Science & Literacy Activity

GRADES 6-8

OVERVIEW

This activity, which is aligned to the Common Core State Standards (CCSS) for English Language Arts, introduces students to scientific knowledge and language related to plate tectonics. Students will read content-rich texts, visit the David S. and Ruth L. Gottesman Hall of Planet Earth and use what they have learned to complete a CCSS-aligned writing task, creating an illustrated text about how plate tectonics plays a role in specific Earth formations.

Common Core State Standards:
WST.6-8.2, WST.6-8.8, WST.6-8.9
RST.6-8.1, RST.6-8.2, RST.6-8.4, RST.6-8.7, RST.6-8.10

New York State Science Core Curriculum:
PS 2.2f

Next Generation Science Standards:
PE MS-ESS2-3
DCI ESS2.B: Plate Tectonics and Large-Scale System Interactions
Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.

Materials in this activity include:
- Teacher instructions for:
    - o Pre-visit student reading
    - o Visit to the Gottesman Hall of Planet Earth and Student Worksheet
    - o Post-visit writing task
- Text for student reading: "Earth's Dynamic Machine: Basics of Plate Tectonics"
- Student Sample Chart
- Student Worksheet for the Gottesman Hall of Planet Earth visit
- Gottesman Hall of Planet Earth Plate Tectonics section map
- Student Writing Guidelines
- Teacher rubric for writing assessment

SUPPORTS FOR DIVERSE LEARNERS: An Overview
This resource has been designed to engage all learners with the principles of Universal Design for Learning in mind. It represents information in multiple ways and offers multiple ways for your students to engage with content as they read about, discuss, view, and write about scientific concepts. Different parts of the experience (e.g. reading texts, or locating information in the hall may challenge individual students. However, the arc of learning is designed to offer varied opportunities to learn. We suggest that all learners experience each activity, even if challenging. We have provided ways to adapt each step of the activities for students with different skill-levels. If any students have an Individualized Education Program (IEP), consult it for additional accommodations or modifications.

1. BEFORE YOUR VISIT

This part of the activity engages students in reading a non-fiction text about plate tectonics. The reading will prepare students for their visit by introducing them to the topic and framing their investigation.

Student Reading
Have students read "Earth's Dynamic Machine." Have them write notes in the large right-hand margin. For example, they could underline key passages, paraphrase important information, or write down questions that they have. They may also use this space for drawings or diagrams of the tectonic processes they're reading about.

After reading, ask students to come up with definitions for the following words as they are used in the article: tectonics, divergent, convergent, and transform. Working in pairs or small groups, they should use context clues from the reading to develop their definitions. During discussion, remind students to use evidence from the text to explain their thinking, and to use specific examples. *(Answers may vary, but should include: Tectonics refers to the motions of the plates, divergent means spreading or moving apart, convergent means coming together, and transform usually means change, but in this case it may refer to movement in different directions that changes a landscape.)*

Then, have them create a chart (such as a multi-columned T-chart) to compare and contrast the four different types of plate boundaries described in the reading (divergent, convergent between oceanic and continental plates, convergent between two continental plates, and transform). Have them include illustrations of the processes they describe.
See included Sample Student Chart for an example of how students could format their charts.

SUPPORTS FOR DIVERSE LEARNERS: Student Reading
- "Chunking" the reading can help keep them from becoming overwhelmed by the length of the text. Present them with only a few sentences or a single paragraph to read and discuss before moving on to the next "chunk."
- Provide "wait-time" for students after you ask a question. This will allow time for students to search for textual evidence or to more clearly formulate their thinking before they speak.
- After the reading, have students explore the following OLogy activity on the effects of plate tectonics on Earth's surface: amnh.org/ology/features/plates

2. DURING YOUR VISIT

This part of the activity engages students in exploring the hall.

