

Plate Tectonics

Grade Level or Special Area: 6th Grade Science

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Length of Unit: Ten lessons (approximately two weeks [10 days]; one day = 50 minutes)

I. ABSTRACT

This unit focuses on the *Core Knowledge Sequence* Grade 6 topic of Plate Tectonics. Students will learn about the surface of the earth, layered structure of the Earth, different crustal movements, earthquakes, volcanoes, mountain ranges and matching rock/mineral types. Students will be doing a variety of activities including class discussion, group work and hands-on experiences.

II. OVERVIEW

A. Concept Objectives

1. Students will understand and recognize the processes and interactions of Earth's systems and the structures and dynamics of Earth. (Colorado State Standard 4 for Science)
2. Students will recognize that different kinds of change help us to predict what will happen next.
3. Students will understand that there are many structures in the natural world including: diversity of life, geological forms, chemical and physical structures.

B. Content from the *Core Knowledge Sequence*

1. Review from Science: Grade 4: Geology: The Earth and Its Changes (page 105)
 1. Crust, mantle
 2. Movement of crustal plates
2. Grade 6: Science: Plate Tectonics (page 152)
 - a. The surface of the Earth
 - i. The surface of the Earth is in constant movement.
 - ii. The present features of Earth come from its ongoing history. After the sun was formed, matter cooled creating the planets. The continents were once joined (Pangaea).
 - b. Layered structure of the Earth
 - i. Crust: Surface layer of mainly basalt or granite, 5 to 25 miles thick
 - ii. Mantle: 1800 miles thick, rock of intermediate density, moves very slowly
 - iii. Outer core: liquid iron and nickel
 - iv. Inner core: solid iron and nickel, 800 miles thick, about 7,000 degrees C
 - c. Crust movements
 - i. The surface of Earth is made up of rigid plates that are in constant motion.
 - ii. Plates move because molten rock rises and falls under the crust causing slowly flowing currents under the plates.
 - iii. Plates move at speeds ranging from 1 to 4 inches (5-10 centimeters) per year.
 - iv. Earthquakes usually occur where stress has been built up by plates moving in opposite directions against each other. Earthquakes cause waves (vibrations), which have: focus, the

2. Lesson Content
 - a. Review from Science: Grade 4 (page 105): Geology: The Earth and Its Changes
 - i. Crust, mantle
 - ii. Movement of crustal plates
 - b. Plate Tectonics: The surface of the Earth
 - i. The surface of the earth in constant movement.
 - ii. The present features of Earth come from its ongoing history. After the sun was formed, matter cooled creating the planets. The continents were once joined (Pangaea).
3. Skill Objective(s)
 - a. The students will use background knowledge of subject to gain an awareness of different surfaces of the Earth and how they move and change.

B. *Materials*

1. Lined paper and pencil for each student
2. Appendix A: Graham Cracker Activity (one copy per student)
3. Graham crackers (two per student; two per teacher)
4. Two-foot length of waxed paper (one per student; one per teacher)
5. Frosting (one store bought canister per two students; extra for teacher)
6. Plastic knives (one per student; one per teacher)
7. Water source or cups of water for each student

C. *Key Vocabulary*

1. Continental drift: continents are consistently moving apart or drifting away from each other
2. Pangaea: all Earth; at one time Earth was single land mass that broke up into large pieces
3. Fossil: preserved remains or traces of an ancient organism
4. Plate tectonics: the moving, irregularly-shaped slabs of earth that fit together like paving stones to form the surface layer of the Earth
5. Lithosphere: the top most solid part of the Earth
6. Convection current: a movement of material caused by differences in temperature
7. Fault: a break or crack along which rocks move
8. Rift: a big crack in the ocean floor

D. *Procedures/Activities*

1. Instruct students to number from one to eight on their paper. Write the eight vocabulary words on the board. Say the definition of one vocabulary word; ask students to write the correct answer from the choices on the board. Teacher will review answers with students. Do not collect papers for a grade; this is a review of background knowledge.
2. Explain the theory of plate tectonics in relation to continental drift:
 - a. The overwhelming evidence for continental drift and ocean-floor spreading caused many of the old theories about the Earth to be discarded.
 - b. **Theory of plate tectonics** – a new theory about the evolution of the Earth.
 - c. The word **plate** refers to the moving, irregularly-shaped slabs that fit together like paving stones to form the surface layer of the Earth.
 - d. The word **tectonics** refers to the branch of geology that deals with the movements that shape the Earth's crust.

- e. The theory of plate tectonics is used to explain the evolution of how the Earth's continents were formed. Additionally, it explains how the Earth has evolved over time with the formation, movements, collision, and destruction of the Earth's crust. Its relationship to continental drift is that the continents are still drifting apart and the landscape of the Earth is ever changing.
 - 3. Hand out Appendix A: Graham Cracker Activity.
 - 4. Students are to complete the lab following the directions as demonstrated by the teacher.
- E. *Assessment/Evaluation*
- 1. Teacher observation of student participation during the lab.

Lesson Two: Surface of the Earth (one 50-minute lesson)

- A. *Daily Objectives*
- 1. Concept Objective(s)
 - a. Students will understand and recognize the processes and interactions of Earth's systems and the structures and dynamics of Earth. (CSS 4)
 - 2. Lesson Content
 - 1. The surface of the Earth
 - i. The surface of the Earth is in constant movement.
 - ii. The present features of Earth come from its ongoing history. After the sun was formed, matter cooled creating the planets. The continents were once joined (Pangaea).
 - 3. Skill Objective(s)
 - a. The students will recognize and describe the physical characteristics of the continents.
- B. *Materials*
- 1. Appendix B, page ones and two (one copy per student of Earth's continents)
 - 2. Appendix C (one copy for teacher)
 - 3. *National Geographic Student Atlas of the World* (one per student)
 - 4. Blue, brown, green and yellow colored pencils (one per student)
 - 5. Blue, brown, green and yellow markers for overhead
 - 6. Appendix D (one copy per student)
- C. *Key Vocabulary*
- 1. Transform Fault: a fault that runs across a mid-ocean ridge
 - 2. Magma: molten rock beneath the Earth's surface
- D. *Procedures/Activities*
- 1. Define Pangaea with relationship shown to plate tectonics
 - 2. Present a map of the Earth's Continent's
 - 3. Ask the students if they remember and can list the seven continents. Guide them if necessary from the world map verbally while the teacher writes on the board.
 - 4. Explain the differences between the terms: plate tectonics, Pangaea, theory of Continental Drift. Site the definitions of each and allow the students to brainstorm regarding the differences of each.
 - a. The plate tectonics is the lithosphere of the earth is divided into a small number of plates which float on and travel independently over the mantle and much of the earth seismic activity occurs at the boundaries of these plates.
 - b. Pangaea – is the single giant landmass that existed more than 200 million years ago and that gave rise to the present-day continents.

- c. Continental Drift Theory – a hypothetical slow movement of the continents on a deep-seated viscous zone within the earth.
 - 5. Tell the students to focus on continental drift theory as they continue through this lesson set.
 - 6. After you have gone through all notes ask the students to check with neighbors to see if they match. Answer questions.
 - 7. Complete shifting activity (Appendix D). The teacher will group the students into groups of three. Distribute materials and allow the students 10 minutes to mix their mud into a consistency comparable to cookie dough mix. After spreading into the pan, have students place pans on a level surface to dry. Observation will be completed during the next day.
 - 8. The differences between Pangaea Theory, Continental Drift and Plate Tectonics is Pangaea is the theory that a single land mass existed 200 million years ago and broke apart to form the different continents, Plate Tectonics is one of the moving irregularly shaped slabs that make up the Earth's lithosphere and Continental Drift is the theory that the continents were once joined together and had since moved apart.
- E. *Assessment/Evaluation*
- 1. Grade student's World Map handout (Appendix B) using Teacher's Key (Appendix C). The Earth's oceans and neighboring continents must be labeled correctly

Lesson Three: Layered Structures of the Earth (one 50-minute lesson)

- A. *Daily Objectives*
- 1. Concept Objective(s)
 - a. Students will understand that there are many structures in the natural world, including: diversity of life, geological forms, chemical and physical structures.
 - 2. Lesson Content
 - a. Crust movements
 - i. The surface of Earth is made up of rigid plates that are in constant motion.
 - ii. Plates move because molten rock rises and falls under the crust causing slowly flowing currents under the plates.
 - iii. Plates move at speeds ranging from 1 to 4 inches (5-10 centimeters) per year.
 - 3. Skill Objective(s)
 - a. The students will use background knowledge of subject to gain an awareness of different surfaces of the Earth and how they move and change.
- B. *Materials*
- 1. Starburst (three different colored pieces per student and teacher)
 - 2. One 4" by 4" square piece of waxed paper per student and teacher
 - 3. Handout, Appendix F: Starburst/Sandstone Activity (one copy per student and teacher)
 - 4. Appendix G: Sandstone Activity Recipe (for teacher only)
 - 5. Two measured cups of play sand per student
 - 6. One cup of water per student
 - 7. One cup of corn starch per student
 - 8. One large sauce pan
 - 9. Hot plate or other heat source

