TECTONIC PLATES | EDUCATOR

Links to Next Generations Science Standards |

MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
MS-ESS2-3: Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.
MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Links to Common Core Standards |

CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

S T E M

Supplement Video |
https://www.youtube.com/watch?v=KCU_O--ycSc
https://vimeo.com/150901376 (password: exploration)
Pacing | 2 - 3 class periods (45 minutes ea)
Background Needed | Layers of the Earth, Density, Earth History
Assessment | Scientific Reporting Rubric provided
Materials/Resources |

- Materials needed per lab group:
  - 2 whole graham crackers
  - 1 index card
  - 1 spoonful of frosting
  - 1 cup of water
  - 1 piece of wax paper
  - Electronic device with internet access
  - Red and blue pens/markers/pencils
- Recommended online resources:
  - http://www.volcanodiscovery.com/volcano-map.htm
  - http://earthquake.usgs.gov/earthquakes/map/
  - http://volcanoes.usgs.gov
  - http://volcano.si.edu/reports_weekly.cfm
  - http://www.nautiluslive.org/video/2013/10/30/big-rocks-big-waves-uncovering-montserrats-geological-history

Overview

This learning module consists of three activities to guide students towards better understanding of tectonic plate movements and boundary types. In the first activity, the students watch a Nautilus Live video to learn how marine geologists study tectonic plates. The second activity is a hands-on activity where students use graham crackers and icing to model plate movements and boundaries and predict the landforms that result. In the third activity the students choose a plate boundary location that interests them and collect real-time earthquake and volcano data for that boundary. They then use the knowledge that they gained from the previous activities to determine the type of boundary that is occurring at that location.

Objectives & Learning Outcomes

- Students will understanding of the cause and effect of tectonic plate movements and how scientists study them.
- Students will be able to describe the three types of plate boundaries and the types of landforms/seafloor features that occur as a result of each.
- Students will be able to use real-time earthquake, volcano, and satellite data to determine the type of plate boundary occurring at a location on Earth.

Extensions & Adaptations

Introductory |

English Language Learners could be given a vocabulary list prior to the activities and they could also be partnered with an english language speaker. Special needs students could be placed in groups with other students. The third activity could be differentiated by giving the students the data and then having them interpret it versus collecting the data on their own.

Advanced |

This activity could be easily differentiated for advanced learners into an open inquiry. In the second activity, students could be given the materials and asked to model the types of plate boundaries without any direction. In the third activity, the guiding questions used in the set-up of the plate inquiry could be removed and the students could develop their own testable question on plate boundaries and develop a plan to collect data on their own.

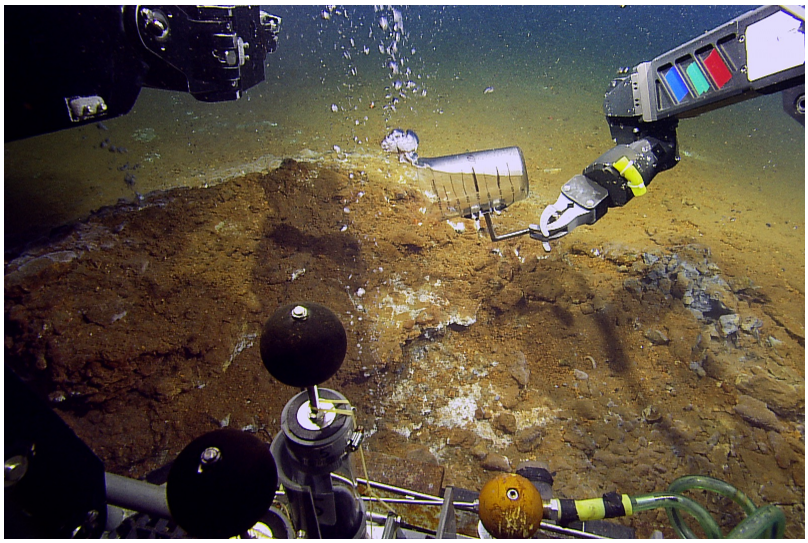
Guiding Questions

- What happens to the tectonic plates resting on the mantle if the rocks under them are moving? Do they stay in one place or do they move too? If they are moving, how does this impact life on land and in the ocean?
- How can we use earthquake and volcano data as well as seafloor and land features to determine the type of plate boundary and predict tectonic plate movement?