Museum Visit & Student Worksheet
Explain to students that they will be focusing on the Plate Tectonics section of the Gottesman Hall of Planet Earth. Distribute the included hall map and show students how specimens found in different areas correspond to different types of plate boundaries. Tell them that they will be using worksheets to gather all the necessary information about rock specimens that correspond to specific plate boundary processes, and that back in the classroom they will refer to these notes when completing the writing assignment.

SUPPORTS FOR DIVERSE LEARNERS: Museum Visit
- Review the Student Worksheet with students, clarifying what information they should collect during the visit.
- Have students explore the hall in pairs, with each student completing their own Student Worksheet.
- Encourage student pairs to ask you or their peers for help locating sources of information. Tell students they may not share answers with other pairs, but they may point each other to places in the hall where answers may be found.

3. BACK IN THE CLASSROOM

This part of the activity engages students in an informational writing task that draws on the pre-visit reading and on observations made at the Museum.

Writing Task
Distribute the Student Writing Guidelines handout, which includes the following prompt for the writing task:

> Based on your reading, your visit to the Gottesman Hall of Planet Earth, and your discussions, write an illustrated history of one of the rock specimens you chose to study during your visit.
>
> Be sure to:
> - define "plate tectonics"
> - explain the plate boundary processes that were involved in your specimen's formation or structural change
> - include a labeled illustration of the specimen as it appears today
> - include a labeled illustration of the processes that the specimen has undergone in its formation or change
>
> Support your discussion with evidence from the reading and the Gottesman Hall of Planet Earth.

Go over the handout with students. Tell them that they will use it while writing, and afterwards, to evaluate and revise their essays.

Before they begin to write, have students use the prompt and guidelines to frame a discussion around the information that they gathered in the Gottesman Hall of Planet Earth, and compare their findings. They can work in pairs, small groups, or as a class. Referring to the writing prompt, have students underline or highlight all relevant passages and information from the reading, the charts they made, and their notes from the hall that can be used in their response to the prompt. Instruct each student to take notes on useful information that their peers gathered as they compare findings. Students should write their essays individually.

SUPPORTS FOR DIVERSE LEARNERS: Writing Task
- Re-read the "Before Your Visit" assignment with students. Ask what they saw in the hall that helps them understand plate tectonics.
- Allow time for students to read their essay drafts to a peer and receive feedback based on the Student Writing Guidelines.

