# LESSON 1 The Earth is Cracking Up

## Lesson at a Glance

Lesson 1 introduces the concept that the Earth is not solid, and that the crust is like a thin skin floating on top of a hot, taffy-like body of magma. This skin is cracked, and each section moves over and under other sections as well as toward and away from the other sections, all of which are movements that create mountains, valleys, island chains, volcanoes, and earthquakes.

## Lesson Duration

Four 45-minute periods

## Essential Question(s)

How does the internal structure of the Earth affect the movement of Earth's crust to create land features?

## Key Concepts

- Earth's crust is a thin layer essentially floating on hot, semifluid rock called magma, which causes the crust to crack and move.
- When two pieces of crust, called plates, interact with each other they create earthquakes, volcanoes, mountain ranges, deep trenches, and island chains; when two pieces of crust move apart, they create rift valleys and oceans.

## Instructional Objectives

- I can create a model of the Earth's layers
- I can use a model to make predictions about what could happen to the Earth's crust in the future.

**Related HCPSIII Benchmark(s):**

Science SC.5.2.1
Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

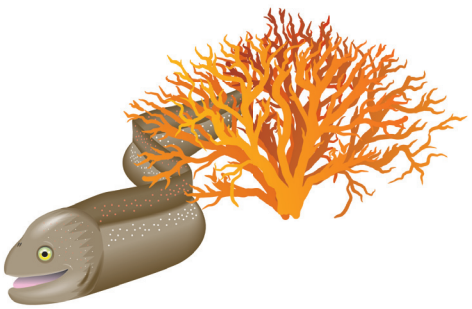
Language Arts LA 5.1.1
Use new grade appropriate vocabulary learned through reading print and online resources and word study, including meaning of roots, affixes, word origins.

Language Arts LA 5.1.2
Use a variety of grade-appropriate print and online resources to research a topic.

Language Arts LA 5.4.1
Write in a variety of grade-appropriate formats for a variety of purposes and audiences

Language Arts LA 5.6.1 Use speaking and listening skills to fill a prescribed role in group activities.

Language Arts LA 5.6.2 Give informal presentations or reports to inform



## Assessment Tools

### Benchmark Rubric:

| Topic | | Unifying Concepts and Themes | |
|---|---|---|---|
| **Benchmark** SC.5.2.1 | | Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world | |
| **Rubric** | | | |
| **Advanced** | **Proficient** | **Partially Proficient** | **Novice** |
| Consistently select and use models and simulations to effectively represent and investigate features of objects, events, and processes in the real world | Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world | With assistance, use models or simulations to represent features of objects, events, or processes in the real world | Recognize examples of models or simulations that can be used to represent features of objects, events, or processes |

| Topic | | Vocabulary and Concept Development | |
|---|---|---|---|
| **Benchmark** LA.5.1.1 | | Use new grade-appropriate vocabulary learned through reading print and online resources and word study, including meanings of roots, affixes, word origins | |
| **Rubric** | | | |
| **Advanced** | **Proficient** | **Partially Proficient** | **Novice** |
| Use new grade-appropriate vocabulary, with fluency, precision, and accuracy | Use new grade-appropriate vocabulary, with minimal difficulty and no significant errors | Use new grade-appropriate vocabulary, with difficulty and a few significant and/or many minor errors | Use new grade-appropriate vocabulary, with great difficulty and many significant errors or rarely use new vocabulary |

| Topic | | Locating Sources/ Gathering Information | |
|---|---|---|---|
| **Benchmark** LA.5.1.2 | | Use a variety of grade-appropriate print and online resources to research a topic | |
| **Rubric** | | | |
| **Advanced** | **Proficient** | **Partially Proficient** | **Novice** |
| Use substantive information from an extensive variety of grade-appropriate print and online resources to thoroughly research a topic | Use relevant information from a variety of grade-appropriate print and online resources to research a topic | Use some relevant information from a few grade-appropriate print and online resources to research a topic | Use very little relevant information from grade-appropriate print and online resources to research a topic |