10. Water source
11. One large piece of poster board

C. *Key Vocabulary*

1. Stress: the forces that push and pull on the Earth's crust, causing its deformation
2. Crust: the surface layer of the Earth
3. Deformation: in geology, any change in the original shape or volume of rocks
4. Compression: the type of stress that squeezes rocks together
5. Normal fault: a fault in which the hanging wall moves down relative to the foot wall
6. Reverse fault: a fault in which the hanging wall moves up relative to the foot wall
7. Hanging wall: the block of rock above the fault
8. Foot wall: the block of rock below the fault

D. *Procedures/Activities*

2. Students will understand that as rocks of the crust undergo stress they slowly change shape and volume
 - a. Compression squeezes rocks of the crust together
 - b. Mountains formed by blocks of rock uplifted many normal faults
1. Students will demonstrate knowledge of the upward and downward force movement of the mantle, which is called isostasy.
2. This lesson will focus on the formation of mountains, valleys, plateaus, and domes related to stress. Ask students how does faulting and folding change the appearance of the Earth's surface? The teacher should lead into a short lecture explaining faulting and folding. The lecture will entail sometimes the Earth's crust will break or create a fault in it due to stress. There are three kinds of faults: a **normal fault** is when stress causes either the hanging wall or foot wall to move up or down the hanging wall. The fault between the two blocks is called a normal fault. A **reverse fault** is a type of fault when compression is acting on the fault, the hanging wall will move up relative to the foot wall, and the **thrust fault** is formed when compression causes the hanging wall to slide over the foot wall. A **fold** is a bend in a rock. Sometimes when stress is applied to the rocks of the crust, the rocks bend but do not break. An upward fold in a rock is called an **anticline**. A downward fold is called a **syncline**.
3. The teacher will write the bold words on the board and have the students take two-column notes.
4. Starburst/Sandstone activity (Appendices F and G) the students will demonstrate an understanding of compression, tension and stress related activities to help shape some of the Earth's formations today.
5. Distribute Appendix F and materials and complete the Starburst Activity. Allow the students to eat the Starburst.
6. Distribute Appendix G and materials and complete the Sandstone Activity. Allow the students to take the Sandstone Activity home.
7. On a poster board, ask students to assist with filling out a KWL chart that will serve as a reference during the rest of this lesson set. A KWL chart includes three columns: the first lists what students already know (background historical knowledge about the Earth and its layers, formations and faults): the second column lists what the students want to know (questions about the different faults, fractures or cracks in the Earth's surface): and the third column lists what students learn (the answers to their questions) after reading the text and exploring the subject matter. The first two columns of this chart should be completed and used to guide future class discussions.

- E. *Assessment/Evaluation*
1. Participation and discussion in KWL chart and activity.
 2. Open classroom discussion on what the students learned during the Starburst and Sandstone activities.
 3. Teacher observation of student participation during the lab. Also, a lab grade may be taken from the observations portion of the lab/activity handout (Appendices F and G).

Lesson Four: Layered Structures of the Earth (one 50-minute lesson)

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. Students will recognize that different kinds of change help us to predict what will happen next.
 2. Lesson Content
 - a. Crust movements
 - i. Earthquakes usually occur where stress has been built up by plates moving in opposite directions against each other. Earthquakes cause waves (vibrations), which have: focus, the point below the surface where the quake begins, or epicenter, the point on the surface above the focus.
 - ii. Severity of ground shaking is measured on the Richter scale; each unit on the scale represents a tenfold severity increase (approximately 31-fold increase in energy released).
 - b. Volcanoes usually occur where plates are pulling apart or coming together, but some occur at holes (hot spots) in the crust away from plate boundaries. As plates move over these hot spots, they cause chains of volcanoes and island chains like the Hawaiian Islands.
 3. Skill Objective(s)
 - a. The students will use their knowledge of Earth to locate different formations, volcanoes and major Earthquakes.
 - b. The students will apply the world's surface changes to understand the present and plan for the future.
 - c. The students will demonstrate a deeper knowledge about particular large geographical areas.
- B. *Materials*
1. Appendix H1
 2. Copy of *Eyewitness Rock and Mineral Video*, narrated by Martin Sheen and produced by Vision Worldwide Americas
- C. *Key Vocabulary*
1. Rock: a hard substance composed of one or more minerals or mineral-like substances
 2. Mineral: a naturally occurring, inorganic solid that has a definite chemical composition and crystal shape
 3. Inorganic: not formed from living things or the remains of living things
 4. Crystal: a solid in which the atoms or molecules are arranged in a definite pattern that is repeated over and over again
 5. Density: the amount of matter in a given space; the mass per unit volume
 6. Fracture: in minerals, the way a mineral that does not cleave breaks along a rough or jagged surface
 7. Cleavage: the tendency of a mineral to break along smooth, definite surfaces

- D. *Procedures/Activities*
1. The students will view the video, respond to, and discuss Rocks and Minerals (Appendix H1)
 2. Watch video *Eyewitness Rock and Mineral Video* (approximately 35 minutes), narrated by Martin Sheen and produced by Vision Worldwide Americas.
 3. Teacher will ask discussion questions for understanding of the video material.
 - a. Discussion questions (Appendix H1)
 4. Begin with short quiz over assigned readings to assess student comprehension and retention (Appendix L pages 1 and 2).
 5. Revisit KWL chart and continue discussion from previous lesson.
- E. *Assessment/Evaluation*
1. Quiz evaluation and class discussion participation (Appendix L)

Lesson Five: Crust Movements (one 50-minute lesson)

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. Students will understand that there are many structures in the natural world including: diversity of life, geological forms, chemical and physical structures.
 2. Lesson Content
 - a. Review from Science: Grade 4: Geology: The Earth and Its Changes (page 105)
 - i. Crust, mantle
 - ii. Movement of crustal plates
 - b. Grade 6: Science: Plate Tectonics (page 152)
 - i. Layered structure of the Earth
 - ii. Crust: Surface layer of mainly basalt or granite, 5 to 25 miles thick
 - iii. Mantle: 1800 miles thick, rock of intermediate density, moves very slowly
 - iv. Outer core: liquid iron and nickel
 - v. Inner core: solid iron and nickel, 800 miles thick, about 7,000 degrees C
 3. Skill Objective(s)
 - a. The students will use background knowledge of subject to gain an awareness of different surfaces of the Earth and how they move and change.
 - b. The students will demonstrate a deeper knowledge about particular large geographical areas.
- B. *Materials*
1. Appendix H2
 2. Appendix J, pages one and two (one copy for each student)
 3. Two blocks of wood, 1: 10 cm X 10 cm X 2.5 cm, 1: 10 cm X 10 cm X 1.5 cm
 4. Basin of water
 5. Metric ruler
 6. 25 metal washers
 7. Copy of *Prentice Hall Science, Dynamic Earth* for each student
- C. *Key Vocabulary*
1. Isostasy: the balancing of the downward force of the crust and the upward force of the mantle

2. Mantle: the layer of the Earth that extends from the bottom of the crust to the core
- D. *Procedures/Activities*
1. Revisit the KWL chart to make any additions, conclusions, etc.
 2. Review what the students know about the Earth's layers and crust, its many movements and how it affects landscape.
 3. Lead students through a discussion and demonstration identifying the seven lithosphere plates. The seven major lithospheric plates are Pacific, North American, South American, Eurasian, African, Indo-Australian and Antarctic Plates (Appendix H2).
 4. Using the *Dynamic Earth* Prentice-Hall text, students will review the Earth's Moving Plates beginning on page 64 and continuing through page 71. They will then complete the Section Review on page 71. *Note to teachers: If this text is not available, any reliable source on the movement of the Earth's Plates may be substituted.*
 5. Divide the class into groups of 3-4. Hand out Appendix J, page one and two: The Model of the Earth.
 6. Students are to begin brainstorming as a group as to what material they will use to show their rendition of the Earth and its many layers.
- E. *Assessment/Evaluation*
2. Completed Prentice-Hall Section Review will be turned in for grading.
 3. Teacher observation of student participation during the take-home lab project, The Model of the Earth, (Appendix J, pages one and two). Use page 2 of Appendix J, the rubric, to grade.

