

R.E.A.L. SCIENCE ODYSSEY

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Earth & Environment **LEVEL 2** Workbook

GRADES 6–10

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



TBYB SAMPLE



REAL Science Odyssey

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Earth & Environment 2: Workbook **Try Before You Buy**

This file contains a preview of RSO Earth & Environment 2: Workbook. 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

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

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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

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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.

Unit I: Introduction

Earth & Environment ^{LEVEL} 2

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



Activity: Getting Your Feet Wet

1. Density is an important concept in earth science.

a. Is Earth's crust the least dense layer or the densest layer?

b. Think about the differentiation of the hydrosphere and atmosphere from the geosphere. What does that tell you about the density of the water and air relative to Earth's crust?

c. What does the location of clouds tell you about the density of water molecules in clouds versus the density of water molecules in the ocean?

2. In this chapter, you learned about the four spheres of Earth. Add the correct prefix to the root word "sphere," and then identify each one in the picture by drawing a line to each sphere, or by coloring each sphere a different color.



3. Scientific discoveries start with a question. What are your five questions about Earth and the environment?

- a.
- b.
- c.
- d.
- e.



Activity: Geologic Timeline Part 1

You are going to make a **geologic timeline** as you work through this course. It will have important events in Earth’s history. Many of the events you will record would not be on a timeline of human history. Earth’s pre-history began 13.82 billion years ago when the universe came into being from an event called the Big Bang. The **Big Bang Theory** is accepted by most scientists as the best explanation for how the universe began and has evolved (changed) since then. Earth wasn’t formed yet, but without the Big Bang, there would not be the material needed to form Earth or any other planetary object. Your solar system began forming 4.6 billion years ago. It was not the first solar system to form, but it was the one that would eventually be home to you. This is part of Earth’s pre-history as well. Earth’s history, and therefore its timeline, starts 4.56 billion years ago. It took a long time to get from Earth’s formation to you, didn’t it?

Fill in the underlined sections with the correct answer. To determine how many years the universe, solar system, and Earth formed before you were born, subtract how old you are in years from the age of these entities.		
Universe	The universe formed 13.82 billion (13,820,000,000) years ago.	
Solar System	The solar system formed 4.6 billion (4,600,000,000) years ago.	9,220,000,000 years after the universe formed, the solar system formed.
Earth	Earth formed 4.56 billion (4,540,000,000) years ago.	9,260,000,000 years after the universe formed, Earth formed. 60,000,000 years after the solar system formed, Earth formed.
Me	I was born _____ years ago.	_____ years after the universe formed, I was born. _____ years after the solar formed, I was born. _____ years after Earth formed, I was born.

The timeline will begin with Earth's formation. Earth has changed many times during its 4.56 billion year history. This year you will learn about Earth's dynamic history, past and present. When Earth formed, it did not look like it does today. The geosphere was not solid. It was a molten ball, too hot for the hydrosphere or atmosphere to form. It was millions of years after Earth's formation and cooling that life evolved and the biosphere came to be. The first organisms were neither animals nor plants. Plants and animals would not evolve for thousands of millions of years. The first organisms were not bacteria either; bacteria did not evolve for hundreds of millions of years. Scientists are not sure what the first organisms of the biosphere looked like, but they would have been simple compared to the organisms of today. They also have evidence that the first organisms evolved at hydrothermal vents, openings in the ocean floor where heated nutrient-rich water flows through.

As Earth's formation progressed, mountains grew to be taller than Mount Everest and shrank. Oceans widened and narrowed. A glacier overtook Antarctica, where there was once a tropical forest where dinosaurs roamed. Organisms have evolved and gone extinct. These events are described on the Geologic Timeline. This is the system scientists use to describe the timing of events in Earth's 4.56-billion-year history. It is an important scientific model that is used to understand the history of Earth's spheres and how they have changed over time.

The Geologic Timeline is divided based on changes in rock records, fossils, and other evidence of geologic events. These events do not happen at regular time intervals. Therefore, the division of time is in units of varying lengths. The largest unit is the **eon**, which is further divided into smaller units such as **eras**, **periods**, and **epochs**. For example, the first eon, the Hadean, spanned from 4,540 billion years ago to 4,000 billion years ago. The Hadean Eon is not broken down into eras, periods, or epochs. However, the eon you are now living in, the Phanerozoic Eon, began 541 million years ago. It is divided into three eras, which are further divided into twelve periods. The five most recent periods are further divided into fifteen epochs.

Materials

- Timeline (page 5)
- Colored pencils
- Pencil or pen

Procedure

1. Go to the timeline on page 5. The units for this timeline are millions of years. If you were to go to the far-right side where it says Today and go back 100 years, it would be so close to today that it would look like they were at the same place on the timeline. Just keep in mind that this timeline is only the length of the page, but it represents a very large amount of time. Also, note that there are two timelines. There are four eons, which are grouped into two supereons: the Precambrian and Cambrian. Find these on the upper and lower timelines. Color the Precambrian Supereon one color and both Cambrian Supereons another color.
2. There are four eons on the timeline. The Precambrian spanned from 4,560 to about 542 million years ago, more than 4 billion years and is divided into three eons: the Hadean, Archean, and Proterozoic. Color each of these a different color. The Cambrian Supereon comprises one eon: the Phanerozoic Eon. Color this eon (on both the upper and lower timeline) using a different color.

3. Discuss with your teacher: Why do you think that the closer the Geologic Timeline gets to today, the more divisions there are?

Precambrian Supereon

4. Hadean Eon: The eon when Earth formed is called the Hadean Eon. During this eon, comets, meteors, and asteroids bombarded Earth, which began to differentiate soon after it began to form.
 - a. Write “Earth formed” along the line at 4,560 million years ago.
 - b. At 4,500 million years ago, write “Earth differentiated.”
 - c. If you are the artistic type, you could even show a few comets and meteors raining down above the box where the dates are.
5. Archean Eon: Evidence of life can be found in rocks from the Archean Eon.
 - a. At 3,800 million years ago, write “Bombardment ended.” This ended the time when Earth was heavily bombarded with asteroids, meteors, comets, and dust from space. The period of heavy bombardment might not sound like a good thing; however, there is evidence that some of the water on Earth came from comets that crashed into it.

Cambrian Supereon

6. The second timeline on your sheet focuses on the Phanerozoic Eon and its eras, periods, and epochs.
7. Phanerozoic Eon: The Phanerozoic Eon spans the entire Cambrian Supereon, 542 million years. Fossil evidence indicates that mammals evolved about 200 million years ago during the Phanerozoic Eon. Dinosaurs evolved 30 million years earlier, a short amount of time on the Geologic Timeline, but a long time based on a person’s lifespan.
 - a. Above the Phanerozoic Eon, write “Dinosaurs evolved” and below and slightly to the right of that write “Mammals evolved.”

Note:

- This is not a complete timeline. You will fill this timeline in more in later chapters. Most of the events on this timeline are geologic events, not biological events.
- These dates do occasionally change as scientists find fresh evidence and as the ability to determine the date events occurred becomes more sophisticated.