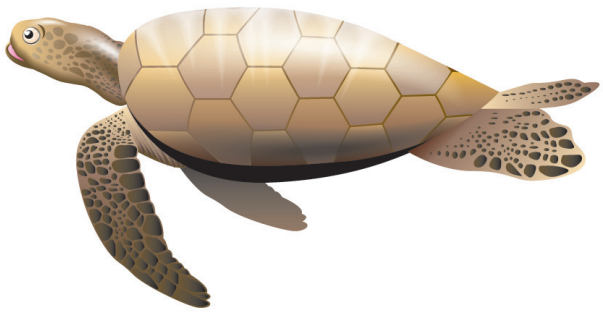
| Topic | | Range of Writing | |
|---|---|---|---|
| **Benchmark** LA.5.4.1 | | Write in a variety of grade-appropriate formats for a variety of purposes and audiences. | |
| **Rubric** | | | |
| **Advanced** | **Proficient** | **Partially Proficient** | **Novice** |
| Insightfully adapt writing to grade-appropriate formats for a variety of purposes and audiences | Adapt writing to grade-appropriate formats for a variety of purposes and audiences | Write with some adaptation to grade- appropriate formats for a variety of purposes and audiences | Write with little adaptation to grade-appropriate formats for a variety of purposes and audiences |

| Topic | | Discussion and Presentation | |
|---|---|---|---|
| **Benchmark** LA.5.6.1 | | Use speaking and listening skills to fill a prescribed role in group activities | |
| **Rubric** | | | |
| **Advanced** | **Proficient** | **Partially Proficient** | **Novice** |
| Use speaking and listening skills to fill a prescribed role in group activities, in a highly effective way | Use speaking and listening skills to fill a prescribed role in group activities | Use some speaking and listening skills that assist in filling a prescribed role in group activities, in a limited way | Use irrelevant speaking and listening skills that do not relate to a prescribed role in group activities |

| Topic | | Discussion and Presentation | |
|---|---|---|---|
| **Benchmark** LA.5.6.2 | | Give informal presentations or reports to inform | |
| **Rubric** | | | |
| **Advanced** | **Proficient** | **Partially Proficient** | **Novice** |
| Give highly effective informal presentations or reports that clearly inform | Give effective informal presentations or reports to inform | Give marginal informal presentations or reports that somewhat inform | Give ineffective informal presentations or reports that do not inform |

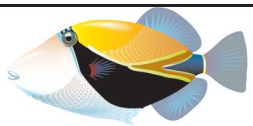
## Assessment/Evidence Pieces

Lesson
- Student Worksheet *Plate Boundary Researchers - Graphic Organizer*
- Student Worksheet *Plate Movement*



## Materials Needed

| Teacher | Class | Group | Student |
|---|---|---|---|
| • Method to project PowerPoint | • None | • Red construction paper<br>• scissors<br>• 1⁄2 a large orange<br>• 1⁄2 a small lemon or lime<br>• 1 maraschino cherry<br>• 4 strips of index card<br>1⁄2 inch wide<br>2 inches long<br>• Scotch tape<br>• 6 toothpicks<br>• 1 spoon<br>(For students with allergies to the fruit, have gloves available.) | • Student Worksheet: *Plate Boundary Researchers- Graphic Organizer*<br>• Student Reading: *Convergent, Divergent and Transform Boundaries*<br>• Student Worksheet: *Plate Movement* |



## Instructional Resources

Teacher Reading: *Teacher Modeling Activity: The Earth*
Student Reading: *Convergent, Divergent, and Transform Boundaries*
Student Worksheet: *Plate Boundary Researchers- Graphic Organizer*
Student Worksheet: *Plate Movement*
PowerPoint Presentation: *Plate Tectonics*
USGS Interpretive map of Plate Tectonics
http://mineralsciences.si.edu/tdpmap/pdfs/interpretive.pdf
http://www.ucmp.berkeley.edu/geology/tecmech.html
http://pubs.usgs.gov/gip/dynamic/dynamic.html
Oceanography, (3rd ed.) Tom Garrison, Wadsworth Publishing Co. (1999) pp. 52–55 & 60–82.