Lesson Six: Crust Movements (one 50-minute lesson)

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. Students will understand that there are many structures in the natural world including: diversity of life, geological forms, chemical and physical structures.
 2. Lesson Content
 - a. Review from Science: Grade 4: Geology: The Earth and Its Changes (page 105)
 - i. Crust, mantle
 - ii. Movement of crustal plates
 - b. Grade 6: Science: Plate Tectonics (page 152)
 - i. Crust movements
 - a) The surface of Earth is made up of rigid plates that are in constant motion.
 - b) Plates move because molten rock rises and falls under the crust causing slowly flowing currents under the plates.
 3. Skill Objective(s)
 - a. The students will use background knowledge of subject to gain an awareness of different surfaces of the Earth and how they move and change.
 - b. The students will describe how and why the continents are now separated.
- B. *Materials*
1. One regulation basketball

2. One roll of blue masking or sports tape
 3. One metric ruler
 4. Appendix M, page one, one copy per student
- C. *Key Vocabulary*
1. Midocean ridge: an undersea mountain chain where new ocean floor is produced; a constructive (divergent) plate boundary
 2. Ocean-floor spreading: the process in which old ocean floor is pushed away from a midocean ridge by the formation of new ocean floor
 3. Transform fault: a fault that runs across a midocean ridge
 4. Trench: a V-shaped valley on the ocean floor where old ocean floor is subducted; a destructive (convergent) plate boundary
 5. Subduction: the process in which lithosphere plunges back into the interior of the Earth
- D. *Procedures/Activities*
1. Review what students know about the Earth's oceans, its many resources and the interaction between ocean-floor spreading and the oceans living things.
 - a. The students will identify how much of the earth is covered by water.
 - b. The students will identify Ocean-floor spreading and how it helps to explain continental drift.
 2. Demonstrate how much of the Earth's surface is covered with water using a basketball and masking tape (using blue tape may help remind students of water). Have the students help measure out 517 centimeters (286 inches) of tape. The tape may be torn any length while measuring. Finally, stick the tape to the basketball without letting it overlap anywhere. This ratio is equal to the amount of surface water found on the Earth. (Taken from Earth: The Water Planet, 6th grade science lesson).
 3. Next, pass out the copies of the world map handout (Appendix B, page two). Students will locate and identify the Earth's major oceans and the continents that are surrounded by these bodies of water.
- E. *Assessment/Evaluation*
1. Students will complete the quiz, Appendix M page one; teacher answer key is Appendix M page two.

Lesson Seven: Volcanoes (one 50-minute lesson)

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. Students will understand that there are many structures in the natural world including: diversity of life, geological forms, chemical and physical structures.
 2. Lesson Content
 - a. Volcanoes usually occur where plates are pulling apart or coming together, but some occur at holes (hot spots) in the crust away from plate boundaries. As plates move over these hot spots, they cause chains of volcanoes and island chains like the Hawaiian Islands.
 3. Skill Objective(s)
 - a. The students will use background knowledge of subject to gain an awareness of different surfaces of the Earth and how they move and change.
 - b. The students will use their knowledge of Earth to locate different formations, volcanoes and major Earthquakes.

- B. *Materials*
1. Copy of *Eyewitness Volcano Video*, narrated by Martin Sheen and produced by Vision Worldwide Americas, a café production for BBC, 1995
 2. 16-oz plastic bottle
 3. One baking pan
 4. Two tablespoons of baking soda
 5. Three-fourths cup of vinegar
 6. One copy of the Explorers Journal per student (Appendix E)
 7. What happens when a volcano erupts, Appendix N (copy for teacher)
- C. *Key Vocabulary*
1. Magma: molten rock beneath the Earth's surface
 2. Lava: molten rock at the Earth's surface
 3. Volcanic ash: rock particles more than 0.25 mm but less than 5 mm across that are blown into the air by a volcanic eruption
 4. Volcanic bomb: rock particles larger than 5 mm in diameter that are blown into the air by a volcanic eruption
 5. Volcanic dust: the smallest rock particles blown into the air by a volcanic eruption
 6. Volcano: a place in the Earth's surface through which molten rock and other materials reach the surface
- D. *Procedures/Activities*
1. Begin with short discussion over assigned readings to assess student comprehension and retention.
 2. While the teacher performs the experiment, *What happens when a volcano erupts*, (Appendix N) have the students complete the Explorers Journal, (Appendix E).
 3. Revisit KWL chart and continue discussion from previous lesson.
 4. The students will view the video, respond to, and discuss volcanoes.
 5. Video: Volcano, Eyewitness (approximately 35 minutes)
- E. *Assessment/Evaluation*
1. Quiz evaluation and class discussion participation, (Appendix O).

Lesson Eight: Volcanoes (one 50-minute lesson)

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. Students will understand that there are many structures in the natural world including: diversity of life, geological forms, chemical and physical structures.
 2. Lesson Content
 - a. Volcanoes usually occur where plates are pulling apart or coming together, but some occur at holes (hot spots) in the crust away from plate boundaries. As plates move over these hot spots, they cause chains of volcanoes and island chains like the Hawaiian Islands.
 3. Skill Objective(s)
 - a. The students will use background knowledge of subject knowledge to gain an awareness of different surfaces of the Earth and how they move and change.
 - b. The students will use their knowledge of Earth to locate different formations, volcanoes and major Earthquakes.
- B. *Materials*
1. Appendix P, one per student and teacher

2. Appendix O, one per student and teacher
- C. *Key Vocabulary*
 1. Cinder cones: volcanoes made mostly of cinders and other rock particles that have been blown into the air
 2. Shield Volcanoes: volcanoes composed of quite lava flows
 3. Composite Volcanoes: Volcanoes built up alternating layers of rock particles and lava
 4. Crater: a funnel-shaped pit or depression at the top of a volcanic cone
 5. Caldera: a roughly circular, steep-sided pit at the top of a volcanic cone whose diameter is at least three times its depth
- D. *Procedures/Activities*
 1. Begin with a short discussion over assigned readings to assess student knowledge and retention. Ask questions from Appendix O.
- E. *Assessment/Evaluation*
 1. Have the students perform Hypothesis Activity (Appendix P).

Lesson Nine: Evidence for Long-Term Movements of Plates (one 50-minute lesson)

- A. *Daily Objectives*
 1. Concept Objective(s)
 - a. Students will understand that there are many structures in the natural world including: diversity of life, geological forms, chemical and physical structures.
 2. Lesson Content
 - a. Review from Science: Grade 4 (page 105): Geology: The Earth and Its Changes
 - i. Crust, mantle
 - ii. Movement of crustal plates
 - b. Grade 6: Science: Plate Tectonics (page 152)
 - i. Evidence for long-term movement of plates includes fit of continents and matches of rock types, fossils, and structures; ocean floor age and topography; ancient climate zones; locations of earthquakes, volcanoes, and mountain ranges; magnetic directions in ancient rocks.
 3. Skill Objective(s)
 - a. The students will recognize and describe the physical characteristics of the continents.
 - b. The students will describe how and why the continents are now separated.
- B. *Materials*
 1. Paper and pencil for each student
 2. Copy of *Prentice Hall Science, Dynamic Earth* for each student.
 3. Newspaper clippings, news magazines that the student could obtain articles dealing with earthquakes, floods, volcanoes, and other Earth-changing events.
- C. *Key Vocabulary*
 1. Shearing: the type of stress that pushes rocks of the crust in two opposite, horizontal directions
 2. Folding: a bend in the rock
 3. Faulting: a break or crack along which rocks move
 4. Anticline: an upward fold in rock
 5. Syncline: a downward fold in rock

- D. *Procedures/Activities*
1. The students will be able to distinguish between folding or faulting.
 2. Using the Prentice Hall text, students will read background information on folding and shearing processes beginning on page 16 and continuing through page 21.
 3. Have the student collect articles dealing with earthquakes, floods and other Earth-changing events. On a map of the world indicate the site of each event. Use a different-colored pencil for each category of the events.
- E. *Assessment/Evaluation*
1. Using the Prentice Hall text, students will complete the 1-1 Section Review, questions one through four and section 1-2 questions one through three.

Lesson Ten: Evidence for Long-Term Movements of Plates (one 50-minute lesson)

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. Students will understand that there are many structures in the natural world including: diversity of life, geological forms, chemical and physical structures.
 2. Lesson Content
 - a. Review from Science: Grade 4 (page 105): Geology: The Earth and Its Changes
 - i. Crust, mantle
 - ii. Movement of crustal plates
 - b. Grade 6: Science: Plate Tectonics (page 152)
 - i. Evidence for long-term movement of plates includes fit of continents and matches of rock types, fossils, and structures; ocean floor age and topography; ancient climate zones; locations of earthquakes, volcanoes, and mountain ranges; magnetic directions in ancient rocks.
 3. Skill Objective(s)
 - a. The students will recognize and describe the physical characteristics of the continents.
 - b. The students will describe how and why the continents are now separated.
- B. *Materials*
1. Paper and pencil for each student
 2. Copy of *Prentice Hall Science, Dynamic Earth* for each student
 3. Six foot long piece of bulletin board paper, any color, colored pencils or markers
- C. *Key Vocabulary*
1. Rift valley: a valley formed when the block of land between two normal faults slides downward
 2. Fault Block Mountains: a mountain formed by blocks of rock uplifted from normal faults
 3. Plateau: a large area of flat land that is raised high above sea level and that consists of horizontal rock layers
- D. *Procedures/Activities*
1. The students will be able to distinguish between folding and faulting.
 2. Using the Prentice Hall text, students will read background information on folding and shearing processes beginning on page 9 and continuing through page 15.

2. Have students get a 6 foot long piece of bulletin board paper. Have the students draw an Earth view cut-out cross section of the crust, mantle, at least one continent and one oceanic plate. Draw all continents, one rift valley, and a plateau. Accept all reasonable efforts.
- E. *Assessment/Evaluation*
1. Using the Prentice Hall text, students will complete the Chapter Review, Concept Mastery, page 29.

