Project DiRT
Disaster Relief Transporter
(responding to Earth's Changing Surface)

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Table of Contents

Dynamic Earth and Project DiRT

Unit and Project Overview

The Earth appears to be moving at a steady state and very slowly. The constant rotation on its axis and the planet's revolution around the sun seem to be non-existent, as we really don't feel that motion, but evidence is clear with the change in the amount of daylight we experience. However, even if we look at the Earth as static, it is actually a dynamic and ever-changing planet. Agents of **erosion** such as wind, water, and ice shape the land. **Volcanic eruptions** and **earthquakes** alter the landscape in dramatic, and often violent, manners. On a much longer timescale, the movement of the Earth's plates slowly reconfigures oceans and continents.

The Earth's changes, in terms of surface geological features, are all natural. Most changes occur really slowly, sometimes over decades or even centuries. Some changes are quick, or even instant. Whether fast or slow, these changes alter the geological features of our planet, which we see on the surface. The erosion evident in Lake Mead and the Las Vegas Wash continue to change our local topography, and believe it or not, earthquake faults are present in the state of Nevada. The Silver State is the nation's third most seismically-active region. With roughly 1,500 faults, Nevada is no different than California (*news3lv.com, July 14th 2014*). With these fault lines beneath us, we are vulnerable to the rapid and devastating changes of our surface structures. The mountains around Las Vegas might not be around long.

When catastrophic events, such as earthquakes or landslides due to massive erosion and flooding, occur people come together and work to help the survivors. However, often bringing supplies to affected areas seems to be impossible.

This unit helps students understand how the Earth's surface is constantly changing and what we can do to help mitigate the effects of natural disasters. Students will design and create a Disaster Relief Transporter (DiRT), which can traverse all types of terrain, focusing on the wheel and tire design. This unit requires from **6 to 7** weeks.

Acknowledgements: Lessons created by Alexa Freshour and Mignon Penalosa, with support from Dr. Erica Marti and UNLV students Hunter Stepanian, Abdel Rahman El Bouri, Priscilla Maiava, and Paul Oko.

Next Generation Science Standards

EARTH'S SYSTEMS   MS-ESS2-3

Students who demonstrate understanding can:

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.** [Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).] [*Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena. - - - - - - - - - - - - - - - - ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Science findings are frequently revised and/or reinterpreted based on new evidence.	**ESS1.C: The History of Planet Earth** • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. *(HS.ESS1.C GBE),(secondary)* **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.	**Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural systems.

Connections to other DCIs in this grade band:
MS.LS4.B

Articulation of DCIs across grade-bands:
3.LS4.A ; 3.ESS3.B ; 4.ESS1.C ; 4.ESS2.B ; 4.ESS3.B ; HS.LS4.A ; HS.LS4.C ; HS.ESS1.C ; HS.ESS2.A ; HS.ESS2.B

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. *(MS-ESS2-3)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS2-3)

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-3)

Mathematics -

MP.2 Reason abstractly and quantitatively. (MS-ESS2-3)

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS2-3)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS2-3)*

Lessons 1 - 3 in unit.   *Table from NGSS Evidence Statements*.

EARTH'S SYSTEMS   MS-ESS2-2

Students who demonstrate understanding can:

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future.	**ESS2.A: Earth's Materials and Systems** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **ESS2.C: The Roles of Water in Earth's Surface Processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.	**Scale Proportion and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Connections to other DCIs in this grade band:
MS.PS1.B ; MS.LS2.B

Articulation of DCIs across grade-bands:
4.ESS1.C ; 4.ESS2.A ; 4.ESS2.E ; 5.ESS2.A ; HS.PS3.D ; HS.LS2.B ; HS.ESS1.C ; HS.ESS2.A ; HS.ESS2.B ; HS.ESS2.C ; HS.ESS2.D ; HS.ESS2.E ; HS.ESS3.D

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS2-2)
WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS2-2)
SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-ESS2-2)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (MS-ESS2-2)
6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS2-2)*
7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS2-2)*

Lessons 4 - 6 in unit.

Table from NGSS Evidence Statements.

EARTH'S AND HUMAN ACTIVITY MS-ESS3-2

Students who demonstrate understanding can:

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.** [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**ESS3.B: Natural Hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data. - - - - - - - - - - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Connections to other DCIs in this grade-band:
MS.PS3.C

Articulation of DCIs across grade-bands
3.ESS3.B ; **4.ESS3.B** ; **HS.ESS2.B** ; **HS.ESS2.D** ; **HS.ESS3.B** ; **HS.ESS3.D**

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. *(MS-ESS3-2)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS3-2)

Mathematics -

MP.2 Reason abstractly and quantitatively. (MS-ESS3-2)

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS3-2)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS3-2)*

Lessons 7 – 9 in unit. *Table from NGSS Evidence Statements.*

ENGINEERING DESIGN MS-ETS1- 1,3,4

MS-ETS1 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-1. **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**

MS-ETS1-2. **Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**

MS-ETS1-3. **Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**

MS-ETS1-4. **Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1) **Developing and Using Models** Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4) **Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3) **Engaging in Argument from Evidence** Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)	**ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

Connections to MS-ETS1.A: Defining and Delimiting Engineering Problems include:

Lessons 7 - 9 in unit.

