands geography channels, Holy Land documentary clips.

KEY TERMS

ark

The big wooden boat God told Noah to build to save his family and the animals from the Flood.

commandment

A rule given by God. God gave Moses the Ten Commandments on Mount Sinai.

hill

A rise of land that is lower and gentler than a mountain.

snowcap

Snow and ice that cover the top of a high mountain, often all year long.

CORE IDEAS

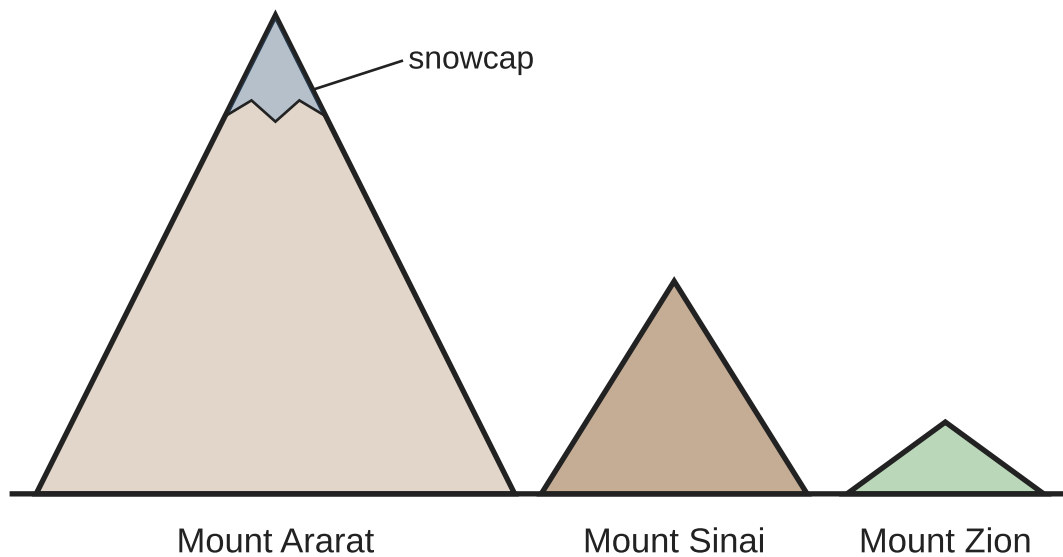
The story. After the great Flood, Noah's ark floated on the water for many days. Then the water began to go down. The Bible says, "the ark rested in the seventh month, on the seventeenth day of the month, upon the mountains of Ararat" (Genesis 8:4). Ararat is a land of high mountains. The tallest mountain there today is called Mount Ararat, in the country of Turkey. Its top is white with snow and ice all year. No one knows the exact spot where the ark came to rest, but Noah could look out and see mountain tops all around as the water went down.

The mountain that shook. Later, God led His people Israel out of Egypt and into the desert to Mount Sinai. The Bible tells us that the whole mountain smoked and shook when the Lord came down upon it (Exodus 19:18). Moses climbed up, and God gave him the Ten **Commandments**, written on two tables of stone. Many people think Mount Sinai is a

mountain in Egypt called Jebel Musa, which means “Mountain of Moses.” It is a bare, rocky mountain of red and gray stone, with almost no trees. Visitors climb it in the dark to watch the sun rise from the top.

The city on a hill. Many years later, King David captured a strong fort on a hilltop called Zion and made it his city, Jerusalem (2 Samuel 5:7). Mount Zion is really a **hill**, much lower than Sinai or Ararat. Yet the Bible calls it “the joy of the whole earth” (Psalm 48:2), because God chose Jerusalem as the place where His temple would stand.

The big idea. Mountains are not all alike. Ararat is tall and cold, with a **snowcap**. It is more than twice as high as Sinai. Sinai is a dry, rocky desert mountain. Zion is a low hill covered with a city. God did great things on all three. On Ararat He kept His promise to Noah. On Sinai He gave His law. On Zion He set His temple. When you see a mountain, remember that the Bible’s stories happened in real places you can find on a map.



Drawn to the same scale: Mount Ararat is the tallest, Mount Sinai is in the middle, and Mount Zion is a low hill. (Heights are measured from the level of the sea.)

PICTURE STUDY



The Descent of Noah from Ararat, Ivan Aivazovsky, 1889 · Oil on canvas · National Gallery of Armenia, Yerevan

Ivan Aivazovsky was a painter of Armenian family who lived by the Black Sea. He painted thousands of pictures of the sea, with crashing waves and shining light. Mount Ararat stands near Armenia, and Armenian people have loved the story of Noah for a very long time.

In this painting Aivazovsky imagined the day Noah and his family came down from the mountains of Ararat after the Flood. The water is gone, the land is fresh, and the animals are walking out into the new world with them.

Look closely

- Find Noah walking at the front. How can you tell he is the leader?
- Look for the animals walking with the people. Which ones can you name?
- Find the mountain behind them. Can you find the ark?
- Look at the light. Where is it brightest? What feeling does the light give you?

Talk about it

1. How do you think Noah's family felt as they walked down onto dry land?
2. Why did the painter put so much soft, shining light in the sky?
3. What would you want to see first if you came off the ark?

MAKE AND DO: THREE BIBLE MOUNTAINS

You will build the three Bible mountains from play dough in the right order of size, decorate each one to tell its story, and then tell the stories to your family.

You will need

- Play dough or clay (white, brown and green if you have them)
- A tray or a piece of cardboard for a base
- Cotton balls for snow
- A small toy boat or a boat cut from paper (the ark)
- Two small pieces of cardboard or two flat pebbles (the tables of stone)
- Small building blocks or sugar cubes (the city of Jerusalem)
- Toothpicks and paper for flags, a pencil, tape

Steps

1. Make Mount Ararat first. It is the tallest, so make it the biggest mountain on your tray. Put cotton snow on the top.
2. Make Mount Sinai next to it. Make it less than half as tall as Ararat. Press little ridges into it to make it look rocky.
3. Make Mount Zion. It is just a low hill, much smaller than Sinai. Make it green.
4. Set the toy ark on the side of Ararat. Stand the two little tables of stone on top of Sinai. Build a tiny city of blocks on Zion.
5. Make three flags and write the names: Ararat, Sinai, Zion. Stick each flag in the right mountain.
6. Point to each mountain and tell its story in your own words: the ark resting, the mountain that shook, and King David's city.

Tips

- Use the picture in this lesson to check the sizes. Ararat should be a little more than twice as tall as Sinai.
- Ask a parent to help you find Turkey, Egypt and Jerusalem on a map or globe.

Check your work

- I built the three mountains in the right order of size.
- I can name each mountain and tell what happened there.
- I can find where they are on a map with help.

FIELD NOTEBOOK

1. Draw Noah's ark resting on a snowy mountain, with the dove flying back carrying an olive leaf.
2. Draw Mount Sinai with smoke at the top and Moses holding two tables of stone.
3. Draw a hill with a walled city on top and label it "Mount Zion: the city of David."

From history. At the foot of Jebel Musa, the mountain many people call Mount Sinai, stands Saint Catherine's Monastery, one of the oldest Christian monasteries still in use. Its library holds very old Bibles and books. In 1844 and again in 1859, a German Bible

scholar named Constantin von Tischendorf found pages there from one of the oldest handwritten Bibles ever discovered. It is called the Codex Sinaiticus, which means “the book from Sinai.”

WORKED EXAMPLES

Example 1. Look at the picture of the three Bible mountains. Put them in order from tallest to lowest.

(Use the map or drawing “Compare the tops to put the mountains in order.” shown earlier in this lesson.)

1. Put your finger on the ground line under all three mountains. They all start at the same place, so we can compare their tops.
2. Find the highest top. It is the snowy one: Mount Ararat. Ararat is first.
3. Find the lowest top. It is the little green hill: Mount Zion. Zion is last.
4. The one left in the middle is Mount Sinai.

Answer: Tallest to lowest: Mount Ararat, Mount Sinai, Mount Zion.

PRACTICE

1. **EASY** Match each mountain to its story. Ararat, Sinai, Zion. Stories: the Ten Commandments; King David’s city; the ark came to rest.
2. **EASY** Point to the mountain in the picture that has snow on top all year. What is its name?
3. **MEDIUM** After the ark rested, Noah sent out a dove. He waited 7 days and sent it again, and it came back with an olive leaf. Then he waited 7 more days and sent it again (Genesis 8:10-12). How many days did Noah wait in all between the first and the last time he sent the dove?
4. **MEDIUM** Draw the three mountains side by side, tallest on the left and lowest on the right. Write a name under each one.
5. **HARD** Tell what happened on Mount Sinai in your own words.

COMMON MISTAKES

- Thinking the Bible names one exact peak where the ark landed. It says “the mountains of Ararat,” which means a land of mountains.
- Thinking Mount Zion is a giant mountain. It is a hill in Jerusalem, much lower than Sinai or Ararat.
- Thinking the Bible’s places are make-believe. Ararat, Sinai and Jerusalem are real places you can find on a map and visit.

Make it a game • Which Mountain Am I? Your parent gives a clue, such as “I have snow on my top,” “I shook and smoked,” “King David built his city on me,” “Tables of

stone were given here,” or “A dove flew over me with an olive leaf.” Run and touch the right play-dough mountain (or cup mountain) and shout its name. One point for each right answer. Then you give the clues.

Scripture. “As the mountains are round about Jerusalem, so the LORD is round about his people from henceforth even for ever.” (Psalm 125:2, KJV)

Jerusalem sits on hills with higher mountains all around it, like a wall. The Bible says God surrounds and protects His people in the same way.

Practice answers

1. Ararat: the ark came to rest. Sinai: the Ten Commandments. Zion: King David’s city.
2. Mount Ararat.
3. 14 days ($7 + 7 = 14$).
4. Ararat (tallest, with snow), then Sinai (middle, rocky), then Zion (a low hill).
5. God led Israel out of Egypt to Mount Sinai. The mountain smoked and shook when the Lord came down. Moses went up, and God gave him the Ten Commandments written on two tables of stone.

1.4 TREE LINE AND SNOW LINE

OBJECTIVES

- Explain that the air gets colder as you go higher up a mountain.
- Find the tree line and the snow line on a picture of a mountain and tell what grows or lies in each zone.
- Tell how Alexander von Humboldt noticed that plants change as you climb a mountain.

Warm-up. Open the refrigerator and hold your hand inside for a few seconds. Now open the freezer and do the same. Which is colder? Which one would a flower like better? A tall mountain is a little like a house with the warm kitchen at the bottom, the refrigerator in the middle and the freezer at the top.

Video. Coming soon. Tree line, alpine tundra and snow line on high mountains, with pikas and mountain goats, for young children: search National Park Service (Rocky Mountain National Park) videos, SciShow Kids, NOAA SciJinks, Homeschool Pop (Alternate), and mountain nature footage.

KEY TERMS

tree line

The height on a mountain above which trees cannot grow, because it is too cold and windy.

alpine meadow

The cold, open land above the tree line, where only low plants grow: grass, tiny flowers, moss and lichens.

snow line

The height on a mountain above which snow stays on the ground all year long.

CORE IDEAS

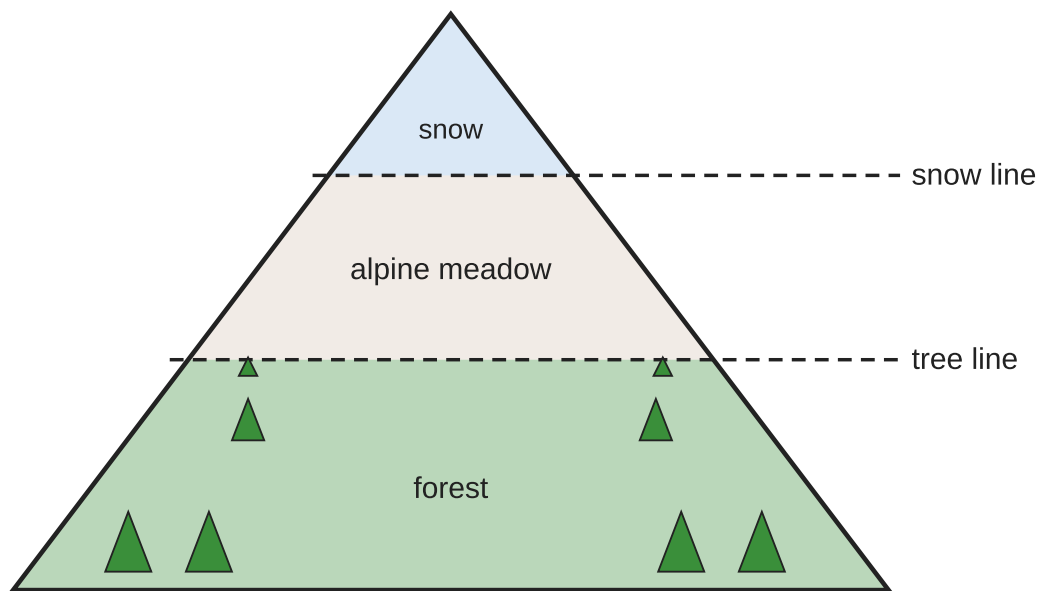
The story. On June 23, 1802, an explorer named Alexander von Humboldt climbed up a giant snowy mountain called Chimborazo, in the country of Ecuador in South America. Back then, people thought it might be the highest mountain in the world. Humboldt and his friends climbed higher than anyone they knew of had ever climbed. Their hands and feet were numb with cold, the air was thin, and at last a deep crack in the ice made them turn back. But Humboldt had noticed something wonderful on the way up.

How he figured it out. Humboldt carried a thermometer, and as he climbed he wrote down how cold it was and which plants he saw. At the bottom there were warm, green forests. Higher up, the trees got smaller. Then there were no trees at all, only grass and little flowers. Higher still, there was bare rock, and at the top, snow and ice. Back home, he drew a big picture of the mountain with the names of plants written at the heights where they

grew. Climbing a tall mountain, he said, is like traveling from a warm land all the way toward the cold North Pole.

The big idea. The higher you go up a mountain, the colder the air gets. That makes bands, or zones, on a mountain. At the bottom is the forest. Near the top of the forest, the trees grow short, bent and twisted by the wind. Then comes the **tree line**, where trees stop. Above it is the **alpine meadow**, with low grass, tiny flowers, moss and lichens hugging the ground. Higher still is the **snow line**. Above it, snow stays all year, even in summer. On a mountain near the equator, the lines are very high. Far to the north, they come much lower down the mountain.

God's handiwork. God made creatures that are at home above the tree line. In the Rocky Mountains, white mountain goats climb steep cliffs, and little round pikas gather grass into haystacks under the rocks to eat all winter. The Bible says, "The high hills are a refuge for the wild goats" (Psalm 104:18). Every zone of the mountain, from the forest to the snow, has its own plants and animals, each one suited to its place.



Zones on a mountain. The higher you go, the colder it gets: forest, then the tree line, then alpine meadow, then the snow line, then snow all year.

PICTURE STUDY



Mountain of the Holy Cross, William Henry Jackson, 1873 · Photograph (albumen print from a glass-plate negative) · National Archives, College Park, Maryland (records of the Hayden Survey)

William Henry Jackson was the photographer for a government team that explored and mapped the Rocky Mountains. For years people had told stories about a mountain in Colorado with a giant cross of snow on it, but few had seen it. In August 1873, Jackson and his helpers carried his heavy camera and glass plates up a neighboring peak so he could take this picture.

The cross is made of snow lying in a long, deep crack running down the mountain and a ledge running across it. The shady crack keeps the snow cold long into the summer, after the snow around it has melted.

Look closely

- Find the cross of snow. Trace it in the air with your finger.
- Look for places where there is no snow. What do you see there instead?
- Look low in the picture for trees. Do the trees go all the way up the mountain, or do they stop?
- Find the highest point of the mountain.

Talk about it

1. Why does the snow stay longer in the deep, shady crack than on the open rock?
2. Where would you draw the tree line on this mountain?
3. Why do you think people traveled a long way just to see this mountain?

MAKE AND DO: MOUNTAIN ZONES MODEL

You will make a mountain with all its zones, from the forest at the bottom to the snow at the top, and mark the tree line and the snow line with yarn.

You will need

- A paper cone (roll a paper plate or stiff paper into a cone and tape it), or an upside-down plastic funnel or bowl
- Crayons, markers or paint in green, brown and gray
- Cotton balls or white paper scraps for snow
- Small green paper triangles or pieces of green pipe cleaner for trees
- Tiny dots of colored paper or a few pinches of colored glitter for alpine flowers
- Two pieces of yarn of different colors
- Glue, tape and a pencil

Steps

1. Color the bottom part of your mountain green. This is the forest.
2. Glue on paper trees. Make them big at the bottom and smaller and smaller as you go up, because trees near the tree line grow short and twisted.
3. Tie or tape one piece of yarn around the mountain just above the last tree. This is the tree line.
4. Above the tree line, color the mountain light green and gray, and add tiny flower dots close to the ground. This is the alpine meadow.
5. Tape the second piece of yarn higher up. This is the snow line.
6. Cover the top above the snow line with cotton snow.
7. Make a tiny paper mountain goat and a pika and put them in the meadow. Then point to each zone and tell what lives there.

Tips

- The tree line and the snow line are not painted on real mountains. They are the places where the trees stop and where the snow stops.
- For an extra try, make a second, smaller mountain for a cold land far to the north. Put its tree line and snow line much lower down.

Check your work

- My mountain has a forest, an alpine meadow and snow, in the right order.
- I can point to the tree line and the snow line.
- I can tell why trees stop growing high on a mountain.

FIELD NOTEBOOK

1. Draw a mountain with its three zones: forest, alpine meadow and snow. Label the tree line and the snow line.
2. Draw a tall straight tree from the bottom of the mountain and a short, twisted tree from near the tree line, side by side.
3. Draw a pika or a mountain goat in its home above the tree line.

From history. Jackson's photograph made the Mountain of the Holy Cross famous all over America. Painters came to paint it, and people traveled to Colorado to see the cross of snow for themselves. In 1929 President Herbert Hoover made the mountain a national monument. Today it is part of a national forest, and hikers still climb a neighboring peak to see the cross just as Jackson did.

WORKED EXAMPLES

Example 1. Look at the picture of the mountain zones. How many zones are there? Which line is higher on the mountain, the tree line or the snow line?

(Use the map or drawing "Count the zones from the bottom up." shown earlier in this lesson.)

1. Start at the bottom and put your finger on each zone as you go up: forest is one, alpine meadow is two, snow is three.
2. Find the tree line. It is the dashed line between the forest and the meadow.
3. Find the snow line. It is the dashed line between the meadow and the snow.
4. Compare: the snow line is closer to the top of the mountain.

Answer: There are 3 zones: forest, alpine meadow and snow. The snow line is higher than the tree line.

PRACTICE

1. **EASY** Point to the tree line in the picture. What happens to the trees there?
2. **EASY** When you climb higher up a mountain, does the air get warmer or colder?
3. **MEDIUM** Sort these into the zone where you would find them: a tall pine tree, a pika, tiny flowers and moss, snow that stays all summer.
4. **MEDIUM** A family hikes up a mountain trail. At the bottom the thermometer reads 70 degrees. At the top of the trail it reads 62 degrees. How many degrees colder is it at the top?
5. **HARD** Tell in your own words why trees cannot grow above the tree line.

COMMON MISTAKES

- Thinking it is warmer at the top of a mountain because it is closer to the sun. The higher you go, the colder the air gets.

- Thinking the tree line is at the same height on every mountain. It is much higher on mountains near the equator and much lower in cold lands far to the north.
- Thinking the snow line is the only place where it snows. Snow can fall all over a mountain in winter. Above the snow line, the snow just never all melts away.

Make it a game · Climb the Zones. Make three zones across the room with pillows or tape: forest, alpine meadow and snow. Your parent calls out a thing: “tall pine tree,” “mountain goat,” “snow all summer,” “tiny flowers,” “twisted little tree.” Run to the zone where it belongs. When you reach the snow, shiver and say “Brrr! It’s colder up high!” One point for each right zone.

Scripture. “The high hills are a refuge for the wild goats; and the rocks for the conies.” (Psalm 104:18, KJV)

Conies are small animals that hide among rocks. God made a home for every creature, even on the highest, coldest mountains above the trees.

Practice answers

1. The child points to the dashed line between the forest and the meadow. The trees stop growing there.
2. Colder.
3. Forest: a tall pine tree. Alpine meadow: a pika and tiny flowers and moss. Above the snow line: snow that stays all summer.
4. 8 degrees colder ($70 - 62 = 8$).
5. Up high it is too cold and windy, and summer is too short for trees to grow. Only low plants that hug the ground, like grass, tiny flowers and moss, can live there.

UNIT 1 REVIEW

Ask each question aloud and let your child answer in their own words. They may point to pictures, use their models, or draw. Give full points for a clear answer with the main idea, even if the words are simple. The review is worth 20 points.

1. (3 pts) Who were the first two men to stand on the top of Mount Everest? Tell me the story.
2. (3 pts) What is the summit of a mountain? Why did the climbers need oxygen tanks near the summit of Everest?
3. (3 pts) Show me with your hands what happens to a flat stack of towels when you push it from both ends. How is that like real mountains?
4. (3 pts) What have climbers found in the rock near the top of Mount Everest? How do many Christians explain it?
5. (3 pts) Tell me what happened on each of these Bible mountains: Ararat, Sinai and Zion.
6. (3 pts) Point to the tree line and the snow line on your mountain model or a picture. What do they mean?
7. (2 pts) Is it warmer or colder at the top of a high mountain? Name one animal that lives above the tree line.

UNIT PROJECT: MY MOUNTAIN BOOK

Make a small book with one page for each lesson. Page 1: draw Mount Everest with the camps and the summit flag, and tell the story of Hillary and Tenzing. Page 2: draw flat layers and folded layers, and glue in a photo of your towel mountains. Page 3: draw Ararat, Sinai and Zion in order of size with the ark, the tables of stone and the city. Page 4: draw a mountain with its forest, alpine meadow and snow, and label the tree line and the snow line. Your parent writes your words under each picture as you tell them. Finish by telling the whole book aloud to your family.

- **Accuracy:** Each page shows the right things: the summit and camps, flat and folded layers, the three Bible mountains in the right order, and the zones in the right order with both lines labeled.
- **Narration:** The child tells each page's story or idea clearly in their own words.
- **Hands-on work:** The book shows work from at least two of the unit's models or projects (towel mountains, Bible mountains, mountain zones).
- **Care:** The drawings are colorful and neat, and every page has a title.

Answer key

1. Edmund Hillary and Tenzing Norgay, on May 29, 1953. They climbed with a big team that set up camps up the mountain, used ropes, ice axes and oxygen tanks, and reached the summit a little before noon.
2. The summit is the very top of a mountain. Up high the air is thin, so each breath brings in less oxygen; the tanks gave the climbers extra oxygen to breathe.

3. The towels bend up into humps and folds. Real rock layers squeezed from the sides bend into folds and rise up into folded mountains.
4. Shells and pieces of little sea animals. The rock was once mud under water and was later pushed high up; many Christians think this happened during the great Flood.
5. Ararat: Noah's ark came to rest on the mountains of Ararat after the Flood. Sinai: God gave Moses the Ten Commandments on two tables of stone. Zion: King David made it his city, Jerusalem.
6. The tree line is where trees stop growing because it is too cold and windy. The snow line is where snow stays on the ground all year.
7. Colder. A mountain goat or a pika.

VOLCANOES

Deep under our feet, the earth is hot. In a few places, melted rock finds a path up to the surface, and a **volcano** is born. In this unit your child will meet real volcanoes: Mount St. Helens in Washington, which lost its top on the morning of May 18, 1980, and the great shield volcanoes of Hawaii, which built whole islands up from the bottom of the sea.

Along the way your child will make a baking-soda volcano and then think like a scientist about what the model gets right and what it gets wrong. They will hold pumice, a rock so full of bubbles that it floats, and learn about obsidian, the shiny black glass that volcanoes make. Every lesson has a picture to study, something to make, and short questions to talk about together.

Above all, these lessons show that the mighty hills belong to the Lord. “He toucheth the hills, and they smoke” (Psalm 104:32). We will see how scientists watch volcanoes to keep people safe, how plants and animals returned to the gray ash at Mount St. Helens, and how a brave Christian woman in Hawaii trusted God at the edge of a fiery crater.

BEFORE YOU BEGIN

- Can listen to a short story and tell it back in a few sentences
- Can count objects to 20 and compare which group has more
- Knows what a mountain is (Unit 1)
- Can use crayons to draw and label a simple picture with help

MASTERY CHECKLIST

- I can tell the story of Mount St. Helens on May 18, 1980.
- I can say what magma and lava are.
- I can tell one thing a baking-soda volcano gets right and one thing it gets wrong.
- I can tell how pumice and obsidian are alike and different, and why pumice floats.
- I can tell how the islands of Hawaii were made and what a shield volcano looks like.

OPTIONAL BOOKS AND RESOURCES

- **USGS Volcano Hazards Program** (<https://www.usgs.gov/programs/VHP>): Free. Photographs, maps and simple explanations from the scientists who watch America’s volcanoes, including Mount St. Helens and Kīlauea. A parent can pick out pictures to show.
- **Hawai’i Volcanoes National Park (National Park Service)** (<https://www.nps.gov/havo/>): Free. Photos, webcams and kid pages about Kīlauea and Mauna Loa, with pictures of pāhoehoe and ‘a‘ā lava. Good for Lesson 2.4.

2.1 MOUNT ST. HELENS (MAY 18, 1980) ★

OBJECTIVES

- Tell the story of the Mount St. Helens eruption on May 18, 1980, in my own words.
- Name the warning signs scientists watched: shaking ground, steam and ash, and a growing bulge.
- Explain how a volcano can change a mountain in one morning, and how plants and animals came back.

Warm-up. Lie a small blanket or towel flat on the floor and set a toy block on top of it. Slide your fist under the blanket and push up very slowly. Watch the bump grow. What happens to the block when the bump gets too big? Tell your parent what you saw. Today you will meet a real mountain that grew a bump like this.

Video. Coming soon. Mount St. Helens 1980 eruption for kids: search USGS Cascades Volcano Observatory, the U.S. Forest Service Mount St. Helens visitor center, Smithsonian, SciShow Kids, Homeschool Pop, and historic news footage of the May 18 eruption and the plants and animals returning.

KEY TERMS

volcano

An opening in the ground where hot melted rock, ash and gas come out. The mountain around the opening is called a volcano too.

eruption

When a volcano pushes out ash, gas or lava.

ash

Tiny bits of broken rock and glass blown out of a volcano. It looks like gray powder, but it is gritty like sand, not soft like wood ash.

crater

A big bowl-shaped hole at the top of a volcano.

CORE IDEAS

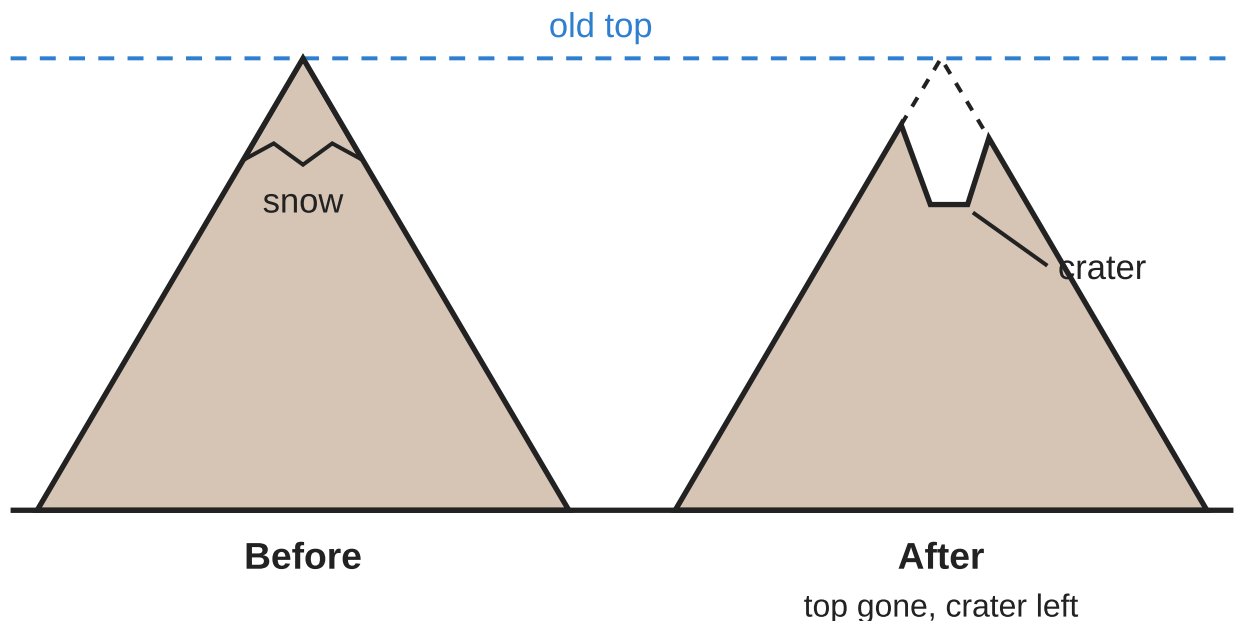
The story. Mount St. Helens is a mountain in the state of Washington. For a long time it looked like a snowy ice-cream cone. Families camped and fished at Spirit Lake at its feet. But Mount St. Helens is a **volcano**. Deep below it is hot, melted rock. In the spring of 1980 the ground began to shake. Steam and gray **ash** puffed out of the top. Then the north side of the mountain began to swell out, like a bump on your head. Scientists from the U.S. Geological Survey watched it every day and asked people to stay away.

How they figured it out. On Sunday morning, May 18, 1980, at 8:32, a young scientist named David Johnston was watching from a ridge across the valley. An earthquake shook the

mountain, and the whole bulging side slid down in a giant landslide. Out burst a blast of hot gas, rock and ash, sideways, like the cork popping out of a bottle. Johnston called on his radio, "Vancouver! Vancouver! This is it!" He did not survive, and some other people near the mountain were lost too. A dark cloud of ash climbed higher than jet planes fly. The wind carried it east. In towns far away, ash fell like gray snow, and the sky turned dark in the middle of the day.

The big idea. When the **eruption** was over, the pointed top of the mountain was gone. In its place was a giant bowl called a **crater**, open on the north side like a horseshoe. Forests were knocked flat like spilled toothpicks. Rivers of mud rushed down the valleys. A volcano can build a mountain, but it can also change one in a single morning. That is why scientists watch for warning signs: shaking ground, steam and ash, and a growing bulge.

God's handiwork. Many people thought nothing would live there for a very long time. But little pocket gophers had been safe in their tunnels under the ground. Frogs and fish had been safe in ponds still covered with ice. Soon purple lupine flowers and pink fireweed bloomed in the gray ash, and elk came back to munch. Layers of ash and mud piled up in hours, not ages, and we will visit the mountain again in Unit 8. God made a world that can heal.



Mount St. Helens before and after May 18, 1980. The dashed line shows where the top used to be.

PICTURE STUDY



Mount St. Helens Erupting, May 18, 1980, Austin Post, U.S. Geological Survey, May 18, 1980 · Photograph · U.S. Geological Survey photo collection

This is a real photograph taken on the very day Mount St. Helens erupted. Scientists of the U.S. Geological Survey took pictures from the air and from the ground so that they could study the eruption later. Because they worked for the United States government, their photographs belong to everyone, and we can look at them freely today.

Look closely

- Find the mountain under the cloud. Can you still see snow on it?
- Look at the cloud. Is it smooth, or puffy and lumpy like cauliflower?
- Find the top of the cloud. Is it higher than the mountain? How much higher?
- Look at the colors. Which parts are gray, white, dark and blue?

Talk about it

1. What do you think the cloud is made of?
2. If you were a scientist far away, what would you write in your notebook about this picture?
3. Why was it wise for people to stay away from the mountain?

Safety first. Balloons can be a choking danger for young children. A grown-up should blow up and handle the balloon, and pick up any broken balloon pieces right away.

MAKE AND DO: THE BULGING MOUNTAIN

Before Mount St. Helens erupted, its north side swelled out like a bump. You will build a play-dough mountain with a balloon hidden inside and watch its side bulge and crack, just as the scientists watched the real mountain.

You will need

- A balloon (a grown-up handles it)
- A bendy straw or a short piece of tubing
- Tape
- Play dough, modeling clay or damp sand
- A tray or baking sheet
- A few small toy trees or broccoli tops (optional)

Steps

1. A grown-up tapes the neck of a flat balloon tightly around one end of a bendy straw.
2. Lay the flat balloon on the tray with the straw sticking out to one side.
3. Build a cone-shaped mountain of play dough or damp sand over the balloon. Make one side thinner than the other. Call the thin side the north side.
4. Stand toy trees around the bottom of the mountain.
5. The grown-up blows very gently into the straw, a little at a time. Watch the north side.
6. Stop and look after each small puff. Does the side bulge? Does it crack? Does it slide?
7. Draw what your mountain looked like before and after.

Tips

- Go slowly. The real bulge grew a little each day for many weeks.
- If nothing happens, make the north side thinner and try again.

Check your work

- I can tell what a bulge on a volcano means.
- I can tell what happened to the top of Mount St. Helens.
- I can draw the mountain before and after.

FIELD NOTEBOOK

1. Draw Mount St. Helens before May 18, 1980, with its snowy pointed top. Then draw it after, with the crater. Label each one.
2. Draw the ash cloud rising and an arrow showing the wind carrying it away. Label ash, cloud and wind.
3. Draw one living thing that came back after the eruption: a gopher, a frog, an elk, a lupine or a fireweed.

From history. Mount St. Helens got its English name in 1792, when Captain George Vancouver of the British navy sailed along the Pacific coast and named it after his friend, a British diplomat called Lord St. Helens. Long before that, the Native American people who lived nearby had their own names for the mountain. The town David Johnston called on his radio, Vancouver, Washington, is named after the same Captain Vancouver.

WORKED EXAMPLES

Example 1. Look at the before-and-after picture of Mount St. Helens. Which mountain is taller, the one before or the one after? How can you tell?

(Use the map or drawing “Lay a pencil along the dashed line to compare.” shown earlier in this lesson.)

1. Find the top of the Before mountain. Put your finger on it.
2. Find the top edge of the After mountain. Put another finger on it.
3. Lay a pencil flat across the picture along the dashed line at the top. The Before mountain touches the line. The After mountain does not reach it.
4. So the Before mountain was taller. The top was blown away and slid down, leaving a crater.

Answer: The mountain before May 18, 1980, was taller. After the eruption it was lower, with a crater where the top used to be.

PRACTICE

1. **EASY** In which state is Mount St. Helens?
2. **EASY** Hold up one finger for each warning sign the scientists watched before the eruption. Name them.
3. **MEDIUM** Point to the crater in the After picture. What is a crater?
4. **MEDIUM** Your parent says these words: gopher, frog, elk, lupine, fireweed, rock. Sort them into “animals” and “plants.” Which one is neither? How many animals and how many plants?
5. **HARD** Tell the story of May 18, 1980, in four sentences: what the mountain looked like, what happened that morning, what it looked like after, and what came back.

COMMON MISTAKES

- Thinking volcano ash is soft like ash in a fireplace. Volcano ash is tiny bits of rock and glass, gritty and heavy when wet.
- Thinking all volcanoes blow straight up. At Mount St. Helens the big blast went out sideways, toward the north.
- Thinking a land covered in ash stays dead forever. Plants and animals began coming back very soon.

Make it a game • Volcano Watcher. The child is the scientist. The parent calls out things that might happen at a mountain: “The ground shakes!” “Birds sing.” “Steam puffs out!” “A bulge grows!” “Snow falls.” If it is a volcano warning sign, the scientist jumps up and calls, “Stay away!” If it is not, the scientist sits still. Score one point for each right answer. Play to ten points, then switch places.

Scripture. “God is our refuge and strength, a very present help in trouble. Therefore will not we fear, though the earth be removed, and though the mountains be carried into the midst of the sea;” (Psalm 46:1-2, KJV)

A whole mountaintop can be carried away in one morning, but God does not move. When the earth shakes, God is still our safe place.

Practice answers

1. Washington.
2. Three fingers: the ground shaking (earthquakes), steam and ash puffing out, and the north side bulging out.
3. The child points to the dip at the top of the After mountain. A crater is a big bowl-shaped hole at the top of a volcano.
4. Animals: gopher, frog, elk (3). Plants: lupine, fireweed (2). Rock is neither, because it is not living.
5. Answers will vary. Example: Mount St. Helens was a snowy, pointed mountain. On May 18, 1980, an earthquake made its side slide away and a blast of ash burst out. Afterward the top was gone and there was a big crater. Later, flowers grew and animals like elk came back.

2.2 BAKING-SODA VOLCANO AND WHAT IT GETS WRONG

OBJECTIVES

- Make a baking-soda volcano and tell what makes the foam: gas bubbles.
- Name what the model gets right (gas pushes stuff up and out) and what it gets wrong (real lava is hot melted rock, and real volcanoes grow by layers).
- Use the words magma and lava correctly.

Warm-up. Pour a little fizzy water or soda pop into a clear cup and look closely. Where do the bubbles come from? Which way do they go? Put your ear near the cup and listen. Gas bubbles that push up and out are one thing a real volcano and a kitchen volcano share.

Video. Coming soon. Baking soda and vinegar volcano and how real volcanoes erupt (magma, gas, layers) for kids: search USGS Volcano Hazards Program, Smithsonian Global Volcanism Program, SciShow Kids, Science Max, Homeschool Pop, and Moody Science classics.

KEY TERMS

model

A small or pretend copy that helps us understand a real thing. A model is never exactly like the real thing.

magma

Hot, melted rock that is still deep under the ground.

lava

Melted rock that has come out on top of the ground. When it cools, it turns hard as rock.

gas

Stuff like air that spreads out to fill any space. You cannot hold it in your hand, but bubbles are full of it.

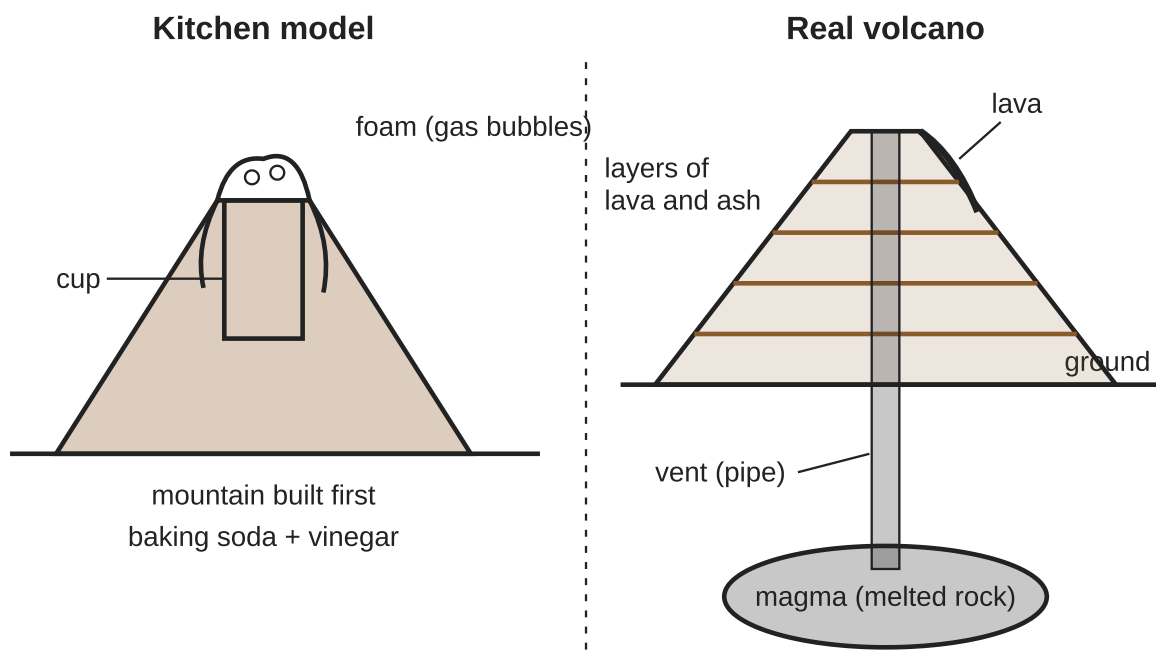
CORE IDEAS

The story. Many children have made a volcano in the kitchen. You build a little mountain around a cup, spoon in baking soda, pour in vinegar, and whoosh! Foam bubbles up and spills down the sides. It is fun to watch. But a good scientist always asks, “How is my **model** like the real thing, and how is it different?”

How they figured it out. Look closely at the foam. It is full of tiny bubbles. When baking soda and vinegar mix, they make a **gas** called carbon dioxide. The gas needs room, so it pushes the liquid up and out of the cup. Real volcanoes have gas too! Deep under the ground, hot melted rock called **magma** holds gas, like the bubbles hiding in a bottle of soda pop. When the magma rises, the gas bubbles grow and push it up and out. That part of the model is right.

The big idea. Now here is what the model gets wrong. First, real volcanoes do not have vinegar or baking soda in them. They have melted rock. When it comes out on top of the ground, we call it **lava**. Second, the foam is cool enough to touch. Real lava is so hot it glows orange and red, and it would burn up a paper mountain at once. Third, a real volcano is not a hollow mountain with a cup inside. The magma sits far, far below. Fourth, and this is the big one: in the kitchen we build the mountain first and then make it erupt. A real volcano is built *by* its eruptions. Each eruption spreads a new layer of lava or ash on top of the old ones, and the mountain grows higher, layer by layer.

Try it and see. Today you will make two volcanoes. One is the fizzy kind. The other is a layer volcano made of play dough, where every “eruption” adds a new layer. When you cut it open, you will see stripes, like the layers inside a real volcano. Scientists use models all the time. The trick is to know what the model can teach you and where it stops being true.



A kitchen model and a real volcano, cut in half so we can see inside.

PICTURE STUDY



Cotopaxi, Frederic Edwin Church, 1862 · Oil on canvas · Detroit Institute of Arts, Detroit, Michigan

Frederic Edwin Church was an American painter who traveled to South America to see its mountains with his own eyes. Cotopaxi is a real volcano in Ecuador, one of the tallest active volcanoes in the world. Church made many sketches there, and later, back in his studio, he painted this great picture of Cotopaxi sending out a cloud of smoke and ash that darkens the sun.

Church loved to paint the works of God in nature as grand and full of light. Notice how the sun and the volcano seem to be speaking to each other across the sky.

Look closely

- Find the volcano. What shape is it? Is it pointed or flat?
- Follow the smoke and ash. Which way is the wind blowing it?
- Find the sun. What color is it, and why do you think it looks that way?
- Find the water: the lake and the waterfall.

Talk about it

1. Is there anything in this painting that looks like a baking-soda volcano? What looks different?
2. Cotopaxi is cone-shaped like Mount St. Helens was. What do you think made it that shape?
3. How does the painting make you feel?

Safety first. Vinegar stings if it gets in your eyes. Wear old clothes or an apron, keep your face back from the cup, and wash hands when you finish. Do the fizzy volcano on a

tray or outdoors.

MAKE AND DO: TWO VOLCANOES: FIZZY AND LAYERED

First you will make a classic baking-soda volcano and watch the gas push the foam out. Then you will build a layer volcano that grows the way a real one does, one eruption at a time.

You will need

- A small cup or empty yogurt cup
- Play dough or modeling clay in 3 or 4 colors
- A tray or baking sheet
- 2 to 3 spoonfuls of baking soda
- About half a cup of vinegar
- A squirt of dish soap and a drop of red or orange food coloring (optional)
- A paper plate and a plastic knife or dental floss

Steps

1. Fizzy volcano: set the cup on the tray and pat play dough around it into a mountain shape. Leave the top of the cup open.
2. Put the baking soda in the cup. Add the dish soap and food coloring if you have them.
3. Pour in the vinegar and step back. Watch the bubbles push the foam up and over.
4. Say one thing the model gets right and one thing it gets wrong.
5. Layer volcano: poke a pencil hole in the middle of a paper plate. This is the vent, where lava comes out.
6. Eruption 1: roll a flat pancake of one color of play dough and lay it over the hole, spreading out from the middle.
7. Eruption 2: lay a slightly smaller pancake of a new color on top. Then do eruptions 3 and 4 with other colors, each a little smaller.
8. Count your eruptions. Then a grown-up slices the mountain in half with a plastic knife or floss. Look at the stripes.

Tips

- Dish soap makes the foam thicker and slower, more like oozing lava.
- In a real volcano, ash layers and lava layers often take turns. Try a sprinkle of flour or sand between two play-dough layers for an ash layer.

Check your work

- I can say what makes the foam in a baking-soda volcano.
- I can name two things the model gets wrong.
- I can show how a real volcano grows by layers.

FIELD NOTEBOOK

1. Draw your fizzy volcano erupting. Label foam, bubbles (gas) and cup.
2. Draw your layer volcano cut in half. Color each layer and number them 1, 2, 3, 4 from the bottom up.
3. Make two boxes. In one, draw magma (under the ground). In the other, draw lava (on top of the ground).

From history. One of the first people to write down what he saw during a volcano eruption was a young Roman named Pliny the Younger. In the year AD 79, he watched Mount Vesuvius in Italy erupt from across the bay. In a letter, he said the great cloud rising from the mountain was shaped like an umbrella pine tree, a tree with a tall trunk and branches spreading out at the top. Today scientists still call a very big, explosive eruption with a tall ash column, like Mount St. Helens, a “Plinian” eruption after him.

WORKED EXAMPLES

Example 1. A family made three baking-soda volcanoes. They used 1 spoonful of baking soda the first time, 2 the second time and 3 the third time, with the same cup of vinegar each time. They measured with fingers how far the foam ran down the side: 2 fingers, 4 fingers and 6 fingers. Which try made the biggest eruption? How many more fingers did try 3 run than try 1?

1. Line up the tries: try 1 ran 2 fingers, try 2 ran 4 fingers, try 3 ran 6 fingers.
2. The biggest number is 6, so try 3 was biggest.
3. Count up from 2 to 6: 3, 4, 5, 6. That is 4 more fingers. ($6 - 2 = 4$)
4. More baking soda made more gas, and more gas pushed out more foam.

Answer: Try 3 (3 spoonfuls) made the biggest eruption. Its foam ran 4 fingers farther than try 1.

PRACTICE

1. **EASY** What do we call melted rock deep under the ground? What do we call it when it comes out on top?
2. **EASY** What is inside the bubbles in the foam?
3. **MEDIUM** Your parent reads these sentences. Say “model” or “real” for each: (a) It is made of melted rock. (b) The foam is cool to touch. (c) It glows red and orange. (d) We built the mountain first.
4. **MEDIUM** Look at your layer volcano. Count the layers. Which layer came out first, the top one or the bottom one?
5. **HARD** Tell one thing the baking-soda volcano gets right and one thing it gets wrong.

COMMON MISTAKES

- Thinking a real volcano is full of baking soda and vinegar. It erupts melted rock, ash and gas.
- Thinking lava glows because it is on fire. Lava glows because it is so very hot, the way a stove coil glows red.
- Thinking a volcano is a hollow mountain full of lava. The magma is stored far below, and the mountain is built from layers of old lava and ash.

Make it a game · Model or Real?. The parent calls out a fact, such as “It is made of vinegar” or “It glows hot orange” or “It grows layer by layer.” The child crouches low for “model” and stands tall with arms up like an eruption for “real.” Score one point for each right answer. After eight turns, the child makes up two facts for the parent to sort.

Scripture. “He looketh on the earth, and it trembleth: he toucheth the hills, and they smoke.” (Psalm 104:32, KJV)

Our kitchen volcano needs a whole cup of vinegar to make a little foam. The real hills that smoke are far mightier, and the One who made them is mightier still.

Practice answers

1. Under the ground it is magma. On top of the ground it is lava.
2. A gas (carbon dioxide), made when baking soda and vinegar mix.
3. (a) real, (b) model, (c) real, (d) model.
4. The count depends on the model (usually 4). The bottom layer came out first, because each new layer lands on top of the older ones.
5. Right: gas bubbles push stuff up and out, as gas pushes magma out of a real volcano. Wrong (any one): real volcanoes erupt hot melted rock, not cool foam; there is no vinegar or baking soda; the magma is far underground, not in a cup at the top; real volcanoes are built by layers from their eruptions.

2.3 LAVA ROCKS: PUMICE AND OBSIDIAN

OBJECTIVES

- Tell how pumice and obsidian both come from lava that cooled very fast.
- Describe how they look and feel different, and test whether each one floats or sinks.
- Explain that the bubbles in pumice let it float.

Warm-up. Look closely at a slice of bread or a kitchen sponge with a magnifying glass if you have one. What do you see? Count how many holes you can find in a space the size of your thumbnail. Now look at a glass cup or a marble. Does it have holes? Today you will meet two lava rocks: one full of holes like the bread, and one smooth like the glass.

Video. Coming soon. Pumice and obsidian volcanic rocks for kids (floating pumice, volcanic glass, Obsidian Cliff in Yellowstone): search USGS, the National Park Service (Yellowstone), Smithsonian National Museum of Natural History, SciShow Kids, Homeschool Pop, and rock-collecting channels for children.

KEY TERMS

pumice

A light, gray or white lava rock full of tiny holes left by gas bubbles. Most pumice can float on water.

obsidian

A shiny, dark lava rock that looks like black glass. It forms when lava cools so fast that it turns to glass.

volcanic glass

Glass made by a volcano, not by people. Obsidian is volcanic glass.

float

To stay up on top of the water instead of sinking.

CORE IDEAS

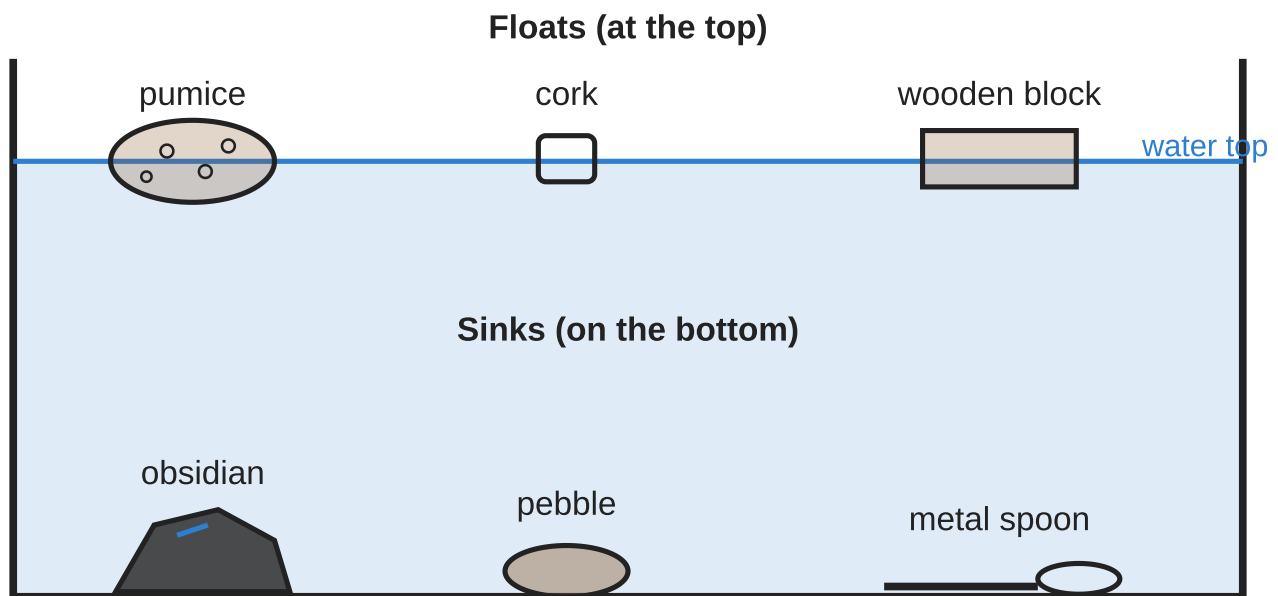
The story. When Mount St. Helens erupted, it blew out mountains of a light, bubbly gray rock. It covered the land north of the volcano so thickly that people now call that place the Pumice Plain. In Yellowstone National Park there is a whole cliff of shiny black rock called Obsidian Cliff. Native Americans came there long ago to break off pieces and make arrowheads and knives. Both rocks were made by volcanoes. Both came from lava. Yet they look as different as a sponge and a glass marble.