## Student Vocabulary Words

**asthenosphere:** fluid layer of upper mantle, causes crustal plates to move (plate tectonics).
**calcium carbonate:** a material that forms coral skeletons. Material occurs in nature as limestone.
**continental crust:** lighter rock of continents, mostly granite.
**convergent boundary:** region where two or more plates are pushing together; form mountains, island arc, or trenches.
**core:** innermost layer of Earth, composed of a solid inner core of mostly iron, and a liquid outer core that is a little lighter and cooler.
**divergent boundary:** region where two plates are moving apart; form new ocean or rift valley.
**earthquake:** a sudden movement of the Earth's crust caused by slippage along fractures in the rocks (faults) or volcanic activity.
**friction:** the opposing forces of two surfaces trying to move past each other; the energy is released as heat.
**hot spot:** a plume of magma rising up from a (relatively) stationary area in the mantle.
**lithosphere:** the mineral (rock) part of Earth, as opposed to the hydrosphere (water) biosphere (living things), and atmosphere (air and other gases) parts of Earth.
**magma:** molten semiliquid rock underground (called lava when it reaches the surface).
**mantle:** main volume of the earth between the crust and the core; increases in pressure and temperature with depth.
**ocean trench:** a depression in the ocean floor with very steep sides, coinciding with a subduction zone.

**oceanic crust:** heavy, thinner rock under oceans, mostly basalt.
**pressure:** force applied all over an object's area by some mass pushing down on it due to gravity.
**rift valley:** a long, narrow valley lying between two plates where the earth's lithosphere has become thin. Unlike river valleys that form primarily through erosion, rift valleys form by the subsidence of the intermediate land as the plates are pulled apart.
**subduction zone:** area where a lithospheric plate is descending into the asthenosphere, creating deep trenches.
**tectonic plates:** the 12 rigid pieces of Earth's lithosphere, made of oceanic or continental crust, which move independently of each other.
**transform boundary:** region where two plates move parallel along each other's edges in opposite directions.

## Lesson Plan

### *Lesson Preparation*

- **NOTE : Both Group activities can either be done as a Teacher Demo or a class activity depending on your time frame or preference.**
- Review the Science Background provided in the Unit's Overview and the Teacher Reading *Teacher Modeling Activity: The Earth.*
- Review the activities, modeling and plate movements, and obtain all the needed materials, background information, vocabulary, and activity directions.
- Review and make copies of Student Reading: *Convergent and Divergent Boundaries*, and Student Worksheets *Plate Boundary Researchers-Graphic Organizer*, and *Plate Movement*, one per student.
- Preview the PowerPoint *Plate Tectonics* and the video about plate tectonics at http://www.learningdemo.com/noaa/ and make arrangements to project them.
- Write out the Instructional Objective *I can* statement for this lesson and post it.

### *I. Earth: It's Not as Solid as It's Cracked Up to Be - Create a Model of the Earth*

A. Break students into groups (4 would be ideal, but break them according to what works in your class). Have them brainstorm and record what they know about the layers of the Earth and how the Earth was formed. Give them a time limit of about 5 minutes (adapt according to your class). Have the groups share out as you record their answers.

B. Perform *Teacher Modeling Activity: the Earth* as a demonstration for the class. Students can participate in the demonstration through placing labels correctly, identifying layers, etc.

C. Inform students that they will each be responsible for creating their own model of the Earth, writing a report on the layers of the Earth, and giving a class presentation. Their models must include: plate boundaries, hot spot, crust, mantle, outer core, and inner core, and be labeled correctly. Students may use any materials or supplies within the classroom.

D. For homework, students must make a sketch of the model they will create and list the materials needed for each section.

E. Give students a deadline for completion, not to exceed a week. In addition to creating the models, they must also research information on the different layers of the Earth and write a report.

F. Guide the class through creating a scoring rubric for their models. The rubric should not exceed 1⁄2 a sheet of paper.

G. When the models are complete, have students present their work to the class. The students will use the rubric to score their classmates, work.