Table from NGSS Evidence Statements.

<table>
<tr><th colspan="2">Dynamic Earth | 7th Grade Science</th></tr>
<tr><td colspan="2">Lesson One: Past Earth vs Present Earth</td></tr>
<tr><td colspan="2">Question: How did the Earth look in the past? Why do lithospheric plates move?</td></tr>
<tr><td colspan="2">Objective: Identify the shapes of the continents and provide evidence that they were once joined as a supercontinent.</td></tr>
<tr><td colspan="2">Phenomena: Supercontinent (plate tectonics)</td></tr>
<tr><td>Science 7 Knowledge Targets</td><td>Science 7 Performance Targets</td></tr>
<tr><td>● Know the shapes of the continents; provide evidence that they were once joined as a large landmass.
● Know the theory of plate tectonics and evidence from fossils, geological features, and seafloor spreading to explain the movement of the Earth's lithospheric plates.
● Know that the lithospheric plates continue to move at a relatively slow rate.</td><td>● Demonstrate how the shapes of the continents could fit together like a jigsaw puzzle.
● Use evidence from fossils and rocks on the edges of continents to show they were previously joined together.
● Analyze the patterns of the ages of rocks on the seafloor to identify evidence of plate motion.</td></tr>
<tr><td>Time</td><td>Vocabulary</td></tr>
<tr><td>Suggested: 5 - 6 periods (50-minute class periods)</td><td>Continental drift theory   Lithosphere
Core   Mantle
Crust   Mid-ocean ridge
Plate boundary   Plate tectonics
Seafloor spreading   Supercontinent</td></tr>
<tr><td>Background Information</td><td>Materials</td></tr>
<tr><td>In 1912, some wondered why there were similar species that looked like each other on different continents of the world. This is when Alfred Wegner proposed that all of the continents were once joined together, before breaking up and drifting to where there are now. Wegner based his theory on the fact that rocks and fossils were found in similar climates, but on different land masses. However, it wasn't until decades later that geoscientists confirmed his theory of Pangea, the supercontinent.

Plate tectonics is a theory of the Earth's crust being fractured into rigid, moving plates. Sea floor spreading on the ocean floor is where new plate material is born. Plates that push together create mountain ranges.</td><td>● Image sort sets (1 set/partner)
● World map
● Globes (1/table or group)
● Articles printed or linked for devices
● World Maps (2/student)
● Scissors
● Glue sticks or tape
● White paper
● Gizmo Simulation assigned to classes

A map should be posted and visible at all times. Because this unit focuses heavily on the Earth's appearance, features, events, and movements, having your map laminated helps you to annotate for students with dry erase markers.</td></tr>
</table>

Lesson Overview (Activities)	*Advance Preparation*
Activity 1: • Examine the present Earth. • Explain continental drift. **Activity 2:** • Examine additional phenomena taken from the ocean floor that leads to the development of the theory of plate tectonics. Continental Drift Article: *Readworks: Our Changing Earth: Plate Tectonics or NewsELA: Plate tectonics: Earth's continents are not stuck in one place* **Activity 3:** • Construct models of the Earth's plates using the *Building Pangea Gizmo* as evidence for CER.	*Most CCSD schools utilize a subscription for their teachers to Explore Learning Gizmo Simulations. By using your CCSD email and the association with your school, you should be able to login/enroll. If your school does not have a subscription, visit the Gizmo website to create a free account here.* *You will also need to create classes within Gizmo so your students can independently run simulations. You can create a class code for students to enroll in your class.*

Procedure

Engage: Show students a large map and have a globe for each group of students. Ask them to make observations. **Explore:** ***A: Map Puzzle*** Use scientific evidence to consider what Earth might have looked like in the past to construct a model of Pangaea. Using the idea of overlaying, students will be able to determine how the continents were put together. ***Student Directions:*** 1. You have two world maps with the continents shown in different colors. Write "Present" on the top of one of the maps. This map represents what Earth looks like today. Do not do anything else to this map. 2. Use scissors to cut the second map apart according to the continents' outlined shapes. 3. Fit the continents together (like a jigsaw puzzle) based on their outlines and other evidence that supports the theory of Pangea, supercontinent. 4. When you are finished, glue or tape the continents in place on a blank sheet of white paper labeled "Past." *This represents your predictions about how the world may have looked 250 million years ago.* 5. Once your map is complete, answer the following questions (*See worksheet below*). ***B: Continental Drift Article*** Students should read and annotate the text assigned: (choice of two: *Readworks: Our Changing Earth: Plate Tectonics or NewsELA: Plate tectonics: Earth's continents are not stuck in one place*) The	How can you explain why the ocean floor is the youngest at the mid-ocean ridge? Why might it have been important to discover that the age of the ocean floor varies depending on location? Why do you think that trenches are only located in certain spots on Earth? How can you explain how the trenches might form on the ocean floor? **Explain:** ***A: Map Puzzle*** To make sense of the past and present maps, students should understand the simulation and respond to the questions. *If students have iPads, they can record all of the possible options for how the continental puzzle pieces fit together.* ***C: Ocean Floor Data*** After students have recorded their notes and observations from the images within the table, students should reply to the questions. (Answers will vary but should reflect these ideas): *1) Scientists came up with a model to synthesize some of what they had learned from the newest ocean floor data.* *2) They called this, model ocean floor (or ocean floor) spreading. This is a relatively simple explanation that has new rocks being formed at the mid-ocean ridge, and spreading the ocean floor apart in different directions. This results* *in the movement of the ocean floor, and also movement of the continents.* *3) This was a very important discovery, as it provided a plausible mechanism for how continents could move around on the surface of the earth. They were not plowing through the ocean floor; the ocean*

