

R.E.A.L. SCIENCE ODYSSEY

READ • EXPLORE • ABSORB • LEARN

Earth & Environment

LEVEL 2
GRADES 6–10

Teacher Guide

WRITTEN BY **BLAIR H. LEE, M.S.**



TBYB SAMPLE



REAL Science Odyssey

Read Explore Absorb Learn

Earth & Environment 2: Teacher Guide

Try Before You Buy

This file contains a preview of RSO Earth & Environment 2: Teacher Guide. Included in this sample are five chapters, one from each unit.

Unit I: Introduction

Chapter 1: Our Big, Blue Marble: The Four Spheres and the Scientific Method

Unit II: The Geosphere

Chapter 2: The Puzzle You Live On: Plate Tectonics

Unit III: Earth-Shaping Forces

Chapter 11: Lava You, Lava You Not: Volcanoes

Unit IV: The Hydrosphere

Chapter 18: Just Keep Swimming: Water Pollution and Some Solutions

Unit V: The Atmosphere

Chapter 21: What a Whirlwind: Storms

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About the Author

Blair H. Lee, M.S., is the founder of Secular Eclectic Academic (SEA) Homeschoolers, a supportive community that advocates for the exclusive use of secular academic materials. Blair is the author of numerous science courses. She also writes about how to craft innovative, academic learning for students in grades K through 12. Blair earned her Bachelor's degree in Biology and Chemistry and Master's degree in Chemistry at the University of California San Diego. She has been an educator for almost 30 years.

When teaching at her local community college, Blair found that many of her students were lacking in basic foundational science upon entering college. She believes science can be and should be taught from the beginning of a child's education. She began working with her own son and his friends on methods of teaching science concepts usually reserved for high school or college students. The results of her research and writing are *RSO Chemistry, Biology, Astronomy*, and *Earth & Environment*—concept-rich, hands-on courses that engage young people's minds and lay a firm foundation of science concepts.

Blair now spends her time writing science for young people. When not homeschooling her son and writing textbooks, she loves to cook (most chemists are good cooks), read, and hike.



REAL Science Odyssey (RSO) Series

Level 1

Life, by Terri Williams

Biology, by Blair H. Lee

Astronomy, by Blair H. Lee

Earth & Environment, by Blair H. Lee

Chemistry, by Blair H. Lee

Physics, by Dahlia Schwartz

Level 2

Biology, by Blair H. Lee

Astronomy, by Blair H. Lee

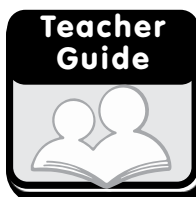
The Stargazer's Notebook: A Yearlong Study of the

Night Sky, by Blair H. Lee

Earth & Environment, by Blair H. Lee

Dedication

This course is dedicated to everyone who wants to learn about the wonders of our planet and the role you can play in preserving it.



Introduction to the Earth & Environment 2 Course

RSO Earth & Environment 2 is a 23-week earth and environmental science course. It is meant to be paired with the 12-week *RSO Astronomy 2* for a complete yearlong course.

The student textbook, student workbook, and the teacher guide contain all the information you need to teach earth and environmental science this year. This course was written so that it could be taught by all educators, even if you do not have a science degree. It is my goal to make science accessible to all, educators and students alike.

Structuring a good science course is like building a house. A well-built house starts with a strong foundation on which all other floors rest. *RSO Earth & Environment 2* starts with the fundamentals, and fact by fact builds from there, creating a strong foundation for future science knowledge to rest on.

While learning the fundamentals of earth and environmental science, students need to learn and practice the methods used by scientists to establish the scientific facts and theories that form the basis of those fundamentals. Understanding the scientific method and application of the processes used by scientists guides students to an understanding of the open-ended thinking that is a part of science. The labs are closely paired with the written material; that way students can see how the results of experiments have led to a better understanding of how the physical world works. The experiments also demonstrate the application of science principles. All of this together gives you a complete science course that teaches the core principles of earth and environmental science while teaching the processes used to develop these principles.

Course Structure

RSO Earth & Environment 2 consists of three books: the student textbook, the student workbook, and the teacher guide. If working with a group, several students can share a textbook, but I recommend each student have a copy of the workbook for written assignments, lab findings, and assessments. The course is comprised of 23 chapters designed as a “long” semester to be paired with the 12-chapter *Astronomy 2* as a “short” semester. This assumes that each chapter is completed within one week plus some extra time for review and testing.

Course Outcomes

This course has six major areas of knowledge that students should understand by the end of the course:

1. **Earth's Systems and Processes:** Students should be able to describe and explain the various physical processes that shape the Earth, including geologic, hydrologic, atmospheric, and ecological systems. They will learn how these systems interact and influence each other.
2. **Scientific Skills and Methods:** Students should develop critical scientific skills, including observing, hypothesizing, experimenting, and drawing conclusions. They should also come to understand the importance of using scientific tools and technologies to gather and analyze data.
3. **Impact of Human Activities:** Students should understand the impact of human activities on Earth's natural systems. This includes an exploration into topics like global warming, deforestation, urbanization, and sustainable development.
4. **Historical and Future Perspectives:** Students should gain knowledge of the Earth's historical climate and geologic changes and be able to discuss predictions for the future based on scientific data. This can help them understand the concept of deep time and the dynamic nature of Earth.
5. **Scientific Models:** Students should understand and be able to construct and use scientific models to represent and predict Earth's dynamic systems. This includes creating models for weather forecasting, climate prediction, and understanding geologic events.
6. **Application of Knowledge:** Students should be able to apply their learning to real-world situations, enhancing their understanding of both meteorological and geologic phenomena. This includes comprehending weather patterns, participating in environmental conservation efforts, and making informed decisions about environmental issues. Additionally, students will gain insights into Earth processes, such as earthquakes and volcanic eruptions. They will also develop the ability to interpret geologic processes that have occurred based on geographic features.

The Course Is Divided into Five Units

Unit I: Introduction

Unit II: The Geosphere

Unit III: Earth-Shaping Forces

Unit IV: The Hydrosphere

Unit V: The Atmosphere

Each Chapter Has Sections

In the student textbook:

- Lesson

In the student workbook:

- Geologic Timeline activities in most chapters
- Earth and environment labs and activities
- Famous Science Series (research assignment)
- Show What You Know (many question types are used: multiple choice, fill in the blank, matching, short answer, and more)
- Optional* unit exams (found in the appendix)

*Not optional for high school level

The Student Textbook

Students begin each chapter by reading a lesson in the textbook. Lessons are designed so that as students read, they are engaged through thought-provoking questions, and in some cases, by participating in a modeling activity to help visualize a concept. This type of direct engagement when incorporated into learning material gives students ownership of the material.

The following are the sections of each chapter found in the textbook and in the workbook. The sections are represented by the RSO acronym R.E.A.L.—Read, Explore, Absorb, and Learn. They are presented here in the order you will find them in both books. Although you can switch the order of the labs and the Famous Science Series within a chapter, you should not change the order of the chapters themselves. Each chapter builds upon the prior one.



READ: The Lesson

In the textbook lesson, the fundamentals of earth and environmental science are explained and built on. These lessons are designed to get students to think about key concepts, ask questions, and apply what they are learning to things they observe in the world around them. The lesson has been written so that most students can read it independently. Science vocabulary and terminology are introduced in context. They are written in **bold**. Formal definitions can be found in the glossary of the textbook.

The Student Workbook

After reading the chapter lesson in the textbook, students complete the labs, activities, research assignments, and assessments found in the workbook for that chapter. Because students will be writing directly in the workbook, it is recommended that each student has their own.

**EXPLORE: Labs and Activities**

After reading the lesson, students turn to their workbook for various activities and labs. Some labs begin with a short modeling activity to help visualize a concept presented in the lesson. Most chapters also have a Geologic Timeline activity to reinforce their understanding of the development of various elements of the geosphere, hydrosphere, and atmosphere of the Earth. Afterward, students will explore lesson concepts through experimentation. Students learn how scientists investigate and practice the scientific method in a meaningful way; gaining new insights into earth and environmental science in the process. The labs relate directly to the written lessons. The two are cohesive. Pairing lessons with labs that support the material studied is living science and is important to the understanding of science.

**ABSORB: Famous Science Series (FSS)**

The skill of researching a topic is essential to being proficient at science. As the famous scientist Isaac Newton once stated, “If I have been able to see farther than others, it was because I stood on the shoulders of giants.” By giants, he means other great scientists. Scientists research what is known about a topic and build on that knowledge when making new discoveries.

The purpose of FSS is to sharpen the researching skills of students taking this course while they learn some interesting history relating to biology. Students are expected to research the questions in FSS on their own; the information is not found in the course material. How you have students conduct research is up to you. I feel that Internet research is adequate for FSS. Wikipedia might give students all the information they need for some of the FSS, but if your student hasn’t yet begun to learn how to critically analyze the information they research online, now is a great time to start. Students should learn how to evaluate sources for reliability and accuracy. I recommend that students use the websites of highly respected organizations, such as NASA, NOAA, USGS, and Britannica. In addition, you might want to have your student do some library research as well.

There are 23 Famous Science Series topics in this course. The topics include famous scientists, discoveries, major events, and various geologic, environmental, and technological wonders. Students will use FSS to learn topics more in depth as they relate to the lesson. If you want to reduce the amount of writing for students, you can have them orally report the results of their research to you.

**LEARN: Show What You Know (SWYK)**

Science can be technical with a lot of new vocabulary words. I have tried to make the text as interesting as possible to keep students engaged in the material, but it is still important to have weekly assessments to ensure they have learned the key concepts. Show What You Know (SWYK) is the title of the question-and-answer section at the end of each chapter. I strongly recommend your students complete the SWYK assessments. They will help you assess whether your student understands the material being covered. If students do not do well in this section, you know they need to go back over the material before moving on to the next chapter. You can use this section like a written test, or you may choose to use SWYK as a format for open discussion. If students are taking the unit exams, this section will help immensely with their performance on the exams.

The Teacher Guide

Your teacher guide is set up to resemble the student books. Each chapter section is reviewed in the teacher guide with further explanation not found in the student text, as well as answers and suggestions. In addition, the teacher guide contains the following:

Weekly Schedule

I have provided you with suggestions for scheduling each chapter based on teaching science two days, three days, and five days. The schedules will help ensure you complete the course in one school year.

Learning Goals

This is a list of all the important concepts in the chapter. Reviewing the learning goals can be particularly helpful when deciphering main ideas that shouldn't be missed from details that are nice, but not necessary.

Extracurricular Resources

This is a list of books and other resources that complement the material presented in the chapter. Links to website and online videos are provided at Pandia Press's website (<https://www.pandiapress.com/weblinks>). Use these resources when your student's interest is sparked, or when you need further clarification on a concept.

Math This Week

The math concepts presented in a chapter are reviewed in the teacher guide. The math presented in a lab can be treated as optional, although I recommend that students at least attempt to complete it. Math is integral to a good science background. Math and science are intertwined in the same way spelling, punctuation, and grammar are for good writing.

Text Review

The text reviews included in this teacher guide are written in outline form. They can be used to teach students strategies on how to take notes, or you can use them to question and discuss with your students. They are the main points from the lesson and are provided to assist you in teaching this course. When I taught as a community college professor, I would use a sheet of written notes, my lecture notes, as a guide to make sure I covered the important points and reviewed the material from previous lectures that related to the material being taught that day.

Unit Exam Answer Keys

The student workbook contains the unit exams in its appendix. There are four of them. The answer keys for the exams can be found in the appendix.

Grading

Grading is up to you, the instructor. Below are two possible grading schemes based on whether you are administering the unit exams. There are grading scales provided for each unit exam, but you will have to determine the grade for each of the other parts of the course. The grading schemes below suggest how to weigh each part, if you choose to assign a grade. You, of course, are the teacher and will do what works best for you and your student.

1. Using all parts of the course

Unit exams = 40%

Labs = 30%

FSS = 10%

SWYK = 20%

2. Not using unit exams

Labs = 40%

FSS = 20%

SWYK = 40%

Materials List

On the following pages is a list of items needed for the labs in each chapter. Refer to the student textbook for quantity and other details. The page number indicates the location of the lab in the student workbook. The items marked with an asterisk (*) are those that are not readily available and need to be purchased through a science supply vendor. We recommend Home Science Tools (www.homesciencetools.com).

Items are listed both alphabetically and by chapter/week. Most materials are common household items.