How they figured it out. Pick up a piece of **pumice**. It is so light it feels like a pretend rock! Look closely and you will see it is full of tiny holes. Each hole was once a gas bubble. When frothy, foamy lava blasts out of a volcano, it cools so fast that the bubbles get trapped inside, like the holes in a slice of bread. All that trapped air makes pumice light, and most

pumice will **float** on water. After some eruptions at sea, sailors have seen great rafts of floating pumice drifting on the waves.

The big idea. Obsidian also comes from lava that cooled very fast, but this lava had lost its bubbles. It cooled so quickly that it turned into **volcanic glass**: smooth, shiny and usually black. Because it is glass, it breaks with curved, very sharp edges. That is why people long ago made arrowheads and knives from it. So here is the rule: fast-cooling lava with lots of bubbles makes pumice. Fast-cooling lava without bubbles makes obsidian. Obsidian is heavy for its size, so it sinks.

Try it and see. You can buy a pumice stone at a drugstore, because people use it to rub rough skin off their feet. Drop it in a bowl of water and watch it bob. Then try other things: a pebble, a cork, a spoon. Scientists do not just guess. They test and write down what happens. God made rocks that tell their own stories: the holes in pumice tell of gas bubbles, and the shine of obsidian tells of lava cooled in a hurry.



A float test. Which things float, and which sink?

PICTURE STUDY



Vesuvius in Eruption, with a View over the Islands in the Bay of Naples, Joseph Wright of Derby, about 1776–1780 · Oil on canvas · Tate Britain, London

Joseph Wright of Derby was an English painter who loved to paint light in the dark: candlelight, firelight and the glow of science experiments. He visited Italy and saw Mount Vesuvius, the volcano near the city of Naples. After he came home, he painted Vesuvius erupting again and again, more than thirty times.

In this painting, red-hot lava pours down the mountain at night. All of that glowing lava will cool and harden into new rock.

Look closely

- Find the brightest part of the painting. What is glowing?
- Follow the lava down the side of the mountain with your finger.
- Find the smoke cloud. What color is it where the fire lights it from below?
- Find the water and the islands. Is it day or night?

Talk about it

1. What will happen to the glowing lava when it cools?
2. Do you think this lava would make pumice, obsidian or another kind of rock? Why might you need to see it up close to know?
3. Why do you think a painter would want to paint the same volcano again and again?

Safety first. Obsidian edges are sharper than a knife. Look at obsidian with your eyes and hold it gently with a grown-up nearby; never try to break it. Pumice is rough and can

scrape skin. Wash hands after handling rocks, and keep small pieces away from very young children.

MAKE AND DO: THE FLOAT-OR-SINK ROCK TEST

You will test pumice and other things in water, guess first, then write down what really happens. This is just what real scientists do: predict, test and record.

You will need

- A pumice stone (sold at drugstores for foot care) or a piece of pumice from a rock shop
- A piece of obsidian if you can get one (rock shops and museum shops often sell small tumbled pieces), or a picture of one
- A clear bowl or tub of water
- A pebble from outside, a cork, a wooden block or clothespin, and a metal spoon
- A magnifying glass (optional)
- Paper and crayons for a chart

Steps

1. Look at the pumice with a magnifying glass. Find the holes where gas bubbles once were. Feel how light it is.
2. If you have obsidian, look at its shine and its smooth curved edges. Do not rub your finger along the edges.
3. Make a chart with two columns: Floats and Sinks.
4. Hold up each thing. Guess: float or sink? Say your guess out loud.
5. Gently set each thing in the water. Watch.
6. Draw each thing in the right column of your chart.
7. Leave the pumice in the water and check it again after an hour. Is it still floating? Water can slowly soak into its holes.

Tips

- Some pumice stones sink after the holes fill with water. That is part of the test, not a mistake.
- Squeeze a wet sponge to see how water fills holes, just as it can fill the holes in pumice.

Check your work

- I can tell why pumice is light.
- I can tell how obsidian is different from pumice.
- I can make a float-or-sink chart.

FIELD NOTEBOOK

1. Draw a piece of pumice as big as your page and draw every hole you can see. Label it: pumice, bubbles.
2. Draw a piece of obsidian. Use black crayon and leave a white streak to show the shine. Label it: obsidian, volcanic glass.
3. Draw your float-or-sink chart and color it.

From history. Obsidian from Obsidian Cliff in Yellowstone was so prized that Native Americans traded it far and wide. Archaeologists have found tools made from Yellowstone obsidian in ancient Hopewell burial mounds in Ohio, more than a thousand miles away. Obsidian Cliff is now a National Historic Landmark. Even today, some eye doctors and surgeons have used blades of obsidian, because a fresh obsidian edge can be sharper than steel.

WORKED EXAMPLES

Example 1. Look at the float-test picture. How many things are floating? How many sank? Which lava rock floated?

(Use the map or drawing “Count the floaters at the top and the sinkers at the bottom.” shown earlier in this lesson.)

1. Look at the top of the water. Count the floaters: pumice, cork, wooden block. That is 3.
2. Look at the bottom of the tub. Count the sinkers: obsidian, pebble, spoon. That is 3.
3. Compare: 3 and 3 are the same.
4. Find the two lava rocks. Pumice is at the top. Obsidian is at the bottom.

Answer: 3 things floated and 3 sank. The pumice floated; the obsidian sank.

PRACTICE

1. **EASY** Point to the rock that is full of holes: pumice or obsidian?
2. **EASY** What made the holes in pumice?
3. **MEDIUM** Your parent names words: shiny, holey, light, glassy, sharp edges, floats. Sort each word to pumice or obsidian.
4. **MEDIUM** In your float test, count your floaters and your sinkers. Which group had more? How many more?
5. **HARD** Why did people long ago make arrowheads and knives from obsidian and not from pumice?

COMMON MISTAKES

- Thinking all rocks sink. Pumice is a rock, but its trapped air bubbles let most pieces float.
- Thinking obsidian is made by people because it looks like glass. It is natural glass made when lava cools very fast.
- Thinking pumice and obsidian come from different places. Both come from lava; the difference is whether the lava was full of bubbles.

Make it a game · Float or Sink? Gather six safe things from around the house. The parent holds up one at a time. The child calls “Float!” and stands tall, or “Sink!” and crouches down. Then test it in a bowl of water. Score one point for each right guess. Then the child explains one guess: “I think it will float because it has air inside, like pumice.”

Scripture. “As for the earth, out of it cometh bread: and under it is turned up as it were fire.” (Job 28:5, KJV)

On top of the earth, God gives us fields of grain for bread. Deep under it is heat like fire, and sometimes that fire comes up as lava and cools into rocks like pumice and obsidian.

Practice answers

1. Pumice.
2. Gas bubbles that were trapped when the frothy lava cooled very fast.
3. Pumice: holey, light, floats. Obsidian: shiny, glassy, sharp edges.
4. Answers depend on the test. In the picture there were 3 floaters and 3 sinkers, so neither had more. The child should count each group and subtract the smaller number from the bigger one.
5. Obsidian is glass, so it breaks with very sharp, smooth edges. Pumice is full of holes and crumbles, so it cannot hold a sharp edge.

2.4 HAWAII'S VOLCANOES

OBJECTIVES

- Tell how the islands of Hawaii were built by volcanoes rising from the bottom of the sea.
- Compare a wide, gentle shield volcano with a steep cone like Mount St. Helens, and tell why runny lava makes a wide shape.
- Name the two kinds of Hawaiian lava rock: smooth pāhoehoe and rough 'a'ā.

Warm-up. Put a plate on the table. Pour one spoonful of pancake syrup in the middle and watch it spread. Next to it, plop one spoonful of peanut butter or thick pudding. Which one spreads out wide and flat? Which one piles up high? Hawaii's lava is like the syrup.

Video. Coming soon. Hawaii's volcanoes for kids (Kīlauea, Mauna Loa, lava flowing into the ocean, pāhoehoe and 'a'ā): search USGS Hawaiian Volcano Observatory, Hawai'i Volcanoes National Park (National Park Service), Smithsonian, SciShow Kids, Homeschool Pop, and nature footage of lava flows.

KEY TERMS

island

Land with water all around it.

shield volcano

A wide volcano with gently sloping sides, shaped like a warrior's round shield lying on the ground. It is built by runny lava that flows far.

pāhoehoe

(pah-HOH-ay-hoh-ay) Hawaiian lava that cools with a smooth or ropy skin.

'a'ā

(AH-ah) Hawaiian lava that cools into rough, sharp, crumbly chunks.

CORE IDEAS

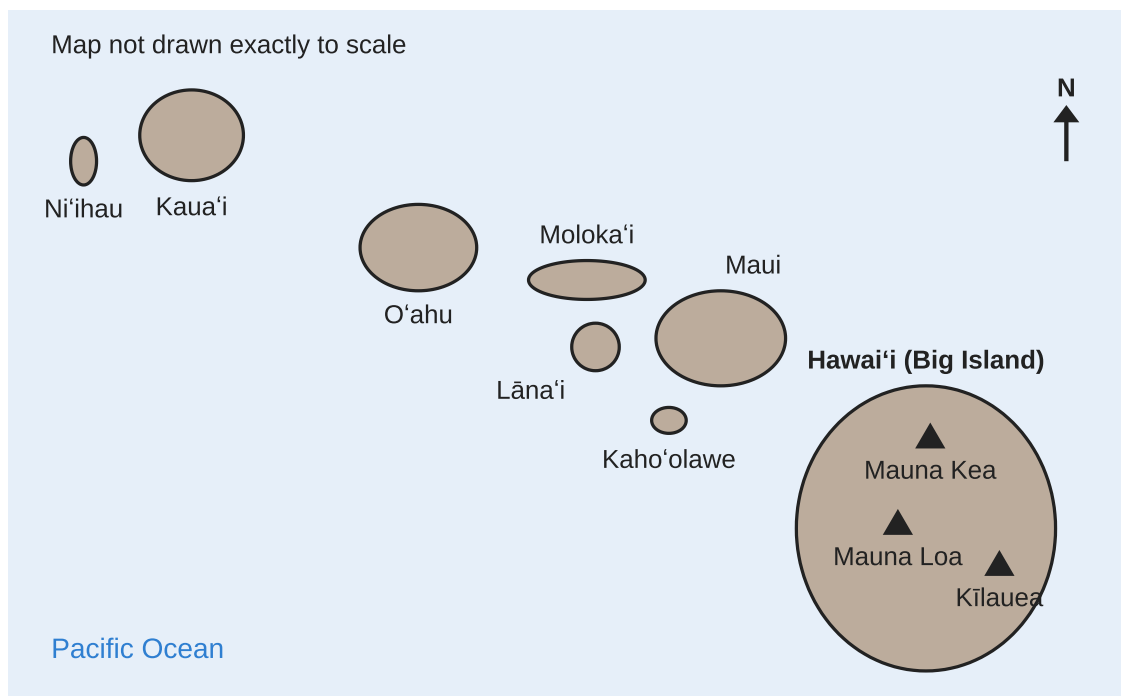
The story. In the middle of the Pacific Ocean, far from any other land, lies a chain of **islands** called Hawaii. Every one of them was built by volcanoes. Lava poured out on the bottom of the sea, cooled, and piled up, layer on layer, until the mountains rose above the waves. The biggest island, also named Hawai'i, is called the Big Island. Its volcanoes are still at work. Kīlauea is one of the busiest volcanoes in the world, and Mauna Loa is the biggest active volcano on earth.

How they figured it out. In 1912 a scientist named Thomas Jaggar set up a little station right on the edge of Kīlauea's crater, so that he could watch the volcano every day. It became the Hawaiian Volcano Observatory, and scientists there still watch the volcanoes today. They learned that Hawaiian lava is runny, like warm syrup. It flows a long way before it cools. So

instead of a steep cone like Mount St. Helens, Hawaii's volcanoes are wide and gently sloped. We call them **shield volcanoes**, because they look like a warrior's round shield lying on the ground.

The big idea. Hawaiian lava cools into two kinds of rock with Hawaiian names. **Pāhoehoe** is smooth, and sometimes it wrinkles into shapes like coils of rope. **'A'ā** is rough, sharp and broken, like a field of jagged cinders. When lava flows into the ocean, the sea cools it with a great hiss of steam, and new land is made right before people's eyes. Mauna Kea, another Big Island volcano, starts deep on the ocean floor. Measured from its bottom under the sea to its top, it is even taller than Mount Everest!

God's handiwork. The Hawaiian people once believed a goddess named Pele lived in Kīlauea. In 1824 a Christian chiefess named Kapi'olani walked to the edge of the crater. She ate the 'ōhelo berries that people believed belonged to Pele, and she told everyone that the God of the Bible, Jehovah, had made the volcano and was the one true God. Nothing harmed her. The fire mountains of Hawaii belong to the Lord who made the sea and the dry land.



The eight main islands of Hawaii. The Big Island is at the lower right.

PICTURE STUDY



Lava Fountain at Pu‘u ‘Ō‘ō, Kīlauea Volcano, C. Heliker, U.S. Geological Survey, Hawaiian Volcano Observatory, September 24, 1984 · Photograph · U.S. Geological Survey photo collection

In 1983 a new vent opened on the side of Kīlauea and began to spray fountains of lava high into the air. Over time the falling lava built a cone called Pu‘u ‘Ō‘ō. Scientists of the Hawaiian Volcano Observatory took photographs like this one to study how the lava moved. Photographs made by U.S. government scientists belong to everyone.

Look closely

- Find the lava fountain. What colors do you see in it?
- Find the cone at the bottom. What do you think built it?
- Look for something small that shows how big the fountain is.
- Look at the sky above the fountain. What is the cloud made of?

Talk about it

1. How is this eruption different from the Mount St. Helens photograph?
2. When this lava cools, will it become pāhoehoe, ‘a‘ā or pumice? How could you find out?
3. Why do you think scientists stay a safe distance away?

Safety first. Check for food allergies before using peanut butter; frosting or thick pudding works just as well. Real lava is never safe to touch or walk near, so only visit lava areas on marked trails with park rangers.

MAKE AND DO: SYRUP SHIELDS AND PEANUT-BUTTER PEAKS

Why are Hawaii's volcanoes wide and gentle while Mount St. Helens was a steep cone? You will build two pretend volcanoes, one with runny "lava" and one with thick "lava," and see which shape each one makes.

You will need

- Two paper plates
- Pancake syrup or honey (runny lava)
- Peanut butter, frosting or thick pudding (thick lava)
- Two spoons
- A ruler
- A crayon or marker

Steps

1. Mark a dot in the middle of each plate. That is the vent.
2. Eruption 1: spoon one spoonful of syrup onto the dot on plate A. Spoon one spoonful of peanut butter onto the dot on plate B.
3. Wait a minute. Then do eruption 2 on each plate, right on top of the first one.
4. Do eruption 3 and eruption 4 the same way.
5. Look at the plates from the side. Which volcano is wide and flat? Which is tall and steep?
6. Use a ruler to measure how wide each one is across. Write down the numbers.
7. Say which plate is like Hawaii and which is like Mount St. Helens.

Tips

- Cold syrup is thicker. Use syrup at room temperature so it flows like Hawaiian lava.
- Bonus: make pāhoehoe ropes by gently pushing a spoon through a layer of frosting so it wrinkles.

Check your work

- I can tell why Hawaii's volcanoes are wide and gentle.
- I can name pāhoehoe and 'a'ā and tell how they look.
- I can measure my model volcanoes with a ruler.

FIELD NOTEBOOK

1. Draw a side view of a shield volcano and a steep cone volcano. Label each one.
2. Draw two boxes. In one draw smooth, ropy pāhoehoe. In the other draw rough, jagged 'a'ā. Label them.
3. Draw lava flowing into the ocean with steam rising. Label lava, ocean, steam and new land.

From history. Kapi‘olani was a high chiefess of the island of Hawai‘i who became a Christian through the teaching of missionaries. In December 1824 she traveled to Kīlauea and went down toward the fiery pit while many people watched, fearing Pele would destroy her. She ate the sacred ‘ōhelo berries without offering them to Pele first, prayed, and declared her trust in Jehovah. Nothing happened to her, and many Hawaiians saw that the old fear had no power. Years later the English poet Alfred Tennyson wrote a poem in her honor.

WORKED EXAMPLES

Example 1. Look at the map of Hawaii. How many main islands are there? Which island is the biggest?

(Use the map or drawing “Touch each island as you count.” shown earlier in this lesson.)

1. Start at the top left and touch each island as you count: Ni‘ihau 1, Kaua‘i 2, O‘ahu 3, Moloka‘i 4, Lāna‘i 5, Maui 6, Kaho‘olawe 7, Hawai‘i 8.
2. There are 8 main islands.
3. Look for the island that takes up the most room on the map. It is at the bottom right.
4. That is Hawai‘i, the Big Island. It is bigger than all the other islands put together.

Answer: There are 8 main islands. The biggest is Hawai‘i, the Big Island.

PRACTICE

1. **EASY** What built the islands of Hawaii?
2. **EASY** Point to the Big Island on the map. Name one of its volcanoes.
3. **MEDIUM** Your parent says: smooth, rough, ropy, sharp, jagged, wrinkly. Sort each word to pāhoehoe or ‘a‘ā.
4. **MEDIUM** In the project, a child measured the syrup volcano 14 centimeters across and the peanut-butter volcano 6 centimeters across. Which one was wider? How many centimeters wider?
5. **HARD** Why are Hawaii’s volcanoes wide and gentle instead of steep like Mount St. Helens? Draw both shapes as you explain.

COMMON MISTAKES

- Thinking all volcanoes are steep, pointy cones. Shield volcanoes like Mauna Loa are wide with gentle slopes.
- Thinking islands float on top of the sea. Hawaii’s islands are the tops of huge volcanoes that stand on the ocean floor.
- Thinking all lava is the same. Runny lava spreads far; thick, sticky lava piles up and can trap gas that explodes.

Make it a game • Island Hop. Cut eight paper shapes for the eight main islands, with one much bigger for the Big Island, and lay them on the floor in a chain. The child hops from island to island, saying each name. On the Big Island, the parent calls “Pāhoehoe!” (the child slides smoothly like a snake) or “‘A‘ā!” (the child takes stiff, crunchy steps like walking on sharp rocks). Count the hops each time and try to beat your best.

Scripture. “In his hand are the deep places of the earth: the strength of the hills is his also. The sea is his, and he made it: and his hands formed the dry land.” (Psalm 95:4-5, KJV)

Hawaii shows all of these: the deep places where lava rises, the strong volcano mountains, the great sea, and new dry land formed as lava cools. Kapi‘olani trusted the God who holds them all in His hand.

Practice answers

1. Volcanoes. Lava piled up from the bottom of the sea until it rose above the water.
2. The child points to the large island at the lower right. Volcanoes: Kilauea, Mauna Loa or Mauna Kea.
3. Pāhoehoe: smooth, ropy, wrinkly. ‘A‘ā: rough, sharp, jagged.
4. The syrup volcano was wider, by 8 centimeters ($14 - 6 = 8$).
5. Hawaiian lava is runny, so it flows far before it cools and spreads into a wide, gentle shield. Mount St. Helens had thick, sticky lava and explosive eruptions of ash, which built a steeper cone.

UNIT 2 REVIEW

This is an oral review. Read each question aloud and let your child answer in their own words. Your child may point, draw or use their models to help. Give full points for a clear answer that shows understanding, even if the words are simple. The review is worth 20 points.

1. (3 pts) Tell me what happened at Mount St. Helens on May 18, 1980.
2. (3 pts) What warning signs did scientists watch before the eruption? Name two.
3. (3 pts) After the eruption, what living things came back to the gray ash?
4. (3 pts) What is the difference between magma and lava?
5. (3 pts) Tell me one thing a baking-soda volcano gets right and one thing it gets wrong.
6. (3 pts) Pumice and obsidian are both lava rocks. How are they different? Which one floats, and why?
7. (2 pts) How were the islands of Hawaii made, and why are their volcanoes wide and gentle?

UNIT PROJECT: MY VOLCANO MUSEUM

Set up a small museum table at home and give a tour to your family. Include your before-and-after drawing of Mount St. Helens, your cut-open layer volcano, your pumice float chart (with a real pumice stone if you have one), and your syrup and peanut-butter volcano drawings showing a shield shape and a steep cone. Make a little label card for each item. Then give a short tour, telling one true thing about each display and saying one verse about God's power over the hills.

- **Accuracy:** Each display is labeled correctly (crater, layers, pumice, obsidian, shield volcano) and the facts told on the tour are true.
- **Hands-on work:** The museum includes at least three things the child made or tested, such as the layer volcano, the float chart and the shield model.
- **Telling:** The child gives the tour in clear sentences in their own words and answers one question from a listener.
- **Care:** Drawings are colored and neat, label cards are readable, and the table is set up with care.

Answer key

1. An earthquake made the bulging side of the mountain slide away, and a blast of hot gas, rock and ash burst out sideways. A huge ash cloud rose high into the sky, and the top of the mountain was gone, leaving a big crater.
2. Any two: the ground shaking (earthquakes), steam and ash puffing out, the north side of the mountain bulging out.
3. Any two or more: pocket gophers, frogs, fish, elk, lupine flowers, fireweed.
4. Magma is melted rock under the ground. Lava is melted rock that has come out on top of the ground.

5. Right: gas bubbles push stuff up and out. Wrong (any one): real lava is hot melted rock, not cool foam; real volcanoes have no vinegar or baking soda; magma is deep underground; real volcanoes are built by layers from their eruptions.
6. Pumice is light and full of holes from gas bubbles; obsidian is shiny, smooth volcanic glass with sharp edges. Pumice floats because of the air trapped in its bubbles; obsidian sinks.
7. Volcanoes piled up lava from the bottom of the sea until they rose above the water. Hawaiian lava is runny and flows far, so it builds wide shield volcanoes.

EARTHQUAKES

The ground under our feet feels still and solid. But sometimes, all at once, it shakes. In this unit you will travel back to a spring morning in 1906, when the ground slipped along the San Andreas Fault and the city of San Francisco shook. You will learn that the outside of the earth is made of giant pieces of rock, and that an **earthquake** happens when two pieces that have been stuck suddenly slip along a crack called a **fault**.

Then you will become a young engineer. You will build a shake table, test block towers, and find out why some buildings fall while others stand: a firm **foundation**, a frame braced with **triangles**, and materials that bend without breaking. You will practice what to do if the ground ever shakes: Drop, Cover, and Hold On.

Last, you will hear about an earthquake in the Bible. At midnight in Philippi, Paul and Silas sang praises in prison, and God sent an earthquake that opened every door. The God who made the earth rules over it, and the people who trust Him need not be afraid, “though the earth be removed” (Psalm 46:2).

BEFORE YOU BEGIN

- Can count to 20 and add small numbers
- Can count by twos
- Can stack blocks and follow simple building steps
- Can listen to a story and tell it back in order

MASTERY CHECKLIST

- I can tell the story of the San Francisco earthquake of 1906.
- I can explain that an earthquake happens when rock slips along a fault.
- I can do Drop, Cover, and Hold On.
- I can build a shake table, run a fair test, and count the blocks that fall.
- I can name three things that help a building stand in an earthquake.
- I can retell the story of Paul and Silas and the earthquake at Philippi.

OPTIONAL BOOKS AND RESOURCES

- **USGS Earthquake Hazards Program** (<https://earthquake.usgs.gov/>): Free. The U.S. Geological Survey’s earthquake site. A parent can open the map of recent earthquakes and show the child how many small earthquakes happen around the world every day, and find historic pages on the 1906 San Francisco earthquake.
- **The Great ShakeOut** (<https://www.shakeout.org/>): Free. Simple pictures and directions for the Drop, Cover, and Hold On drill, used by schools and families. Good for practicing the drill in Lesson 3.1.

3.1 SAN FRANCISCO, 1906 ★

OBJECTIVES

- Tell the story of the San Francisco earthquake of April 18, 1906.
- Explain that an earthquake is a sudden shaking of the ground when giant pieces of rock slip along a crack called a fault.
- Show what to do when the ground shakes: Drop, Cover, and Hold On.

Warm-up. Set a bowl of gelatin (or a clear bowl of water) in the middle of the kitchen table. Tap the table gently with your fist. Watch it wiggle. Now tap a little harder. What changed? Today you will hear about a morning when a whole city wiggled.

Video. Coming soon. San Francisco earthquake of 1906 for kids: historic photographs, the San Andreas Fault and how earthquakes happen; search USGS, Smithsonian, SciShow Kids, Homeschool Pop (Alternate) and the Great ShakeOut “Drop, Cover, and Hold On” videos.

KEY TERMS

earthquake

A sudden shaking of the ground.

fault

A long crack in the earth’s rock where two big pieces of rock can slip past each other.

San Andreas Fault

A very long fault that runs through California. The ground slipped along it in 1906.

aftershock

A smaller shake that comes after a big earthquake.

CORE IDEAS

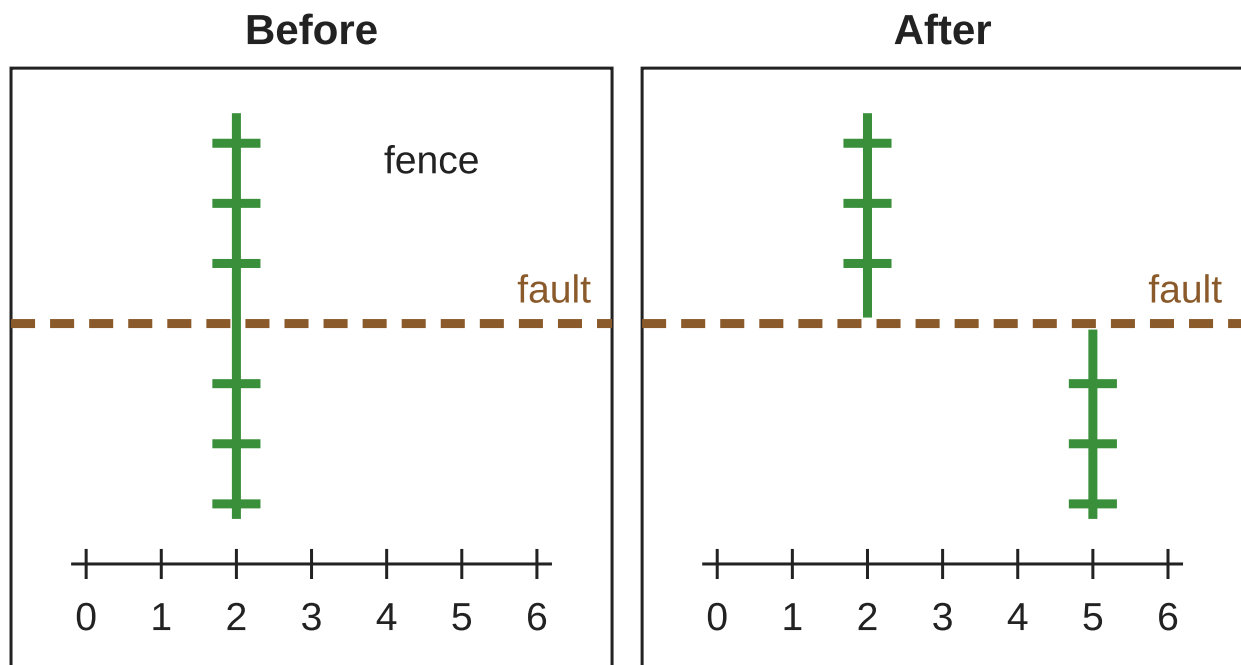
The story. Very early in the morning on April 18, 1906, most people in San Francisco, California, were still asleep. A few milk wagons rolled down the dark streets. Then, a little after five o’clock, the ground began to shake. Houses creaked and rocked. Dishes crashed to the floor. Chimneys tumbled into the streets. The hard shaking lasted only about one minute. But stoves had tipped over and gas pipes had broken, and fires began. The water pipes were broken too, so the firemen had very little water. The fires burned for three days. Families camped in the parks and cooked their meals on stoves set out in the street. Neighbors shared food and blankets, and soon they began to build their city again.

How they figured it out. After the earthquake, a scientist named Andrew Lawson and his helpers walked for many miles along a long crack in the ground. They found fences cut in two. They found roads broken apart. One side of the crack had slid sideways past the other

side! In some places the ground slid farther than the length of a car. Scientists call a crack like this a **fault**. This one is the San Andreas Fault, and it runs a long way through California.

The big idea. The outside of the earth is made of rock. That rock is broken into giant pieces, a little like the cracked shell of a hard-boiled egg. Along a fault, two pieces press against each other. They want to slide, but they are stuck. The push builds and builds. Then, all at once, the rock slips! The slip sends shaking out through the ground, the way ripples spread when you drop a pebble in a pond. That shaking is an **earthquake**. Smaller shakes that come later are called **aftershocks**.

In the world today. We cannot stop earthquakes, but we can be ready. Children in earthquake places practice three steps: **Drop, Cover, and Hold On**. Drop to your hands and knees. Cover your head and neck under a strong table. Hold on until the shaking stops. Stay away from windows and tall shelves. God's people do not need to be afraid. The Bible says God is "a very present help in trouble," even if the earth itself moves (Psalm 46:1-2).



A fence crossing a fault, before and after the ground slipped.

PICTURE STUDY



Looking Down Sacramento Street, San Francisco, April 18, 1906, Arnold Genthe, April 18, 1906 · Photograph (gelatin silver print) · Library of Congress, Washington, D.C. (prints are also kept in other collections)

Arnold Genthe was a photographer who lived in San Francisco. The earthquake damaged his studio and his cameras, so he borrowed a camera from a shop and walked out into the streets to take pictures. This is his most famous one. He took it on the very morning of the earthquake, as the fires were starting to spread.

A photograph is a true record of one moment. Scientists and historians still study pictures like this one to learn what happened that day.

Look closely

- Find the giant cloud of smoke at the end of the street. Where is it coming from?
- Find the people standing in the street. Are they running, or standing and watching?
- Look at the buildings on each side of the street. Are they standing up or fallen down?
- Look at how the street slopes. San Francisco is a city of steep hills.

Talk about it

1. The shaking was over in about one minute. Why was the city still in danger after the shaking stopped?
2. If you were standing in that street, what would you hear and smell?
3. How do you think the neighbors helped one another after this day?

Safety first. For the Drop, Cover, and Hold On drill, choose a sturdy table, clear the floor of toys, and practice slowly first. Never practice near glass or under a shelf that could tip.

MAKE AND DO: SLIP THE FAULT

You will make a paper model of the San Andreas Fault, draw a fence across it, and make the ground slip just as it did in 1906. Then you will practice what to do if the ground ever shakes where you live.

You will need

- Two sheets of plain paper
- Crayons or markers
- A ruler
- A sturdy kitchen table for the drill

Steps

1. Lay the two sheets of paper on the table so their long edges touch. The line where they meet is your fault.
2. Draw a green field on both sheets. Then draw a straight fence that goes right across the fault from one sheet to the other. Add a road too if you like.
3. Put one hand flat on each sheet. Push the sheets against each other along the fault. Feel how they stay stuck.
4. Now slide one sheet sideways, quickly, all at once. Look at your fence. It is cut in two!
5. Use the ruler to measure how far the fence slid. Say the number out loud.
6. Now practice the drill. A parent calls “Earthquake!” Drop to your hands and knees, crawl under the table, cover your head and neck with one arm, and hold on to a table leg with the other hand. Stay until the parent says “All clear.”
7. Tell back the story of the San Francisco earthquake to someone in your family, using your paper model.

Tips

- In a real fault the rock is stuck for a long time, then slips all at once. Push hard before you slide so you feel the “stuck” part.
- Practice the drill in more than one room so you know a safe spot in each.

Check your work

- I can show how the ground slid along a fault.
- I can measure how far my paper fence slid.
- I can do Drop, Cover, and Hold On.

FIELD NOTEBOOK

1. Draw your fence before and after the slip. Label the fault.
2. Draw the safe place in your home where you would Drop, Cover, and Hold On.
3. Draw the wiggling gelatin from the warm-up, with little wiggle lines around it.

From history. A young banker named Amadeo Giannini ran a small bank in San Francisco. On the morning of the earthquake, before the fires reached his bank, he loaded its money into a wagon, hid it under crates of fruit and vegetables, and carried it safely out of the city. A few days later he set up a plank across two barrels near the waterfront and began lending money to families and shopkeepers so they could rebuild. His little bank grew into one of the biggest banks in America.

WORKED EXAMPLES

Example 1. Look at the After picture. The top half of the fence is at mark 2. The bottom half is at mark 5. How many marks did the fence slide?

(Use the map or drawing “Count the marks between the two halves of the fence.” shown earlier in this lesson.)

1. Put your finger on mark 2, where the top half of the fence is.
2. Count each jump as you move to the bottom half of the fence: 3, 4, 5.
3. You made 3 jumps.

Answer: The fence slid 3 marks.

PRACTICE

1. **EASY** What is an earthquake?
2. **EASY** Point to the fault in the fence picture. What happened to the fence there?
3. **MEDIUM** Sort these into “safe spot” and “not safe” for an earthquake: under a strong table, next to a big window, beside a tall bookshelf, against an inside wall away from windows.
4. **MEDIUM** The fires started on a Wednesday and burned for 3 days. Count the days on your fingers: Thursday, Friday, Saturday. On which day were the fires put out?
5. **HARD** Tell in your own words why the fences near the San Andreas Fault were broken in two.

COMMON MISTAKES

- Thinking the ground opens into a giant crack that swallows whole towns. In most earthquakes the ground shakes and slides; it does not open wide and close again.
- Thinking you should run outside while the ground is shaking. Running is how people fall and get hurt. Drop, Cover, and Hold On right where you are.
- Thinking earthquakes only happen in California. They happen in many places, such as Alaska, Japan and Greece, and even sometimes in the middle of the United States.

Make it a game · Shake and Freeze. Everyone walks, hops or plays quietly around the room. When the parent calls “Earthquake!” each player must Drop, Cover, and Hold On in

a safe spot within a count of five. The parent counts slowly to ten, then calls “All clear!” Anyone who picked a spot near a window or tall shelf tells where a safer spot would be. Play five rounds in different rooms.

Scripture. “God is our refuge and strength, a very present help in trouble. Therefore will not we fear, though the earth be removed, and though the mountains be carried into the midst of the sea;” (Psalm 46:1-2, KJV)

A refuge is a safe place to run to. Even when the ground itself moves, God does not move. We can be ready and calm because He is with us.

Practice answers

1. A sudden shaking of the ground.
2. The fault is the dashed line. The fence was cut in two because the ground on one side slid sideways.
3. Safe spot: under a strong table; against an inside wall away from windows. Not safe: next to a big window; beside a tall bookshelf.
4. Saturday.
5. The rock on each side of the fault was stuck, then slipped all at once. One side slid sideways past the other, so anything built across the fault, like a fence, was pulled apart.

3.2 SHAKE TABLE WITH BLOCKS ★

OBJECTIVES

- Build a simple shake table and test block towers on it, the way engineers test buildings.
- Compare a tall, skinny tower with a short, wide tower and count the blocks that fall.
- Explain why a fair test uses the same number of blocks and the same shaking for each tower.

Warm-up. Stand with your feet close together. Have a parent give your shoulder a very gentle nudge from the side. Now stand with your feet wide apart and try again. Which way was it easier to keep your balance? Today you will find out if towers are the same.

Video. Coming soon. Shake table tests for kids: block towers and model buildings on homemade shake tables, and engineers testing full-size buildings on giant shake tables; search Science Max, SciShow Kids, Homeschool Pop (Alternate), USGS and university engineering channels.

KEY TERMS

shake table

A flat platform that slides back and forth to copy the shaking of an earthquake.

engineer

A person who plans and tests things like buildings and bridges so they are strong and safe.

base

The bottom part that something stands on.

fair test

A test where you change only one thing and keep everything else the same.

CORE IDEAS

The story. Builders do not want to wait for a real earthquake to find out if a building is strong. So engineers build **shake tables**. A shake table is a big, flat floor that machines push back and forth, just like the ground in an earthquake. Engineers set a model building on top and shake it. In Japan and in California there are shake tables so big that engineers can shake a real house, several floors tall, and watch what happens.

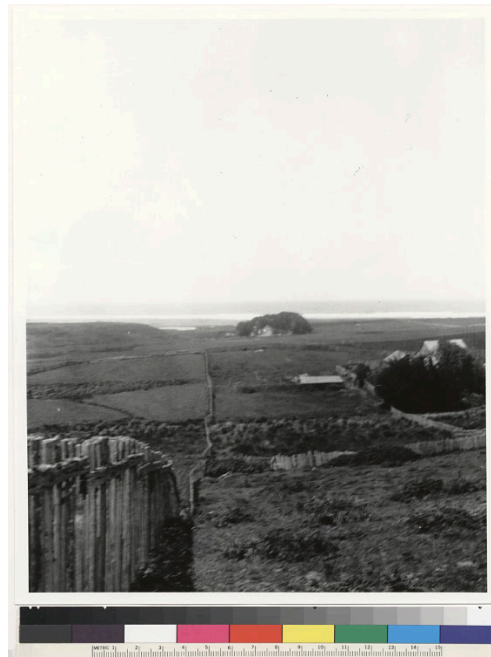
How they figured it out. Engineers watch their tests very closely. They use cameras that record every wiggle. They change only one thing at a time. If they test a tall building and a short building, they shake both the same way. That is called a **fair test**. Then they know that any difference came from the one thing they changed. They test again and again to be sure.

The big idea. Earthquakes shake the ground mostly side to side, and a little up and down. A tall, skinny tower sways a lot at the top, and it tips over easily. A short tower with a wide

base stays steady, just as you did with your feet apart. Heavy things piled on top make a tower tip more. Gentle shaking may knock down a few blocks. Hard, fast shaking knocks down more.

Try it and see. You can make your own shake table with a box lid, some marbles and a piece of cardboard. You will build two towers with the same number of blocks and shake them the same way. Then you will count the blocks that fall. **God's handiwork.** God made His world orderly. When you shake a tall tower, it falls the same way today as it will tomorrow. Because God's world follows His steady rules, we can test, learn and build wisely.

PICTURE STUDY



Fence Broken by the Fault North of Manchester, California, François E. Matthes, for the California State Earthquake Investigation Commission, 1906 · Photograph · The Bancroft Library, University of California, Berkeley

François Matthes was a geologist, a scientist who studies the earth. After the San Francisco earthquake, a team of scientists led by Andrew Lawson traveled along the San Andreas Fault to record what the ground had done. Near the little town of Manchester, on the coast north of San Francisco, Matthes photographed this farm fence. It had once run in a straight line. Now it was broken in three places where cracks of the fault crossed it, and the pieces had moved sideways with the ground.

Your shake table moves the top board side to side. In 1906 the real ground moved sideways too, and this fence shows it.

Look closely

- Find the places where the fence breaks. How many breaks can you count?
- Follow the fence with your finger. Is it still one straight line?

- Look at the ground near the breaks. Can you see where the cracks run?

Talk about it

1. Which way did the ground move: up and down, or sideways? How can you tell?
2. Why would a scientist take a picture instead of just writing down what he saw?

Safety first. Marbles are a choking hazard, so keep them away from babies and toddlers and pick up every one when you finish. Build towers no taller than your chest, keep faces back from falling blocks, and shake the board with your hands only. Never stand on the shake table.

MAKE AND DO: MY BLOCK SHAKE TABLE

You will build a small shake table and run a fair test: a tall, skinny tower against a short, wide tower, each made of 10 blocks. You will count how many blocks fall and show your results in a picture chart.

You will need

- A large, shallow box lid or baking pan with sides (the frame)
- 6 to 8 marbles
- A piece of stiff cardboard that fits inside the frame with a little room to slide (the shake board)
- 20 wooden or plastic building blocks of the same size
- Paper and crayons for the chart

Steps

1. Set the frame on the floor or a low table. Spread the marbles inside it.
2. Lay the cardboard shake board on top of the marbles. Push it gently. It should slide back and forth.
3. Build Tower 1: stack 10 blocks straight up, one on top of another. This is the tall, skinny tower.
4. Hold the edge of the shake board. Push it side to side 10 times while everyone counts out loud. Count the blocks that fell. Draw that many blocks on your chart next to “Tall, skinny.”
5. Build Tower 2 with the same 10 blocks: make a wide, low pyramid, with 4 blocks on the bottom, then 3, then 2, then 1 on top.
6. Shake it the same way, 10 pushes, just as hard. Count the blocks that fell and draw them on your chart next to “Short, wide.”
7. Do the test two more times. Did the same tower win each time? Tell your family what you found.

Tips

- Keep it fair: same blocks, same number of pushes, same strength, same person shaking.
- Try a gentle shake and a hard shake. Which knocks down more blocks?
- Save your shake table. You will use it again in the next lesson.

Check your work

- I built a shake table that slides back and forth.
- I counted the fallen blocks for each tower and drew them on a chart.
- I can tell which tower stood better and why.

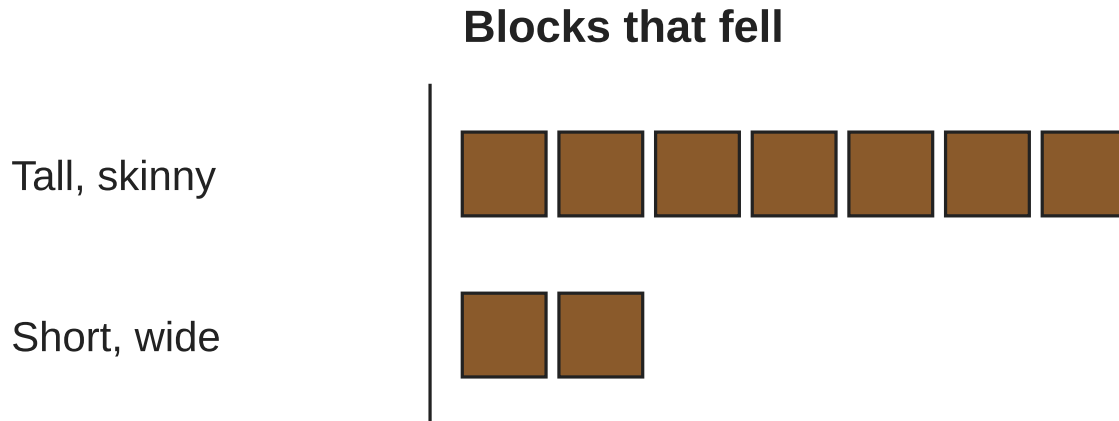
FIELD NOTEBOOK

1. Draw your shake table and label the frame, the marbles and the shake board.
2. Draw your two towers side by side, before shaking and after shaking.
3. Draw yourself standing with feet together and with feet wide apart. Circle the steadier one.

From history. Long ago in China, in the year 132, a wise man named Zhang Heng built a bronze jar to tell when an earthquake had happened. Eight dragons sat around the top of the jar, each holding a small ball in its mouth. Below each dragon sat a bronze toad with its mouth open. When the ground shook, a ball dropped from a dragon into a toad's mouth with a loud clang, and the people could tell which way the shaking had come from.

WORKED EXAMPLES

Example 1. Look at the picture chart from a shake table test. Which tower lost more blocks? How many more?



Each square is one block that fell.

1. Count the blocks in the “Tall, skinny” row: 1, 2, 3, 4, 5, 6, 7. Seven blocks fell.
2. Count the blocks in the “Short, wide” row: 1, 2. Two blocks fell.
3. Seven is more than two, so the tall, skinny tower lost more.
4. To find how many more, count up from 2 to 7: 3, 4, 5, 6, 7. That is 5 more.

Answer: The tall, skinny tower lost 5 more blocks than the short, wide tower (7 compared with 2).

PRACTICE

1. **EASY** What does a shake table copy?
2. **EASY** Which tower stands better on a shake table: a tall, skinny tower or a short, wide tower?
3. **MEDIUM** Why should both towers have 10 blocks and get 10 pushes?
4. **MEDIUM** Anna tested her tall tower three times. It lost 6 blocks, then 8 blocks, then 7 blocks. How many blocks fell in all?
5. **HARD** Draw a tower you think would stand well on the shake table. Tell why you built it that way.

COMMON MISTAKES

- Thinking a taller tower is always a stronger tower. On a shake table, a tall, skinny tower sways the most and tips over first.
- Thinking one test tells the whole story. Engineers test again and again, because blocks can fall a little differently each time.

- Thinking earthquakes only shake up and down. The ground shakes mostly side to side, and that is the shaking that pushes buildings over.

Make it a game · Steady Tower Challenge. Each player gets 10 blocks and one minute to build any tower. Then each tower gets 5 shakes on the shake table while everyone counts. A block left standing scores 1 point. After each round, the winner tells what made the tower steady. Play three rounds and try a new idea each time.

Scripture. “He looketh on the earth, and it trembleth: he toucheth the hills, and they smoke.” (Psalm 104:32, KJV)

The whole earth trembles before God. The same God who made the earth gave us minds to study it, to test, and to build carefully for our neighbors.

Practice answers

1. The shaking of the ground in an earthquake.
2. A short, wide tower, because its wide base keeps it steady.
3. To make it a fair test. If only the shape is different, we know the shape is what made one tower stand better.
4. $6 + 8 = 14$, and $14 + 7 = 21$. In all, 21 blocks fell.
5. Answers will vary. A good tower is low, has a wide base, and keeps heavy blocks at the bottom, so it does not tip over easily.

3.3 WHY BUILDINGS FALL OR STAND

OBJECTIVES

- Name three things that help a building stand in an earthquake: a strong foundation on firm ground, a braced frame, and materials that bend a little without breaking.
- Build a square frame and a braced frame and show that the triangle keeps its shape.
- Tell what people learned about buildings from the San Francisco earthquake.

Warm-up. Hold a stick of dry spaghetti in one hand and a pipe cleaner (or a plastic drinking straw) in the other. Bend each one gently. Which one snaps? Which one bends and stays in one piece? Keep that in mind as you learn about buildings.

Video. Coming soon. How earthquake-safe buildings are made, for kids: foundations, cross bracing, triangles, rubber base pads and shake-table tests; search Science Max, SciShow Kids, Homeschool Pop (Alternate), USGS and university engineering channels.

KEY TERMS

foundation

The strong bottom part of a building that sits in the ground and holds everything up.

frame

The skeleton of a building: the posts and beams inside the walls.

brace

A slanted piece that goes from corner to corner in a frame and makes a triangle, so the frame cannot lean.

flexible

Able to bend a little without breaking.

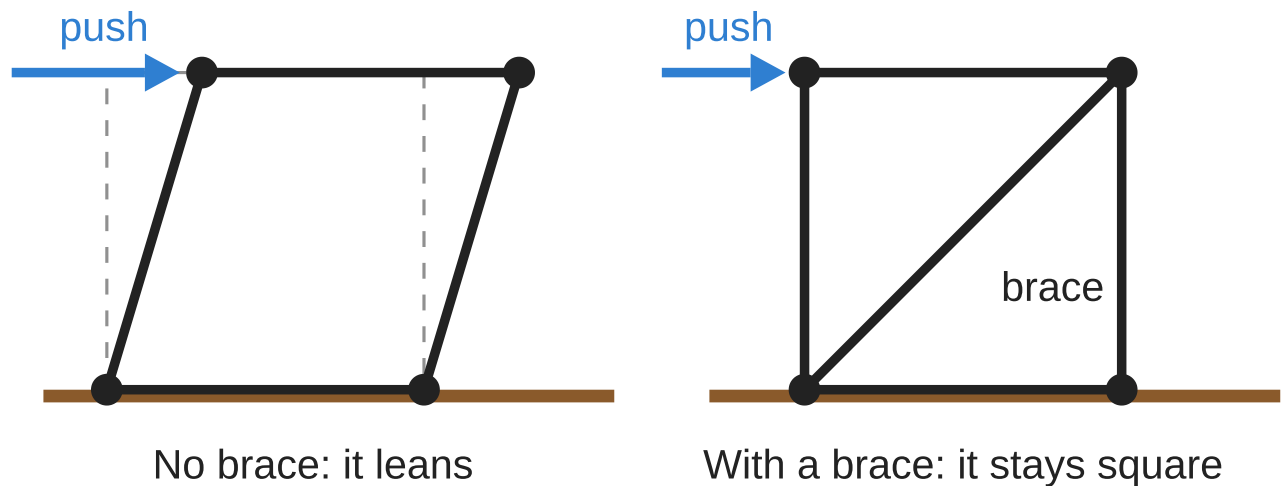
CORE IDEAS

The story. After the San Francisco earthquake of 1906, people walked through the city and looked closely at what had fallen and what still stood. Many old brick walls had cracked and tumbled down. Many wooden houses on hard, rocky hills were still standing. Buildings near the bay, on soft, wet ground that people had filled in with sand and dirt, had shaken the worst. Tall buildings with strong steel frames mostly stayed up, even though fire later burned the rooms inside. At City Hall the stone walls fell away, but the steel frame of the great dome still stood.

How they figured it out. Scientists and builders compared the buildings, street by street. They saw that hard rock shakes less. Soft, wet ground jiggles like the gelatin in your bowl, and the buildings on top jiggle too. They saw that brick walls with nothing to hold them together broke apart. Lessons like these, from San Francisco and from later earthquakes, helped builders make stronger rules for how to build.

The big idea. Three things help a building stand. First, a strong **foundation** on firm ground. Second, a **frame** with **braces**. A square frame can be pushed into a leaning shape. But add one slanted brace, and the square becomes two triangles. A triangle cannot be squished out of shape, so the frame stays square. Third, **flexible** materials. Steel and wood bend a little and spring back, like your pipe cleaner. Brick and stone with nothing inside them snap, like your spaghetti. Today some buildings even sit on thick rubber pads, so the ground can shake underneath while the building rocks gently on top.

Try it and see. You will build little frames from toothpicks and mini marshmallows and test them on your shake table. Jesus told of a wise man who built his house upon a rock. The storm beat on that house, “and it fell not” (Matthew 7:25). Good builders still start with a good foundation.