Lab Sheet: Geologic Timeline

[illegible]

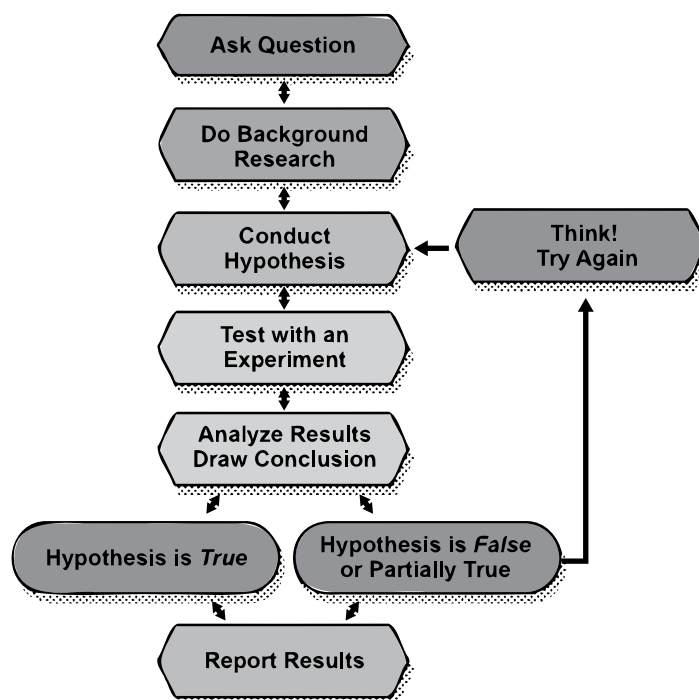
248	206	144	65	56	34	23	5	2.5	11,700 ya	Today
			Paleocene Epoch	Eocene Epoch	Oligocene Epoch	Miocene Epoch	Pliocene Epoch	Pleistocene Epoch		Holocene Epoch
Triassic Period	Jurassic Period	Cretaceous Period	Paleogene Period			Neogene Period				
Mesozoic Era			Cenozoic Era							
Phanerozoic Eon										
Cambrian (Supereon)										



Famous Science Series: The History of the Scientific Method

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?

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?

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?

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

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?

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?



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 _____ in a given amount of _____.
6. Earth's layers differentiate, going from _____ dense at the bottom to _____ dense at the top.
7. All _____ models must explain _____ and _____.
8. The scientific method uses _____, _____, and _____ to develop scientific models and theories.
9. A scientific _____ is a widely accepted _____ of something observed in science that has been tested many times by different researchers who get results that are _____.

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. ____ It will rain on March 14.
11. ____ There are 60 seconds in one minute.
12. ____ $\text{Force} = \text{mass} \times \text{acceleration}$.
13. ____ 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. ____ Clouds contain water molecules.
15. ____ 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. ____ Earth's lithosphere is divided into tectonic plates that move like ice in a lake relative to each other.
17. ____ If a plant grows larger, it will need more nutrients to continue growing.

Unit II: The Geosphere

Earth & Environment LEVEL 2

Chapter 2: The Puzzle You Live On: Plate Tectonics



Activity: Modeling Plate Tectonics

Materials

- Metric ruler or measuring tape
- 8 or more chocolate sandwich cookies (Double Stuf Oreos are best)

Note: Make sure to answer all the questions on the lab sheet before you eat your cookie models!

Procedure

Part 1: Modeling the Lithosphere and Asthenosphere

1. Sandwich cookies are used to model the lithosphere and asthenosphere. Hold one of the cookies between your fingers and slide the top cookie around on top of the filling. The cookie floats and moves on the filling, similar to how the lithosphere floats and moves on the asthenosphere.
2. Answer questions 1, 2, and 3 on the lab sheet on page 13.
3. The lithosphere is broken into pieces called tectonic plates. Break the upper chocolate cookie in half to make a model with two tectonic plates. The bottom unbroken cookie is not a part of the model. You can leave it or eat it. Yummy!
4. Answer question 4 on the lab sheet on page 13.

Part 2: Modeling a Divergent Boundary

1. Separate the top half from the bottom half of a cookie.
2. Carefully make a crack through the center of one half and place it back on the other half.
3. Slowly slide the two sides on either side of the crack away from each other, pushing down on the cookie so white cream oozes up.
 - a. If this were really a divergent boundary, this white cream would harden and make new crust.
 - b. If there was a large supply of white cream in the cookie, the white cream crust would grow taller and taller as more oozed through the divergent boundary and hardened on top of that crust.
 - c. The chocolate edge of the crack is a model for the ridge that forms.

4. Answer questions 5 and 6 on your lab sheet on page 14.

Part 3: Modeling a Convergent Continental-Continental Boundary

1. Carefully crack the top half of a sandwich cookie.
2. Push the two sides together trying to break the crust along the boundary. This will force the chocolate cookie pieces up to push and crunch against each other to form a “mountain.” If the cookie crumbles before the “mountain” forms, you might need to use a bit of the filling to make your mountain.
3. Answer question 7 on the lab sheet on page 14.

Part 4: Modeling a Convergent Oceanic-Oceanic Boundary

1. Carefully make a crack down the center of the top half of a sandwich cookie.
2. The two sides look the same, but in this model, one of them will be denser than the other. Decide which half is the denser plate and have it slide beneath the other as it is subducted.
3. Answer question 8 on the lab sheet on page 15.
4. Between the subducting plate and the plate on top, rock melts into magma. This is the location where magma bubbles to the surface and volcanic island arcs form. You can try to gently squeeze filling between the two layers, crack the cookie again and squeeze magma (cookie cream) onto the top cookie to model a volcanic island arc forming.

Part 5: Modeling a Convergent Oceanic-Continental Boundary

1. You need two sandwich cookies for this model. Carefully make a crack down the center of the top half of both cookies.
2. Remove one half of the cracked top from one of the cookies, and place it on top of one side of the other cracked cookie. The side that is two cookies thick models the less dense continental crust. The other side that is one cookie thick models the denser oceanic crust.
3. Slide the single layer of dense, oceanic crust beneath the continental crust to model subduction.
4. Answer question 9 on the lab sheet on page 15.

Part 6: Modeling a Transform Boundary

1. Carefully make a crack down the center of the top half of a sandwich cookie.
2. Slide the two cookie halves back and forth against each other. It should feel rough because the two sides are not smooth.
3. Slide the pieces so the two sides are about 1 cm (1/2 in.) past each other.
4. Answer question 10 on your lab sheet on page 16.

Lab Sheet: Modeling Plate Tectonics

Modeling Plate Tectonics

Part 1: Modeling the Lithosphere and Asthenosphere

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

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

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

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?

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.



Activity: Geologic Timeline Part 2

1. Several hundred million years ago, there was only one continent, Pangaea. Add “Pangaea supercontinent” to the timeline at 335 million years before present.
2. Today there are seven continents. Along the outside margin to the right of Today, write “Seven continents.”
3. The last time Earth’s magnetic field reversed from what it is today was 780,000 years ago. This is called the Brunhes-Matuyama reversal. Add “Brunhes-Matuyama reversal” to the timeline at 780,000 years before present.



Lab: It’s Magnetic

Plate tectonics is proof that Earth is a dynamic planet. So is the fact that the polarity (direction) of Earth’s magnetic field changes over geologic time. Earth’s magnetic field is caused by its fast-flowing liquid core that is filled with charged particles called ions. The direction the charged particles are flowing in the liquid core can reverse, when that happens the polarity of the magnetic field reverses. During the past 20 million years the magnetic field has reversed about every 200,000 to 300,000 years. The last time it reversed, however, was 780,000 million years ago, so it is overdue and could reverse at any time! But don’t let that worry you; when scientists look at the fossil record, the reversal of Earth’s magnetic field has not resulted in any serious consequences for the biosphere, and reversals are not a sudden flip. They occur slowly, taking a few thousand years to fully reverse.

The model you are making in this lab simulates the Mid-Atlantic Ridge that goes north and south through the middle of the Atlantic Ocean where the North American and Eurasian tectonic plates are spreading apart. As the plates are pulled apart, lava cools to form new oceanic crust. As it’s cooling, the ocean floor becomes magnetized in direction of Earth’s magnetic field at the time. In this model, you will magnetize metal pins to alternate polarity, north or south, on a series of stripes. Similar to the way scientists study magnetic striping in the ocean, you will use a magnetic compass to determine the polarity of the stripes.