Alphabetical

Required

- Alka-Seltzer tablets, 2
- Another person
- Antacid tablets, 4
- Baggies, 3
- Baking pan with lid
- Balloons, 2
- Bar magnet with a clear north end
- Box of straight pins
- Butter knife
- Calcium carbonate tablet (calcium supplement), 1
- Camera
- Cardboard box, 10" to 14" long
- Cardstock, 2 pieces 8" × 11"
- Chocolate sandwich cookies, 8
- Clear soda, 3 cans
- Clipboard
- Coin or pebble
- Colored markers
- Colored pencils
- Computer
- Construction paper, 1 black and 1 white
- Containers, 2 small, plastic
- Containers, 2 shallow, wide
- Containers, 6 qt. and 15 qt. clear plastic or similar size
- Cups, 4 small clear
- Cups, 3 unused disposable coffee cups with lids
- Desk lamp with a 60-watt bulb
- Dirt, 1 and 1/2 cups
- Dowel
- Drinking glasses, 3 tall
- Duct tape
- Felt-tip markers, black and red
- Field guide for rocks in your area
- Flour, 8 and 1/2 cups
- Food coloring, yellow, red, and blue
- Glass bowls, 1 large and 1 small
- Glass jars, 2
- Glue
- Hole punch
- Hot mitt
- Ice cube tray
- Ice, cubed and crushed
- Ice pack
- Index cards, 6 unlined
- Internet access
- Kleenex, 1
- Landscape gravel and/or pebbles
- Lego bricks, 3
- M&Ms, 100
- Magnetic compass
- Magnifying glass
- Measuring cups, including one that measures 1 liter
- Measuring spoons
- Metric ruler or measuring tape
- Mixing bowl, large
- Needle
- Nonstick cooking spray
- Outdoor access
- Paper, unlined and graph paper
- Pen or pencil
- Pennies or rocks, cupful
- Permanent marker
- Petroleum jelly (e.g., Vaseline)
- pH paper
- Photos of or access to a rock face with layering
- Piece of cloth
- Piece of glass, small
- Piece of unglazed tile
- Plastic drinking straw, longest one available

- Plastic mountain or short funnel
- Play-Doh or clay, 4 colors
- Poster board, 2
- Pot and lid
- Potted plant or a mossy patch, small
- Pump and tube from lotion, soap, or other type of pump bottle
- Pyrex mixing cup or other heatproof clear glass container
- Refrigerator
- Rocks: talc, magnetite, muscovite mica, pyrite, plagioclase feldspar, and quartz crystal (from Real Science Odyssey Rock and Mineral kit or elsewhere)
- Roll of adding machine paper
- Rolling pin
- Rubber band
- Sandpaper
- Scissors
- Scotch tape
- Sharp knife or X-Acto knife
- Slinky
- Spoon
- Spray bottle
- Stacks of books, boxes, or tables of same height, 2
- Steel file or pocketknife
- Steel wool, 2 small new pieces
- Stove
- String, nine 20" pieces
- Sugar: 1 pinch regular, 4 cubed, 1 tablespoon each green- and red-colored
- Syringe, eyedropper, or pipette
- Table salt, 4 and 1/4 cups
- Tennis ball (or other soft ball)
- Test tube, graduated cylinder, or glass with a small circumference
- Thermometers, 2
- Timer
- Toothpicks
- Water, tap and distilled
- Water, distilled, 3/4 cup
- Wax paper or parchment paper
- White vinegar, 2 and 3/4 cups
- Wood blocks, 2
- Wood chip the size of a coin

Optional

- Calculator
- Glass microscope slides
- Microscope
- Natural history museum, nature center, and/or geology department at a local college
- Printer
- REAL Science Odyssey Rock and Mineral kit
- Red paint
- World map

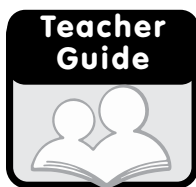
By Chapter/Week

Chapter/ Week	Items Needed
1	Timeline (page 5); Colored pencils; Pencil or pen
2	Metric ruler or measuring tape; 8 or more chocolate sandwich cookies; Scotch tape; Box of straight pins; Bar magnet with a clear north end; Magnetic compass; 2 stacks of books, 2 boxes, or 2 tables (approximately 9" tall); Pangaea puzzle sheet (page 27); 2 pieces 8" x 11" cardstock; Scissors; Glue; Colored pencils; World map (optional)
3	Rock; Periodic Table (page 36); Pencil; Penny; 1/4 cup vinegar; Syringe, eyedropper, or pipette; Piece of unglazed tile; Small piece of glass; Sandpaper; Steel file or pocketknife; Magnifying glass; Lab sheet; Table salt, a pinch; Sugar, a pinch; Magnet; REAL Science Odyssey Rock and Mineral kit or create your own rock kit, including the following minerals: talc, magnetite, muscovite mica, pyrite, plagioclase feldspar, and quartz crystal
4	Camera; Field guide for rocks in your area; Computer; Clipboard; Pencil; Lab sheet; Natural history museum, nature center, and/or geology department at a local college (optional)
5	Internet access; Computer; Lab sheet
6	Lab sheet; Pencil; Photos of or access to a rock face with layering
7	Pencil or pen; 100 M&Ms; Baking pan with a lid; Lab sheet; Timer
8	2 and 1/2 cups room-temperature tap water; 2 cups room-temperature white vinegar (acetic acid); 4 antacid tablets; 4 sugar cubes; 2 small pieces of new steel wool; Lab sheets; Pencil or pen; 4 clear cups; 1 small clear plastic container; 2 baggies; Measuring cup; Spoon; Timer
9	Needle; Piece of cloth; Another person; Cup with a flat bottom; 1 piece of wax paper or parchment paper approximately 30 cm x 30 cm; 4 different colors of 4-ounce containers of Play-Doh or clay; 4 colored pencils that match the colors of the Play-Doh; Rolling pin; Butter knife; Lab sheet; Pen or pencil; Metric ruler or measuring tape
10	Slinky; Another person; Disposable cup; Sturdy 10" to 14" cardboard box that is taller than your disposable cup; Three 20" pieces of string; Roll of adding machine paper (or 2 sheets of paper cut into 3 long strips each and taped together to make one long strip); Pennies or rocks, cupful; Felt-tip markers, black and red; Duct tape; Dowel that is longer than the box is wide Scissors, X-Acto knife, or sharp knife; Metric ruler or measuring tape; Another person; Lab sheets; Pen or pencil
11	3 cans of clear soda (two at room temperature and one refrigerated overnight); Permanent marker; Pot; Stove; pH paper; 2 clear glasses (one at room temperature and one refrigerated overnight); Refrigerator; 1 Pyrex mixing cup or other heatproof clear glass container; Timer; Lab sheet; Pen or pencil
12	Metric ruler or measuring tape; Pencil; Large glass bowl; 2 blocks of wood; Wood chip the size of a coin; Coin or pebble; Ice cubes; Lab sheet
13	Desk lamp with a 60-watt bulb; 1 piece of black construction paper; 1 piece of white construction paper; 2 thermometers; 2 disposable coffee cups with lids; Scissors or X-Acto knife; Scotch tape; Outdoor access; Lab sheet; 2 different colored pens or pencils; Timer; String
14	Clear plastic container, 6 quart or similar size; Small, short bowl; Desk lamp; Water; 1 cup of crushed ice, plus a cube for your glacier; Small potted plant or a mossy patch that is short enough to fit inside the box with the lid closed; 1 small baggie; Plastic mountain or short funnel; Lab sheet; Pencil
15	1/2 cup dirt; 2 cups water; 1/2 cup of flour; 1 tablespoon; 2 glass jars; Clear plastic container, 15 quart or similar size; Water, 10 L; 1-liter measuring cup; Food coloring, blue; Ice cube tray; Ice pack; Measuring spoon; Lab sheet; Pen or pencil; 1 cup dirt; Calculator (optional)

Chapter/ Week	Items Needed
16	Clear plastic container, 6 quart or similar size; 8 cups flour; 4 cups table salt; 4 cups boiling water; Pot to boil water in; Nonstick cooking spray; Large mixing bowl; Food coloring, yellow, red, and blue; Red paint or marker (optional); Paper, unlined and graph paper; Pencil or pen; Toothpicks; Scotch tape; Internet; Scissors
17	3/4 cup distilled water; 1 test tube, graduated cylinder, or a glass with a small circumference; Food coloring, red and blue; Syringe, eyedropper, or pipette; 3 tablespoons table salt; Measuring spoons; 2 small plastic containers (for mixing); Measuring cup; Colored pencils, red and blue; Timer
18	Spray bottle; Clear plastic container, 6 quart or similar size; Landscape gravel and/or pebbles; 1 tablespoon each green- and red-colored sugar; 3 Lego bricks; Water; 4 small clear cups; Pump and tube from lotion, soap or other type of pump bottle; Lab sheet; Colored pencils, green and red
19	Internet access; Colored markers; Poster board; Glue and other craft supplies as needed
20	Glass jar; 2 large round balloons; Scissors; Rubber band; Scotch tape; Plastic drinking straw, longest one available; Pin (a small nail or needle will also work); Paper; Metric ruler or measuring tape; Pen, pencil, or marker; Lab sheet
21	Computer with internet access; Pen or pencil; Lab sheet; Your barometer from the previous lab; Printer (optional)
22	Tennis ball; Another person; 1/2 cup vinegar; 1 calcium carbonate tablet (calcium supplement); Small bowl; 1 teaspoon table salt; Tap water; 2 shallow, wide containers; 3 tall drinking glasses; Food coloring, red and blue; 2 Alka-Seltzer tablets; Piece of cardboard; Pot; Stove; Kleenex; Hot mitt; Lab sheet; Internet access
23	Smooth white poster board or unlined index cards, 5; Hole punch (a nail will also work); String, 5 pieces; Scissors; Permanent marker; Petroleum jelly (e.g., Vaseline); Metric ruler or measuring tape; Lab sheet; Microscope or magnifying glass; Glass microscope slides (if using microscope); Scotch tape (to attach slides to poster board if using microscope)

Note on Fieldwork

Several labs in the course require fieldwork. You may want to skip them, but I encourage you not to do so. Fieldwork is important for an earth science curriculum, because it allows students to experience firsthand the concepts they are learning in the course. By exploring natural environments, students can observe geologic formations, collect rock and soil samples, and witness the effects of weathering and erosion. This hands-on approach makes learning more engaging and memorable while helping learners develop critical thinking and observational skills. Fieldwork fosters a deeper appreciation for the natural world and leads to an understanding of Earth's long history over geologic time.



Introduction to the Student Unit Exams

There are four exams spanning five units. The exams are found in the appendix of the student textbook. Answers to the exams are found in this teacher guide following each unit beginning with Unit 2. The exams have a variety of question types, including multiple choice, vocabulary matching, true/false, fill in the blanks, short written answers, and others. There is no cumulative mid-term or final exam. One could be made by combining questions from the unit exams.

What Each Exam Covers

Exam 1: Unit I Introduction and Unit II The Geosphere, Chapters 1 – 7

Exam 2: Unit III Earth-Shaping Forces, Chapters 8 – 13

Exam 3: Unit IV The Hydrosphere, Chapters 14 – 18

Exam 4: Unit V The Atmosphere, Chapters 19 – 23

Administering the Exam

As the instructor, it is up to you how the exam is administered. Here are some possible options:

1. A closed-book exam with no notes;
2. A closed-book exam with one sheet of notes (more pages of notes than this just get in the way);
3. An open-book exam; or
4. Don't use it as an exam at all; use it as a review.

Structure of the Exams

Exams have a combination of some of the following question types:

- Multiple choice
- Vocabulary matching
- Fill in the blank
- True or false
- Either/or
- Labeling
- Correct order
- Short answer

Unless noted, the material from the Famous Science Series and the labs is not tested. Each exam is 100 points. Each exam has opportunities for extra credit. Please note that Unit III has an out-of-class portion. Make sure to plan additional time to complete this part of the exam.

Grading the Exams

- The questions that require written answers can make grading a little more difficult. Use my answers as a guide. Just remember, partial credit should be applied to these questions if students get most, but not all, of the answer correct.
- Students can get more than 100 percent on the exam if they get the extra credit points.

After the Exam

- Go over with your students any questions they missed. Use mistakes as an opportunity to learn.
- You can hand back the exam with incorrect answers marked and give half credit for any exam questions students correct. I like to do this because it keeps the focus on the primary reason for studying a course: to learn the material, NOT to get a grade.

Unit I: Introduction

Earth & Environment ^{LEVEL} 2

Teacher Guide



Chapter 1: Our Big, Blue Marble: The Four Spheres and the Scientific Method

WEEKLY SCHEDULE

Science Two Days a Week

DAY 1

- ☐ Lesson: The Four Spheres
- ☐ Activity: Getting Your Feet Wet
- ☐ FSS: Scientific Method
- ☐ SWYK

DAY 2

- ☐ Text Review
- ☐ Activity: Geo Timeline 1

Science Three Days a Week

DAY 1

- ☐ Lesson: The Four Spheres
- ☐ Activity: Getting Your Feet Wet

DAY 2

- ☐ Text Review
- ☐ FSS: Scientific Method
- ☐ SWYK

DAY 3

- ☐ Activity: Geo Timeline 1

Science Five Days a Week

DAY 1

- ☐ Lesson: The Four Spheres
- ☐ Activity: Getting Your Feet Wet

DAY 2

- ☐ Text Review

DAY 3

- ☐ FSS: Scientific Method

DAY 4

- ☐ SWYK

DAY 5

- ☐ Activity: Geo Timeline 1

Abbreviations used in the Schedule: FSS = Famous Science Series; SWYK = Show What You Know.

Unit I is an introductory unit that is one chapter long. There are five units in this course. Unit I is the only unit that does not have a separate test available. Unit I and II Test covers elements from both Unit I and Unit II.

Beginning in Chapter 1, and throughout the course, there is a focus on scientific modeling. A scientific model is a representation—whether physical, conceptual, or mathematical—of a real phenomenon in science that cannot be experienced directly or that is too complex to understand without simplifying some of the components. An example of scientific modeling includes models used to predict how global warming is causing climate change. Earth and environmental scientists rely heavily on scientific models because often the systems being studied are inaccessible, as is Earth's core, or they are complicated, such as predicting earthquakes. It is essential to science literacy that students learn how to create, develop, and interpret scientific models.

Throughout this text, students will also learn by reading about and using existing working scientific models. In this manner, students will learn how to interpret current scientific models.

Learning Goals

- Describe the four spheres into which scientists divide Earth.
- Define scientific model, scientific theory, and scientific method, and express how these relate to each other.
- Describe the geologic timescale.
- Distinguish between scientific facts, hypotheses, laws, and theories.

Extracurricular Resources

Books

The Four Spheres of Earth, by Paul Larson

Geological and Fossil Evidence (Timeline: Life on Earth), by Michael Bright

Investigating the Scientific Method with Max Axiom, by Donald B. Lemke

Videos

Please visit Pandia Press's website for additional resource links:
<https://www.pandiapress.com/weblinks>.



Lesson: The Four Spheres

The lesson for this week begins by explaining one way that scientists divide and classify Earth. I chose this classification because it helps to show how even within this division, each of these spheres, as I call them in the chapter, is heavily influenced by the others. The course is loosely structured based on this classification. Units II and III cover geology and the geosphere. Unit IV focuses on the hydrosphere. The atmosphere is covered in Unit V (as is meteorology, which relates to all three of these). Discussions of the environment and the biosphere are woven throughout the course.

Lesson 1 concludes with explanations and definitions of the terms scientific modeling, scientific theory, and scientific method. Understanding, interpreting, and developing scientific models to explain complex systems or those that scientists find inaccessible is critical to understanding how the natural and physical world works, and therefore to all of science.