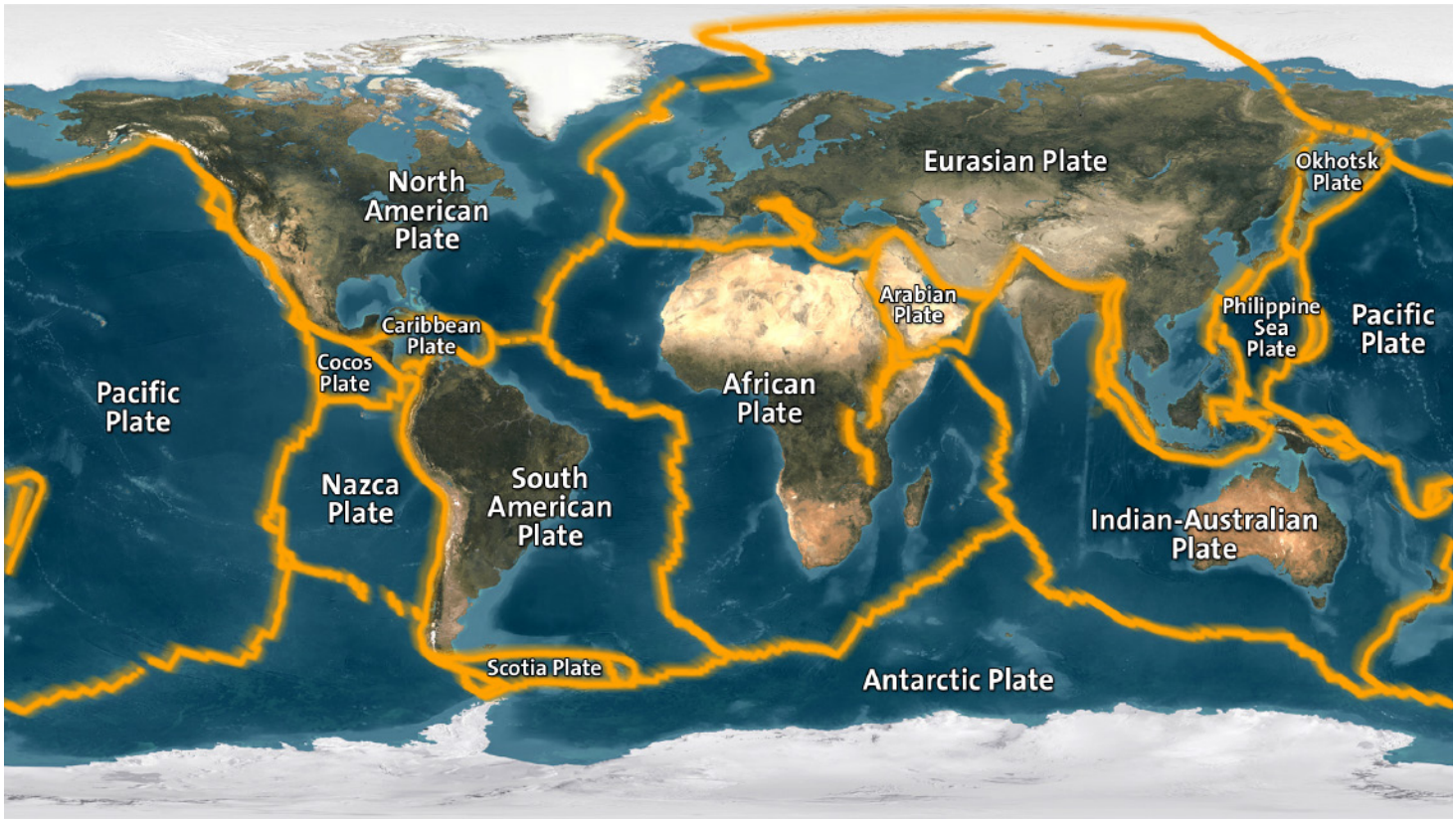
Student Reading

Earth's Dynamic Machine: Basics of Plate Tectonics

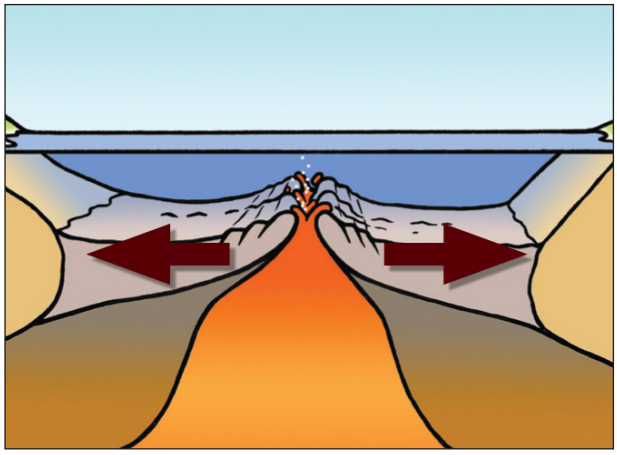
Text adapted from *The Earth Machine: The Science of a Dynamic Planet* by Edmond A. Mathez. Columbia University Press, 2007.

The lithosphere, the rigid, strong outermost shell of Earth, is broken into ten large plates. The mantle below those plates is solid rock. However, over time – and at high temperatures and pressures – the solid rock of the mantle very slowly flows in enormous circular motions called convective currents. These currents cause the plates to move, a process geologists describe with the theory of plate tectonics.

Because of plate tectonics, Earth's surface is in constant motion. Plates separate. They slip past one another. They even collide with each other. Arabia, for instance, pulls away from Africa, opening up the Red Sea. North America creeps away from Europe at about one inch per year – roughly the rate at which a fingernail grows! Large regions of the Pacific seafloor dive beneath the surrounding continents. And as India pushes north into Asia, it creates the world-famous mountain range called the Himalayas.