VI. CULMINATING ACTIVITY

- A. Visit a local (dormant) volcano located two hours south of Colorado Springs, Colorado situated in the Northwest corner of New Mexico. This volcano is part of the National Park Service. The students and teachers will participate in a self-guided tour and hike around the three-fourths mile trail around the rim.
- B. Plate Tectonics chapter test, (Appendix Q).
- C. Copy of *Eyewitness Rock and Mineral Video*, narrated by Martin Sheen and produced by Vision Worldwide Americas

VII. HANDOUTS/WORKSHEETS

- A. Appendix A: Graham Cracker Activity
- B. Appendix B: Lithospheric Plate Map (two pages)
- C. Appendix C: Lithospheric Plate Map Answer Key
- D. Appendix D: Shifting Plates Activity
- E. Appendix E: Explorer's Journal
- F. Appendix F: Starburst Activity
- G. Appendix G: Sandstone Activity
- H. Appendix H: Discussion Questions
- I. Appendix I: Isostasy Lab Investigation (two pages)
- J. Appendix J: Model of the Earth, 3D Project (two pages)
- K. Appendix K: Major Oceans/Continents Answer Key
- L. Appendix L: Lesson Four Quiz (two pages)
- M. Appendix M: Plate Tectonics Quiz (two pages)
- N. Appendix N: Volcano Eruption Activity
- O. Appendix O: Volcano Discussion Questions (two pages)
- P. Appendix P: Hypothesis Activity (two pages)
- Q. Appendix Q: Student Plate Tectonics Chapter Outline

VIII. BIBLIOGRAPHY

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Appendix A

Graham Cracker Activity

Adapted from *Geology Rocks! 50 Hands-on Activities to Explore the Earth* by Cindy Blobaum

Background: Plate tectonics is the moving of irregularly shaped slabs of earth that fit together like paving stones to form the surface layer of the Earth. A fault is a break or crack along which rocks move.

SET-UP

1. With your plastic knife, spread a thick layer of frosting on your waxed paper, leaving at least an inch margin all the way around the waxed paper.

CREATE A RIFT

1. Place your two graham crackers touching together on the waxed paper. Now slowly push them apart.
2. As the plates separate, notice how the magma oozes up from below and makes new ocean floor or creates underwater mountain ranges.
3. You have just created a rift (a big crack in the ocean floor).

SHAPE A VOLCANO

1. Push the graham crackers toward each other, allowing one graham cracker to slide underneath the other (**do NOT break the graham cracker**).
2. When plates of the Earth do this, the bottom plate starts to melt from the intense heat and pressure. The bottom plate becomes new magma that floats up between the two plates, building up and up over many years until a volcano blast occurs!

CAUSE AN EARTHQUAKE

1. Place your two graham crackers side by side. Applying slight pressure towards each other, slide one graham cracker up away from you and slide the other graham cracker down and toward you.
2. Earthquakes occur when plates move past each other like this, get stuck on each other, give a great lurch, and move on.
3. Waves of vibrations are sent throughout the Earth's interior (similar to the ripple effect from a pebble dropped in water) = earthquake!

MAKE A MOUNTAIN RANGE

1. Moisten the edge of ONE of your graham crackers with the water.
2. Place your two graham crackers side by side on the waxed paper. Slowly push the graham crackers together.
3. When two of the Earth's plates slowly crumbled together, mountain ranges were formed.

Appendix B, page 1

Lithospheric Plate Map

Adapted from *Dynamic Earth* by Prentice Hall

Background: The lithosphere is the topmost solid part of the Earth, which is composed of the crust and some of the mantle.

Question: How are the locations of the Earth's mountain ranges, earthquakes, and volcanoes related to the locations of the lithospheric plates?

Materials:

1. blank map handout
2. colored pencils (red, orange, yellow, green, purple, brown, black)

Procedures:

1. Use your black pencil to label the seven continents of the world.
2. Draw the Ring of Fire on the world map with your red pencil.
3. Draw the Mid-Atlantic Ridge with your orange pencil.
4. Draw the Mediterranean Zone with your purple pencil.
5. Locate the world's major mountain ranges and shade in the boundaries with your brown pencil.
 - a. Include: the Rockies, Alps, Andes, and Himalayas.
6. Draw the seven lithospheric plates with your green pencil. Label each plate.
7. Draw the Arabian and Caribbean plate boundaries with your green pencil. Label each plate.

Observations:

1. What relationship can you site of the Pacific Plate to the Ring of Fire?
2. In relation to the lithospheric plates, where are the most mountain ranges, earthquakes, and volcanoes located?

Analysis and Conclusions:

1. Explain the relationships between the occurrence of mountain ranges, earthquakes, and volcanoes and the lithospheric plates.

Homework Assignment:

1. Note: some volcanic activity is due to "hot spots."
2. Mark the locations of the major hot spots on your map with a yellow pencil.
3. You may use library or Internet reference sources.
4. How do hot spots provide support for plate movement? Explain.

Appendix B, page 2

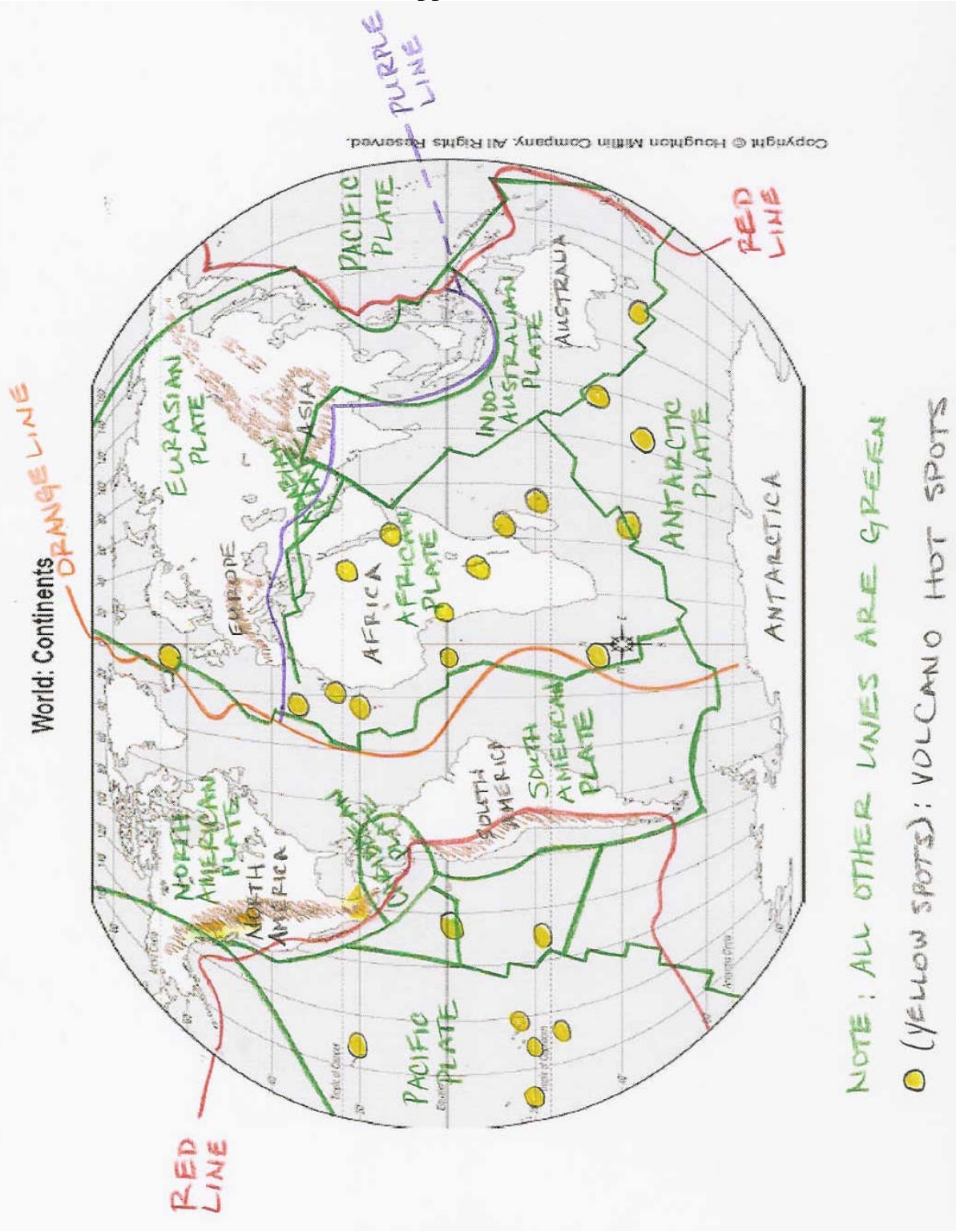
Lithospheric Plate Map

Adapted from *Dynamic Earth* by Prentice Hall

World: Continents



Appendix C



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Appendix D

Shifting Plates Activity

Adapted from *Earth Science for Every Kid* by Janice VanCleave

Background: The Earth once had a single landmass that broke up into large pieces, which have since drifted apart. The continents of the Earth are like large jigsaw-puzzle pieces. The continental coastlines have irregular shapes that could fit back together to reform a single landmass.