Materials

- 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)

Procedure

1. Remove (or make copies of) the lab sheets on pages 19 and 21. Cut the sheets where indicated.
2. To model oceanic crust, push two pins into each colored and white stripe at the markers on both lab sheets. The direction of the pin heads alternates with each stripe. Both lab sheets should follow the same directional pattern.
3. Tape the sheets together along the top short side so that when the sheets are folded along the tape, they are mirror images.
4. Magnetize the stripes.
 - a. Keeping the magnet away from the pins on the white stripes (to avoid polarizing them), run the magnet's north end from pin head to pointed end along all the pins on the colored stripes.
 - b. Keeping the magnet away from the pins on the colored stripes (to avoid changing their polarity), run the magnet's north end from pin head to pointed end along all the pins on the white stripes.
5. To model the Mid-Atlantic Ridge, push the stacks of books (or boxes or tables) together with a narrow divide between them. Lay your magnetized oceanic crust model over your oceanic ridge model with the tape strip lining up with the divide. Gently push the crust model into the ridge model until only the last stripe at either end of the crust is visible.
6. Slowly move the compass across the two colored stripes that are visible and write the direction of the compass points. Simulate millions of years of tectonic plate movement by slowly and evenly pulling the paper out of the divide from both sides. Pull until the next set of pins (white stripes) are visible. Slowly move the compass across the white stripes and record the direction the compass points on the space provided. Continue this process recording the magnetic direction of each set of stripes until you reach the "youngest" set of stripes at the tape line, which, if all went well, points north.
7. Lay your oceanic crust model on a flat surface. You will use the compass like a simple magnetometer similar to that used by scientists when they study magnetic striping in the ocean. Slowly move the compass over the model. Observe the compass needle changing direction. Record or correct the directions on the model.

Lab Sheet: It's Magnetic



tape sheets together along this edge

Direction _____

Direction _____

Direction _____

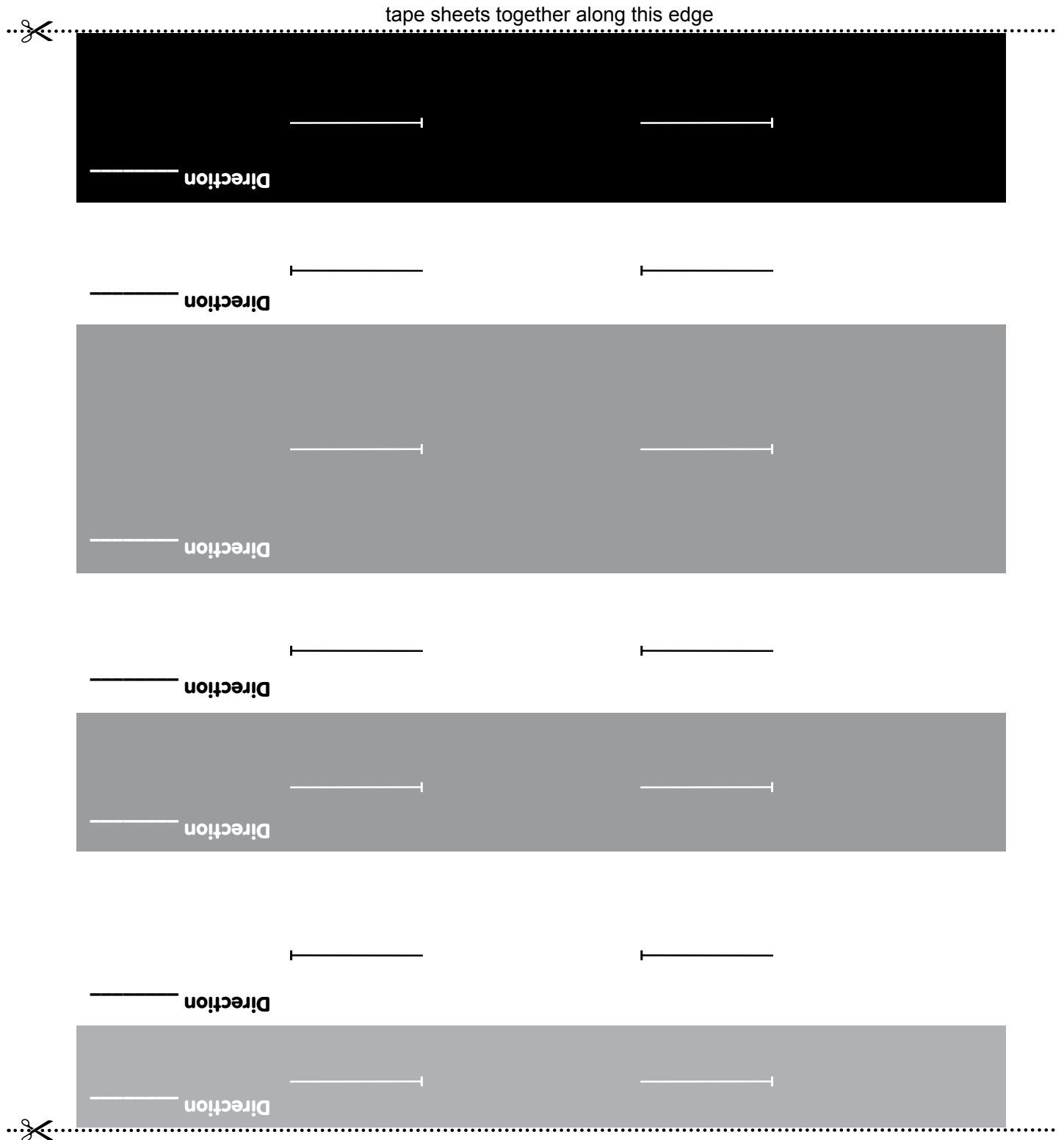
Direction _____

Direction _____

Direction _____

Direction _____







Famous Science Series: Alfred Wegener, Famous Geologist and Meteorologist

1. When and where was Alfred Wegener born?

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

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

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?

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

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

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



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

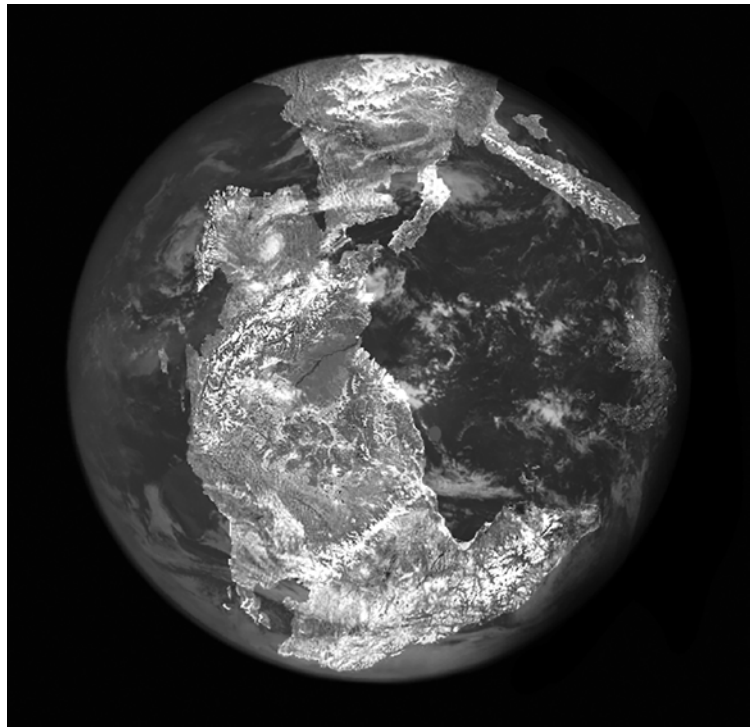
9. How, when, and where did Wegener die? How old was he?



Activity: What Did Wegener See?

In 1596, the Dutch mapmaker Abraham Ortelius wrote that the Americas were “torn away from Europe and Africa.” He indicated that a careful study of these continents’ coasts showed they had once been joined. In 1912, Alfred Wegener said the same thing. Have you ever thought of the continents as pieces of a puzzle that could be joined?