text will enhance students' thinking, and be used for explanation. ***C: Ocean Floor Data*** Show students three images of the ocean. While showing them the images, ask questions and annotate on your map; students can also update and record their own observations. ***Prompts*** Where are the mountains located on the map? How did you know those were mountains on the map? Are there different elevations in the oceans? How do you know? Is there any evidence of mountains on the ocean floor?	*floor itself was also moving.* **Extend** To further the idea of plate movement and students' understanding of the Earth, show students a series of five images. Ask students to organize the images from past to present. This will allow them to demonstrate that the continental plates didn't change from the past Earth (Pangea) to the present Earth. Students can also explain their reasons for understanding. **Evaluate:** After completing the Ocean Floor Data analysis, students will determine what scientists understand to support the idea of plate movement and Pangea.
Suggested Assessment(s)	***Additional Resources***
1: Continental Image Sort 2: Students should construct a CER (Claim Evidence Reasoning), using screenshots from the Gizmo. (*See examples below.)*	• The Desert Research Institute offers a *Green Box* for Plate Tectonics • Pangea Video • Understanding Geologic Time • ReadWorks: Our Changing Earth - Plate Tectonics • NewsELA: Plate tectonics • Building Pangea Gizmo

Continental Image Sort

Teacher Preparation:

1. Make a set for pairs
2. Cut & place into envelopes

Key: E, B, A, D, C

World Map

Teacher Preparation:

1. Make 2 copies/student.
2. To save paper, both maps can be printed on the same page.

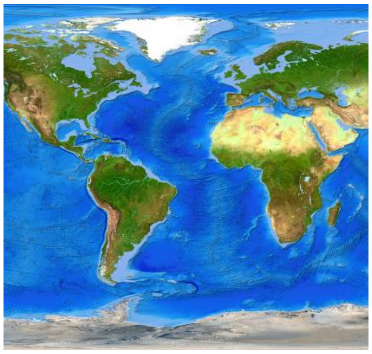
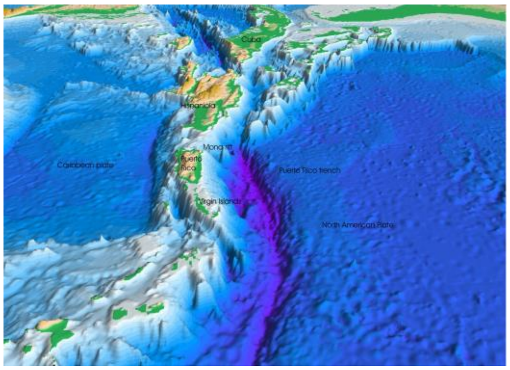
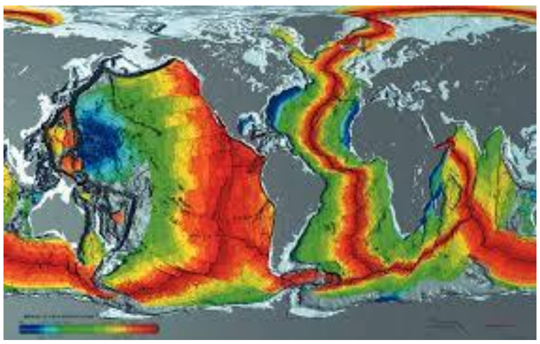
Map Reflection Questions - Provide for students to record in their notebooks or online.

1. Observe and identify all the ways the past and the present maps are different. What caused these changes? List as many possibilities as you can.

2. Is the theory of continental drift a reasonable explanation that continents move over the surface of the earth? Why?

3. Explain another way that you think continents could have changed position over Earth's history.

Ocean Floor Data

Evidence	***Notes***
	***Mountain Range in the Ocean***
	***Age of Ocean Floor***
	***Trenches in the Ocean Floor***

Q: What did the scientists conclude about the ocean floor after discovering these three new ideas?

Claim, Evidence, Reasoning (CER)

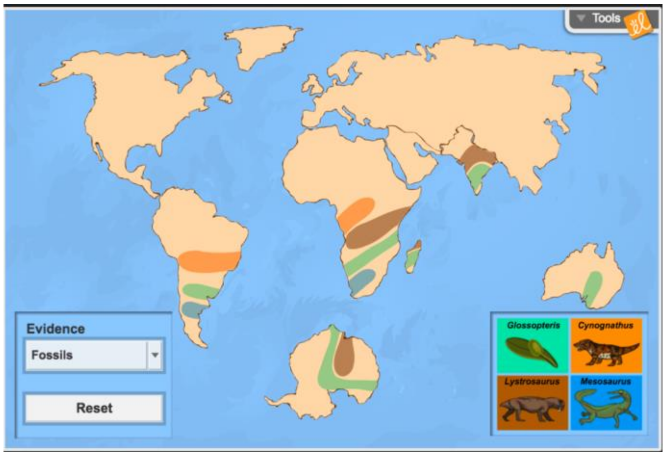
Name ___________________________________ Period __________ Date_________________