A brace turns a square into two triangles, and triangles hold their shape.

PICTURE STUDY



San Francisco City Hall after the Earthquake, Unknown photographer, 1906 · Photograph · Many photographs of this scene were taken in 1906; copies are kept in public libraries and historical archives

San Francisco's City Hall was a grand building with a tall dome. It took many years to build. The earthquake shook its heavy stone walls loose, and they crashed to the ground. But the steel frame of the dome kept standing. Photographers came from all over the city to take pictures of it.

This picture is like a lesson in building. It shows us which parts were strong and which parts were weak.

Look closely

- Find the dome at the top. What is it made of now that the walls are gone?
- Find the piles of broken stone. Where did they come from?
- Look for small things like people, wagons or lamp posts. How do they help you see how big the building was?
- Find something in the picture that is still standing and something that fell.

Talk about it

1. Why do you think the steel frame stood while the stone walls fell?
2. If you were the builder, what would you do differently next time?

Safety first. Toothpicks are sharp: point them away from eyes and hand them carefully. Marshmallows can be a choking hazard for very small children; keep little brothers and sisters away from the building table.

MAKE AND DO: SQUARE OR TRIANGLE? TOOTHPICK FRAMES

You will build two little building frames from toothpicks and mini marshmallows. One will have only squares. The other will have braces that make triangles. Then you will push them and shake them to see which one stands.

You will need

- About 30 round toothpicks
- About 20 mini marshmallows (or small balls of clay)
- Your shake table from Lesson 3.2
- Paper and crayons

Steps

1. Make a square: push 4 toothpicks into 4 marshmallows so they make a flat square. Lay it on the table.
2. Hold the bottom edge down and gently push the top edge sideways with one finger. Watch the square lean over and change shape.
3. Now add one more toothpick from one corner to the opposite corner. This is a brace. Count the triangles you made.
4. Push the top edge again, just as gently. Does the braced square lean?
5. Build a cube with only squares: a square on the bottom, 4 toothpicks standing up, and a square on top. Then build a second cube and add a brace to each of its 4 sides.
6. Set both cubes on the shake table. Shake 10 times, the same way for both. Which one leans or falls apart? Which one stands?
7. Draw both cubes and circle the one that stood better.

Tips

- Push gently. You are testing shape, not trying to break the marshmallows.
- Look around your home for triangles that brace things: under a table, on a swing set, in a ladder or a bridge.

Check your work

- I built a square frame and a braced frame.
- I can show that a square leans and a triangle holds its shape.
- I can name three things that help a building stand in an earthquake.

FIELD NOTEBOOK

1. Draw a square frame and a braced frame. Label the brace.
2. Draw a house on rock and a house on soft, wet ground. Draw wobble lines to show which one shakes more.
3. Go on a triangle hunt at home or outside. Draw three places where you found triangles bracing something.

From history. On September 1, 1923, a great earthquake struck Tokyo, Japan. Many buildings fell, and fires burned across the city. But the new Imperial Hotel, planned by the American architect Frank Lloyd Wright, was still standing. Wright knew Tokyo sat on soft ground, so he planned the hotel in low sections that could move a little, joined together, instead of one stiff block. News that the hotel had come through the earthquake made Wright famous around the world.

WORKED EXAMPLES

Example 1. One brace turns a square into 2 triangles. A wall has 3 squares in a row, and each square gets one brace. How many triangles are in the wall?

(Use the map or drawing “One brace makes 2 triangles in each square.” shown earlier in this lesson.)

1. Each braced square has 2 triangles.
2. There are 3 braced squares, so count by twos three times: 2, 4, 6.
3. Check by drawing it: draw 3 squares, add a slanted line in each, and count the triangles one by one.

Answer: The wall has 6 triangles.

PRACTICE

1. **EASY** What is a foundation?
2. **EASY** Point to the frame in the picture that leans when it is pushed. Point to the one that stays square. What is different about it?
3. **MEDIUM** Sort these into “bends a little” and “snaps”: a pipe cleaner, a stick of dry spaghetti, a rubber band, a cracker, a piece of chalk, a plastic ruler.
4. **MEDIUM** A toothpick cube has 4 sides. Each side gets one brace, and each brace makes 2 triangles. How many triangles are on the 4 sides?
5. **HARD** In 1906, why did buildings on filled-in ground near the bay shake more than buildings on rocky hills?

COMMON MISTAKES

- Thinking thick, heavy walls are always the strongest. Heavy brick or stone walls with nothing inside to hold them together can crack and fall in an earthquake.
- Thinking squares are the strongest shape for a frame. A square can be pushed into a leaning shape; a triangle cannot.
- Thinking a building that sways a little must be weak. Good buildings are made to bend a little and spring back, so they do not snap.

Make it a game • Triangle Hunt. Set a timer for five minutes and hunt through the house or yard for triangles that brace something: the legs of a stool, a swing set, a ladder,

a roof, a bridge in a picture book. Each triangle you find and point to scores 1 point. Score 2 points if you can tell what would lean or fall without it.

Scripture. “Therefore whosoever heareth these sayings of mine, and doeth them, I will liken him unto a wise man, which built his house upon a rock: And the rain descended, and the floods came, and the winds blew, and beat upon that house; and it fell not: for it was founded upon a rock.” (Matthew 7:24-25, KJV)

A house is only as strong as what it stands on. Jesus says a life built on hearing and doing His words is like a house on rock: it stands when the storms come.

Practice answers

1. The strong bottom part of a building that sits in the ground and holds everything up.
2. The square frame on the left leans. The frame on the right stays square because it has a brace that makes triangles.
3. Bends a little: pipe cleaner, rubber band, plastic ruler. Snaps: dry spaghetti, cracker, chalk.
4. Count by twos four times: 2, 4, 6, 8. There are 8 triangles.
5. Soft, wet ground jiggles like gelatin and makes the shaking stronger, so the buildings on it shook more. Hard rock is firm and shakes less.

3.4 THE EARTHQUAKE AT PHILIPPI (ACTS 16:26)

OBJECTIVES

- Retell the story of Paul and Silas and the earthquake at Philippi from Acts 16.
- Explain that God made the earth and rules over its shaking, and name another earthquake in the Bible.
- Find Philippi on a map and tell that it was a real city whose ruins people still visit.

Warm-up. Turn the lights down low, as if it were the middle of the night. Sit together on the floor and quietly sing a song of praise you know, such as “Jesus Loves Me.” How does it feel to sing in the dark? Paul and Silas sang in a dark prison at midnight.

Video. Coming soon. Paul and Silas in prison at Philippi (Acts 16) told for children, plus footage of the ruins of ancient Philippi in northern Greece; search Christian children’s Bible story channels, Bible lands travel footage and museum or archaeology channels.

KEY TERMS

Philippi

A city in Macedonia, in the north of Greece today, where Paul started a church. You can still visit its ruins.

stocks

Heavy wooden boards with holes that held a prisoner’s feet tight so he could not move.

jailer

The man whose job is to guard a prison and the prisoners in it.

foundations

The strong bottom parts of a building that hold it up. At Philippi the earthquake shook the prison’s foundations.

CORE IDEAS

The story. Paul and his friend Silas traveled to the city of Philippi to tell people the good news about Jesus. A woman named Lydia, who sold purple cloth, believed and was baptized. But some angry men had Paul and Silas beaten and thrown into prison. The jailer put them in the inner prison, deep inside, and locked their feet in wooden **stocks**. It was dark. Their backs hurt. And at midnight, what did they do? “Paul and Silas prayed, and sang praises unto God: and the prisoners heard them” (Acts 16:25).

What happened next. “And suddenly there was a great earthquake, so that the foundations of the prison were shaken” (Acts 16:26). Every door flew open. Every prisoner’s chains fell off! The jailer woke up and saw the open doors. He was terribly afraid, because he thought the prisoners had run away. But Paul called out, “Do thyself no harm: for we are all here.” The trembling jailer fell down before Paul and Silas and asked, “Sirs, what must I do to be

saved?" They said, "Believe on the Lord Jesus Christ, and thou shalt be saved, and thy house." That very night the jailer washed their hurt backs, and he and his whole family were baptized, full of joy.

The big idea. Earthquakes happen often in Greece, because big pieces of the earth's rock meet there, just as they do along the San Andreas Fault. But this earthquake was not just an ordinary shake. It came at exactly the right moment. It opened *every* door and loosed *every* chain, and not one prisoner ran away. An ordinary earthquake knocks things down; this one set people free. God made the earth, and the earth obeys Him.

God's handiwork. The Bible tells of other earthquakes too. Mount Sinai "quaked greatly" when God came down to give His law (Exodus 19:18). The earth shook when Jesus died on the cross (Matthew 27:51), and there was "a great earthquake" on the morning He rose, when an angel rolled back the stone (Matthew 28:2). Philippi was a real city. Today visitors walk on its old stone streets in northern Greece and remember Paul and Silas, who sang in the dark.

PICTURE STUDY



The Apostle Paul in Prison, Rembrandt van Rijn, 1627 · Oil on panel · Staatsgalerie Stuttgart, Germany

Rembrandt was a Dutch painter who loved to paint Bible stories and to show light shining in dark places. This painting shows the apostle Paul in prison. Paul was put in prison more than once. This picture probably shows a later time, when he sat writing letters to the churches. One of those letters went to his friends in Philippi.

Paul does not look angry or afraid. He looks like a man who is thinking and praying. The same Paul sang praises at midnight in the prison at Philippi.

Look closely

- Find the window. Where does the light fall?
- Find the books and papers. What do you think Paul is doing with them?
- Look at Paul's face. Does he look scared, or calm and thoughtful?
- Find the straw on the floor. What does it tell you about the prison?

Talk about it

1. Why do you think Rembrandt made the prison dark but put bright light on Paul?
2. How could Paul and Silas sing praises in a place like this?
3. If you were in a hard place, what song could you sing?

Safety first. A parent should do all the cutting with scissors or a craft knife.

MAKE AND DO: THE SHAKING PRISON BOX

You will make a little prison from a shoebox, with doors that stay shut until the box is shaken. Then you will tell the story of Paul and Silas and make your own earthquake.

You will need

- A shoebox with its lid
- Scissors (for a parent to use)
- Paper, crayons and tape
- Two clothespins, craft sticks or paper cut-outs for Paul and Silas
- Thin paper strips to make paper chains
- Your shake table from Lesson 3.2 (or your hands)

Steps

1. Color the inside of the box dark, like a prison at night. Draw stone walls if you like.
2. A parent cuts two doors in the side of the box: three sides cut, one side left on as the hinge.
3. Close each door and hold it shut with a small folded slip of paper tucked lightly into the gap. It should hold, but only just.
4. Make Paul and Silas from clothespins, craft sticks or paper. Make small paper-chain loops and tape them very lightly around their feet.
5. Put Paul and Silas inside and put on the lid. Tell the story up to midnight. Hum or sing a song of praise together.
6. Now make the earthquake: shake the box on the shake table or in your hands. Watch for the doors to swing open and the chains to fall off.
7. Open the lid. Paul and Silas are still inside! Tell the rest of the story: the jailer, his question, and his family's joy.

Tips

- If the doors open too easily, tuck the paper latch in a little deeper. If they never open, loosen it.
- Let each child in the family take a turn telling one part of the story.

Check your work

- I made a prison box with doors that open when it shakes.
- I can retell the story of Paul and Silas in order.
- I can tell why this earthquake was different from an ordinary one.

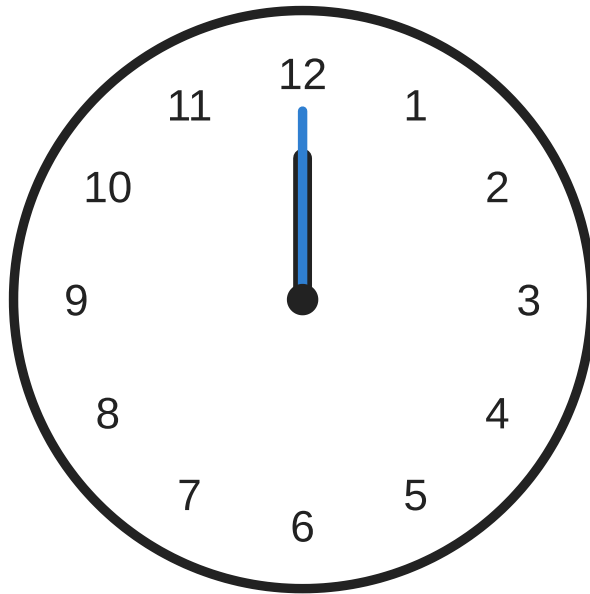
FIELD NOTEBOOK

1. Draw Paul and Silas singing in the prison at midnight. Draw a clock showing 12 o'clock.
2. Draw the prison doors flying open and the chains falling off.
3. Find Greece on a map or globe. Draw its shape and put a dot for Philippi in the north.

From history. Philippi was named for King Philip of Macedon, the father of Alexander the Great. Paul's visit there was the first time the good news about Jesus was preached in that part of Europe, and Lydia was the first believer. Years later, while Paul was again in prison, he wrote a letter to his friends at Philippi. We have it in our Bibles as the book of Philippians. In it he wrote, "Rejoice in the Lord always: and again I say, Rejoice" (Philippians 4:4).

WORKED EXAMPLES

Example 1. Paul and Silas were singing at midnight. Midnight is 12 o'clock at night. If your bedtime is 8 o'clock, how many hours after your bedtime is midnight?



Midnight
12 o'clock at night

At midnight both hands point to the 12.

1. Look at the clock. Both hands point to the 12. That is 12 o'clock.
2. Start at 8 o'clock, your bedtime.
3. Count each hour as you move forward: 9, 10, 11, 12.
4. You counted 4 hours.

Answer: Midnight is 4 hours after an 8 o'clock bedtime. Paul and Silas were still awake, praying and singing, long after bedtime.

PRACTICE

1. **EASY** Who was in the prison at Philippi singing praises?
2. **EASY** Point to the 12 on the clock. Show where both hands point at midnight.
3. **MEDIUM** Put these in order: the doors open and chains fall off; Paul and Silas sing at midnight; the jailer and his family are baptized; a great earthquake shakes the prison; the jailer asks, "What must I do to be saved?"
4. **MEDIUM** Match each Bible earthquake to what happened: Mount Sinai, the cross, the empty tomb, Philippi. (a) An angel rolled back the stone. (b) Prison doors opened. (c) God came down to give His law. (d) Jesus died.
5. **HARD** Tell in your own words how the earthquake at Philippi was different from an ordinary earthquake.

COMMON MISTAKES

- Thinking Philippi was a make-believe place. It was a real city in a real land where earthquakes happen, and its ruins can still be visited.
- Thinking Paul and Silas ran away when the doors opened. They stayed, and so did the other prisoners, and that is how the jailer came to hear the good news.
- Thinking earthquakes happen with no one in charge. God made the earth and rules over it; even its shaking is in His hands.

Make it a game • Midnight in Philippi. Choose players for Paul, Silas, the jailer and the other prisoners. Turn the lights low. Paul and Silas sit with their feet “in the stocks” and sing. When the parent calls “Earthquake!” everyone shakes and wobbles for a count of five, then the prisoners hold up their hands to show the chains are gone. The jailer must ask the right question, and Paul and Silas must give the right answer from Acts 16:31. Switch parts and play again.

Scripture. “And at midnight Paul and Silas prayed, and sang praises unto God: and the prisoners heard them. And suddenly there was a great earthquake, so that the foundations of the prison were shaken: and immediately all the doors were opened, and every one’s bands were loosed.” (Acts 16:25–26, KJV)

“Bands” means chains. Paul and Silas praised God in the dark before anything changed. God answered with an earthquake that set every prisoner free.

Practice answers

1. Paul and Silas.
2. Both hands point straight up to the 12.
3. 1. Paul and Silas sing at midnight. 2. A great earthquake shakes the prison. 3. The doors open and chains fall off. 4. The jailer asks, “What must I do to be saved?” 5. The jailer and his family are baptized.
4. Mount Sinai: (c). The cross: (d). The empty tomb: (a). Philippi: (b).
5. It came at exactly the right moment, while Paul and Silas were praising God. It opened every door and loosed every prisoner’s chains, and no prisoner ran away. God sent it, and it led the jailer and his family to believe.

UNIT 3 REVIEW

This is an oral review. A parent reads each question aloud, and the child answers by telling, pointing, building or showing. Give full points for a clear answer in the child's own words. The review is worth 20 points.

1. (3 pts) Tell me what happened in San Francisco on April 18, 1906.
2. (3 pts) What is a fault? What makes the ground shake in an earthquake?
3. (2 pts) Show me what you do if the ground starts to shake.
4. (3 pts) On your shake table, which tower stood better: the tall, skinny tower or the short, wide tower? Why?
5. (2 pts) Why did both towers need the same number of blocks and the same number of shakes?
6. (4 pts) Name three things that help a building stand in an earthquake. Show me why a brace helps a frame.
7. (3 pts) Tell me the story of the earthquake at Philippi.

UNIT PROJECT: MY SHAKE-PROOF TOWN

Build a small town on your shake table: at least three buildings made from blocks, toothpicks and marshmallows, or cardboard. Make at least one building tall and skinny, one short and wide, and one with braces. Draw a picture of your town before you shake it. Then give it 10 shakes, count what falls, and draw it again. Last, tell your family which buildings stood, which fell, and why, and show them how to Drop, Cover, and Hold On.

- **Building:** The town has at least three buildings, including one with braces that make triangles.
- **Testing:** The test is fair, with the same shakes for the whole town, and the fallen pieces are counted correctly.
- **Telling:** The child explains why some buildings stood and others fell, using the words base, brace or foundation.
- **Care:** The before and after drawings are neat, colorful and labeled.

Answer key

1. Early in the morning the ground shook hard for about one minute. Chimneys and buildings fell, and fires started and burned for three days. People camped in the parks, helped one another, and rebuilt the city.
2. A fault is a long crack in the earth's rock. The rock on each side gets stuck, the push builds up, and then the rock slips all at once. That slip sends shaking through the ground.
3. Drop to hands and knees, Cover the head and neck under a strong table, and Hold On until the shaking stops, away from windows and tall shelves.
4. The short, wide tower stood better, because its wide base kept it steady. The tall, skinny tower swayed and tipped over.
5. So it was a fair test. Only the shape was different, so we knew the shape made the difference.

6. A strong foundation on firm ground, a frame with braces, and materials that bend a little without breaking (like steel and wood). A brace turns a square into triangles, and a triangle cannot be pushed out of shape.
7. Paul and Silas were in prison with their feet in stocks. At midnight they prayed and sang praises to God. A great earthquake shook the prison, every door opened, and every chain fell off. The jailer asked, "What must I do to be saved?" They told him to believe on the Lord Jesus Christ, and he and his family were baptized.

CAVES

Under our feet lies a hidden world. In this unit we go underground. We will visit Mammoth Cave in Kentucky, the longest cave anyone has found, and walk with Stephen Bishop, the brave guide who explored its dark tunnels and rivers. We will learn how water soaking through limestone slowly dissolves the rock and makes a cave, with a hard sandstone roof on top.

Then we will watch drips build stone icicles and grow our own stalactite on a string with Epsom salt. We will follow Jim White to the cloud of bats rising out of Carlsbad Caverns and learn how bats “see” with echoes. Last, we will open the Bible to 1 Samuel 22, where young David hid from King Saul in the cave of Adullam, in limestone hills much like Mammoth Cave. “In his hand are the deep places of the earth” (Psalm 95:4).

BEFORE YOU BEGIN

- Can count to 100 and add small numbers
- Can measure with hand spans and read whole centimeters on a ruler
- Knows that water can dissolve sugar or salt
- Knows the story of David and Goliath

MASTERY CHECKLIST

- I can tell about Mammoth Cave and its guide, Stephen Bishop.
- I can explain how water dissolves limestone to make a cave.
- I can tell a stalactite from a stalagmite and show how I grew one on a string.
- I can explain that bats are mammals that find bugs with echoes.
- I can retell how David hid in the cave of Adullam and who his true refuge was.

OPTIONAL BOOKS AND RESOURCES

- **Mammoth Cave National Park (National Park Service)**
(<https://www.nps.gov/macav/>): Free. Photos, cave facts and tour information for Lesson 4.1. The park also has a Junior Ranger program for children.
- **Carlsbad Caverns National Park (National Park Service)**
(<https://www.nps.gov/cave/>): Free. Pictures of the Big Room’s stalactites and the summer evening bat flight, for Lessons 4.2 and 4.3.
- **Bat Conservation International** (<https://www.batcon.org/>): Free pictures and facts about bats. A parent may choose the pages to share.

4.1 MAMMOTH CAVE ★

OBJECTIVES

- Tell who Stephen Bishop was and what he found in Mammoth Cave.
- Explain in simple words how water dissolves limestone to make a cave.
- Point to the soil, sandstone, limestone and cave passage on a simple drawing.

Warm-up. Drop a piece of clean eggshell or a small seashell into a clear cup of vinegar. Watch closely. Do you see tiny bubbles? Shells are made of the same stuff as a rock called limestone. Today we will see how water can eat away limestone and make a cave.

Video. Coming soon. Mammoth Cave National Park for kids: search the National Park Service (NPS) Mammoth Cave channel, Smithsonian, SciShow Kids and gentle cave-tour footage showing passages, underground rivers and lantern tours.

KEY TERMS

cave

A hollow space under the ground, big enough for a person to go inside.

limestone

A rock made of the same stuff as seashells. Water can slowly dissolve it.

dissolve

To mix into water and seem to disappear, like sugar in tea.

sandstone

A hard rock made of sand grains stuck together. It makes a strong roof over Mammoth Cave.

CORE IDEAS

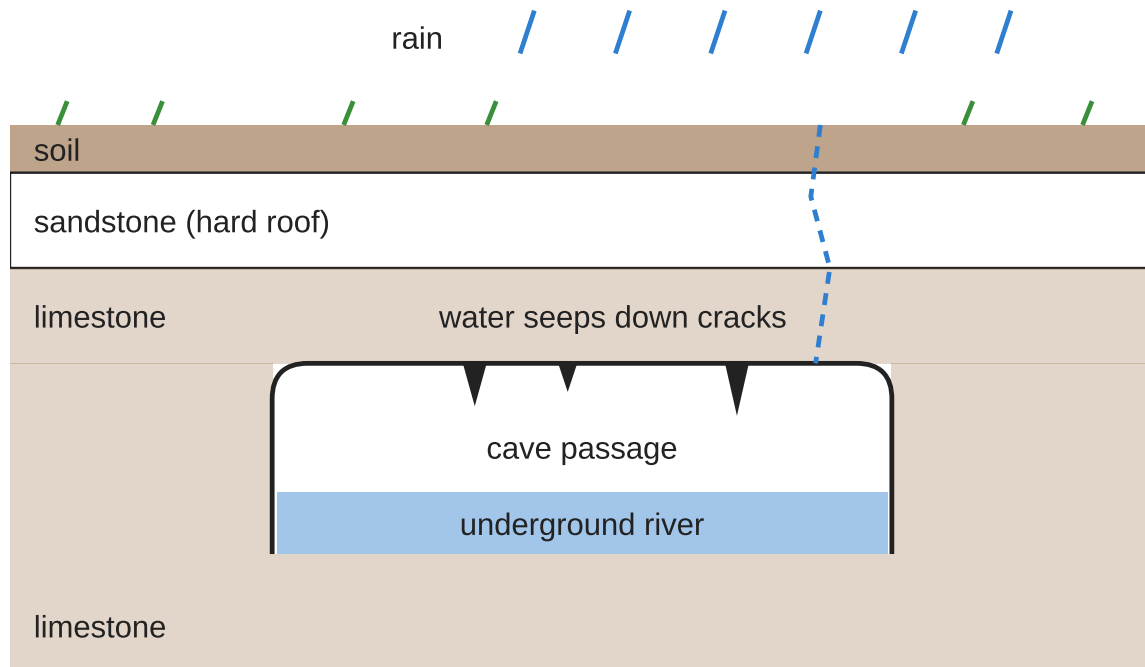
The story. Under the green hills of Kentucky lies the longest cave anyone has ever found. It is called Mammoth Cave. “Mammoth” means very, very big. People have mapped more than 400 miles of its tunnels, and they keep finding more. Long ago a young man named Stephen Bishop became its most famous guide. He was enslaved, but under the ground he was a leader and a brave explorer. Starting in 1838, he carried his lamp into dark passages no one had ever seen. He found a way across a deep hole called the Bottomless Pit. He explored underground rivers where little white fish swim with no eyes at all. Then he drew a map of the cave from memory, and people used it for many years.

How they figured it out. How did the cave get there? Guides and scientists looked closely at the walls. Most of the cave is in a rock called **limestone**. When rain soaks through the soil, it picks up a tiny bit of sourness, like very weak vinegar. This water seeps down through cracks in the limestone and slowly **dissolves** the rock, the way water dissolves a sugar cube. The cracks grow wider and wider into tunnels. Underground rivers carry the bits away. On

top of the limestone lies a hard rock called **sandstone**. Water cannot dissolve it, so it works like a strong roof.

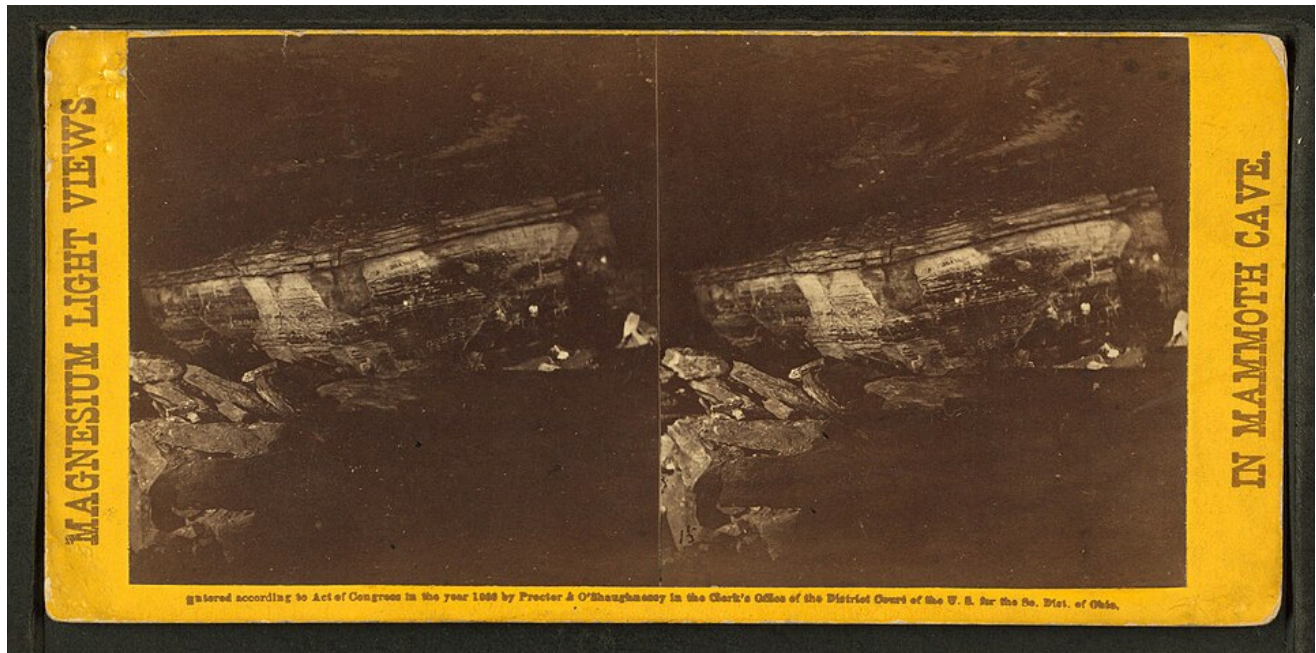
The big idea. A **cave** is a hollow space under the ground, big enough for a person to go in. Most big caves are made when water dissolves limestone. Inside a cave it is dark all the time, even at noon. The air stays cool in summer and in winter. Some animals live their whole lives in the dark, like the eyeless cave fish and a tiny eyeless shrimp found in Mammoth Cave's rivers.

God's handiwork. The Bible says, "In his hand are the deep places of the earth" (Psalm 95:4). God knows every tunnel, even the ones no one has found yet. Many creation scientists think thick limestone layers were laid down in the waters of the Flood, and water soaking through them afterward carved out caves. Today park rangers lead families down into Mammoth Cave with lights, so you can walk where Stephen Bishop walked.



Rain soaks down through cracks. It dissolves the limestone and makes a cave. The sandstone on top makes a strong roof.

PICTURE STUDY



Mammoth Cave Views (photographs made by magnesium light), Charles Waldack, 1866 · Photographs, many printed as stereographs · New York Public Library (Robert N. Dennis collection), the Filson Historical Society and other collections

Charles Waldack was a photographer from Cincinnati, Ohio. In 1866 he carried his heavy camera down into Mammoth Cave. Cameras back then needed a lot of light, and the cave was pitch black. So he burned bright strips of a metal called magnesium to light up the rooms while the camera took the picture. His photographs were some of the very first ever taken deep inside a cave.

Many of his pictures were printed as stereographs: two almost matching pictures side by side. When you look at them through a special viewer, the cave seems to pop out in 3D.

Look closely

- Find the Giant's Coffin, the huge block of rock. How big is it next to the cave walls?
- Find the ceiling and the floor of the cave. Is the ceiling smooth or bumpy?
- Look for cracks and lines in the rock. Could water have soaked through there?
- Look at the light and the shadows. Where do you think the bright light was burning?

Talk about it

1. Why was it so hard to take a photograph inside a cave long ago?
2. If you could walk into this picture, what would you hear and feel?
3. What would you want to bring with you on a cave tour?

Safety first. Never go into a wild cave without a trained adult guide. Caves are dark, slippery and easy to get lost in. On a park tour, stay with the ranger and do not touch the

rock formations.

MAKE AND DO: SUGAR-CUBE CAVE

Sugar dissolves in water much faster than limestone does, so we can use sugar cubes to watch a cave form right on the kitchen table. The clay will be our hard sandstone roof.

You will need

- About 20 sugar cubes
- Modeling clay (the kind that stays soft and does not dry out)
- A baking pan or tray
- A cup of warm tap water and a spoon
- A toothpick

Steps

1. Stack the sugar cubes in the pan to make a block two cubes high. This is your “limestone.”
2. Press a thin layer of clay over the top and sides of the block. Leave one end open. This is your “sandstone” roof and the cave’s front door.
3. Use the toothpick to poke three or four small holes through the clay roof. These are the cracks where rain soaks in.
4. Spoon a little warm water into the holes, a few drops at a time. This is the rain.
5. Watch the open end. What runs out? Keep adding water slowly.
6. When no more sugar comes out, tip the pan gently and peek inside with a flashlight. You made a cave!

Tips

- Go slowly. A drip at a time works better than a big pour.
- If the roof falls in, that is a real cave idea too. Some cave roofs fall in and make a dip in the ground called a sinkhole.

Check your work

- I can tell what the sugar and the clay stood for.
- I can explain how water made my cave.
- I can tell why Mammoth Cave has a strong roof.

FIELD NOTEBOOK

1. Draw the ground cut open like a cake: rain, soil, sandstone, limestone and a cave. Label each part.
2. Draw Stephen Bishop with his lamp in a dark tunnel. Write his name under your picture.

3. Draw an eyeless cave fish. Write one sentence about why a fish in the dark might not need eyes.

From history. During the War of 1812, workers dug dirt from Mammoth Cave to make saltpeter, an important part of gunpowder. They poured water through the cave dirt in big wooden boxes and sent the salty water through long wooden pipes. Some of those old wooden pipes and boxes are still in the cave today, and visitors can see them on tours.

WORKED EXAMPLES

Example 1. On a pretend cave map, the main tunnel is 9 hand spans long. A side tunnel is 4 hand spans long. Which tunnel is longer? How much longer is it?

1. Lay your hand on the map and count the spans along the main tunnel: 9.
2. Count the spans along the side tunnel: 4.
3. 9 is bigger than 4, so the main tunnel is longer.
4. Count up from 4 to 9: 5, 6, 7, 8, 9. That is 5 more spans.

Answer: The main tunnel is longer, by 5 hand spans.

PRACTICE

1. **EASY** What rock is most of Mammoth Cave made in?
2. **EASY** Look at the cave drawing. Point to the soil, the sandstone, the limestone and the cave passage.
3. **MEDIUM** Sort these animals into two groups, “lives in the dark cave all its life” and “lives outside”: eyeless cave fish, cow, eyeless cave shrimp, robin.
4. **MEDIUM** A cave tour goes down 12 steps, then 8 more steps. How many steps is that in all?
5. **HARD** Tell in your own words: why doesn’t the roof of Mammoth Cave fall in?

COMMON MISTAKES

- Thinking Mammoth Cave was named for mammoth animals. It was named “mammoth” because it is so big.
- Thinking caves are dug out by animals or people. Most big caves are made by water dissolving limestone.
- Thinking a cave is warm inside in summer. Deep caves stay cool all year long.

Make it a game • Lantern Tour. A parent hides five paper pictures around a dim room: an eyeless fish, a cave shrimp, an underground river, a lamp and a map. The child is the cave guide, like Stephen Bishop, and uses a flashlight to find each one. When you find a picture, tell one thing about it to score a point. Then switch and let the parent be the guide.

Scripture. “In his hand are the deep places of the earth: the strength of the hills is his also.” (Psalm 95:4, KJV)

No one has seen every tunnel of Mammoth Cave, but God knows them all. The deep places that are dark to us are in His hand.

Practice answers

1. Limestone.
2. Soil is the thin top layer under the grass. Sandstone is the next layer down. Limestone is the thick layer below it. The cave passage is the hollow space inside the limestone, with the river at its bottom.
3. Lives in the cave: eyeless cave fish and eyeless cave shrimp. Lives outside: cow and robin.
4. $12 + 8 = 20$ steps.
5. Over the limestone lies a layer of hard sandstone. Water cannot dissolve sandstone, so it stays strong and makes a roof over the cave.

4.2 STALACTITES FROM STRING AND EPSOM SALT

OBJECTIVES

- Tell the difference between a stalactite, a stalagmite and a column.
- Explain that drips of water carry a mineral and leave it behind.
- Grow Epsom salt crystals on a string and measure them with a ruler.

Warm-up. Wet a dark plate or a dark cup with a little salty water and set it in a sunny window. Come back after lunch. What is left when the water goes away? Water can carry something hidden inside it, and leave it behind.

Video. Coming soon. How stalactites and stalagmites form, for kids: search the National Park Service (Carlsbad Caverns, Mammoth Cave, Luray Caverns), SciShow Kids, Science Max and time-lapse videos of Epsom salt string stalactite experiments.

KEY TERMS

stalactite

A stone icicle that hangs down from a cave ceiling. It holds “tight” to the ceiling.

stalagmite

A stone bump that grows up from a cave floor, under a drip. It “might” reach the ceiling one day.

column

What you get when a stalactite and a stalagmite grow together and meet.

mineral

A natural, nonliving solid, like salt or the stuff limestone is made of. Water can carry some minerals and leave them behind.

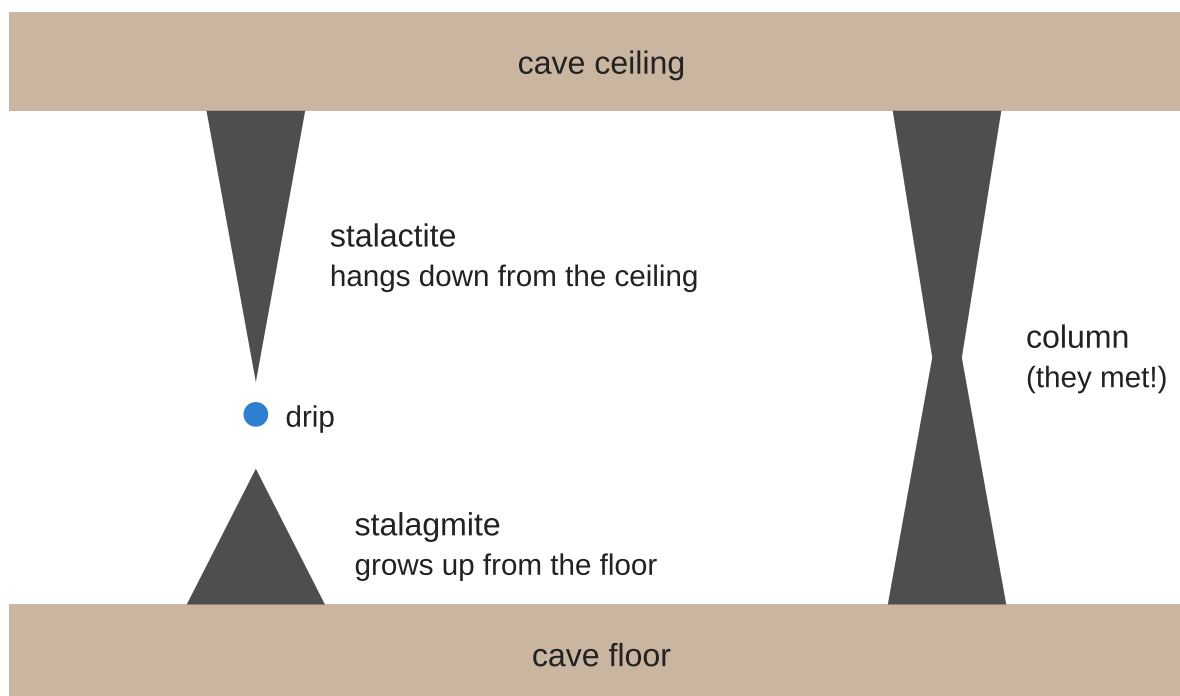
CORE IDEAS

The story. In 1941 a photographer named Ansel Adams climbed down into Carlsbad Caverns in New Mexico. He set up his camera in a giant room called the Big Room. All around him were stone icicles hanging from the ceiling and stone towers rising from the floor. Some were thin as straws. Some were as big as trees. He took careful pictures so that people all over the country could see them.

How they figured it out. Where did the stone icicles come from? People watched the drips. In a cave, water slowly drips from the ceiling. Each drop carries a tiny bit of dissolved limestone hidden inside it. When the drop hangs on the ceiling, it leaves a thin ring of rock behind before it falls. Ring by ring, a little stone tube grows down. Cave explorers call these thin tubes “soda straws.” Later they fill in and grow fat. That is a **stalactite**.

The big idea. A stalactite hangs from the ceiling. It holds on *tight*. When the drop falls to the floor, it leaves a little rock there too, and a bump grows up. That is a **stalagmite**. It *might* reach the ceiling one day! When a stalactite and a stalagmite meet, they make a **column**. Here is a trick: stalactite has a “t” for **top**, and stalagmite has an “m” for the ground it grows from, like a **mound**.

Try it and see. We cannot bring a cave home, but we can make a drip that leaves a **mineral** behind. Epsom salt is a mineral that dissolves in warm water. When salty water creeps along a string and drips, the water dries up and leaves the salt behind as crystals. Our crystals are salt, not limestone, but the idea is the same: water carries a mineral, then leaves it behind. Look at God’s handiwork: tiny drops, one after another, can build something beautiful.



A stalactite hangs down. A stalagmite grows up under the drip. When they meet, they make a column.

Thinking About Time

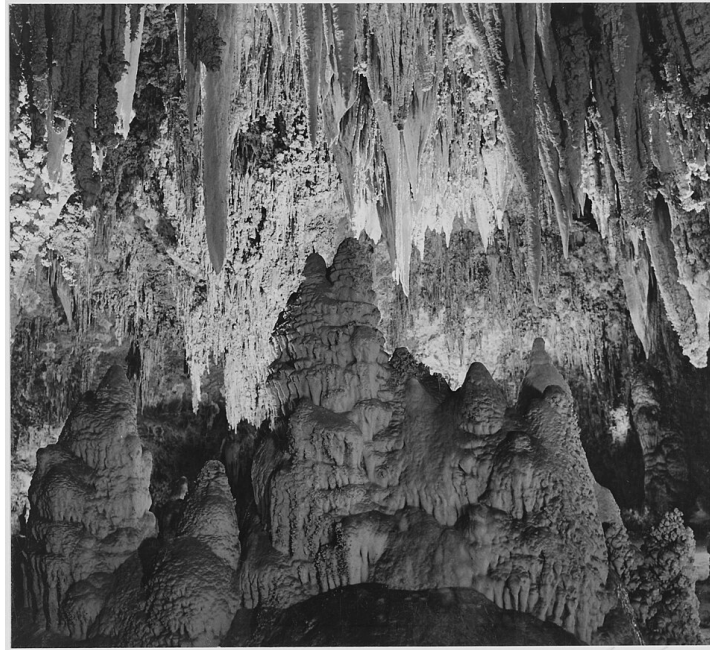
What the sign says. Some cave signs say stalactites grow so slowly that the cave must be very, very old.

What we observe. We can watch stalactites grow today. Some have grown under bridges, and some under the Lincoln Memorial after it was built. How fast they grow depends on how much water drips and how much mineral it carries.

How Christians read it. Many Christians believe God made the world not so long ago, and that caves formed after the Flood. When lots of mineral-rich water drips, stalactites can grow quickly.

Try it. Measure your string stalactite each day. Did it take a long time or a short time to start?

PICTURE STUDY



Formations along the wall of the Big Room, near the Crystal Spring Dome, Carlsbad Caverns National Park, Ansel Adams, 1941 · Black-and-white photograph · National Archives at College Park, Maryland

Ansel Adams was an American photographer who loved to take pictures of mountains, trees and national parks. In 1941 the government asked him to photograph the national parks so that people could see how wonderful they were. One of the places he went was Carlsbad Caverns, deep under the desert in New Mexico. He worked in the dark with lights and a big camera to show the shapes of the stone.

Look closely

- Find something that hangs down. What is it called?
- Find something that grows up from below. What is it called?
- Can you find a place where two of them meet, or almost meet?
- Look for the lightest and the darkest parts of the picture.

Talk about it

1. What do the stone shapes remind you of?
2. Why do you think the photographer used black and white instead of color?
3. If you could name one of these stone shapes, what name would you give it?

Safety first. An adult should handle the hot water. Epsom salt is not a snack, so do not eat it, and wash your hands after the project. Set the jars where little children and pets cannot tip them over.

MAKE AND DO: GROW A STRING STALACTITE

In about a week, you can grow your own salty stalactite and stalagmite. The salt water will creep along a string, drip in the middle and leave crystals behind.

You will need

- 2 glass jars the same size
- Epsom salt (about 1 cup)
- Very warm water from the tap
- Thick cotton or wool yarn, about as long as your arm
- 2 paper clips or metal washers
- A small plate or saucer
- A spoon and a ruler

Steps

1. An adult fills both jars with very warm water.
2. Stir Epsom salt into each jar, one spoonful at a time, until no more will dissolve and a little stays on the bottom.
3. Set the jars in a quiet place, about one hand-width apart, with the plate between them.
4. Tie a paper clip to each end of the yarn. Dip the whole yarn in one jar to wet it.
5. Drop one end into each jar. Let the yarn sag down in the middle over the plate, but not touch it.
6. Look at your string each day. Draw what you see in your notebook.
7. When a little salt icicle hangs from the string, measure it with a ruler. Look for a bump growing on the plate under it, too.

Tips

- If the string drips a lot but nothing grows, slide the jars a little closer together so it drips more slowly.
- Do not bump or move the jars. Crystals grow best when they are left alone.
- Damp weather makes it go slower. Dry, warm air makes it go faster.

Check your work

- I can point to my stalactite and my stalagmite.
- I can tell where the salt came from.
- I measured my stalactite with a ruler.

FIELD NOTEBOOK

1. Draw a cave with a stalactite, a stalagmite and a column. Label all three.
2. Draw your string jars on the first day and again on the last day. Write how long your stalactite grew.

3. Draw a soda straw stalactite with a drop of water hanging from its tip.

From history. Luray Caverns in Virginia was found in 1878 by a few men who felt cool air blowing out of a hole in a hillside. In the 1950s a man named Leland Sprinkle built the Great Stalacpipe Organ there. When someone plays its keyboard, little rubber-tipped hammers tap on stalactites all through the cave. Each stalactite rings with its own note, and together they make music.

WORKED EXAMPLES

Example 1. On Monday your string stalactite was 1 centimeter long. On Saturday it was 4 centimeters long. How much did it grow?

1. Line up the ruler so the 0 is at the top of the stalactite, where it hangs from the string.
2. On Monday the tip reached the 1. On Saturday the tip reached the 4.
3. Count up from 1 to 4 on the ruler: 2, 3, 4. That is 3 steps.
4. So $4 - 1 = 3$.

Answer: It grew 3 centimeters.

PRACTICE

1. **EASY** Which one hangs down from the ceiling: a stalactite or a stalagmite?
2. **EASY** Look at the cave drawing. Point to the stalactite, the stalagmite and the column.
3. **MEDIUM** A cave picture shows 7 stalactites and 5 stalagmites. How many are there in all?
4. **MEDIUM** Your string stalactite was 2 centimeters long on the third day and 5 centimeters long on the seventh day. How much did it grow?
5. **HARD** Tell in your own words: why does the stalactite grow in the middle of the string, over the plate?

COMMON MISTAKES

- Mixing up the two words. Stalactites hang from the **top**. Stalagmites grow up like a **mound** from the ground.
- Thinking stalactites are made of ice. Cave stalactites are made of stone left behind by dripping water.
- Thinking it is fine to touch cave formations. The oil from our fingers can stop them from growing, so park rules say look but do not touch.

Make it a game • Top or Mound? A parent calls out “stalactite,” “stalagmite” or “column.” For a stalactite, reach your hands up high and wiggle your fingers down like drips. For a stalagmite, crouch down low and grow slowly upward. For a column, stretch

from the floor to the sky. Get it right to score a point. Play to ten, then let the child be the caller.

Scripture. “For he maketh small the drops of water: they pour down rain according to the vapour thereof:” (Job 36:27, KJV)

God made the small drops of water. In a cave, small drops build stalactites. Small things done again and again can make something great.

Practice answers

1. A stalactite.
2. The stalactite hangs from the ceiling on the left with a drip below it. The stalagmite is on the floor under it. The column on the right reaches from the ceiling all the way to the floor.
3. $7 + 5 = 12$.
4. $5 - 2 = 3$ centimeters.
5. The salt water creeps along the string to the lowest point in the middle. It drips there. The water dries up and leaves the salt behind, so the crystals pile up at the drip.

4.3 BATS IN CAVES

OBJECTIVES

- Tell how Jim White found Carlsbad Caverns by following a cloud of bats.
- Explain that bats are mammals whose wings are made like hands.
- Explain in simple words how bats find bugs in the dark with echoes.

Warm-up. Go into a small room with hard walls, like a bathroom, and clap once. Then clap in a room full of soft things, like a bedroom with pillows and blankets. Which clap seemed to ring back at you? That ringing back is an echo. Bats use echoes to find their way.

Video. Coming soon. Bats and echolocation for kids, and the evening bat flight at Carlsbad Caverns: search the National Park Service (Carlsbad Caverns), Bat Conservation International, Smithsonian’s National Zoo, SciShow Kids and nature footage of bats leaving a cave at dusk.

KEY TERMS

mammal

An animal with hair or fur that feeds its babies milk. Dogs, cows, people and bats are mammals.

echo

A sound that bounces off something and comes back to you.

echolocation

Finding things by making sounds and listening for the echoes. Bats do it to find bugs in the dark.

roost

A place where bats hang up to rest, such as a cave ceiling.

CORE IDEAS

The story. About 1898, a young cowboy named Jim White was riding across the desert in New Mexico. As the sun went down, he saw a dark cloud rising out of the ground. Was it smoke from a fire? He rode closer. It was bats! Thousands and thousands of bats were pouring out of a hole in the earth. Jim came back with a lantern and a ladder he made himself from wire and sticks, and he climbed down. He found giant rooms full of stone icicles. Today that place is Carlsbad Caverns National Park.

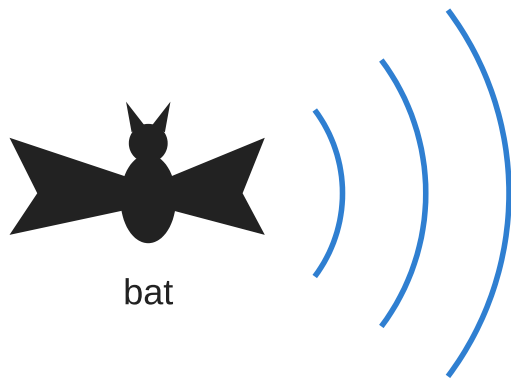
How they figured it out. How can bats fly in a pitch-dark cave without bumping into the walls? Long ago an Italian scientist named Lazzaro Spallanzani wondered the same thing. He hung strings across a dark room. His bats flew around them, even when they could not see. Then another scientist plugged bats’ ears, and they began to bump into things. So bats were

using their *ears*! Later, special microphones showed that bats squeak while they fly. The squeaks are too high for us to hear. The sound bounces off a moth and comes back as an **echo**. This is called **echolocation**.

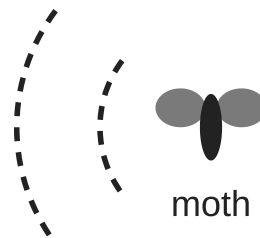
The big idea. A bat is not a bird. It is a **mammal**, with soft fur, and its babies drink their mother's milk. A bat's wing is made like your hand: a thumb and four very long fingers, with thin skin stretched between them. Bats sleep in the daytime, hanging upside down in a **roost**. Caves make good roosts because they are dark and safe, and they stay cool in summer and not too cold in winter. Most bats in our country eat bugs, such as moths, beetles and mosquitoes. Some bats in warm lands eat fruit or sip nectar from flowers.

God's handiwork. On summer evenings at Carlsbad Caverns, visitors sit quietly near the cave's mouth at sunset. Then the bats swirl out in a great dark ribbon to hunt bugs all night. God gave each little bat a way to "see" with its ears. "But ask now the beasts, and they shall teach thee" (Job 12:7).

1. The bat squeaks.



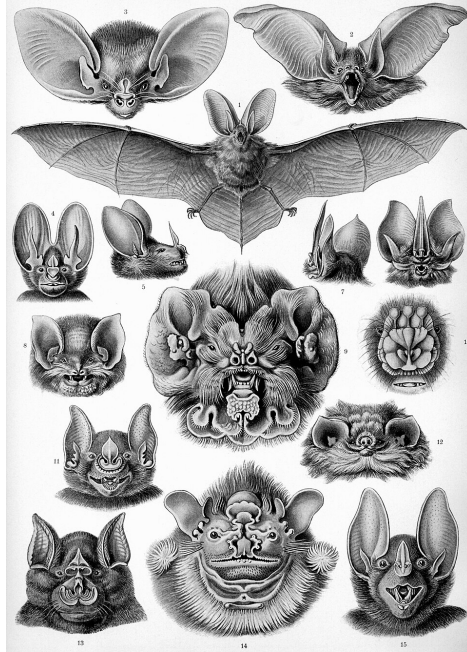
2. The sound bounces off the moth.