As continents move over time, there is some rotation and some loss from the outer coastlines. This must be accounted for when you put them back together to form the supercontinent **Pangaea**. A **supercontinent** occurs when most or all of Earth’s landmasses form a single large landmass. Scientists think there have been at least two and probably several supercontinents over geologic time. The shape of the continents is just one indication that the continents were joined. The distribution of fossils and distinctive rock patterns also give evidence for the existence of the supercontinent Pangaea. This seven-piece puzzle is a model showing how the continents of today fit together to form one large supercontinent. Can you put the puzzle together? Can you see what Ortelius and Wegener did?



Pangaea formed about 335 million years ago.

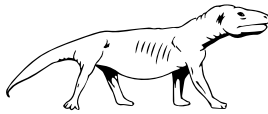
Materials

- Pangaea puzzle sheet (page 27)
- 2 pieces 8" × 11" cardstock
- Scissors
- Glue
- Colored pencils, optional
- World map, optional

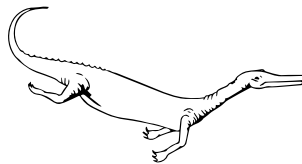
Procedure

1. Remove or make a copy of the Pangaea puzzle sheet on page 27. Glue the puzzle sheet onto the cardstock and let it dry.
2. When it is dry, color the shapes if you want to and cut out the puzzle pieces along the shaded outlines. There are 12 pieces.
3. Fit the pieces together. Use the clues on the pieces as well as the overall shape of the continents. Remember the continents turned a bit when they moved. If you get stuck, it may help to look at a current world map for reference. When you are finished with placing the pieces, glue them to the other piece of cardstock to preserve your completed puzzle.

Map Key



Cynognathus



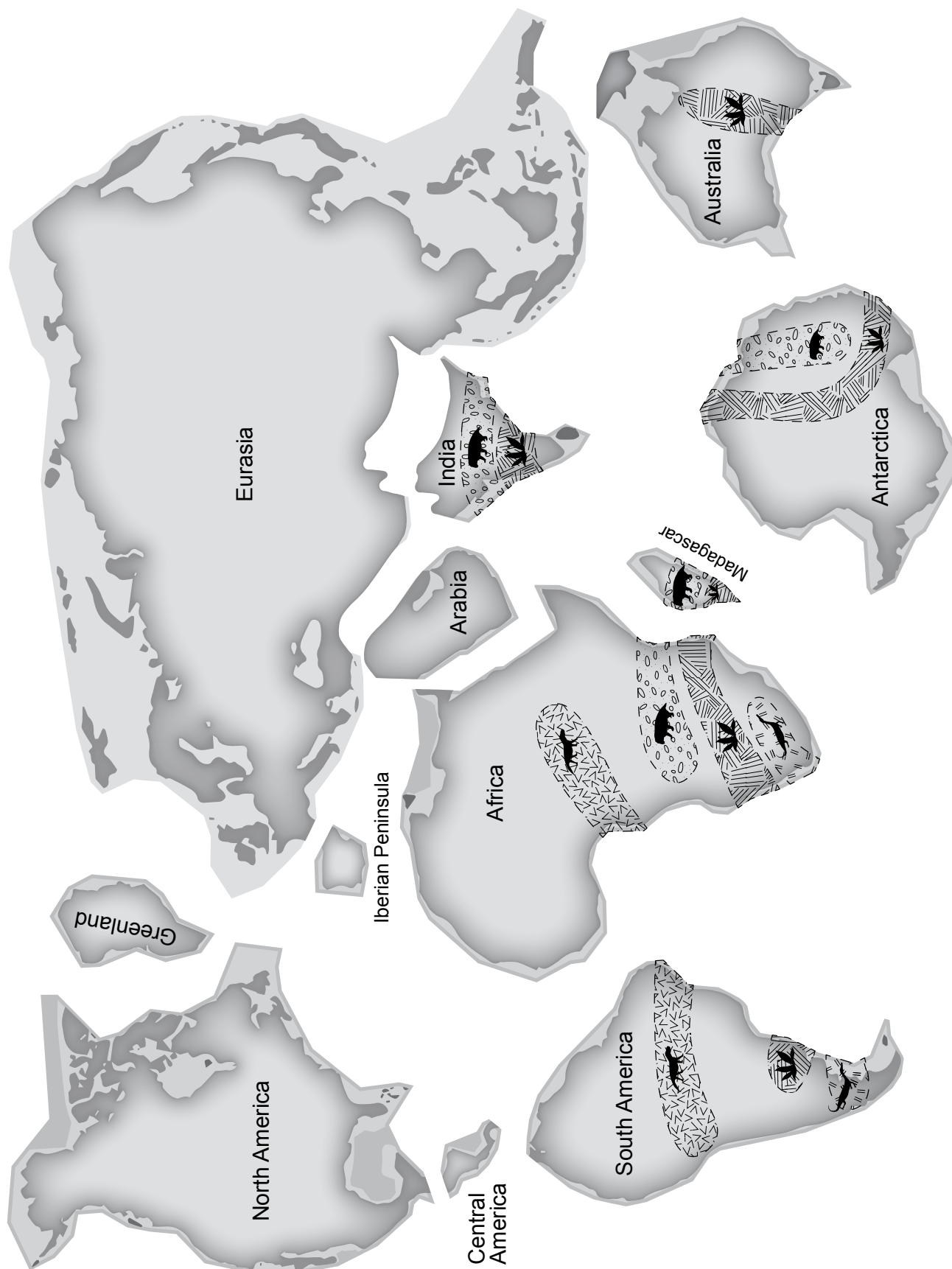
Mesosaurus



Lystrosaurus



Glossopteris





Show What You Know

Multiple Choice

1. The outer rocky layer of Earth is called the
 - a. lithosphere.
 - b. asthenosphere.
 - c. core.
 - d. mantle.
2. When one tectonic plate sinks below another into the mantle, it is called
 - a. convergence.
 - b. divergence.
 - c. convection.
 - d. subduction.
3. Deep ocean trenches, like the Mariana Trench, form at which type of boundary?
 - a. Convergent
 - b. Divergent
 - c. Transform
4. Fracture zones, like the San Andreas Fault, form at which type of boundary?
 - a. Convergent
 - b. Divergent
 - c. Transform
5. Mountain ranges, like the Andes, form at which type of boundary?
 - a. Convergent
 - 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. Continental-continental boundary
7. Volcanic island arcs, like the Caribbean Islands, form at what type of convergent boundary?
- a. Oceanic-continental boundary
 - b. Oceanic-oceanic boundary
 - c. Continental-continental boundary
8. Volcanic mountain ranges along a continental coast, like the Cascade Range, form at what type of convergent boundary?
- a. Oceanic-continental boundary
 - b. Oceanic-oceanic boundary
 - c. Continental-continental boundary