Activity/Tasks

Students will:

- Activity 1: How do scientists study moving tectonic plates?
  - Students watch a Nautilus Live video on Marine Geology and discuss how marine geologists study tectonic plates.
- Activity 2: What happens when tectonic plates move?
  - Students use graham crackers and icing to model plate movements and boundaries and predict the landforms that result.
- Activity 3: Be the scientist! Can you use data to predict the type of plate boundary?
  - Students choose a plate boundary location that interests them and collect real-time earthquake and volcano data for that boundary. They then use the knowledge that they gained from the previous activities to determine the type of boundary that is occurring at that location.



Extensions & Adaptations

Extension I
Use GPS coordinates taken from fine-scale instruments to plot tectonic plate movements around the world (http://nautl.us/1Vl8fog)

Implementation Notes, Thoughts & Ideas

Educator: Lesson Procedure/Directions

Activity One:

- Show students this video clip http://nautl.us/1WoJ0T9 and lead a group discussion on how marine geologist study plate tectonics.

Activity Two:

- Distribute materials to the lab groups. Each group will get two full graham crackers and a spoonful of icing on their wax paper. They will also need a small cup of water and an index card. As the students are doing the activity, the teacher should be circulating to make sure that the students are making their hypotheses before they test their graham crackers and that they are following the directions correctly. When the students have completed the activity, the teacher should facilitate a discussion on what the students noticed when their graham cracker plates collided, moved apart, and slid past one another.

Activity Three:

- Assist students with guiding questions to formulate their problem statement and data collection. Students will use several internet sites to collect earthquake, volcano, and landform data, and then plot data on a map and data table. Some groups may need more guidance in using the websites to collect their data. They also may struggle in finding patterns and interpreting the data that they collect.

TECTONIC PLATES | STUDENT

Learning Goals

- Understand the cause and effect of tectonic plate movements and how scientists study them.
- Describe the three types of plate boundaries and the types of landforms/ seafloor features that occur as a result of each.
- Use real-time earthquake, volcano, and satellite data to determine the type of plate boundary occurring at a location on Earth.

THINK About It!

Discuss the key terms at right with a partner. Draw a picture or symbol next to each term to help you remember what each word means.

Challenge: Test your marine geology skills! Use graham crackers and icing to illustrate the different ways Earth's crust moves. Investigate evidence from earthquakes and volcanoes at plate boundaries to predict global tectonic patterns.

Introduction |

Imagine you are building a jigsaw puzzle. All the pieces fit together, but rather than building the puzzle on a firm table you build it on a pan of jello. What would happen to your completed jigsaw puzzle? Would the pieces stay in one place?

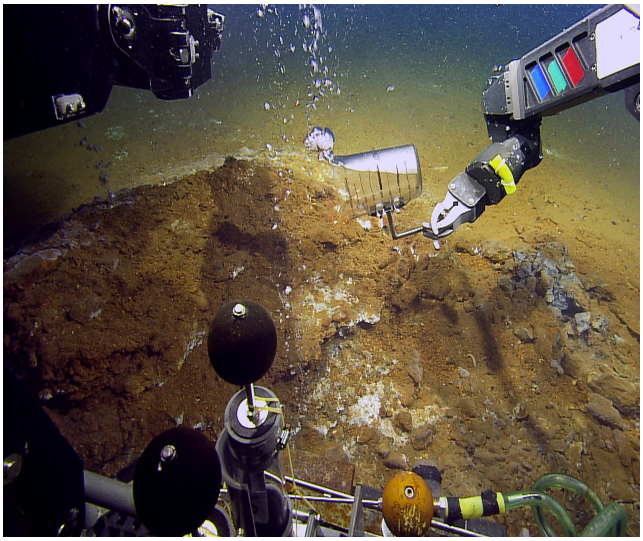
The crust of the Earth is broken up into pieces called tectonic plates which fit together like jigsaw puzzle pieces. However, they are resting on a layer of the Earth called the mantle which is is made of rock that is neither a solid nor a liquid. As a result of convection currents in the mantle, the semi-solid mantle rocks rise and fall in large circles called convection currents. So what happens to the tectonic plates resting on the mantle if the rocks under them are moving? Do they stay in one place or do they move too? If they are moving, how does this impact life on land and in the ocean? Through the following activities you will be investigating tectonic plates to find the answers to all these questions!