Plates Moving Apart



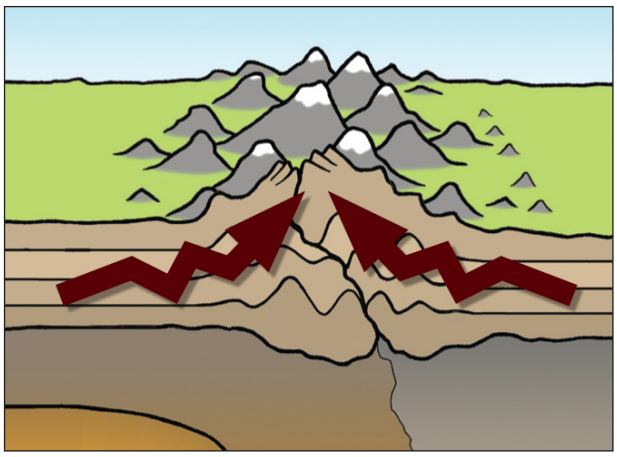
Where plates separate, or diverge, ocean basins are created. 85% of Earth's volcanic eruptions occur along *divergent boundaries*. Many small earthquakes happen along these boundaries at shallow depths (less than 6 miles). As the plates move apart, magma rises from the mantle to fill the empty space. In this way, the plates grow as they separate. By this process, entire ocean basins re-form about every 200 million years.

Most divergent plate boundaries run through the world's oceans. In the Atlantic, the boundary divides the ocean basin almost exactly in half. This boundary is called a *mid-ocean ridge*. This term means that there is a range of volcanic mountains running through the bottom of the Atlantic Ocean. This range is part of a worldwide system of such ranges. Together, they form a system of mountain ranges 50,000 miles long.

The lithosphere near the mid-ocean ridges is thin and warm. As the lithosphere moves away from the mid-ocean ridge, it cools and becomes denser. Then it sinks. That means the depth of the ocean is greater farther from a mid-ocean ridge. Mid-ocean ridges are chains of volcanoes sitting on broad rises with vast and deep oceanic plains on both sides.

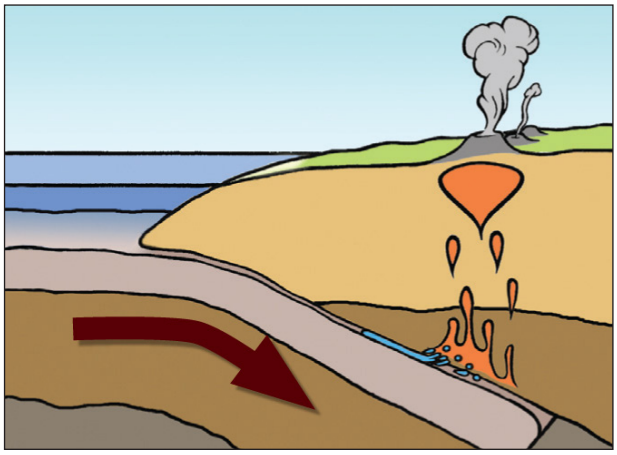
Divergent boundaries are not always in the middle of ocean basins, however. In a few places, divergent boundaries run right through continents. In those places, the lithosphere stretches and thins. This causes rifts to form in the overlying continental crust. Basaltic magma intrudes into the thinned lithosphere. It then erupts onto the continent, and may melt portions of the continental crust to form other lava types. When such rifts develop long enough, an ocean begins to form. The Red Sea is one such rift. It may eventually grow as large as the Atlantic Ocean!

Plates Coming Together



Where plates collide, or converge, a variety of landforms are created. Such structures include mountains, volcanic island arcs and deep-sea trenches. Convergent plate boundaries produce large and small earthquakes. They build great, explosive volcanoes as well. Exactly what happens at a convergent plate boundary depends on what collides with what.