3. The echo comes back to the bat's ears.

The bat squeaks. The sound bounces off the moth. The echo comes back, and the bat knows where the moth is.

PICTURE STUDY



Chiroptera (Bats), Plate 67 of Art Forms in Nature, Ernst Haeckel, 1904 · Printed color plate from a drawing
· From the book *Kunstformen der Natur* (Art Forms in Nature)

Ernst Haeckel was a German scientist who loved to draw living things in great detail. He made a famous book of one hundred pictures called *Art Forms in Nature*. On this page he drew the faces of many kinds of bats. Look how different they are! Some have huge ears. Some have strange flaps on their noses that help them aim their squeaks.

Look closely

- Find the eyes on one bat face. Are they big or small next to the ears?
- Find the biggest ears on the page. Why might a bat need big ears?
- Find a bat with a leaf-shaped flap on its nose.
- Count how many bat faces you can find.

Talk about it

1. Which bat face do you like best? Why?
2. How are these bats alike? How are they different?
3. Why do you think the artist put the faces in a neat pattern on the page?

Safety first. Never touch a bat, alive or dead, even if it looks hurt. Some bats carry a sickness called rabies. If you find a bat on the ground or inside the house, stay away and tell an adult right away.

MAKE AND DO: MY HAND-WING BAT

Your hand is the pattern for a bat's wing. You will trace your hands to make a bat with real "finger bones" in its wings, then hang it upside down to roost.

You will need

- Brown, black or gray paper
- Pencil and crayons
- Child-safe scissors
- Glue or tape
- A piece of string or yarn

Steps

1. Spread your fingers wide on the paper and trace your hand. Do it again with your other hand.
2. Draw a curvy line from the tip of each finger to the next finger, like skin stretched between them. These are the wings.
3. Cut out both hand-wings along the curvy lines. A parent can help.
4. Draw a small furry body with a round head and two big ears. Cut it out.
5. Glue one hand-wing on each side of the body, with the thumbs pointing up.
6. Draw a face. Tape string to the bat's feet and hang it upside down from a doorknob or shelf, like a bat in its roost.

Tips

- Color the finger lines darker so they look like bones.
- Real bats have a little claw on each thumb. Draw one on yours.

Check your work

- I can show where my bat's thumb and fingers are.
- I can tell why my bat hangs upside down.
- I can tell what kind of animal a bat is.

FIELD NOTEBOOK

1. Draw a bat hanging upside down in a cave. Label the fur, the ears and the wings.
2. Draw a bat, a moth and curvy lines to show the squeak going out and the echo coming back.
3. Draw your own hand next to a bat wing. Circle the thumb on each one.

From history. In 1938 a college student named Donald Griffin brought some bats to a scientist named George Washington Pierce at Harvard University. Pierce had built a machine that could pick up sounds too high for people to hear. When the bats flew past it,

the machine picked up their squeaks again and again. Griffin went on to study bats for many years, and he gave this way of finding things by echoes its name: echolocation.

WORKED EXAMPLES

Example 1. A family counted bats flying out of a barn at sunset. On the first night they made 3 bundles of tally marks. On the second night they made 2 bundles. Each bundle is four lines with one line across, and stands for 5 bats. Which night had more bats? How many more?

1. Each bundle stands for 5 bats. Count the first night by fives: 5, 10, 15. There were 15 bats.
2. Count the second night by fives: 5, 10. There were 10 bats.
3. 15 is bigger than 10, so the first night had more.
4. Count up from 10 to 15: 11, 12, 13, 14, 15. That is 5 more.

Answer: The first night had more bats, 5 more.

PRACTICE

1. **EASY** Is a bat a bird or a mammal? How do you know?
2. **EASY** Look at the echo drawing. Point to the bat, the squeak going out, the moth and the echo coming back.
3. **MEDIUM** Sort these into “bats eat it” and “bats do not eat it”: moths, rocks, mosquitoes, fruit, grass.
4. **MEDIUM** 25 bats flew out of a cave. Then 30 more flew out. How many bats flew out in all?
5. **HARD** Tell in your own words: why do bats like to rest in caves?

COMMON MISTAKES

- Thinking bats are birds. Bats are mammals with fur, and they feed their babies milk.
- Thinking bats are blind. Bats can see, but they use their ears and echoes to catch bugs in the dark.
- Thinking bats want to fly into your hair. Bats steer around people. They are busy hunting bugs.

Make it a game • Bat and Moth. Play in an open room with nothing to trip over. One player is the bat and closes their eyes. The others are moths. The bat calls “Bat!” and every moth must answer “Moth!” right away. The bat listens and walks slowly toward the sounds to tag a moth. Moths may take only small steps. When a moth is tagged, it becomes the next bat.

Scripture. “But ask now the beasts, and they shall teach thee; and the fowls of the air, and they shall tell thee:” (Job 12:7, KJV)

Scientists learned about echoes by watching little bats. When we study the animals God made, they teach us about His wisdom.

Practice answers

1. A mammal. It has fur, and its babies drink their mother's milk.
2. The bat is on the left. The solid curved lines going right are the squeak. The moth is on the right. The dashed curved lines coming back are the echo.
3. Bats eat it: moths, mosquitoes and fruit (fruit bats). Bats do not eat it: rocks and grass.
4. $25 + 30 = 55$ bats.
5. Caves are dark and safe from animals that might eat them. They stay cool in summer and not too cold in winter, so bats can rest there in the day and sleep through the winter.

4.4 DAVID IN THE CAVE OF ADULLAM (1 SAMUEL 22)

OBJECTIVES

- Retell the story of David hiding in the cave of Adullam and who came to him there.
- Explain why the hills of Judah have so many caves.
- Say Psalm 142:5 and tell how God is a refuge, a safe place.

Warm-up. Throw a blanket over a table and crawl underneath with a flashlight. Is it darker under there? Quieter? Would it keep off the rain or the hot sun? Talk about why a person long ago might choose a cave for a hiding place.

Video. Coming soon. David in the cave of Adullam, 1 Samuel 22, for children: search Bible storytelling channels for young children, Holy Land travel footage of limestone caves in the Judean hills, and gentle read-aloud videos of the story of David and Saul.

KEY TERMS

refuge

A safe place to run to when you are in danger.

stronghold

A hard-to-reach place that is easy to keep safe, like a cave in a hill. The Bible calls it a “hold.”

captain

A leader who is in charge of a group of men.

CORE IDEAS

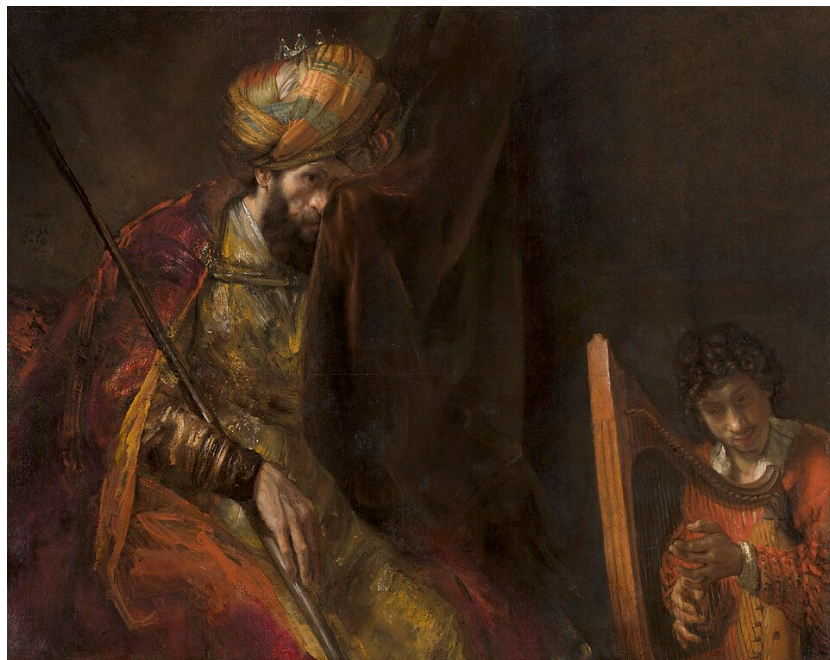
The story. Young David had beaten the giant Goliath, and all the people praised him. King Saul grew jealous and angry. One day, while David played his harp for the king, Saul threw a spear at him! David had done nothing wrong, but he had to run for his life. The Bible says, “David therefore departed thence, and escaped to the cave Adullam” (1 Samuel 22:1). Soon his brothers and all his father’s family came down to him. Then other people came too: people who were in trouble, people who owed money, and people who were unhappy. About four hundred men gathered, and David became their **captain**.

How they figured it out. Why was there a cave to hide in? The hills of Judah, where David grew up, are made mostly of limestone. That is the same kind of rock as Mammoth Cave! Water soaking through the limestone has carved many caves in those hills. In Bible times shepherds kept their sheep in caves, and people hid in caves when enemies came (Judges 6:2). Adullam was a town in the low hills of Judah, not far from the valley where David fought Goliath.

The big idea. A cave makes a good **stronghold**. It is out of the hot sun and the rain. It stays cool. It can hold many people, and its narrow doorway is easy to guard. But David knew that the cave was not what really kept him safe. Two of his psalms say in their titles that he prayed them in a cave (Psalm 57 and Psalm 142). In one he prayed, “Thou art my refuge and my portion in the land of the living” (Psalm 142:5). God was his true **refuge**.

Try it and see. Later, while David stayed at the cave of Adullam, he said how much he longed for a drink from the well of Bethlehem, his hometown. Three of his brave men slipped right through the enemy camp and brought him that water. But David would not drink it. He poured it out to the LORD, because his men had risked their lives for it (2 Samuel 23:13-17). Build a blanket cave, and act out the story: the hiding, the family coming, the brave men and the water poured out.

PICTURE STUDY



Saul and David, Rembrandt van Rijn, about 1651-1658 · Oil on canvas · Mauritshuis, The Hague, the Netherlands

Rembrandt was a Dutch painter who loved to paint Bible stories and the feelings on people's faces. This painting shows the time before David ran to the cave. David is playing his harp to calm King Saul. Saul is sad and troubled, and he is holding a spear. Soon he will throw a spear at David, and David will have to run away and hide.

Look closely

- Find King Saul. What is he holding in his hand?
- Find David. What is he doing?
- Look at Saul's face. Is he happy, sad or angry?
- Find the brightest colors in the painting. What do they show?

Talk about it

1. Why did David have to run away from King Saul?
2. Where did David go to hide? Who came to be with him?
3. Who was David's real refuge?

MAKE AND DO: THE CAVE OF ADULLAM IN MY HOUSE

You will build a blanket cave, act out David's story inside it, and make a little card of David's cave prayer to hang at the door.

You will need

- A table or two chairs
- One or two blankets or sheets
- Pillows, a flashlight and a cup of water
- Paper, crayons and tape

Steps

1. Drape a blanket over a table so it hangs to the floor. Leave a small doorway at one end. This is your cave in the limestone hills.
2. Put pillows inside for rocks. Bring in a flashlight, because caves are dark.
3. Act out the story. One person is David running from King Saul. He crawls into the cave to hide.
4. Others come to the doorway one at a time: "I am David's brother." "I am in trouble." David lets each one in.
5. Now three brave men go out and bring back a cup of water from "Bethlehem." David thanks them, then pretends to pour it out to the LORD.
6. On a card, write or trace: "Thou art my refuge" (Psalm 142:5). Decorate it and tape it over the cave door.

Tips

- Pour the water into a sink or a plant, not on the floor.
- Have each actor tell why they came to David's cave.

Check your work

- I can tell why David hid in a cave.
- I can tell who came to him there.
- I can say Psalm 142:5 and tell what "refuge" means.

FIELD NOTEBOOK

1. Draw David and his men in a cave in a rocky hillside. Show the dark doorway and the hills around it.

2. Draw the three brave men carrying water from Bethlehem. Write: “but poured it out unto the LORD” (2 Samuel 23:16).
3. Write or trace Psalm 142:5. Draw a picture of a safe place around the words.

From history. The limestone hills of the Holy Land have kept treasures as well as people safe. In 1947 a shepherd looking for a lost goat near the Dead Sea threw a stone into a cave and heard a jar break. Inside were old scrolls. More caves nearby held more scrolls, now called the Dead Sea Scrolls. One of them is a long scroll of the whole book of Isaiah, kept safe in the dry, dark caves.

WORKED EXAMPLES

Example 1. When David was at the cave of Adullam, about 400 men came to him (1 Samuel 22:2). A little later, the Bible says he had about 600 men (1 Samuel 23:13). Did his group get bigger or smaller? By how many hundreds?

1. Draw 4 big boxes. Each box stands for one hundred men. That is 400.
2. Draw 6 big boxes for 600.
3. 6 boxes is more than 4 boxes, so the group got bigger.
4. Count up from 4 to 6: 5, 6. That is 2 more boxes, or 2 hundreds.

Answer: The group got bigger, by about 200 men (2 hundreds).

PRACTICE

1. **EASY** Why did David have to hide in a cave?
2. **EASY** Who came to David at the cave of Adullam?
3. **MEDIUM** What kind of rock are the hills of Judah mostly made of, the rock that has so many caves in it? Which cave from this unit is in the same kind of rock?
4. **MEDIUM** Psalm 57 has 11 verses. Psalm 142 has 7 verses. Both have titles that say David prayed them in a cave. How many verses are there in all? Which psalm is longer?
5. **HARD** Tell in your own words: the three brave men brought David water from Bethlehem. Why did David pour it out instead of drinking it?

COMMON MISTAKES

- Thinking David was hiding because he did something bad. He had done nothing wrong. King Saul was jealous.
- Mixing up the caves. David hid in the cave of Adullam in 1 Samuel 22. The time he cut a piece of Saul’s robe was in a different cave, near En-gedi, in 1 Samuel 24.
- Thinking the cave was what kept David safe. David knew that God was his true refuge.

Make it a game • Refuge Tag. Play tag in the yard. A blanket, a tree or a porch step is the cave of Adullam, the safe base. A player can stay safe in the cave only while saying,

“Thou art my refuge!” Then they must run out again. When someone is tagged, they become the new tagger. After the game, sit in the cave together and say Psalm 142:5.

Scripture. “David therefore departed thence, and escaped to the cave Adullam: and when his brethren and all his father’s house heard it, they went down thither to him.” (1 Samuel 22:1, KJV)

God gave David a safe cave in the limestone hills and sent his family to be with him. When we are afraid, God is our refuge too.

Practice answers

1. King Saul was jealous and angry and wanted to kill him, even though David had done nothing wrong.
2. His brothers and all his father’s family, and then people who were in trouble, in debt or unhappy. About four hundred men came.
3. Limestone. Mammoth Cave is in limestone too.
4. $11 + 7 = 18$ verses. Psalm 57 is longer, by 4 verses.
5. His men had risked their lives to get it, so it was too precious to drink. He gave it to the LORD instead.

UNIT 4 REVIEW

This is an oral review. A parent reads each question aloud, and the child answers in their own words, pointing or drawing where it helps. Give full points for a clear answer with the main ideas. The review is worth 20 points.

1. (3 pts) Tell me about Mammoth Cave. Where is it, and who was its famous guide?
2. (3 pts) How does water make a cave? What keeps the roof of Mammoth Cave strong?
3. (3 pts) What is a stalactite? What is a stalagmite? What do we call it when they meet?
4. (3 pts) Tell me how you grew a stalactite on a string.
5. (3 pts) Is a bat a bird? How does a bat find bugs in the dark?
6. (3 pts) Why did David hide in the cave of Adullam, and who came to him there?
7. (2 pts) Say Psalm 142:5, or tell what it means. How is God like a cave for David?

UNIT PROJECT: MY SHOEBOX CAVE

Turn a shoebox on its side and make it into a cave. Color the walls like limestone and put a strip of “sandstone” across the top. Add a blue paper underground river, stalactites and stalagmites made of clay or paper (and your Epsom salt string, if it will fit), at least one column, and a paper bat hanging upside down in its roost. Label each part. Then use a flashlight to give a family “cave tour,” telling about Mammoth Cave, how caves form, and the bats, and finish by telling the story of David in the cave of Adullam.

- **Cave parts:** The cave shows limestone, a sandstone roof, an underground river, a stalactite, a stalagmite, a column and a bat.
- **Labels:** Each part is labeled with the right word, spelled as well as the child can.
- **Cave tour:** The child explains how water made the cave, how stalactites grow and how bats find bugs, and retells David’s story.
- **Care:** The cave is neat, colorful and built with patience, like a real scientist’s model.

Answer key

1. Mammoth Cave is in Kentucky. It is the longest cave anyone has found. Stephen Bishop was its famous guide. He explored its dark tunnels and rivers and drew a map of it.
2. Rainwater soaks through the soil and down cracks in the limestone. It slowly dissolves the rock, and the cracks grow into tunnels. A layer of hard sandstone on top does not dissolve, so it makes a strong roof.
3. A stalactite hangs down from the ceiling. A stalagmite grows up from the floor under the drip. When they meet, they make a column.
4. We dissolved Epsom salt in warm water in two jars and laid a yarn between them, sagging over a plate. The salt water crept along the yarn and dripped in the middle. The water dried up and left salt crystals behind, which grew into a little stalactite.
5. No. A bat is a mammal with fur, and its babies drink milk. Its wings are made like hands. It squeaks and listens for the echo that bounces back from a bug. That is called echolocation.

6. King Saul was jealous and wanted to kill him. His brothers and his father's family came, and then people who were in trouble, in debt or unhappy, about four hundred men. David became their captain.
7. "I cried unto thee, O LORD: I said, Thou art my refuge and my portion in the land of the living." A cave was a safe place for David, but God was his true refuge, the safe place he could always run to.

GLACIERS AND ICE

Snow is soft enough to catch on your tongue, yet piled high and packed down it becomes a glacier strong enough to carve mountains. In this unit we paddle into Glacier Bay, Alaska, with John Muir and his Tlingit guides and learn how snow turns into a slow-moving river of ice. We watch glaciers calve into the sea. Then we follow Louis Agassiz onto a Swiss glacier, where a row of wooden stakes showed that the ice really moves, and we become glaciers ourselves, carving clay with sandy ice cubes.

Next we float our own icebergs and find out why about 9 parts out of 10 hide under the water, and why ships keep watch for them. Last, we travel to the ends of the earth with Roald Amundsen, first to the South Pole, and Ernest Shackleton, who brought every man home after the ice crushed his ship. All through the unit we remember God's question to Job: "Out of whose womb came the ice?" (Job 38:29).

BEFORE YOU BEGIN

- Can count to 100 and add and subtract small numbers
- Can measure with a ruler in whole inches or centimeters
- Knows that water freezes into ice and ice melts into water
- Can find the top and bottom of a globe

MASTERY CHECKLIST

- I can tell how John Muir explored Glacier Bay and explain how snow becomes a glacier.
- I can show with an ice cube and clay how a glacier scratches and carves the land, and tell a U-shaped valley from a V-shaped valley.
- I can show that ice floats and that most of an iceberg is under the water.
- I can tell about Amundsen at the South Pole and Shackleton's ship, the *Endurance*.
- I can tell one difference between the Arctic and Antarctica.

OPTIONAL BOOKS AND RESOURCES

- **Glacier Bay National Park and Preserve (National Park Service)** (<https://www.nps.gov/glba/>): Free. Photos of tidewater glaciers, whales and seals, and the history of John Muir's visits, for Lesson 5.1. The park also has a Junior Ranger program.
- **National Snow and Ice Data Center** (<https://nsidc.org/>): Free. Photos and plain explanations of glaciers, icebergs and sea ice for Lessons 5.1 to 5.4. A parent may choose the pages to share.

5.1 GLACIER BAY ★

OBJECTIVES

- Tell how John Muir explored Glacier Bay in Alaska by canoe in 1879.
- Explain in simple words that a glacier is a huge field of packed snow and ice that moves slowly downhill.
- Tell what happens when a glacier reaches the sea and pieces break off.

Warm-up. Scoop a big handful of snow or crushed ice (or shaved ice from the freezer) and squeeze it hard in a mitten or a plastic bag. Open your hand. Is it still soft and fluffy, or has it turned into a hard lump? That is the very first step in making a glacier.

Video. Coming soon. Glacier Bay National Park for kids: search the National Park Service (NPS) Glacier Bay channel, Smithsonian, SciShow Kids and nature footage of tidewater glaciers calving into the sea, with seals and whales in the icy water.

KEY TERMS

glacier

A huge field of ice, made from snow packed down hard, that moves slowly downhill like a very slow river.

bay

A part of the sea that reaches into the land, with land on three sides.

calving

When big chunks of ice break off the front of a glacier and splash into the water.

explorer

A person who travels to new places to find out what is there.

CORE IDEAS

The story. Far up in Alaska there is a long arm of the sea called Glacier Bay. In 1794 a sea captain named George Vancouver sailed past. His men saw only a tall wall of ice at the edge of the water. There was hardly a bay at all! In 1879 a Scottish-American explorer named John Muir came in a long wooden canoe. With him came a missionary friend and Tlingit (KLINK-it) guides who knew those waters. They paddled through cold rain and fog. Muir was amazed. The ice had melted back, and now a long bay of open water stretched for many miles into the mountains.

How they figured it out. Muir climbed the rocks and looked at the ice. He saw that it was a **glacier**, a river of ice. A glacier begins as snow. In some high, cold places, more snow falls in winter than melts in summer. The snow piles up, layer on layer. The heavy top layers press the bottom snow into hard, blue ice. When the ice gets thick and heavy enough, it starts to

slide and creep downhill, slower than a snail. Glaciers grow when lots of snow falls. They shrink when more ice melts than snow comes.

The big idea. Some glaciers flow all the way down to the sea. Their fronts are tall cliffs of ice. Every so often a great chunk cracks off and crashes into the water with a boom and a giant splash. This is called **calving**, like a mother cow having a baby calf. The floating pieces become icebergs. In Glacier Bay you can still watch glaciers calve today. Seals rest on the floating ice, and humpback whales swim in the **bay**.

God's handiwork. God asked Job, "Hast thou entered into the treasures of the snow?" (Job 38:22). A glacier is snow that God has stored up, layer on layer. Today Glacier Bay is a national park. Visitors ride boats to see the ice cliffs, and one big glacier there is named Muir Glacier after the **explorer** who loved it.

PICTURE STUDY



Muir Glacier, Alaska, Thomas Hill, 1887-1888 · Oil on canvas · Oakland Museum of California, Oakland, California

Thomas Hill was an American painter who was famous for his big pictures of Yosemite Valley in California. He traveled north to Alaska and painted Muir Glacier, the glacier named for John Muir. In those days, steamships carried visitors right up to the glacier's icy front so they could watch chunks of ice fall into the sea. Hill wanted people far away to see what those visitors saw.

Look closely

- Find the front of the glacier. Is it a gentle slope or a tall cliff?
- Look for pieces of ice floating in the water. Where do you think they came from?

- Find something small in the picture, like a boat or a person. How big is the glacier next to it?
- Look at the colors in the ice. Can you find any blue?

Talk about it

1. If you sat in a boat in front of this glacier, what might you hear?
2. Why do you think the painter made the glacier so big in the picture?
3. How is a glacier like a river? How is it different?

Safety first. Play with ice and water on a towel or in the sink, and wipe up spills so no one slips. In a real park, never walk on a glacier or go near an ice cliff. Ice can fall without warning.

MAKE AND DO: CALVING GLACIER IN A PAN

We will make a little glacier that reaches the sea, then watch it calve. Real glaciers take a long time to move, but our kitchen glacier will show the idea in one afternoon.

You will need

- A small loaf pan or plastic container
- Water and a freezer
- A large baking pan with sides
- A few books or a block to tilt the pan
- A cup of water for the “sea”

Steps

1. Fill the loaf pan with water and freeze it overnight. This is your glacier.
2. The next day, set the big baking pan on a towel. Put a book under one end so it tilts like a hillside.
3. Pour water into the low end of the big pan. This is the sea, like Glacier Bay.
4. Run warm water over the bottom of the loaf pan for a few seconds and slide out your ice block.
5. Set the ice block at the high end of the big pan so its front edge sticks out over the water.
6. Watch and wait. As the ice warms, it slides down a little and the front cracks and falls. Did your glacier calve? Count the icebergs floating in your sea.

Tips

- Mix a few drops of blue food coloring into some of the water before freezing to make the ice look like real glacier ice.
- Pour a little warm water along the front of the ice to help it calve faster.

Check your work

- I can tell what my ice block and the water stood for.
- I can explain what calving means.
- I can tell where icebergs come from.

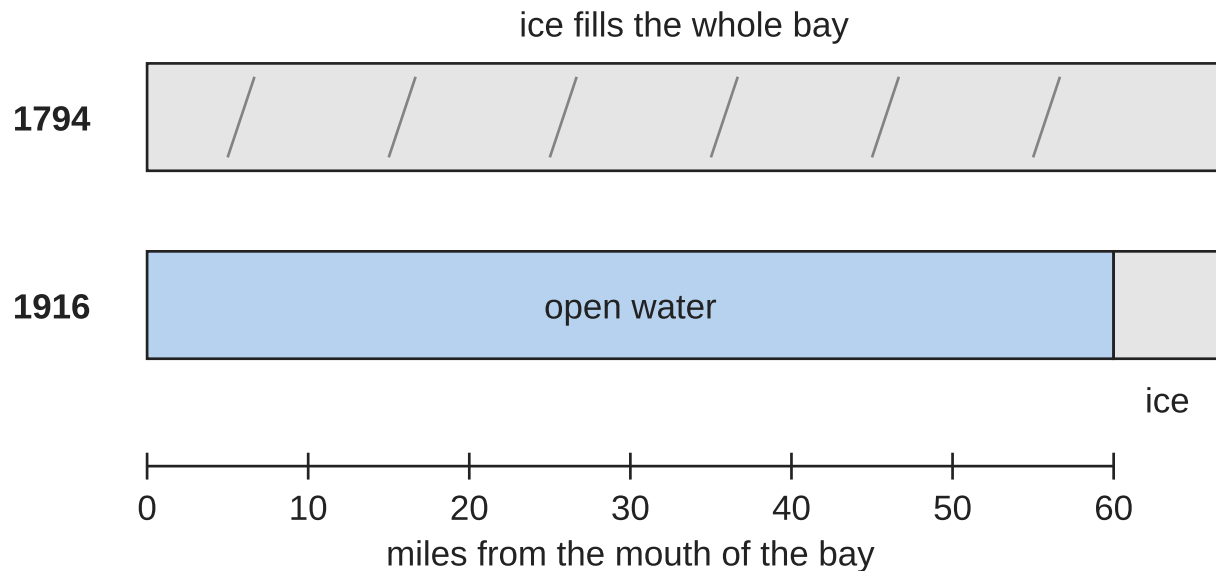
FIELD NOTEBOOK

1. Draw John Muir's canoe in Glacier Bay, with a tall wall of ice and floating icebergs. Label the glacier, the bay and the canoe.
2. Draw three boxes in a row: fluffy snow, packed snow, hard blue ice. Write "snow becomes a glacier" under them.
3. Draw a seal resting on a piece of floating ice. Write one sentence about what the seal might see.

From history. John Muir came back to Alaska the next year, in 1880. A small, shaggy dog named Stickeen followed him onto a glacier in a storm. To get home they had to cross a deep crack in the ice on a thin bridge of ice. Stickeen was afraid, but at last he crept across and then ran and leaped for joy. Muir later wrote a little book about it called *Stickeen*, and many children still love the story.

WORKED EXAMPLES

Example 1. Look at the picture chart. In 1794 ice filled the whole bay. By 1916 the ice had melted back more than 60 miles. Let's use 60 miles. A boat goes 10 miles every hour. How many hours does it take the boat to go 60 miles up the bay?



In 1794 ice filled the bay. By 1916 the ice had melted back more than 60 miles.

1. Put your finger on 0, the mouth of the bay, where the sea comes in.
2. Count by tens along the chart, one hop for each hour: 10, 20, 30, 40, 50, 60.
3. Count your hops: 1, 2, 3, 4, 5, 6.

Answer: 6 hours. The boat could sail 60 miles of open water where there used to be ice.

PRACTICE

1. **EASY** What is a glacier made from?
2. **EASY** Point to the 1794 strip on the chart. Was the bay full of ice or full of water?
3. **MEDIUM** Put these in order: hard blue ice, fluffy snow falls, the snow piles up and gets packed down, the ice slides slowly downhill.
4. **MEDIUM** On a boat trip you count 7 icebergs in the morning and 8 more in the afternoon. How many icebergs did you see in all?
5. **HARD** Tell in your own words: what is calving, and what does it make?

COMMON MISTAKES

- Thinking a glacier is just frozen lake or sea water. A glacier is made of snow that piled up on land and was pressed into ice.
- Thinking glaciers stand still. Glaciers are always moving, very slowly, downhill.

- Thinking a glacier only shrinks. Glaciers grow when lots of snow falls and shrink when more ice melts than snow comes.

Make it a game · Glacier, Glacier, Calve!. Everyone stands in a line holding hands. This is the glacier, and it creeps slowly across the room toward the “sea” (a blanket on the floor). When the parent calls “Calve!”, the person at the front lets go and splashes onto the blanket as an iceberg. To climb back on, the iceberg must tell one thing about glaciers or about John Muir. Keep going until every person has been an iceberg.

Scripture. “Hast thou entered into the treasures of the snow? or hast thou seen the treasures of the hail,” (Job 38:22, KJV)

God asked Job if he had seen where the snow is stored. A glacier is like a great storehouse of snow, packed into ice. God made it and knows every layer.

Practice answers

1. Snow that piles up and gets packed down into hard ice.
2. Full of ice.
3. Fluffy snow falls; the snow piles up and gets packed down; hard blue ice; the ice slides slowly downhill.
4. $7 + 8 = 15$ icebergs.
5. Calving is when a big chunk of ice breaks off the front of a glacier and falls into the water. The floating chunks become icebergs.

5.2 ICE THAT CARVES (ICE CUBE ON CLAY) ★

OBJECTIVES

- Show with an ice cube and clay how a glacier carries rocks that scratch and carve the land.
- Tell how Louis Agassiz used a row of stakes to show that a glacier moves.
- Tell a V-shaped river valley from a U-shaped glacier valley.

Warm-up. Press a clean ice cube onto a flat piece of play dough or clay and slide it back and forth five times. Look closely. Now dip the ice cube in a little sand and do it again. Which one made more scratches?

Video. Coming soon. How glaciers carve valleys for kids: search the National Park Service (NPS), USGS, SciShow Kids, Homeschool Pop (Alternate) and Science Max for glacier erosion, U-shaped valleys, moraines and glacial scratches on rock.

KEY TERMS

carve

To cut or scrape away bit by bit to make a new shape.

moraine

A long pile of rocks, sand and gravel that a glacier pushed or dropped.

U-shaped valley

A valley with steep sides and a wide, rounded bottom, carved by a glacier.

boulder

A very large rock, bigger than you can lift.

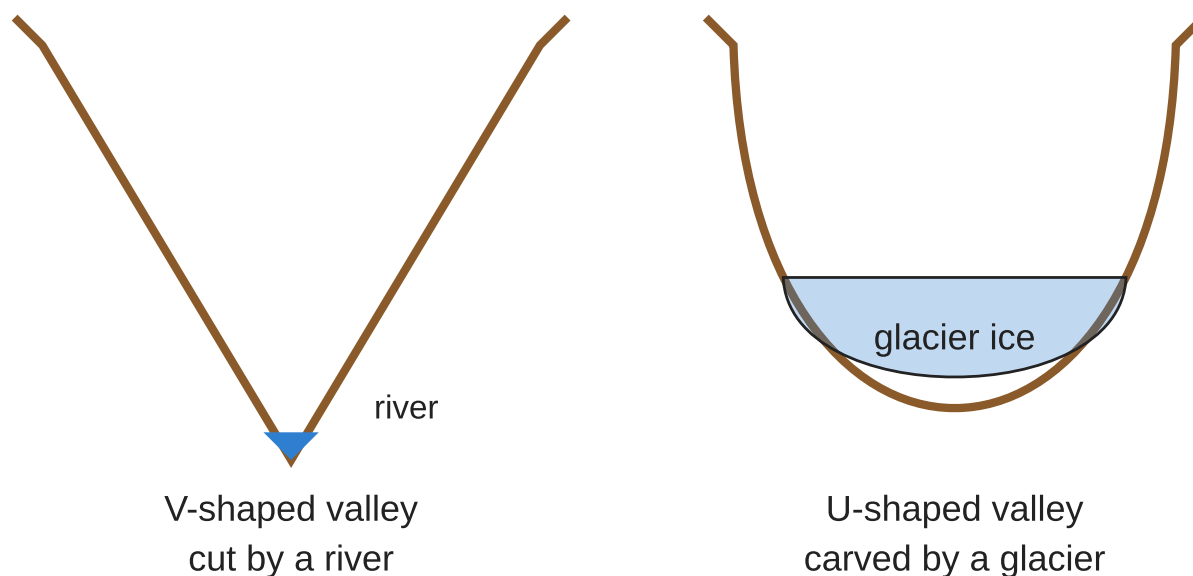
CORE IDEAS

The story. Long ago in the high mountains of Switzerland, a scientist named Louis Agassiz (AG-uh-see) wanted to learn how glaciers work. He and his helpers camped right on top of a glacier! One summer they pounded a straight row of wooden stakes across the ice, from one side of the valley to the other. Then they waited. When they came back, the stakes were not in a straight line anymore. All of them had moved downhill, and the ones in the middle had moved the farthest. The ice was flowing like a very slow, very cold river.

How they figured it out. Agassiz looked at the rocks too. Under and beside the glacier, the rock was smooth and polished, with long straight scratches. How could ice scratch rock? Ice by itself is softer than rock. But a glacier picks up sand, stones and even giant **boulders** and freezes them into its bottom. As the heavy ice slides, those stones scrape the ground like sandpaper. At the sides and front, the glacier leaves long piles of rock called **moraines**. Then Agassiz found the same scratches, moraines and lost boulders in places where there was no glacier at all. He decided that ice must once have covered those lands too.

The big idea. Glaciers **carve** the land. A river cuts a narrow valley shaped like a **V**. A glacier is much wider and heavier, so it scrapes out a valley shaped like a **U**, with steep walls and a wide, rounded floor. Yosemite Valley in California has that U shape. When you see a U-shaped valley, scratched rock or a big boulder sitting all alone in a field, you can say, “A glacier was here.”

Try it and see. A clean ice cube on clay hardly makes a mark. An ice cube with sand frozen into its bottom digs grooves! In the project you will be the glacier and carve your own little valley.



A river cuts a V-shaped valley. A glacier carves a U-shaped valley.

Thinking About Time

What the sign says. What the sign says: Museums often talk about the “Ice Age.” They say great sheets of ice covered much of the north very, very long ago.

What we observe. What we observe: Far from any glacier today, we find scratched rock, moraines, lost boulders and U-shaped valleys. They look just like the marks glaciers make now.

How Christians read it. How Christians read it: Many creation scientists think there was one Ice Age after Noah’s Flood. The oceans were warm, so lots of snow fell. Later the ice melted back and left these marks.

Try it. Look at a picture of Yosemite Valley and trace its U shape with your finger.

Job 37:10

PICTURE STUDY



*The Lower Aar (Unteraar) Glacier, with Hugi's Hut, Plate 14 from *Études sur les glaciers* (Studies on Glaciers), Joseph Bettannier, from drawings made for Louis Agassiz, 1840 · Lithograph (a print made from a drawing on stone) · Atlas of Agassiz's book *Études sur les glaciers*; copies are kept in many libraries*

Louis Agassiz wrote a book about glaciers called *Études sur les glaciers*, which is French for “Studies on Glaciers.” It came with a big book of pictures. Artists drew the glaciers of the Swiss Alps very carefully, and the drawings were printed from flat stones. One of the glaciers Agassiz loved best was the Unteraar Glacier, where he and his friends camped on the ice.

Look closely

- Find the glacier. Which way do you think the ice is flowing?
- Look for a dark stripe of rocks on the ice. That is a moraine. Where did those rocks come from?
- Look at the shape of the valley walls. Do they look more like a V or a U?
- Look for cracks in the ice. What would it be like to walk there?

Talk about it

1. Why do you think Agassiz wanted careful drawings instead of quick sketches?
2. If you camped on this glacier, what would you want to measure?
3. How is this picture like a scientist's notebook?

Safety first. Use plain ice cubes and play dough or clay at the table. Wash hands after handling sand and gravel, and keep small stones away from little brothers and sisters who might put them in their mouths.

MAKE AND DO: BE THE GLACIER

You will make two “glaciers”: a clean ice cube and a rocky ice cube. Then you will slide each one across clay and compare the marks, the way Agassiz compared the rocks under real glaciers.

You will need

- An ice cube tray
- A spoonful of sand and a few small pebbles
- A ball of modeling clay or play dough, pressed flat on a plate
- A ruler
- A towel

Steps

1. Sprinkle sand and a few small pebbles into two or three cups of the ice cube tray. Fill all the cups with water and freeze overnight.
2. Press the clay into a flat slab on a plate. Roll a clay hill along each side to make a little valley.
3. Take a clean ice cube. Push it down the valley five times, pressing gently. Look at the clay.
4. Now take a rocky ice cube, sandy side down. Push it down the valley five times. Look again.
5. Measure the longest groove with your ruler and count the scratches.
6. Leave the rocky ice cube at the end of the valley until it melts. What is left behind? That pile is your moraine!

Tips

- Press down firmly but gently, like a heavy glacier, and go the same way each time.
- Look at the clay with a magnifying glass if you have one. Real geologists look closely at scratches on rock.

Check your work

- I can tell which ice cube carved more and why.
- I can point to the scratches and the moraine I made.
- I can tell what shape valley a glacier carves.

FIELD NOTEBOOK

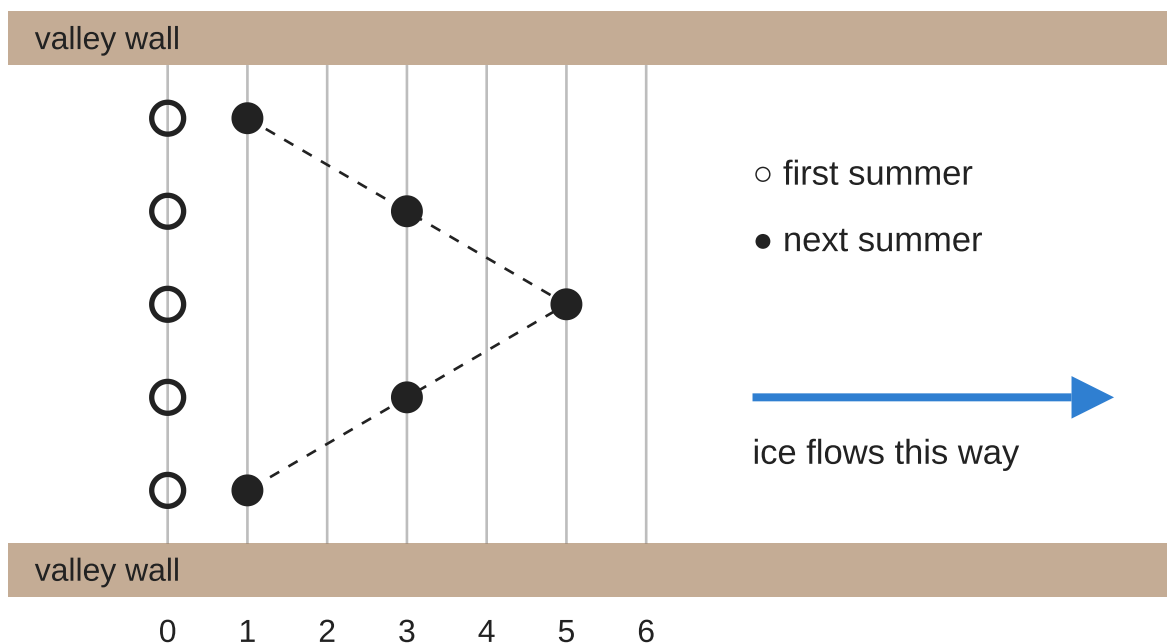
1. Draw a V-shaped valley with a river and a U-shaped valley with a glacier. Label each one.
2. Draw the clay after the clean ice cube and after the rocky ice cube. Write “more scratches” under the right one.

3. Draw Agassiz's row of stakes on the glacier, first in a straight line and then bent. Draw an arrow to show which way the ice moved.

From history. Louis Agassiz later moved to America and became a famous teacher at Harvard. He told his students to look at a single fish for hours and write down everything they saw, then look again. He wanted them to learn from real things, not only from books. He believed that God made each kind of living thing, and he loved to show his students the wise plan he saw in nature.

WORKED EXAMPLES

Example 1. Look at the picture of Agassiz's stakes. Count the squares each stake moved. Which stake moved the most? Which stakes moved the least?



The stakes started in a straight line. The next summer the middle stake had moved the farthest.

1. Find the open circles in a straight line. That is where the stakes were the first summer.
2. Find the dark dots. That is where the stakes were the next summer.
3. Count the squares from each circle to its dot. The stakes next to the valley walls moved 1 square. The next ones in moved 3 squares. The middle stake moved 5 squares.
4. 5 is the biggest number, so the middle stake moved the most. 1 is the smallest, so the stakes by the walls moved the least.

Answer: The middle stake moved the most (5 squares). The stakes by the walls moved the least (1 square each). The middle of a glacier flows fastest.

PRACTICE

1. **EASY** Which carves more: a clean ice cube or an ice cube with sand and pebbles frozen in it?
2. **EASY** Look at the valley picture. Point to the valley a glacier carved. What letter is it shaped like?
3. **MEDIUM** Sort these into “a glacier left this” or “a river made this”: a U-shaped valley, a long pile of rocks called a moraine, a narrow V-shaped valley, long scratches on smooth rock.
4. **MEDIUM** Your rocky ice cube made 9 scratches. Your clean ice cube made 2. How many more scratches did the rocky ice cube make?
5. **HARD** Ice is softer than rock. Tell in your own words how a glacier can still scratch rock.

COMMON MISTAKES

- Thinking the ice itself scratches the rock. The stones frozen into the bottom of the glacier do most of the scratching.
- Thinking a glacier moves all in one piece at the same speed. The middle flows faster than the sides, where the ice rubs on the valley walls.
- Thinking every valley was carved by a glacier. Narrow V-shaped valleys are cut by rivers.

Make it a game · Glacier or River?. A parent says a clue, such as “a valley shaped like a U,” “a narrow valley shaped like a V,” “a big boulder alone in a field,” “long scratches on smooth rock” or “a pile of rocks at the end of the ice.” The child makes a big U with both arms for “glacier” or a sharp V with two fingers for “river.” Score a point for each right answer and a bonus point for telling why.

Scripture. “He giveth snow like wool: he scattereth the hoarfrost like ashes. He casteth forth his ice like morsels: who can stand before his cold?” (Psalm 147:16-17, KJV)

Snow falls soft as wool, yet when it is packed into a glacier it is strong enough to carve valleys. Both the soft snow and the mighty ice come from God.

Practice answers

1. The ice cube with sand and pebbles. The stones scrape the clay like sandpaper.
2. The valley on the right. It is shaped like a U.
3. A glacier left: the U-shaped valley, the moraine and the scratches on smooth rock. A river made: the narrow V-shaped valley.
4. $9 - 2 = 7$ more scratches.
5. A glacier picks up sand, stones and boulders and freezes them into its bottom. The heavy ice drags them along the ground, and the stones do the scratching.

5.3 ICEBERGS FLOAT, MOSTLY UNDER WATER

OBJECTIVES

- Show that ice floats and that most of an iceberg, about 9 parts out of 10, hides under the water.
- Explain that water grows a little bigger when it freezes, so ice is lighter than the same amount of water.
- Tell why ships keep watch for icebergs.

Warm-up. Fill a small plastic cup with water right up to a line you draw with a marker. Put it in the freezer. After it freezes, look again. Is the ice higher or lower than your line? Water grows a little bigger when it turns to ice.

Video. Coming soon. Why icebergs float for kids: search NOAA, the U.S. Coast Guard International Ice Patrol, SciShow Kids, Science Max and nature footage of icebergs above and below the water.

KEY TERMS

iceberg

A big chunk of glacier ice that broke off and floats in the sea.

float

To stay up at the top of the water instead of sinking.

waterline

The line where the water touches something that is floating.

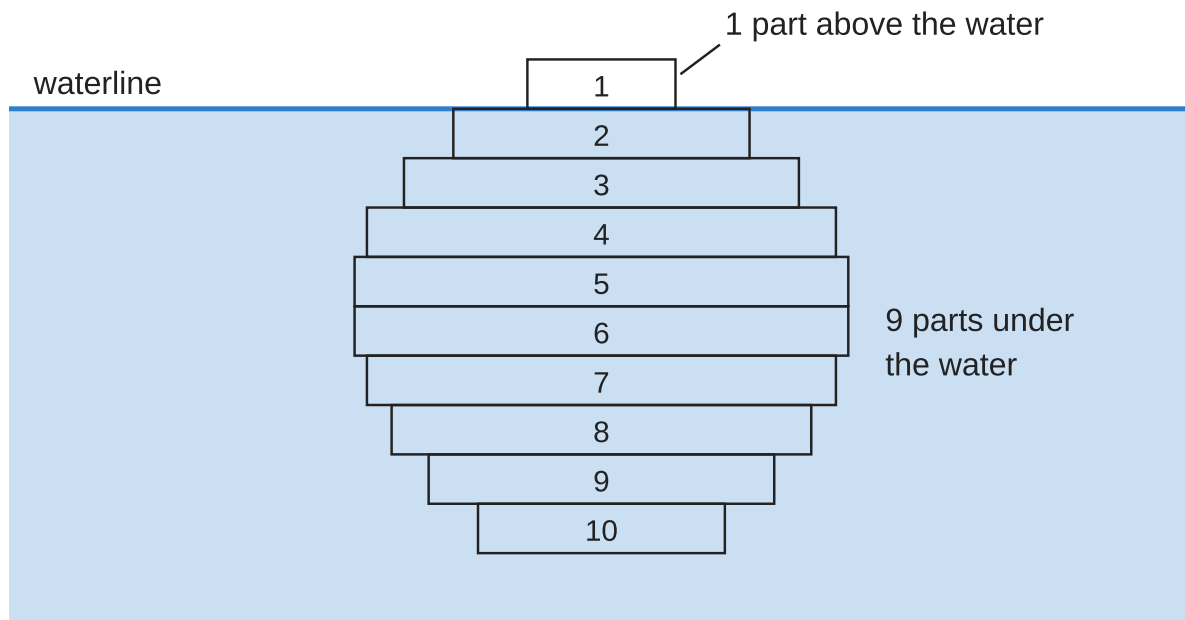
CORE IDEAS

The story. Out in the cold north Atlantic Ocean, sailors have always watched for icebergs. In April of 1912 a great new ship named the *Titanic* was crossing the ocean at night. It struck an iceberg and sank, and many people were lost. The lookouts saw the iceberg only when it was very close, and the ship could not turn away in time. After that sad night, nations agreed to keep watch together. Since 1914, the International Ice Patrol has watched for icebergs and warned ships where they are. The United States Coast Guard runs it, and it still keeps watch today.

How they figured it out. Why was the iceberg so hard to see? Because most of it was hidden. Put an ice cube in a glass of water and look from the side. Only a little bit sticks up. The big part hangs below the **waterline**. An **iceberg** is the same. If you cut an iceberg into 10 equal parts, about 1 part would stick up above the sea, and about 9 parts would stay under the water.

The big idea. Ice **floats** because water does something special when it freezes. It grows a little bigger! The same amount of water takes up more room as ice, so ice is a little lighter than the same size of water. That is why ice floats, but only just. Most of it stays down in the water. Icebergs come from glaciers that calve into the sea, so they are made of fresh water from snow, not salty sea water.

God's handiwork. Most things get smaller when they freeze, and the solid sinks. Water is different, and that is a great gift. When a pond freezes in winter, the ice floats on top like a lid. The water underneath stays liquid, and the fish live safely below until spring. The Bible says, "The waters are hid as with a stone, and the face of the deep is frozen" (Job 38:30).



About 1 part of an iceberg is above the water. About 9 parts are hidden under the water.

PICTURE STUDY



The Icebergs, Frederic Edwin Church, 1861 · Oil on canvas · Dallas Museum of Art, Dallas, Texas

Frederic Church was an American painter who traveled to see the wonders of the world for himself. In 1859 he sailed to the cold waters off Newfoundland and Labrador to sketch icebergs. He rowed out close to them in a small boat and drew them again and again as they turned and changed. Back home he painted this huge picture. Later he added a broken piece of a ship's mast in the front to show how dangerous the ice could be.

For many years the painting was lost from sight. It hung in a house in England, and few people knew where it was. Then it was found again, and today it hangs in a museum in Texas.

Look closely

- Find the biggest iceberg. What shapes can you see in it: caves, arches, towers?
- Find the waterline around the icebergs. Can you imagine how much ice is hidden underneath?
- Look for the broken piece of a ship's mast. What do you think happened?
- Find all the colors in the ice. Is the ice only white?

Talk about it

1. Why do you think Church rowed so close to sketch the icebergs?
2. What does this painting tell sailors about icebergs?
3. If you could rename this painting, what would you call it?

Safety first. Use plastic cups and bowls, not glass, and work on a towel. Wipe up spilled water so no one slips. Keep salt away from eyes.

MAKE AND DO: MAKE AN ICEBERG AND FIND THE WATERLINE

You will freeze your own iceberg, float it, and mark how much hides under the water. Then you will test it in salty water, like the sea.

You will need

- A small plastic cup or a clean yogurt cup
- Water and a freezer
- A large clear plastic bowl or clear plastic container
- A marker or a strip of tape
- Salt and a spoon
- A ruler

Steps

1. Fill the small cup with water and freeze it overnight. This is your iceberg.
2. Fill the clear bowl with water. Run warm water on the outside of the small cup and slide out your iceberg.
3. Gently set the iceberg in the bowl. Get down low and look from the side.
4. Hold the ruler beside the iceberg. Measure how much sticks up and how much hangs below. Which is more?
5. Mark the waterline on the outside of the bowl with tape.
6. Take the iceberg out. Stir in 6 big spoonfuls of salt until it mostly dissolves. Put the iceberg back. Does it float a little higher in salty water, like the sea?
7. Draw your iceberg with the waterline in your notebook.

Tips

- A drop of blue food coloring in the iceberg water makes it easier to see under the water.
- Try a tall, thin iceberg and a short, wide one. Do both hide most of their ice below?

Check your work

- I can show that most of my iceberg was under the water.
- I can tell why ice floats.
- I can tell what happened in salty water.

FIELD NOTEBOOK

1. Draw an iceberg with the waterline across it. Color the small top part white and the big bottom part light blue.
2. Draw a frozen pond with fish swimming under the ice. Write "Ice floats like a lid."
3. Draw a ship with a lookout high on the mast watching for icebergs.

From history. Today the International Ice Patrol flies airplanes over the north Atlantic to look for icebergs and sends out warnings to ships. Every spring, on the anniversary of the *Titanic*, the patrol drops a wreath of flowers into the sea near where the ship went down, to remember the people who were lost.