Short Answer

9. How does seafloor spreading relate to plate tectonics?

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

- a. Magnetic symmetry: _____

- b. Earthquakes and volcanoes: _____

c. GPS: _____

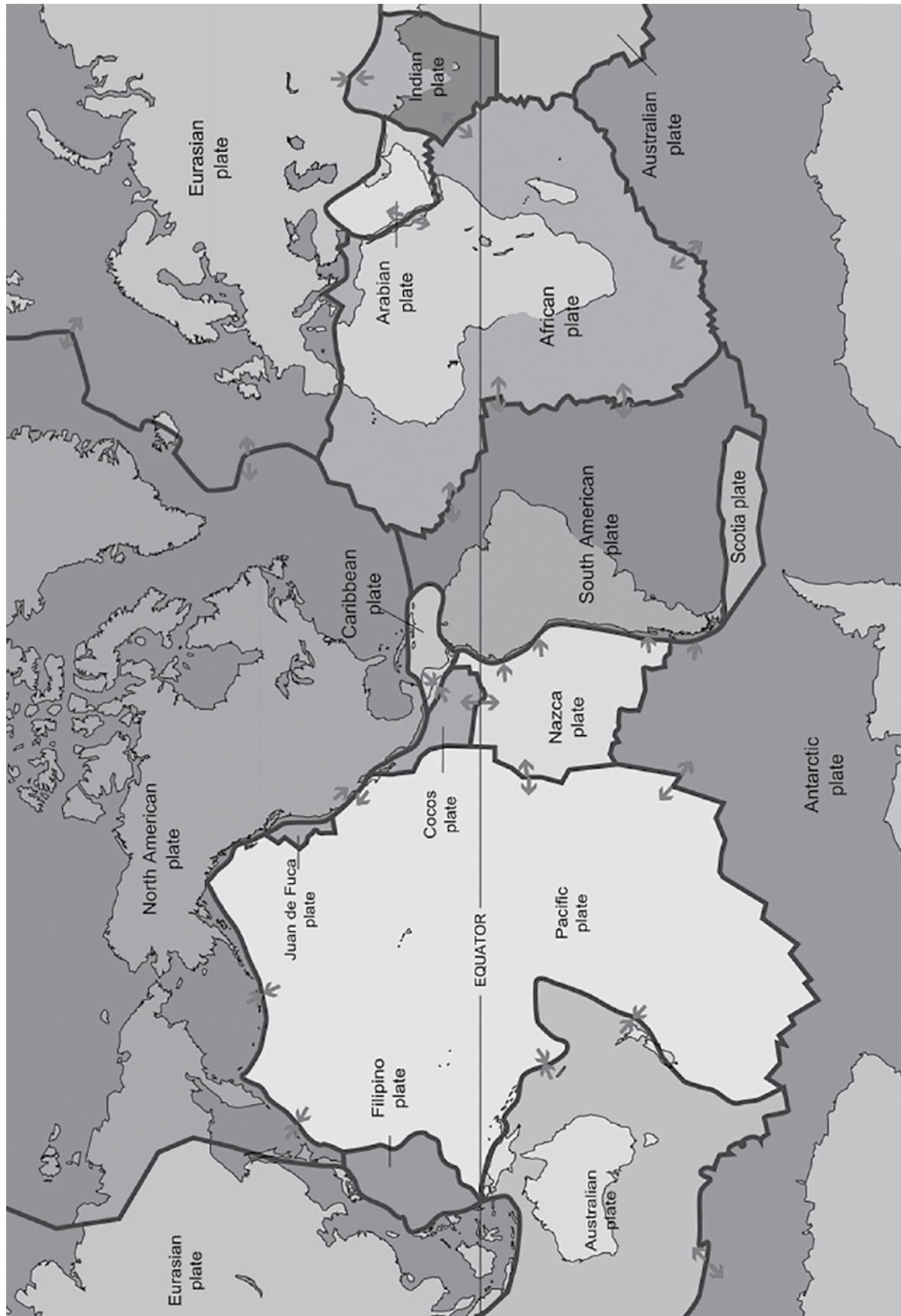
11. Why is convection important to the theory of plate tectonics?

12. Learn about the tectonic plate where you live.

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

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

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



Chapter 11: Lava You, Lava You Not: Volcanoes



Activity: Geologic Timeline Part 10

Earth has been volcanically active throughout its entire 4.56-billion-year history. Here are two volcanic events to add to your timeline:

1. Scientists believe an asteroid striking Earth and a series of volcanic eruptions at the Deccan Traps in western India occurring at the same time were part of a double whammy, leading to the extinction of all non-avian dinosaurs. Add the label “Deccan Traps erupted” to the timeline at 66 million years ago.
2. The oldest Hawai’ian Island is Oahu. Add the label, “Oahu, Hawai’i formed” to the timeline at 3.4 million years ago.



Lab: Outgassing Experiment in Progress

When solids and liquids heat up, gases trapped inside them are released. This is called outgassing. Scientists believe outgassing from volcanic eruptions were the main source of Earth’s early atmosphere. Of course, scientists were not around when the atmosphere first formed. This is a working scientific theory that scientists have developed based on observations made in their laboratories millions of years after the early atmosphere formed. This theory is also based on observations scientists have made when studying active volcanoes. What do you think you would observe if you heated liquid that had gas trapped inside it? Do you think you could observe outgassing?

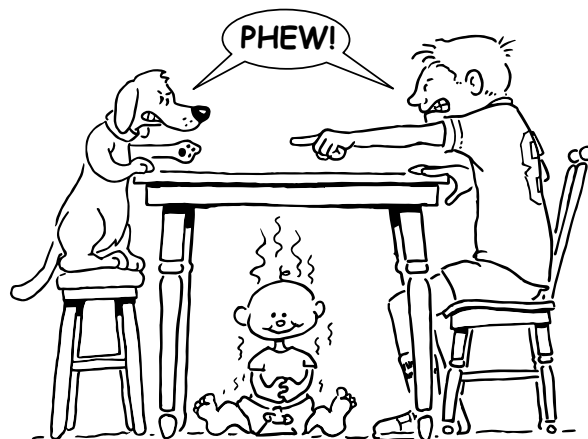
When outgassing occurs, how does it change the liquid? One simple way to test if there is a change in the chemical makeup of a liquid is with pH paper, which is used to detect changes in the pH of liquids. **pH** is a measure of the amount of acid or base in a solution.

Acids produce hydrogen ions (H^+). A **hydrogen ion** is formed when a hydrogen atom loses its electron. A hydrogen atom is made from one proton and one electron, so a hydrogen ion is made of one proton, nothing more.

Bases produce hydroxide ions (OH^-). A **hydroxide ion** is an oxygen atom and a hydrogen atom bonded together with an extra electron. You might have noticed that if you put the hydrogen ion and the hydroxide ion together, they form a water molecule.



If you observe a change in the pH paper color, it indicates a change in the solution’s pH.



Materials

- 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

Procedure

Preparation and Hypotheses

1. Label the refrigerated can A. Label the other two cans of room-temperature sodas B and C, respectively.
2. Write your hypotheses on the lab sheet before conducting the experiment. Here is some information to help when predicting the outcome:
 - a. You will be looking at the concentration of gas in solution at three separate temperatures. 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? Think about what scientists have observed when looking at volcanoes.
 - b. You will be experimenting to determine if you can observe a change in acidity or basicity to the three soda solutions. Do you expect there to be a change in pH when and if soda outgasses, releasing CO_2 ? When you use the pH paper at the beginning of this experiment, you will see that soda is acidic. Carbonated beverages like sodas contain carbonic acid. The chemical formula for carbonic acid is H_2CO_3 . Carbonic acid decomposes: $\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2$. One of the products, carbon dioxide (CO_2) is what makes soda fizz.

Time: o

1. Open the three cans of soda.
2. Pour the refrigerated soda into the refrigerated glass and label it A.
3. Pour one can of room-temperature soda into the room-temperature glass and label it B.
4. Pour the second can of room-temperature soda into the pot. This will be C. You can label it if you want, but because there isn't another pot being used, you probably won't mix up this sample with anything else!
5. Use pH paper on each soda solution. When using pH paper, hold the paper strip with your fingers and carefully dip it into the solution. Remove it. The color will change immediately, so there is no need to hold the strip in the liquid. Strips cannot be reused.

6. Compare the color of your paper strip with the color-coded pH result strip that came in your package. This will help you determine the pH of each soda solution. Record your values in the data table on the lab sheet, and tape the strips in the slots allotted on the lab sheet. In the beginning, the soda should change the pH paper to an orange-ish color, which correlates to a pH of approximately 3.
7. Compare the amount of dissolved gas in and coming out of each solution. Record your observations in the observations table on the lab sheet.

Time: 1 minute

1. Put the cold soda (A) uncovered back in the refrigerator.
2. Leave the room-temperature soda (B) sitting uncovered on the counter.
3. Put the pot on the stove and turn on the heat to a low setting. Set the timer for 1 minute and press start. Monitor the heating soda (C), so that it doesn't boil. If it starts to boil, turn the heat down.
4. After 1 minute, what do you notice about the quantity of bubbles in each of the three solutions? Record your observations for "Time = 1 minute" in the observations table on the lab sheet.

Time: 2 minutes

1. Heat the soda (C) gently for another 60 seconds. What do you notice about the quantity of bubbles in each of the three solutions? Record your observations for "Time = 2 minutes" in the observations table on the lab sheet.