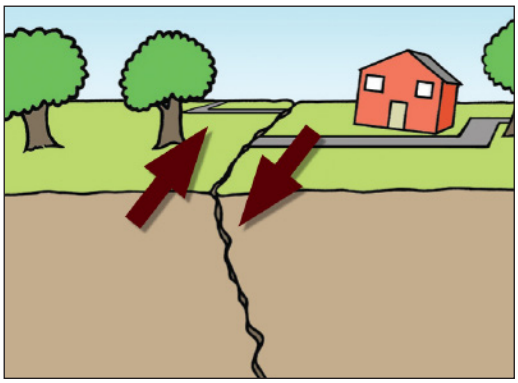
Most plate convergence occurs between oceanic and continental plates. When this happens, the colder and denser oceanic plate sinks below the continental plate into the mantle. That process is known as *subduction*. The boundary where it occurs is called a subduction zone.



The subducted plate becomes heated by the mantle, and it loses water, producing an aqueous rich fluid. The fluid moves upward and infiltrates the overlying mantle. This causes the mantle to partially melt, producing a magma that rises up through the mantle and crust to feed volcanoes on the surface. This process usually produces volcanic mountain chains on the overlying continental plate, such as the Andes. If two oceanic plates converge then the older, colder plate sinks beneath the younger, warmer plate and an arc of islands, like the Aleutians off the coast of Alaska forms on the overlying oceanic plate. Deep-sea trenches are created along convergent margins. That is where the oceanic lithosphere bends into the subduction zone. Trenches are the deepest parts of the ocean. Some have depths in excess of 36,000 feet.

A different type of convergent boundary occurs where two continents collide. In this case subduction does not occur, because both continents have crust with a similar density. Neither is forced down into the mantle. Instead, a mountain range forms as one continent overrides the other. This forms an unusually high and thick crust. The Himalayas are the best example of this type of convergent plate boundary. Behind these mountains, the crust of the Tibetan Plateau can be nearly 50 miles thick.

Plates Sliding By



Where plates slip past each other, they form long furrows in the lithosphere called transform boundaries. These boundaries are typically hundreds to thousands of miles long. At transform boundaries, crust is not created, nor does it disappear. The plates on either side of the fault may be moving in opposite directions. Or they could be moving in the same direction, but at different speeds.

Many people have heard of the San Andreas Fault in California. Or perhaps they know about the Anatolian Fault that runs through northern Turkey. Both of these transform faults are among the most active earthquake zones on Earth, and both have been struck by devastating earthquakes.

Where transform faults bend, one of two different structures will form. A pull-apart basin may grow. This type of long, narrow depression collects sediment or fills with water. The Dead Sea between Jordan and Israel is one such basin. On the other hand, plate motion may cause blocks of crust to jam together, creating ridges and folds called transverse ridges. A good example of this is the Transverse Ranges in California, to the north of Los Angeles. There, a bend in the San Andreas Fault causes the crust to wrinkle.

What Plate Tectonics Tells Us

The theory of plate tectonics teaches us a lot about Earth. It describes how the mantle and crust of Earth interact with each other. It makes clear why mountains, ocean basins or continents form where they do. It also explains why volcanoes and earthquakes so often appear on plate boundaries.

Sample Student Chart

Plate boundary name	Description of plate movement	Processes that occur there	Diagram of plate movement
Divergent	*Plates move away from each other*	*Ocean basins created, volcanism, small shallow earthquakes occur*	*[students should sketch in this space]*
Convergent (oceanic and continental)	*Plates collide, oceanic plate moves under continental plate (subduction)*	*Volcanic mountain chains and oceanic trenches form*	*[students should sketch in this space]*
Convergent (continental and continental)	*Plates collide, both plates are pushed up, one overrides the other*	*High mountain ranges and plateaus form*	*[students should sketch in this space]*
Transform	*Plates slip past each other*	*Strong earthquakes occur, pull-apart basins and ridges are formed*	*[students should sketch in this space]*

Student Worksheet: Investigate Plate Tectonics

Rock specimen name: _____

Where was it found?