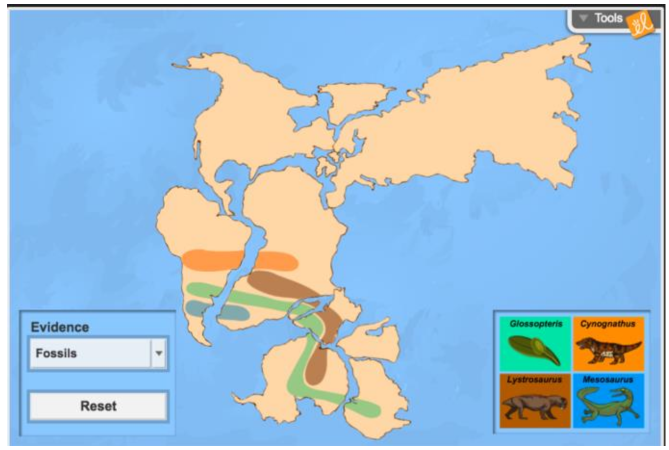
CER: Plate Tectonics

Directions: *1: Answer the question (create your claim). 2: Use the Pangea Gizmo to manipulate the continents to provide evidence for the following: fossils, glaciers, and rocks. Take screenshots of each map that provides evidence for each type and paste within each evidence box. 3: Explain your reasoning of how each type of evidence supports your claim.*

Question: How do rock formation, glaciers, and fossils support the theory of Pangea?		
Evidence	This matters because…. (***Reasoning***: How does this evidence support the claim?)	Therefore, …. (***Claim***)
Fossils		
Glaciers		
Rock Formations		