Purpose of Activity: To provide a visual representation of continental separation.

Materials:

- 2 cups of dirt
- bowl (1 quart)
- cookie sheet
- spoon
- water

Procedure:

- Place dirt in the bowl.
- Stirring with the spoon, add water until the dirt becomes a thick mud.
- Spread the contents of the bowl onto the cookie sheet.
- Place the cookie sheet with the mud in the sun for two to three days.
- After the mud has dried, push down around the sides of the dried mud.

Results:

- The surface of the dried mud cracks into several puzzle-like pieces. The pieces have jagged edges but still fit together.

Observation:

How does the cracked mud help explain continental separation? Explain.

Appendix E

Explorer's Journal

Adapted from *Creative Kid's Science Project on Volcanoes*

Carefully recording observations represents good science. Accuracy allows others to repeat your experiments and either agree or disagree with your conclusions. Use this Explorer's Journal to record your observations about volcanoes.

Location When and where did your experiment or investigation take place?	
Purpose What questions were you trying to answer?	
Conditions and Procedures What materials were you using? What conditions affected your experiment?	
Observations Describe as accurately as you can what you noticed?	
Next Experiment What new questions need to be investigated next?	

Appendix F

Starburst Activity

Adapted from *Geology Rocks! 50 Hands-on Activities to Explore the Earth* by Cindy Blobaum

Background: If rocks get hot, they melt and become magma again. If rocks are put under pressure without enough heat or time, they break apart; nothing really changes except their size. You need all three conditions to make a metamorphic rock: heat + pressure + time.

Materials:

1. Starburst (three different colored pieces per student and teacher)
2. One 4" x 4" square piece of waxed paper per student and teacher

SET-UP

1. Unwrap your three different-colored pieces of Starburst. On your piece of waxed paper, put one Starburst on top of the other, making a tower.

CREATE MARBLE

1. Wrap your tower in the waxed paper and squeeze them as tightly as you can for two minutes. Do NOT rub or smear the Starburst! Squeeze straight on.
2. Examine your piece of "marble." Marble is a common metamorphic rock with swirls of color throughout. It typically has a grainy surface with "folds" and "bends" that occur during metamorphosis. Pure marble is white; other minerals add characteristic swirls of color.
3. If you had been squeezing pieces of limestone, they would have metamorphosed into marble.

Appendix G

Sandstone Activity

Adapted from *Geology Rocks! 50 Hands-on Activities to Explore the Earth* by Cindy Blobaum

Background: Compressed sand becomes sandstone. In nature, this sedimentary rock is sculpted into fascinating formations by the eroding forces of wind and water blasting away at it.

Example: Bryce Canyon National Park, Utah, contains sedimentary rock formations of red, pink, and white sandstone and limestone, shaped over time by wind and water.

Ingredients:

2 cups of play sand per student

1 cup of water per student

1 cup of cornstarch per student

1 large old saucepan

Hot plate or other heat source

Instructions:

1. Combine the sand, water, and cornstarch in the pan (enough for the number of students in class, depending on the size of your saucepan).
2. Heat the mixture slowly until it's thick.
3. Allow the mixture to cool.
4. Distribute equal globs of "sandstone" to each student.
5. NOTE TO TEACHER: The above instructions represent teacher combining ingredients and completing mixture beforehand. If you intend for STUDENTS to complete this portion of the activity in class, you will need to provide goggles and potholders for student safety.

CREATE A SANDSTONE SCULPTURE

1. The teacher will provide you with a glob of sandstone.
2. Act like a force of nature using your hands and create your own canyon of sandstone with folds and bends of erosion.

Appendix H1

1. What is meant by The Floating Crust? The mantle is the layer of the Earth that extends from the bottom of the crust downward about 2900 km to the Earth's core. A layer of the upper mantle is made of rock that flows slowly sort of like molasses or hot, thick tar. Because the mantle is much denser than the crust, the solid, rocky crust floats on the mantle.
2. What balances the downward force of the crust? The mantle's upward force balances the downward force of the crust.
3. What is this balancing of forces called? The balancing of these forces is called isostasy.
4. Which are less dense, the crustal rocks or the mantle rocks? The crustal rocks are less dense than the mantle rocks.
5. What happens when sediments are deposited on the ocean floor? When sediments are deposited on the ocean floor, the crust sinks slightly.

Appendix H2

1. The theory of plate tectonics, which links together the ideas of continental drift and ocean-floor spreading, explains how the Earth has evolved over time. It helps to explain the formation, movement, collisions, and destruction of the Earth's crust. According to the theory of plate tectonics, the topmost solid part of the Earth, called the lithosphere is made of a number of plates. The plates contain a thin layer of crust above a thick layer of relatively cool, rigid mantle. The plates usually contain both oceanic and continental crust. There are seven major lithospheric plates, each of which is named after its surface features. The Pacific plate, which covers one-fifth of the Earth's surface, is the largest plate. The other major plates are the North American, South American, Eurasian, African, Indo-Australian, and Antarctic plates.
2. Plates move at different speeds and in different directions. Large plates that are weighted down with continents move only a few millimeters per year.

Appendix I, page 1

Isostasy Lab Investigation

Adapted from *Dynamic Earth* by Prentice Hall

Background: Isostasy is the balancing of the downward force of the crust and the upward force of the mantle.

Materials:

1. metric ruler
2. basin of water
3. 25 metal washers (1/4" diameter)
4. 2 blocks of wood-
 - a. block 1 = 10 cm x 10 cm x 2.5 cm
 - b. block 2 = 10 cm x 10 cm x 1.5cm

Procedure:

1. Label the larger block "BLOCK 1" and label the smaller block "BLOCK 2"
2. Place BLOCK 1 in the basin of water. Measure the amount of wood above the water's surface with the metric ruler. Record your measurement in the data table.
3. Place 10 washers across the surface of BLOCK 1. Again, measure the amount of wood above the water's surface with the metric ruler. Record your measurement in the data table.
4. Now add two washers at a time and measure the amount of wood above the water's surface with the metric ruler each time you add two more washers. When the wood sinks, stop adding washers.
5. Repeat steps 2 through 4 for BLOCK 2.

Observations:

1. Do you notice differences in the way the two blocks of wood originally float, without the washers? Explain. Do you notice differences after the washers are added? Explain.
2. Is BLOCK 1 or BLOCK 2 able to hold more washers? Why do you think this is?

Analysis and Conclusions:

1. Do the two blocks of wood resemble continental and ocean crust? Explain.
2. How is the water like the Earth's mantle?
3. Which crust supports the most weight if BLOCK 1 represents continental crust and BLOCK 2 represents oceanic crust? Explain your thinking
4. Explain how the Earth's crust is able to stay balanced on the mantle?
5. How does this lab investigation explain isostasy?

Follow-up Experiment:

1. Create your own experiment using thick mud to represent the mantle.
2. Record your measurements in a data table similar to the one you used for this investigation.
3. Design your own observation and analysis/conclusion questions.

Appendix J, page 1

Model of the Earth 3D Project

PROJECT DUE DATE: _____

OBJECTIVE:

- You will create a 3D model of the earth, labeling the various layers of the Earth's composition.

REQUIREMENTS:

- You will need to have a cutout portion in the side of your sphere to show the interior layers of the Earth.
- The cutout should measure at least 6 inches x 6 inches.
- The model must be securely attached to a base.
- Include your name and the date.

DIMENSIONS:

- The model must be at least one foot in diameter and no more than two feet in diameter.

MATERIALS:

- You may use a variety of materials. **BE CREATIVE!**
- Example materials for the sphere might be:
 - Styrofoam spheres purchased from a hobby store
 - Food items, such as fruit
 - Clay
 - Paper mache
- Example materials for coloring the layers might be:
 - Paint
 - Markers
 - Beads, pipe cleaners, etc.
 - Other food items

LABELS: You **MUST** label all of the following on your model.....