WORKED EXAMPLES

Example 1. Look at the iceberg picture. It is cut into 10 equal parts. How many parts are above the water? How many are under the water?

(Use the map or drawing “Count the parts above and below the waterline.” shown earlier in this lesson.)

1. Find the waterline, where the blue water starts.
2. Count the parts above the waterline: 1.
3. Count the parts below the waterline: 1, 2, 3, 4, 5, 6, 7, 8, 9.
4. Check: $1 + 9 = 10$. That is all the parts.

Answer: 1 part is above the water and 9 parts are under the water. Most of the iceberg is hidden.

PRACTICE

1. **EASY** Does ice sink or float in water?
2. **EASY** Point to the waterline on the iceberg picture. Is the bigger part above it or below it?
3. **MEDIUM** Where do icebergs come from? Are they made of fresh water or salty sea water?
4. **MEDIUM** A lookout counts 4 icebergs on Monday, 6 on Tuesday and 5 on Wednesday. How many icebergs is that in all?
5. **HARD** Tell in your own words why fish can live all winter in a frozen pond.

COMMON MISTAKES

- Thinking the part of an iceberg you can see is the whole iceberg. Most of it, about 9 parts out of 10, is under the water.
- Thinking icebergs are frozen sea water. Icebergs break off glaciers, so they are fresh water from snow.
- Thinking ice floats because it has air in it. Ice floats because water grows bigger when it freezes, so ice is lighter than the same amount of water.

Make it a game • Hidden Iceberg. Lay a blanket over a pile of pillows so only one small pillow pokes out. That small part is the tip of the iceberg. The child is a ship’s lookout and must guess how many pillows are hiding under the blanket, then lift it to count. Switch places. Each time, say the rule out loud: “Most of an iceberg is under the water!”

Scripture. “Out of whose womb came the ice? and the hoary frost of heaven, who hath gendered it? The waters are hid as with a stone, and the face of the deep is frozen.” (Job 38:29-30, KJV)

God asked Job who made the ice. God did! He made ice float on top “as with a stone,” like a lid over the water, so the living things below are kept safe.

Practice answers

1. It floats.
2. Below it. Most of the iceberg is under the water.
3. They break off, or calve, from glaciers. They are made of fresh water from snow.
4. $4 + 6 + 5 = 15$ icebergs.
5. Ice floats, so it stays on top like a lid. The water under the ice does not freeze, so the fish can swim there until spring.

5.4 POLAR EXPLORERS

OBJECTIVES

- Tell how Roald Amundsen reached the South Pole and how Ernest Shackleton brought all his men home after their ship was crushed by ice.
- Point to the North Pole and the South Pole on a globe and tell one difference between the Arctic and Antarctica.
- Test which wrappings keep warmth in, the way explorers chose warm clothes.

Warm-up. Find the top and the bottom of a globe or a ball. Put a sticker on each one. These are the North Pole and the South Pole, the coldest ends of the earth. Which animals do you think live at each end?

Video. Coming soon. Polar explorers for kids: search Smithsonian, Royal Museums Greenwich, the Scott Polar Research Institute, SciShow Kids and archive footage or photographs of Shackleton's *Endurance* and Amundsen's South Pole journey with sled dogs.

KEY TERMS

pole

One of the two ends of the earth, the farthest north or the farthest south.

Antarctica

The icy land around the South Pole, covered by a thick sheet of ice.

Arctic

The cold area around the North Pole, mostly an ocean covered with floating sea ice.

sled

A low cart with long runners that slides over snow and ice, often pulled by dogs.

CORE IDEAS

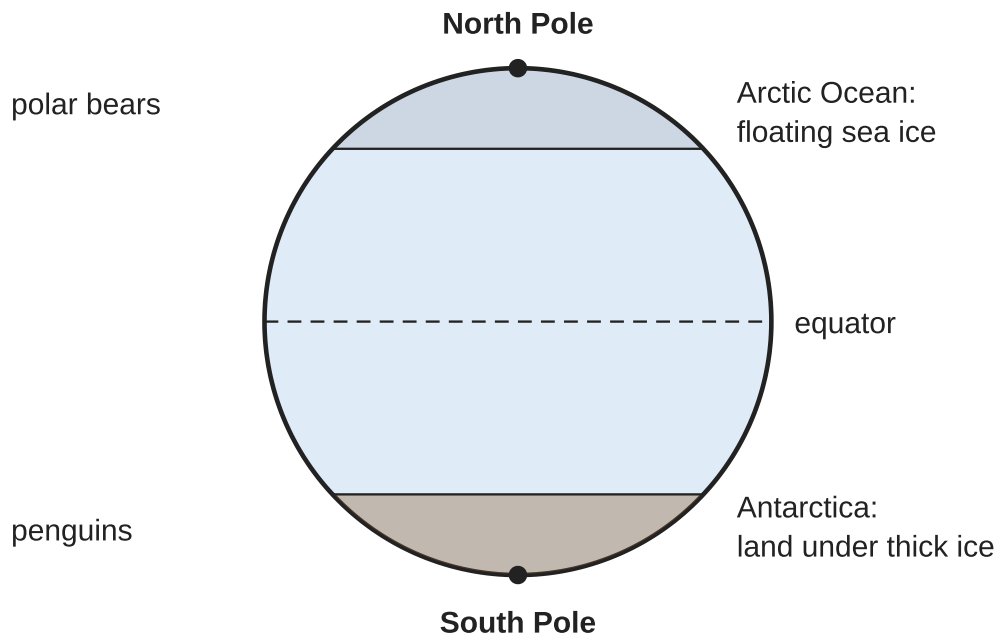
The story. For a long time no one had ever stood at the South Pole, the bottom of the world. Roald Amundsen (ROLE-ahl AH-mun-sen) of Norway wanted to be first. He had learned from the Inuit people of the far north how to dress in furs and how to drive teams of sled dogs. He and four friends set out across **Antarctica** on skis, with dogs pulling their **sleds**. They climbed up glaciers and crossed wide plains of snow. On December 14, 1911, they reached the South **Pole** and set up a small tent with the flag of Norway.

How they figured it out. A few years later, Ernest Shackleton sailed south in a ship named *Endurance*. The sea froze around the ship and held it tight. For months the men lived on the ship, waiting. Then the heavy ice squeezed until the ship cracked, and it sank. The men camped on the floating ice. When the ice broke up, they rowed small boats to a rocky island. Shackleton and five men sailed one little boat across the stormy sea to find help. They

climbed over icy mountains to a whaling station. Then Shackleton went back again and again until he could reach the others. Every one of the men on *Endurance* came home alive.

The big idea. The two ends of the earth are very different. Around the North Pole is the **Arctic**. It is mostly ocean, covered with floating sea ice. Polar bears live there. Around the South Pole is Antarctica. It is real land, buried under a thick sheet of glacier ice. Penguins live there. Explorers needed warm layers, good food, strong dogs or ships, and great courage.

In the world today. In 2022, explorers found the *Endurance* deep at the bottom of the icy sea. Cameras showed her name still on the back of the ship. Scientists live and work in Antarctica today, studying its ice. But wherever they go, God is there too. “If I take the wings of the morning, and dwell in the uttermost parts of the sea; Even there shall thy hand lead me” (Psalm 139:9-10).



The Arctic is an ocean covered with sea ice. Antarctica is land covered with a thick sheet of ice.

PICTURE STUDY



The Sea of Ice, Caspar David Friedrich, 1823–1824 · Oil on canvas · Hamburger Kunsthalle, Hamburg, Germany

Caspar David Friedrich was a German painter who loved to paint quiet, lonely places in nature. In his day, brave sailors were trying to sail through the frozen Arctic seas, and some of their ships were trapped and crushed by ice. Friedrich had never been to the Arctic. So one cold winter he went down to the river near his home and made careful paintings of the broken river ice. Then he used those studies to paint this great sea of ice.

Look closely

- Find the big pile of ice slabs. What shape does the pile make?
- Look on the right side for part of a ship. How much of it can you see?
- Look at the sky. Is it stormy or calm?
- Find the sharpest, pointiest piece of ice. Trace its edge in the air with your finger.

Talk about it

1. What do you think happened to the ship in this painting?
2. How is this picture like what happened to Shackleton's ship, the *Endurance*?
3. How does this painting make you feel: cold, afraid, quiet, amazed?

Safety first. Use warm tap water, not hot water from the stove, for the warmth test. If you feel ice water with your fingers, take them out after a few seconds and dry them well.

MAKE AND DO: EXPLORER'S WARMTH TEST

Amundsen dressed in furs, and Shackleton's men wore thick wool. Which wrapping keeps warmth in best? We will wrap jars of warm water, wait, and feel which stays warm, just as explorers had to choose their clothes.

You will need

- 3 small jars or plastic bottles, all the same size, with lids
- Warm tap water
- A wool sock or scarf
- A piece of aluminum foil
- Rubber bands
- A kitchen thermometer, if you have one
- A timer

Steps

1. Fill all 3 jars with the same warm tap water and close the lids.
2. Pull the wool sock over jar 1. Wrap jar 2 in foil. Leave jar 3 bare.
3. Set all 3 jars in the refrigerator or outside in the cold for 30 minutes. This is your Antarctica.
4. Guess first: which jar will stay warmest? Say why.
5. When the timer rings, unwrap each jar and feel it, or put the thermometer in each one and read the number.
6. Put the jars in order from warmest to coldest and draw them in your notebook.

Tips

- Keep everything the same except the wrapping: same jars, same water, same time, same cold place.
- Try a fourth jar wrapped in two layers, a thin cloth and then the sock. Explorers wore layers too.

Check your work

- I can tell which wrapping kept the water warmest.
- I can tell why explorers wore wool and furs.
- I kept everything the same except the wrapping.

FIELD NOTEBOOK

1. Draw a globe with the North Pole and the South Pole. Draw a polar bear near the top and a penguin near the bottom.
2. Draw Amundsen's dog sled crossing the snow to the South Pole tent with a flag.

3. Draw the *Endurance* stuck in the ice. Write one word that tells how the men must have felt.

From history. A photographer named Frank Hurley sailed with Shackleton. He took pictures of the *Endurance* trapped in the ice, the sled dogs and the men at work. When the ship was sinking, he waded into the cold water inside to save his glass picture plates. The men could carry only a little, so he chose the best pictures to keep. Those photographs still let us see what the men saw.

WORKED EXAMPLES

Example 1. When Shackleton went for help, 6 men sailed in the little boat and 22 men waited on the island. How many men were there in all? Did every man come home?

1. Start with the bigger number: 22 men on the island.
2. Count on 6 more for the men in the boat: 23, 24, 25, 26, 27, 28.
3. That makes 28 men in all.
4. Shackleton brought all 28 home, so no one was left behind.

Answer: $22 + 6 = 28$ men. Every one of the 28 men came home.

PRACTICE

1. **EASY** Who was the first to reach the South Pole?
2. **EASY** Look at the earth picture. Point to the North Pole and the South Pole.
3. **MEDIUM** Match each animal to its home: polar bear, penguin. Homes: the Arctic, Antarctica.
4. **MEDIUM** A sled team has 12 dogs. 4 more dogs join. How many dogs pull the sled now?
5. **HARD** Tell in your own words: what is one big difference between the Arctic and Antarctica?

COMMON MISTAKES

- Thinking polar bears and penguins live together. Polar bears live in the far north, and penguins live in the far south.
- Thinking the North Pole is on land. It is in the middle of an ocean covered with floating sea ice. The South Pole is on land.
- Thinking a coat makes heat. Warm clothes do not make heat. They hold in the warmth your body makes.

Make it a game • Race to the Pole. Put a pillow at the far end of the room. That is the South Pole. The child is a sled dog team and must answer a question to move one big step: Which pole has penguins? Is the Arctic land or ocean? What was Shackleton's ship called? Who reached the South Pole first? What keeps an explorer warm? Each right

answer is one step. When you reach the pole, plant a paper flag on it and shout, “We made it!”

Scripture. “If I take the wings of the morning, and dwell in the uttermost parts of the sea; Even there shall thy hand lead me, and thy right hand shall hold me.” (Psalm 139:9–10, KJV)

Explorers went to the very ends of the earth, to places with no towns at all. But no place is too far for God. His hand leads and holds His people even at the bottom of the world.

Practice answers

1. Roald Amundsen of Norway and his four friends, in 1911.
2. The North Pole is at the top. The South Pole is at the bottom.
3. Polar bear: the Arctic. Penguin: Antarctica.
4. $12 + 4 = 16$ dogs.
5. The Arctic is mostly ocean covered with floating sea ice. Antarctica is land covered with a thick sheet of ice. (Also: polar bears live in the Arctic, and penguins live in Antarctica.)

UNIT 5 REVIEW

This is an oral review. A parent reads each question aloud, and the child answers in their own words, pointing or drawing where it helps. Give full points for a clear answer with the main ideas. The review is worth 20 points.

1. (3 pts) Who explored Glacier Bay in a canoe, and what did he find?
2. (3 pts) How does snow become a glacier? What is calving?
3. (3 pts) Tell me about your ice cube and clay test. Which ice cube carved more, and why?
4. (3 pts) What shape valley does a glacier carve? What shape does a river cut? What did Agassiz's stakes show?
5. (3 pts) Why does ice float? How much of an iceberg is under the water?
6. (3 pts) Who reached the South Pole first? What happened to Shackleton's ship and his men?
7. (2 pts) Point to the North Pole and the South Pole on a globe. Which one is ocean covered with sea ice, and which one is land under ice?

UNIT PROJECT: MY GLACIER VALLEY MODEL

Build a glacier valley in a baking pan. Shape a clay mountain valley at one end and pour a little water "sea" at the other. Freeze a block of ice with sand and pebbles in its bottom and slide it down the valley to carve a U shape and leave a moraine where it melts. Float a homemade iceberg in the sea and mark its waterline. Add paper labels for the glacier, U-shaped valley, moraine, iceberg and waterline, and a small paper canoe for John Muir. Then give your family a tour, telling how snow becomes a glacier, how glaciers carve, why icebergs float, and the story of one polar explorer.

- **Model parts:** The model shows a glacier, a U-shaped valley, scratches, a moraine, a floating iceberg and a marked waterline.
- **Labels:** Each part is labeled with the right word, spelled as well as the child can.
- **Tour:** The child explains how snow becomes a glacier, how ice carves, why most of an iceberg hides under water, and retells one explorer's story.
- **Care:** The model is neat and built with patience, like a real scientist's model.

Answer key

1. John Muir, with a missionary friend and Tlingit guides. He found that the ice had melted back, and a long bay of open water now reached for many miles into the mountains.
2. More snow falls than melts. It piles up and the heavy snow on top presses the bottom snow into hard ice, which slowly moves downhill. Calving is when chunks of ice break off the front of a glacier into the water.
3. The ice cube with sand and pebbles frozen in it carved more. The stones scraped the clay like sandpaper. A real glacier carries stones and boulders that scratch the rock.
4. A glacier carves a U-shaped valley. A river cuts a V-shaped valley. Agassiz's stakes moved downhill, and the middle ones moved the most, so the glacier really flows.

5. Water grows a little bigger when it freezes, so ice is lighter than the same amount of water. About 9 parts out of 10 of an iceberg are under the water.
6. Roald Amundsen of Norway, with dog sleds. Shackleton's ship, the *Endurance*, was trapped and crushed by sea ice and sank, but Shackleton went for help and every man came home.
7. The North Pole (top) is in the Arctic, an ocean covered with floating sea ice. The South Pole (bottom) is in Antarctica, land covered by a thick sheet of ice.

OCEANS AND SHORES

On the third day of creation, God gathered the waters together and called them Seas, “and God saw that it was good” (Genesis 1:10). In this unit you will go down to the edge of the sea. You will watch the tide creep in and slide back out twice a day, pulled by the moon. You will see how the wind makes waves, and how waves carry sand away and bring it back. You will even learn why workers once rolled a whole lighthouse back from the sea.

You will look at sand with a magnifying glass and find bits of shell that were once part of living clams, snails and corals. You will visit an old Spanish fort in Florida built of shell rock. Last, you will find the wrack line on the beach and learn the words God spoke to the sea: “Hitherto shalt thou come, but no further” (Job 38:11). Like a real scientist, you will build beaches in a pan, measure, count and draw what you see.

BEFORE YOU BEGIN

- Can count to 50 and add two numbers under 20
- Can measure with a ruler or by counting steps
- Knows that the moon can be seen in the sky, sometimes even in the daytime
- Can tell the difference between land and water on a picture or map

MASTERY CHECKLIST

- I can tell what high tide and low tide are, and that the moon’s pull makes the tides.
- I can point to the crest and trough of a wave and tell that the wind makes most waves.
- I can show how waves move sand and make rocks smooth.
- I can tell how a shell becomes sand, and test shell bits with vinegar.
- I can find the wrack line in a picture and say Job 38:11.

OPTIONAL BOOKS AND RESOURCES

- **NOAA Tides and Currents** (<https://tidesandcurrents.noaa.gov/>): Free, from the U.S. government. A parent can look up the times of high and low tide for any U.S. beach. Plan a real tide-pool visit for low tide (Lesson 6.1).
- **Castillo de San Marcos National Monument (National Park Service)** (<https://www.nps.gov/casa/>): Free. Photos and information about the old Spanish fort in St. Augustine, Florida, built of coquina shell rock (Lesson 6.3).

6.1 TIDES ★

OBJECTIVES

- Tell what high tide and low tide are and point to each in a picture.
- Say that the moon's pull is the main cause of the tides, and that most beaches get two high tides and two low tides each day.
- Name three living things that can be found in a tide pool.

Warm-up. Float a toy boat or a bottle cap in the sink or bathtub. Slowly run the water and watch the boat rise. Now pull the plug a little and watch it sink back down. Ask: Did the boat move up and down, or did the water? The sea does something like this every day by the shore.

Video. Coming soon. High tide and low tide for kids, the Bay of Fundy and Hopewell Rocks time-lapse, and tide pool animals: search NOAA Ocean Service, SciShow Kids, Homeschool Pop (Alternate), Science Max and nature footage of tide pools.

KEY TERMS

tide

The slow rising and falling of the sea along the shore, which happens every day.

high tide

The time when the sea has come far up the beach.

low tide

The time when the sea has gone far out and you can see wet sand and rocks.

tide pool

A little pool of sea water left among the rocks when the tide goes out. Small sea animals live there.

CORE IDEAS

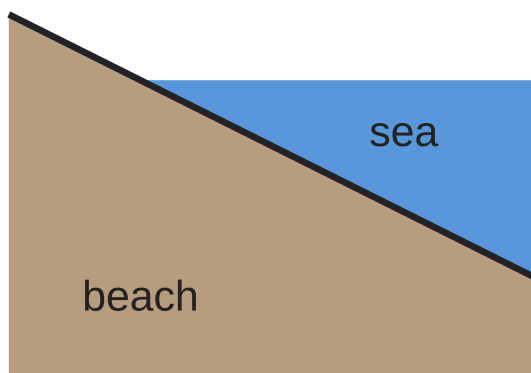
The story. In Canada there is a bay called the Bay of Fundy. At a place named Hopewell Rocks, tall rocks stand on the shore like giant flowerpots with trees on top. At low tide, families can walk on the wet sea floor between the rocks. They look at seaweed and snails. A few hours later, the very same place is full of deep water, and people paddle kayaks where they once walked! The Bay of Fundy has the biggest tides in the world. The water rises higher than a four-story house.

How they figured it out. People who lived by the sea watched the water come in and go out. They saw that it happened about two times every day. They also saw that the tides kept time with the moon. A great scientist named Isaac Newton explained why. The moon pulls on the earth, and it pulls on the ocean water too. Water can slide and move, so the moon's pull makes the ocean bulge a little.

The big idea. A **tide** is the slow rise and fall of the sea. When the water has come far up the beach, it is **high tide**. When the water has gone far out, it is **low tide**. The earth turns all day long. Your beach turns into the bulge of water, then out of it, then into the other bulge on the far side of the earth. So most beaches get two high tides and two low tides each day. The sun pulls on the sea a little bit too. Waves splash all the time, but a tide is slow. You can only see it if you watch for an hour or more.

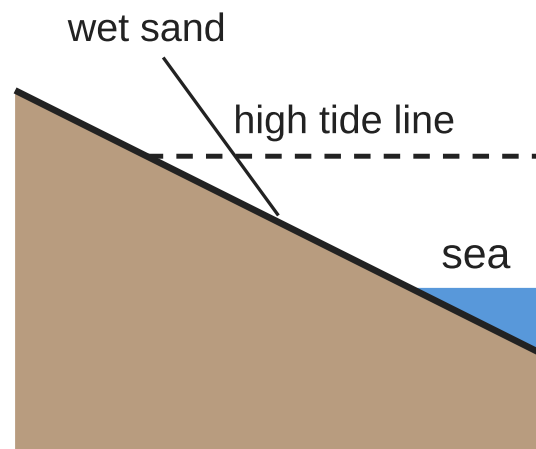
Try it and see. At low tide, little pools of water are left among the rocks. These are **tide pools**. Sea stars, crabs, snails and sea anemones live in them. They wait there until the sea comes back. **God's handiwork.** God made the moon to shine at night, and He also made it to move the oceans. The Bible says, "He appointed the moon for seasons" (Psalm 104:19). Every high tide comes right on time.

High tide



The sea comes far up.

Low tide



The sea goes far out.

The same beach at high tide and at low tide.

PICTURE STUDY



Low Tide at Pourville, near Dieppe, Claude Monet, 1882 · Oil on canvas · Cleveland Museum of Art, Cleveland, Ohio

Claude Monet was a French painter who loved to paint outdoors. He liked to paint the same place at different times of day to show how light and water change. In 1882 he stayed near the little village of Pourville, by the sea in France, and painted the shore again and again. In this painting the tide has gone out.

Look closely

- Find the sea. Find the shore. Where does the water stop?
- Look at the colors Monet used for the water. How many can you name?
- Look closely at the brushstrokes. Are they long and smooth, or short and quick?
- Put your finger where you think the water will be when the tide comes back in.

Talk about it

1. How can you tell this is low tide and not high tide?
2. If Monet came back to this spot a few hours later, how would his painting look different?
3. What would you like to look for on this shore while the tide is out?

Safety first. At the real seashore, stay with a grown-up at all times. Tides can come in quickly and cover rocks and sandbars. Always keep watching the water, and never turn your back on the sea. In tide pools, look gently and put animals back where you found them. Never leave a child alone near the water-filled pan or bathtub.

MAKE AND DO: A TIDE IN A PAN

You will build a little beach in a pan, then make the tide come in and go out. You will mark where the water reaches so you can see the difference between high tide and low tide.

You will need

- A large baking pan or plastic storage tub
- Sand or soil, enough to make a slope at one end
- A pitcher of water and a cup for scooping
- Toothpicks and two small paper flags (one marked H, one marked L)
- A few small shells, pebbles or a toy crab
- A towel for spills

Steps

1. Pile the sand at one end of the pan and pat it into a slope. This is your beach.
2. Press a small dip into the sand near the bottom of the slope. Put a shell or toy crab in it. This will become your tide pool.
3. Slowly pour water into the low end of the pan until it comes about halfway up the beach. This is high tide. Push the H flag into the sand right where the water stops.
4. Now scoop water out with the cup, slowly, until the water is far down the slope. This is low tide. Push the L flag into the sand where the water stops now.
5. Look at your tide pool. Is there still water in the dip? Your crab is safe until the tide returns.
6. Pour the water back in slowly to make the next high tide. Say, "The tide is coming in!"
7. Count how many finger-widths it is from the L flag to the H flag.

Tips

- Pour and scoop slowly. A real tide takes hours, not seconds.
- If the sand washes away, pat it firm with a spoon before you begin.

Check your work

- I can show high tide and low tide on my pan beach.
- I can point to the tide pool and tell why water stays in it.
- I can say what pulls the sea to make the tides.

FIELD NOTEBOOK

1. Draw the same beach two times: once at high tide and once at low tide. Color the water blue in both.
2. Draw a tide pool with at least three animals in it, such as a sea star, a crab and a snail. Label them.

3. Draw the moon above the sea and draw an arrow to show that the moon pulls on the water.

From history. Sailors and fishermen knew about tides for a very long time, but no one could explain them well. In 1687 the English scientist Isaac Newton wrote a famous book about how things pull on each other. He called this pull gravity. In his book he showed that the pull of the moon, and a smaller pull from the sun, makes the tides. Newton believed that God made the world with order, so he expected to find laws that were the same everywhere.

WORKED EXAMPLES

Example 1. Sam put his towel on the beach. At high tide, he walked 4 steps from his towel to the water. At low tide, he walked 15 steps to reach the water. At which tide was the water farther away? How many more steps did he walk?

1. Compare the two numbers: 4 steps and 15 steps. 15 is bigger than 4.
2. So the water was farther away at low tide. That makes sense, because at low tide the sea goes far out.
3. To find how many more steps, count up from 4 to 15: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15. That is 11 counts. Or subtract: $15 - 4 = 11$.

Answer: The water was farther away at low tide. Sam walked 11 more steps.

PRACTICE

1. **EASY** Look at the picture of the two beaches. Point to high tide. Point to low tide.
2. **EASY** What in the sky pulls on the ocean and makes the tides?
3. **MEDIUM** Most beaches have 2 high tides every day. How many high tides is that in 2 days? In 3 days?
4. **MEDIUM** At low tide, Mia counted 6 snails in one tide pool and 9 snails in another. How many snails did she count in all?
5. **HARD** Ben left his toy shovel right at the edge of the water at low tide and went to eat lunch. Tell what will happen to the shovel when the tide comes in, and why.

COMMON MISTAKES

- Thinking tides and waves are the same thing. Waves splash in every few seconds and are made mostly by the wind. A tide is the slow rise and fall of the whole sea over hours, made mostly by the moon's pull.
- Thinking the moon pulls on the sea only at night. The moon is pulling all the time, even in the daytime when we cannot see it.
- Thinking high tide comes at the same clock time every day. The tides come a little later each day, because they keep time with the moon.

Make it a game · High Tide, Low Tide. A parent calls out “High tide!” and everyone stretches up tall with arms over their heads. At “Low tide!” everyone crouches down low. At “Tide pool!” everyone freezes like a sea star with arms and legs spread out. Call faster and faster. Anyone who moves the wrong way becomes the caller.

Scripture. “He appointed the moon for seasons: the sun knoweth his going down.”
(Psalm 104:19, KJV)

God gave the moon its work to do. It lights the night, it marks the months, and its pull moves the oceans up and down every day. The tides are steady because God made the world in order.

Practice answers

1. High tide is the left picture, where the water covers most of the beach. Low tide is the right picture, where the water is far out.
2. The moon. (The sun pulls a little too.)
3. 4 high tides in 2 days and 6 high tides in 3 days.
4. $6 + 9 = 15$ snails.
5. The water will come up the beach and cover the shovel, and it may float away. This happens because the tide rises slowly after low tide until it is high tide.

6.2 WAVES SHAPE BEACHES

OBJECTIVES

- Tell that the wind makes most ocean waves, and point to the crest and the trough of a wave.
- Show with a pan of sand and water how waves carry sand away and bring it back.
- Tell why the Cape Hatteras Lighthouse had to be moved.

Warm-up. Fill a shallow bowl with water. Blow gently across the top with a straw, then blow harder. Watch the ripples. Ask: What made the little waves? What happened when you blew harder?

Video. Coming soon. How wind makes ocean waves, why waves break on the beach, and the 1999 move of the Cape Hatteras Lighthouse: search NOAA Ocean Service, the National Park Service, SciShow Kids, Homeschool Pop (Alternate), Science Max and slow-motion wave footage.

KEY TERMS

wave

A moving bump of water on the sea, made mostly by the wind.

crest

The top of a wave.

trough

The low dip between two waves.

erosion

When water or wind carries bits of sand, soil or rock away.

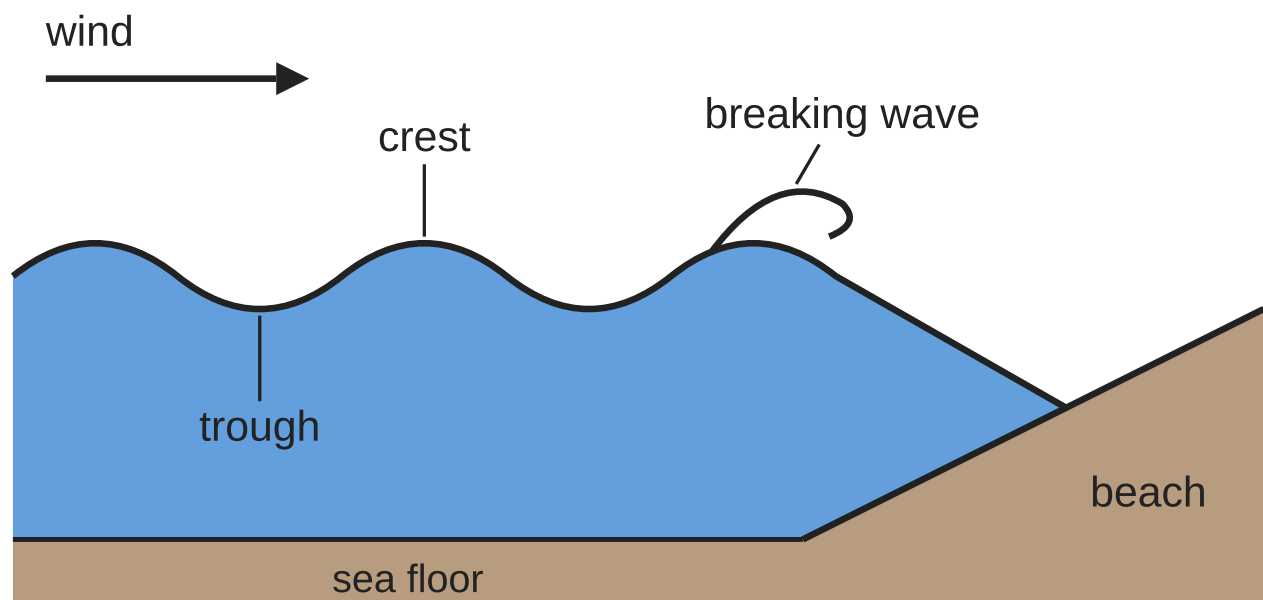
CORE IDEAS

The story. On the coast of North Carolina stands the Cape Hatteras Lighthouse. It is very tall, with black and white stripes that twist around it like a candy cane. It is the tallest brick lighthouse in America. When it was built, it stood far back from the sea. But year after year, the waves carried the beach sand away. Little by little, the ocean came closer, until the water was almost at the lighthouse's feet! So in 1999, workers lifted the whole lighthouse onto steel tracks. They slowly rolled it back, about half a mile, to a safe place. It still shines there today.

How they figured it out. People who watched beaches saw that a beach is never quite the same. After winter storms, much of the sand was gone. In calm summer weather, the sand came back. They learned that waves are always moving sand, like busy workers with tiny buckets.

The big idea. Most **waves** are made by the wind. Wind blows over the sea and pushes the water into bumps. The top of a wave is the **crest**. The low part between waves is the **trough**. Far out at sea, the water mostly bobs up and down as the wave passes by. Near the shore the water gets shallow. The bottom of the wave drags on the sand, and the top tips over and crashes. That is a breaking wave. Big stormy waves pull sand out to sea. Small gentle waves push sand back up the beach. When water or wind carries sand and rock away, we call it **erosion**. Waves also roll rocks against each other until they are round, smooth pebbles.

Try it and see. You can watch waves move sand in a pan at home. **God's handiwork.** Waves are strong enough to move a whole beach, but God is stronger still. The Bible says, "The LORD on high is mightier than the noise of many waters, yea, than the mighty waves of the sea" (Psalm 93:4).



Wind makes the waves. Each wave has a crest and a trough. Near the beach, waves break.

PICTURE STUDY



The Great Wave off Kanagawa, Katsushika Hokusai, about 1831 · Color woodblock print · Many prints were made. Copies are kept at the Metropolitan Museum of Art in New York, the Library of Congress and other museums.

Katsushika Hokusai was a Japanese artist. He carved his pictures into blocks of wood, put ink on them and pressed them onto paper, so that many copies could be made. This is the most famous picture he ever made. It shows a giant wave rising over fishing boats, with the snowy top of Mount Fuji far away.

Look closely

- Find the crest of the big wave. What does the white foam at the top look like to you?
- Find the boats. How many can you count? Can you see the rowers holding on?
- Find Mount Fuji. Does it look big or small next to the wave?
- Find a trough, a low dip in the water between the waves.

Talk about it

1. What do you think made such a big wave out at sea?
2. How do you think the rowers feel? What would you do if you were in the boat?
3. Why do you think Hokusai made the mountain look so small?

Safety first. At the beach, stay with a grown-up and stay out of the water unless a grown-up is with you. Even small breaking waves can knock a child down. Never leave a child alone with a pan or tub of water.

MAKE AND DO: A BEACH IN A PAN

You will build a sandy beach in a pan and make waves with a lid. You will watch where the sand goes when the waves are gentle and when they are big and stormy.

You will need

- A large baking pan or plastic storage tub
- Sand
- Water
- A flat plastic lid or a wide spatula for making waves
- A ruler
- A few small pebbles and a block or toy house

Steps

1. Pile sand at one end of the pan and pat it into a smooth slope. This is your beach.
2. Set the toy house near the top of the beach. Put a few pebbles at the water's edge.
3. Pour water in the low end until it comes a little way up the beach.
4. Hold the lid in the water at the far end. Push it gently back and forth to make 10 small waves. Watch the sand. Does it move up or down the beach?
5. Now make 10 big, stormy waves. Watch the sand again. Is the beach getting smaller? Is the water getting closer to the house?
6. Hold the ruler up in the water to see how tall your small waves and big waves are.
7. Move the house back up the slope, just like the workers moved the lighthouse.

Tips

- Use damp sand and pat it firm so the beach holds its shape.
- Make waves slowly at first. Very fast pushing just splashes water out of the pan.

Check your work

- I can make small waves and big waves in my pan.
- I can tell what happened to the sand when the waves were big.
- I can point to the crest and the trough of a wave.

FIELD NOTEBOOK

1. Draw a wave and label the crest and the trough.
2. Draw the Cape Hatteras Lighthouse with its twisting black and white stripes. Draw the sea close to it, and an arrow showing where it was moved.
3. Draw one rough rock and one smooth beach pebble. Write under the pebble: "Waves made me smooth."

From history. Benjamin Franklin loved to test things for himself. Sailors told him that oil poured on the sea made the waves calmer. So one windy day in 1773, on a pond at Clapham Common near London, he poured out about one teaspoon of oil. It spread over the water in a thin film, and the little waves on a large part of the pond went flat and smooth. Franklin wrote about it to a friend. Scientists still study why a thin film of oil quiets small waves.

WORKED EXAMPLES

Example 1. Lucy held a ruler in her pan. Her small waves were 2 centimeters tall. Her big, stormy waves were 5 centimeters tall. Which waves were taller? How much taller?

1. Compare: 5 is bigger than 2, so the stormy waves were taller.
2. Count up from 2 to 5 on the ruler: 3, 4, 5. That is 3 marks. Or subtract: $5 - 2 = 3$.

Answer: The stormy waves were taller, by 3 centimeters.

PRACTICE

1. **EASY** Look at the wave picture. Point to a crest. Point to a trough. Point to the breaking wave.
2. **EASY** What makes most ocean waves?
3. **MEDIUM** Jack counted 10 small waves in his pan and then 10 big waves. How many waves did he make in all?
4. **MEDIUM** A parent sets out some rough, sharp rocks and some round, smooth pebbles. Sort them into two piles. Which pile was most likely rolled by the waves on a beach?
5. **HARD** Tell in your own words why the Cape Hatteras Lighthouse had to be moved.

COMMON MISTAKES

- Thinking the water in a wave travels all the way across the sea to the beach. Out at sea, the water mostly bobs up and down as the wave passes, like a duck riding over a bump.
- Thinking a beach always stays the same. Waves carry sand away in storms and bring it back in calm weather, so beaches change all the time.
- Thinking the moon makes the waves. The moon makes the slow tides. The wind makes most of the waves.

Make it a game · Make a Wave. Stand in a line side by side with your family. The first person squats down and stands up, then the next person, then the next, so a “wave” runs down the line. Notice that nobody walks anywhere! The wave moves down the line, but each person stays in place, just like water bobbing as a sea wave passes. Try a slow, gentle wave and a fast, stormy one.

Scripture. “The LORD on high is mightier than the noise of many waters, yea, than the mighty waves of the sea.” (Psalm 93:4, KJV)

Waves can move sand, round off rocks and even push a beach right up to a lighthouse. But God, who made the wind and the sea, is mightier than all of them.

Practice answers

1. The crest is the top of a wave, the trough is the low dip between two waves, and the breaking wave is the one curling over near the beach.
2. The wind blowing over the water.
3. $10 + 10 = 20$ waves.
4. The smooth, round pebbles. Waves roll rocks against each other until the sharp corners wear off.
5. Waves carried the beach sand away little by little, so the sea came closer and closer to the lighthouse. Workers moved it back from the water so it would be safe.

6.3 SAND FROM SHELLS

OBJECTIVES

- Tell how a shell made by a sea animal can be broken and rubbed by the waves until it becomes sand.
- Look at sand with a magnifying glass and sort bits of shell from bits of rock.
- Tell how the Spanish built a strong fort in Florida from rock made of shells.

Warm-up. Hold a seashell in one hand and a pinch of sand in the other. Feel them both. Rub the shell gently on a rough sidewalk or a piece of sandpaper for one minute and look at the white dust it leaves. Ask: Could the sea turn a whole shell into sand?

Video. Coming soon. Sand under a microscope, how shells and coral become sand, parrotfish making sand, Bermuda’s pink sand, and coquina rock at Castillo de San Marcos: search the National Park Service, NOAA Ocean Service, the Smithsonian, SciShow Kids and close-up nature footage.

KEY TERMS

sand

Tiny grains of rock or shell, small enough to run through your fingers.

shell

The hard outside covering that a sea animal such as a clam or snail makes to protect its soft body.

coquina

A rock made of small shells and shell bits stuck together. Its name is a Spanish word for tiny clams.

CORE IDEAS

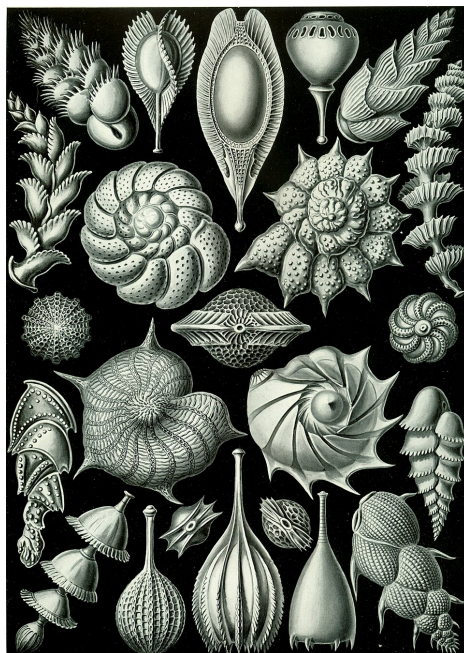
The story. In St. Augustine, Florida, there is an old stone fort by the sea called the Castillo de San Marcos. Spanish builders began it in 1672. They did not have hard granite to build with. Instead, they dug up a rock called **coquina** on an island across the bay. Coquina is made of thousands of tiny shells stuck together! Later, when enemy soldiers fired cannons at the fort, the cannonballs sank into the shell walls, like a thumb pressing into soft bread. The walls did not crack apart. The fort still stands today.

How they figured it out. If you look at beach sand with a magnifying glass, you will find many kinds of grains. Many are clear or tan bits of rock. Others are curved, white or pink, with little lines on them. Those are bits of **shell**! Here is a test scientists use. Drop shell bits into vinegar, and they make tiny bubbles. Most rock sand does not bubble at all.

The big idea. Shells are made by living animals. Clams, snails, oysters, sea urchins and corals all build hard shells or skeletons. When an animal dies, its shell is left behind. Waves roll it, bang it on rocks and rub it against other shells. It breaks into pieces. The pieces get smaller and smaller, until they are **sand**. Some beaches are almost all shell sand. On Shell Beach in Australia, the beach is made of tiny white cockle shells, piled deep. In Bermuda, the sand is pink because tiny sea creatures with red shells are mixed in. In warm seas, parrotfish bite off bits of coral with their hard beaks and crunch it up. Then they leave sand behind them!

Try it and see. You can break shells and watch them fizz in vinegar. **God's handiwork.** Every grain of shell sand was once part of a living creature God made. There are more sand grains than anyone could count. Yet the Bible says God's thoughts toward His people are even more: "If I should count them, they are more in number than the sand" (Psalm 139:18).

PICTURE STUDY



*Thalamophora (tiny shelled sea creatures), Plate 81 of Art Forms in Nature, Ernst Haeckel, 1904 · Color printed plate from the book *Kunstformen der Natur* (Art Forms in Nature) · Published in Leipzig, Germany; copies are kept in many libraries*

Ernst Haeckel was a German scientist and artist who studied tiny sea creatures with a microscope. He drew them very large and very carefully, so people could see their beauty. This page shows a kind of tiny sea creature that builds a shell, many of them smaller than a grain of sand. In some places, like the pink beaches of Bermuda, shells like these are part of the sand.

Look closely

- Find a shell that curls around in a spiral, like a snail.
- Find a shell with rows of little rooms or chambers.

- Find a shell with spikes or points. How many points can you count?
- Look at how the shells are arranged on the page. Are they in a pattern?

Talk about it

1. Why do you think Haeckel drew these shells so much bigger than they really are?
2. If these little shells broke into pieces on a beach, what would they become?
3. Which shell is your favorite? Why?

Safety first. Broken shells can have sharp edges. A grown-up should do the crushing, with the shells sealed inside a zip bag. Do not put shell bits or sand in your mouth. Keep vinegar away from your eyes, and wash your hands when you are done.

MAKE AND DO: MAKE SHELL SAND AND TEST IT

You will turn shells into sand, look at it up close, test it with vinegar, and then glue it into a little block of your own coquina rock.

You will need

- A few clean seashells (from a beach or a craft store)
- A heavy zip bag and a rolling pin
- A small plastic jar with a lid
- A handful of play sand or beach sand
- A magnifying glass
- White vinegar and two small clear cups
- White school glue and an ice-cube tray or paper cup

Steps

1. A grown-up puts the shells in the zip bag, seals it, and rolls and taps it with the rolling pin until the shells are in small pieces.
2. Put the pieces in the jar with the lid on tight. Shake the jar hard and count to 50. Open it and look. Are the pieces smaller? Is there any white dust? This is what the waves do, over and over.
3. Look at your shell bits and your play sand with the magnifying glass. How are they different?
4. Put a spoonful of shell bits in one cup and a spoonful of play sand in the other. Pour a little vinegar into each cup. Watch closely. Which one makes tiny bubbles?
5. Mix the rest of your shell bits with a few squeezes of glue. Press the mix into an ice-cube tray or paper cup. Let it dry overnight. Pop it out. You made coquina!

Tips

- The bubbles from shell bits are small. Hold the cup up to the light or look with the magnifying glass.

- Thin shells, like small clam shells, break more easily than thick ones.

Check your work

- I can tell how a shell becomes sand.
- I can tell which cup bubbled in the vinegar, and why.
- I can show my coquina block and tell what it is made of.

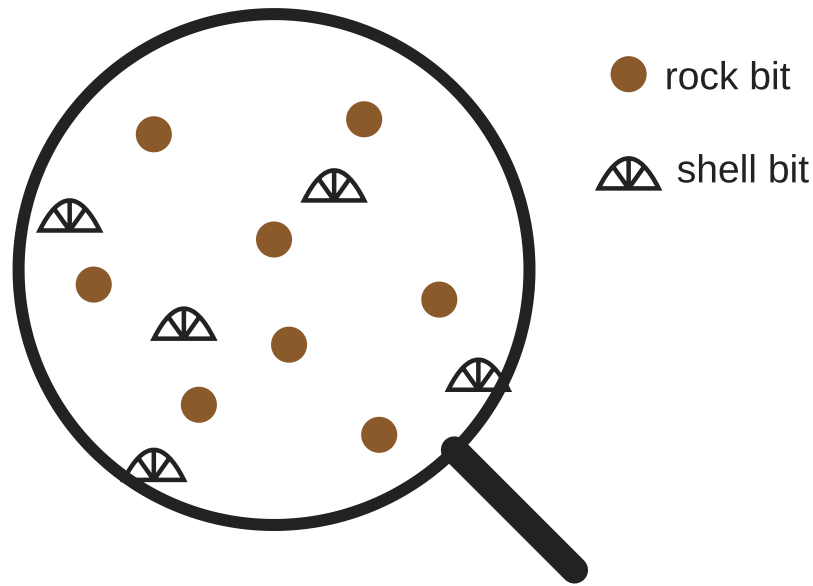
FIELD NOTEBOOK

1. Draw what a shell looks like as it turns into sand: first a whole shell, then big pieces, then small pieces, then tiny grains.
2. Look at sand with a magnifying glass. Draw five grains just as big as they look in the glass, and color them.
3. Draw the Castillo de San Marcos with a cannonball stuck in its shell wall. Write:
“Coquina is made of shells.”

From history. Shell Beach, in Shark Bay in Western Australia, is covered with tiny white cockle shells instead of sand, and the shells are piled very deep. In some places the shells have packed together into soft rock, a kind of coquina. Long ago, people cut blocks of this shell rock and used them to build some of the buildings in the nearby town of Denham. Today Shark Bay is protected, so people may visit and look, but the shells are left in place.

WORKED EXAMPLES

Example 1. Look at the magnifying-glass picture of sand. The round brown dots are bits of rock. The little fan shapes with lines are bits of shell. Count only the grains inside the glass, not the two in the key. How many rock bits are there? How many shell bits? Which kind is there more of?



Sand up close. Count the rock bits and the shell bits.

1. Touch and count each round brown dot: 1, 2, 3, 4, 5, 6, 7, 8. There are 8 rock bits.
2. Touch and count each fan shape: 1, 2, 3, 4, 5. There are 5 shell bits.
3. Compare: 8 is more than 5. Count up from 5 to 8: 6, 7, 8. That is 3 more.

Answer: 8 rock bits and 5 shell bits. There are more rock bits, 3 more than shell bits.

PRACTICE

1. **EASY** Name three sea animals that make shells.
2. **EASY** Which fish bites off bits of coral and leaves sand behind?
3. **MEDIUM** Emma found 7 white shell bits and 5 pink shell bits in her sand. How many shell bits did she find in all?
4. **MEDIUM** A parent mixes a spoonful of crushed shells and a spoonful of play sand into two cups. Before pouring vinegar on them, guess which one will bubble. Then test it and tell what happened.
5. **HARD** Tell the story of how a clam shell becomes sand. Use the words “waves,” “pieces” and “sand.”

COMMON MISTAKES

- Thinking all sand is made of shells. Most beach sand is made of tiny bits of rock. Shell sand is common on some beaches, especially in warm seas.
- Thinking shells are made by the sea itself. Every shell was built by a living animal, such as a clam, snail or coral.
- Thinking a shell turns into sand in one big crash. It happens bit by bit, as waves roll, break and rub the pieces over and over.

Make it a game · Shell or Rock?. A parent fills a tray with a mix of small shells, shell pieces, pebbles and bits of gravel. Set a timer for one minute. Sort them into two piles: Shell and Rock. When time is up, count each pile. Then trade places and let the parent sort while you check their work. Look for curved shapes and little lines to spot the shells.

Scripture. “If I should count them, they are more in number than the sand: when I awake, I am still with thee.” (Psalm 139:18, KJV)

No one can count all the grains of sand on the seashore. David says God’s thoughts toward him are even more than that. God never stops caring for His children, morning, noon and night.

Practice answers

1. Any three of these: clams, snails, oysters, mussels, scallops, cockles, sea urchins, corals.
2. The parrotfish.
3. $7 + 5 = 12$ shell bits.
4. The crushed shells bubble in vinegar. The play sand, which is mostly bits of rock, does not bubble.
5. A clam makes its shell. When the clam dies, the shell is left on the sea floor or the beach. The waves roll it and bang it on rocks until it breaks into pieces. The pieces keep getting rubbed and broken until they are tiny grains of sand.

6.4 “HITHERTO SHALT THOU COME” (JOB 38:11)

OBJECTIVES

- Say Job 38:11 and tell what it means: God set a boundary for the sea.
- Find the high tide line and the wrack line in a picture, and make a wrack line in a pan.
- Tell how sand dunes and beach grass help hold the shore in place.

Warm-up. Fill the bathroom sink halfway and sprinkle a few bits of torn paper or dried herbs on the water. Now let a little water out. Look at the side of the sink. Did some of the bits stay stuck where the water was highest? That line shows how far the water came.

Video. Coming soon. The wrack line and the high tide line on a beach, sand dunes and dune grass, and what lives in seaweed on the shore: search NOAA Ocean Service, the National Park Service, SciShow Kids, Homeschool Pop (Alternate), Moody Science classics and nature footage of beaches.

KEY TERMS

shore

The edge of the land where it meets the sea.

boundary

A line that marks how far something can go.

wrack line

A wiggly line of seaweed, shells and driftwood left on the beach where the high tide stopped.

sand dune

A hill of sand at the top of a beach, piled up by the wind and often held in place by grass.

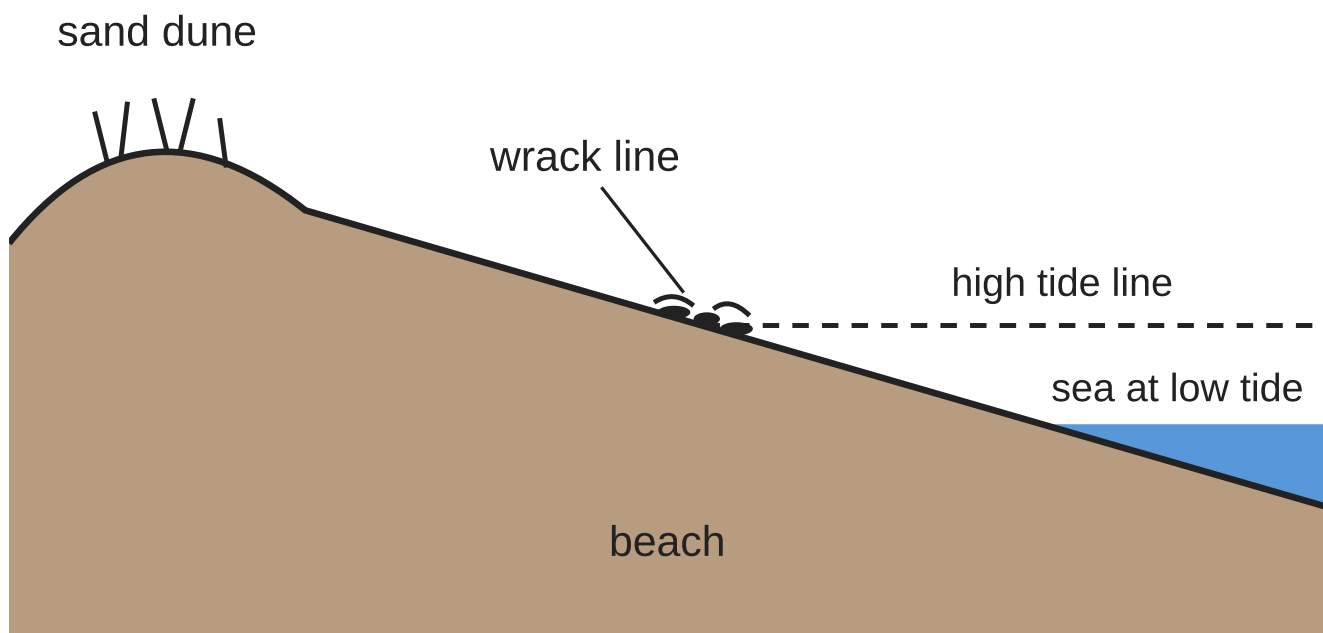
CORE IDEAS

The story. Walk along a beach after the tide has gone out, and look up the sand. You will find a long, wiggly line of seaweed, shells, crab shells and bits of driftwood. This is the **wrack line**. It shows exactly where the high tide stopped and turned back. Long ago, God spoke to a man named Job out of a whirlwind. He asked Job who had shut up the sea with doors. Then God told what He had said to the sea: “Hitherto shalt thou come, but no further: and here shall thy proud waves be stayed” (Job 38:11). *Hitherto* is an old word that means “this far.”