Key Terms:

Tectonic Plates
Crust
Mantle
Divergent Plate Boundary
Convergent Plate Boundary
Transform Plate Boundary
Continental Plate
Oceanic Plate
Convection Currents

Materials: [per lab group]

- 2 whole graham crackers
- 1 index card
- 1 spoonful of frosting
- 1 cup of water
- 1 piece of wax paper
- Computer or tablet with internet access
- Red & blue pencils, pens or markers



Activity One

How do scientists study moving tectonic plates?

When the tectonic plates move, earthquakes and volcanoes can occur as a result. Watch the following clip to see how the Corps of Exploration studied a past volcanic eruption in the Caribbean in 2013 and its impact on the biology and geology of the area. Answer the questions after you watch the clip and be prepared to discuss your answers.

Video Clip: http://nautl.us/1WoJ0T9

1. What was the Corps of Exploration studying off the coast of Montserrat? How were the scientists collecting data to study this area?

2. What is a tsunami? How might a volcanic eruption cause a tsunami?

3. What do you think is happening to the tectonic plates to form the volcanoes in this region of the Caribbean?

Activity Two

What happens when tectonic plates move?

Where two or more tectonic plates meet it is called a plate boundary. There are three types of basic plate boundaries recognized by what direction the plates are moving at the boundary. When the two plates move apart (diverge) it is called a divergent boundary. When two plates collide, it is called a convergent boundary. When two plates slide past each other horizontally it is a transform boundary. There are two types of tectonic plates, oceanic and continental, and they differ in density. Continental plates contain much less dense rocks than oceanic plates. The densities of the plates determine what happens when the plates collide and what type of landform results. In this activity you will model these three types of plate boundaries to see what kind of landforms may result.

Plate Boundary #1: A Divergent Boundary
Problem: What will happen when you move two graham cracker plates away from each other when they are resting on icing?
Hypothesis:

Procedure:
1. Place a spoonful of frosting in the center of your wax paper.
2. Break off two pieces (quarters) of your graham cracker.
3. Lay the two crackers next to one another on top of the frosting.
4. Press down LIGHTLY (don't break the crackers) and slowly push the crackers away from each other (1-2 cm).

Conclusion:
Draw a picture of what you observed. What type of land or seafloor features result from this type of boundary? Label your drawing to show how this boundary produces these land features.

Activity Two

Plate Boundary #2: A Continental-Oceanic Convergent Boundary
Problem: What will happen when you push a graham cracker into an index card?
Hypothesis:

Procedure:
1. Lay one of the cracker sections on your wax paper (NOT in the frosting).
2. Place the index card next to it (end-to-end).
3. Slowly push the cracker and index card towards each other.

Conclusions:
Which plate (index card or graham cracker) was less dense? How do you know? Which one would represent the continental plate and which one would represent the oceanic plate?

Draw a picture of what you observed. What type of land or seafloor features result from this type of boundary? Label your drawing to show how this boundary produces these land features.

Activity Two

Plate Boundary #3: A Continental-Continental Convergent Boundary

Problem: What will happen when you push two soggy graham crackers together?

Hypothesis:

Procedure:

1. Take two pieces of graham cracker and dip one end of each into water (less than half).
2. Place the crackers on the wax paper with their wet ends touching and gently push them together.

Conclusions:

Draw a picture of what you observed. What type of land features result from this type of boundary? Label your drawing to show how this boundary produces these land features.