Sample Gizmo Screenshots for CER Evidence

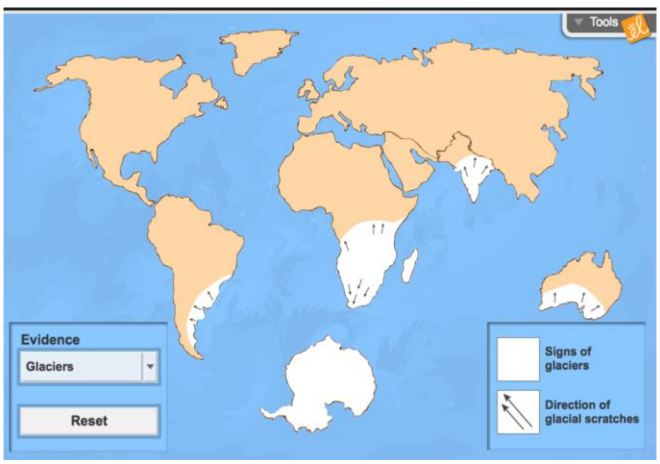


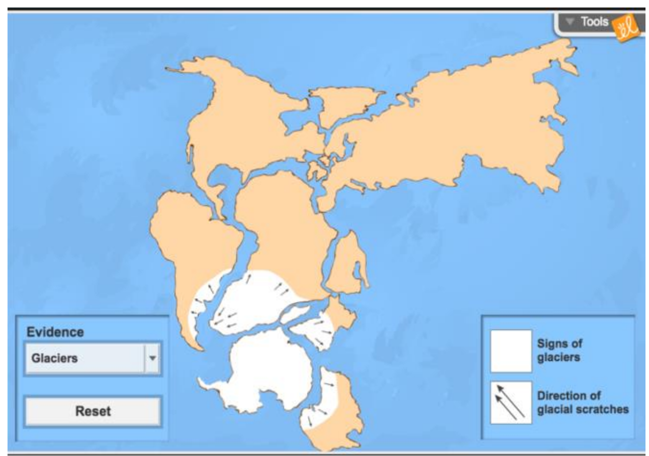


Before Manipulation of Plates

Evidence - Post Manipulation of Plates

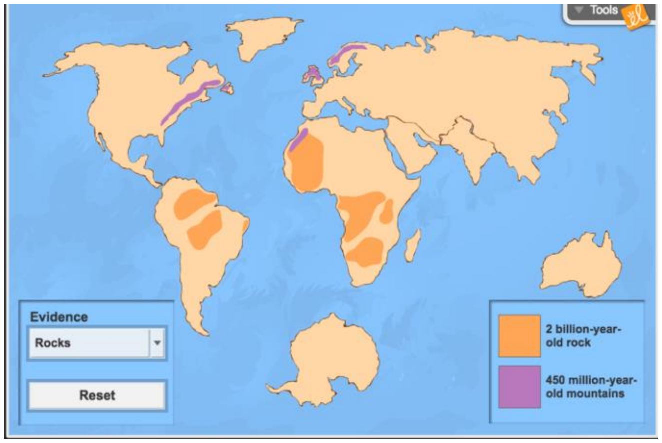
Glaciers

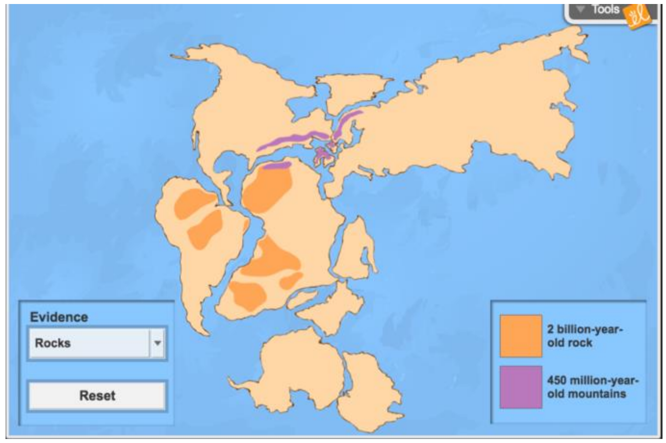




Before Manipulation of Plates

Evidence - Post Manipulation of Plates





Before Manipulation of Plates

Evidence - Post Manipulation of Plates

Lesson Two: Lithospheric Plates

Question: Why do lithospheric plates move?

Objective: Determine how plates in the lithosphere move.

Phenomena: Convection Currents

Science 7 Knowledge Targets	***Science 7 Performance Targets***
• Know that the lithospheric plates continue to move at a relatively slow rate.	• Model how convection currents cause crustal plates to move.
Time	***Vocabulary***
Suggested: 2-3 periods (50-minute periods)	Convection current, Lithosphere Core, Mantle Crust, Mid-ocean ridge Plate boundary, Plate tectonics Density/dense, Heat transfer
Background Information	***Materials***
There are three different forms of heat transfer: conduction, convection, and radiation. Conduction of heat refers to the transfer of heat through a solid. Convection refers to the transfer of heat by a fluid material (such as air or water) moving from one place to another. Warm air is less dense than cold air, so it rises and cold air sinks. This is called natural convection. Air is constantly circulating indoors and outdoors, moving heat from one place to another. Within the Earth's lithosphere, convection takes place. The mantle receives its heat from the core. Areas that are hotter (less dense), rise upwards, and oppositely, areas that are cooler (more dense) sink downwards. This is the process of convection within the mantle, producing mantle material close to the Earth surface.	• Articles: "How heat moves" & "How Earth's surface morphs" • 1 Electric kettle or coffee pot • Sink access *Per Group (materials that are available to you)* • Clear plastic bin filled with water (size - must be able to be supported by the Styrofoam cups) • 3 Styrofoam cups (8 or 12 oz; all same size) • Food Coloring (2 different colors/group) • Ice pack or cubes
Lesson Overview (Activities)	***Advance Preparation***
Activity 1 • Imaging Analysis ***Activity 2*** • Modeling Convection currents in the ocean	*Test the demonstration ahead of time to ensure that you can demonstrate efficiently.* *This activity can get messy fast. You might wish to*

<table>
<tr>
<td>
Example of lab (for teacher preparation)
Activity 3
Partner Jigsaw
How heat Moves
How Earth’s surface morphs article
Activity 4
Plates on the Move
</td>
<td>
set it up outside or use a larger tray or drop cloth underneath to catch spills.

While this activity works much better as a small group activity, it is possible to complete it as a class.

Gather the materials together and set up one equipment tray for each group of three to four students.

Each tray should include 1 clear bin, three cups, food coloring and two droppers.

The students need to have access to tap water and hot water. For better results, use hotter water. Tap water will work, but the results are not as dramatic.

Figure 1. Diagram showing the lab setup.
2. Draw a picture on the board of the side view of the pan with the cups of water under it. It should look like the set-up of the experiment shown in Figure 1.
</td>
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<tr>
<td colspan="2">Procedure</td>
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Engage:
When learning about thermal energy in sixth grade, students should have learned about the way in it which transfers: convection, conduction, and radiation. Tap into students' prior knowledge by showing them an example of each and asking them how the heat is transferring in different ways.

Explore:
A: Modeling Convection Currents
Students will model convection currents in the mantle by using the materials listed above. Student will record what they see by drawing and labeling the diagrams below. Student Instructions:
Form a hypothesis about the way water will move in the pan.
Gather your equipment tray and set up your experiment. Fill the clear bin 2/3 full with water. Turn two of the cups upside down (to use as supports) and set a pan of water on top of the two cups. Fill the third cup with hot water and place it under the center of the bin of water. Leave the bin for several minutes until the water has stopped moving. Put one drop of food coloring on the bottom of the pan in the center (directly over the heat source), and put one drop on the bottom halfway to the edge, with a different color.
</td>
<td>
Explain:
A: Modeling Convection Currents
1: Which way does the water move over the heat source? What happens to the water when it reaches the surface? What happens to the water when it reaches the edge? Which way does the water move along the bottom of the bin?
2: Is there a difference in temperature? How does this affect the drops of food coloring? Summarize the results again, but this time in the context of the temperature changes.
3: What happens if you use ice and make the water colder? How does cold water affect the currents?

B: Partner Jigsaw
Students then interview each other to gain an understanding of the opposite article to respond to the questions. Students shouldn’t be copying responses, yet, interviewing by asking the questions of their partner to record their own responses.