Time: 5 minutes

1. Gently heat the soda (C) for 3 more minutes. You do not need to stop at the end of each minute.
2. At the end of 5 minutes, turn off the burner. What do you notice about the quantity of bubbles in each of the three solutions? Record your observations for "Time = 5 minutes" in the observations table on the lab sheet.

Time: 20 minutes

1. Let the pan sit for 15 additional minutes.
2. Take the glass with soda (A) out of the refrigerator. Do not put it next to the pan. You do not want heat transfer to affect your results.
3. Test each solution for changes in pH using pH paper. Did the solution turn yellower (and therefore less acidic) or redder (and therefore more acidic), or does it appear the same as before? Record your values in the data table on the lab sheet, and tape the strips in the slots allotted on the lab sheet.
4. How does the amount of fizz relate to the amount of dissolved gas in each of the solutions? What do you notice about the quantity of bubbles in each of the three solutions? Record your observations for "Time = 20 minutes" in the observations table on the lab sheet.

Time: 3 hours, 20 minutes

1. Put the cold glass of soda (A) back in the refrigerator. Leave the other two soda solutions (B and C) on the counter.
2. Wait 3 hours.
3. After 3 hours, test for changes in pH using pH paper. Did the solution turn yellower (and therefore less acidic) or redder (and therefore more acidic), or does it appear the same as before? Record your values in the data table on the lab sheet, and tape the strips in the slots allotted on the lab sheet.
4. What do you notice about the quantity of bubbles in each of the three solutions? Record your data and observations for “Time = 3 hours, 20 minutes” in the observations table on the lab sheet.
5. Answer Questions 1–5 on your lab sheet.

Lab Sheet: Outgassing Experiment in Progress

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?

2. What change in pH do you expect to see when and if soda outgasses, releasing CO_2 ?

Data and Observations

pH Data

[illegible]

Outgassing Observations

Time	Soda A (Refrigerated)	Soda B (Room Temperature)	Soda C (Heated)
0 minutes			
1 minute			
2 minutes			
5 minutes			
20 minutes			
3 hours, 20 minutes			

Questions

1. How did temperature affect the amount of gas trapped in the soda?
2. How did pH change when there was less gas in the soda?
3. Can you think of another gas besides CO₂ that could come from the heating solution?
4. How does this support the working scientific theory that volcanic outgassing was partially responsible for the formation of the hydrosphere?
5. How do you think the amount of dissolved gas is affected by the temperature of magma?



Famous Science Series: Mount Tambora, Famous Volcanic Eruption

1. Where is Mount Tambora located?

2. When did Mount Tambora erupt?

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

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

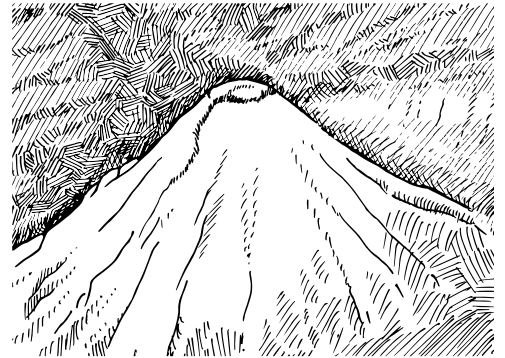
5. Is Mount Tambora on a convergent plate or a divergent plate, or is it an intra-plate volcano?

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

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

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

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





Show What You Know

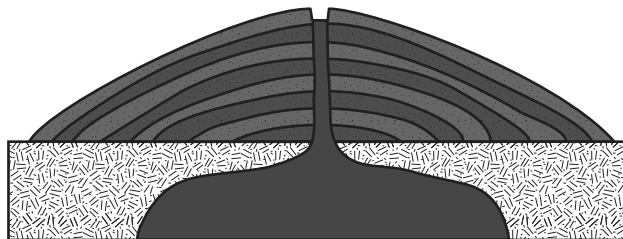
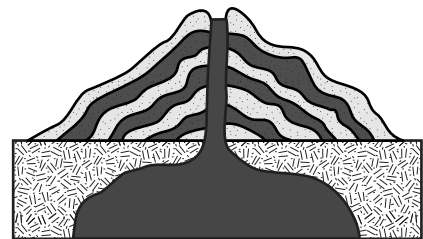
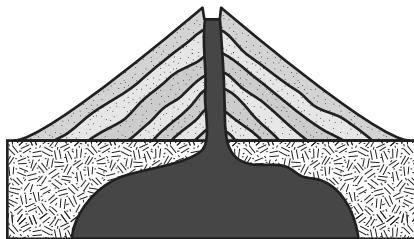
Multiple Choice

1. Divergent plates give rise to _____.
 - a. plate tectonics
 - b. explosive gas-rich magma
 - c. hotspots
 - d. mid-oceanic ridges
2. High-viscosity magma typically forms what type of volcano?
 - a. Shield volcano
 - b. Composite cone
 - c. Cinder cone
3. Why does magma rise toward Earth's surface?
 - a. It is made from continental crust.
 - b. As it heats, it becomes less dense.
 - 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. low, less
5. Viscosity is determined by _____.
 - a. temperature
 - b. silica content
 - c. the source of melting rock
 - d. all of the above

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. active volcano
 - b. dormant volcano
 - c. extinct volcano
 - d. viscous volcano
7. Fast-moving avalanches of rock, ash, water, and gas are called _____.
- a. pyroclastic flows
 - b. lahars
 - c. tephra
 - d. scoria

Short Answer

8. Identify the type of volcano from its picture.



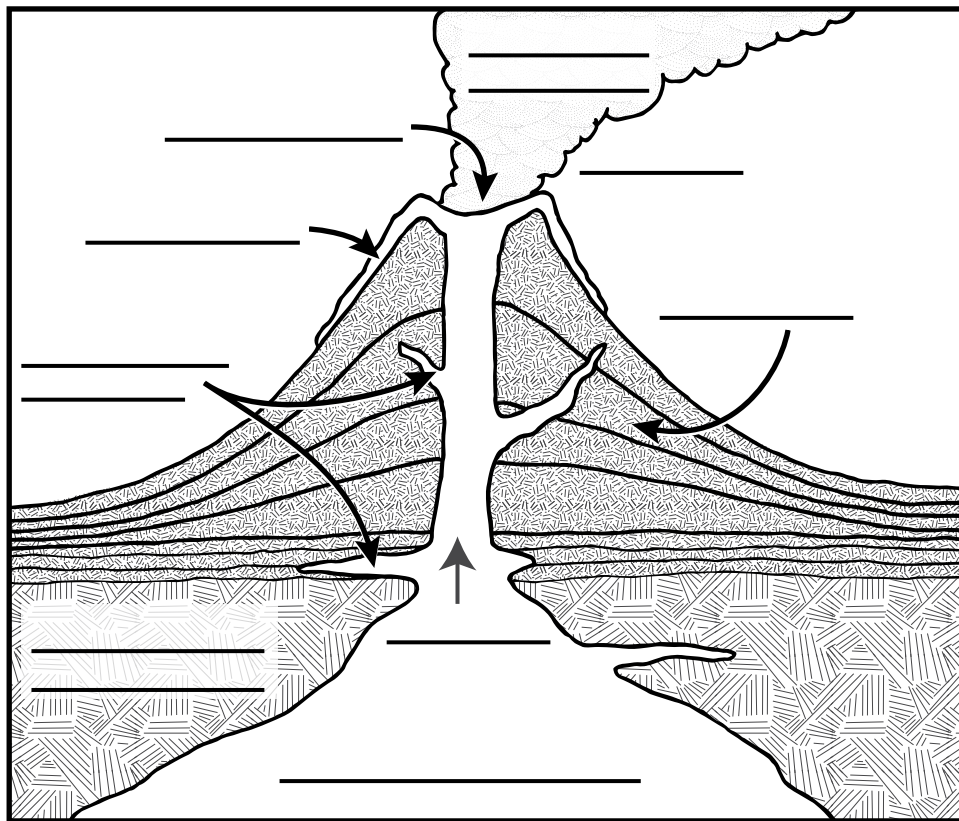
9. Why do many volcanoes form at the boundaries of convergent plates?