Plate Boundary #4: A Transform Boundary

Problem: What will happen when two graham crackers slide past one another?

Hypothesis:

Procedure:

1. Place two graham crackers next to each other on the wax paper (long ways).
2. Place one hand on each piece and slowly apply pressure and push the two pieces together and also slide the pieces past one another.

Conclusions:

Draw a picture showing what happened to the graham crackers as you slid them past one another. Based on what you observed, why do you think there would be a lot of earthquakes in this area?

Activity Three

Be the Scientist! Can you use data to predict the type of plate boundary?

Now that you are familiar with the three types of plate boundaries, you will test your knowledge by examining actual earthquake and volcano data to predict the specific interactions at a plate boundary. The Corps of Exploration use earthquake and volcano data, collect rock and sediments samples, examine biological communities, and analyze video transects to determine the geologic activity in an area. In this activity you will become a marine geologist and choose a plate boundary to research and determine the type of plate boundary based upon evidence.

Pre-Lab Questions

1. What is a divergent boundary? What kind of landforms/seafloor features are found at a divergent boundary?

2. What is a convergent boundary?

   A. What kind of landforms/seafloor features are found at a convergent boundary between an oceanic plate and continental plate?

   B. What kind of landforms/seafloor features are found at a convergent boundary between two oceanic plates?

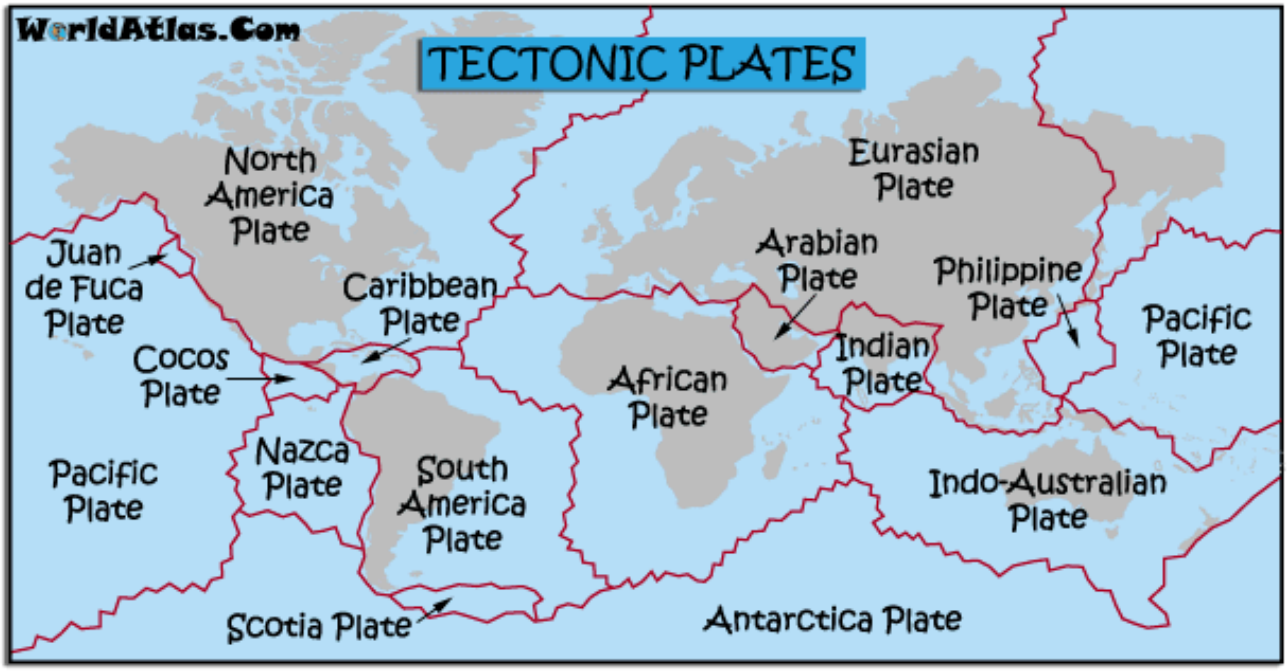
   C. What kind of landforms/seafloor features are found at a convergent boundary between two continental plates?