How they figured it out. Map makers and sailors carefully measured where the sea meets the land. They found that the tide rises to its high tide line, then turns and goes back out, day after day. They draw the edge of the land on their maps along the line where high tide usually stops.

The big idea. On the third day of creation, God gathered the waters into one place and let the dry land appear (Genesis 1:9). The oceans fill the great low places of the earth. The **shore** is the edge where land and sea meet. It may be a sandy beach, a rocky cliff or a marsh. The tide rises to a **boundary** and turns back. Waves run up the sand and slide back down. A big storm can push the water higher for a while, but then the sea goes back to its place. At the top of many beaches stand **sand dunes**. Grass grows on them, and its long roots hold the sand like fingers, so the dunes guard the land behind them.

God's handiwork. Once, in Noah's day, God sent the Flood, and the waters covered the whole earth. Afterward God made a promise: "neither shall there any more be a flood to destroy the earth" (Genesis 9:11). Every wrack line is a little reminder that the sea stops where God tells it to stop.



The wrack line shows where the high tide stopped.

PICTURE STUDY



The Monk by the Sea, Caspar David Friedrich, 1808-1810 · Oil on canvas · Alte Nationalgalerie (Old National Gallery), Berlin, Germany

Caspar David Friedrich was a German painter who loved to paint the sea, the mountains and the sky. In this painting a man stands alone at the very edge of the land, looking out at a dark, wide sea. The sky above him is huge. Many people think Friedrich wanted us to feel how small we are, and how great is the God who made the sea and the sky.

Look closely

- Find the man. Is he big or small in the picture?
- Find the shore, the sea and the sky. Which one takes up the most room?
- Look at the line where the sand meets the water. Does the sea come up past it?
- What colors did Friedrich use for the sea? For the sky?

Talk about it

1. What do you think the man is thinking about as he looks at the sea?
2. How does this painting make you feel? Big or small? Quiet or noisy?
3. If you stood on this shore, what verse could you say about the sea?

Safety first. At a real beach, stay with a grown-up and keep away from the water's edge unless a grown-up is with you. When you explore the wrack line, look but do not touch jellyfish, even ones that seem dead, because they can still sting. Watch out for sharp shells, fish hooks and broken glass. Wash your hands afterward.

MAKE AND DO: MAKE A WRACK LINE

You will build a beach in a pan, sprinkle “seaweed” on the water, and make the tide go up and down. The floating bits will be left behind in a line that shows how far your sea could come. Then you will mark the boundary with a verse card.

You will need

- A large baking pan or plastic storage tub
- Damp sand, piled into a slope at one end
- A pitcher of water and a cup for scooping
- Small floating bits: torn green paper, dried parsley or oregano, tiny twigs
- A craft stick and a small card with Job 38:11 written on it
- A ruler

Steps

1. Pat the damp sand into a slope at one end of the pan. Pile a little hump at the very top for a sand dune.
2. Pour water into the low end until it reaches partway up the beach.
3. Sprinkle the floating bits on the water. This is your seaweed.
4. Slowly pour in more water to make high tide. Watch the bits float up the beach.
5. Now scoop out water slowly to make low tide. Look at the sand. Where did the bits stop? That is your wrack line!
6. Use the ruler to measure from the low tide water to your wrack line.
7. Tape the verse card to the craft stick and push it into the sand just above the wrack line. Read it aloud together: “Hitherto shalt thou come, but no further: and here shall thy proud waves be stayed.”

Tips

- Pour slowly so the bits ride up gently and are left in a neat line.
- Do it twice, once with a little water and once with more. Which wrack line is higher up the beach?

Check your work

- I can show where my wrack line is and tell what made it.
- I can say Job 38:11.
- I can tell how dune grass helps the shore.

FIELD NOTEBOOK

1. Draw a beach from the side, with a sand dune, the wrack line and the sea. Label all three.
2. Copy Job 38:11 in your best handwriting and draw a wave stopping at a line under it.

3. If you can visit a beach, draw five things you find in the wrack line. If not, draw five things you think you might find there.

From history. Matthew Fontaine Maury was an American Navy officer who studied the sea. He gathered the logbooks of many ships and used their notes on winds and currents to make charts that helped sailors find faster, safer routes across the oceans. In 1855 he wrote a book called *The Physical Geography of the Sea*. Maury was a Christian, and he believed the winds and waters move by laws that God set in place.

WORKED EXAMPLES

Example 1. Grace stood at the edge of the sea at low tide. She walked 12 steps up the beach to the wrack line. Then she walked 9 more steps to the sand dune. How many steps did she walk in all, from the water to the dune?

(Use the map or drawing “From the low tide water, up to the wrack line, then up to the dune.” shown earlier in this lesson.)

1. First part: from the water to the wrack line was 12 steps.
2. Second part: from the wrack line to the dune was 9 steps.
3. Put them together: $12 + 9$. Start at 12 and count on 9: 13, 14, 15, 16, 17, 18, 19, 20, 21.

Answer: Grace walked 21 steps from the water to the dune.

PRACTICE

1. **EASY** What is the wrack line? What does it show?
2. **EASY** In Job 38:11, who tells the sea, “Hitherto shalt thou come, but no further”?
3. **MEDIUM** Look at the beach picture. Point to the sand dune, the wrack line, the high tide line and the sea at low tide.
4. **MEDIUM** In the wrack line, Noah counted 14 shells and 9 crab shells. How many did he count in all?
5. **HARD** Tell why it helps to have grass growing on sand dunes.

COMMON MISTAKES

- Thinking the sea could spill over all the land at any time. The oceans fill the low places God made for them, and the tide rises to its line and turns back.
- Thinking each high tide goes higher and higher forever. Tides rise and fall over and over. A storm can push water higher for a short time, but then it goes back.
- Thinking Job 38:11 means the beach never changes. Waves still move sand around, as we saw in Lesson 6.2. But the sea as a whole stays within the bounds God set.

Make it a game • Hitherto!. Lay a rope or a line of tape on the floor or grass. That is the shore. Children are the waves. They start far away and “roll” toward the line, waving their arms. When a parent calls “Hitherto!” every wave must stop right at the line and roll back, without stepping over. Anyone who crosses the line becomes the caller. End by saying Job 38:11 together.

Scripture. “And said, Hitherto shalt thou come, but no further: and here shall thy proud waves be stayed?” (Job 38:11, KJV)

God asked Job these questions to show him how great God is. Only the One who made the sea can tell it where to stop. The same God who holds back the proud waves holds us safely in His care.

Practice answers

1. It is a line of seaweed, shells and driftwood on the beach. It shows where the high tide stopped.
2. God.
3. The dune is the hill on the left, the wrack line is the row of seaweed and shells in the middle of the beach, the dashed line shows the high tide line, and the blue water on the right is the sea at low tide.
4. $14 + 9 = 23$.
5. The long roots of the grass hold the sand together, so the wind and waves cannot carry the dune away as easily. The dune then protects the land behind it.

UNIT 6 REVIEW

This is an oral review. A parent reads each question aloud, and the child answers out loud, points or draws. Give full points for a clear answer in the child's own words. The review is worth 20 points.

1. (3 pts) What is high tide? What is low tide?
2. (3 pts) What pulls on the ocean to make the tides? How many high tides do most beaches get each day?
3. (3 pts) What makes most ocean waves? Draw a wave and point to its crest and its trough.
4. (3 pts) Why did workers move the Cape Hatteras Lighthouse?
5. (3 pts) Tell how a shell becomes sand.
6. (3 pts) What is coquina? What did the Spanish build with it?
7. (2 pts) What is the wrack line? Say what God told the sea in Job 38:11.

UNIT PROJECT: MY SEASHORE IN A BOX

Build a seashore in a shoebox lid or a baking pan. Shape a sand dune with grass at the top, a sloping beach and a blue sea at the bottom (paper, paint or real water). Mark the high tide line and the low tide line with small flags, lay a wrack line of torn paper seaweed and tiny shells, press a tide pool into the rocks with a sea star or crab, and add a little block of your homemade coquina. Stand a verse card with Job 38:11 at the wrack line. Then give your family a tour and tell what each part is and how it got there.

- **Parts of the shore:** The dune, beach, sea, high tide line, low tide line, wrack line and tide pool are all shown and labeled.
- **Telling the science:** The child explains tides, how waves move sand, and how shells become sand, in their own words.
- **Scripture:** The child says Job 38:11 and tells what it means.
- **Care:** The seashore is made carefully and neatly, with real looking and real effort.

Answer key

1. High tide is when the sea has come far up the beach. Low tide is when the sea has gone far out.
2. The moon (and the sun a little). Most beaches get 2 high tides each day.
3. The wind. The crest is the top of the wave; the trough is the low dip between waves.
4. Waves carried the beach sand away little by little until the sea was close to the lighthouse, so they rolled it back to a safe place.
5. An animal makes the shell. After it dies, waves roll the shell and bang it on rocks until it breaks into smaller and smaller pieces, which become sand.
6. Coquina is rock made of small shells stuck together. The Spanish built the Castillo de San Marcos, a fort in St. Augustine, Florida, with it.

7. The wrack line is a line of seaweed, shells and driftwood that shows where high tide stopped.
“Hitherto shalt thou come, but no further: and here shall thy proud waves be stayed.”

DINOSAUR LANDS

God made every land animal on the sixth day of creation, “every thing that creepeth upon the earth after his kind” (Genesis 1:25). Some of the most amazing were the dinosaurs. In this unit we visit real places where the rocks hold their bones and footprints, and we learn to read those clues like real scientists.

You will climb the ridge in Utah where Earl Douglass found eight dinosaur tail bones in 1909, and see the wall of bones at Dinosaur National Monument. You will walk the Paluxy River near Glen Rose, Texas, where Roland T. Bird dug up a trackway of giant footprints. You will become a tooth detective like Gideon Mantell and sort plant eaters from meat eaters. Then you will open Genesis to see what God says about every creeping thing that went into Noah’s ark.

Along the way you will meet a few **museum words**, like Jurassic and Cretaceous, that you will see on signs. You will learn what the signs say, what we can really see and measure, and how Christians who read Genesis as history understand dinosaurs and the Flood.

BEFORE YOU BEGIN

- Can count objects to 20 and add small numbers
- Knows that rock can form in layers (from earlier units)
- Knows the story of Noah and the Flood
- Can draw a simple picture and label it with help

MASTERY CHECKLIST

- I can tell what Earl Douglass found and why so many bones are buried together at Dinosaur National Monument.
- I can explain how a footprint in mud becomes a footprint in rock.
- I can tell walking tracks from running tracks.
- I can tell a plant eater from a meat eater by the shape of its teeth.
- I can tell from Genesis that God made land animals and people on the sixth day and saved every kind on the ark.
- I can tell what a museum sign says about time and how Christians read it.

OPTIONAL BOOKS AND RESOURCES

- **Dinosaur National Monument (National Park Service)**
(<https://www.nps.gov/dino/>): Free. Photos of the Quarry Exhibit Hall wall of bones, the story of Earl Douglass and ranger pages for kids. Good for Lesson 7.1.
- **Dinosaur Valley State Park (Texas Parks and Wildlife)**
(<https://tpwd.texas.gov/state-parks/dinosaur-valley>): Free to browse. Photos and visiting tips for the Paluxy River dinosaur tracks at Glen Rose. Good for Lesson 7.2.

7.1 DINOSAUR NATIONAL MONUMENT ★

OBJECTIVES

- Tell who Earl Douglass was and what he found in Utah in 1909.
- Explain in simple words how many dinosaur bones ended up together in one layer of sandstone.
- Dig up pretend bones carefully and map where each one was found, like a real bone hunter.

Warm-up. Pour a cup of sand into a pan and hide three small things in it, like a button, a paper clip and a toy. Give your child a paintbrush or an old toothbrush. Can they find all three without using their fingers? Brushing slowly is how real bone hunters work.

Video. Coming soon. Dinosaur National Monument Quarry Exhibit Hall wall of bones for kids: search the National Park Service (NPS) Dinosaur National Monument channel, Carnegie Museum of Natural History, Smithsonian, SciShow Kids and Homeschool Pop (Alternate) for footage of the bone wall and rangers explaining the dig.

KEY TERMS

fossil

Any sign of a living thing kept in rock, like a bone, a tooth, a shell or a footprint.

quarry

A place where people dig rock out of the ground. A bone quarry is where they dig out fossil bones.

sandstone

A rock made of sand grains stuck together. Many dinosaur bones are found in it.

paleontologist

A scientist who digs up and studies fossils. Say it: pay-lee-on-TOL-uh-jist.

CORE IDEAS

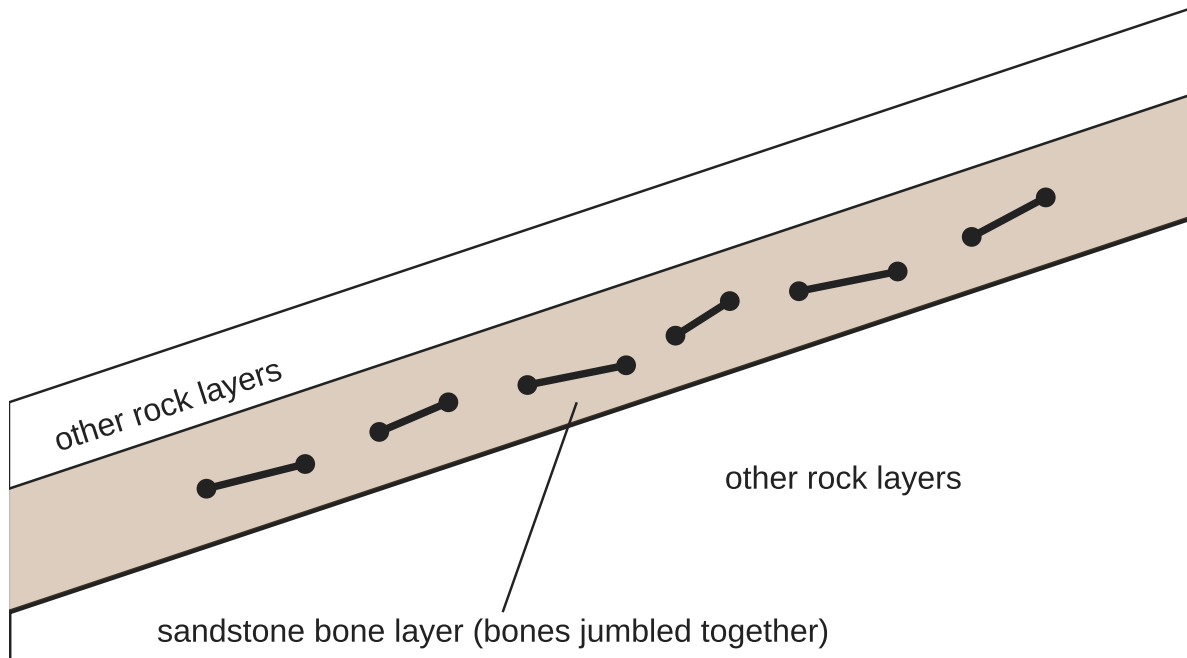
The story. On August 17, 1909, a bone hunter named Earl Douglass was climbing a rocky ridge in Utah, near the little town of Jensen. He worked for the Carnegie Museum in Pittsburgh. He had searched for weeks. Then, at the top of the ledge, he saw them: eight tail bones of a giant long-necked dinosaur, still lying in a row in the rock, just as they had been in the animal's tail. He wrote about it in his diary that very night. It was the start of one of the greatest dinosaur digs ever.

How they figured it out. Douglass and his helpers dug for many years. They found bone after bone in one thick layer of **sandstone**. Some were from plant eaters, like Apatosaurus, Diplodocus, Camarasaurus and Stegosaurus. Some were from meat eaters, like Allosaurus. Many of the bones were jumbled together, as if something had piled them up. The sand

around them showed that moving water had carried and dropped it. So the scientists wondered what could pile up so many animals in one place. They saw that water must have swept the bodies together and buried them in sand. In 1915 President Woodrow Wilson made the place a national monument so it would be kept safe.

The big idea. A **fossil** is a sign of a living thing kept in rock. Most animals that die are eaten or rot away and leave nothing. To become a fossil, a bone usually has to be buried quickly in mud or sand. Then the sand hardens into rock around it. That is why a big pile of fossil bones tells a story of fast burial, often by water.

In the world today. Dinosaur National Monument sits on the line between Utah and Colorado. Douglass hoped people could one day see the bones right where they lay. Today you can! Inside the Quarry Exhibit Hall, one whole wall of rock still holds about 1,500 dinosaur bones. **Paleontologists** brushed the sand away but left the bones in place. You can even touch a few real dinosaur bones there. Every one was made by God, who said, “Let the earth bring forth the living creature after his kind” (Genesis 1:24).



At Dinosaur National Monument the rock layers are tipped up on a slant. One sandstone layer is packed with bones. The Quarry Exhibit Hall is built over part of this layer.

Thinking About Time

What the sign says. What the sign says: the signs call this the Jurassic, a museum word for a time they say was very, very long ago, long before any people lived.

What we observe. What we observe: we see one thick layer of sandstone full of jumbled bones. Moving water laid down that sand and buried the bones fast.

How Christians read it. How Christians read it: many Christians think a great rush of water, likely during Noah's Flood, piled up these animals and buried them quickly. God made land animals and people on the same day, the sixth day.

Try it. Bury a toy in a cup of wet sand and pat it down. Water and sand can hide things fast.

Genesis 7:19

PICTURE STUDY



The Wall of Bones, Quarry Exhibit Hall, National Park Service photograph, 2013 · Photograph · Dinosaur National Monument, near Jensen, Utah

This picture was taken by the National Park Service inside the Quarry Exhibit Hall. It is not a painting. It is a real wall of sandstone with real dinosaur bones still stuck in it. Workers carefully chipped and brushed away the rock so the bones stand out, but they left the bones right where they were found.

This is just what Earl Douglass hoped for. He wanted families to come and see the bones lying in the rock, the way God's world had kept them.

Look closely

- Find one very long bone. Could it be a leg bone? How many of your arms long might it be?
- Find some round, knobby bones. Those might be backbones or tail bones, like the eight Douglass first saw.
- Are the bones lined up in neat skeletons, or are they jumbled together?
- Look at the rock around the bones. Does it look like hardened sand?

Talk about it

1. Why do you think so many bones were piled up in one place?
2. Why might it be better to leave some bones in the rock instead of taking them all to a museum?
3. If you could touch one bone on this wall, which one would you pick?

Safety first. Use a soft paintbrush or toothbrush, not a sharp tool, to dig. Keep sand away from eyes. At a real park, never dig, climb on rock walls or take fossils home; leave them for rangers and scientists.

MAKE AND DO: MY BONE QUARRY DIG

You will be a paleontologist like Earl Douglass. You will dig pretend bones out of “sandstone,” draw a map of where each bone lay, and then try to put your dinosaur back together.

You will need

- A baking pan or plastic tub
- Sand or cornmeal, enough to fill the pan a few inches deep
- About 12 pieces of dry pasta in different shapes (long noodles for leg bones, small tubes for backbones, shells for a skull)
- A soft paintbrush or old toothbrush and a spoon
- Paper, pencil and a ruler

Steps

1. Ask a parent to bury the pasta bones in the sand while you look away. They can jumble the bones, just like the bones at the monument.
2. With the ruler and pencil, draw a big tic-tac-toe grid on your paper. This is your quarry map. Draw the same grid in the sand with your finger.
3. Dig slowly with the spoon and brush. When you find a bone, stop!
4. Before you lift it, draw it on your map in the right square. Real bone hunters always map a bone before they move it.
5. Lift the bone out and set it on a towel. Keep going until you find all of them.
6. Count your bones. Then try to lay them out in the shape of a dinosaur. Which bone is a leg? Which bones make the tail?

Tips

- Go slow. A real paleontologist may brush for hours to uncover one bone.
- If two bones were found touching, they may have come from the same animal. Your map helps you remember.

Check your work

- I can tell who Earl Douglass was.
- I mapped each bone before I moved it.
- I can explain why so many bones were found together.

FIELD NOTEBOOK

1. Draw Earl Douglass on the rocky ledge looking at the eight tail bones. Write his name and “1909.”
2. Draw the slanted rock layers from the lesson picture. Color the bone layer and draw bones in it.
3. Draw one bone from the picture study. Label it with your best guess: leg, backbone, rib or skull.

From history. The first great skeleton Douglass dug out was a long-necked plant eater. It was taken to the Carnegie Museum in Pittsburgh and named *Apatosaurus louisae*, after Louise Carnegie, the wife of Andrew Carnegie, who paid for the dig. You can still see it standing in the museum today.

WORKED EXAMPLES

Example 1. A bone hunter makes a picture chart of the bones she dug up today. Each  is one bone. Allosaurus:   . Stegosaurus:      . Apatosaurus:        . Which dinosaur had the most bones found? How many more than Stegosaurus?

1. Count each row. Allosaurus has 3. Stegosaurus has 5. Apatosaurus has 8.
2. 8 is the biggest number, so Apatosaurus had the most bones found.
3. To find how many more than Stegosaurus, count up from 5 to 8: 6, 7, 8. That is 3 more.

Answer: Apatosaurus had the most, 8 bones. That is 3 more than Stegosaurus. (Eight is also how many tail bones Earl Douglass first saw!)

PRACTICE

1. **EASY** Who found the first bones at Dinosaur National Monument?
2. **EASY** Dinosaur National Monument sits on the line between two states. Can you name them?
3. **MEDIUM** Look at the drawing of the hill. Point to the bone layer. Is it flat or slanted?
4. **MEDIUM** Douglass first saw 8 tail bones. The next day, say he found 7 more. How many tail bones is that in all?
5. **HARD** Tell in your own words: why are so many dinosaur bones jumbled together in one layer of sandstone?

COMMON MISTAKES

- Thinking every animal that dies becomes a fossil. Most rot away or are eaten. A bone usually must be buried quickly to become a fossil.
- Thinking the bones at the monument are standing up as whole skeletons. Most are jumbled together in the rock.
- Thinking fossil bones are just old dry bones. Over time minerals from the water in the rock soak into them, so they become heavy and hard like stone.

Make it a game · Bone Hunter Says. Play like Simon Says. The parent calls out bone hunter jobs: “Bone Hunter says brush slowly!” “Bone Hunter says draw a map!” “Bone Hunter says lift the bone gently!” Act each one out. If the parent leaves off “Bone Hunter says,” freeze! Then switch so the child is the head paleontologist.

Scripture. “But ask now the beasts, and they shall teach thee; and the fowls of the air, and they shall tell thee: Or speak to the earth, and it shall teach thee: and the fishes of the sea shall declare unto thee.” (Job 12:7-8, KJV)

Earl Douglass “asked” the rocks by looking very closely, and the earth taught him. When we study God’s creatures, even their bones, we learn about the world He made.

Practice answers

1. Earl Douglass, a bone hunter from the Carnegie Museum, in 1909.
2. Utah and Colorado.
3. The child points to the sandstone layer full of bones. It is slanted (tipped up).
4. $8 + 7 = 15$ tail bones.
5. Moving water carried the animals and bones and dropped them together, then buried them quickly in sand. The sand hardened into sandstone around the bones.

7.2 FOOTPRINTS IN ROCK (GLEN ROSE, TEXAS)

OBJECTIVES

- Tell how Roland T. Bird dug up dinosaur tracks from the Paluxy River near Glen Rose, Texas.
- Explain in simple words how a footprint in soft mud can turn into a footprint in rock.
- Read a trackway to tell which animal was walking and which was running.

Warm-up. Press your hand into a ball of play dough. Now press it into a hard table. Which one kept your handprint? Next, press your hand in the dough and pour a little water over it and rub. What happens to the print? A footprint needs soft mud to start and must be covered up fast to last.

Video. Coming soon. Dinosaur tracks at Dinosaur Valley State Park, Glen Rose, Texas, and the Paluxy River trackway: search Texas Parks and Wildlife, the American Museum of Natural History (AMNH), Smithsonian, SciShow Kids for footage of the riverbed tracks.

KEY TERMS

track

A footprint left by an animal. A fossil track is a footprint kept in rock.

trackway

A line of footprints made by one animal as it walked or ran.

mud

Wet, soft dirt. Feet sink into it and leave a print.

limestone

A rock that can form from limey mud. The Glen Rose tracks are pressed into limestone.

CORE IDEAS

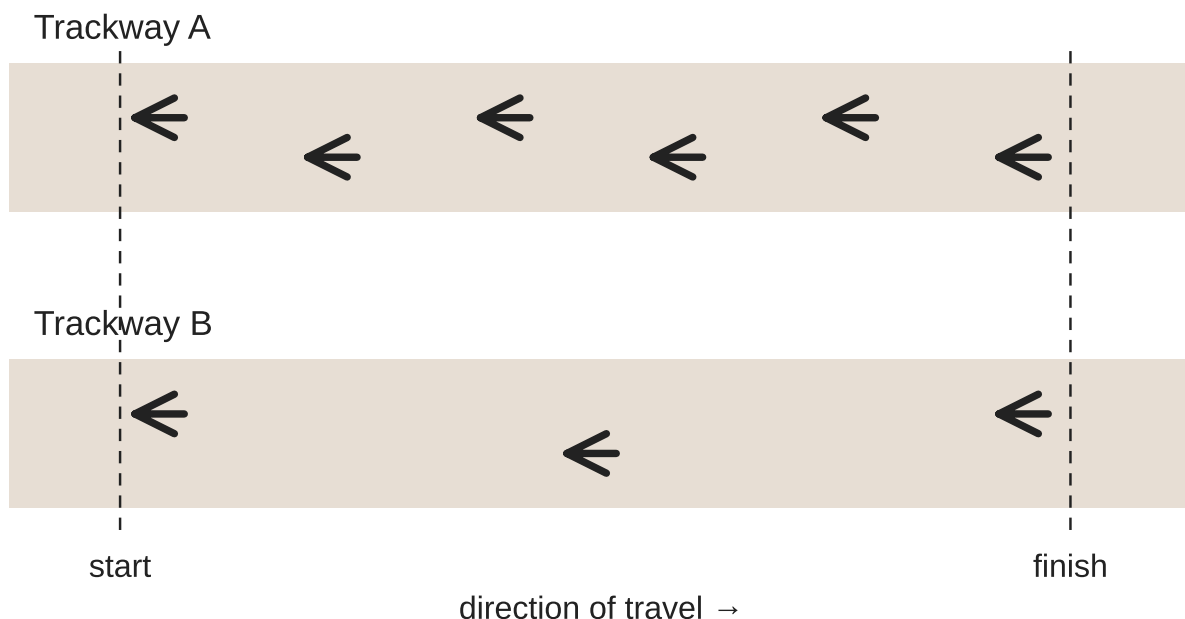
The story. In Texas, near the town of Glen Rose, the Paluxy River runs over flat gray rock. When the water is low in summer, you can see something amazing in the riverbed: dinosaur footprints! Some are big, round tracks from a giant long-necked plant eater, big enough for a child to sit in. Others are long, three-toed tracks from a meat eater. In 1938 a man named Roland T. Bird came from the American Museum of Natural History in New York to see them. In 1940 he and a team of workers dug a long line of tracks right out of the riverbed, cut it into blocks and sent it to museums.

How they figured it out. Bird looked closely at the two **trackways**. The plant eater's round tracks went one way. The meat eater's three-toed tracks went the same way, right beside them. Bird wondered whether the meat eater had been following the plant eater. Footprints can tell us how an animal moved. If the prints are close together, the animal was walking. If

they are far apart, it was running. Footprints can even show where an animal turned or limped.

The big idea. How does a footprint turn into stone? First an animal steps in soft **mud**. Then, before rain or waves can wash the print away, new mud or sand must cover it quickly. Later the mud hardens into rock. At Glen Rose the rock is **limestone**. A **track** is a fossil too, even though it is not a bone. It is a sign that a living animal was really there, walking.

Try it and see. Today you can visit Dinosaur Valley State Park in Glen Rose and walk right beside the tracks. Part of Bird's trackway is in New York, set under a giant long-necked dinosaur skeleton. Another part is in Austin, Texas. When you look at a footprint, you can almost see the animal stepping. God made these great creatures, and He knows every step they took.



Two trackways cover the same distance. Count the prints. Which animal took bigger steps?

Thinking About Time

What the sign says. What the sign says: park signs call this the Cretaceous, a museum word for a time they say was very long ago.

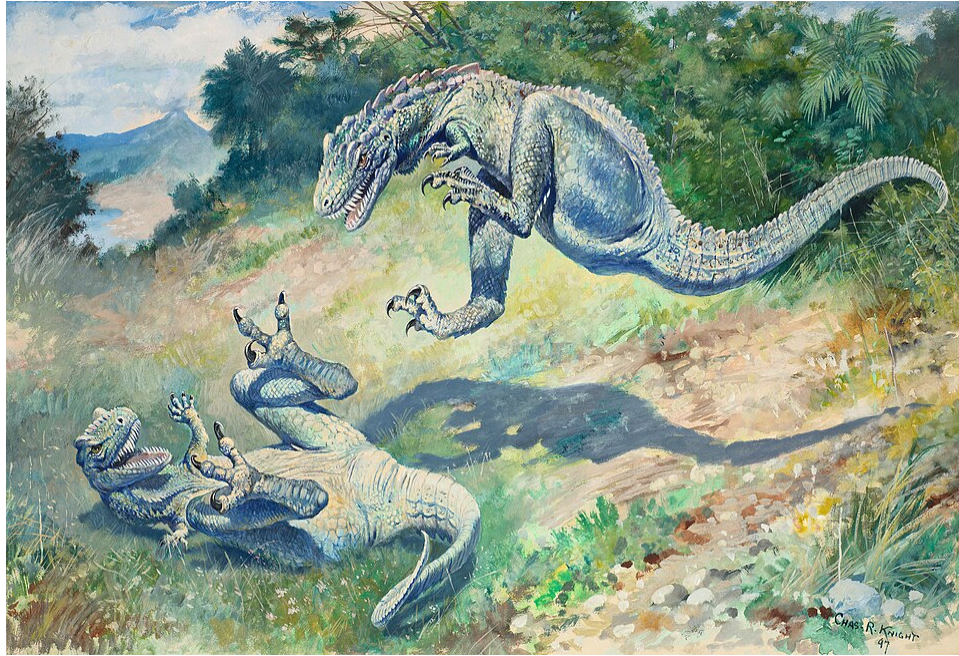
What we observe. What we observe: we see tracks pressed into a layer of limestone with more rock layers on top. Tracks only last if they are covered quickly.

How Christians read it. How Christians read it: many creation scientists think these animals were walking on soft mud during Noah's Flood, and new layers of mud covered the tracks quickly.

Try it. Make a print in wet sand at the edge of a puddle. Watch what water does to it if it is not covered.

Genesis 7:17

PICTURE STUDY



Leaping Laelaps, Charles R. Knight, 1897 · Watercolor · American Museum of Natural History, New York

Charles R. Knight was one of the first artists to paint dinosaurs as if they were alive. He studied real bones with scientists and drew living animals at the zoo, so his paintings would look right. In this painting he shows two meat eaters that were found in New Jersey. Back then they were called Laelaps. Today scientists call them Dryptosaurus.

Most people in those days pictured dinosaurs as slow and clumsy. Knight painted these two leaping and fighting, quick and strong. Look closely at their feet. Big three-toed feet like these made the meat-eater tracks at Glen Rose.

Look closely

- Find the feet of the leaping dinosaur. How many big toes do you see on each foot?
- Which dinosaur is in the air? Which one is on the ground?
- Look at the tails. How might a long tail help a dinosaur balance while it runs or jumps?
- Look at the ground under them. If they stepped in mud, what kind of tracks would they leave?

Talk about it

1. If this dinosaur ran across soft mud, would its tracks be close together or far apart?
2. How could Knight paint an animal that no one had ever seen alive?

3. Do you think this painting is exciting? Why?

Safety first. Wash hands after playing in mud. If you visit the Paluxy River, stay with an adult near the water, watch for slippery rock and never pry at or scratch real tracks.

MAKE AND DO: MAKE A TRACKWAY

You will make tracks two ways: tiny tracks in dough with a toy dinosaur, and big tracks with your own feet. Then you will find out how tracks show walking and running.

You will need

- Play dough or salt dough (1 cup flour, half a cup salt, about half a cup water)
- A toy dinosaur or a fork (to press three-toed prints)
- A long strip of brown paper or several sheets of newspaper taped end to end
- A shallow pan of water and an old towel
- Crayons and a ruler or tape measure

Steps

1. Roll the dough flat like a muddy riverbed. Walk your toy dinosaur across it, pressing each foot down. If you have no toy, press a fork in sideways to make three-toed prints.
2. Let the dough dry for a day. Now your “mud” has turned to “rock.”
3. Next, lay the paper on the floor outside or in the kitchen. Dip your bare feet in the water, step on the towel once, then walk slowly along the paper.
4. Have a grown-up trace your wet prints with a crayon before they dry. This is your walking trackway.
5. Dip your feet again and run along a new piece of paper. Trace these prints too. This is your running trackway.
6. Count how many prints are on each trackway. Use the ruler to measure the space between two prints. Which steps were longer?

Tips

- Running on wet paper can be slippery. A grown-up can hold your hand, or you can take giant steps instead of running.
- Your running steps will be farther apart. That is just how scientists tell when a dinosaur was running.

Check your work

- I can tell how a footprint becomes rock.
- I can find a walking trackway and a running trackway.
- I can tell what Roland T. Bird did at the Paluxy River.

FIELD NOTEBOOK

1. Draw a big round plant-eater track and a three-toed meat-eater track side by side. Label each one.
2. Draw the Paluxy River with tracks in the riverbed. Draw yourself standing beside them.
3. Draw three steps in a row: an animal steps in mud, mud covers the print, the mud turns to rock.

From history. Roland T. Bird traveled the country hunting fossils for his museum. When he and his workers dug out the Paluxy trackway in 1940, they worked right in the riverbed, cutting the rock into heavy blocks. The blocks were numbered so they could be fitted together again like a puzzle, and the New York part was later set behind a long-necked dinosaur skeleton at the museum, as if the dinosaur had just walked there.

WORKED EXAMPLES

Example 1. Look at the two trackways in the drawing. Both animals went from the start line to the finish line. Which animal was running?

(Use the map or drawing “Same distance, different steps.” shown earlier in this lesson.)

1. Count the prints in Trackway A: 1, 2, 3, 4, 5, 6. There are 6 prints.
2. Count the prints in Trackway B: 1, 2, 3. There are 3 prints.
3. Both went the same distance. Trackway B needed fewer steps, so each step was longer.
4. Long steps far apart mean running. Short steps close together mean walking.

Answer: The animal that made Trackway B was running. Its 3 prints are far apart. Trackway A, with 6 prints close together, was walking.

PRACTICE

1. **EASY** Hold up your fingers to show how many toes the meat-eater tracks at Glen Rose have.
2. **EASY** Who dug up a long trackway from the Paluxy River and sent it to museums?
3. **MEDIUM** Sort these into “can leave a track” and “cannot leave a track”: soft mud, hard rock, wet sand, a wooden floor.
4. **MEDIUM** A trackway has 9 plant-eater prints and 6 meat-eater prints. How many prints in all?
5. **HARD** Tell in your own words how a dinosaur footprint in mud became a footprint in rock.

COMMON MISTAKES

- Thinking only bones are fossils. Footprints, eggs and teeth marks are fossils too.

- Thinking any footprint will turn to stone. Most are washed or blown away. A track must be covered quickly to last.
- Thinking there are human footprints beside the dinosaur tracks at Glen Rose. Some people once said so, but careful creation scientists checked those long marks and found they were not good human prints, so they ask people not to use them. Honest science matters.

Make it a game · Who Made This Track?. The parent walks across the room like an animal while the child closes their eyes and listens: heavy slow stomps for a big plant eater, quick light steps for a fast meat eater, hops for a rabbit. The child guesses the animal and says whether it was walking or running. Then trade places. Score a point for each right guess.

Scripture. “O LORD, how manifold are thy works! in wisdom hast thou made them all: the earth is full of thy riches.” (Psalm 104:24, KJV)

“Manifold” means many and of many kinds. Big round tracks, long three-toed tracks: the earth is full of the works of God, even pressed into stone.

Practice answers

1. Three toes.
2. Roland T. Bird, from the American Museum of Natural History.
3. Can leave a track: soft mud and wet sand. Cannot: hard rock and a wooden floor.
4. $9 + 6 = 15$ prints.
5. The dinosaur stepped in soft mud. New mud or sand quickly covered the print before water could wash it away. Then the mud hardened into rock, keeping the shape of the footprint.

7.3 PLANT EATERS AND MEAT EATERS

OBJECTIVES

- Tell how Gideon Mantell used fossil teeth to learn that *Iguanodon* ate plants.
- Tell a plant eater's teeth from a meat eater's teeth by their shape.
- Sort dinosaurs into plant eaters and meat eaters.

Warm-up. Take a mirror and look at your own teeth. Find your thin front teeth. Bite a carrot stick with them: they cut. Now chew it with your wide back teeth: they grind. The shape of a tooth tells what job it does. Today we will be tooth detectives for dinosaurs.

Video. Coming soon. Dinosaur teeth, herbivores and carnivores for kids: search the American Museum of Natural History (AMNH), Natural History Museum London, Smithsonian, SciShow Kids, Homeschool Pop (Alternate) for close-ups of fossil teeth and what they show about diet.

KEY TERMS

plant eater

An animal that eats leaves, stems, seeds or fruit. Scientists call it an herbivore.

meat eater

An animal that eats other animals. Scientists call it a carnivore.

tooth shape

Whether a tooth is flat, peg-like, leaf-shaped or sharp and curved. The shape gives a clue to what an animal ate.

serrated

Having a row of tiny bumps along the edge, like a saw or a bread knife.

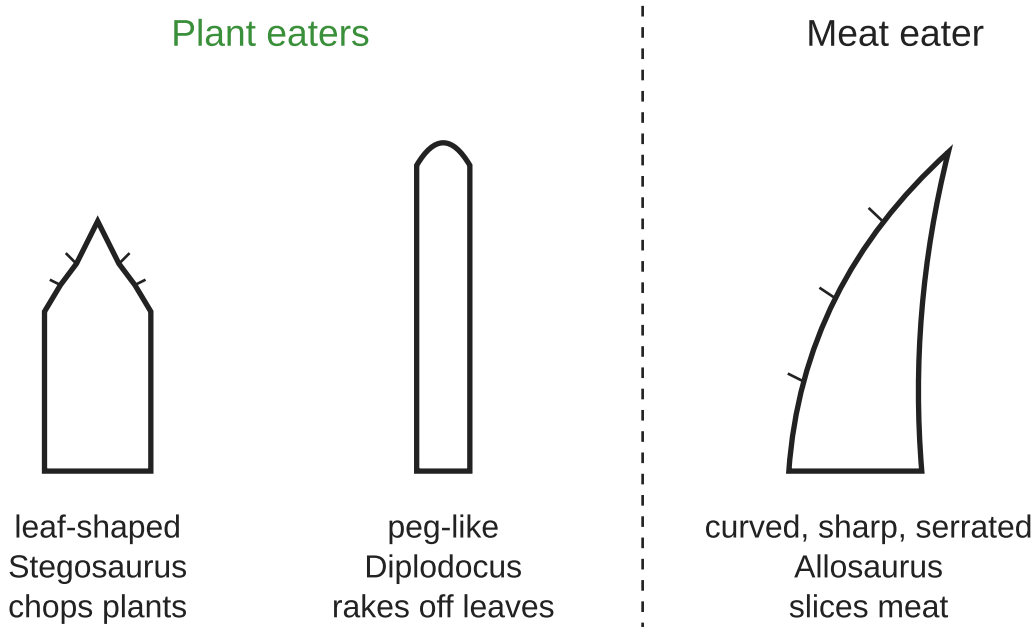
CORE IDEAS

The story. Long ago in Sussex, England, there lived a doctor named Gideon Mantell who loved fossils. In the early 1820s he got some strange teeth out of the rock. The story is often told that his wife, Mary Ann, found the first one. The teeth were big, and the tops were worn flat, as if they had chewed and chewed. Some experts said they were only fish teeth or the teeth of a mammal. Mantell was not sure they were right.

How they figured it out. Mantell took his teeth to a museum in London and searched drawer after drawer. At last a young man there showed him the skeleton of an iguana, a lizard that eats plants. Its tiny teeth looked just like Mantell's giant ones! So Mantell decided his teeth came from a huge plant-eating reptile. In 1825 he named it *Iguanodon*, which means "iguana tooth."

The big idea. A tooth is a tool, and its **tooth shape** tells its job. **Plant eaters** like Stegosaurus had small, leaf-shaped teeth for chopping plants. Diplodocus had thin teeth like pegs at the front of its mouth, and it raked leaves off branches like a comb. Triceratops had a sharp beak and rows of teeth that sliced plants like scissors. **Meat eaters** like Allosaurus and Tyrannosaurus had sharp teeth that curved back, with **serrated** edges like a steak knife. Many of the very biggest dinosaurs were plant eaters, not meat eaters!

God's handiwork. The Bible says that at the very beginning God gave "every green herb" to the animals for food (Genesis 1:30). So Christians believe every animal ate plants at first. After Adam sinned, the world changed, and some animals began to eat meat. Sharp teeth do not always mean meat, either. The giant panda has sharp, pointed front teeth like a meat eater's, but it eats mostly bamboo.



Tooth shapes are clues. Leaf-shaped and peg-like teeth worked on plants. Curved, sharp, serrated teeth sliced meat.

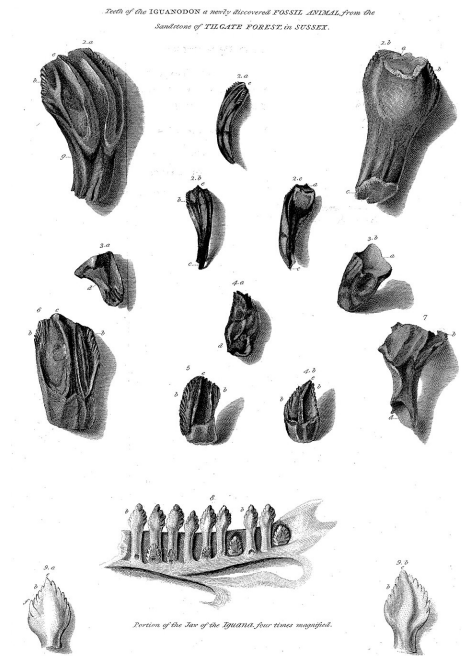
Thinking About Time

What the sign says. What the sign says: museum signs often say meat-eating dinosaurs hunted other animals for a very long time before any people lived.

What we observe. What we observe: we find fossil teeth with different shapes, and sometimes bones with bite marks on them.

How Christians read it. How Christians read it: Genesis says that at first every animal ate green plants. Christians believe meat eating came after Adam sinned, so these meat eaters lived after the Fall.

PICTURE STUDY



Teeth of the Iguanodon, Printed plate made for Gideon Mantell's report on the Iguanodon, 1825 · Lithograph (a printed picture) · Printed in the *Philosophical Transactions of the Royal Society of London*

When Gideon Mantell told other scientists about the Iguanodon, he could not send them his real teeth. So careful drawings of the teeth were drawn onto a flat stone and printed in a science journal. A picture printed this way is called a lithograph. Each tooth was drawn from more than one side, so scientists far away could study its shape.

This is how scientists shared what they found before there were photographs: with patient, careful drawings, just like the ones you make in your sketchbook.

Look closely

- Count how many teeth you can see on the page.
- Find a tooth with a flat, worn top. What could have worn it down?
- Look at the edges of the teeth. Are they smooth or bumpy?
- Find the little numbers. Why do you think the artist numbered each drawing?

Talk about it

1. Do these teeth look more like a plant eater's teeth or a meat eater's teeth? Why?
2. Why did the artist draw each tooth from different sides?
3. If you found a fossil tooth, how would you draw it so a friend could see it clearly?

Safety first. Use only plastic knives, and let a grown-up help with cutting. Do not put clay in your mouth.

MAKE AND DO: TOOTH DETECTIVE TOOL TEST

You will make clay dinosaur teeth, then test kitchen tools that work like teeth: a comb like Diplodocus's peg teeth, and a saw-edged knife like Allosaurus's teeth.

You will need

- Modeling clay or play dough
- A hand mirror
- A clean comb with wide teeth
- A sprig of fresh parsley, dill or another leafy herb
- A plastic knife with a smooth edge and a plastic knife with a serrated (bumpy) edge
- A ripe tomato or a slice of bread with crust

Steps

1. Look at the tooth drawing in the lesson. With clay, make one leaf-shaped tooth, one peg tooth and one curved, sharp tooth. Press tiny bumps along the edge of the sharp one with a toothpick or fingernail.
2. Hold the herb sprig by its stem. Pull the comb down the stem. Do the leaves come off? That is how Diplodocus raked leaves off branches with its peg teeth.
3. Now try to cut the tomato skin or bread crust with the smooth plastic knife. Is it hard?
4. Try again with the serrated plastic knife, using a back-and-forth motion. Which one works better?
5. Tell what you found: saw edges grip and slice, just like a meat eater's teeth.
6. Use the mirror to find your own cutting teeth and grinding teeth. Make a clay copy of one of each.

Tips

- Set your clay teeth on a paper plate and label them: plant eater or meat eater.
- If you do not have a serrated plastic knife, look at a bread knife in the kitchen with a grown-up, without touching the edge.

Check your work

- I can tell a plant eater's tooth from a meat eater's tooth.
- I can explain why a comb is like Diplodocus's teeth.
- I can tell what Gideon Mantell figured out from his teeth.

FIELD NOTEBOOK

1. Draw a leaf-shaped tooth, a peg tooth and a curved, sharp tooth. Label each one plant eater or meat eater.
2. Fold a page in half. Draw plant-eating dinosaurs on one side and meat-eating dinosaurs on the other.
3. Draw Gideon Mantell holding a big tooth next to a little iguana. Write “Iguanodon: iguana tooth.”

From history. Iguanodon was only the second dinosaur ever given a scientific name. The first, named the year before in 1824 by William Buckland of Oxford, was Megalosaurus, which means “great lizard.” It was known from a jaw with sharp, curved, serrated teeth, so the very first named dinosaur was a meat eater and the second was a plant eater. The word “dinosaur” itself was not made up until 1842, by Richard Owen.

WORKED EXAMPLES

Example 1. A child sorts a box of toy dinosaurs. Plant eaters: Stegosaurus, Triceratops, Diplodocus, Apatosaurus, Iguanodon, Ankylosaurus, Parasaurolophus. Meat eaters: Allosaurus, Tyrannosaurus, Velociraptor, Spinosaurus. Are there more plant eaters or more meat eaters? How many more?

1. Count the plant eaters: 1, 2, 3, 4, 5, 6, 7. There are 7.
2. Count the meat eaters: 1, 2, 3, 4. There are 4.
3. 7 is bigger than 4, so there are more plant eaters.
4. Count up from 4 to 7: 5, 6, 7. That is 3 more.

Answer: There are more plant eaters: 7 plant eaters and 4 meat eaters, so 3 more plant eaters.

PRACTICE

1. **EASY** Point to the tooth in the drawing that came from a meat eater. How can you tell?
2. **EASY** Sort these into plant eaters and meat eaters: Stegosaurus, Allosaurus, Triceratops, Tyrannosaurus, Diplodocus.
3. **MEDIUM** Match each kitchen tool to the teeth it is like: comb, steak knife. (a) Diplodocus’s peg teeth (b) Allosaurus’s serrated teeth.
4. **MEDIUM** Each Triceratops had 3 horns. How many horns do 4 Triceratops have in all?
5. **HARD** Tell in your own words how Gideon Mantell knew his Iguanodon ate plants.

COMMON MISTAKES

- Thinking all dinosaurs were fierce meat eaters. Most kinds of dinosaurs we know were plant eaters.

- Thinking the biggest dinosaurs were meat eaters. The very biggest, like the long-necked dinosaurs, were plant eaters.
- Thinking sharp teeth always mean an animal eats meat. The giant panda has sharp, pointed front teeth like a meat eater's but eats mostly bamboo.

Make it a game · Chomp or Munch. The parent names a food, like a leaf, a bone, a fern, a fish, a pine cone or a steak. If a plant eater would eat it, the child munches slowly like Stegosaurus. If a meat eater would eat it, the child makes sharp claws and says "Chomp!" like Allosaurus. Then the parent names a dinosaur, and the child shows munch or chomp. Score a point for each right answer.

Scripture. "And to every beast of the earth, and to every fowl of the air, and to every thing that creepeth upon the earth, wherein there is life, I have given every green herb for meat: and it was so." (Genesis 1:30, KJV)

In the old English of the King James Bible, "meat" means food. At the beginning God gave green plants as food to every animal. Every dinosaur tooth reminds us that God gave each creature what it needed.

Practice answers

1. The curved, sharp tooth (Allosaurus). It is pointed, curves back and has saw-like bumps on its edge.
2. Plant eaters: Stegosaurus, Triceratops, Diplodocus. Meat eaters: Allosaurus, Tyrannosaurus.
3. Comb goes with Diplodocus's peg teeth (a). Steak knife goes with Allosaurus's serrated teeth (b).
4. $3 + 3 + 3 + 3 = 12$ horns.
5. Its teeth were worn flat from chewing, and they looked like big copies of the teeth of an iguana, a lizard that eats plants.

7.4 DINOSAURS ON THE ARK? WHAT GENESIS SAYS ABOUT “EVERY CREEPING THING”

OBJECTIVES

- Tell from Genesis on which day God made land animals and people, and what kinds of animals came onto the ark.
- Explain why young dinosaurs could fit on Noah’s ark.
- Measure with a cubit, the body ruler Noah used.