Text Review

- I. Four Spheres of Earth
 - A. Geosphere
 1. The solid, mineral part of Earth, extending from the lithosphere through to the inner core
 2. The lithosphere is composed of the crust and mantle
 3. The geosphere is differentiated (separated) into layers based on the density of each layer
 4. Density is a measure of the number of particles in an amount of space, or the mass per volume
 5. Each layer going from the crust inward is denser than the layer above it
 - B. Hydrosphere
 1. The water portion of Earth
 2. The hydrosphere covers most of Earth's surface
 3. The hydrosphere is considered essential for the evolution of life
 4. The hydrosphere includes all solid, liquid, and gaseous water (water vapor)
 5. Water vapor is water in its gaseous state
 - C. Atmosphere
 1. The envelope of gas that surrounds Earth
 2. Just because you cannot see air, do not make the mistake that there are not many molecules in even a small amount of air

3. Differentiation is the separation of the matter into different layers based on the density of each layer
 - a. Denser layers sink below less dense layers
4. The geosphere, hydrosphere, and atmosphere are differentiated, which explains their position relative to each other
- D. Biosphere
 1. The entire area of Earth where organisms live
 2. An organism is a living being
 3. Abiotic conditions in the geosphere, hydrosphere, and atmosphere are responsible for the evolution of life
 - a. Abiotic means non-living
 - b. Biotic means living
 4. Organisms have had a big effect on Earth's environment over its 4.56-billion-year history
- II. Environmental science
 - A. Defined as the natural and anthropogenic processes and interactions between the geosphere, hydrosphere, atmosphere, and biosphere
- III. Scientific model
 - A. Defined as simplified representation of a real system
 - B. Can study large, complex scientific principles and systems
 - C. Can study, predict, and explain outcomes for scientific phenomenon and systems
 - D. Used in every area of science
 - E. Must explain the data and observations
 - F. Must be able to predict new observations as they come up
- IV. Scientific method
 - A. Defined as method used by scientists to use observation, experimentation, and reasoning to develop scientific models and theories
- V. Scientific theory
 - A. Defined as a widely accepted explanation of something observed in science that has been tested many times by different researchers who get results that are consistent
- VI. Facts, Hypotheses, Laws, and Theories in Science
 - A. Fact = an objective, unbiased, and verifiable observation about the world around us
 - B. Hypothesis = a testable prediction
 - C. Law = a description of observations
 1. Doesn't explain why something happens or what makes it happen
 2. Often includes mathematical equations
 - D. Theory = summary of related hypotheses shown to be correct in repeated experiments
 1. Laws and facts are also incorporated into scientific theories

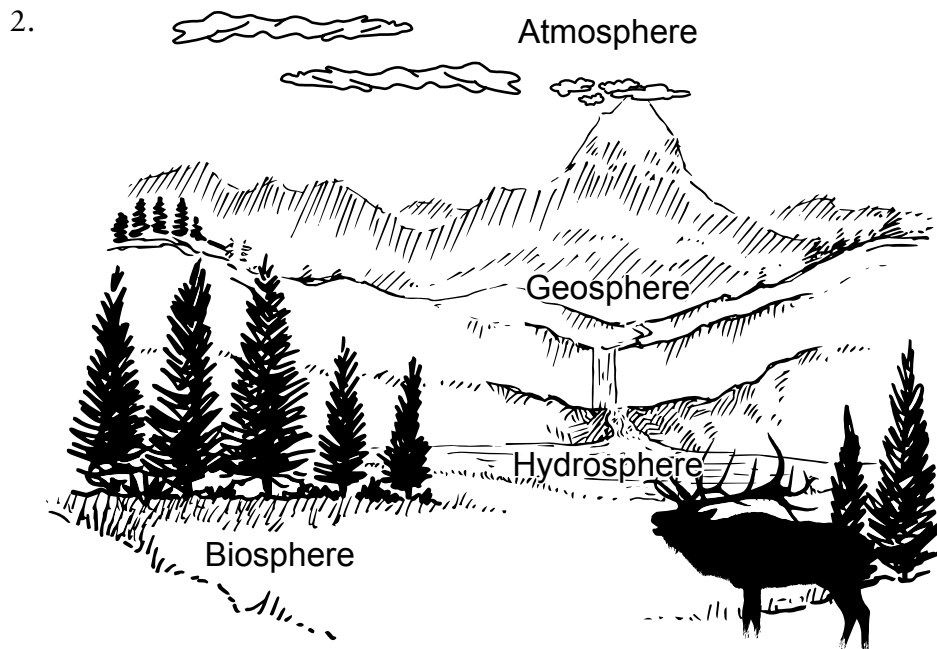


Worksheet: Getting Your Feet Wet

This is a worksheet that students will cycle back around to in the final chapter to see if they can answer (or at least have a good conversation about) the questions they brought up in the beginning of their study of earth and environmental science. There are also a couple questions to test comprehension of the four spheres and the concept of density, which were discussed in the lesson.

Answers

1. a. *The crust is the least dense layer.*
- b. *The density of the atmosphere and hydrosphere is less than that of the Earth's crust.*
- c. *The density of water molecules in clouds is lower than that in the ocean.*



3. *Answers (or rather questions students come up with) will vary.*



Activity: Geologic Timeline Part 1

The procedure for the timeline should be carefully read. Several concepts are discussed within it. Students will work through the timeline for the course, when important dates are discussed in the lesson. When concepts are discussed as a part of the timeline, those events and the scientific explanations should not be treated as ancillary to the course material. This is important to learn while studying Earth's history. To help students recognize those, the information is in a textbox.

There are two reasons for putting this information in the procedure. First, the timeline is like an outline of important events in Earth's history. Making notes in this fashion helps learn when events occurred within the scope of Earth's overall history. Secondly, many of the topics have been presented in *RSO Biology 2* and/

or *RSO Astronomy 2*. This material is important to learn, but for students who used one of those courses before this one, I do not want them to feel like they keep learning the same material.

Step 3 asks the student to discuss the following question with their teacher: Why do you think that the closer the Geologic Timeline gets to today, the more divisions there are? The answer is there is more existing evidence for things that happened 40 million years ago than for those that happened 400 million years ago. There is still less evidence for events that happened 4,000 million years ago. The timeline reflects the case that the more scientists know, the more complete their understanding of events is.

For a visual of the final Geologic Timeline, go to page 211.



Famous Science Series: The History of the Scientific Method

The systemization of a scientific method was critically important to the development of science as a discipline. It incorporates the process of critical thinking into a logical sequence that provides a framework for rigorous inquiry, ensuring that observations were objective, repeatable, and open to scrutiny. This standardized approach replaced reliance on intuition or personal beliefs, ushering in an era of evidence-based knowledge. By establishing a set of shared principles and procedures, the scientific community could collaborate effectively, building upon one another's discoveries and refining understanding as a collective whole. This systematic approach not only facilitated the accumulation of knowledge but also instilled a culture of critical thinking, essential for challenging existing assumptions and pushing the boundaries of the known. The development and standardization of the scientific method was not done by one person. It took time to develop and time for people to accept it. The goal of this lesson is to explicitly teach the basic tenets of the scientific method to help students understand how the use of this approach adds credence to science information and findings.

The scientific method is an important part of the critical thinking process that is essential for the advancement of knowledge, problem-solving, and our understanding of the natural and physical world. It is a cornerstone of rational thinking and informed decision-making, enabling us to continually expand our understanding of the universe and improve the human condition. The scientific method is well understood, providing a systematic and structured approach to inquiry, allowing us to ask questions, test hypotheses, and draw evidence-based conclusions.

The scientific method was not invented by a single individual. It evolved over centuries through the contributions of many scientists, philosophers, and thinkers. However, several key figures and developments played significant roles in shaping the scientific method as we know it today.

1. The ancient Greek philosophers, Aristotle and Plato, laid the groundwork for empirical investigation by emphasizing the importance of observation, reason, and systematic inquiry. When did Aristotle and Plato live? What does the phrase empirical investigation mean?

Plato 427–347 BCE

Aristotle 384–322 BCE

Empirical investigation is research based on observed and measured phenomena and derives knowledge from actual experience rather than from theory or belief.

2. Ibn Al-Haytham (Alhazen) was an Islamic scholar considered to be the father of modern optics. His research changed the understanding of light and vision. What was Alhazen's scientific method? Did he conduct an empirical investigation?

Alhazen developed a hypothesis based on observations of light, and then designed an experiment to test that hypothesis. Yes, he did conduct an empirical investigation by making careful measurements that he used to form meaningful conclusions.

3. In 1620, the English politician Francis Bacon proposed a method for philosophers and scientists to use to determine the truthfulness of knowledge. It was called the Baconian Method. The Baconian Method uses empirical observation for inductive reasoning. Look up the phrase inductive reasoning. How does that relate to forming a hypothesis?

Inductive reasoning is a method of reasoning that involves making generalizations or drawing conclusions based on specific observations or evidence. It is a bottom-up approach, where specific observations or data points lead to the development of a broader, general statement or hypothesis.

4. The Baconian Method also urged scientists to make methodical instead of random observations. Why is making methodical observation important when forming conclusions in science?

Methodical observation is fundamental to the scientific process because it underpins the reliability, validity, and objectivity of scientific research. It ensures that scientific conclusions are based on sound evidence and that the scientific method is applied rigorously to advance our understanding of the natural world.

5. René Descartes played a pivotal role in shaping the scientific method by emphasizing careful mathematical measurements and the application of

mathematical principles to the study of science. How does making careful mathematical measurements help when forming conclusions?

Making careful mathematical measurements is essential for scientific research because it enhances precision, accuracy, objectivity, and consistency in data collection. This improves the reliability of scientific conclusions.

6. Scientists and philosophers continued to go back and forth until 1934 when Karl Popper systemized the scientific method into the steps we recognize today. How does having a standardized method for scientists to use when conducting research benefit science?

Standardization is important in order to ensure the quality of research processes and the reliability of the results.



Show What You Know

Multiple Choice

Choose all answers that are correct.

1. The geosphere
 - a. includes Earth's crust.
 - b. ☐ is the solid mineral part of Earth.
 - c. is less dense than the hydrosphere.
 - d. ☐ extends from the lithosphere through to the inner core.
2. The hydrosphere
 - a. ☐ is the water portion of Earth.
 - b. covers 25% of Earth's surface.
 - c. only includes salt water.
 - d. ☐ differentiated to sit on top of the geosphere.
3. The atmosphere
 - a. is denser than liquid water, so it differentiated above Earth's surface.
 - b. ☐ is less dense than liquid water, so it differentiated above Earth's surface.
 - c. ☐ is the envelope of gas around Earth.
 - d. ☐ has very few molecules in it.

4. The biosphere
 - a. did not come into existence until 6,000 years ago.
 - b. has been a part of Earth's systems for 3.5 billion years.
 - c. affects Earth's environment.
 - d. is the entire area of Earth where organisms live.

Fill in the Blanks

5. Density is a measure of the quantity of particles in a given amount of space.
6. Earth's layers differentiate, going from more (or most) dense at the bottom to less (or least) dense at the top.
7. All scientific models must explain data and observations.
8. The scientific method uses experimentation, observation, and reasoning to develop scientific models and theories.
9. A scientific theory is a widely accepted explanation of something observed in science that has tested many times by different researchers who get results that are consistent.

Fact, Hypothesis, Law, or Theory?

Each of the eight sentences below is a fact, hypothesis, law, or theory. Mark the statements as a Fact (F), Hypothesis (H), Law (L), or Theory (T).

10. (H) It will rain on March 14.
11. (F) There are 60 seconds in one minute.
12. (L) $\text{Force} = \text{mass} \times \text{acceleration}$.
13. (T) All living organisms are composed of cells. Cells are the basic unit of structure and organization in organisms and can only arise from other cells.
14. (F) Clouds contain water molecules.
15. (L) The velocity of a moving object can be calculated by dividing the distance the object traveled by the time it took to travel that distance.
16. (T) Earth's lithosphere is divided into tectonic plates that move like ice in a lake relative to each other.
17. (H) If a plant grows larger, it will need more nutrients to continue growing.

Unit II: The Geosphere

Earth & Environment ^{LEVEL} 2

Teacher Guide



Chapter 2: The Puzzle You Live On: Plate Tectonics

WEEKLY SCHEDULE

Science Two Days a Week

DAY 1

- ☐ Lesson: Plate Tectonics
- ☐ Activity: Modeling Plate Tectonics
- ☐ Activity: Geo Timeline 2
- ☐ FSS: Wegener
- ☐ SWYK

DAY 2

- ☐ Text Review
- ☐ Activity: What Did Wegener See?
- ☐ Lab: It's Magnetic

Science Three Days a Week

DAY 1

- ☐ Lesson: Plate Tectonics
- ☐ Activity: Modeling Plate Tectonics
- ☐ Activity: Geo Timeline 2

DAY 2

- ☐ Text Review
- ☐ FSS: Wegener
- ☐ SWYK

DAY 3

- ☐ Activity: What Did Wegener See?
- ☐ Lab: It's Magnetic

Science Five Days a Week

DAY 1

- ☐ Lesson: Plate Tectonics
- ☐ Activity: Modeling Plate Tectonics

DAY 2

- ☐ Text Review
- ☐ Activity: Geo Timeline 2

DAY 3

- ☐ FSS: Wegener

DAY 4

- ☐ SWYK

DAY 5

- ☐ Activity: What Did Wegener See?
- ☐ Lab: It's Magnetic

Abbreviations used in the Schedule: FSS = Famous Science Series, FSS; SWYK = Show What You Know.

Unit II

The structure of this, and all following units, is to have several chapters focused on earth science with one or more chapters on related environmental science.

Unit II has five chapters focusing on the basics of geology, including one focused on environmental science. This unit starts with a chapter on plate tectonics. This is followed by some of the chemical principles needed to understand how minerals form and how they are structured. Chapter 4 explains the rock cycle and how rocks are made from minerals that are exposed to extreme heat and pressure. Chapter 5 looks at how organisms that lived 286 to 360 million years ago, before the age of the dinosaurs, fossilized to form what are today called fossil fuels. The last two chapters in this unit explain how ages are established for the Earth and the rocks that make it. This unit includes labs and suggested activities that get kids outside looking at what is there. I think the best way to study earth science is to learn the key scientific theories of the discipline, and then go out and investigate what was just learned.