3. What is a transform boundary? What kind of evidence/landforms/seafloor features are found at a transform boundary?

Activity Three

Choose a Plate Boundary

Use the picture of the Earth's tectonic plates above to select a plate boundary between two specific plates that you are interested in. Record your two plates in the problem statement below.



Problem Statement: What type of plate boundary occurs between the _____ Plate and the _____ Plate?

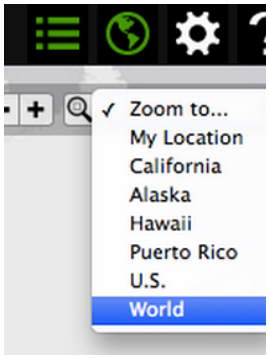
Your Hypothesis: *What do you think is the answer to the question you asked above and explain why?*

Activity Three

Data Collection

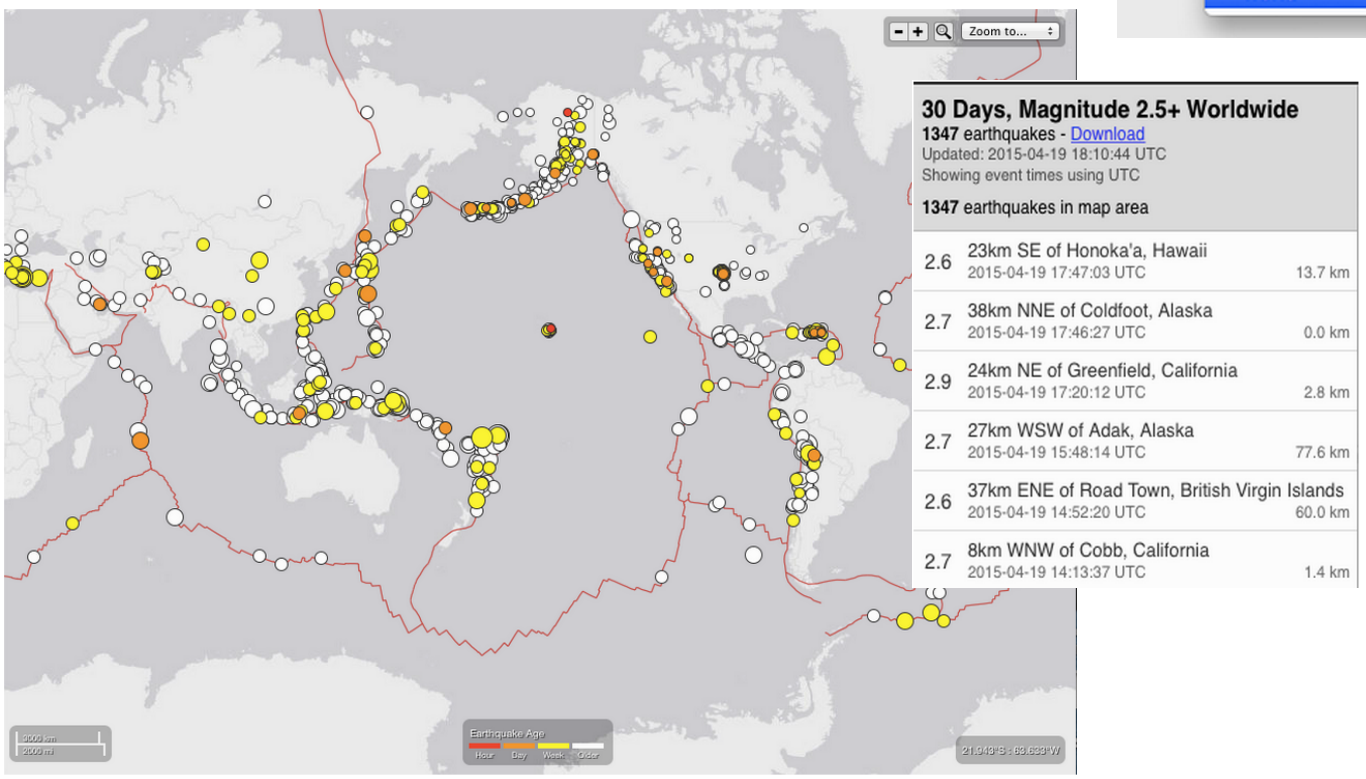
Earthquake Data

Go to: http://earthquake.usgs.gov/earthquakes/map/



1. In the upper right corner click "Zoom to World". The map will show a global map with red lines marking the plate boundaries and dots for earthquakes.

2. Click the gear button in the upper right and chose the setting "30 Days, Magnitude 2.5+ Worldwide". Your map should look like the one below.



3. Select a specific plate boundary, begin examining local earthquake data by either clicking on the earthquake circle or looking at the list on the left side of the screen.

4. Complete the Earthquake Data Table recording data for ten earthquakes from the last month along the plate boundary you selected. Some boundaries are more active than others.

5. After you have collected your data. Plot each earthquake on your plate boundary map with a blue dot.

Activity Three

Earthquake Data Table

	Magnitude	Date	Location	Latitude	Longitude
	2.6	4-19-15	Honoka'a, Hawaii	19.9 N	155.3 W
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Volcano Data