Warm-up. Hold out your arm and bend it. Measure from your elbow to the tip of your longest finger with a piece of string. That length is your cubit! Now measure a grown-up’s cubit. Whose is longer? God told Noah to build the ark using cubits.

Video. Coming soon. Noah’s ark and dinosaurs for kids, and in Kentucky: search Institute for Creation Research and Creation Ministries International, and Moody Science classics for a creation view of dinosaurs and the Flood.

KEY TERMS

ark

The huge wooden boat God told Noah to build to keep his family and the animals safe in the Flood.

kind

A family of animals that God made to have babies like themselves, “after his kind” (Genesis 1:25).

creeping thing

A King James Bible name for animals that move along close to the ground, like lizards and other reptiles.

cubit

A length from the elbow to the tip of the longest finger. Noah built the ark in cubits.

CORE IDEAS

The story. The Bible tells us that on the sixth day of creation, God said, “Let the earth bring forth the living creature after his kind, cattle, and creeping thing, and beast of the earth” (Genesis 1:24). Every land animal was made that day, so dinosaurs were too. On that same sixth day, God made Adam and Eve. Later, people grew wicked, and God sent a great Flood. He told Noah to build an **ark** and to bring in animals “of every creeping thing of the earth after his kind, two of every sort” (Genesis 6:20).

How they figured it out. The word “dinosaur” was made up long after the King James Bible was printed, so you will not find it there. But dinosaurs were land animals that breathed air,

and many looked like giant lizards. So Christians who read Genesis as true history say dinosaurs were among the land animals and **creeping things** that came onto the ark. Job 40:15 also tells of a huge animal called behemoth, “which I made with thee; he eateth grass as an ox.”

The big idea. Could giant dinosaurs fit? God did not need to send the biggest, oldest animals. Every dinosaur hatched from an egg, and even the biggest dinosaur eggs ever found were tiny next to a grown-up dinosaur. Most dinosaur eggs were smaller than a football. Young animals are small, eat less and grow up strong to fill the earth after the Flood. And Noah did not need every type of dog or every type of dinosaur. He needed two of each **kind**. God made each kind to have babies like itself, and there can be many types inside one kind, the way there are many types of dogs.

In the world today. Genesis 6:15 gives the ark’s size in **cubits**: three hundred cubits long, fifty wide and thirty high. That is big enough for pens full of animals, and young dinosaurs would have needed far less room than grown ones. When you see a dinosaur skeleton in a museum, you can remember that God made it, cared for it and saved its kind on the ark.



Thinking About Time

What the sign says. What the sign says: many museum signs say dinosaurs died out long, long before there were any people, so no person ever saw one.

What we observe. What we observe: we dig up dinosaur bones, eggs and tracks, often buried in layers laid down by water. Bones do not come with labels telling when the animal lived.

How Christians read it. How Christians read it: God made land animals and people on the same day. Christians who read Genesis as history believe people and dinosaurs lived at the same time, and dinosaur kinds rode on the ark.

Try it. Line up a toy person and a toy dinosaur. Read Genesis 1:24-27 and point to each one when it is made.

Genesis 1:24-27

PICTURE STUDY



The Entry of the Animals into Noah's Ark, Jan Brueghel the Elder, 1613 · Oil on panel · J. Paul Getty Museum, Los Angeles

Jan Brueghel the Elder was a Flemish painter who loved to paint flowers and animals in tiny, careful detail. He studied real animals, some of them kept in a zoo of the rulers of Brussels, so he could paint them true to life. In this picture he shows the animals gathering to go into Noah's ark.

Brueghel painted this long before anyone knew about dinosaurs. No one had dug up a dinosaur bone and known what it was. So there are no dinosaurs in his picture, even though we believe dinosaur kinds went into the ark too.

Look closely

- Find the ark. Is it near the front of the picture or far in the back?
- Find two animals of the same kind standing near each other.
- Count the birds you can find in the trees and in the sky.
- Find an animal that eats plants and an animal that eats meat. Are they fighting?

Talk about it

1. Why are there no dinosaurs in this painting?
2. If you could add one pair of young dinosaurs to this picture, which kind would you add, and where would you put them?
3. How do you think Noah felt seeing all these animals come to him?

MAKE AND DO: MY SHOEBOX ARK

You will build a small ark from a shoebox, measure it in your own “cubits,” and load it with animals two by two, including young dinosaurs.

You will need

- A shoebox with a lid
- Brown paper or paint and a brush
- Tape, glue and scissors (a grown-up helps with cutting)
- Small toy animals, or animals drawn on paper and cut out
- A piece of string and a crayon

Steps

1. Read Genesis 6:15–16 with a grown-up. The ark had one door, a window and three floors, which the Bible calls “lower, second, and third stories.”
2. Cover the shoebox with brown paper so it looks like wood. Have a grown-up cut a door in one side.
3. Fold two strips of cardboard and tape them inside to make three floors.
4. Gather your animals in pairs. Include at least two pairs of small, young dinosaurs.
5. Load them in, two by two. Put bigger animals on the bottom floor.
6. Use your string cubit from the warm-up. Did your shoebox measure less than one cubit long, or more?

Tips

- If you do not have toy dinosaurs, draw baby dinosaurs hatching from eggs and cut them out.
- Count your animals as you load them. Do you always have an even number? Pairs always make an even number.

Check your work

- I can tell on which day God made land animals and people.
- I can explain why young dinosaurs could fit on the ark.
- I can measure with my cubit.

FIELD NOTEBOOK

1. Draw the ark with its three floors. Draw two young dinosaurs on one of the floors.
2. Copy Genesis 6:20 in your best handwriting, or have a grown-up write it and you trace it. Underline “every creeping thing.”
3. Draw a dinosaur egg next to a football. Under it, write: “Every dinosaur started small.”

From history. The word “dinosaur” was invented in 1842 by the English scientist Richard Owen. It means “terrible lizard” or “fearfully great lizard.” The King James Bible

was printed long before that, in 1611, so its translators used older words like “creeping thing,” “beast” and “behemoth” for the animals God made.

WORKED EXAMPLES

Example 1. A father measures the kitchen table with his cubit and gets 3 cubits. His child measures the same table and gets 5 cubits. Why are the numbers different? Whose cubit is longer?

1. The table did not change. It is the same length for both of them.
2. The child needed more cubits (5) than the father (3) to cover the same table.
3. If you need more of something to cover the same length, each one must be shorter.
4. So the child’s cubit is shorter, and the father’s cubit is longer.

Answer: The numbers are different because their arms are different lengths. The father’s cubit is longer, so he needed fewer cubits. That is why builders later agreed on one standard cubit.

PRACTICE

1. **EASY** On which day did God make the land animals? Who else did He make on that same day?
2. **EASY** Show a grown-up your cubit. Where does it start and where does it end?
3. **MEDIUM** Noah brought dinosaur kinds in pairs. If 6 dinosaur kinds came, two of each, how many dinosaurs is that?
4. **MEDIUM** How many floors did the ark have? How many people were in Noah’s family on the ark?
5. **HARD** Tell in your own words why Noah did not need room for huge, full-grown dinosaurs.

COMMON MISTAKES

- Thinking the Bible never talks about dinosaurs because the word “dinosaur” is not in it. The word was invented much later, but the Bible tells of all the land animals and creeping things God made.
- Thinking Noah had to fit every type of animal, like every type of dog. He needed two of each kind, and many types can come from one kind.
- Thinking all dinosaurs were giants. Many dinosaurs were small, some no bigger than a turkey, and every one started out as a small baby from an egg.

Make it a game • Two by Two. The parent hands out cards with animal pictures or names, two cards for each animal, including a few dinosaurs. Mix them up and lay them face down. Take turns flipping two cards. If they match, say “Two by two!” and march that pair into the shoebox ark. If they do not match, flip them back. The player who loads

the most pairs wins. Then close the door, and remember that in the real story “the LORD shut him in” (Genesis 7:16).

Scripture. “Of fowls after their kind, and of cattle after their kind, of every creeping thing of the earth after his kind, two of every sort shall come unto thee, to keep them alive.” (Genesis 6:20, KJV)

God brought the animals to Noah “to keep them alive.” He cared about every kind He had made, from the smallest creeping thing to the biggest dinosaur.

Practice answers

1. The sixth day. He made Adam and Eve, the first people, on that same day.
2. It starts at the elbow and ends at the tip of the longest finger.
3. 6 pairs is $2 + 2 + 2 + 2 + 2 + 2 = 12$ dinosaurs.
4. Three floors (Genesis 6:16). Eight people: Noah, his wife, his three sons and their three wives.
5. God could send young dinosaurs, which are much smaller. Every dinosaur hatched from an egg and started small. Young animals also eat less, and they would grow up after the Flood to fill the earth.

UNIT 7 REVIEW

A parent asks each question aloud. The child answers in their own words, points or draws. Give full points for a clear answer that has the main idea. The review is worth 20 points.

1. (3 pts) Who was Earl Douglass, and what did he see on the rocky ledge in Utah?
2. (3 pts) Why are so many dinosaur bones jumbled together in one layer of sandstone at Dinosaur National Monument?
3. (3 pts) How does a dinosaur footprint in mud become a footprint in rock?
4. (2 pts) Draw two trackways: one for a walking dinosaur and one for a running dinosaur. Which has the prints farther apart?
5. (3 pts) Draw or describe a plant eater's tooth and a meat eater's tooth. How are they different?
6. (2 pts) What did Gideon Mantell name the dinosaur whose teeth looked like an iguana's? Did it eat plants or meat?
7. (2 pts) On which day did God make the land animals, and who else did He make that day?
8. (2 pts) How could dinosaurs fit on Noah's ark?

UNIT PROJECT: MY DINOSAUR FIELD GUIDE

Make a little book about dinosaurs, like the guidebooks rangers sell at parks. Include a page for Dinosaur National Monument with your quarry map from Lesson 7.1, a page of walking and running tracks from Lesson 7.2, a page sorting plant eaters and meat eaters with drawings of their teeth from Lesson 7.3, and a page with your shoebox ark or a drawing of young dinosaurs on the ark from Lesson 7.4. On the last page, copy or trace Genesis 1:25 and tell a grown-up, in your own words, what each page shows.

- **Science:** Each page shows a true idea: bones buried quickly, tracks in mud turned to rock, tooth shapes that show diet, and kinds on the ark.
- **Observation:** Drawings are careful and labeled, like a real scientist's notebook.
- **Narration:** The child tells about each page clearly in their own words, naming Earl Douglass, Roland T. Bird or Gideon Mantell where they fit.
- **Care:** The book is neat, colorful and finished, with a title page and the Scripture page.

Answer key

1. He was a bone hunter for the Carnegie Museum. In 1909 he saw eight tail bones of a giant long-necked dinosaur still lying in a row in the rock.
2. Moving water carried the animals and bones together and buried them quickly in sand, which hardened into sandstone.
3. The dinosaur steps in soft mud. New mud or sand covers the print quickly before it washes away. Then the mud hardens into rock.
4. The running trackway has prints farther apart. The walking trackway has prints closer together.

5. A plant eater's tooth is leaf-shaped or peg-like, for chopping or raking plants. A meat eater's tooth is sharp and curved back, with serrated (saw-like) edges for slicing meat.
6. Iguanodon ("iguana tooth"). It ate plants.
7. The sixth day. He also made Adam and Eve, the first people.
8. Noah needed only two of each kind, and God could send young dinosaurs, which are small.
Every dinosaur hatched from an egg and started small.

THE GRAND CANYON

The Grand Canyon is one of the deepest, widest, most colorful valleys on earth. In this unit your child will ride along with John Wesley Powell, the one-armed explorer who floated through the canyon in little wooden boats in 1869. Then we will look closely at the canyon's walls, stacked in flat layers like a giant cake, and find the sea shells and footprints hidden in them.

Next we will ask a big question: **how fast can water carve a canyon?** At Mount St. Helens in 1982, a rush of water and mud carved a little canyon in less than a day. Your child will test slow water and fast water on a sand hill and measure the results. Finally, your child will build a canyon diorama in a shoebox, with layered cliffs and slopes, a river, and the plants and animals that live there.

All through the unit we will remember that God made the rocks, the rivers and the creatures of the canyon. As the psalm says, "The works of the LORD are great, sought out of all them that have pleasure therein" (Psalm 111:2).

BEFORE YOU BEGIN

- Can count to 50 and count by twos
- Can measure a short line with a ruler, with help
- Knows that water flows downhill
- Remembers the Mount St. Helens eruption from Unit 2

MASTERY CHECKLIST

- I can tell the story of John Wesley Powell's boat trip through the Grand Canyon.
- I can explain what a canyon is and name its parts: rim, walls, layers and river.
- I can show that in flat layers the bottom one was laid down first and the top one last.
- I can tell how water carved a little canyon at Mount St. Helens in less than one day.
- I can explain that fast water carves more than slow water and soft ground carves faster than hard rock.
- I can build a canyon model with cliffs, slopes and a river.

OPTIONAL BOOKS AND RESOURCES

- **Grand Canyon National Park (National Park Service)** (<https://www.nps.gov/grca/>): Free. Photos, webcams, animal and plant pages, and Junior Ranger activities. Good for finding real pictures of the layers, the river and the condors.
- **Mount St. Helens (U.S. Geological Survey)** (<https://www.usgs.gov/volcanoes/mount-st.-helens>): Free. Photos and short articles from the scientists who watch the volcano. A parent can find before-and-after pictures of the valleys around the mountain for Lesson 8.3.

- **John Wesley Powell's writings (free at Project Gutenberg)**
(<https://www.gutenberg.org/ebooks/search/?query=powell+colorado>): Free. Powell's own account of the 1869 trip. It is written for grown-ups, so a parent may choose a short passage about the rapids or the canyon walls to read aloud.

8.1 JOHN WESLEY POWELL'S VOYAGE (1869) ★

OBJECTIVES

- Tell who John Wesley Powell was and how he traveled through the Grand Canyon in 1869.
- Explain that a canyon is a deep valley with steep sides and a river at the bottom.
- Follow Powell's trip on a simple map from start to finish.

Warm-up. Lay two couch cushions or two stacks of books side by side with a narrow gap between them. Roll a toy car or a marble down the gap. The tall sides are like canyon walls, and the gap is where the river runs. Ask: if you were very small and floating down that gap, could you see over the walls?

Video. Coming soon. John Wesley Powell 1869 Colorado River expedition and Grand Canyon river trips for kids: search the National Park Service (Grand Canyon National Park) channel, USGS, Smithsonian, SciShow Kids, Homeschool Pop (Alternate) and river-rafting nature footage of the Colorado River rapids.

KEY TERMS

canyon

A deep valley with steep, rocky sides. Most canyons have a river at the bottom.

rapids

A part of a river where the water runs fast and rough over rocks.

explorer

A person who travels to a place few people know, to learn about it and tell others.

map

A drawing of a place as if you were looking down on it from the sky.

CORE IDEAS

The story. On May 24, 1869, a man named John Wesley Powell pushed off in a little wooden boat on the Green River in Wyoming. Powell had only one arm. He lost his right arm in a battle in the Civil War. But he loved rocks, rivers and maps. He wanted to float down the Green River and then the Colorado River, through deep canyons that no mapmaker had ever drawn. Nine men went with him, in four wooden boats.

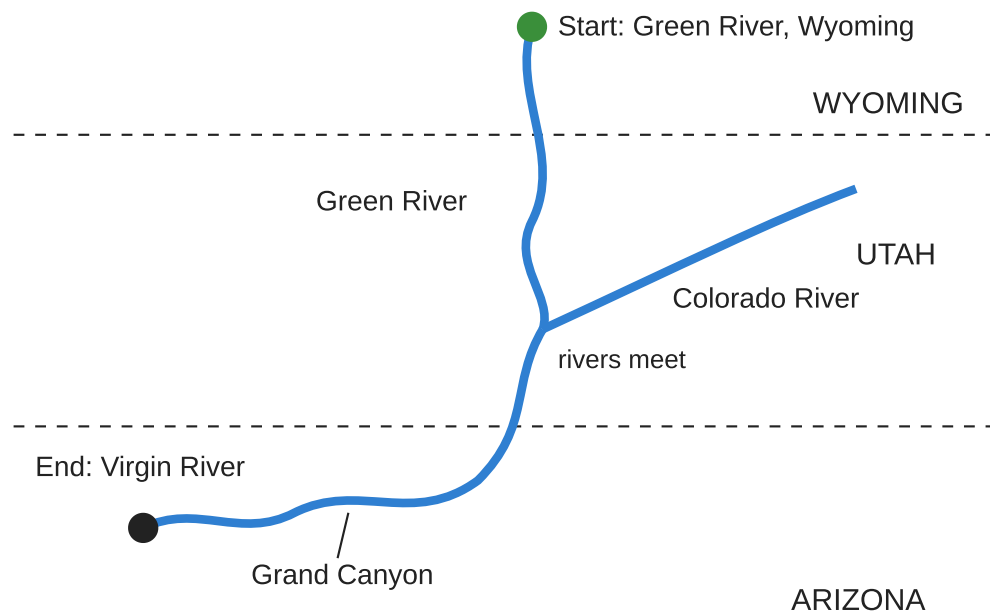
How they figured it out. The river was wild. Rapids tossed the boats like toys. One boat, the *No Name*, smashed on the rocks, and the men lost some of their food. When a rapid looked too dangerous, the men carried the boats and supplies along the shore. Powell climbed the steep walls to look ahead. He wrote notes and measured how high the cliffs were. In August they floated into the deepest canyon of all. Powell called it “the Great Unknown.” Food ran low. Near the end, three men climbed out and left. Powell and five men

kept going. On August 30, 1869, they floated out of the canyon. They were the first people we know of to travel the whole Grand Canyon by boat.

The big idea. A **canyon** is a deep valley with steep, rocky sides. Most canyons have a river at the bottom. The Grand Canyon is in Arizona. It is about a mile deep in places. That is so deep that the river at the bottom looks like a thin ribbon from the top! Its walls are striped with layers of rock, red and tan and gray.

In the world today. The Grand Canyon is now a national park. Families stand at the edge and look down. Some people still float the Colorado River in boats, just as Powell did, and they still meet the roaring rapids. Powell later helped lead the U.S. Geological Survey, a group that makes maps and studies rocks for our country.

God's handiwork. Powell saw cliffs and colors that took his breath away. Every stripe of rock and every drop of the river was made by God, who "sendeth the springs into the valleys" (Psalm 104:10).



Powell's trip in 1869. He started on the Green River in Wyoming, followed it to the Colorado River, and floated through the Grand Canyon to the mouth of the Virgin River.

PICTURE STUDY



The Chasm of the Colorado, Thomas Moran, 1873–1874 · Oil on canvas · Smithsonian American Art Museum, Washington, D.C. (lent by the U.S. Department of the Interior)

Thomas Moran was a painter who loved the wild places of the West. In 1873 he traveled with John Wesley Powell to the north side of the Grand Canyon and made many drawings. When he got home, he painted this enormous picture. It is about as wide as a small room!

In 1874 the U.S. Congress bought the painting and hung it in the Capitol building, so people who could never travel west could see the canyon Powell had explored.

Look closely

- Find the storm clouds. Is the weather sunny or stormy?
- Look for stripes of color in the cliffs. Count how many colors you can find.
- Look for the river. Is it easy or hard to find? Why do you think it looks so small?
- Find the tallest rock tower. Point to its top and its bottom.

Talk about it

1. If you were floating in Powell's little boat at the bottom of this canyon, what would you see when you looked up?
2. Why do you think Moran made his painting so big?
3. What would you name this painting if you were the artist?

Safety first. Play with water only when a grown-up is right there. Wipe up spills so no one slips.

MAKE AND DO: POWELL'S BOAT

Powell's boats had to carry men, food and tools without sinking. You will build a little boat out of foil, float it on your own "river" and see how much cargo it can carry.

You will need

- A piece of aluminum foil about as big as a sheet of paper
- A sink, bathtub or big tub of water
- About 30 pennies (or dried beans) for cargo
- A spoon for stirring
- Paper and crayons

Steps

1. Fold up the edges of the foil to make a flat boat with low sides. Give it a name, like Powell's boats had.
2. Set the boat on the water. Does it float?
3. Load your cargo one penny at a time. Count out loud. Spread the pennies out so the boat stays level.
4. Stop when water starts coming in. How many pennies did your boat carry? Write the number down.
5. Now make "rapids." Ask a grown-up to stir the water with a spoon to make waves. Load a new boat and count again. Does it carry more or fewer pennies in rough water?
6. Draw your boat on the river. Write your two numbers next to it.

Tips

- A wide, flat boat usually carries more than a narrow one.
- Powell's men lost a boat on the rocks. If your boat tips, that is part of the adventure. Just build another one!

Check your work

- I built a boat that floats.
- I counted how much cargo it carried in calm water and in rough water.
- I can tell what rapids are.

FIELD NOTEBOOK

1. Draw Powell in his wooden boat on the river with tall canyon walls on each side. Write "Powell 1869."
2. Copy the trip map from the lesson. Put a green dot where Powell started and a red dot where he finished.
3. Draw the stripes of color you saw in Moran's painting, one stripe on top of another.

From history. Powell went down the river a second time in 1871 and 1872. This time he brought a photographer and mapmakers so he could make better maps and pictures. On that trip he tied a wooden armchair to the middle of his boat, the *Emma Dean*. He sat up high in the chair so he could see the rapids coming and shout directions to the men rowing.

WORKED EXAMPLES

Example 1. Here is a picture chart of the men on Powell's trip. Each ● is one man. At the start: ●●●●●●●●●● At the end of the canyon: ●●●●●● How many men started? How many finished? How many fewer finished?

1. Count the dots in the first row: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Ten men started (Powell and nine men).
2. Count the dots in the second row: 1, 2, 3, 4, 5, 6. Six men finished the canyon.
3. To find how many fewer, count up from 6 to 10: 7, 8, 9, 10. That is 4.

Answer: 10 men started and 6 finished. That is 4 fewer. (One man left the trip early, and three men climbed out near the end.)

PRACTICE

1. **EASY** What happened to Powell's right arm?
2. **EASY** Name the two rivers Powell floated down.
3. **MEDIUM** Point to the map. Show where Powell started and where he finished. Trace his trip with your finger.
4. **MEDIUM** Powell started with 4 boats. One boat smashed on the rocks. How many boats were left?
5. **HARD** Tell in your own words: what is a canyon, and why was Powell's trip so dangerous?

COMMON MISTAKES

- Thinking a canyon is a hole that people dug. Canyons are carved by moving water, not by people.
- Thinking the river runs along the top of the canyon. The river is at the very bottom, between the walls.
- Thinking Powell was the first person ever to see the Grand Canyon. Native American families lived near it long before, and Spanish explorers saw it from the rim in 1540. Powell was the first we know of to float all the way through it.

Make it a game · Rapids Ahead!. Spread a blanket on the floor. That is your boat. The parent is Captain Powell, sitting in the "armchair" and calling out the river: "Calm water!" (row slowly), "Rapids!" (hold on tight and wobble), "Big rocks ahead!" (jump out

and carry the blanket around the room), “Food is low!” (pretend to eat one bean). Then switch, and the child is the captain.

Scripture. “He sendeth the springs into the valleys, which run among the hills.” (Psalm 104:10, KJV)

The water that fills the Colorado River starts as rain, snow and springs high in the mountains. God sends it down into the valleys. Powell followed that water all the way through the canyon.

Practice answers

1. He lost it in a battle in the Civil War. He explored the canyon with only one arm.
2. The Green River and the Colorado River.
3. The child points to the start in Wyoming at the top, traces down the Green River to the Colorado River, then west through the Grand Canyon to the end at the Virgin River.
4. $4 - 1 = 3$ boats.
5. A canyon is a deep valley with steep, rocky sides and usually a river at the bottom. Powell's trip was dangerous because of the fast, rough rapids, the rocks that could smash the boats, the steep walls that were hard to climb out of, and running low on food.

8.2 LAYERS LIKE A CAKE

OBJECTIVES

- Tell that the walls of the Grand Canyon are made of flat rock layers stacked like the layers of a cake.
- Explain that the bottom layer was laid down first and the top layer was laid down last.
- Name two things found in the canyon's layers, such as sea shells and animal footprints.

Warm-up. Make a quick stack on a plate: a slice of bread, a cracker, a slice of cheese, another cracker. Ask: which one did I put down first? Which one went on last? How do you know? (The bottom one went first, because you cannot slide something under a stack without lifting it.)

Video. Coming soon. Grand Canyon rock layers for kids (Kaibab, Coconino, Redwall, Tapeats): search the National Park Service (Grand Canyon National Park and its Trail of Time), USGS, Smithsonian, SciShow Kids, Homeschool Pop (Alternate), and the Institute for Creation Research for the creation view of the layers.

KEY TERMS

layer

One flat sheet of rock or soil lying on top of another, like one layer of a cake.

sandstone

Rock made of sand grains stuck together.

limestone

Rock often made from tiny bits of shells and sea creatures.

shale

Soft rock made of hardened mud. It breaks into thin flat pieces.

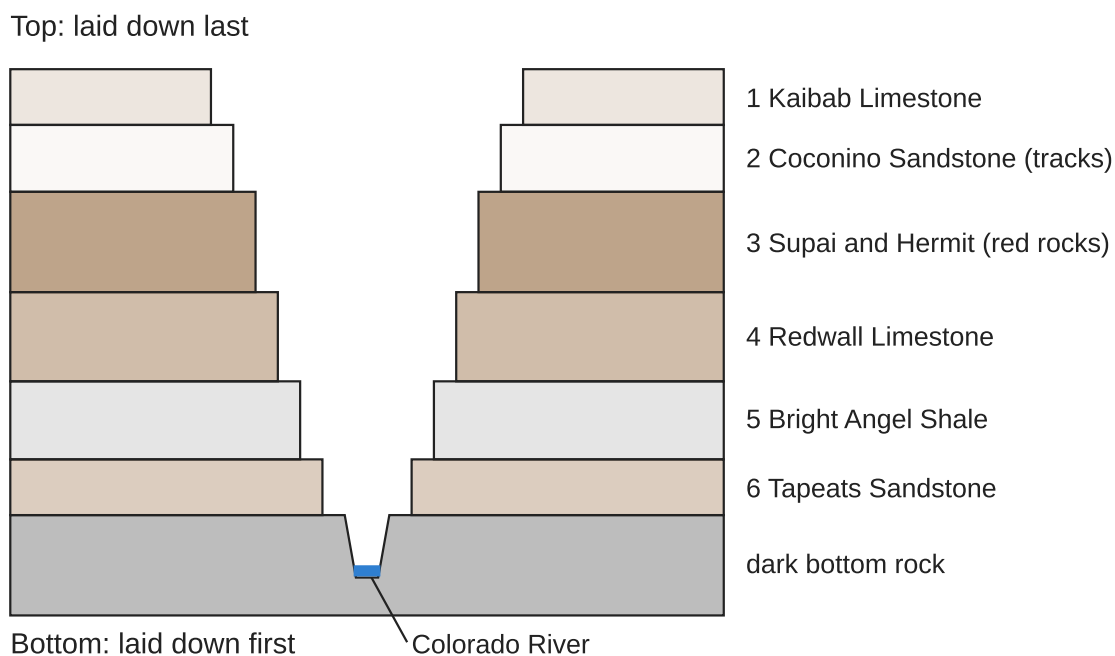
CORE IDEAS

The story. Have you ever cut a layer cake? When the knife goes down, you see the stripes: cake, frosting, cake, frosting. The walls of the Grand Canyon look just like that! When John Wesley Powell floated through the canyon, he saw stripes of rock stacked one on top of another, all the way up the walls. Red rock, tan rock, white rock and gray rock lay in flat bands, as neat as a cake on a plate.

How they figured it out. Rock hunters long ago learned a simple rule. When layers are laid down, the bottom one comes first. Each new layer goes on top. So the lowest flat layer in the canyon wall was laid down first, and the layer at the very top was laid down last. Scientists climbed the walls and looked closely. In some layers they found **sandstone**, made of sand. In others they found **shale**, made of hardened mud. In others they found **limestone**, often made from tiny bits of shells.

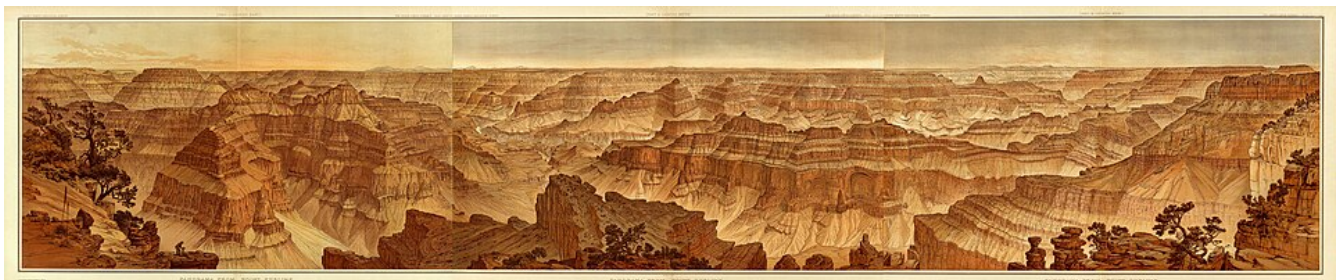
The big idea. Each layer holds clues. The bottom layers have fossils of sea creatures, like trilobites, little crawling animals with hard shells. The thick red cliff near the middle, called the Redwall, is full of sea shells too. A white sandstone layer near the top, the Coconino Sandstone, has rows of footprints left by four-legged animals. And even the top layer, right at the rim where visitors stand, holds shells of sea creatures! Water must have spread sand, mud and shells across a huge land. Some layers stretch far beyond the canyon, across many miles.

God's handiwork. How did so many flat layers get stacked so high? Many Christians think a lot of them were laid down quickly by moving water during Noah's Flood, when the waters covered the whole earth (Genesis 7). Then the river carved down through the stack, and now we can see inside, like cutting into God's great layer cake. When you look at the canyon walls, you are reading pages of the earth's history.



The Grand Canyon's walls are stacked like a cake. The six flat layers lie on top of a dark bottom rock. The Colorado River runs at the very bottom.

PICTURE STUDY



Panorama from Point Sublime (from the Atlas of the Grand Cañon District), William Henry Holmes, 1882 · Printed picture (lithograph) made from Holmes's drawing · Published by the U.S. Geological Survey in Clarence Dutton's atlas of the Grand Canyon; copies are in many libraries

William Henry Holmes was an artist and a scientist. He worked with the U.S. Geological Survey, the same group John Wesley Powell helped lead. Holmes stood at a high spot on the north edge of the canyon called Point Sublime and drew everything he could see, stripe by stripe.

Holmes drew so carefully that you can follow one rock layer with your finger from one cliff to the next, far across the canyon. Scientists used his drawings to learn about the layers.

Look closely

- Put your finger on one stripe of rock. Follow it to the next cliff. Does it line up at the same height?
- Find a rock tower with a flat top. What does its top look like? A table? A ship?
- Find the pine trees on the rim near the front. How small are they next to the cliffs?
- Look for steep cliffs and gentle slopes. Which stripes make cliffs?

Talk about it

1. Why do you think the stripes line up across the canyon?
2. How is this drawing like a layer cake cut open?
3. Why might a scientist want a drawing this careful?

Safety first. A grown-up should do any cutting with a butter knife. If you use food for the layers, check for food allergies first.

MAKE AND DO: MY CANYON LAYER CAKE

You will build your own stack of rock “layers” out of colored play dough, then cut a canyon through it and see the stripes inside, just like the Grand Canyon’s walls.

You will need

- Play dough in 4 to 6 colors (red, tan, white, gray, brown if you have them)
- A rolling pin or a smooth cup
- A plastic butter knife
- A clear straw (for a bonus “core sample”)
- A ruler, paper and crayons

Steps

1. Roll each color of dough into a flat pancake about as big as your hand.
2. Lay the first pancake on the table. This is your bottom layer. Say, “Laid down first!”
3. Stack the next color on top, then the next, until all your layers are used. Say, “Laid down last!” for the top one.
4. Count your layers out loud.
5. With a grown-up, use the butter knife to cut a V-shaped canyon down through the middle. Gently pull the two sides apart.

6. Look at the walls of your canyon. Do the stripes match on both sides?
7. Bonus: push the clear straw straight down into one part of your stack and pull it out. Look at the stripes inside the straw. Scientists drill out rock this way to see layers deep underground.
8. Draw your canyon walls on paper and color each stripe. Label the bottom layer “first” and the top layer “last.”

Tips

- Press each layer down gently so the stack holds together.
- Use a ruler to measure how tall your whole stack is.

Check your work

- I made a stack of layers and cut a canyon through it.
- I can show which layer was laid down first and which was laid down last.
- I saw that the stripes match on both sides of my canyon.

FIELD NOTEBOOK

1. Draw a layer cake cut open beside a canyon wall. Color the stripes in each one.
2. Draw a trilobite, a sea shell and a set of little footprints. Next to each, write which canyon layer it can be found in.
3. Copy the layer drawing from the lesson. Draw an arrow pointing up and write “first” at the bottom and “last” at the top.

From history. The rule that the bottom layer was laid down first was written down by Nicolas Steno, a Danish scientist and a Christian, in 1669. Steno studied rock layers in Italy. He also said that layers start out flat and spread out sideways. These simple rules still help scientists read rock layers today, in the Grand Canyon and all over the world.

WORKED EXAMPLES

Example 1. Look at the drawing of the canyon layers. Count the flat layers above the dark bottom rock. Which flat layer was laid down first? Which was laid down last?

(Use the map or drawing “Count the flat layers from top to bottom.” shown earlier in this lesson.)

1. Start at the top and point to each flat layer: Kaibab Limestone (1), Coconino Sandstone (2), Supai and Hermit red rocks (3), Redwall Limestone (4), Bright Angel Shale (5), Tapeats Sandstone (6).
2. There are 6 flat layers.
3. The bottom flat layer went down first. That is the Tapeats Sandstone.
4. The top layer went down last. That is the Kaibab Limestone, at the rim.

Answer: 6 flat layers. The Tapeats Sandstone (bottom) was laid down first. The Kaibab Limestone (top) was laid down last.

PRACTICE

1. **EASY** Point to the top layer in the drawing. Now point to the bottom flat layer. Which one went down first?
2. **EASY** Match each rock to what it is made of: sandstone, shale, limestone. Choices: hardened mud, sand stuck together, bits of shells.
3. **MEDIUM** In which layer can you find animal footprints? In which layers can you find sea creatures?
4. **MEDIUM** Your play dough cake has 5 layers. You add 3 more. How many layers now?
5. **HARD** Tell in your own words: how are the Grand Canyon’s walls like a layer cake?

COMMON MISTAKES

- Thinking the top layer is the oldest because it is the biggest or easiest to see. In flat layers, the bottom one was laid down first.
- Thinking the Redwall Limestone is red all the way through. It is really gray rock. Red mud washing down from the red layers above stains its outside.
- Thinking the layers were painted or colored on. The colors come from what the rock is made of, like iron, which can turn rock red.

Make it a game · Stack It Up. Gather 6 pillows, books or blocks. The parent calls out layer names one at a time: “Tapeats!” “Bright Angel!” “Redwall!” “Supai!” “Coconino!” “Kaibab!” The child stacks one thing for each name. At the end, the parent asks, “Which one was laid down first?” The child must point to the bottom. Then knock it down and let the child call the names while the parent stacks.

Scripture. “The works of the LORD are great, sought out of all them that have pleasure therein.” (Psalm 111:2, KJV)

God’s works are great, and people who enjoy them love to search them out. When you look closely at the layers of the canyon, you are seeking out the works of the Lord, just like Steno and Powell.

Practice answers

1. The child points to the Kaibab Limestone at the top and the Tapeats Sandstone at the bottom. The bottom one, the Tapeats Sandstone, went down first.
2. Sandstone: sand stuck together. Shale: hardened mud. Limestone: often bits of shells.
3. Footprints are in the Coconino Sandstone. Sea creatures like trilobites and shells are in the bottom layers, in the Redwall Limestone and even in the top layer at the rim.
4. $5 + 3 = 8$ layers.
5. Both are made of flat layers stacked one on top of another. The bottom layer was put down first and the top layer last. When you cut through a cake, or when a river carves through rock, you can see the stripes inside.

8.3 HOW FAST CAN WATER CARVE? MOUNT ST. HELENS' LITTLE CANYON (1982)

OBJECTIVES

- Tell how a rush of water and mud from Mount St. Helens carved a little canyon in one day in 1982.
- Explain that a lot of fast water carves more than a little slow water, and soft rock carves faster than hard rock.
- Test slow and fast water on a sand hill and measure the ditches with a ruler.

Warm-up. Pile up a small hill of sugar or salt on a plate. Use a spoon to drip a few drops of water on top, very slowly. Then pour a little splash all at once on another side. Which one cut a deeper groove?

Video. Coming soon. Mount St. Helens 1982 mudflow and the “Little Grand Canyon” of the Toutle River, and how water erodes canyons for kids: search USGS Volcano Hazards Program and the Cascades Volcano Observatory, the Mount St. Helens Institute, SciShow Kids, Homeschool Pop (Alternate), Moody Science classics, and the Institute for Creation Research for the creation view.

KEY TERMS

erosion

When water, wind or ice wears away rock and soil and carries it somewhere else.

mudflow

A fast, rushing river of mud, water and rocks.

carve

To cut away a little at a time, or a lot all at once, until a shape is left.

CORE IDEAS

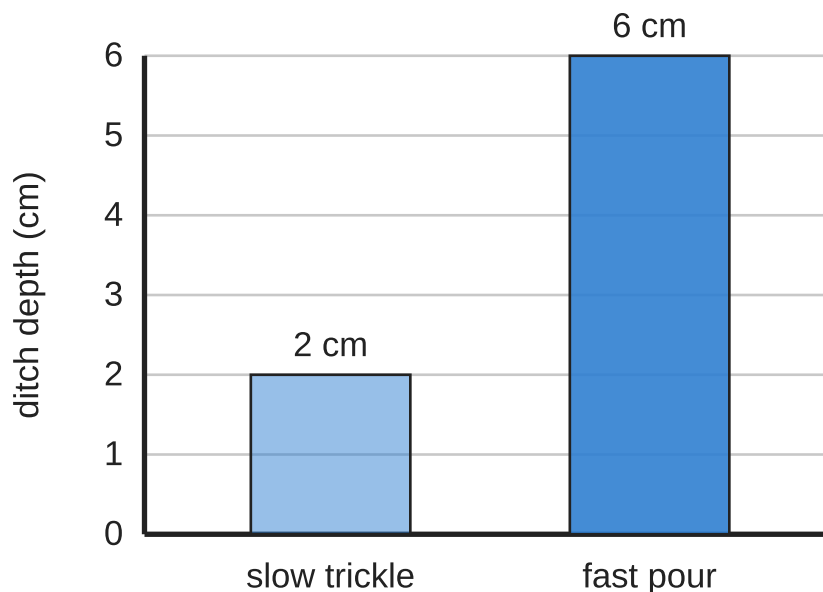
The story. Remember Mount St. Helens? When it blew up on May 18, 1980, it filled the valleys around it with deep piles of ash, mud and broken rock. Then, on March 19, 1982, the mountain puffed again. The heat melted the snow inside its crater. A huge flood of water and mud rushed down the side of the mountain. In less than one day, that **mudflow** carved a brand-new canyon through the soft piles of ash and rock, with steep walls on both sides.

How they figured it out. Scientists had been watching the mountain closely, so they knew the canyon was not there before. Now it was! Its walls even showed thin layers, and those layers had been laid down by the eruptions just a short time before. A creation scientist named Steve Austin studied it and called it a little Grand Canyon. It is much smaller than the Grand Canyon, but it looks like a little copy of it. Today a creek runs along its bottom, so

people might think the creek carved it slowly. But the scientists know it was carved fast, by the mudflow.

The big idea. Wearing away rock and soil is called **erosion**. How fast water carves depends on two things. First, how much water there is and how fast it moves. A drip carves a tiny bit. A flood carves a lot. Second, how soft or hard the ground is. Soft ash and sand wash away fast. Hard rock wears away much more slowly. Many scientists point out that the rock of the Grand Canyon is much harder than the ash at Mount St. Helens. That is a good thing to think about!

Try it and see. Scientists test ideas. You can too. In this lesson you will build a sand hill and pour water down it, slowly and then fast. You will measure each ditch with a ruler. Mount St. Helens taught everyone that a canyon does not always take a very long time. A big rush of water can carve a canyon fast. God, who made the waters, also set them their bounds.



How deep was each ditch in the sand hill? The fast pour carved a deeper ditch than the slow trickle.

Thinking About Time

What the sign says. What the sign says: many signs say the Colorado River carved the Grand Canyon very slowly, a tiny bit at a time, over a very, very long time.

What we observe. What we observe: at Mount St. Helens, a big rush of water and mud carved a little canyon with layered walls in less than one day. The ground there was soft and new.

How Christians read it. How Christians read it: many Christians think huge amounts of water rushing off the land at the end of Noah's Flood carved the Grand Canyon fast, while its layers were still soft.

Try it. Pour water slowly, then quickly, down a sand hill. Which one carves more?

Genesis 8:5

PICTURE STUDY



The Grand Canyon of the Yellowstone, Thomas Moran, 1872 · Oil on canvas · Smithsonian American Art Museum, Washington, D.C. (lent by the U.S. Department of the Interior)

This is a different canyon from the Grand Canyon in Arizona. It is in Yellowstone, far to the north, in Wyoming. Thomas Moran traveled there with a team of explorers in 1871. He made sketches of the Yellowstone River pouring over a great waterfall and rushing through a deep, yellow canyon. Then he painted this enormous picture.

In 1872 the U.S. Congress made Yellowstone the very first national park, and that same year Congress bought this painting. The canyon's yellow walls are volcanic rock that hot underground water made soft and crumbly. Soft rock carves fast, just like the ash at Mount St. Helens!

Look closely

- Find the waterfall. Where does the water go after it falls?
- Follow the river with your finger along the bottom of the canyon.
- Count the colors in the canyon walls. Which color is used the most?
- Look closely at the front of the picture. Can you find any tiny people? How small do they look next to the canyon?

Talk about it

1. What do you think carved this canyon?

2. Moran painted the canyon walls bright yellow. Why do you think the place is called Yellowstone?
3. Would you rather visit this canyon or the Grand Canyon? Why?

Safety first. Do this outside or in a big tub, with a grown-up nearby. Keep sand out of eyes and wipe up spilled water so no one slips. Never go near real mudflows, flooded creeks or the edge of a canyon wall.

MAKE AND DO: SLOW WATER, FAST WATER

You will test the big question of this lesson: does a little slow water or a big fast rush of water carve a deeper ditch? You will keep everything the same except how fast the water comes.

You will need

- A large baking pan or plastic tub
- Damp sand (or soil), enough to make two hills the same size
- Two cups of water that are the same size
- A paper cup with a small hole poked in the bottom by a grown-up
- A ruler
- Paper and pencil

Steps

1. Build two sand hills side by side in the pan. Make them the same size and pat them firm.
2. Guess first: which hill will get the deeper ditch, the slow one or the fast one? Draw your guess.
3. Slow water: hold the paper cup with the hole over the top of the first hill. Pour one cup of water into it and let it trickle out slowly.
4. Fast water: pour the second cup of water straight onto the top of the second hill, all at once.
5. Look at the ditches. Lay the ruler across each one and measure how deep it is. Ask a grown-up to help you read the ruler.
6. Write both numbers down. Which ditch is deeper? Was your guess right?
7. Look at the sides of your ditches. Can you see little walls, like a tiny canyon?

Tips

- Use the same amount of water for both hills. The only thing that changes is how fast it comes.
- If you have time, try one hill of hard-packed sand and one of loose sand, with the same fast pour. Which one carves more?

Check your work

- I made a guess before I tested.
- I measured both ditches with a ruler.
- I can tell which carved more: slow water or fast water.

FIELD NOTEBOOK

1. Draw Mount St. Helens with a rush of mud and water flowing down its side. Write “1982” and draw the little canyon it carved.
2. Draw your two sand hills after the test. Label them “slow” and “fast” and write how deep each ditch was.
3. Draw the waterfall from Moran’s painting and the river running away from it.

From history. Mount St. Helens is in the state of Washington. After the big eruption in 1980, the U.S. Geological Survey opened a volcano observatory in nearby Vancouver, Washington, to keep watch on the mountain. They named it after David Johnston, a USGS scientist who was watching the volcano when it erupted and was killed. Because the scientists watched so closely, they saw the land change quickly: new layers, new canyons and, later, plants and animals coming back to the gray hills.

WORKED EXAMPLES

Example 1. A child tested slow water and fast water on two sand hills. The ruler showed the slow-trickle ditch was 2 centimeters deep. The fast-pour ditch was 6 centimeters deep. Look at the bar chart. Which ditch was deeper? How many centimeters deeper?

(Use the map or drawing “Read each bar to find how deep each ditch was.” shown earlier in this lesson.)

1. Find the slow trickle bar. It stops at 2.
2. Find the fast pour bar. It stops at 6.
3. 6 is bigger than 2, so the fast pour ditch was deeper.
4. Count up from 2 to 6: 3, 4, 5, 6. That is 4 more.

Answer: The fast pour carved the deeper ditch. It was 4 centimeters deeper than the slow trickle ($6 - 2 = 4$).

PRACTICE

1. **EASY** What carved the little canyon at Mount St. Helens in 1982?
2. **EASY** Did the little canyon take a very long time or less than one day to carve?
3. **MEDIUM** Sort these into “carves a little” and “carves a lot”: a drip from a faucet, a big flood, a light rain, a mudflow.
4. **MEDIUM** Point to the bar chart. Which bar is taller? If the fast ditch were 9 centimeters deep and the slow ditch were 3 centimeters deep, how much deeper would the fast one be?

5. **HARD** Tell in your own words: what two things decide how fast water carves a canyon?

COMMON MISTAKES

- Thinking a canyon must always take a very long time to carve. At Mount St. Helens, a little canyon was carved in less than one day.
- Thinking the little creek at the bottom of a canyon must have carved it. Sometimes a much bigger flood did the carving, and only a little creek is left today.
- Thinking all ground carves the same. Soft ash and sand wash away much faster than hard rock.

Make it a game · Trickle or Flood? The parent names a kind of water: “a dripping faucet,” “a giant flood,” “a sprinkle of rain,” “a mudflow down a volcano,” “a bathtub draining.” The child acts it out: tiptoe and wiggle fingers for a trickle, or run and spread arms wide for a flood. Then the child says, “Carves a little!” or “Carves a lot!” Switch turns so the child calls out the water.

Scripture. “Thou coveredst it with the deep as with a garment: the waters stood above the mountains. At thy rebuke they fled; at the voice of thy thunder they hasted away.” (Psalm 104:6-7, KJV)

This psalm tells how the waters once stood above the mountains and then hurried away at God’s command. Fast-moving water is powerful. It can carve deep valleys in a short time.

Practice answers

1. A fast rush of water and mud (a mudflow) from melted snow in the crater.
2. Less than one day.
3. Carves a little: a drip from a faucet, a light rain. Carves a lot: a big flood, a mudflow.
4. The fast pour bar is taller. $9 - 3 = 6$ centimeters deeper.
5. How much water there is and how fast it moves (a big fast flood carves more than a slow trickle), and how soft or hard the ground is (soft ash and sand wash away faster than hard rock).

8.4 A CANYON DIORAMA

OBJECTIVES

- Build a small model of the Grand Canyon with layered walls, a river at the bottom, and plants and animals.
- Tell that hard rock layers make steep cliffs and soft layers make gentle slopes.
- Name the main parts of a canyon: rim, walls, layers and river.

Warm-up. Turn an empty shoebox on its side so the open part faces you. Point to the floor and the two walls. Ask: where would the river go? Where would the top edge, the rim, be? Where would you stand to look down?

Video. Coming soon. Grand Canyon rim, cliffs, river and animals (bighorn sheep, California condors, ravens, mule deer) for kids, plus how to make a canyon diorama: search the National Park Service (Grand Canyon National Park), Smithsonian, SciShow Kids, Homeschool Pop (Alternate), Science Max, and nature footage of the Grand Canyon.

KEY TERMS

diorama

A small model of a real place, built inside a box, with a painted background and little things in front.

rim

The top edge of a canyon, where you can stand and look down.

cliff

A very steep wall of rock that goes almost straight up and down.

slope

Ground that slants gently, like the side of a hill.

CORE IDEAS

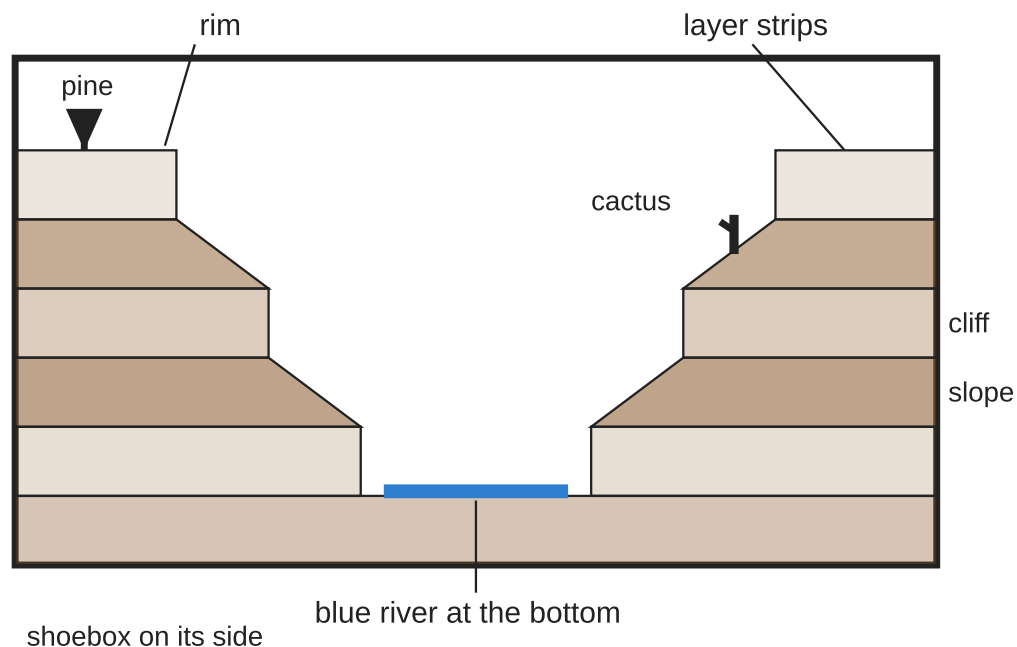
The story. When John Wesley Powell came home from the river, he had a problem. Most people would never see the Grand Canyon. How could he show them? So he worked with artists and picture makers. Thomas Moran painted huge paintings. William Henry Holmes drew the layers stripe by stripe. Photographers like Jack Hillers carried heavy cameras down to the river and took pictures. Each one made a small picture of a giant place, so people far away could see it.