H. Display the models in the classroom or another area in school.

## *II. Convergent, Divergent and Transform Boundaries*

A. Show the PowerPoint: *Plate Tectonics* or show the video about plate tectonics at http://www.learningdemo.com/noaa/ .

B. Have students take notes on the PowerPoint or plate tectonic video.

C. Break students up into groups of three. Assign each student with #1, #2, or #3. These are their "home groups."

D. Distribute Student Reading: *Convergent, Divergent, and Transform Boundaries*, to students. Discussion questions are provided, which can be used within the reading or may be used after the entire reading is completed as an optional formative assessment piece.

E. Break students into their number grouping (i.e., all #1s gather together, all #2s gather together, and all #3s gather together). Announce that the #1s are the "Convergent researchers," the #2s are the "Divergent researchers" and the #3s are the "Transform Boundary researchers."

F. Distribute Student Worksheet: *Plate Boundary Researchers-Graphic Organizer* to students to help them organize information. Each group of researchers will fill in only the part of the chart that is for their assigned boundary type. Each group will be using the reading and any other source of information to help them explain the type of boundary they were assigned (Give them about 10 minutes, but you can always check to see how things are going. You may also want to suggest breaking up the work within the group.).

G. After 10 minutes (if the groups are ready), send students back to their "home groups." Each member of the "home group" will teach the other group members about the boundary they researched. The other home group members will fill in the portion of the chart that is blank.

H. Create a class chart, filling in the information for all three boundaries. Have groups share information to fill in the chart.

I. Following the completion of the *Plate Boundary Researchers-Graphic Organizer*, distribute the *Plate Movement* worksheet. Ask the students to contribute their knowledge of the various tectonic plates, including their status as a divergent, convergent, or transformation zone. Students will use colored pencils/crayons/markers to trace the boundary lines between the plates. You should have a transparency or something that you can be marking while the students are marking. Use blue for convergent and orange for divergent boundaries (or whichever colors you choose). This will help the students further identify the plates and which direction they are moving.

J. Give students time to write down other questions they may have and/or to answer some of the questions they previously wrote down. If time allows, discuss some of their questions. An option is to have discussion questions interspersed during the reading to provoke dialogue, discussion, and thought, and are best asked and answered in whole group settings.

# LESSON 1 - Teacher Reading

## Teacher Modeling Activity: The Earth

### Materials

- Half a large orange, half a small lime, one maraschino cherry
- Six strips of index card, half an inch wide and two inches long.
- Scotch tape
- Six toothpicks
- One spoon
- One black fine point Sharpie pen

A. Label the index cards as follows:
   1. Plate boundary
   2. Hot spot
   3. Crust 10–30 km thick, -60°C – +60°C.
   4. Mantle 2,900 km, 500°C – 2000°C.
   5. Outer Core 2,250 km thick, 2000°C – 4000°C.
   6. Inner Core 1,200 km thick, 4,000°C – 5,000°C.

B. Tape the index cards on the flat end of each toothpick to make a label.

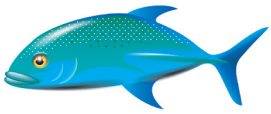
C. Draw a line with the Sharpie pen on the outside of the orange peel from top to bottom. Stick the toothpick labeled **Plate Boundary** into this crack.

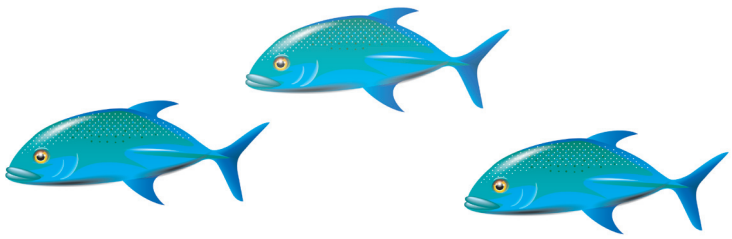
D. Poke a hole through the orange peel *crust* with the toothpick labeled **Hot Spot**. Squeeze out a little juice (magma) from the hole, then leave the toothpick in.