The first Unit Exam includes material from Chapters 1–7.

Chapter 2

Chapter 2 covers plate tectonics. Plate tectonics is the working scientific theory that explains the movement of the lithosphere throughout Earth's history. The physical manifestations of this movement have resulted in many of Earth's geologic features. The Famous Science Series this week is an important part of this chapter. Even if you don't regularly do the Famous Science Series, I recommend you do it this week. What an interesting world we live on!

Learning Goals

- Define the vocabulary central to and the fundamentals of the theory of plate tectonics.

- Detail the different properties of different rock types.
- Explain how the physical and mechanical properties of convection, gravity, and subduction drive plate movement.
- Describe the three main ways that tectonic plates move and the physical properties that determine how they move.
- Describe divergent boundaries, convergent boundaries, and transform boundaries.
- Summarize the geologic features formed by the movement at each boundary type.
- Examine the evidence that led to the development of the theory of plate tectonics.
- Explain how Earth's magnetism provides evidence for the theory of plate tectonics.

Extracurricular Resources

Books

Earth's Shifting Surface (Sci-Hi: Earth and Space Science), by Robert Snedden

What Is the Theory of Plate Tectonics?, by Craig Saunders

Alfred Wegener: Uncovering Plate Tectonics: Earth and Space Science, by Greg Young

The Incredible Plate Tectonics Comic: The Adventures of Geo, Vol. 1, by Kanani K. M. Lee and Adam Wallenta

Earth's Changing Crust: Plate Tectonics and Extreme Events, by Rebecca Harman

The Creation of Islands (Land Formation: the Shifting, Moving, Changing Earth), by Greg Roza

Alfred Wegener: Pioneer of Plate Tectonics, by Greg Young

Alfred Wegener: Creator of the Continental Drift Theory, by Lisa Yount

Our Patchwork Planet, by Helen Roney Sattler

On Shifting Ground: The Story of Continental Drift, by J.S. Kidd and Renee A. Kidd

Plate Tectonics, by Stephen M. Tomecek

Videos and Articles

Please visit Pandia Press's website for additional resource links:

<https://www.pandiapress.com/weblinks>.



Lesson: Plate Tectonics

The modeling and puzzle activities can take the place of the lab.

I have the students use sandwich cookies as simple models of the different types of movement at plate boundaries. Feel free to use something other than Oreos. I do get complaints when I introduce food items, and I am sympathetic to these complaints. The reason I use food items is that they are inexpensive and easy to obtain.

The topics in this chapter are greatly enhanced with videos. I have included an extensive list of videos that are quite good. If nothing else, please look at Dr. Atwater's videos and incorporate them throughout the text. You could even have a series of them lined up in your browser and go over this material with students looking at the videos as they go through the written material.

The important concept of convection is discussed in this chapter. Convection is an important concept in earth and environmental science. Matter that is hot relative to other matter rises, while the cooler matter sinks. This concept will come up again in the units covering hydrology, atmospheric science, environmental science, and climatology. Scientists have confirmed the movement of continents with modern GPS technology.

Text Review

- I. Earth's Layers
 - A. Lithosphere = the solid, outer layer of the Earth
 - B. Asthenosphere = below the lithosphere; made from hot, semisolid, plastic-like rock
- II. Theory of Plate Tectonics
 - A. Describes the movement of Earth's tectonic plates
 - B. The lithosphere is broken into tectonic plates, the number of which changes over time
 - C. A tectonic plate is a rigid piece of Earth's crust
 - D. Tectonic plates move between 2 cm and 15 cm annually
 - E. The tectonic plates "float" on top of the asthenosphere
- III. Convection
 - A. Drives the movement of tectonic plates
 - B. Earth has convection cycles that cause the movement of fluid matter
 - C. Hot rock is less dense than cooler rock: This creates a cycle where hot, less dense material rises and cool, denser material sinks
 - D. Convection cycles are called convection currents
- IV. Subduction
 - A. When one plate moves below another, the lower plate is pulled down by gravity
- V. Types of Boundaries
 - A. Divergent boundaries = plates moving apart from each other
 - 1. Rift valleys and oceanic ridges occur at divergent boundaries
 - 2. Mid-Atlantic Ridge
 - a. Ocean ridge formed at a divergent boundary
 - b. The longest continuous mountain chain on Earth
 - 3. Oceanic ridges have high heat flow, earthquakes, and volcanism
 - B. Convergent boundaries = plates moving together
 - 1. Continental-continental boundary

- a. Oceanic crust is subducted below the continental crust, dragging continents that are on the same plate with it
 - b. When the continents on the two plates encounter each other, neither is subducted; both are uplifted, forming mountain ranges (Himalayas)
- 2. Oceanic-oceanic boundary
 - a. The denser of the two basaltic oceanic crusts is subducted and recycled in the rock cycle below the other crust
 - b. Volcanic island arcs can form (Hawai'ian Islands)
 - c. Deep oceanic trenches can form (Mariana Trench)
- 3. Oceanic-continental boundary
 - a. More dense basaltic oceanic crust is subducted and recycled below less dense granitic continental crust
 - b. Chains of volcanoes form along the continental boundary
- C. Transform boundary – the two boundaries slide past each other
 - 1. Fracture zones can form (San Andreas Fault)
 - 2. Transform boundaries are earthquake prone
- VI. Evidence for the Movement of Tectonic Plates
 - A. Magnetism
 - 1. Earth's magnetic field is created by the flow at its outer core
 - 2. Earth's magnetic field has changed direction many times over Earth's history
 - 3. The changes in Earth's magnetic field is recorded in basaltic rocks
 - 4. Oceanic crust is iron-rich
 - a. Iron acts as magnets lining up in the direction of Earth's magnetic field
 - b. The iron particles point in opposite directions for the two magnetic fields
 - c. There is magnetic symmetry with matching bands of magnetic rocks aligned in the same direction on either side of ocean ridges showing the seafloor has been spreading as hot rock flows out through ocean ridges
 - B. Age and Thickness of Sediment Layers
 - 1. Rocks along ocean ridges are younger
 - 2. Sediments are older and thicker farther away from ocean ridges
 - 3. Shows seafloor spreading
 - C. Earthquakes and volcanoes
 - 1. Result from the movement of tectonic plates
 - 2. Give evidence that Earth is an active planet
 - D. GPS technology
 - 1. Scientists can directly observe the speed and direction of movement of tectonic plates
 - 2. Scientists can observe seafloor spreading using GPS



Lab: Modeling Plate Tectonics

Part 1: Modeling the Lithosphere and Asthenosphere

1. What state of matter is the filling: solid, liquid, or gas?

The state of matter of the filling is solid.

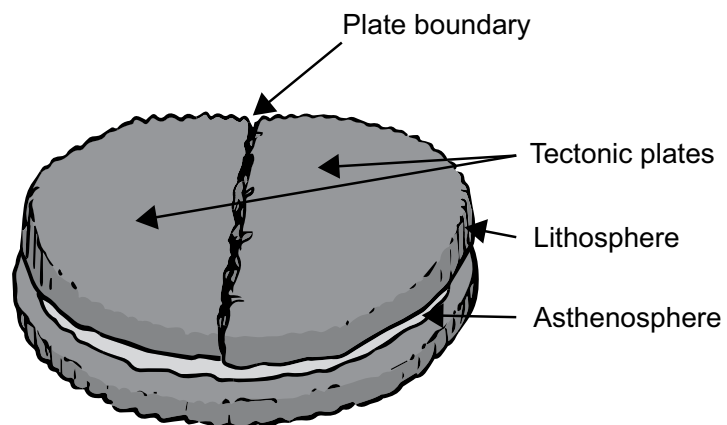
2. How does the filling model the solid asthenosphere that deforms under pressure?

The filling models the solid asthenosphere because it is solid but can still change shape when pressure is applied, mimicking how the asthenosphere flows slowly under the lithosphere.

3. What state of matter is the chocolate cookie: solid, liquid, or gas? How does the cookie model the solid, hard lithosphere?

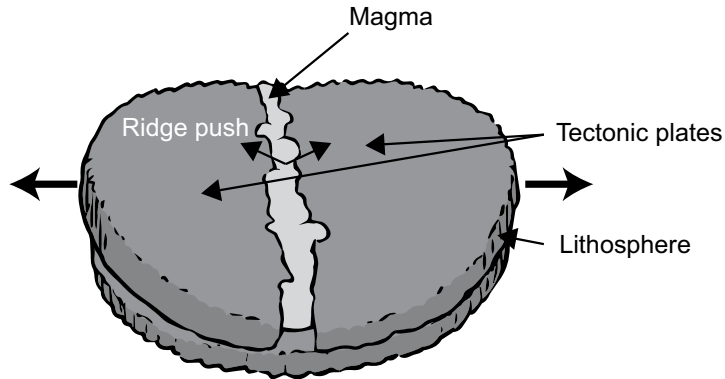
The chocolate cookie is a solid. The cookie models the solid, hard lithosphere because it is rigid and strong, just like the lithosphere. The lithosphere is the outermost layer of the Earth that includes the crust and upper part of the mantle.

4. Draw and label (or photograph and label) the part of the model that represents the lithosphere, asthenosphere, tectonic plates, and plate boundary (where the two plates meet).



Part 2: Modeling a Divergent Boundary

5. Draw a picture of your cookie model, and then label the lithosphere, magma, ridge push, and tectonic plates. Use arrows to show the direction the two plates are moving.

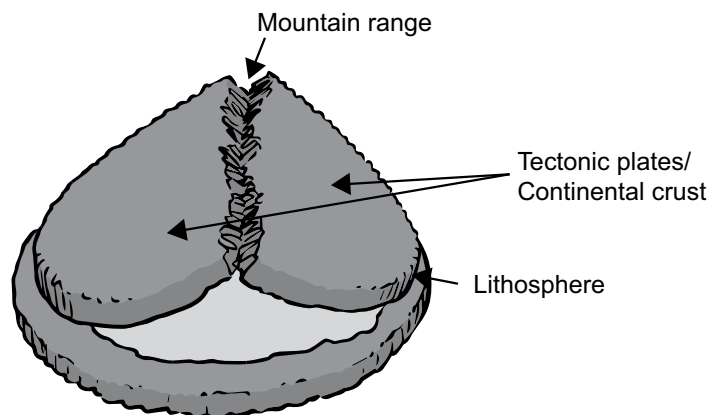


6. The youngest crust on Earth is found at divergent plate boundaries. Why do you think this is?

The youngest crust on Earth is found at divergent plate boundaries because these are the regions where tectonic plates are moving apart from each other. As the plates separate, magma from the mantle rises up to fill the gap. When this magma cools and solidifies, it forms new crust. This process is continuous, which means that the crust closest to the boundary is always the youngest.

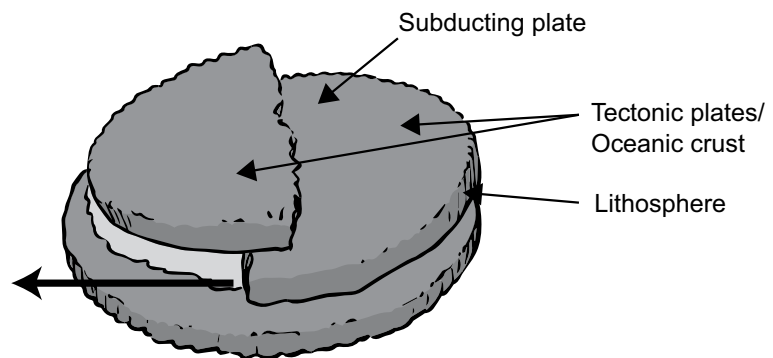
Part 3: Modeling a Convergent Continental-Continental Boundary

7. Draw a picture of your cookie model and label the lithosphere, tectonic plates, continental crust, and mountain range.



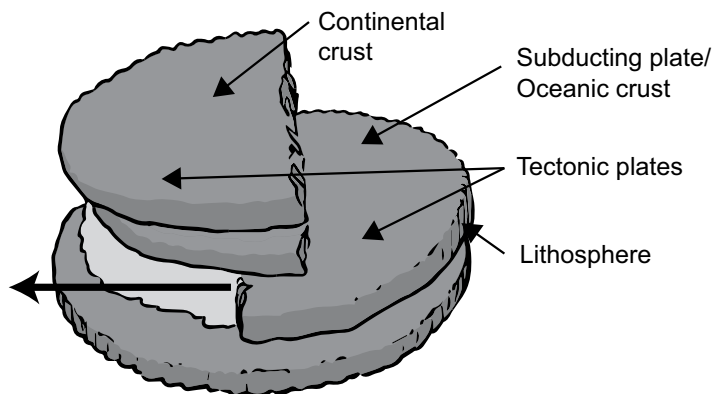
Part 4: Modeling a Convergent Oceanic-Oceanic Boundary

8. Draw a picture of your model and label the lithosphere, tectonic plates, oceanic crust, and subducting plate. The boundary where the plate is being subducted is where the trench would form, label that as well. Draw and label arrows showing water being dragged along with the subducting plate.



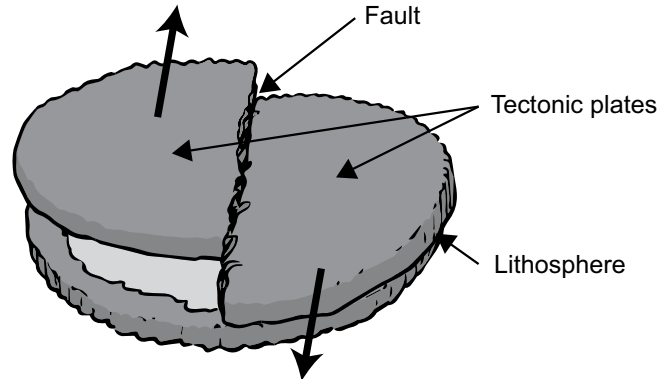
Part 5: Modeling a Convergent Oceanic-Continental Boundary

9. Draw a picture of your model and label the lithosphere, tectonic plates, oceanic crust, continental crust, and subducting plate. Draw an arrow showing the direction of the movement of the subducting plate.