For volcano data within the United States visit: http://volcanoes.usgs.gov.
For volcano data worldwide visit: http://volcano.si.edu/reports_weekly.cfm OR http://www.volcanodiscovery.com/volcano-map.html.

Zoom to the plate boundary you are researching and record any volcanic activity in the table below. After completing the data table, plot each volcano on your plate boundary map (below) with a red dot.

Activity Three

Volcano Data Table

	Volcano Name	Location	Status	Latitude	Longitude
	Cleveland	Aleutian Islands, AK	Active	52.8 N	170 W
1					
2					
3					
4					
5					
6					
7					

Landform Data

Use a map or mapping website like Google Maps (in satellite view) to answer the questions about landforms seen along your plate boundary.

1. Is your plate boundary on land, under the ocean, or both?

2. What types of landforms on land or in the water do you see along your plate boundary? Do you see mountains, evidence of faults, volcanoes, islands, etc…along the plate boundary?

3. How are humans using the land along your plate boundary? Are there any major cities, roads, structure, famous landmarks, etc...along the plate boundary?

* *Label any major landforms, cities, or human structures/landmarks that fall along your plate boundary on the included map.*

Additional Resources

Biography: Meet a Marine Geologist, Nicole Raineault - http://www.nautiluslive.org/people/nicole-raineault

Article: What is an Ocean Bottom Seismometer? - http://www.whoi.edu/instruments/viewInstrument.do?id=10347

IRIS Seismic Monitoring Data - http://ds.iris.edu/seismon/

Activity Three

Data Analysis - Find the Patterns!

List and describe three patterns that you notice in your earthquake, volcano, and/or landform data along your plate boundary:

1.

2.

3.