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

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

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



Lab: Pollution of Watery Ways

When people spray pesticides to get rid of insects they don't like or put fertilizer on their plants to help them grow, they may not think about how far those pesticides and fertilizers might travel. You spray them in one place, but when it rains or snows or they encounter other sources of running water, they dissolve and flow along with the water. This lab investigates point source pollution and how water-soluble pollutants travel away from the source. When water-soluble pollutants are released from a point source into the ground and make their way to the water table, the pollutant makes a plume, called a **pollution plume**, away from the site of entry as it spreads throughout the groundwater.

Materials

- 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

Procedure

Part 1: Setup

1. Fill the spray bottle with water.
2. Gently pour gravel into the container. Push the gravel so that it starts as a hill along one side and slopes down to one layer thick and 2 to 3 cm (1 in.) from the edge of the container. Leave one corner without gravel to model an open water source.
3. Put the Legos on top of the gravel. The Legos represent houses. They can be spread however you want, but make sure they are not right next to each other and are spread out up and down the hill with one at the top. One of these houses will represent your house. Place your house toward the bottom of the hill, below the other two houses.

4. Pour 1 cup of clean water into the container. Reorganize the Legos so that all are above the water line.
5. Take a photo or draw a picture of your setup. Label your house on your drawing.

Part 2: Modeling Rain

1. Let it rain on the Lego houses. You model this by spraying water from the spray bottle. This could take a while, depending on the size of the spray bottle. Take a break if you need to. Spray until there is pooled water along the edge of the container. Do not bump, move, or tilt the container.
2. Use one of the plastic cups to sample the water from the open water source in your container. Be careful not to move the container. If there is not enough water to get a sample, let it rain more on the Lego houses.
3. You will determine water quality based on the clarity of the water. Color in the cup for Sample 1 and write your observations about water quality on your lab sheet.

Part 3: Modeling Pesticide Use

1. In one of the houses lives a person who doesn't like insects, especially ants or spiders. They use pesticides to get rid of them. Sprinkle the red sugar, which models pesticides, around that person's Lego house.
2. On your drawing, label the house that uses pesticides.
3. Just a few days after they use pesticides to get rid of the insects around their house, it rains, rains, and rains some more. Use the spray bottle to make it rain.
4. Take a second water sample. Sit this next to the first water sample. Color in the cup for Sample 2 and write your observations about water quality on your lab sheet.
5. Carefully lift the container without tilting it and look at the water from beneath. Write your observations on your lab sheet.

Part 4: Modeling Fertilizer Use

1. In the other house lives a person who likes a nice green lawn. They use lots of fertilizer so that their lawn will look as nice as possible. Sprinkle the green sugar, which models fertilizer, around that person's Lego house.
2. On your drawing, label the house that uses fertilizer.
3. Just a few days after they use fertilizer at their house, it rains, rains, and rains some more. Use the spray bottle to make it rain.
4. Take a third water sample. Place this next to the other water samples. Color in the cup for Sample 3 and write your observations about water quality on your lab sheet.
5. Carefully lift the container without tilting it and look at the water from beneath. Write your observations on your lab sheet.

Part 5: Modeling Pollution

You do not use fertilizers or pesticides at your house. That means your house is not polluted, right? Let's find out.

1. You decide to sink a well so that your family will have lots of clean drinking water.
2. Push the end of the pump through the gravel next to your house. Don't worry if you jiggle your house a bit.
3. Now pump a fourth water sample with the spray pump into a cup and set it next to the other samples.
4. Color the cup for Sample 4 and write your observations about water quality on your lab sheet.
5. Carefully lift the container without tilting it and look at the water from beneath your house. Write your observations on your lab sheet.
6. Complete the lab sheet.

Lab Sheet: Pollution of Watery Ways

Part 1: Setup

Include an illustration or photo of your setup.

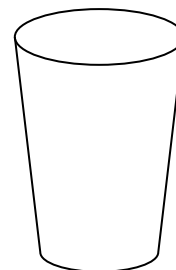
Make sure to label your house, the house that uses pesticides, the house that uses fertilizer, and your well as you get to these parts in your lab.

Part 2: Modeling Rain

Water Sample 1

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

Water quality:



Did you see a pollution plume? Yes No

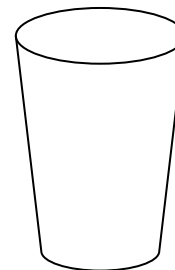
Part 3: Modeling Pesticide Use

Water Sample 2

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

Water quality:

Did you see a pollution plume? Yes No



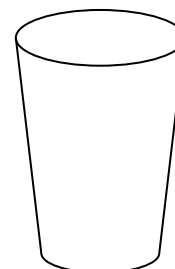
Part 4: Modeling Fertilizer Use

Water Sample 3

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

Water quality:

Did you see a pollution plume? Yes No



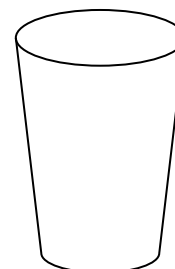
Part 5: Modeling Pollution

Water Sample 4

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

Water quality:

Did you see a pollution plume? Yes No



Conclusions

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

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

3. Describe the pollution plumes if you see any evidence of them.

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

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.

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?

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

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?



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

Winona LaDuke

1. What is Winona LaDuke's tribal affiliation?

2. Where does LaDuke live?

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?

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



Eriel Deranger

5. What is Eriel Deranger's tribal affiliation?

6. Where does Deranger live?



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?

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

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



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. ____ The Great Pacific Garbage Patch | A. Remove lead from gasoline. |
| 8. ____ Acidification | B. Use wastewater treatment facilities. |
| 9. ____ Oil pollution | C. Capture water from farms before it enters waterways. |
| 10. ____ Pesticides | D. Stop littering and dumping trash in the ocean. |
| 11. ____ Sewage | E. Reduce emissions of atmospheric pollutants. |
| 12. ____ Heavy metals | F. Switch to organic farming. |
| 13. ____ 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.

Chapter 21: What a Whirlwind: Storms



Lab: So You Want to Be a Meteorologist!

Meteorologists monitor and report the weather. One of the important tools they use to do this is the weather maps made from Doppler radar. Based on what the maps show, a meteorologist predicts the weather. This week, you will examine weather maps in the United States and make forecasts for the weather. You will monitor and predict how air masses will move. You will use information about where low-pressure and high-pressure areas are to predict which areas have stormy weather and which areas don't. For the first three days, you will study movement patterns of air masses across the U.S. On the third day, you will make a prediction about the weather based on how the masses moved the day before. The prediction you make about what will happen from one day to the next is a hypothesis. Making hypotheses about the behavior of weather, and then studying the accuracy of those hypotheses is an important part of developing scientific models for weather. It is what meteorologists do.

Some Things to Keep in Mind

Type of Front	Weather Found at This Type of Front
Cold Front	When a cold front forms, cold air moves in, displacing a warmer air mass. If the warm air mass has enough humidity, precipitation can occur along the cold front.
Warm Front	When a warm air mass comes in contact with a cold air mass, it moves up and over the cold air mass. A warm front forms if the warm air mass pushes the cold air mass along with it. If there is enough humidity in the warm front, light precipitation can occur.
Occluded Front	When a warm air mass is caught between two cold air masses, the warm air mass is pushed up as the cold air masses come together. These types of fronts can have strong winds and heavy precipitation.
Stationary Front	The weather at stationary fronts varies from clear to severe, depending on the temperatures and humidity levels of the two air masses.

High-pressure systems result from denser air masses. Air that is denser tends to be drier and cooler. High-pressure systems tend to result in clear weather.