- Core
- Mantle
- Crust
- Ocean rift
- Solid inner core
- Liquid outer core (nickel-iron)
- Metallic oxides and sulfides
- Iron rock (Meteorite material)
- Pyroxinite
- Dunite
- Granite

Appendix J, page 2

Model of the Earth 3D Project Rubric

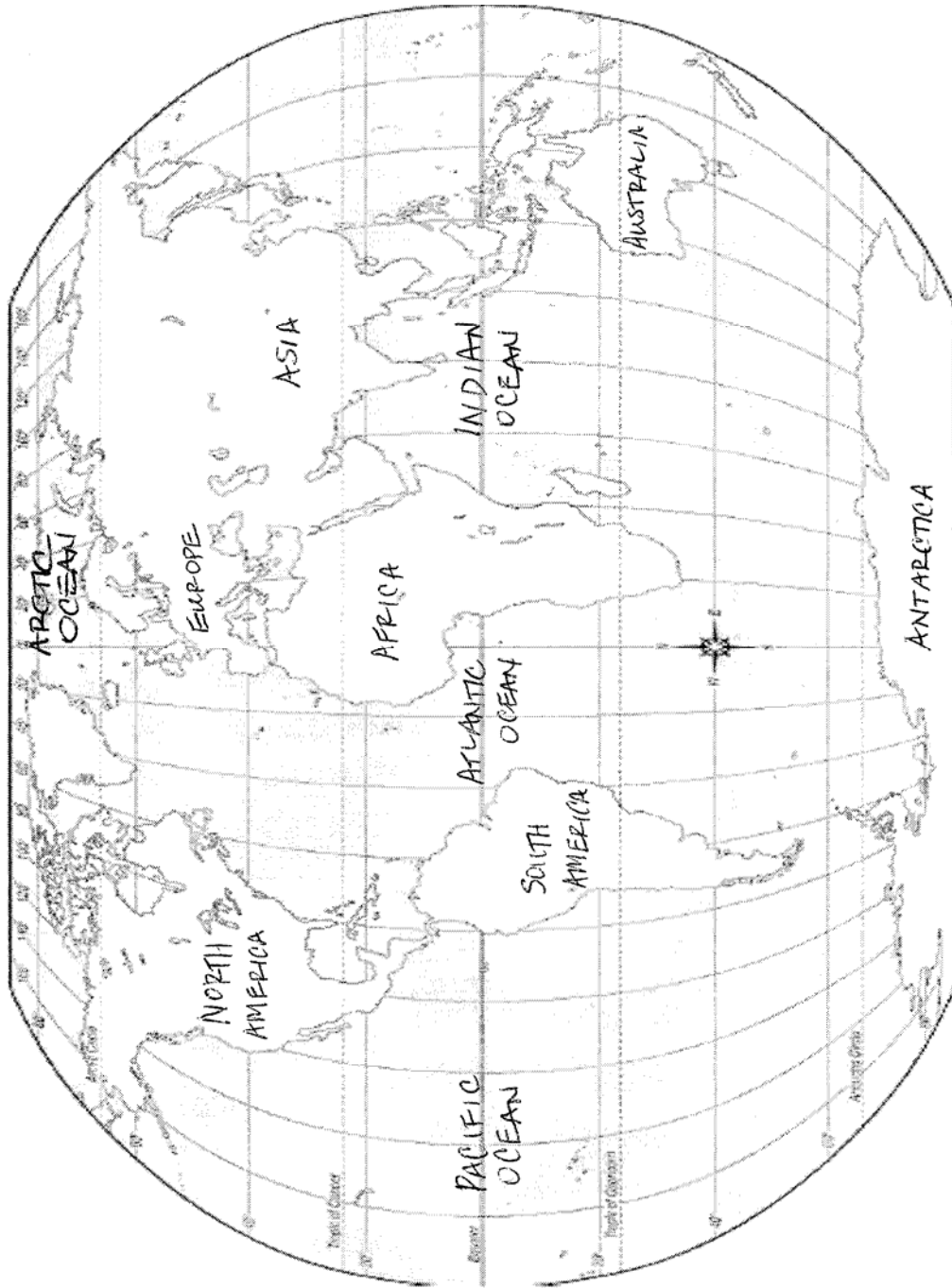
Building A Structure: Model of the Earth 3D Project

Teacher Name: _____

Student Name: _____

CATEGORY	4	3	2	1
Construction - Materials	Appropriate materials were selected and creatively modified in ways that made them even better.	Appropriate materials were selected and there was an attempt at creative modification to make them even better.	Appropriate materials were selected.	Inappropriate materials were selected and contributed to a product that performed poorly.
Construction - Care Taken	Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.	Construction was careful and accurate for the most part, but one-two details could have been refined for a more attractive product.	Construction accurately followed the plans, but three-four details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.
Plan	Plan is neat with clear measurements and labeling for all components.	Plan is neat with clear measurements and labeling for most components.	Plan provides clear measurements and labeling for most components.	Plan does not show measurements clearly or is otherwise inadequately labeled.

Appendix K



Appendix L, page 1

Lesson Four Quiz

Class participation/discussion: Using the writing process, imagine that you are an area of the Earth's crust. Write a brief autobiography describing the many changes due to stress that you have experienced over the millions of years of your existence. (Hint: What type of rock formation are you now? What were you in your "childhood"? Were the changes you experienced fun, scary, or exciting? How did they make you feel?)

Quiz, Lesson Four

Name:

Date:

1. The rocky outermost layer of the Earth is the?
2. The form of stress that pulls apart rocks of the crust is?
3. The block of rock above a fault is called the what?
4. Older rock layers may slide up and over younger rock layers in what kind of fault?
5. Rocks are more likely to fault than fold if they are what?

Appendix L, page 2

Lesson Four Quiz Answers

Class participation/discussion: Using the writing process, imagine that you are an area of the Earth's crust. Write a brief autobiography describing the many changes due to stress that you have experienced over the millions of years of your existence. (Hint: What type of rock formation are you now? What were you in your "childhood"? Were the changes you experienced fun, scary, or exciting? How did they make you feel?)

Quiz, Lesson 4

Name:

Date:

1. The rocky outermost layer of the Earth is the? Crust
2. The form of stress that pulls apart rocks of the crust is? Tension
3. The block of rock above a fault is called the what? Hanging Wall
4. Older rock layers may slide up and over younger rock layers in what kind of fault? Thrust fault
5. Rocks are more likely to fault than fold if they are what? Brittle

Appendix M, page 1

Plate Tectonics Quiz

Name:

Date:

1. What is continental drift? Who first developed a scientific argument for continental drift?
2. How do scientists explain the existence of fossils of the same plants and animals on continents thousands of kilometers apart?
3. “Wegener’s lack of formal training in geology helped him to develop the theory of continental drift, but hurt him in getting his ideas accepted.” What is the reasoning behind this statement? Do you agree? Why or why not?
4. What process helps explain how continents drift?
5. Los Angeles, on the Pacific plate, is slowly moving northwest. San Francisco, on the North American plate, is slowly moving southeast. These two cities are moving toward each other at a rate of about 5 centimeters per year. About 11 million years from now, the two cities will be next to each other. How many meters does each city have to travel before they meet?
6. What is the theory of plate tectonics?
7. How does plate tectonics relate to continental drift?

Appendix M, page 2

Plate Tectonics Quiz Answer Key

Name:

Date:

1. What is continental drift? Who first developed a scientific argument for continental drift? Continental drift, the theory that the Earth had had one giant landmass that split to form today's continents, was first developed by Alfred Wegener.
2. How do scientists explain the existence of fossils of the same plants and animals on continents thousands of kilometers apart? Scientists use the theory of continental drift to explain this phenomenon.
3. "Wegener's lack of formal training in geology helped him to develop the theory of continental drift, but hurt him in getting his ideas accepted." What is the reasoning behind this statement? Do you agree? Why or why not?
Students' answers will vary.
4. What process helps explain how continents drift?
The process of ocean-floor spreading helps to explain how continents drift.
5. Los Angeles, on the Pacific plate, is slowly moving northwest. San Francisco, on the North American plate, is slowly moving southeast. These two cities are moving toward each other at a rate of about 5 centimeters per year. About 11 million years from now, the two cities will be next to each other. How many meters does each city have to travel before they meet?
6. What is the theory of plate tectonics?

The theory of plate tectonics combines the theories of continental drift and ocean-floor spreading to explain how the Earth has evolved.

Appendix N

Volcano Eruption Activity

Observing the Natural World (Adapted from *Creative Kid's Science Project on Volcanoes*)

What happens when a volcano erupts? A volcano is like a safety valve in the planet Earth. In Earth's mantle, there are pockets of magma (melted rock material) and gases. As heat and pressure build up in these magma chambers, the gases expand. The increasing internal pressure finally produces an eruption. The magma is forced up the vent and out the opening at the top of the volcano. The eruption ends when all the pressure has been relieved.

What you need: 16-oz plastic bottle
 Baking pan or dishpan
 Tablespoon
 Baking soda
 White vinegar
 A copy of the Explorer's Journal

What to do: Place the bottle in the pan. Measure and pour 2 tablespoons of baking soda into the bottle. Measure and pour $\frac{3}{4}$ cup of vinegar into the bottle. Record the results on the Explorer's Journal.

What happens: The baking soda reacts with the vinegar, producing carbon dioxide gas. Pressure builds up inside the bottle (magma chamber). The gas expands and moves up the bottle (vent), pushing the liquid (magma) out of the top of the bottle (crater). Foam (lava) then flows from the top of the bottle (volcano) down the sides.

Appendix O, page 1

Volcano Discussion Questions

Discussion questions over Lesson Eight:

1. What are some other natural disasters?
2. What do you think causes a volcano?
3. Do volcanoes exist everywhere on the Earth?
4. What is one advantage of a volcanic eruption over other types of natural disasters?
5. What are the three types of volcanoes?
6. What do you think it would be like to live through an earthquake or the eruption of a volcano?

Appendix O, page 2

Volcano Discussion Questions Answer Key

Discussion questions over Lesson Eight:

1. What are some other natural disasters? Student answers will vary.
2. What do you think causes a volcano? The place in the Earth's surface through which magma and other materials reach the surface.
3. Do volcano's exist everywhere on the Earth? No
4. What is one advantage of a volcanic eruption over other types of natural disasters? Eruptions are somewhat predictable and allow time for residents to move from its path therefore causing almost no deaths.
5. What are the three types of volcanoes? Cinder cones, Shield Volcanoes and Composite Volcanoes

What do you think it would be like to live through an earthquake or the eruption of a volcano? Student answers will vary

Appendix P, page 1

Hypothesis Activity

Thinking like a scientist.