Part 6: Modeling a Transform Boundary

10. Draw a picture of your model and label the lithosphere, tectonic plates, the direction the two plates slid, and the fault.



Lab: It's Magnetic

The in-chapter modeling work and puzzle activity can take the place of the lab. This lab looks at an important property of Earth, its magnetism, which is used as a piece of evidence for plate tectonics. It is a simple lab to conduct. Most middle school students have played around with magnets, but the concept that Earth's polarity changes is not something most students are aware of. That is one reason for the inclusion of this lab. The other is to reinforce the concept that Earth is a dynamic planet. The fact that the direction of flow of Earth's liquid core can change gives definite and additional evidence for that.



Famous Science Series: Alfred Wegener, Famous Geologist and Meteorologist

Alfred Wegener is a very interesting guy with an eclectic intellect. His development of the theory of continental drift, which was rejected by most of his peers, only to be revived years later when it was incorporated into the theory of plate tectonics, is another great example of how science really works. His peer group rejected the theory of continental drift because he was incorrect about some key observable points, and he did not have a mechanism explaining the mechanics of how continents would drift. It is important to think about this sort of rejection. It means that scientists were looking at his theory and thinking about it. Wegener spent his time continuing to study this and strengthening those parts of the theory he was correct about. I don't go into detail about this in the text, but the process of science is something that I hope kids come to understand with the inclusion of scientists and scientific theories that have been rejected and then revived as a part of a more robust working scientific theory.

1. When and where was Alfred Wegener born?

November 1, 1880; Berlin, Germany.

2. Wegener received a Ph.D. in what subject?

Astronomy.

3. In 1906, he took the first of four expeditions to Greenland to study something. What was it?

Polar air circulation.

4. Wegener proposed the theory of continental drift. He called it continental displacement, but most people today call it continental drift. What was his proposed theory?

Wegener proposed that there had been one large supercontinent he called Pangaea that had separated into continents that gradually drifted across Earth's surface over geologic time to their present locations.

5. What are the four pieces of evidence Wegener used to support his theory?

- 1. The continents look like they could fit together like puzzle pieces.*
- 2. The rock layers from continents across the Atlantic Ocean are the same or very similar, e.g., the Appalachian Mountains and those in Scotland.*
- 3. Fossils from continents across the Atlantic Ocean are the same or very similar.*
- 4. Fossilized organisms were found in areas with climates where they could not have survived, e.g., palm tree fossils found in Alaska.*

6. What is the problem with the theory of continental drift?

Wegener did not propose a mechanism for how the drift would occur.

7. Did most scientists agree with Wegener's theory in his lifetime?

No.

8. What is the difference between the theory of continental drift and the theory of plate tectonics?

The theory of continental drift is a part of the theory of plate tectonics. The theory of plate tectonics explains the mechanism for how drift occurs.

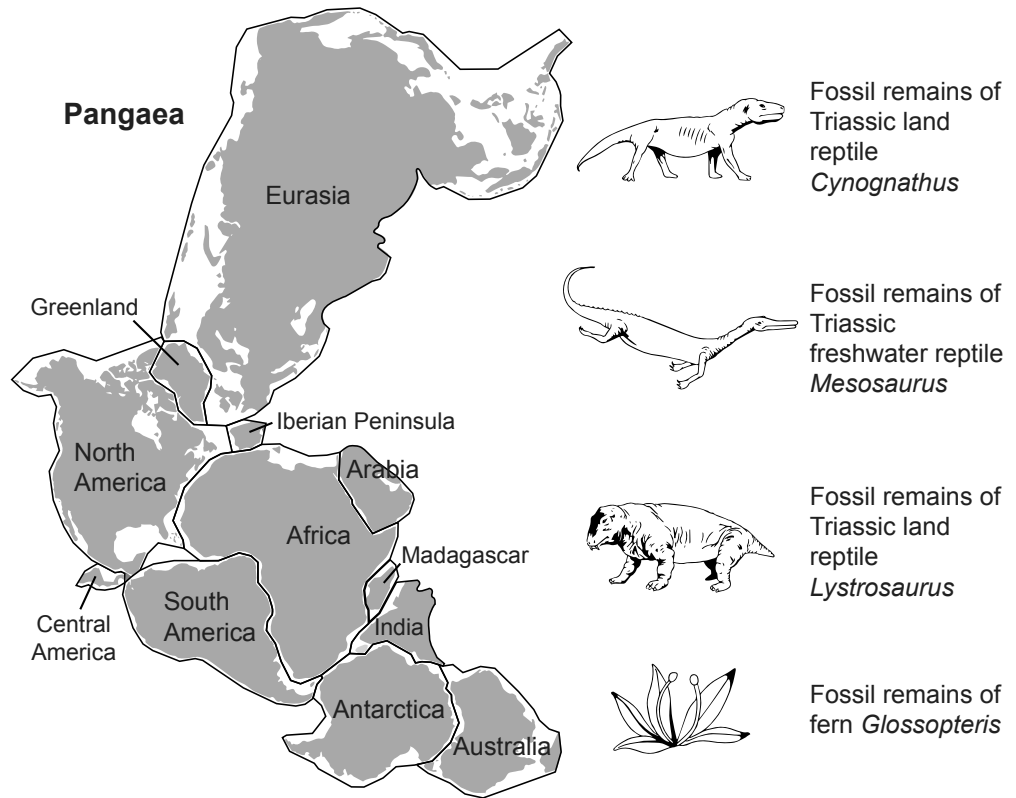
9. How, when, and where did Wegener die? How old was he?

Wegener died on an ice sheet in Greenland when he was 50 years old. He might have frozen to death or died of heart failure or a stroke. He was a heavy smoker, and it is thought that his smoking might have contributed to his death. He died in November 1930.



Activity: What Did Wegener See?

Students manipulate the continents to come to a better understanding of how they fit together.



Show What You Know

Multiple Choice

- The outer rocky layer of Earth is called the
 - .
 - asthenosphere.
 - core.
 - mantle.
- When one tectonic plate sinks below another into the mantle, it is called
 - convergence.
 - divergence.
 - convection.
 - .

3. Deep ocean trenches, like the Mariana Trench, form at which type of boundary?
 - a. Convergent
 - b.
 - c. Transform
4. Fracture zones, like the San Andreas Fault, form at which type of boundary?
 - a. Convergent
 - b. Divergent
 - c.
5. Mountain ranges, like the Andes, form at which type of boundary?
 - a.
 - b. Divergent
 - c. Transform
6. The Southern Alps in New Zealand are a mountain range that is typical of the type of landform that forms at what type of convergent boundary?
 - a. Oceanic-continental boundary
 - b. Oceanic-oceanic boundary
 - c.
7. Volcanic island arcs, like the Caribbean Islands, form at what type of convergent boundary?
 - a. Oceanic-continental boundary
 - b.
 - c. Continental-continental boundary
8. Volcanic mountain ranges along a continental coast, like the Cascade Range, form at what type of convergent boundary?
 - a.
 - b. Oceanic-oceanic boundary
 - c. Continental-continental boundary

Short Answer

9. How does seafloor spreading relate to plate tectonics?

Seafloor spreading is a driving force for the movement of tectonic plates. The creation of new crust at plate boundaries as is happening with seafloor spreading provides a driving force for the movement of tectonic plates.

10. Briefly explain why each of these gives evidence of plate tectonics.

a. Magnetic symmetry

If there is seafloor spreading, when new basaltic rock oozes up at ridges, it would ooze equally on both sides of the ridge. There would be matching bands of basaltic rock with the same magnetism, normal or reversed, on both sides of the ridge. These matching bands are present. This matching of these bands is called magnetic symmetry.

b. Earthquakes and volcanoes

Earthquakes and volcanoes are more likely to occur along plate boundaries, because of the movement of tectonic plates.

c. GPS

GPS technology has monitored and confirmed plate movement.

11. Why is convection important to the theory of plate tectonics?

Convection is the mechanism driving the movement of tectonic plates.

12. Learn about the tectonic plate where you live.

Answers will vary. An example of an answer is given below.

a. Using the map on the next page, determine which tectonic plate you are on right now.

I live on the North American plate.

b. Use the internet to learn how fast it is moving, and in what direction.

The North American plate moves in roughly a southwest direction away from the Mid-Atlantic Ridge (which is a divergent boundary) at a rate of about 2.3 centimeters (~1 inch) per year.

c. Choose one of the plate's boundaries, and state the type of boundary it is: divergent, convergent, or transform.

Answers will vary. The following answer is provided for someone living on the west coast. The boundary on the west side of the plate meets the Juan de Fuca plate and the Pacific plate. The North American plate forms a transform boundary with the Pacific plate along the coast of California. The North American plate also forms a convergent boundary with the Juan de Fuca plate.



Chapter 11: Lava You, Lava You Not: Volcanoes

WEEKLY SCHEDULE

Science Two Days a Week

DAY 1

- ☐ Lesson: Volcanoes
- ☐ FSS: Mount Tambora
- ☐ SWYK

DAY 2

- ☐ Text Review
- ☐ Activity: Geo Timeline 10
- ☐ Lab: Outgassing Experiment

Science Three Days a Week

DAY 1

- ☐ Lesson: Volcanoes

DAY 2

- ☐ Text Review
- ☐ FSS: Mount Tambora
- ☐ SWYK

DAY 3

- ☐ Activity: Geo Timeline 10
- ☐ Lab: Outgassing Experiment

Science Five Days a Week

DAY 1

- ☐ Lesson: Volcanoes

DAY 2

- ☐ Text Review

DAY 3

- ☐ FSS: Mount Tambora

DAY 4

- ☐ SWYK

DAY 5

- ☐ Activity: Geo Timeline 10
- ☐ Lab: Outgassing Experiment

Abbreviations used in the Schedule: FSS = Famous Science Series; SWYK = Show What You Know.

Earthquakes, volcanoes, and mountain building (the subject of Chapter 12) all occur primarily because of plate tectonics. It is fascinating. If you live near an active, dormant, or extinct volcano, I hope you visit it while studying this chapter. In fact, the year you study geology should be the year of science field trips! I recommend you use the internet to look for nearby geologic features that relate to the topic in the chapter, and then take the time to conduct field research.

Learning Goals

- Recall the basic structure of a volcano.
- Describe how density differences affect the movement of matter.
- Explain the correlation between plate boundary type and the occurrence of volcanoes.
- Explain how and why most volcanoes form at convergent plate boundaries.
- Detail how and why intra-plate volcanoes form.
- Summarize how intra-plate volcanoes show the movement of tectonic plates.
- Describe the factors that affect the explosiveness of magma.
- Summarize the five main environmental and health hazards from volcanoes.

Extracurricular Resources

Books

Volcano: The Eruption and Healing of Mount St. Helens, by Patricia Lauber
Bodies from the Ash: Life and Death in Ancient Pompeii, by James M. Deem
Volcanoes: Journey to the Crater's Edge, by Robert Burleigh
Volcanoes: Eruptions and Other Volcanic Hazards (The Hazardous Earth), by Timothy M. Kusky
Investigating Plate Tectonics, Earthquakes, and Volcanoes, edited by Michael Anderson
Volcanoes, by Neil Morris
Nature's Wrath: Surviving Natural Disasters, by Ellyn Sanna

Videos

Please visit Pandia Press's website for additional resource links:
<https://www.pandiapress.com/weblinks>.



Lesson: Volcanoes

The illustration for the anatomy of a volcano is meant to be generic. It is possible when students get to the section discussing different types of volcanoes that they will wonder how the differences affect the anatomy. If that happens, have them use the anatomy of a volcano illustration to label those volcanoes too.

There are more than three types of volcanoes. The text gives information about the three most common. There are infinite combinations of viscosity and amount of dissolved gas that can affect eruptions. I focused on the basic concepts and scientific principles instead of including lists of rock types and possible mixtures. If you have never studied volcanoes before, there is a lot of new vocabulary.

Math This Week

Ratios and percentages are included as a part of the discussion about the chemical composition of rocks that affect the physical property of viscosity.

Students make deductions where they use direct observations to form conclusions about the effects of the outgassing of soda.

Text Review

Use the illustration from the text to review the anatomy of a volcano.

- I. Volcanoes
 - A. Formation
 1. Rock heats to form magma
 2. Magma is less dense than the surrounding rock
 3. Magma rises toward the surface because it is less dense
 - B. Vocabulary terms
 1. Volcanologists = people who study volcanoes
 2. Active volcano = a volcano that has erupted in the past 10,000 years
 3. Dormant volcano = a volcano that has not erupted in the past 10,000 years, but is expected to erupt again
 4. Extinct volcano = a volcano that is not expected to erupt ever again
 5. Viscosity = the ability to resist flow
 - C. Locations where volcanoes form
 1. Divergent plates = mid-oceanic ridges
 2. Convergent plates = at subduction zone
 - a. 75% of all volcanoes form at these
 - b. Look at the illustration on page 82 in the textbook to review the process
 - c. Pacific Ring of Fire is an example
 3. Intra-plate = magma chamber beneath crust that melts until it forms a hotspot
 - a. Good evidence for the movement of plates
 - b. Hawai'ian Islands are an example

- D. Explosiveness of eruptions
 - 1. Viscosity of magma is affected by silica content and temperature
 - 2. Dissolved gas in magma also affects explosiveness
 - 3. More viscous lava means more dissolved gas, which makes the eruption more explosive
- II. Three Main Types of Volcanoes
 - A. Cinder cone volcano
 - 1. Small = from small magma chamber
 - 2. Made from tephra
 - 3. Forms on sides of larger volcanoes
 - 4. Single eruption
 - 5. Most common type
 - 6. Explosive
 - B. Shield volcano
 - 1. Large
 - 2. Sides slope gently
 - 3. No violent eruptions
 - 4. Low-viscosity magma
 - 5. Less dissolved gas
 - 6. Common at intra-plate volcanoes and divergent boundaries
 - C. Composite cone volcano
 - 1. Large
 - 2. Steep sides
 - 3. Violent eruptions
 - 4. More dissolved gas
 - 5. High-viscosity magma
 - 6. Common at convergent plate boundaries
- III. Environmental and Health Hazards
 - A. Outgassing of harmful gas
 - B. Lava can burn things in its path
 - C. Pyroclastic flow = extremely hot, highspeed avalanches of rock, water, ash, and gas
 - D. Tephra can produce lightning
 - E. Ash can affect climate
 - F. Lahars = fast-moving mudslides that can harm things in their path



**Lab: Outgassing
Experiment in
Progress**

Gases are less soluble in warmer liquids. This has implications for organisms that live in water as the water warms along with the planet. I briefly discuss acids and bases. These will be covered in *RSO Chemistry 2* in detail. Check out the YouTube videos for this topic if your student needs more information.