Low-pressure systems result from less dense air masses. Air that is less dense tends to have more humidity (more water molecules present in the air) and be warmer. Low-pressure systems tend to result in stormy weather.

Materials

- Computer with internet access
- Pen or pencil
- Lab sheet
- Your barometer from the previous lab
- Printer (optional)

Procedure

Day 1

1. Answer the Pre-Lab Questions.
2. Go to The National Weather Prediction Center: National Forecast Chart, http://origin.wpc.ncep.noaa.gov/national_forecast/natfcst.php?day=1. Only look at the map for today's date. The information will be fluid, based on your location and the time of year. Bookmark this page so it's easily accessible for the rest of this lab.
3. You will want to have one image of the daily weather map every day for three days. There are two easy ways to do this: print the map or copy, paste, and save the map to a document. Microsoft Word or Adobe Photoshop works well for this.
4. Answer the questions on your lab sheet for Day 1.

Day 2

1. Go to The National Weather Prediction Center: National Forecast Chart. Only look at today's map.
2. Note where low- and high-pressure systems are and how they have moved or disappeared from the map.
3. Use arrows on the printed map to track the movement of systems and storms. These generally move west to east and north and south.
4. Save the weather map from today, and answer the questions on your lab sheet for Day 2.

Day 3

1. Go to The National Weather Prediction Center: National Forecast Chart. Only look at today's map.
2. Note where low- and high-pressure systems are and how they have moved or disappeared from the map.
3. Use arrows to track the movement of systems and storms, if there are any, from the previous day.
4. Save the weather map from today, and answer the questions on your lab sheet for Day 3.

Day 4

1. Go to The National Weather Prediction Center: National Forecast Chart. Only look at today's map.
2. Answer the questions on your lab sheet for Day 4.

Lab Sheet: So You Want to Be a Meteorologist!

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?

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

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?

Day 1

1. In the table below, next to each type of front, detail the type of weather observed. State the location of each front when you describe it. If there is stormy weather at that front, give a reason for the weather based on information from your lab introduction.

Type of Front	Weather
Cold Front	
Warm Front	
Occluded Front	
Stationary Front	

2. Describe the weather across the United States.

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

High-pressure systems were (clear stormy).

Low-pressure systems were (clear stormy).

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

Day 2

1. In the table below, next to each type of front, detail the type of weather observed. State the location of each front when you describe it. If there is stormy weather at that front, give a reason for the weather based on information from your lab introduction.

Type of Front	Weather
Cold Front	
Warm Front	
Occluded Front	
Stationary Front	

2. Describe the weather across the United States.

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 stormy).

Low-pressure systems were (clear stormy).

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

Day 3

1. In the table below, next to each type of front, detail the type of weather observed. State the location of each front when you describe it. If there is stormy weather at that front, give a reason for the weather based on information from your lab introduction.

Type of Front	Weather
Cold Front	
Warm Front	
Occluded Front	
Stationary Front	

2. Describe the weather across the United States.

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 stormy).

Low-pressure systems were (clear stormy).

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

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?

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.

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

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

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

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

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



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

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

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

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

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

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

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

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





Show What You Know

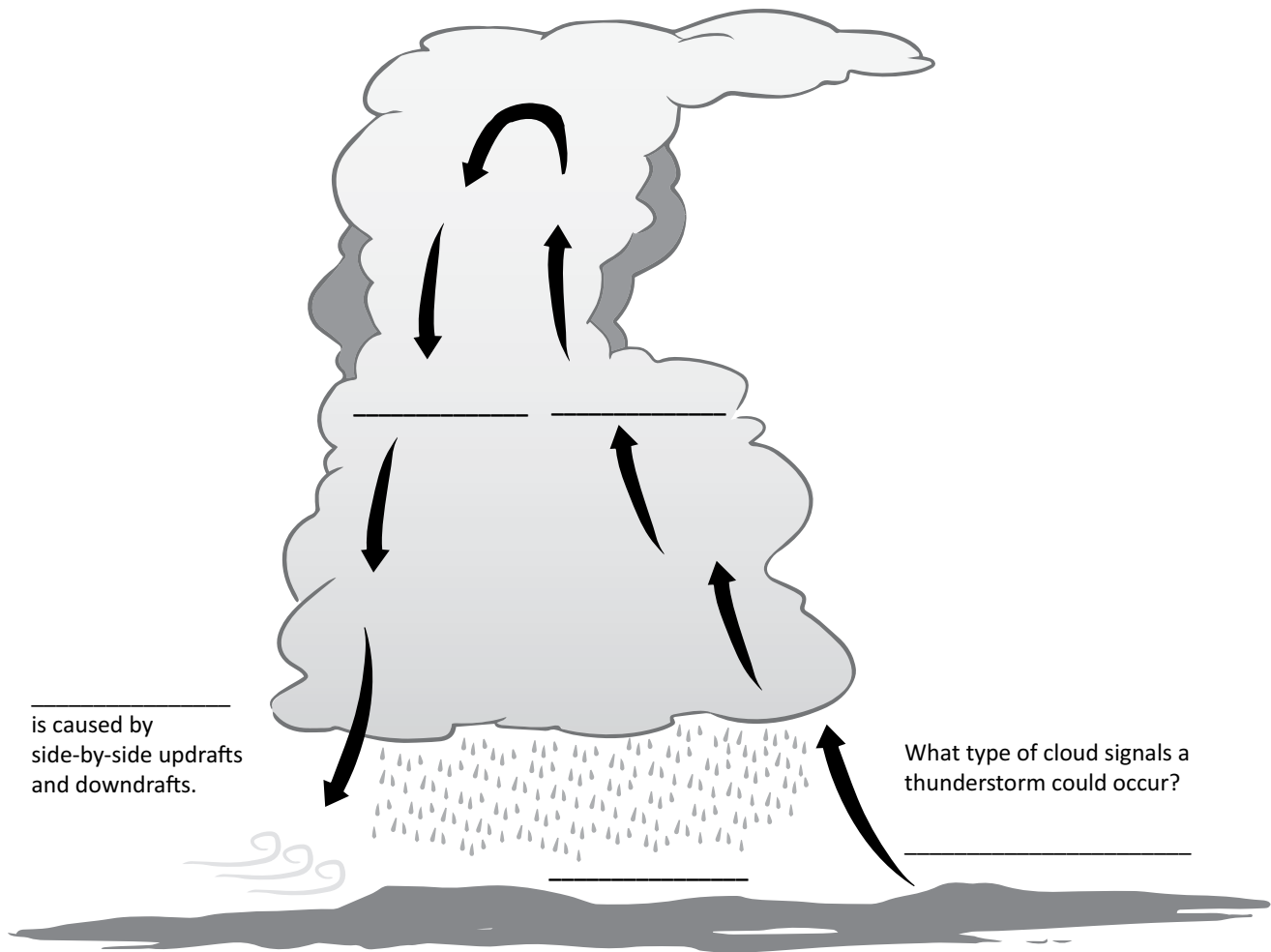
Multiple Choice

1. 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 _____.
 - a. stable
 - b. unstable
2. 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. A warm, wet air mass and a warm, dry air mass
 - b. A cold, wet air mass and a cold, dry air mass
 - c. A warm, wet air mass and a cold, dry air mass
 - d. A cold, wet air mass and a warm, dry air mass
3. Hurricanes have a _____-pressure air mass above a _____-pressure air mass.
 - a. low, high
 - b. low, low
 - c. high, low
 - d. 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. Hails 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.

11. Fill in the illustration of the mature stage of a thunderstorm, and answer the questions.

Thunderstorm: Mature Stage



What is lightning, and how does lightning cause 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 _____?
200	In this type of storm, updrafts and downdrafts are the same strength, which can lead to flooding and tornadoes.	What is a _____?
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 _____?
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 _____?
500	During this part of a thunderstorm, updrafts and downdrafts exist side by side, and precipitation falls.	What is the _____?
600	A blizzard is an extreme example of this type of storm.	What is a _____?
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 _____?

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 _____?
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