Volcanologists need to understand how Earth is put together, and what forces cause it to sometimes violently change from time to time. The ability to predict where and when volcanoes will occur requires that the volcanologists closely study local geological conditions such as the composition of rock, and the shapes of landforms like mountains and stream beds. From this information, the volcanologists can make the following predictions:

Volcanoes are most frequently associated with fissures in Earth's crust, called faults.

Pressure building up under the surface causes volcanoes to erupt occasionally as the pressure is relieved.

The greatest potential volcanoes will occur in those places along larger faults where the pressure hasn't been relieved for many years, perhaps even centuries.

Often volcanoes are preceded by a swelling or bulge that forms in the ground around the fault, and sometimes even a change in the level of groundwater.

In preparing these hypotheses, volcanologists have been studying volcano hotspots around the world for decades. Can you find out where the high-volcanoes regions are located?

Glossary:

Crater: the bowl-shaped depression at the top of a volcano.

Crust: the outermost, coolest layer of planet Earth.

Friction: resistance to motion

Lava: magma that has reached Earth's surface

Magma: melted rock material beneath Earth's surface.

Magma chamber: a pool of melted rock deep within Earth.

Mantle: the layer of the planet Earth just below the crust.

Vent: channel of a volcano that connects the source of magma to the volcano's

Opening:

Viscosity: the measurement of a liquid's ability to flow.

Volcano: an opening in Earth's crust from which molten rock, steam, ash, and rock fragments are thrown up.

Facts about volcanoes:

Lava can flow as quickly as 50 miles per hour, but speeds of less than 10 miles per hour are more usual.

In 1815 Mount Tambora, a volcano in what is now Indonesia, erupted with such violence that there was almost total darkness for three days in places up to 300 miles away.

Appendix P, page 2

Hypothesis Activity

The word volcano comes from the name Vulcan, the Roman god of fire and metalworking.

The Hawaiian islands developed when volcanoes erupted under the Pacific Ocean.

Appendix Q, page 1

Student Plate Tectonics Chapter Test

PLATE TECTONICS

NAME: _____
DATE: _____

I. Overview

- a. Earth's landmasses resemble pieces of a giant _____
i. Ex: the east coast of _____ matches up with the west coast of _____

II. Earth's Drifting Continents (Section 3-1)

- a. Past theory = a land _____ once stretched across the _____ and connected South America and Africa
i. Evidence for theory = _____ of plants and animals that could not have crossed an ocean found in South American and Africa
1. _____ = the preserved remains of _____ organisms
ii. Theory false
1. _____ (balancing of the downward force of the crust and the upward force of the mantle) shows that _____ crust cannot sink into denser _____ crust
b. Theory of _____ drift = the Earth once had a single landmass that broke up into large pieces, which have since drifted apart
i. _____ = name for this giant landmass
1. Pangaea means "_____ "
ii. _____ (meteorologist) - first to build a detailed scientific case in support of the idea
1. Met with great hostility and rejected by most scientists
c. Evidence from fossils
i. Fossils show connections among _____
ii. Many organisms of the distant past lived on a single _____, Pangaea
1. This landmass later _____
2. The pieces of the broken landmass (today's _____) slowly drifted away from one another, carrying their _____ with them
iii. Fossil example = Glossopteris (an _____ plant)
1. Glossopteris fossils found in _____, Australia, India and _____
d. Evidence from rocks
i. Rock formations in _____ line up with matching ones in South America
ii. Similar rock deposits left behind by _____

Appendix Q, page 2

- iii. Salts, coal, and limestone from coral reefs provide evidence of changes in _____ caused by continental drift
 - 1. _____ deposits – form in areas between 10 and 35 degrees north and south of the equator
 - 2. _____ – forms in warm, swampy climates
 - 3. _____ from coral reefs – form in tropical climates

III. Earth's _____ Ocean Floor (section 3-2)

- a. The ocean floor has a large system of underwater _____ that have a deep crack, called a _____, running through their center
 - i. _____ = underwater mountains
 - 1. The midocean ridges form the single _____ mountain chain in the world (approx. _____ km long and _____ km high)
 - ii. Volcanic activity – much occurs at the _____
 - 1. _____ erupts from the rift valley that runs the length of the ridge
 - 2. As the _____ moves away on either side of the ridge, lava wells up and hardens
 - 3. The hardened lava forms new ocean floor = _____
 - a. Ocean-floor spreading helps to explain how continents _____
 - b. As a piece of the ocean floor _____, it takes its continent with it
 - iii. Ridges as a whole curve because the straight edges are offset by thin cracks known as _____
- b. Rock samples from the ocean floor indicate that rocks next to a midocean ridge are _____ than rocks farther away
- c. _____ in ocean-floor rocks further convinced scientists of ocean-floor spreading
 - i. The pattern of magnetic stripes is _____ on both sides of a midocean ridge
 - 1. As _____ hardens into rock, half the rock moves in one direction and the other half moves in the other direction
- d. The ocean floor is being _____ as fast as it is being formed by ocean-floor spreading
 - i. _____ = V-shaped valleys that lie along the bottom of the oceans
 - 1. Trenches are the _____ parts of the oceans
 - ii. Eventually, the _____ ocean floor moves down deep into the Earth along the trenches

Appendix Q, page 3

1. _____ = crust plunging back into the Earth
 2. When rocks are pushed deep enough, they _____
 - a. Some molten rock will produce _____
 - b. Most molten rock will become part of the _____
 - iii. As new rocks are formed along the _____ ridges, older rocks are _____ into the trenches
 1. One process _____ the other
 2. The Earth's _____ remains the same size
- IV. Earth's Moving _____ (section 3-3)
- a. New theory = theory of _____
 - i. The theory of plate tectonics, which links together the ideas of _____ and _____, explains how the Earth has evolved over time
 - ii. _____ refers to the moving, irregularly shaped slabs that fit together like paving stones to form the surface layer of the Earth
 - iii. _____ refers to the branch of geology that deals with the movements that shape the Earth's crust
 - b. Lithospheric Plates
 - i. _____ = the topmost solid part of the Earth made of a number of plates
 - ii. 7 major lithospheric _____
 1. _____ plate – largest plate / covers _____ Earth's surface
 2. North American plate
 3. _____ American plate
 4. Eurasian plate
 5. _____ plate
 6. _____ - _____ plate
 7. Antarctic plate
 - iii. Many _____ plates
 1. Examples: Caribbean and _____ plates
 - iv. Plates move at different _____ and in different directions
 - c. Plate Boundaries – _____ types
 - i. Because the plates move apart (diverge) at midocean ridges, the ridges are called _____ (also called constructive boundaries)
 - ii. Because the plates come together (converge) at the trenches, the trenches are called _____
 1. Trenches are also called _____ because collision of plates at convergent boundaries can cause _____ and volcanoes
 - iii. _____ – boundaries formed by _____ faults

Appendix Q, page 4

1. Two plates grind together and slip past each other

d. Plate Motion

- i. Scientists are not sure exactly what makes the plates _____
- ii. One hypothesis is that large _____ within the Earth move the plates
 1. _____ = the movement of material caused by differences in _____
- iii. _____ – the denser plate edge is subducted (pushed down), and the other plate edge “_____” over it
 1. _____ = has a colliding edge that consists of dense oceanic crust
 2. _____ = has a colliding edge that contains large amounts of relatively light continental crust
 3. All plates contain _____ crust and most plates contain _____ crust
 4. A _____ plate may act as a continental plate in one collision and as an oceanic plate in another
 5. When an oceanic and a continental plate collide, the oceanic plate is _____
 6. Some of the material from the _____ oceanic plate rises upward and erupts as volcanoes
 7. When two continental plates collide, the continental crust is pushed together and upward to form large _____
 - a. Example: _____ Mountains when Africa collided with North America
 8. When two _____ plates collide, the denser plate is subducted
 - a. Some of the material from the melting plate rises upward and erupts on the ocean floor, forming an _____
 - i. Examples: Japan and _____
 - b. _____ plates are denser because plates grow denser as they _____, and older plates have had longer to cool
- iv. Earth’s _____ plates fit together so closely, any change in one plate or boundary affects all the other plates and _____
 1. Continental plates may _____ together
 2. A _____ may “switch direction”
 3. New _____ boundaries may form in the center of continents
 4. Plates may be completely subducted and _____

Appendix Q, page 5

- e. _____ = scientists who study the processes that change and shape the Earth
- i. Study the Earth's surface, _____, oceans, and _____
- V. Plate Tectonics and Life on Earth
- a. The movement of plates causes changes in _____, in _____ features such as mountains, and in the types of _____ things with which a species interacts
 - b. When landmasses join together, diversity _____
 - i. Only the families of animals that compete the most successfully _____; the rest _____
 - ii. On a _____ landmass, animals can easily move to suitable places and avoid the more challenging environments
 - c. When landmasses split apart, the diversity of land animals _____
 - i. On a _____ landmass, animals are stuck where they are and thus must _____ to local conditions
 - ii. Animals are also cut off from _____ and _____ on other landmasses
 - iii. This combination of conditions results in an enormous number of new _____