Extend:
Students can deepen their understanding of the different types of plate boundaries; how tectonics plates affect the Earth, forming of oceans and continents; and the occurrence of earthquakes and volcanic eruptions. By visiting plates on the move students can record notes in their notebooks. The next lesson will be on subduction.
</td>
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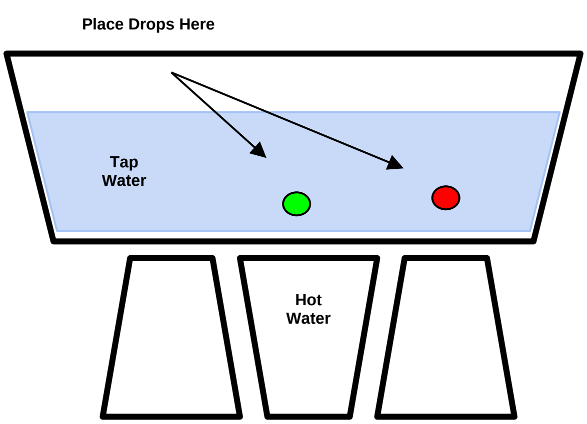
</table>

3. Observe what happens to the drops in your pan. Draw a diagram of what you observed. 4. Take the temperature of the water directly over the heat source and off to the side of the pan. 5. Set up the investigation again. This time put hot water on the edges instead of the center of the bin. ***B: Partner Jigsaw*** Select partner A or B to read either article and annotate (highlight key terms, ask questions, record thoughts in margins). The selection of articles is your preference, based on your understanding of your students. Each partner reads an article and completes the comprehension questions that align to their question.	
Suggested Assessment	***Additional Resources***
1: Students will watch this video and explain how their model/investigation demonstrates what is occurring in the Earth's lithosphere: *Why do lithospheric plates move?* Students should also include evidence from the texts. *Response Format* ● *Option 1:* Written response ● *Option 2*: Flipgrid verbal explanation. Flipgrid is an app that students can provide a verbal explanation, versus a written one. Great option for ELL students.	● PhET Simulation: Plate Tectonics

Figure 1



Lesson Three: Rocky Subduction Zones

Question: How do tectonic processes differ between the oceanic and continental crusts?

Objective: Explain subduction zones involving continental and oceanic crusts based on density.

Phenomena: Density

Science 7 Knowledge Targets	***Science 7 Performance Targets***
• Know that oceanic crust has a greater density than continental crust.	• Use density to explain subduction zones.
Time	***Vocabulary***
Suggested: 1-2 periods (50-minute class period)	Lithosphere Crust Plate boundary Density/dense Volume Basalt Mantle Mid-ocean ridge Plate tectonics Mass Granite Subduction
Background Information	***Materials***
Earth is a layered planet, similar to a baseball or golf ball. Its layers are the core, mantle, and crust. Each layer is a different composition. The layers are: the lithosphere, a rigid outer layer containing the crust and upper-mantle; the asthenosphere, a weaker, semi-molten layer in the mantle; and the mesosphere, a stronger layer in the lower mantle. When discussing plate tectonics, the lithosphere will be the layer of focus. Subduction is a geological process that occurs at convergent boundaries of tectonic plates. This is where one plate moves under another due to density, slowly over millions of years. The crust of the Earth is divided into two types: oceanic and continental. Most oceanic crust is composed of the rock basalt. Basalt has a high magnesium and iron content. Continental crust has more range in composition; the most similar composition is the rock, granite. Granite has a high feldspar and silica content, composed of quartz, potassium-rich feldspar, and mica. Mafic rocks contain denser minerals, and therefore, oceanic crust is denser than continental crust. Continental crust is	*Rocky Density Lab* *Per Group* • Basalt • Granite • Triple beam balance • Water • 250 mL Beaker or graduated cylinder • Data tables *Floating Demo* • Clear bin (large enough to easily hold wood and Styrofoam pieces) • Water • 1 piece of wood* • 1 piece of Styrofoam* * pieces should be similar if not exact size

much thicker and older than oceanic crust. We know this because the ocean floor is where new plate material is born (Lesson One).	
Lesson Overview (Activities)	***Advance Preparation***
Activity One ● Density Review ● Floating Demo ***Activity Two*** ● Rocky Density Lab ***Activity Three*** ● Ring of Fire ● Examples of Subduction	● Place all materials into bins for students for more efficient distribution. ● Prep demonstration
Procedure	
Engage: *Density Review* What is the difference between mass, density, and volume? How do they relate to one another? All objects share two characteristics in common, they have mass and volume, no matter the shape. Mass measures the amount of matter an object contains. Volume measures the amount of space an object takes up. Density is the ratio/proportion of mass to volume. You must know the volume and mass of an object to determine its density (review from Unit 1: Matter and Chemical Reactions). *Floating Styrofoam vs. Wood* Using a clear bin filled halfway, ask students to predict which object (wood or Styrofoam) is most dense. Have students share their thinking with a partner and then some with the class. Place both objects in the water. Ask students what they see. Students should notice that the Styrofoam is less dense than the wood. Save any additional connections/explanations until after the lab has concluded. This will provide more evidence for students to compare these objects to oceanic and continental crusts. **Explore:** Students should work in groups of 3-4 for the lab. *If you have enough materials, pairs would support more students practicing measuring and equipment skills.* Review the procedure with class. Then, review how to calculate for density. *Procedure* 1. Use the balance to find the mass of the material, ***while dry***. Record in data table.	*Lab Analysis* 1: The theory of planetary formation is that in the early history of a planet, a process called differentiation occurs, where denser matter sinks under its own weight toward the center of the planet, and lighter matter floats to the surface. How do the observations from this lab relate to this theory? 2: At a convergent plate boundary, usually one plate will subduct (go under) the other. If an oceanic plate meets a continental plate, which one will subduct and why? 3: If an oceanic plate collides with another oceanic plate, which plate do you think will subduct and why? *Hint: They will both be composed of basalt, so density differences will not be based on composition.* What are other factors that affect density? 4: Using your discussions of Plate Tectonics theory, and your observations from this lab today, how would you expect the density of the oceanic crust to change with distance from a mid-oceanic ridge? **Extend:** Display *Image A* to the class. Ask students to make some general observations. Where have some of the worst earthquakes occurred over the past 117 years? Display *Image B* to class. Ask students to make general observations. What process is occurring? How do you know? Display *Image C* to class. Which plate it the continental plate? Which is the oceanic plate? Describe their relationship to each