Hypotheses

1. Do you think you will observe a difference in the amount of gas trapped in the soda based on the temperature of the soda? If yes, how?

I believe the warm soda fizzes more readily than cold soda, so I expect there to be less dissolved gas in the soda at a higher temperature.

2. What change in pH do you expect to see when and if soda outgasses, releasing CO₂?

I expect soda without carbon dioxide to be less acidic.

Data

Outgassing Observations

Time	Soda A (Refrigerated)	Soda B (Room Temperature)	Soda C (Heated)
0 minutes	<i>Less gas effervescing</i>	<i>More gas effervescing</i>	<i>(Before heating) More gas effervescing</i>
1 minute	<i>Least amount of gas effervescing (gas mostly still in liquid)</i>	<i>Moderate amount of gas effervescing</i>	<i>Fizzier, most amount of gas effervescing</i>
2 minutes	<i>Least amount of gas effervescing (gas mostly still in liquid)</i>	<i>Moderate amount of gas effervescing</i>	<i>Fizzier, most amount of gas effervescing</i>
5 minutes	<i>Least amount of gas effervescing (gas mostly still in liquid)</i>	<i>Moderate amount of gas effervescing</i>	<i>Stopped fizzing/effervescing</i>
20 minutes	<i>Least amount of gas effervescing (gas mostly still in liquid)</i>	<i>Moderate amount of gas effervescing</i>	<i>Stopped fizzing/effervescing</i>
3 hours, 20 minutes	<i>Least amount of gas effervescing (gas mostly still in liquid)</i>	<i>Moderate amount of gas effervescing</i>	<i>Stopped fizzing, but there are now some bubbles in it. I think they are air bubbles dissolving back into the soda.</i>

A note about pH: Different sodas and soda brands can have different pHs. Whatever the soda brand and starting pH is, soda with CO₂ has a lower pH (is more acidic) than soda without CO₂.

When CO₂ dissolves in water, a small portion reacts to form carbonic acid (H₂CO₃). This carbonic acid is what lowers the pH.

As the CO₂ bubbles out of flat soda, the carbonic acid breaks down, reducing the acidity and raising the pH.

However, the difference in pH between sodas with and without CO₂ isn't drastic. The pH of soda with CO₂ ranges from 2.5 to 3.5. The pH of soda without CO₂ ranges from 3 to 4.5.

Questions

1. How did temperature affect the amount of gas trapped in the soda?

The higher the temperature, the less gas there is in the soda.

2. How did pH change when there was less gas in the soda?

The pH change was very small. I saw a difference between the refrigerated soda and the heated soda, but not much. Cold soda is more acidic than flat soda.

3. Can you think of another gas besides CO₂ that could come from the heating solution?

Water vapor.

4. How does this support the working scientific theory that volcanic outgassing was partially responsible for the formation of the hydrosphere?

If water vapor and other gases were trapped in the magma, it would outgas with magma and through the vents of volcanoes.

5. How do you think the amount of dissolved gas is affected by the temperature of magma?

The hotter the magma, the more gas outgasses from it and the less dissolved gas would be in the magma.



**Famous Science
Series: Famous
Volcanic Eruptions:
Mount Tambora**

It was hard to choose the volcanic eruption for this chapter's Famous Science Series. Other options were the eruptions from the Deccan Traps that might have contributed to the extinction of the dinosaurs, Vesuvius's eruption in 79 C.E. that led to the burying of Pompeii, or the eruption of Thera that might be an explanation for what really happened to the city of Atlantis. All would have been good choices. Mount Tambora was chosen because of its environmental impact.

1. Where is Mount Tambora located?

On the island of Sumbawa, Indonesia.

2. When did Mount Tambora erupt?

1815.

3. What happened to Mount Tambora when the volcano erupted?

The top third of the 13,000-foot-tall mountain was blown off.

4. What type of volcano is Mount Tambora? Is it active or dormant?

Mount Tambora is an active composite volcano, also called a stratovolcano.

5. Is Mount Tambora on a convergent plate or a divergent plate, or is it an intra-plate volcano?

It is on a convergent plate at a subduction zone; it is situated on a fault along the Java Trench System.

6. The eruption was so strong it caused a seismic tidal wave. What is another name for a seismic tidal wave?

Tsunami.

7. The eruption of Mount Tambora threw dust and gases into the atmosphere that affected the environment for the next year. The eruption led to the Year Without Summer in the summer of 1816. Describe what it was like in the Year Without Summer.

In spring and summer of 1816, temperatures decreased in Europe and North America. The sky was overcast all the time, which caused temperatures to plummet. Low temperatures and lack of sunlight led to food shortages because of crop failure and livestock deaths.

8. In Ireland, the change in climate caused eight straight weeks of rain, which led to the failure of what crop?

The potato crop.

9. The dark winter inspired Mary Shelley to write what classic novel?

Frankenstein.

**Show What You Know**

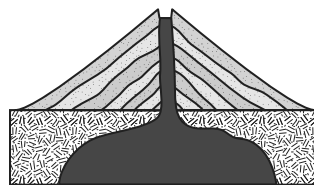
Multiple Choice

1. Divergent plates give rise to _____.
 - a. plate tectonics
 - b. explosive gas-rich magma
 - c. hotspots
 - d.
2. High-viscosity magma typically forms what type of volcano?
 - a. Shield volcano
 - b.
 - c. Cinder cone
3. Why does magma rise toward Earth's surface?
 - a. It is made from continental crust.
 - b.
 - c. Viscosity causes magma to rise.
 - d. Magnetism causes magma to rise.
4. Shield volcanoes have _____ viscosity lava with _____ dissolved gas in it.
 - a. high, less
 - b. high, more
 - c. low, more
 - d.
5. Viscosity is determined by _____.
 - a. temperature
 - b. silica content
 - c. the source of melting rock
 - d.

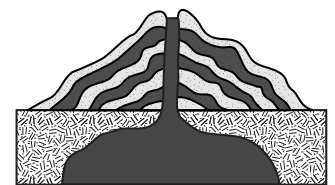
6. Lo'ihi is the youngest Hawai'ian volcano in the chain. Its top is 1,000 m (about 3,280 ft.) below sea level. Due to its regular eruptions, it is expected to be at sea level in 10,000 to 100,000 years. Lo'ihi is an example of a(n) _____.
- a.
 - b. dormant volcano
 - c. extinct volcano
 - d. viscous volcano
7. Fast-moving avalanches of rock, ash, water, and gas are called _____.
- a.
 - b. lahars
 - c. tephra
 - d. scoria

Short Answer

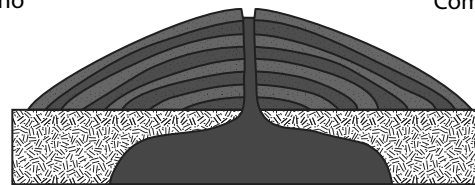
8. Identify the type of volcano from its picture.



Cinder cone volcano



Composite cone volcano



Shield volcano

9. Why do many volcanoes form at the boundaries of convergent plates?

Oceanic crust takes water-logged sediments with it when it is subducted. The water vapor that is formed lowers the melting point of the rock. The melted rock and water vapor mix to make explosive gas-rich magma, which is the source of magma for these volcanoes.

10. How do intra-plate volcanoes give evidence that tectonic plates move?

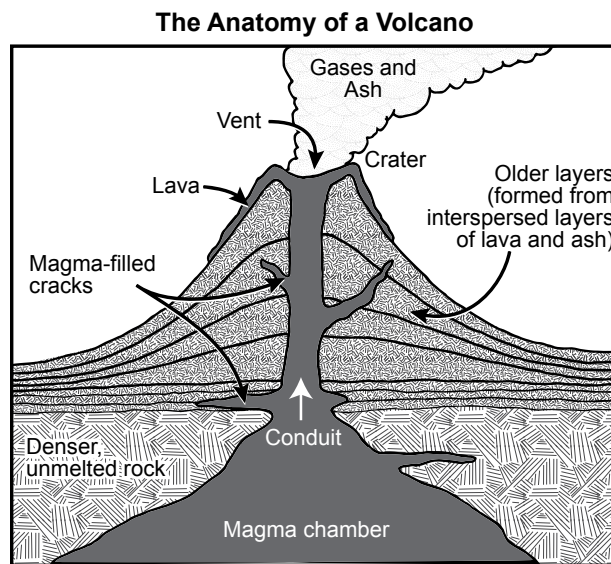
The magma chamber that forms the hotspot does not move. As the tectonic plate moves, the location of the hotspot, but not the magma chamber making the hotspot, moves with it. This results in a line of volcanoes forming in the middle of the tectonic plate, with the hotspot located at the youngest volcanic island.

11. The largest volcano in the solar system is on Mars. What can you infer from this?

There must have been a source of heat hot enough to make magma on Mars in the past.

12. Label the illustration below with these labels.

Crater	Vent	Magma chamber	Lava	Conduit
Gases and ash	Older layers	Magma-filled cracks	Denser, unmelted rock	





Chapter 18: Just Keep Swimming: Water Pollution and Some Solutions

WEEKLY SCHEDULE

Science Two Days a Week

DAY 1

- ☐ Lesson: Water Pollution
- ☐ FSS: LaDuke and Deranger
- ☐ SWYK

DAY 2

- ☐ Text Review
- ☐ Lab: Pollution of Watery Ways

Science Three Days a Week

DAY 1

- ☐ Lesson: Water Pollution

DAY 2

- ☐ Text Review
- ☐ FSS: LaDuke and Deranger
- ☐ SWYK

DAY 3

- ☐ Lab: Pollution of Watery Ways

Science Five Days a Week

DAY 1

- ☐ Lesson: Water Pollution

DAY 2

- ☐ Text Review

DAY 3

- ☐ FSS: LaDuke and Deranger

DAY 4

- ☐ SWYK

DAY 5

- ☐ Lab: Pollution of Watery Ways

Abbreviations used in the Schedule: FSS = Famous Science Series; SWYK = Show What You Know.

This chapter explores the concept of water quality and how pollutants impact it. Understanding the science behind pollution is crucial, but finding solutions is equally important. For that reason, the chapter concludes with a call to action. Inventing solutions, like Boyan Slat's garbage patch cleanup system, and taking individual actions, like responsible waste disposal, are key steps towards cleaner water and a healthier planet.

This is the last chapter in Unit IV. There is an exam focused on Chapters 14 to 18.

Learning Goals

- Describe the relationship between water quality and water pollution.
- Determine if pollution came from a point or nonpoint source.
- Describe the relationship between water solubility and water pollution.
- Explain the major sources of water pollution.
- Discuss some of the solutions that are being used to combat water pollution.

Extracurricular Resources

Books

The Yucky Duck Rescue: A Mystery about Pollution, by Lynda Beauregard
Plastic, Ahoy!: Investigating the Great Pacific Garbage Patch, by Patricia Newman
Going Blue: A Teen Guide to Saving Earth's Oceans, Lakes, Rivers & Wetlands, by Cathryn Berger Kaye
The Call of the Osprey, by Dorothy Hinshaw Patent
Save the Planet: Keeping Water Clean, by Courtney Farrell
Caring for Nature: The Troubled Waters (Rescuing the Ganga) by Subhadra Sen Gupta
Clean Water: Global Citizens: Environmentalism (21st Century Skills Library: Global Citizens: Environmentalism), by Ellen Labrecque
John Wesley Powell: Soldier, Explorer, Scientist, by Jean Thor Cook

Down the Colorado: John Wesley Powell, the One-Armed Explorer, by Deborah Kogan Ray

The Last River: John Wesley Powell & the Colorado River Exploring Expedition, by Stuart Waldman

Videos and Free Poster

Please visit Pandia Press's website for additional resource links:

<https://www.pandiapress.com/weblinks>.



Lesson: Water Pollution and Some Solutions

Environmental issues are often depressing to write about and depressing to study. That is why I paired each environmental problem with something that is being done to solve that problem. Often it is only a partial solution, but in each case, where there is a problem, something is being done to combat it. It is a tough topic to end with, but knowledge is power. And if these environmental problems are going to be fixed, the first step is understanding the science explaining them.

Text Review

- I. Vocabulary Terms
 - A. Water quality = the chemical, physical, and biological characteristics of water, including the water's appearance and smell
 - B. Point source pollution = a source of pollution that you can point to
 - C. Nonpoint source pollution = a source of pollution that is generated over a widespread area
 - D. Water-soluble = dissolves in water
 - E. Eutrophication = increase in plant growth due to runoff containing fertilizer
- II. Water-soluble Pollutants
 - A. Fertilizer
 1. Fertilizer in runoff causes eutrophication
 2. Because of increased growth, they use up oxygen needed by other organisms
 3. Those other organisms die or leave
 4. Solutions
 - a. Use less fertilizer
 - b. Use compost as an alternative
 - c. Use treatment facilities to clean wastewater
 - B. Sewage and animal waste
 1. Bacteria and nitrogen in sewage can cause eutrophication
 2. Bacteria can cause disease
 3. Solution
 - a. Use treatment facilities to clean wastewater

- C. Pesticides and herbicides
 - 1. These chemicals kill not only the unwanted plants and animals, but others as well
 - 2. Solutions
 - a. Minimize the use of pesticides and herbicides
 - b. Switch to organic gardening and farming
 - D. Heavy metals
 - 1. These are toxic to organisms
 - 2. Solutions
 - a. Eliminate heavy metals from commonly used materials
 - b. Dispose of heavy metals away from aqueous environments
 - E. Acidification
 - 1. CO_2 and water form carbonic acid
 - 2. As the CO_2 concentration in oceans increases, they become more acidic
 - 3. Solution
 - a. Reduce carbon emissions
- III. Water-Insoluble Pollutants
- A. Oil and gas
 - 1. These are harmful to organisms
 - 2. They are hard to remove because they are fluids
 - 3. The chemicals used to break them up can also be harmful
 - 4. Solutions
 - a. Reduce dumping of oil
 - b. Reduce global dependence on oil and gas
 - B. Littering and trash disposal
 - 1. Animals mistake litter for food and eat it
 - 2. Animals get caught in litter
 - 3. Litter contains chemicals that make water toxic
 - 4. Solutions
 - a. Don't litter or dump trash in the ocean
 - b. Reduce, reuse, recycle



Lab: Pollution of Watery Ways

This lab is messy, wet, educational, and fun. It is a good lab for comparing point source and nonpoint source pollutants and pollution plumes. If the weather is nice, you could do it outside; otherwise, I recommend setting the lab up in a basin in the bathtub or kitchen.