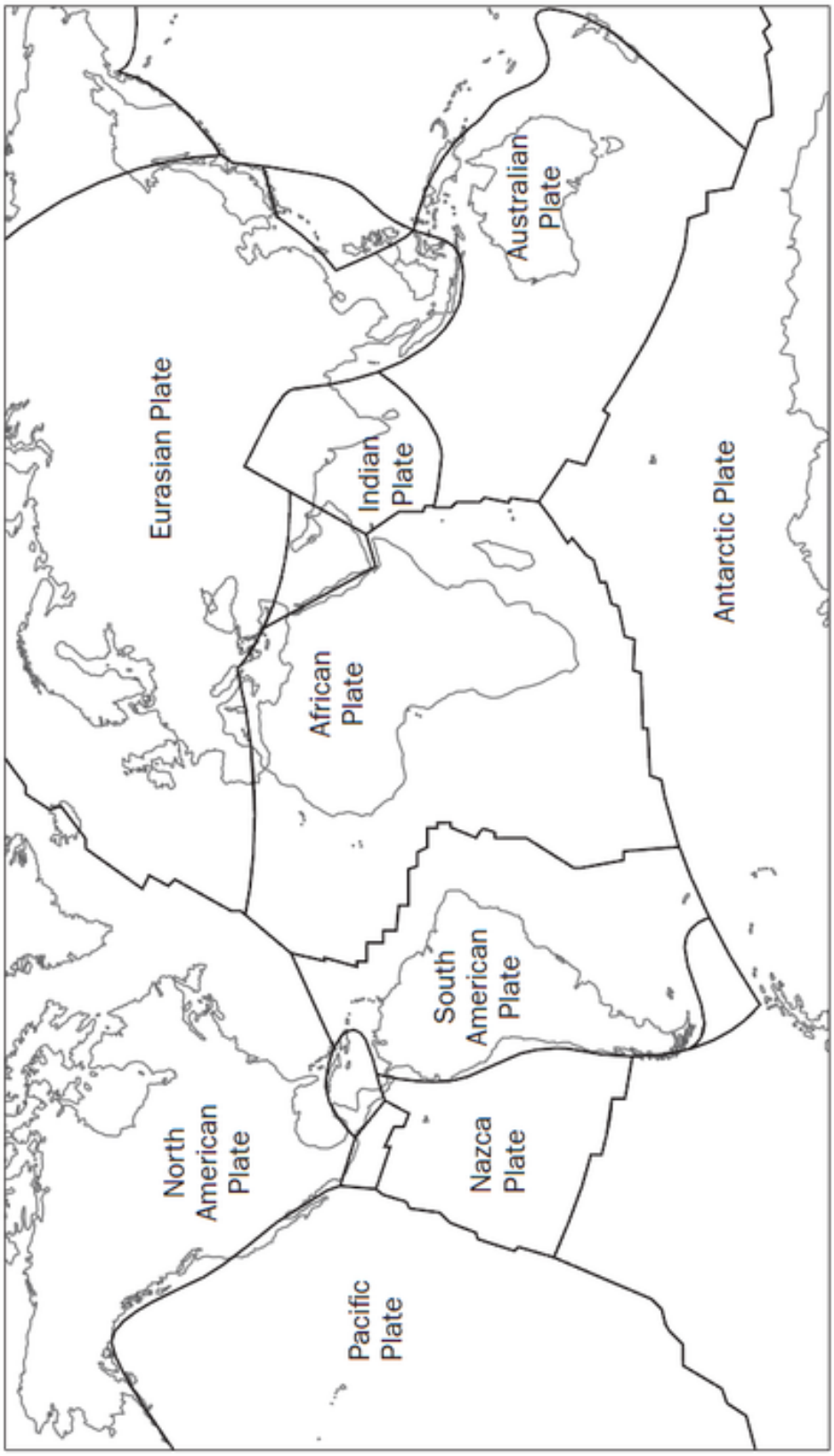
Draw Your Conclusions

1. Based on your data, what type of plate boundary do you think your boundary represents? [divergent, transform convergent (oceanic, continental, or oceanic with continental] Support your response with data you have collected as to why it is only type and why it is not the others.

2. Did you accept or reject your initial hypothesis? Explain why using data you collected in your explanation.

3. Why do you think it is important to research and better understand plate boundaries and their movements?

4. If you were exploring with the Corps of Exploration at this plate boundary, what type of exploration would you want to conduct to test your hypothesis?