2. Pour enough water into the large beaker for the rock samples. Measure and record the volume of the water in the data table. This is the initial volume. 3. Carefully place the material being tested in the graduated cylinder. *Ensure that the material is* ***completely submerged*** *under water.* Find the volume of the water plus the material. This is the final volume. ***Subtract the initial volume from the final volume.*** This is the volume of the material. Note that 1 ml = 1 cm^3. 4. ***Divide mass by the volume to find the density.*** D = m/v **Explain:** A teacher-led discussion to conclude their findings based on the analysis of the density lab.	other. Then, Share a *ring of fire video* to show how two oceanic plates can shift during subduction. **Evaluate:** *Floating Styrofoam vs. wood* After students complete the lab, they can visit the demo that is still set up, to use a model to evaluate which material is most like the continental and oceanic plates. Allow students to find the mass, volume, and density of both objects. *The styrofoam is most like the contineta l crust, whereas the wood is most like the oceanic crust, due to density. Because continental crust is less dense than oceanic crust, it floats higher on the mantle, just like a piece of Styrofoam floats higher on water than a piece of wood does.*
Suggested Assessment	***Additional Resources***
• Density Lab • Image analysis	• Density Gizmo • Ring of Fire video, CNN

Name _________________________ P ______

Rocky Density Lab

Materials:

2 Graduated cylinders
2 Large beakers
1 Triple Beam Balance
Water
Basalt & Granite samples (1 each)

Procedure

1. Use the balance to find the mass of the material, ***while dry***. Record in the data table.
2. Pour enough water into the large beaker for the rock samples. Measure and record the volume of the water in the data table. This is the initial volume.
3. Carefully place the material being tested in the graduated cylinder. *Ensure that the material is* ***completely submerged*** *under water.* Find the volume of the water plus the material. This is the final volume. ***Subtract the initial volume from the final volume.*** This is the volume of the material. Note that 1 ml = 1 cm^3.
4. ***Divide mass by the volume to find the density.*** D = m/v

	Mass of material (g)	***Initial water vol. (ml)***	***Final water vol. (ml)***	***Volume of material (ml)***	***Density of material g/ml or g/cm3***
Basalt (oceanic crust)					
Granite (continental crust)					

Analysis: *Explain your understanding of density as it relates to oceanic and continental crusts by responding to the questions below in complete sentences.*

1: The theory of planetary formation is that in the early history of a planet, a process called differentiation occurs where denser matter sinks under its own weight toward the center of the planet, and lighter matter floats to the surface. How do the observations from this lab relate to this theory?

2: At a convergent plate boundary, usually one plate will subduct (go under) the other. If an oceanic plate meets a continental plate, which one will subduct and why?

3: If an oceanic plate collides with another oceanic plate, which plate do you think will subduct and why? *Hint: Both are composed of basalt, so density differences will not be based on composition.* What are other factors that affect density?

4: Using your discussions of Plate Tectonics theory, and your observations from this lab today, how would you expect the density of oceanic crust to change with distance from a mid-oceanic ridge?