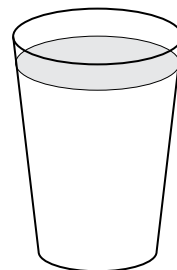
Part 2: Modeling Rain

Water Sample 1

Use colored pencils to show the color of the water sample.

Water quality: *Clear and clean*

Did you see a pollution plume? Yes ☐ No ☒



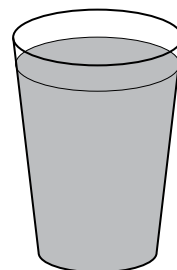
Part 3: Modeling Pesticide Use

Water Sample 2

Use colored pencils to show the color of the water sample.

Water quality: *Red and polluted*

Did you see a pollution plume? ☒ Yes ☐ No



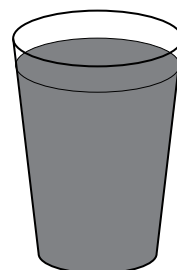
Part 4: Modeling Fertilizer Use

Water Sample 3

Use colored pencils to show the color of the water sample.

Water quality: *Greenish brown and polluted*

Did you see a pollution plume? ☒ Yes ☐ No



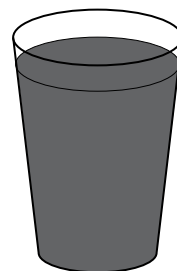
Part 5: Modeling Pollution

Water Sample 4

Use colored pencils to show the color of the water sample.

Water quality: *Brownish green and polluted*

Did you see a pollution plume? ☒ Yes ☐ No



Conclusions

1. Which of these water samples would you most like to drink and why?

Water Sample 1 because it's clean.

2. Where did the point source(s) of pollution occur?

At the two houses that used pesticides and fertilizer.

3. Describe the pollution plumes if you saw any.

The colored water was pluming in all directions away from the site of entry into the water.

4. Why isn't the water from your new well clear in color?

The pollution went into the ground in one location, but it spread throughout when it reached the groundwater.

5. The pollution at your house came from two different sources. Is the source of pollution at your house still point source pollution, or is it nonpoint source pollution? Explain your reasoning.

There are two point sources of pollution, because both sources can be pointed to. The source of pollution is not generated over a widespread area, as would happen with a nonpoint source of pollution. I could clearly see a pollution plume from both sources.

6. Acid rain is a nonpoint source of pollution. Which would be harder to stop from polluting at your house: a point source of pollution or a nonpoint source of pollution? Why?

A nonpoint source would be harder to stop from polluting at my house, because there is no one single source to eliminate to fix the problem.

7. How does topography affect the spread of point source pollution?

Things flow downward because of gravity. Pollutants will be more likely to plume downward than upward. Elevated areas will generally be less affected by point sources of pollution if they are downslope. Areas that are downslope of the pollution source are more affected.

8. From the standpoint of nonpoint source pollution, are you better off with a house on the hill or one by the river? Or does it matter?

For nonpoint source pollution, it does not matter; however, it is possible that topography and elevation benefit certain locations depending on the pollutant.



**Famous Science
Series: Winona
LaDuke and Eriel
Deranger: Famous
Water Protectors**

This Famous Science Series focuses on two Indigenous activists, Winona LaDuke and Eriel Deranger. As part of the focus on solutions, LaDuke, through her work with the White Earth Land Recovery Project, champions sustainable agriculture practices and habitat restoration to protect water quality.

Deranger, a member of the Athabasca Chipewyan First Nation, tirelessly fights against tar sands development and advocates for clean water access for her community. These individuals inspire us to take action and demonstrate the power of Indigenous knowledge and leadership in safeguarding our planet's precious resources.

Winona LaDuke

1. What is Winona LaDuke's tribal affiliation?

Anishinaabe

2. Where does LaDuke live?

Winona LaDuke lives on the White Earth Reservation in northern Minnesota.

3. In 2016, Winona LaDuke was a leader at the Dakota Access Pipeline protests. The protests started because the Standing Rock Sioux believed the pipeline was potentially harmful to the water quality of the Missouri River. What states and countries does the Missouri River run through?

States: Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming

Countries: The United States and Canada

4. Winona LaDuke started the Hemp & Heritage Farm. How does it serve as a model for sustainable water use in agriculture?

The farm focuses on growing hemp, a drought-resistant crop. It uses water-efficient irrigation techniques. The farm actively works to restore native prairies and wetlands.

Eriel Deranger

5. What is Eriel Deranger's tribal affiliation?

Athabasca Chipewyan First Nation

6. Where does Deranger live?

She lives in Northern Alberta, Canada

7. Deranger works with the Athabasca Chipewyan First Nation to fight against tar sands development. What are tar sands, and why are they a problem for water quality?

Tar sands are a mixture of sand, clay, water, and a substance called bitumen. Bitumen is a type of fossil fuel that is extremely heavy crude oil. There are two major problems with tar sands: First, for every gallon of gasoline produced by tar sands, 2 to 4 gallons of fresh water are used as a part of the extraction and refining process. Second, after the oil is extracted, leftover sand, clay, and other pollutants are dumped into ponds. These pollutants contain harmful chemicals that often leak into surrounding water bodies and groundwater.

8. In 2015, Deranger was one of several cofounders of Indigenous Climate Action. What is the goal of this organization?

The goal of Indigenous Climate Action is to connect and support Indigenous communities to reinforce their place as leaders driving climate change solutions.

9. What is the connection between climate change solutions and solutions to water conservation for Indigenous communities?

Climate change worsens the difficulties around water quality that is already faced by many Indigenous communities. Both LaDuke and Deranger are working to help by advocating for the use of Indigenous water conservation methods, such as restoring watersheds and improving soil health.



Show What You Know

Multiple Choice

1. Which is a good example of a nonpoint source of pollution?
 - a. A leaky gas tank beneath the filling station that has contaminated an entire aquifer.
 - b. The 240 million gallons of used motor oil dumped into storm drains every year.
 - c. An oil tanker that capsizes and leaks oil into the ocean.
 - d. A mine that is releasing toxic sludge as it separates metal from rock.
2. Water-soluble pollutants are a problem because _____.
 - a. the chemicals needed to remove them from water are toxic
 - b. they cannot be cleaned up at treatment facilities
 - c. they are point sources of pollution
 - d. they dissolve in water, creating a toxic solution

3. Fertilizers and sewage cause pollution by releasing nitrogen and phosphorus, which leads to increased growth of some bacteria and plants. The plants and bacteria use up oxygen needed by other organisms. What is this called?
- a. Eutrophication
 - b. Cholera
 - c. Acidification
 - d. Point source pollution
4. Cleaning waste from water is a process with several steps. Which answer lists the steps in the correct order?
- a. Bacteria eat substances in the water, solids are removed, and chemicals kill pathogens.
 - b. Solids are removed, chemicals kill pathogens, and bacteria eat substances in the water.
 - c. Solids are removed, bacteria eat substances in the water, and chemicals kill pathogens.
 - d. Chemicals kill pathogens, bacteria eat substances in the water, and solids are removed.
5. What is the cause of the Great Pacific Garbage Patch?
- a. Fertilizers from the California drainage basin.
 - b. Litter and trash dumped into the ocean.
 - c. Oil dumped into the ocean.
 - d. Acidification.
6. Why is it a problem that many pollutants are water-soluble?
- a. They do not dissolve in water.
 - b. They evaporate easily.
 - c. They can easily spread through water sources, contaminating drinking water and ecosystems.
 - d. They react with salt.

Vocabulary Matching

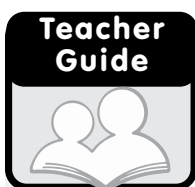
Match each type of pollution with a solution.

- | | |
|--|---|
| 7. <u>D</u> The Great Pacific
Garbage Patch | A. Remove lead from gasoline. |
| 8. <u>E</u> Acidification | B. Use wastewater treatment facilities. |
| 9. <u>G</u> Oil pollution | C. Capture water from farms before it enters
waterways. |
| 10. <u>F</u> Pesticides | D. Stop littering and dumping trash in the ocean. |
| 11. <u>B</u> Sewage | E. Reduce emissions of atmospheric pollutants. |
| 12. <u>A</u> Heavy metals | F. Switch to organic farming. |
| 13. <u>C</u> Fertilizers | G. Reduce the global dependence on oil and
gasoline; properly dispose of used oil. |

Short Answer

14. From the list above, choose one of the environmental problems and try to come up with a solution. Write about the solution, or talk to somebody about how you would solve it. If you think that one person can't make a difference, consider William Kamkwamba, a 14-year-old from Malawi who built a windmill from scrap materials to provide electricity and water to his village. His innovative efforts improved local living conditions and also inspired global conversations about renewable energy and resourcefulness.

Answers will vary.



Chapter 21: What a Whirlwind: Storms

WEEKLY SCHEDULE

Because this week's lab is a four-day lab, we recommend doing science five days for at least this particular week. Don't worry: several of the days require only 5–15 minutes of work.

Science Five Days a Week

DAY 1

- ☐ Lesson: Storms

DAY 2

- ☐ Text Review
- ☐ Lab: Day 1

DAY 3

- ☐ FSS: Hurricanes
- ☐ Lab: Day 2

DAY 4

- ☐ SWYK
- ☐ Lab: Day 3

DAY 5

- ☐ Lab: Day 4

Abbreviations used in the Schedule: FSS = Famous Science Series; SWYK = Show What You Know.

Storms are the subject of Chapter 21. There are specific atmospheric conditions that cause storms. As with many of the phenomena studied this year, convection plays a key role in storm formation. The lab is a four-day lab where students track changing weather in the U.S., using weather maps available online through the National Weather Service. The Famous Science Series has students learn how hurricanes are named.

Learning Goals

- Recognize the relationship between unstable air and storm formation.
- Identify the three ways air becomes unstable.
- Describe the varying conditions needed for the different types of storms.
- Explain the stages of thunderstorm formation.
- State the relationship between hearing thunder and seeing lightning.
- Summarize how different types of storms form using correct vocabulary.
- Explain the relationship between low-pressure systems and storms.
- Identify the three parts of a hurricane.
- Describe the conditions that cause hurricane formation.

Extracurricular Resources

Books and Articles

The Everything Kids' Weather Book: From Tornadoes to Snowstorms, Puzzles, Games, and Facts that Make Weather for Kids Fun!, by Joe Snedeker
Extreme Weather! A Weather Book for Kids with Fun Facts on Storms & Natural Disasters, by Leanne Annett
Extreme Weather! Weather For Kids Book on Storms: Hurricanes, Tornadoes, Blizzards & More, by Leanne Annett
Basher Basics: Weather: Whipping Up a Storm!, by Simon Basher and Dan Green
Meteorology: Cool Women Who Weather Storms, by Karen Bush Gibson

Videos and Articles

Please visit Pandia Press's website for additional resource links:
<https://www.pandiapress.com/weblinks>.

**Lesson: Storms**

Convection causes storms. By now, students should be well versed in how convection works. If they are not, go over it again. Convection is a driving force of movement in fluids on land, water, and air. And not just on this planet. The scientific principle that warmer matter rises in relation to cooler matter holds true on other planets as well.

Math This Week

The math this week entails chart reading, map reading, and division.

Text Review

- I. Air Masses and Storms
 - A. Differences in temperature or humidity in an air mass or at its boundary leads to convection of the air
 - B. This air is unstable and can lead to formation of a storm
 - C. Three ways air becomes unstable:
 1. When cold air converges with warm air, the mass with lower density becomes unstable
 2. Warm air collides with a mountain and is forced up
 3. Surface heating occurs when hot ground transfers heat to air making a pocket of hot, less dense air that rises; this causes cold air to sink, creating a convection cycle of unstable air
- II. Storms
 - A. There is a side-by-side updraft (unstable air) and downdraft (stable air)
 - B. As warm up goes up, it cools and releases moisture
 - C. As air cools, it sinks
- III. Thunderstorms
 - A. Defined as having lightning and thunder (often with high wind, rain, hail)
 - B. Inside the cumulonimbus clouds, positive and negative ions form and separate
 - C. Negative charge at bottom of cloud discharges energy (lightning)
 - D. Lightning heats the air, causing it to expand and contract rapidly, producing thunder
 - E. Three stages of a thunderstorm
 1. First stage = cumulus stage: unstable air rises, bringing water vapor up in atmosphere; this water vapor forms a cumulonimbus cloud
 2. Second stage = mature stage: side-by-side updraft and downdraft, thunder and lightning occur, often with rain or hail
 3. Third stage = dissipation stage: storm ends
 - F. Supercell = thunderstorm where updraft and downdraft are the same strength

G. Types of thunderstorms

1. Tornadoes
 - a. Usually start in a supercell
 - b. Form at the front between a warm, moist air mass and a cool, dry air mass
 - c. The greater the temperature difference between the two air masses, the greater the wind speeds in the tornado
2. Hurricanes (also called cyclones or typhoons)
 - a. Start as group of thunderstorms over ocean
 - b. High-pressure layer forms over a low-pressure area
 - c. Air begins circulating rapidly; high winds at over 119 km/h (74 mph).
 - d. Three main parts:
 - i. Eye = center of the hurricane
 - ii. Eye wall = the ring of cumulonimbus clouds swirling around the eye; worst precipitation and winds
 - iii. Spiral rainbands = bands of rain showers that spiral inward around the eye

IV. Other Types of Storms

A. Snowstorms

1. Snowstorms form within areas of low pressure where warm air meets cold air
2. Snow forms when water vapor within clouds condenses
3. If surface temperatures are below freezing, snow falls
4. If surface temperatures are above freezing, the precipitation falls as rain or freezing rain

B. Windstorms

1. Windstorm = storm with strong winds
2. Windstorms occur with or without precipitation, depending on the moisture content in the air masses responsible for the storm



So You Want to Be a Meteorologist!