What is it made of?

How was it formed?

What type of plate boundary is it related to?

Draw it.

Rock specimen name: _____

Where was it found?

What is it made of?

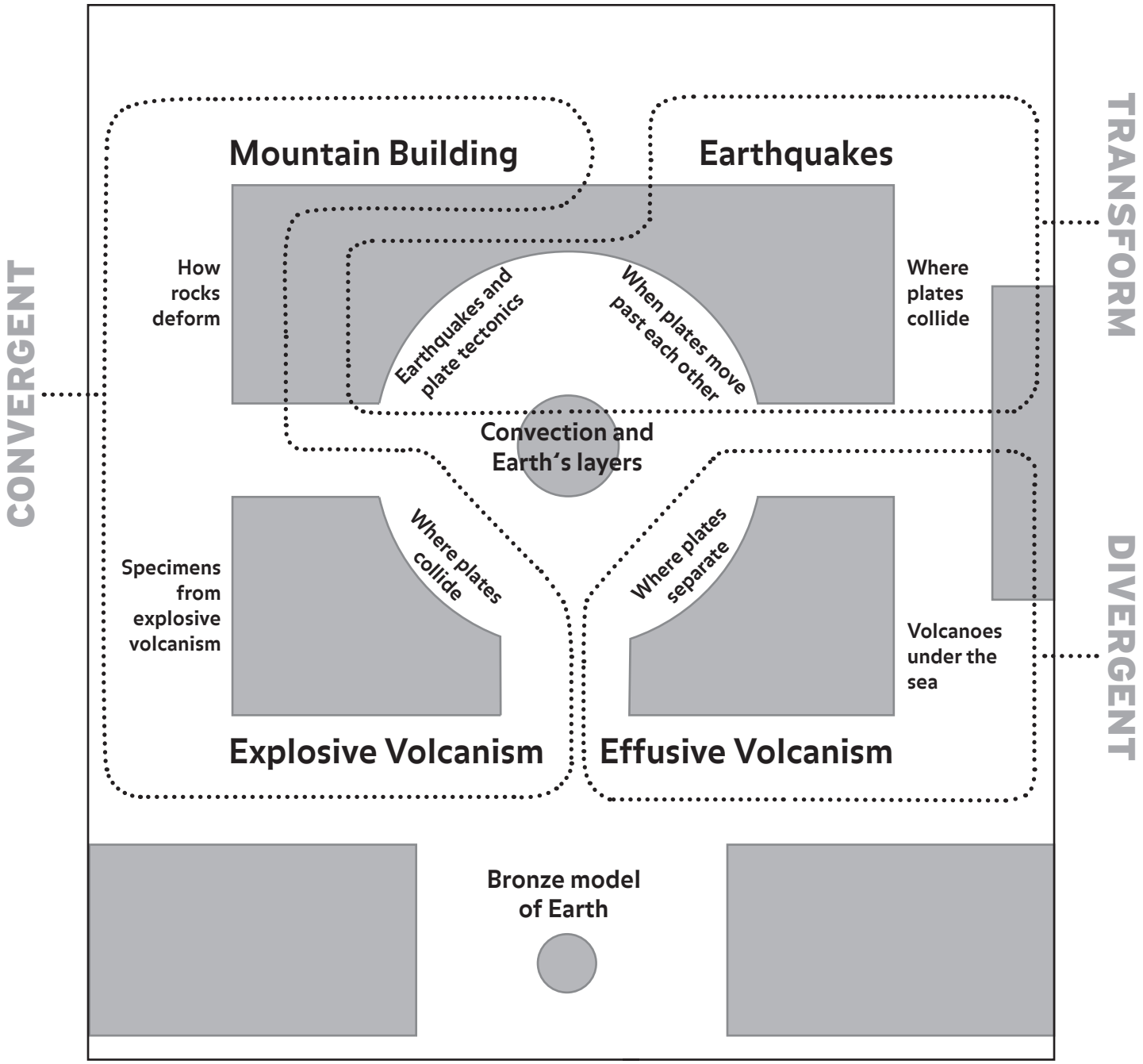
How was it formed?