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Student Plate Tectonics Chapter Test Answer Key

PLATE TECTONICS

- I. Overview
 - a. Earth's landmasses resemble pieces of a giant jigsaw puzzle
 - i. Ex: the east coast of South America matches up with the west coast of Africa
- II. Earth's Drifting Continents (Section 3-1)
 - a. Past theory = a land bridge once stretched across the Atlantic Ocean and connected South America and Africa
 - i. Evidence for theory = fossils of plants and animals that could not have crossed an ocean found in South American and Africa
 - 1. Fossils = the preserved remains of ancient organisms
 - ii. Theory false
 - 1. Isostasy (balancing of the downward force of the crust and the upward force of the mantle) shows that continental crust cannot sink into denser oceanic crust
 - b. Theory of continental drift = the Earth once had a single landmass that broke up into large pieces, which have since drifted apart
 - i. Pangaea = name for this giant landmass
 - 1. Pangaea means "all Earth"
 - ii. Alfred Wegener (meteorologist) – first to build a detailed scientific case in support of the idea
 - 1. Met with great hostility and rejected by most scientists
 - c. Evidence from fossils
 - i. Fossils show connections among continents
 - ii. Many organisms of the distant past lived on a single landmass, Pangaea
 - 1. This landmass later split apart
 - 2. The pieces of the broken landmass (today's continents) slowly drifted away from one another, carrying their fossils with them
 - iii. Fossil example = Glossopteris (an extinct plant)
 - 1. Glossopteris fossils found in South Africa, Australia, India and Antarctica
 - d. Evidence from rocks
 - i. Rock formations in Africa line up with matching ones in South America
 - ii. Similar rock deposits left behind by glaciers
 - iii. Salts, coal, and limestone from coral reefs provide evidence of changes in climate caused by continental drift
 - 1. Salt deposits – form in areas between 10 and 35 degrees north and south of the equator
 - 2. Coal – forms in warm, swampy climates
 - 3. Limestone from coral reefs – form in tropical climates

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III. Earth's Spreading Ocean Floor (section 3-2)

- a. The ocean floor has a large system of underwater mountains that have a deep crack, called a rift valley, running through their center
 - i. Midocean ridges = underwater mountains
 1. The midocean ridges form the single largest mountain chain in the world (approx. 80,000 km long and 3 km high)
 - ii. Volcanic activity – much occurs at the midocean ridges
 1. Lava erupts from the rift valley that runs the length of the ridge
 2. As the ocean floor moves away on either side of the ridge, lava wells up and hardens
 3. The hardened lava forms new ocean floor = ocean-floor spreading
 - a. Ocean-floor spreading helps to explain how continents drift
 - b. As a piece of the ocean floor moves, it takes its continent with it
 - iii. Ridges as a whole curve because the straight edges are offset by thin cracks known as transform faults
- b. Rock samples from the ocean floor indicate that rocks next to a midocean ridge are younger than rocks farther away
- c. Magnetic stripes in ocean-floor rocks further convinced scientists of ocean-floor spreading
 - i. The pattern of magnetic stripes is identical on both sides of a midocean ridge
 1. As magma hardens into rock, half the rock moves in one direction and the other half moves in the other direction
- d. The ocean floor is being destroyed as fast as it is being formed by ocean-floor spreading
 - i. Trenches = V-shaped valleys that lie along the bottom of the oceans
 1. Trenches are the deepest parts of the oceans
 - ii. Eventually, the older ocean floor moves down deep into the Earth along the trenches
 1. Subduction = crust plunging back into the Earth
 2. When rocks are pushed deep enough, they melt
 - a. Some molten rock will produce volcanoes
 - b. Most molten rock will become part of the mantle
 - iii. As new rocks are formed along the midocean ridges, older rocks are subducted into the trenches
 1. One process balances the other
 2. The Earth's crust remains the same size

IV. Earth's Moving Plates (section 3-3)

- a. New theory = theory of plate tectonics
 - i. The theory of plate tectonics, which links together the ideas of continental drift and ocean-floor spreading, explains how the Earth has evolved over time

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- ii. Plate refers to the moving, irregularly shaped slabs that fit together like paving stones to form the surface layer of the Earth
 - iii. Tectonics refers to the branch of geology that deals with the movements that shape the Earth's crust
- b. Lithospheric Plates
- i. Lithosphere = the topmost solid part of the Earth made of a number of plates
 - ii. 7 major lithospheric plates
 1. Pacific plate – largest plate / covers 1/5 Earth's surface
 2. North American plate
 3. South American plate
 4. Eurasian plate
 5. African plate
 6. Indo-Australian plate
 7. Antarctic plate
 - iii. Many smaller plates
 1. Examples: Caribbean and Arabian plates
 - iv. Plates move at different speeds and in different directions
- c. Plate Boundaries – 3 types
- i. Because the plates move apart (diverge) at midocean ridges, the ridges are called divergent boundaries (also called constructive boundaries)
 - ii. Because the plates come together (converge) at the trenches, the trenches are called convergent boundaries
 1. Trenches are also called destructive boundaries because collision of plates at convergent boundaries can cause earthquakes and volcanoes
 - iii. Strike-slip boundaries – boundaries formed by lateral faults
 1. Two plates grind together and slip past each other horizontally
- d. Plate Motion
- i. Scientists are not sure exactly what makes the plates move
 - ii. One hypothesis is that large convection currents within the Earth move the plates
 1. Convection current = the movement of material caused by differences in temperature
 - iii. Colliding plates – the denser plate edge is subducted (pushed down), and the other plate edge “floats” over it
 1. Oceanic plate = has a colliding edge that consists of dense oceanic crust
 2. Continental plate = has a colliding edge that contains large amounts of relatively light continental crust
 3. All plates contain oceanic crust and most plates contain continental crust
 4. A lithospheric plate may act as a continental plate in one collision and as an oceanic plate in another

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5. When an oceanic and a continental plate collide, the oceanic plate is subducted
 6. Some of the material from the melting oceanic plate rises upward and erupts as volcanoes
 7. When two continental plates collide, the continental crust is pushed together and upward to form large mountain ranges
 - a. Example: Appalachian Mountains when Africa collided with North America
 8. When two oceanic plates collide, the denser plate is subducted
 - a. Some of the material from the melting plate rises upward and erupts on the ocean floor, forming an island arc
 - i. Examples: Japan and Indonesia
 - b. Older plates are denser because plates grow denser as they cool, and older plates have had longer to cool
 - iv. Earth's lithospheric plates fit together so closely, any change in one plate or boundary affects all the other plates and boundaries
 1. Continental plates may fuse together
 2. A trench may "switch direction"
 3. New divergent boundaries may form in the center of continents
 4. Plates may be completely subducted and disappear
 - e. Geophysicist = scientists who study the processes that change and shape the Earth
 - i. Study the Earth's surface, interior, oceans, and atmosphere
- V. Plate Tectonics and Life on Earth
- a. The movement of plates causes changes in climate, in geographic features such as mountains, and in the types of living things with which a species interacts
 - b. When landmasses join together, diversity decreases
 - i. Only the families of animals that compete the most successfully survive; the rest die out
 - ii. On a big landmass, animals can easily move to suitable places and avoid the more challenging environments
 - c. \When landmasses split apart, the diversity of land animals increases
 - i. On a small landmass, animals are stuck where they are and thus must adapt to local conditions
 - ii. Animals are also cut off from competitors and natural enemies on other landmasses
 - iii. This combination of conditions results in an enormous number of new species

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Chapter Test Word Bank

Place the appropriate word in the blank: (some words may be used more than once)

South America, continental plate, Indonesia, Africa, bridge, competitors, ancient, isostasy, continental, crust, oceanic, Pangaea, "all Earth," Alfred Wegener, continents, divergent boundaries, split apart, extinct, older, South Africa, earthquakes, glaciers, climate, Arabian, coal, limestone, spreading, mountains, living, rift valley, midocean ridges, largest, 3, lateral, lava, drift, moves, younger, Atlantic Ocean, salt, identical, magma, destroyed, trenches, deepest, fossils, older, subduction, melt, jigsaw puzzle, Antarctica, mantle, midocean, subducted, plates, plate tectonics, continental drift, plate, tectonics, lithosphere, 1/5, lithospheric, South, African, Indo-Australian, smaller, speeds, convergent boundaries, destructive boundaries, Appalachian, ocean floor, ocean-floor spreading, magnetic stripes, strike-slip boundaries, horizontally, move, volcanoes, balances, convection currents, divergent, temperature, transform faults, colliding plates, floats, oceanic plate, oceanic, melting, mountain ranges, island arc, cool, boundaries, fuse, trench, disappear, geophysicist, interior, atmosphere, climate, Pacific, landmass, geographic, die out, decreases, survive, big, increases, small, adapt, natural enemies, species, 80,000