E. Scoop out the center of the half orange large enough to fit the half lime, and put the lime in the hole.

F. Scoop out the center of the lime large enough to fit the maraschino cherry, and put the cherry in the hole.

G. Name each part by sticking the **toothpick** label into the appropriate section:
Orange skin = **Crust**; orange fruit = **Mantle**; lime = **Outer Core**; cherry = **Inner Core**





# LESSON 1

## Name: _____ Date: _____

## Plate Boundary Researchers - Graphic Organizer

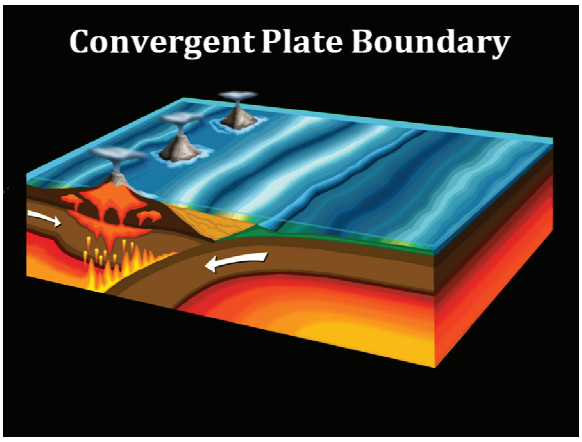
| | Description | Example | Diagram |
|---|---|---|---|
| **Divergent** | | | |
| **Convergent** | | | |
| **Transform** | | | |

# LESSON 1 - Student Reading

## Convergent, Divergent, and Transform Boundaries

### CONVERGENT BOUNDARY

Where two plates meet and come together, that is called a **convergent boundary**.




Convergent boundaries are like a slow-motion train wreck, a head-on collision between the two biggest monster trucks imaginable. Trillions of tons of rock from one plate are smashing into trillions of tons of rock from another, and neither one is giving an inch, neither stopping nor slowing down.

Volcanoes are created by this collision of plates, too, as well as all the world's mountain ranges! How do you think this happens?

When the two giant masses of rock come together, they have to go somewhere, right? Sometimes they form tall mountains, like Mount Everest, where two continental plates smash, or collide, into each other. But they can also form different types of features along **subduction zones**.

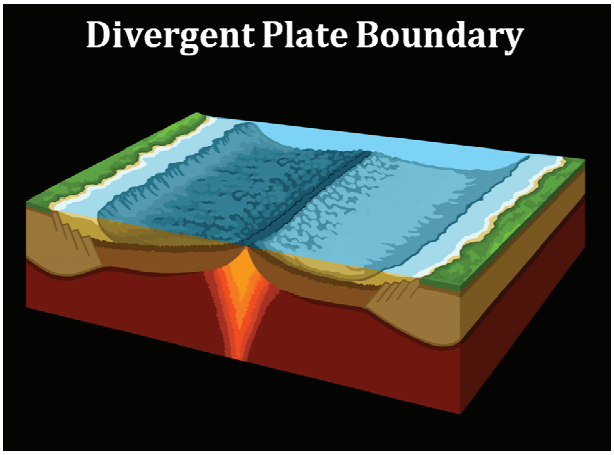
**Subduction zones** occur where heavier rock, which is the lithosphere from the ocean bottom, or **oceanic crust**, grinds its way under and sinks beneath the lighter rock of the **continental crust**. Where this sinking occurs, deep **trenches** are formed beneath the sea. Some of these deep ocean trenches, like the Mariana Trench — where the Pacific Plate sinks beneath the Eurasia Plate — are the deepest places on Earth. At over 11 kilometers (over 6.8 miles deep); the Mariana Trench is 1 mile deeper than the tallest mountain, almost 7 times as deep as the Grand Canyon in Arizona, and 10 times deeper than Waimea Canyon in *Kaua'i*, which Mark Twain called the "Grand Canyon of the Pacific."

The rocks of oceanic plates contain a lot of water and, as they sink beneath other, often continental plates (during the process of subduction), the sinking plates become very hot. This is because temperature increases from the surface to the interior of the Earth. The water that is in the sinking oceanic plate becomes so hot that it boils and creates superheated steam that is so hot, hotter than normal water steam, it melts the surrounding rock and forms **magma**. Some of this magma rises up through cracks in the rock and may form volcanoes on the Earth's surface. That is the reason there are lots of volcanoes along convergent boundaries where there are subduction zones.