What type of plate boundary is it related to?

Draw it.

Hall Map: Plate Tectonics Section

The major processes occurring at plate boundaries are explained in the center ring area, and the rock specimens and landforms associated with those processes are shown in the outside rectangular walkway. The dotted lines group together which areas relate to which processes.



Student Writing Guidelines

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Be sure to:
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- explain the plate boundary processes that were involved in your specimen's formation or structural change
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- include a labeled illustration of the processes that the specimen has undergone in its formation or change

Support your discussion with evidence from the reading and the Gottesman Hall of Planet Earth.

Use this checklist to ensure that you have included all of the required elements in your essay.

- ☐ I introduced plate tectonics.
- ☐ I defined "plate tectonics."
- ☐ I clearly named the specimen that I chose and described how it formed, including the plate boundary process involved.
- ☐ I included a labeled illustration of my specimen as it appears today.
- ☐ I included a labeled illustration of the processes that the specimen has undergone in its formation or change.
- ☐ I only included relevant information about plate tectonics.
- ☐ I used information from "Earth's Dynamic Machine" to explain plate tectonics in detail.
- ☐ I used information from the Gottesman Hall of Planet Earth to explain plate tectonics in detail.
- ☐ I used academic, non-conversational tone and language.
- ☐ I included a conclusion at the end.
- ☐ I proofread my essay for grammar and spelling errors.

Assessment Rubric

	Scoring Elements	1 Below Expectations	2 Approaches Expectations	3 Meets Expectations	4 Exceeds Expectations
RESEARCH	**Reading**	Attempts to present information in response to the prompt, but lacks connections to the texts or relevance to the purpose of the prompt.	Presents information from the text relevant to the purpose of the prompt with minor lapses in accuracy or completeness.	Presents information from the text relevant to the prompt with accuracy and sufficient detail.	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the text.
	AMNH Exhibit	Attempts to present information in response to the prompt, but lacks connections to the Museum exhibit content or relevance to the purpose of the prompt.	Presents information from the Museum exhibit relevant to the purpose of the prompt with minor lapses in accuracy or completeness.	Presents information from the Museum exhibit relevant to the prompt with accuracy and sufficient detail.	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the Museum exhibit.
WRITING	**Focus**	Attempts to address the prompt, but lacks focus or is off-task.	Addresses the prompt appropriately, but with a weak or uneven focus.	Addresses the prompt appropriately and maintains a clear, steady focus.	Addresses all aspects of the prompt appropriately and maintains a strongly developed focus.
	Development	Attempts to provide details in response to the prompt, including retelling, but lacks sufficient development or relevancy.	Presents appropriate details to support the focus and controlling idea.	Presents appropriate and sufficient details to support the focus and controlling idea.	Presents thorough and detailed information to strongly support the focus and controlling idea.
	Conventions	Attempts to demonstrate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics.	Demonstrates an uneven command of standard English conventions and cohesion. Uses language and tone with some inaccurate, inappropriate, or uneven features.	Demonstrates a command of standard English conventions and cohesion, with few errors. Response includes language and tone appropriate to the purpose and specific requirements of the prompt.	Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors. Response includes language and tone consistently appropriate to the purpose and specific requirements of the prompt.
SCIENCE	**Content Understanding**	Attempts to include science content in explanations, but understanding of the topic is weak; content is irrelevant, inappropriate, or inaccurate.	Briefly notes science content relevant to the prompt; shows basic or uneven understanding of the topic; minor errors in explanation.	Accurately presents science content relevant to the prompt with sufficient explanations that demonstrate understanding of the topic.	Integrates relevant and accurate science content with thorough explanations that demonstrate in-depth understanding of the topic.