Australian Plate
Eurasian Plate
Indian Plate
Antarctic Plate
African Plate
South American Plate
North American Plate
Nazca Plate
Pacific Plate

Scientific Reporting Rubric

OBJECTIVE	CRITERIA			
	4 Exemplary	3 Commended	2 Emerging	1 Developing
Communication of Data and Analysis |	Student chooses appropriate formats (graphs, charts, tables, diagrams, etc.) to best communicate data. No errors in data format (includes titles, units, captions, etc.). Student provides a thorough and detailed written summary of data, including key observations, trends, and identification of outliers or anomalies.	Student chooses appropriate formats (graphs, charts, tables, diagrams, etc.) to best communicate data. Data may contain minor errors in format. Student provides a written summary of data, including key observations, trends, and identification of outliers or anomalies.	Student attempts to choose appropriate formats (graphs, charts, tables, diagrams, etc.) to best communicate data. Data may contain errors in format or may be missing some information. Student provides a weak written summary of data.	Student does not choose appropriate formats (graphs, charts, tables, diagrams, etc.) to best communicate data. Data may contain errors in format or may be missing some information. Student provides a minimal written summary of data.
Critical Thinking |	Student includes effective use of sources, facts and data to support what was learned in a conclusion or overview statement. Student is able to reflect on implications, errors and limitations of the data and connect to other topics. Student can suggest next steps or future improvements & modifications to topic(s) addressed.	Student uses sources, facts and data to support what was learned in a conclusion or overview statement. Student is able to reflect on implications, errors and/or limitations of the data. Student can suggest a next step or future improvement/ modification to topic(s) addressed.	Student uses some sources, facts or data to support what was learned in a conclusion or overview statement. Student is able to weakly reflect on implications, errors and/or limitations of the data. Student attempts at suggesting a next step or future improvement/ modification to topic(s) addressed.	Student uses few sources, facts or data to support what was learned in a conclusion or overview statement. Student is able to weakly reflect on implications, errors and/ or limitations of the data.
Language and Conventions |	Student produces clear and coherent writing in which the development, organization and style are appropriate to task, purpose and audience. Demonstrates an exemplary command of standard English conventions.	Student produces writing in which the development, organization and style are appropriate to task, purpose and audience. Demonstrates a command of standard English conventions; errors do not interfere with understanding.	Student produces writing in which some development, organization and style are appropriate to task, purpose and audience. Demonstrates a limited and/or inconsistent command of standard English conventions; errors may interfere with understanding.	Student produces writing in which there is limited development, organization and style appropriate to task, purpose and audience. Demonstrates a weak and/or inconsistent command of standard English conventions; errors interfere with understanding.
Total Score: _____	**Comments:**			

How Large is Nautilus Nation?

Tracking the reach of Ocean Exploration Trust's education programs is essential in ensuring we are funded to continue making discoveries and inspiring the next generation of explorers.

Name: **My Community (City, State):**

Email Address:

School's Name:

Instruction date: **Grade level instructed:**

Subject area:

My education space is a...

- ❑ Classroom
- ❑ After school program / Club meeting
- ❑ Fair / Festival / Event
- ❑ Museum / Science Center
- ❑ Other. Tell us more:

Who did you engage in your teaching?

Students

Community Members

Select all the OET materials you used in your instruction:

- ❑ STEM Learning Modules. Which ones? _____
- ❑ Digital Resource Library materials. Which ones? _____
- ❑ Nautilus Live website: photo albums ❑ highlight videos ❑ live stream
- ❑ Meet the Team STEM mentor profiles
- ❑ Facebook (NautilusLive) ❑ Twitter (@EVNautilus) ❑ Instagram (@nautiluslive)
- ❑ Other. Tell us more: _____

_____

What made working with OET resources valuable to your instruction (select all that apply)?

- ❑ Hands-on activities ❑ STEM career connections
- ❑ Easy to use lessons ❑ Standards-based lessons
- ❑ Website resource access ❑ Real world application of curricula topics
- ❑ Excitement of cutting-edge discoveries / Unfamiliarity of deep ocean
- ❑ Another reason. Tell us more: _____

_____

Using OET resources increased my confidence in teaching my science, technology, engineering, or math subjects.	❑ Yes	❑ No
OET provided me with helpful and relevant teaching resources.	❑ Yes	❑ No
Using OET resources increased my awareness of STEM careers.	❑ Yes	❑ No
If yes, how so? How can we improve?		

Please scan this document or snap a picture of it with your phone. Email the feedback or questions to education@oet.org. You can also submit feedback online: http://nautl.us/2cp3PNu

Thank You For All You Do!