The lab this week spans four days. Learners might need some help with this. It is important on Days 2 and 3 that you help kids track the movement of air masses by comparing the maps between Days 1 and 2 and between Days 2 and 3. By looking at the directions the masses and storms moved and the amount of area they moved over, kids will get experience reading these types of maps. They will also have a better idea about part of the predictive analysis that goes into weather reporting. These maps are an important tool used in the scientific modeling of weather behavior.

Pre-Lab Questions

1. Stormy weather happens where there are updrafts that lead to unstable air. When this happens, does a low-pressure system or a high-pressure system develop?

When air moves up, a low-pressure system develops.

2. In the U.S., weather tends to move from the west to the east. Why might that be?

The direction Earth rotates affects the direction weather moves.

3. As you will observe, weather also moves north and south because of temperature differences. Temperature differences also affect whether a front rises or sinks. Do you expect a cold front to rise or sink if it meets a warmer front? Why?

Colder air masses are denser so I would expect them to sink.

Day 1

Answers for Days 1–4 will vary. Here is a sample of what they might look like.

- 1.

Type of Front	Weather
Cold Front	<i>Many of the cold fronts had rain and snow at them, indicating that the warm front being pushed out of the way by the cold front had humidity in it. The cold fronts in the middle of the country did not accompany precipitation.</i>
Warm Front	<i>None on map</i>
Occluded Front	<i>Rainy</i>
Stationary Front	<i>It was mixed. Some of the stationary fronts had rain and snow along them; others had clear weather.</i>

2. Describe the weather across the United States.

There is precipitation in the northwest, southeast, and around the Great Lakes. Cold weather is moving across the country. There are some areas with stationary fronts.

3. Overall, was it clear or stormy at each type of pressure system? Circle the correct choice.

High-pressure systems were *clear*.

Low-pressure systems were *stormy*.

4. Check your barometer today and note where the pointer is.

Answers will vary.

Day 2

- 1.

Type of Front	Weather
Cold Front	<i>It was mixed. There was no weather to note in the southeast in the Atlantic Ocean along the cold front or in the middle of the U.S. In the Great Lakes region and Northern California, there was precipitation.</i>
Warm Front	<i>None on map</i>
Occluded Front	<i>Stormy</i>
Stationary Front	<i>It was mixed. Some of the stationary fronts had rain and snow along them; others had clear weather.</i>

2. Describe the weather across the United States.

There is precipitation in the northwest, southeast, and around the Great Lakes. Cold weather is moving across the country.

3. Overall, was it clear or stormy at each type of pressure system? If there were anomalies, make a note of those. Circle the correct choice.

High-pressure systems were *clear*.

Low-pressure systems were *stormy*.

4. Check your barometer today and note where the pointer is. How did the position of the pointer change?

Answers will vary.

Day 3

- 1.

Type of Front	Weather
Cold Front	<i>Dry</i>
Warm Front	<i>Dry</i>
Occluded Front	<i>Stormy in the northeast Calm in the middle of the country</i>
Stationary Front	<i>Dry</i>

2. Describe the weather across the United States.

There is precipitation in the northwest and off-and-on along the Canada-U.S. border from Montana to the eastern seaboard. The storms in Texas and Florida are shrinking and moving south.

3. Overall, was it clear or stormy at each type of pressure system? If there were anomalies, make a note of those. Circle the correct choice.

High-pressure systems were *clear*.

Low-pressure systems were *stormy*.

4. Check your barometer today and note where the pointer is. How did the position of the pointer change?

Answers will vary.

5. Predict the weather for Day 4. Based on your observations over the past three days, what do you expect the weather to be in the U.S. tomorrow? Where will the low- and high-pressure systems and the storms have moved?

Answers will vary.

Day 4

1. Large bodies of water can affect the weather. The Great Lakes, toward the northeastern part of the United States at the Canada–U.S. border, are large enough to modify the weather. Water temperatures change more slowly than temperatures on land (do you remember why?). This results in lake effect snow, cooler springs, more temperate summers, and delayed frosts in the area around the Great Lakes. Did you observe weather patterns that could be attributed to the lake effect? If so, describe those weather patterns.

The heat capacity of water explains why water temperatures change more slowly than temperatures on land. (Hydrogen bonding is also an acceptable answer.) I observed a lake effect. There was constant precipitation in the Great Lakes area over the week I monitored the weather.

2. Did there seem to be more precipitation near water, such as along the coast? If yes, why do you think that is?

There was more precipitation where there was water. I think that is due to the higher humidity in those areas, because there is a constant source of water. Higher humidity leads to a greater likelihood of precipitation.

3. When a scientist makes a hypothesis, they predict a future outcome. How good were you at predicting the weather?

Answers will vary.

4. Did you notice any patterns for how the fronts and storms moved?

I did not notice any patterns for the fronts.

Storms tended to move in a southeasterly direction.

5. Were there any large storms? Did they get larger or shrink over the course of the week?

Answers will vary.

6. Did the weather change much where you live? Did your barometer alert you to the change?

Answers will vary.



**Famous Science
Series: It's All in a
Name: Hurricanes,
Cyclones and
Typhoons**

This week students will research how hurricanes are named and classified. They also research and learn about some of the specific conditions of this type of storm.

1. What must occur for a thunderstorm to receive a name? What type of storm is it called when it first gets its name?

Once a storm's winds reach sustained speeds of 63 km/h (39 mph), it receives a name. At that point, the storm becomes what is known as a tropical storm.

2. Who picks the names for storms? How are the names decided?

The lists for storm names are maintained by the World Meteorological Organization. The names used are names common to the area of the world the storm is located in.

3. Why are some names removed, never to be used again?

This is done when a storm caused a lot of death or destruction.

4. What is the difference between hurricanes, cyclones, and typhoons?

They are all the same kind of storm. They simply use different terms in different parts of the world.

5. Where are the terms hurricanes, cyclones, and typhoons used?

The term hurricane is used in the Atlantic and Northeast Pacific. The term typhoon is used in the Northwest Pacific. The term cyclone is used in the South Pacific and Indian Ocean.

6. The winds in a thunderstorm rotate in a specific direction. How does this differ in different parts of the world?

If one of these storms occurs north of the equator, it rotates counterclockwise. If it occurs south of the equator, it rotates clockwise.

7. There are five categories based on wind speeds. What are the wind speeds for each category?

Category 1 = 119–153 km/h (74–95 mph)

Category 2 = 154–177 km/h (96–110 mph)

Category 3 = 178–208 km/h (111–129 mph)

Category 4 = 209–251 km/h (130–156 mph)

Category 5 = 252 km/h + (157 mph+)



Show What You Know

Multiple Choice

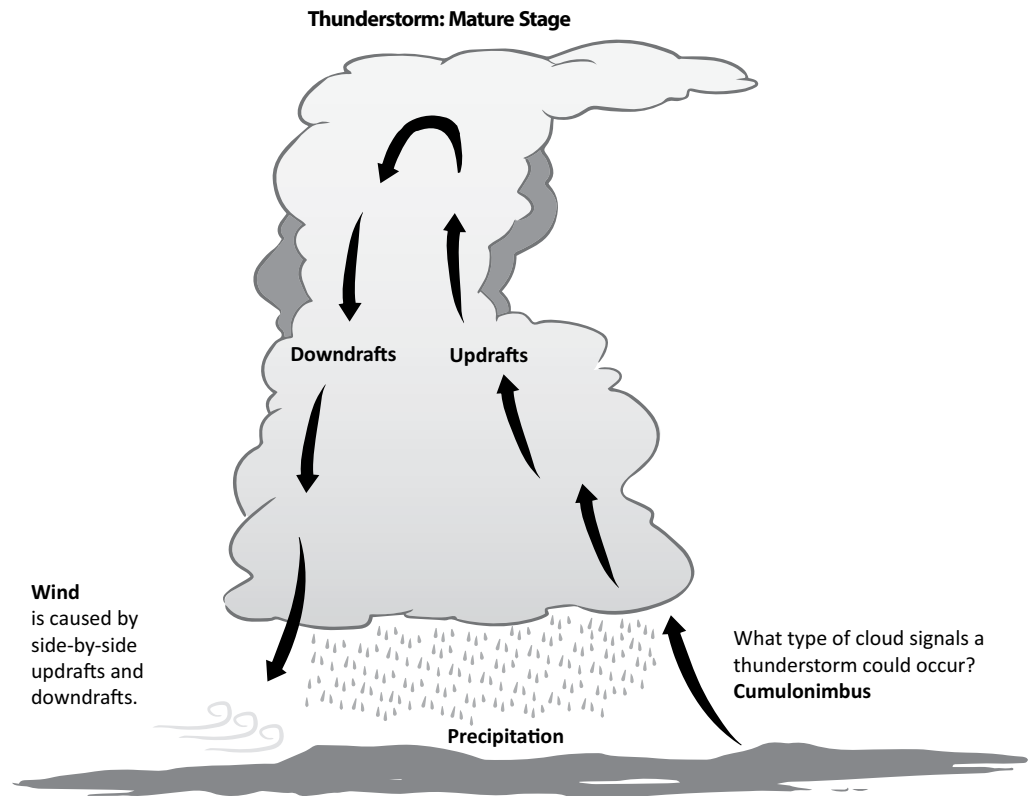
- Yesterday you were playing outside with your friends. This morning, you woke up to heavy rain, lightning, and thunder. The air in your area is _____.
 - stable
 - ☐ unstable
- Most tornadoes in the U.S. form along the front of two air masses in an area called Tornado Alley. What type of air masses cause these tornadoes to form?
 - A warm, wet air mass and a warm, dry air mass
 - A cold, wet air mass and a cold, dry air mass
 - ☐ A warm, wet air mass and a cold, dry air mass
 - A cold, wet air mass and a warm, dry air mass
- Hurricanes have a ____-pressure air mass above a ____-pressure air mass.
 - low, high
 - low, low
 - ☐ high, low
 - high, high

4. Thunderstorms need a specific type of air packet to rise quickly. What are the specific conditions of that air packet?
- a. ☐ It must be warm and wet.
 - b. ☐ It must be cold and wet.
 - c. ☐ It must be cold and dry.
 - d. ☐ It must be warm and dry.
5. What is lightning?
- a. ☐ A quick updraft of air
 - b. ☐ A fast-moving, low-pressure air mass
 - c. ☐ A release of energy from a cloud
 - d. ☐ Rapidly expanding air
6. Why do you see lightning before you hear its thunder?
- a. ☐ Lightning travels at the speed of light, and thunder travels at the speed of sound.
 - b. ☐ Thunder travels at the speed of light, and lightning travels at the speed of sound.
 - c. ☐ It takes a while for the air, that makes the sound of thunder, to expand.
7. What is the heat released or absorbed by a substance undergoing a change of state called?
- a. ☐ Condensation
 - b. ☐ Latent heat
 - c. ☐ Heat capacity
 - d. ☐ Melting point
8. What happens when a fast updraft is strong enough to carry water drops to an altitude above the freezing level?
- a. ☐ Hail forms.
 - b. ☐ A high-pressure system forms.
 - c. ☐ A low-pressure system forms.
 - d. ☐ A tornado forms.
9. What is the primary factor that leads to the formation of snowstorms?
- a. ☐ High-pressure systems

- b. Collision of a warm, wet air mass with a cold air mass
- c. Absence of wind
- d. Presence of thunderstorms

10. Which statement best describes the formation of windstorms?

- a. Windstorms form when warm air meets cold air, leading to the formation of thunderstorms.
- b. Windstorms occur when there is no contrast in temperature and pressure between two air masses.
- c. Windstorms primarily involve precipitation, such as rain or hail.
- d. Windstorms are caused by a significant contrast in temperature and pressure between two air masses, resulting in strong winds.



What is lightning, and how does lightning cause thunder?

Lightning is a discharge of energy caused when an electrical connection is made between charged molecules in the bottom of a cloud and on the land below. Heat from the lightning causes the air along its path to expand rapidly. The sound produced by the rapidly expanding air is thunder.

Jeopardy

Below you will find descriptions for types of storms. After reading the statement that describes each storm, identify the storm by answering in the form of a question. The format has been added for you, so all you have to do is put the name of that type of storm in the blank.

Category: Storms	Answer	Question
100	These storms occur when there is lightning and thunder in a mass of moist, unstable air.	What is a <i>thunderstorm</i> ?
200	In this type of storm, updrafts and downdrafts are the same strength, which can lead to flooding and tornadoes.	What is a <i>supercell</i> ?
300	This type of storm forms over oceans when a continental air mass blows off the continent and converges with a warm, wet maritime air mass over warm ocean water. The minimum wind speed for this type of storm is 119 km/h.	What is a <i>hurricane</i> ?
400	This is a violent twisting column of air that forms when there is rapid convection of air at the front between a warm, moist air mass and a cool, dry air mass.	What is a <i>tornado</i> ?
500	During this part of a thunderstorm, updrafts and downdrafts exist side by side, and precipitation falls.	What is the <i>mature stage</i> ?
600	A blizzard is an extreme example of this type of storm.	What is a <i>snowstorm</i> ?
700	Santa Ana storms are a type of this kind of storm. They occur in Southern California. The storms originate in desert areas. The dry, warm winds can reach speeds up to 60 mph.	What is a <i>windstorm</i> ?

How many did you get correct? Add the points for each question that you got correct.

You can choose how much or how little you want to wager in the Final Jeopardy Question.

Final Jeopardy Question	This causes storms.	What is <i>convection</i> ?
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