How they figured it out. Picture makers looked very carefully before they began. They saw that the canyon is wide at the top and narrow at the bottom. They saw that the walls do not go straight down like the sides of a box. Instead they go down like a giant staircase. Hard rock layers, like the Redwall Limestone, stand up as tall, steep **cliffs**. Soft layers, like the

shale made of mud, crumble into gentle **slopes**. Cliff, slope, cliff, slope, all the way down to the river.

The big idea. A **diorama** is a small model of a real place, built in a box. Your canyon diorama will have the main parts of a canyon. The **rim** is the top edge. The walls are made of layers, with cliffs and slopes. The Colorado River runs at the very bottom. You can add living things too. Pine trees grow on the rim. Cactus and bushes grow on the dry slopes. Bighorn sheep climb the cliffs, ravens and big California condors fly overhead, and mule deer walk near the rim.

God's handiwork. When we make a model, we copy something that is already there. God did not copy anything. He made the canyon, the river and every animal from nothing but His word. Building a little canyon helps us see how wise and great the real Maker is.



A plan for your canyon diorama. Stack layer strips like a staircase, so cliffs and slopes take turns all the way down to the river.

PICTURE STUDY



Black Cañon, Colorado River, from Camp 8, Looking Above, Timothy H. O'Sullivan, 1871 · Photograph (albumen print) · Library of Congress and other collections; made for the U.S. Army's Wheeler Survey

Timothy O'Sullivan was one of the first people to photograph the canyons of the Colorado River. In 1871 he traveled with an Army survey team that rowed and pulled their boats up the river. Cameras then were big wooden boxes, and every picture was made on a sheet of glass. O'Sullivan even kept a little darkroom on one of the boats.

This photograph shows Black Canyon, a narrow part of the Colorado River downstream from the Grand Canyon. Look at how the boat helps you see how tall the walls really are.

Look closely

- Find the boat. How big is it next to the canyon walls?
- Look at the walls. Are they steep cliffs or gentle slopes?
- Where does the light come from? Which parts of the picture are dark?
- Look at the water. Is it rough rapids or calm?

Talk about it

1. Why do you think the photographer put a boat in the picture?
2. This photograph has no color. What colors do you think the real rocks were?
3. What could you put in your diorama to show how big your canyon is?

Safety first. A grown-up should help with scissors and do any cutting of cardboard. Use school glue or a glue stick, not hot glue, unless a grown-up runs the glue gun.

MAKE AND DO: MY GRAND CANYON DIORAMA

You will build a small Grand Canyon in a shoebox, with layered walls that step down like a staircase, a blue river, and the plants and animals that live there.

You will need

- A shoebox (or a cereal box cut open by a grown-up)
- Construction paper or cardboard strips in red, tan, white, gray and brown
- Blue paper, blue yarn or blue plastic wrap for the river
- Glue, tape, child safety scissors and a ruler
- Small sticks, pebbles and green paper for trees and cactus
- Crayons or markers, and paper for animal cutouts (bighorn sheep, raven, condor, deer)

Steps

1. Turn the box on its side. Color or paint the back wall as the sky and the far side of the canyon, with stripes of rock.
2. Lay the blue river along the bottom middle of the box.
3. Cut paper strips about 2 centimeters tall for your layers. Use the ruler to measure.
4. On each side of the river, glue strips one on top of another, from the bottom up, like the layers were laid down. Fold some strips so they stand straight up as cliffs. Let others lean back as slopes. Each layer should step back a little from the one below, like stairs.
5. Glue a flat piece of tan paper across the top of each side for the rim.
6. Add pine trees on the rim and cactus on the slopes. Stand pebbles up as rocks.
7. Draw, color and cut out animals. Put a bighorn sheep on a cliff and a condor or raven flying in the sky.
8. Make a tiny paper boat for the river, like Powell's. Then give a tour of your canyon to your family: point to the rim, a cliff, a slope, the layers and the river.

Tips

- Put the widest part at the top and the narrowest part at the river. That is the shape of a real canyon.
- Use the same color order on both sides of the river, so the layers match across the canyon just like the real ones.

Check your work

- My canyon has a rim, layered walls and a river at the bottom.
- My walls step down with cliffs and slopes.
- I put living things in the right places and can name them.

FIELD NOTEBOOK

1. Before you build, draw a plan of your diorama. Label the rim, a cliff, a slope and the river.
2. Draw a bighorn sheep standing on a cliff. Write one sentence about why its feet are good for climbing.
3. After you build, draw your finished diorama and write the names of the animals you put in it.

From history. California condors are the biggest flying birds in North America. With wings spread out, a condor is wider than a big couch is long. Long ago they had almost all disappeared. People caught the last wild condors, raised chicks in safe places and then set young condors free again. Since 1996 condors have been let go near the Grand Canyon, and today visitors can sometimes see them soaring over the rim.

WORKED EXAMPLES

Example 1. You glue 5 paper layer strips on top of each other on one side of your canyon. Each strip is 2 centimeters tall. Use your ruler or count by twos. How tall is your canyon wall?

(Use the map or drawing “Each layer strip adds 2 centimeters to the height of the wall.” shown earlier in this lesson.)

1. Each strip is 2 centimeters tall. There are 5 strips.
2. Count by twos, one count for each strip: 2, 4, 6, 8, 10.
3. Check with the ruler: lay it next to the wall. It should reach the 10 centimeter mark.

Answer: The canyon wall is 10 centimeters tall.

PRACTICE

1. **EASY** Point to the rim, a cliff, a slope and the river on your diorama (or on the drawing).
2. **EASY** Is the canyon wider at the top or at the bottom?
3. **MEDIUM** Match each living thing to where it belongs: pine tree, cactus, bighorn sheep, condor. Places: on the rim, on a dry slope, climbing a cliff, flying in the sky.
4. **MEDIUM** Your wall has 4 strips, and each strip is 3 centimeters tall. Count by threes. How tall is the wall?
5. **HARD** Tell in your own words: why do some layers make steep cliffs and others make gentle slopes?

COMMON MISTAKES

- Making the canyon walls straight up and down like the sides of a box. Real Grand Canyon walls step down like stairs, with cliffs and slopes.

- Putting the river at the top. The river is always at the lowest place, the bottom of the canyon.
- Thinking nothing lives in the canyon because it is rocky and dry. Many plants and animals live there, from pine trees on the rim to fish in the river.

Make it a game · Canyon Tour Guide. The child is the park ranger. The parent is a visitor who asks questions: “Where is the rim?” “Show me a cliff!” “Where would a bighorn sheep be?” “Where did Powell’s boat go?” The ranger answers by pointing to the diorama. Every right answer earns a pebble. After five pebbles, switch, and the child asks the parent tricky questions.

Scripture. “For thou, LORD, hast made me glad through thy work: I will triumph in the works of thy hands.” (Psalm 92:4, KJV)

God’s work makes us glad. When we build a little canyon, we are thinking about the great works of His hands and thanking Him for them.

Practice answers

1. The child points to the top edge (rim), a steep straight-up layer (cliff), a gently slanting layer (slope) and the blue river at the bottom.
2. Wider at the top. It is narrow at the bottom where the river runs.
3. Pine tree: on the rim. Cactus: on a dry slope. Bighorn sheep: climbing a cliff. Condor: flying in the sky.
4. 3, 6, 9, 12. The wall is 12 centimeters tall.
5. Hard rock layers, like limestone, wear away slowly and stand up as steep cliffs. Soft layers, like shale made of mud, crumble easily and wear back into gentle slopes.

UNIT 8 REVIEW

This is an oral review. Ask each question aloud and let your child answer in their own words, point, or draw. Give full points for a clear answer in the child's own words. The review is worth 20 points.

1. (3 pts) Who was John Wesley Powell, and what did he do in 1869?
2. (3 pts) What is a canyon? What is at the bottom of the Grand Canyon?
3. (3 pts) Show me with your hands or a stack of books: which layer was laid down first, the top or the bottom?
4. (3 pts) Name one thing found in the Grand Canyon's layers.
5. (3 pts) Tell what happened at Mount St. Helens in 1982.
6. (3 pts) Which carves more, a slow trickle or a big fast flood? Which washes away faster, soft sand or hard rock?
7. (2 pts) Point to the rim, a cliff, a slope and the river on your diorama.

UNIT PROJECT: MY GRAND CANYON DIORAMA AND FIELD BOOK

Finish your shoebox canyon diorama with layered walls that step down in cliffs and slopes, a blue river, Powell's little boat, and at least three living things in the right places. Beside it, set out your sketchbook pages: Powell's trip map, your drawing of the layers with "first" and "last" labeled, and your slow-water and fast-water test with both measurements. Then give your family a tour, telling Powell's story and how water carves canyons.

- **Canyon shape:** The diorama is wide at the top and narrow at the river, with matching layers on both sides that step down in cliffs and slopes.
- **Living things:** At least three plants or animals are placed where they really live: pines on the rim, cactus on slopes, sheep on cliffs, birds in the sky.
- **Field book:** The map, layer drawing and water test pages are complete, labeled and include the measured numbers.
- **Telling the story:** The child tells Powell's trip, which layer came first, and how fast water can carve, in their own words.

Answer key

1. He was a one-armed explorer who floated in wooden boats down the Green River and the Colorado River, all the way through the Grand Canyon.
2. A canyon is a deep valley with steep, rocky sides. The Colorado River runs at the bottom of the Grand Canyon.
3. The bottom layer was laid down first. The top layer was laid down last.
4. Any one: sea shells, trilobites, or animal footprints (in the Coconino Sandstone).
5. Heat from the mountain melted snow in the crater, and a rush of water and mud flowed down. In less than one day it carved a little canyon with layered walls in the soft ground.
6. A big fast flood carves more. Soft sand washes away faster than hard rock.

7. The child points to the top edge (rim), a steep wall (cliff), a gently slanting part (slope) and the river at the bottom.

BONUS: FIELD LAB

This bonus unit takes everything you learned about mountains, earthquakes, rivers, canyons and shores and carries it outside. A real scientist does not only read about the earth. A scientist walks on it, looks closely, tests ideas and writes down what happened. In these four short field labs you will be that scientist, with a clipboard, a pencil and a grown-up by your side.

You will hike to find hills, valleys and slopes, build a little river in a tray of sand, shake towers on rock and on sand, and visit a creek or a shore to watch moving water at work. Along the way you will meet John Muir with his notebook, Thomas Moran at the edge of a yellow canyon, and John Constable sketching by his river. Every lab ends with drawing, counting and telling what you saw, and with thanks to the God who made heaven and earth.

BEFORE YOU BEGIN

- Can count to 20 and make tally marks
- Can add and subtract small numbers, under 20
- Can draw a simple picture and label it with a parent's help
- Has finished some of Units 1-8, especially mountains, earthquakes and shores

MASTERY CHECKLIST

- I can find and name a hill, a valley, a slope and flat land outdoors.
- I can show how running water carves a channel and drops sand where it slows down.
- I can tell why a building stands better on solid rock than on loose sand.
- I can find fast and slow water in a creek and tell why pebbles are smooth.
- I can keep a field notebook with drawings, tally marks and counts.

OPTIONAL BOOKS AND RESOURCES

- **USGS Water Science School** (<https://www.usgs.gov/special-topics/water-science-school>): Free. Pictures and short articles from the U.S. Geological Survey about rivers, streams and erosion. A parent can read pieces aloud before the stream table and creek labs.
- **National Park Service** (<https://www.nps.gov/>): Free. Find a park, trail or seashore near you for the landform hike and creek or shore visit. Many parks offer free Junior Ranger booklets for children.

9.1 LANDFORM HIKE

OBJECTIVES

- Find and name landforms near home: a hill, a valley, a slope and flat land.
- Keep a simple field notebook with tally marks and a drawn map of a walk.

Warm-up. Lay a bath towel flat on the floor. Push the ends toward the middle so it bunches up into bumps and dips. Point to a high place (a hill), a low place between two bumps (a valley), and a flat place. Run a toy car down the side of a bump. Which way does it roll?

Video. Coming soon. Landforms for kids: hills, valleys, plains and slopes, with real outdoor footage; search SciShow Kids, Homeschool Pop (Alternate), National Park Service junior ranger videos and USGS kids clips.

KEY TERMS

landform

A shape of the land, like a hill, a valley or a flat plain.

hill

Land that rises up higher than the land around it. A hill is smaller than a mountain.

valley

A low place between hills or mountains. Water often runs along the bottom of a valley.

slope

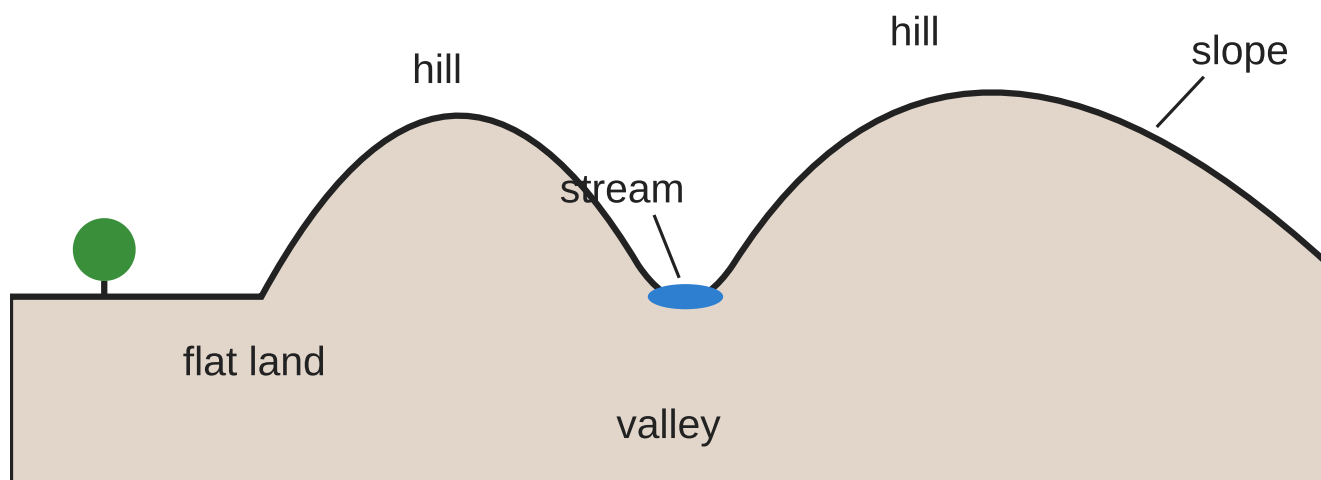
Land that tilts, so one side is higher and the other side is lower. Balls and water roll down a slope.

CORE IDEAS

The story. In 1867 a young man named John Muir set out to walk all the way from Kentucky to the seashore in Florida. He carried a small bag, a plant press and a notebook. Every day he wrote down the hills he climbed, the rivers he crossed and the plants he found. On the inside of his notebook he wrote his address as “John Muir, Earth-planet, Universe.” Muir knew that a good scientist goes outside, looks closely and writes things down.

The big idea. The ground is not flat everywhere. It has shapes, and we call those shapes **landforms**. A **hill** rises up high. A **valley** is a low place between high places. A **slope** is land that tilts, and anything loose on a slope, like water, pebbles or a ball, goes downhill. Flat land is a landform too. Even a small park or a backyard has little hills, dips and slopes if you look carefully. Big landforms, like mountains and canyons, have the same shapes, only much larger.

Try it and see. Today you will go on a landform hike, just like Muir. Walk slowly. Look up, look down and look far away. Each time you find a hill, a valley, a slope or a flat place, make a tally mark in your notebook. When you get home, draw a map of where you walked. **God's handiwork.** The psalm writer lifted up his eyes to the hills and remembered that his help comes from the Lord, who made heaven and earth. When you stand on a hill and look around, you are looking at land God shaped.



Four landforms to look for on your hike: flat land, a hill, a valley and a slope.

PICTURE STUDY



View from Mount Holyoke, Northampton, Massachusetts, after a Thunderstorm (The Oxbow), Thomas Cole, 1836 · Oil on canvas · The Metropolitan Museum of Art, New York

Thomas Cole loved to hike up hills with his sketchbook. In this painting he stands on top of Mount Holyoke in Massachusetts and looks down at the Connecticut River. The river bends in a big loop that looks like the curved wooden collar on an ox, so people call this painting *The Oxbow*.

Cole put himself in the picture. Look very closely near the bottom, and you will find a tiny painter in a hat working at his easel, turning to look at you.

Look closely

- Find the hill where the painter is sitting. Is he up high or down low?
- Find the river. Trace its big loop with your finger.
- Find the flat land near the river. What are people doing with that flat land?
- Find the storm. Which side of the painting is stormy, and which side is sunny?

Talk about it

1. How many landforms can you name in this painting?
2. Why do you think farmers chose the flat land by the river for their fields?
3. If you climbed a hill near your home, what would you see?

Safety first. Hike only with a grown-up and stay on the path. Wear closed shoes, bring water, and do not touch plants you do not know (poison ivy has leaves in groups of three). Check for ticks when you get home. Leave wild animals alone.

MAKE AND DO: MY LANDFORM HIKE AND MAP

You will take a short walk in your yard, a park or a trail, count the landforms you find, and draw a map of your hike when you get home.

You will need

- A clipboard or a piece of cardboard with a clothespin
- Paper and a pencil
- Crayons or colored pencils
- A small ball or a marble
- A water bottle

Steps

1. Before you go, draw four boxes on your paper. Label them with a small drawing: a bump for *hill*, a dip for *valley*, a tilted line for *slope* and a flat line for *flat land*.
2. Walk slowly with your grown-up. Each time you find one of these landforms, make a tally mark in its box.
3. Find a slope. Set the ball on it and let go. Watch which way it rolls. That way is downhill.
4. Stand on the highest spot you can find. Look around and name one thing that is lower than you.
5. At home, draw a map of your walk. Mark where you started with a star. Draw the path and the hills, valleys and flat places you saw.
6. Count your tally marks and tell your grown-up which landform you saw the most.

Tips

- Small landforms count! A bump in the yard is a little hill, and a ditch is a little valley.
- After a rain, look for where water ran. It always shows you the low places.

Check your work

- I can point to a hill, a valley, a slope and flat land.
- I can show which way is downhill.
- I drew a map of my hike.

FIELD NOTEBOOK

1. Draw the highest place you stood on your hike and what you could see from there.
2. Draw a slope with a ball rolling down it. Add an arrow that points downhill.
3. Draw your tally chart and circle the landform you saw most.

From history. John Muir's notebook from his long walk was turned into a book called *A Thousand-Mile Walk to the Gulf*. It was printed after he died, so people today can still

read what he saw on the hills and rivers of the South. Muir later helped people protect Yosemite Valley in California as a park for everyone to visit.

WORKED EXAMPLES

Example 1. On the hike, Ben made this tally chart. Hills: |||. Valleys: |. Big rocks: ||||. Which did he see the most? How many things did he see in all?

1. Count the hill marks: 1, 2, 3. Three hills.
2. Count the valley marks: 1. One valley.
3. Count the big rock marks: 1, 2, 3, 4. Four big rocks.
4. Four is the biggest number, so he saw big rocks the most.
5. Add them all: $3 + 1 + 4 = 8$.

Answer: He saw big rocks the most (4). He saw 8 things in all.

PRACTICE

1. **EASY** Point to the picture of the hill on the landform chart. Now point to the valley.
2. **EASY** Which is lower: a hill or a valley?
3. **EASY** You set a ball on a slope and let go. Does it roll up or down?
4. **MEDIUM** On your walk you counted 6 hills and 7 slopes. How many landforms is that in all?
5. **MEDIUM** Draw a picture with a hill, a valley and flat land. Label each one.

COMMON MISTAKES

- Thinking landforms are only big, faraway mountains. A small bump in the yard is a landform too.
- Thinking the ground is flat almost everywhere. Look closely and you will see slopes and dips nearly everywhere.
- Thinking water can run uphill by itself. Water always runs downhill, to the lowest place it can reach.

Make it a game • I Spy a Landform. Take turns saying, “I spy a landform that is high,” or “low,” or “tilted,” or “flat.” The other player points and names it: hill, valley, slope or flat land. A right answer earns a pebble. The first player to collect 10 pebbles wins.

Scripture. “I will lift up mine eyes unto the hills, from whence cometh my help.” (Psalm 121:1, KJV)

When the psalm writer looked at the hills, he remembered the God who made them. On your hike, look up at the hills and say thank you to the Lord who made heaven and earth.

Practice answers

1. The hill is the high bump; the valley is the low place between the two hills, where the stream is.
2. A valley is lower.
3. Down. Loose things roll downhill on a slope.
4. $6 + 7 = 13$ landforms.
5. The drawing shows a high bump labeled hill, a low dip labeled valley and a level stretch labeled flat land.

9.2 YARD STREAM TABLE

OBJECTIVES

- Build a stream table outdoors and watch running water carry sand downhill.
- Tell where water carves a channel and where it drops sand.
- Measure a channel with a ruler and compare before and after.

Warm-up. Pour a spoonful of sugar into a little hill on a plate. Drip water on top of it one drop at a time with a spoon or a dropper. Watch the hill. Where does the water go, and what does it take with it?

Video. Coming soon. Stream table erosion and deposition demonstrations for children, plus footage of the Grand Canyon of the Yellowstone; search USGS, National Park Service, SciShow Kids, Science Max and Homeschool Pop (Alternate).

KEY TERMS

stream

Water that keeps running downhill along the ground, like a small river.

erosion

When water or wind carries soil, sand and rock away.

channel

The groove or path a stream cuts and runs in.

deposit

To drop sand and mud in a new place. Water deposits sand where it slows down.

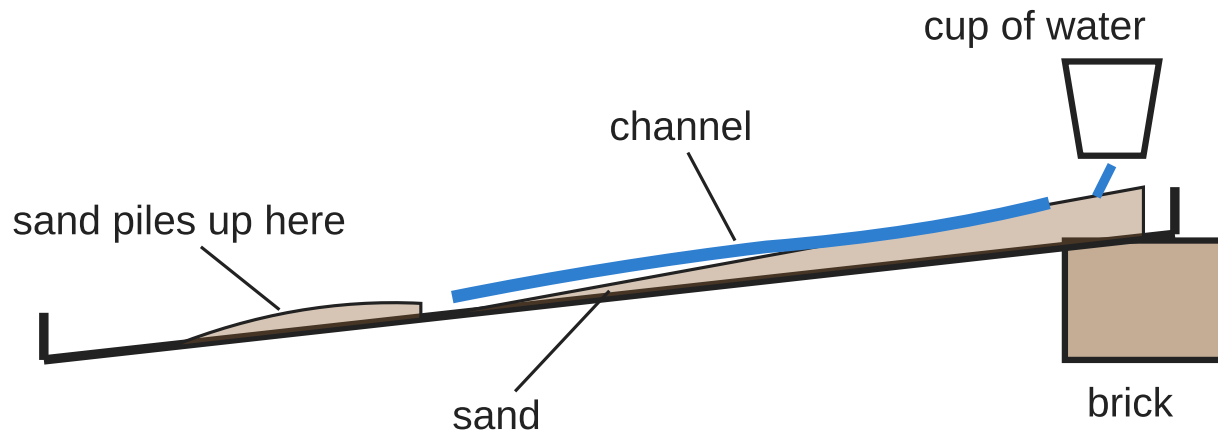
CORE IDEAS

The story. In 1871 the painter Thomas Moran rode with a team of explorers into a wild place called Yellowstone. There he stood at the edge of a deep canyon with walls of yellow, orange and white rock. Far below, the Yellowstone River rushed along the bottom, and a great waterfall thundered into the canyon. Moran filled his sketchbook. His paintings, and the photographs taken on the same trip, helped people back home see how wonderful the place was. In 1872 Yellowstone became the very first national park.

The big idea. A river like the Yellowstone is always at work. Running water picks up sand, mud and pebbles and carries them away. We call this **erosion**. The water wears a groove called a **channel**. Where water runs fast, it carries a lot. Where it slows down, it cannot hold so much, so it drops the sand in a new place. We say the water **deposits** the sand. A steep slope makes water run faster, so it carves more.

Try it and see. You can watch this happen in your own yard. Pile sand in a tray, tip the tray up on a brick and let water trickle down from the top. In a few minutes a little stream will

cut its own channel and build a fan of sand at the bottom. It is like a tiny canyon and a tiny river mouth in one tray. **God's handiwork.** Psalm 104 says the waters go up by the mountains and go down by the valleys to the place God founded for them. Water running downhill follows the order God built into the world.



A yard stream table: water carves at the top and drops sand at the bottom.

PICTURE STUDY



The Lower Falls of the Yellowstone, William Henry Jackson, 1871 · Photograph · National Archives, College Park, Maryland (photographs of the Hayden Survey)

William Henry Jackson was the photographer on the same 1871 trip to Yellowstone that took Thomas Moran there. Moran painted and sketched, and Jackson carried a big wooden camera and heavy glass plates. The two men often worked side by side, looking at the same waterfalls and canyon walls.

This photograph shows the Lower Falls of the Yellowstone River, the waterfall at the head of the yellow canyon. Jackson's photographs and Moran's pictures helped people back East believe that such a wonderful place was real.

Look closely

- Find the top of the waterfall. Trace with your finger where the water goes after it falls.
- Look at the canyon walls on each side. Are they steep cliffs or gentle slopes?
- Find the bottom of the falls. What does the water look like where it lands?
- This photograph has no color. What colors do you think the real rocks were?

Talk about it

1. How is this river like the little stream in your stream table? How is it different?
2. The falling water hits the river below very hard. What do you think it does to the rock and sand there?
3. Why do you think Jackson wanted to take a photograph if Moran was already painting the same place?

Safety first. Work outdoors with a grown-up close by. Do not drink the muddy water, and wash your hands when you finish. Empty every tub and bucket of water when you are done, because even shallow water is dangerous for small children.

MAKE AND DO: BUILD A YARD STREAM TABLE

You will make a small river in a tray of sand and watch it carve a channel and drop sand at the bottom. Then you will make the slope steeper and see what changes.

You will need

- A large baking pan, plastic storage tub lid or old cookie sheet with sides
- Sand or garden soil, enough to fill the pan about 2 inches deep
- A brick, a book in a plastic bag or a block of wood
- A paper or plastic cup with a small hole poked in the bottom (a grown-up pokes it)
- A pitcher or jug of water
- A ruler
- A few small pebbles

Steps

1. Pack damp sand into the upper two-thirds of the pan. Leave the low end empty, like a lake.

2. Set the high end of the pan on the brick so it tilts.
3. Press a few pebbles into the sand here and there.
4. Hold the cup at the high end and fill it with water. Let the water drip and trickle out onto the sand. Use 3 cups of water in all.
5. Watch closely. Where does the water carve? Where does the sand pile up? Do the pebbles move?
6. Measure how wide the channel is with your ruler. Write the number down.
7. Now set the high end on two bricks to make it steeper. Smooth the sand and try again with 3 cups. Measure again. Which channel is wider and deeper?

Tips

- Damp sand works better than dry sand, because it holds its shape.
- Keep the cup in the same spot each time, so the test is fair.

Check your work

- I saw water carve a channel.
- I saw sand dropped at the bottom where the water slowed down.
- I can tell what happened when the slope was steeper.

FIELD NOTEBOOK

1. Draw your stream table from the side. Label the cup, the channel and the fan of sand.
2. Draw the channel after 3 cups on the gentle slope and after 3 cups on the steep slope, side by side.
3. Find a place in your yard or street where rainwater has washed soil away. Draw it.

From history. Congress bought Thomas Moran's *Grand Canyon of the Yellowstone* in 1872 for \$10,000 and hung it in the U.S. Capitol. Moran loved Yellowstone so much that people called him Thomas "Yellowstone" Moran, and he began signing his paintings with the letters "TYM."

WORKED EXAMPLES

Example 1. After the first cup of water, Anna measured her channel: it was 2 inches wide. After 3 cups, it was 5 inches wide. Which time was the channel wider? How many inches wider?

(Use the map or drawing “Measure across the channel with a ruler.” shown earlier in this lesson.)

1. Compare: 5 is bigger than 2, so the channel was wider after 3 cups.
2. Find how much wider: start at 2 and count up to 5: 3, 4, 5. That is 3 counts.
3. Check with subtraction: $5 - 2 = 3$.

Answer: The channel was wider after 3 cups, by 3 inches. More water carried away more sand.

PRACTICE

1. **EASY** On the stream table picture, point to the place where the water carves. Now point to where the sand piles up.
2. **EASY** Does water run uphill or downhill?
3. **MEDIUM** Which carves faster: water on a gentle slope or water on a steep slope?
4. **MEDIUM** You poured 4 cups on the gentle slope and 4 cups on the steep slope. How many cups did you pour in all?
5. **HARD** Tell in your own words why sand piles up at the bottom of the tray.

COMMON MISTAKES

- Thinking rivers stay the same forever. Running water keeps moving sand and changing its channel.
- Thinking slow water carries more. Fast water carries more; slow water drops its sand.
- Thinking the sand just disappears. The sand is not gone; the water carried it to a new place.

Make it a game • Pebble Rafting. Each player sets one small pebble at the top of the stream table. Pour one cup of water slowly. Whose pebble moved the farthest? Measure with your fingers or a ruler. Try again with bigger and smaller pebbles. Which kind of pebble does the water move most easily?

Scripture. “They go up by the mountains; they go down by the valleys unto the place which thou hast founded for them.” (Psalm 104:8, KJV)

Water runs down through the valleys to the low places, just as God set it up to do. Your stream table shows the same thing in a tray.

1. The water carves the channel on the slope near the top; the sand piles up in a fan at the low end.
2. Downhill.
3. Water on a steep slope. It runs faster, so it carries away more sand.
4. $4 + 4 = 8$ cups.
5. At the bottom the water spreads out and slows down. Slow water cannot carry as much sand, so it drops (deposits) the sand there.

9.3 SHAKE TEST DAY

OBJECTIVES

- Build small towers on solid ground and on loose sand, shake them, and compare which stand.
- Watch wet sand turn soft and runny when it is shaken.
- Tell why builders want strong foundations on solid ground.

Warm-up. Set a plastic cup upside down on a pillow and another on a hard table. Stack three blocks on each cup. Gently bump the pillow and then the table with the same small push. Which tower wobbles more?

Video. Coming soon. Liquefaction of wet sand in earthquakes, shown with a simple tray or jar demonstration, and kid-friendly shake table tests; search USGS, IRIS Earthquake Science, Science Max, SciShow Kids and Homeschool Pop (Alternate).

KEY TERMS

earthquake

A sudden shaking of the ground when rocks deep under the earth slip.

foundation

The strong bottom part of a building that sits on the ground and holds everything up.

solid ground

Hard ground, like rock, that stays firm when it is shaken.

loose ground

Soft ground, like sand or piled-up dirt, that can slide and sink when it is shaken.

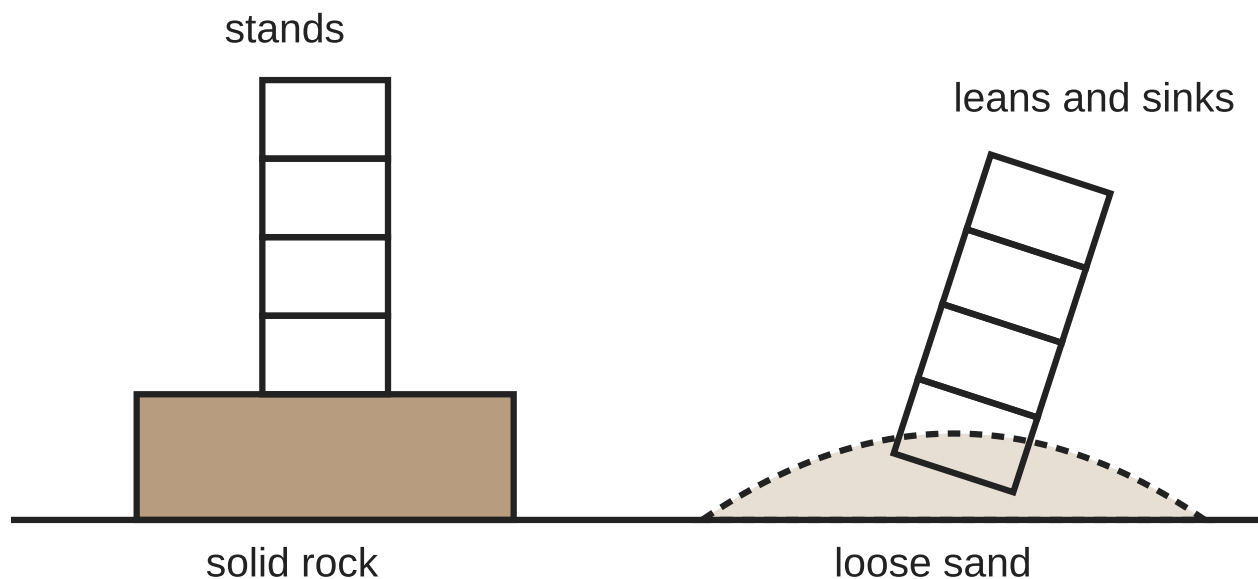
CORE IDEAS

The story. On October 17, 1989, thousands of people were sitting in a ballpark in San Francisco, waiting for a big baseball game to begin. Suddenly the ground began to shake. It was an earthquake. When it stopped, people found something surprising. In one part of the city, called the Marina, houses tipped and sank. That neighborhood had been built on loose, filled-in ground at the edge of the bay. Houses on hard, rocky hills nearby shook much less.

The big idea. Not all ground shakes the same way. **Solid ground**, like rock, holds firm. **Loose ground**, like sand and piled-up dirt, jiggles much more. When loose sand is full of water and gets shaken, the grains slide apart and the sand turns soft and runny, almost like a milkshake. Heavy things on top can sink or tip over. That is why wise builders dig a strong **foundation** down to solid ground. A wide, heavy bottom helps too.

Try it and see. Today you will be the earthquake scientist. Outside, you will build towers on a hard brick and on a pile of loose sand, then shake them and count which ones stay up. You

will also make a tray of wet sand, stand a toy on top and tap, tap, tap. Watch what happens to the toy! **God's handiwork.** King David called the Lord his rock and his fortress. When the ground under us shakes, God does not. He is the solid ground we can build our lives on.



After shaking: the tower on solid rock stands, and the tower on loose sand leans and sinks.

PICTURE STUDY



The Tower of Babel, Pieter Bruegel the Elder, 1563 · Oil on panel · Kunsthistorisches Museum, Vienna, Austria

Pieter Bruegel was a painter from Flanders, in what is now Belgium. Here he painted the tower from Genesis 11, which proud people tried to build up to heaven. Bruegel painted it like a huge building site of his own day, with cranes, ladders, carts and hundreds of tiny workers.

Look carefully at the bottom of the tower. Bruegel built it right around a big hill of rock. Builders in his time knew that a heavy building needs a solid base.

Look closely

- Find the rock that pokes out at the bottom of the tower.
- Find a crane or a ladder. How are the workers lifting heavy stones?
- Find the king in the front corner. What are the stone carvers doing?
- Look at the whole tower. Is it wide at the bottom or wide at the top?

Talk about it

1. Why would a builder want a very tall tower to sit on rock instead of sand?
2. How many workers can you count in one small part of the painting?
3. In the Bible, God stopped the tower. Why was building it a proud idea?

Safety first. Use only small, light blocks so nothing heavy can fall on toes. Shake gently with your hands, never by stomping on the tray. Wash sandy hands before snack time.

MAKE AND DO: ROCK OR SAND SHAKE TEST

You will build towers on solid ground and loose ground, shake them the same way, and count which ones stand. Then you will see wet sand turn runny.

You will need

- A large baking pan or plastic tub
- A brick or a flat paving stone
- Sand
- A pitcher of water
- Small blocks or sugar cubes (about 20)
- A small heavy toy, like a metal car or a plastic figure with a heavy base
- A spoon and paper for tally marks

Steps

1. Put the brick at one end of the pan. Pile loose, dry sand at the other end.
2. Build a tower of 5 blocks on the brick and a tower of 5 blocks on the sand.
3. Hold the sides of the pan and shake it gently back and forth 5 times. Make a tally: which tower stood? Which fell or leaned?
4. Build again and try 10 shakes. Is it the same?

5. Now build one tall, thin tower and one short, wide tower on the brick. Shake. Which stays up longer?
6. For the last test, clear the pan. Fill it with sand and slowly pour in water until the water just reaches the top of the sand. Pat the sand flat.
7. Stand the toy on top. Tap the side of the pan with a spoon again and again. Watch the toy and the top of the sand.

Tips

- Shake the same way each time, so the test is fair.
- In the wet sand test, water rises to the top and the toy sinks or tips. That is what happened to some houses on loose, wet ground in real earthquakes.

Check your work

- I built towers on solid ground and loose ground and shook them the same way.
- I can tell which tower stood best and why.
- I saw wet sand turn soft and runny when shaken.

FIELD NOTEBOOK

1. Draw your two towers after shaking: the one on the brick and the one on the sand.
2. Draw the toy in the wet sand before tapping and after tapping.
3. Draw a house with a deep, strong foundation that goes down to rock.

From history. In 1933 an earthquake shook Long Beach, California, and many school buildings were badly damaged. It happened in the evening, when the schools were empty. Afterward, California passed a law called the Field Act, which said new school buildings must be built strong enough to stand up to earthquakes.

WORKED EXAMPLES

Example 1. Sam stacked blocks until each tower fell during shaking. The tower on the brick held 8 blocks. The tower on loose sand held only 5 blocks. Which tower held more? How many more?

(Use the map or drawing “Solid ground holds a tower better than loose sand.” shown earlier in this lesson.)

1. Compare: 8 is bigger than 5, so the tower on the brick held more.
2. Count up from 5 to 8: 6, 7, 8. That is 3 more.
3. Check: $8 - 5 = 3$.

Answer: The tower on the brick held 3 more blocks. Solid ground made a better base.

PRACTICE

1. **EASY** Point to the tower on solid rock in the picture. Point to the tower on loose sand. Which one is leaning?
2. **EASY** Sort these into solid ground and loose ground: rock, sand, a brick, a pile of dirt.
3. **MEDIUM** Which stays up better in a shake: a tall, thin tower or a short, wide tower?
4. **MEDIUM** You shook the pan 10 times for the first test and 10 times for the second test. How many shakes in all?
5. **HARD** Tell what happened to the toy when you tapped the pan of wet sand, and why.

COMMON MISTAKES

- Thinking all ground shakes the same in an earthquake. Loose, wet ground shakes and sinks much more than solid rock.
- Thinking the tallest tower is the strongest. A wide, low tower with a strong base stands better.
- Thinking sand is always firm because it feels hard to walk on. Wet sand can turn runny when it is shaken.

Make it a game • Earthquake Freeze. One player is the “ground.” Everyone else stands tall like towers. When the ground says “Shake!” the towers wiggle. When the ground says “Rock!” the towers must stand with feet wide apart and freeze. When the ground says “Sand!” the towers slowly sink down to sit on the floor. Anyone who does the wrong move becomes the next ground.

Scripture. “The LORD is my rock, and my fortress, and my deliverer; my God, my strength, in whom I will trust; my buckler, and the horn of my salvation, and my high tower.” (Psalm 18:2, KJV)

Your tower on the brick stood firm when the sand gave way. David says the Lord is like that rock: strong and safe when everything else is shaking.

Practice answers

1. The tower on loose sand is leaning and sinking.
2. Solid ground: rock, a brick. Loose ground: sand, a pile of dirt.
3. A short, wide tower. Its wide bottom keeps it from tipping.
4. $10 + 10 = 20$ shakes.
5. The toy sank or tipped over and water came up to the top. Shaking made the wet sand grains slide apart, so the sand turned soft and runny and could not hold the toy up.

9.4 CREEK OR SHORE VISIT

OBJECTIVES

- Visit a creek, river bank, pond edge or seashore and observe how water moves and shapes the land.
- Find where water runs fast and slow, and sort pebbles by size and shape.

Warm-up. Put five small rocks or dried beans in a plastic jar with a lid. Add a spoonful of sand and a little water. Close it tight and shake for one minute. Pour it out. Do the rocks look or feel any different? This is what water does to pebbles in a creek, only very slowly.

Video. Coming soon. How creeks and rivers move pebbles and sand, fast and slow water at a river bend, and waves on a beach, for young children; search USGS Water Science School, National Park Service, SciShow Kids, Homeschool Pop (Alternate) and nature footage.

KEY TERMS

current

Water moving in one direction, like the water flowing along a creek.

bank

The land along the side of a creek or river.

pebble

A small, smooth stone. Water rolls pebbles and rubs off their sharp corners.

shore

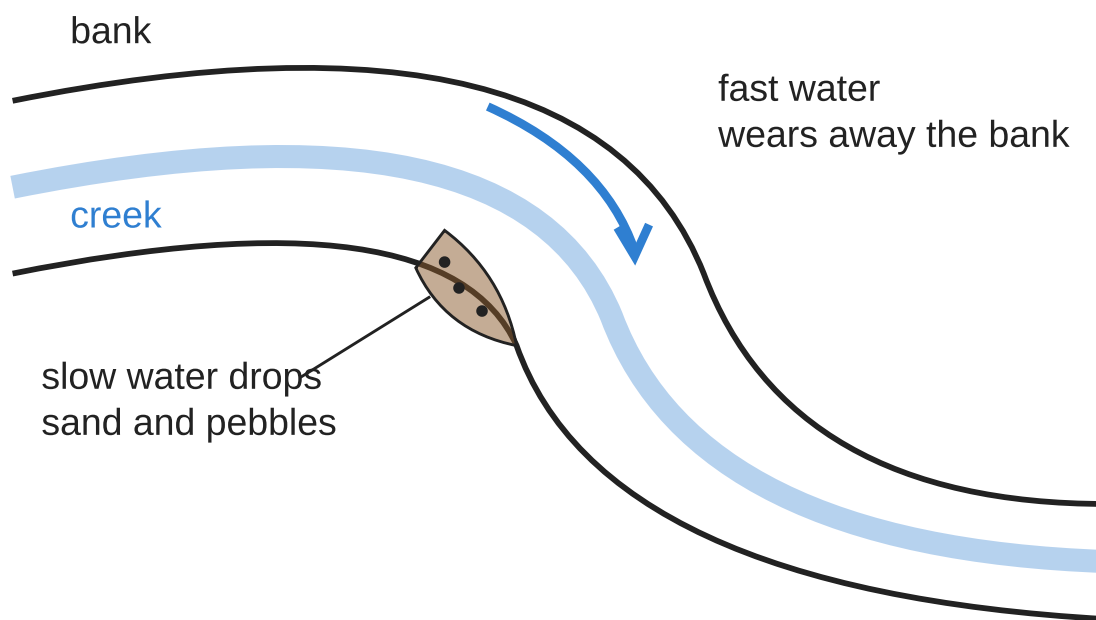
The land at the edge of a lake or the sea, where the water meets the land.

CORE IDEAS

The story. When John Constable was a boy in England, he lived near the River Stour, where his father owned a water mill. He spent hours by the river, watching the water slide past the banks, the boats float by and the clouds drift overhead. When he grew up, he became a painter, and he painted his river again and again. He said those scenes by the river made him a painter. A creek or a shore is one of the best places for a young scientist too.

The big idea. The water in a creek is always moving. That moving water is called the **current**. The current is fast in some places and slow in others. Where a creek bends, the water on the outside of the bend runs fast and wears away the **bank**. On the inside of the bend the water is slow, and it drops sand and pebbles there. As water tumbles **pebbles** along, it knocks off their sharp corners, so creek stones are round and smooth. At the seashore, waves do the same work, rolling sand and shells back and forth along the **shore**.

Try it and see. At the water, drop a leaf in and watch where the current carries it. Find a fast place and a slow place. Collect pebbles from the edge and sort them by size. Feel which ones are smooth. **God's handiwork.** In the book of Job, God says He told the sea, "Hitherto shalt thou come, but no further." The waves come up the beach and stop where God set the line. Even the mighty sea obeys its Maker.



At a bend, fast water wears away the outside bank, and slow water drops sand and pebbles on the inside.

PICTURE STUDY



The Hay Wain, John Constable, 1821 · Oil on canvas · The National Gallery, London

A wain is an old word for a farm wagon. In this painting a wagon has rolled into the shallow River Stour, near the mill where Constable grew up. The water is low enough for the horses to walk right through it.

Constable made many sketches outdoors by the river, then painted the big picture in his studio in London. He loved to paint ordinary country places, with real clouds, real water and real light.

Look closely

- Find the wagon in the water. How deep do you think the water is there?
- Find the bank on the left side. What is built on it?
- Find the dog. Where is it standing?
- Look at the water. Does it look fast and rough, or slow and calm?

Talk about it

1. Why do you think the driver chose this shallow spot to cross the river?
2. What would you hear if you stood on the bank next to the dog?
3. How is this river like a creek you have seen?

Safety first. Go only with a grown-up, and stay where they can reach you. Never wade in fast water or water deeper than your knees. Wet rocks are slippery, so walk slowly. At the beach, watch the waves and never turn your back on them. Do not drink creek water, leave wild animals alone, and wash your hands afterward.

MAKE AND DO: CREEK OR SHORE FIELD VISIT

You will visit moving water, watch the current, and bring home a small collection of pebbles to sort. If you live far from a creek, a pond edge, a lake beach or even a rainy-day gutter will work.

You will need

- Rubber boots or old shoes that can get wet
- A few leaves or small sticks
- A small bag or egg carton for pebbles
- Paper, pencil and crayons on a clipboard
- A ruler
- A towel

Steps

1. Stand safely on the bank with your grown-up. Look and listen for one quiet minute. What do you hear?
2. Drop a leaf into the water. Watch which way it floats. That is the way the current is going.

3. Drop another leaf in a different spot. Does it go faster or slower? Find one fast place and one slow place.
4. If the creek bends, look at the outside of the bend and the inside. Which side has a steep bank? Which side has sand and pebbles?
5. Pick up 10 pebbles from the edge (only where it is allowed). Feel them. Are they smooth or sharp?
6. At home, sort your pebbles into big and small. Then sort them into round and pointy. Count each pile.
7. Draw a picture of the creek or shore and the place where you found your pebbles.

Tips

- At a seashore, watch where the highest wave stops and draw a line in the sand with a stick. Watch for a few minutes. Do the waves come past your line?
- In parks that ask visitors to leave rocks in place, draw and count the pebbles instead of taking them.

Check your work

- I watched a leaf show me the current.
- I found a fast place and a slow place in the water.
- I sorted pebbles by size and shape and counted them.

FIELD NOTEBOOK

1. Draw the creek or shore from where you stood. Add an arrow showing which way the water moved.
2. Trace around three pebbles: one big, one middle-sized and one small. Write a word for how each one feels.
3. Draw a creek bend. Color the fast water on the outside dark blue and the slow water on the inside light blue.

From history. John Constable loved the sky as much as the river. For two summers he went out on Hampstead Heath near London and painted quick sketches of clouds, and on the back of many of them he wrote the date, the time of day and which way the wind was blowing. He watched nature like a scientist and painted it like an artist.

WORKED EXAMPLES

Example 1. Grace sorted the pebbles she found. She had 6 big pebbles and 9 small pebbles. Which pile had more? How many pebbles did she find in all?

1. Compare: 9 is bigger than 6, so there were more small pebbles.
2. Add the piles: start at 9 and count on 6 more: 10, 11, 12, 13, 14, 15.
3. Check: $9 + 6 = 15$.

Answer: There were more small pebbles. She found 15 pebbles in all.

PRACTICE

1. **EASY** On the creek bend picture, point to the fast water. Now point to where sand and pebbles pile up.
2. **EASY** You drop a leaf in a creek. What does the leaf show you?
3. **EASY** Why are creek pebbles round and smooth?
4. **MEDIUM** You found 12 round pebbles and 5 pointy pebbles. How many more round pebbles than pointy ones?
5. **MEDIUM** Tell your grown-up one thing you saw the water doing to the land at the creek or shore.

COMMON MISTAKES

- Thinking water in a creek moves at the same speed everywhere. It is faster in narrow places and on the outside of bends, and slower in wide, shallow places.
- Thinking pebbles were always round. Water slowly rubbed off their corners as it rolled them along.
- Thinking the sea could wash up over all the land again. Since the Flood, God has set a bound for the waters “that they turn not again to cover the earth” (Psalm 104:9).

Make it a game • Leaf Boat Race. Each player picks a leaf and marks a starting spot on the bank. Drop the leaves in at the same time and count slowly until each leaf reaches a rock or stick your grown-up chooses as the finish line. The leaf with the smallest count was in the fastest current. Race again in a different spot and see if the fast lane changes.

Scripture. “And said, Hitherto shalt thou come, but no further: and here shall thy proud waves be stayed?” (Job 38:11, KJV)

God set a limit for the sea. The waves roar and roll, but they stop where God tells them to stop. The God who rules the sea also cares for you.

Practice answers

1. The fast water is on the outside of the bend; the sand and pebbles pile up on the inside of the bend.
2. Which way the current is moving and how fast it is going.
3. The water rolls and tumbles them against each other and against sand, which rubs off their sharp corners.
4. $12 - 5 = 7$ more round pebbles.
5. Answers will vary, for example: fast water wearing away a bank, sand and pebbles piled where the water was slow, or waves moving sand up and down the beach.

UNIT 9 REVIEW

This is an oral review. Ask each question aloud and let your child answer in their own words, point to a picture or show with their hands. Give full points for a clear answer in the child's own words. The review is worth 20 points.

1. (3 pts) Show me a hill and a valley with your hands. Which one is higher?
2. (3 pts) On a hike you counted 4 hills and 5 slopes. How many landforms is that?
3. (4 pts) Tell me what happened in your stream table. Where did the water carve, and where did the sand go?
4. (3 pts) Which tower stood better when we shook the pan: the one on the brick or the one on loose sand? Why?
5. (3 pts) What happened to the toy in the pan of wet sand when we tapped it?
6. (4 pts) At the creek or shore, how did you find out which way the water was moving? Why are creek pebbles smooth?

UNIT PROJECT: MY FIELD LAB NOTEBOOK

Put all four field labs together in one notebook or folder. Include your landform hike map and tally chart, your stream table drawing with the channel measurements, your rock-and-sand shake test tally, and your creek or shore drawing with your pebble sort. Make a cover with your name and a picture of your favorite place outdoors. Then show your notebook to your family and tell them about each lab.

- **Observation:** Drawings show real things the child saw: landforms, a channel, towers after shaking, moving water and pebbles.
- **Records:** Tally marks, counts and the ruler measurement are written down and match what happened.
- **Telling:** The child can explain each lab in their own words, using words like hill, valley, erosion, foundation and current.
- **Care:** Pages are labeled, colored and kept neat, like a real scientist's field notebook.

Answer key

1. A hill rises up high; a valley is a low place between high places. The hill is higher.
2. $4 + 5 = 9$ landforms.
3. The water ran downhill and carved a channel in the sand. It carried the sand down and dropped it in a pile at the bottom, where the water slowed down.
4. The one on the brick. Solid ground stays firm, but loose sand slides and sinks when it shakes.
5. The sand turned soft and runny, water came up, and the toy sank or tipped over.
6. We dropped a leaf and watched where the current carried it. Pebbles are smooth because the water tumbles them and rubs off their sharp corners.