The Indian Plate, carries a huge piece of continental crust, including the country of India, that used to be separate from the rest of Asia. Millions of years ago, the Indian plate looked like the Australian Plate, with a big island in the middle of the ocean. Then, it began to drift northward. When the Indian Plate finally reached the Eurasian Plate, and the continent of Asia, it began to push against it. Since the landmass of India riding on top of the Indian Plate was made of light continental crust, like that of the Asian continent, it did not sink beneath the land, but just kept pushing into it. Both plates bent, twisted, and rose, and eventually formed the highest mountain range in the world, the Himalayas.

## DIVERGENT BOUNDARY

**Divergent boundaries** occur when two plates move away from each other. Interestingly, almost all these boundaries are under the sea. One of the few places where there is a divergent boundary between two parts of a continent is in Africa. This boundary has created the Great Rift Valley, which runs north/south through the northeastern portion of Africa. Over time, as the rift valley becomes wider, the Red Sea will flow into this region and eventually divide Africa into two land masses, which will lie on two separate tectonic plates.

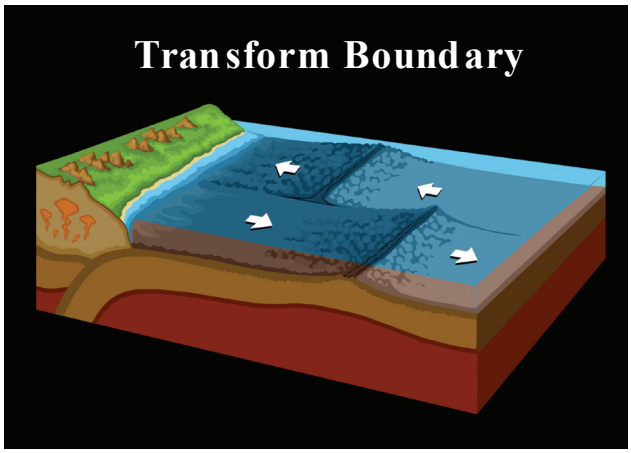



Where divergent boundaries occur, magma flows up from the cracks that are created in the Earth's crust. On oceanic plates, this forms new seafloor and widens the ocean basin. These undersea types of divergent boundaries, called mid-ocean ridges, may form underwater mountain ranges, like the **Mid-Atlantic Ridge**, and deep-sea **hydrothermal vents**, such as those found off the Nazca plate near the Galapagos Islands. One of the fastest spreading boundaries is between the Pacific and Antarctic plates, widening both oceans as well as the ocean between Antarctica and the other continents.

In some locations, an **upwelling** plume (or stationary region of upward flow) of magma rises from the center of the Earth and can erupt as a volcano on the surface. These areas are called **hot spots**. Most hot spots are found in the interior of tectonic plates, like the hot spot that created the Hawaiian Islands or the volcanic features of Yellowstone National Park, and not along plate boundaries. However, the country of Iceland is an exception where both the Mid-Atlantic Ridge and hot-spot volcanism create a dramatic landscape of volcanic features and deep trenches.

## TRANSFORM BOUNDARY

A **transform plate boundary** is where two plates are sliding horizontally past one another. This type of boundary is more commonly known as a transform fault.




While most transform faults are found on the ocean floor on the same tectonic plate, a few, such as the San Andreas Fault in California, occur on land between two different tectonic plates.

When a transform fault is between two plates, the plates frequently stick against each other for awhile as they try to move past. When this **sticking** pressure builds up to a very high level, the plates will suddenly break free and slide past one another. This motion causes earthquakes, which can sometimes be very large if the pressure build up is very high. There are no volcanoes associated with transform plate boundaries because, in this case, the movement of plates was not associated with an upwelling mantle plume (hot spot volcanism) or a subducting and melting tectonic plate (subduction zone volcanism).

# LESSON 1

## Plate Movement