Image A

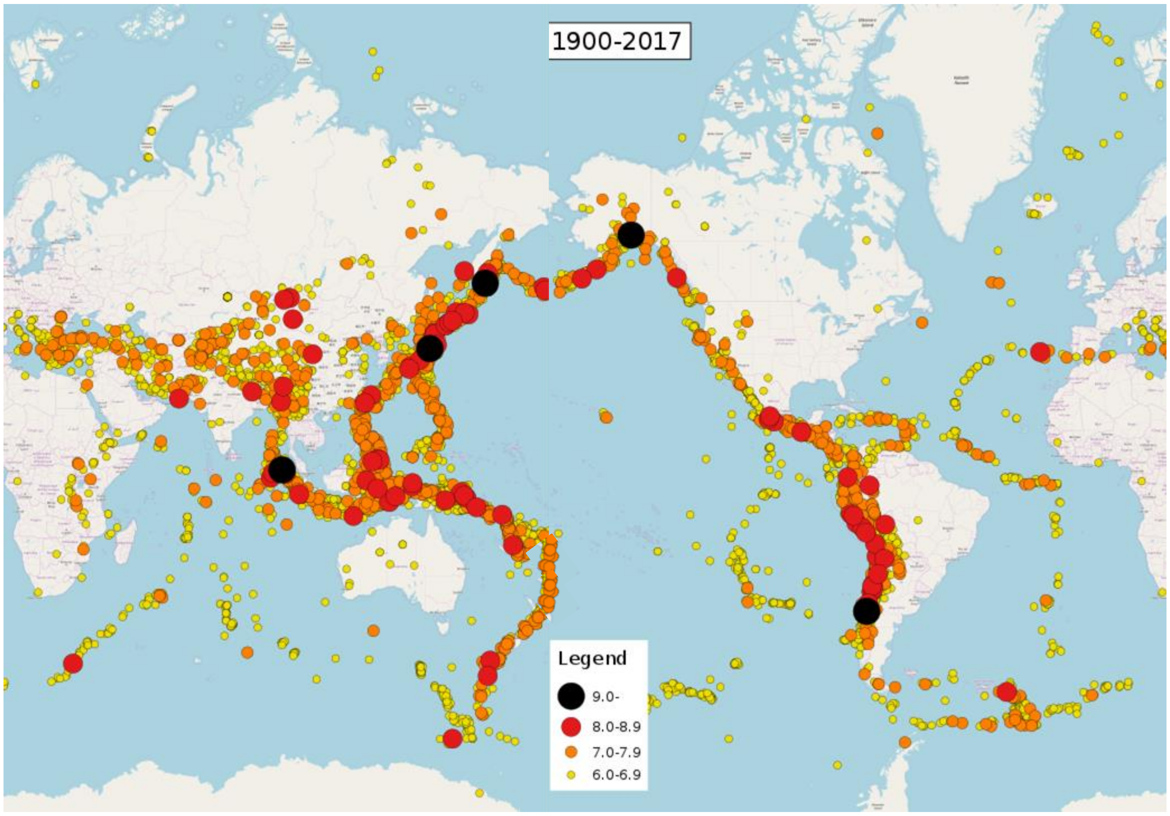


Image B

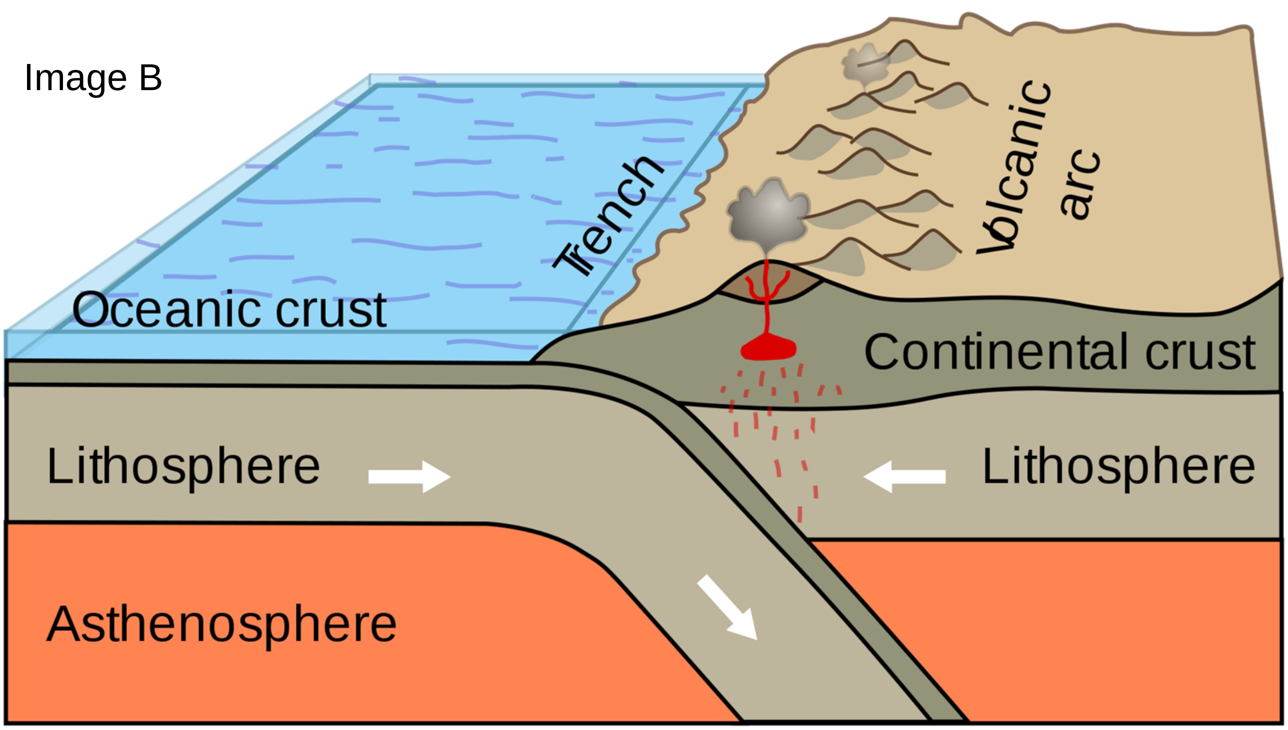
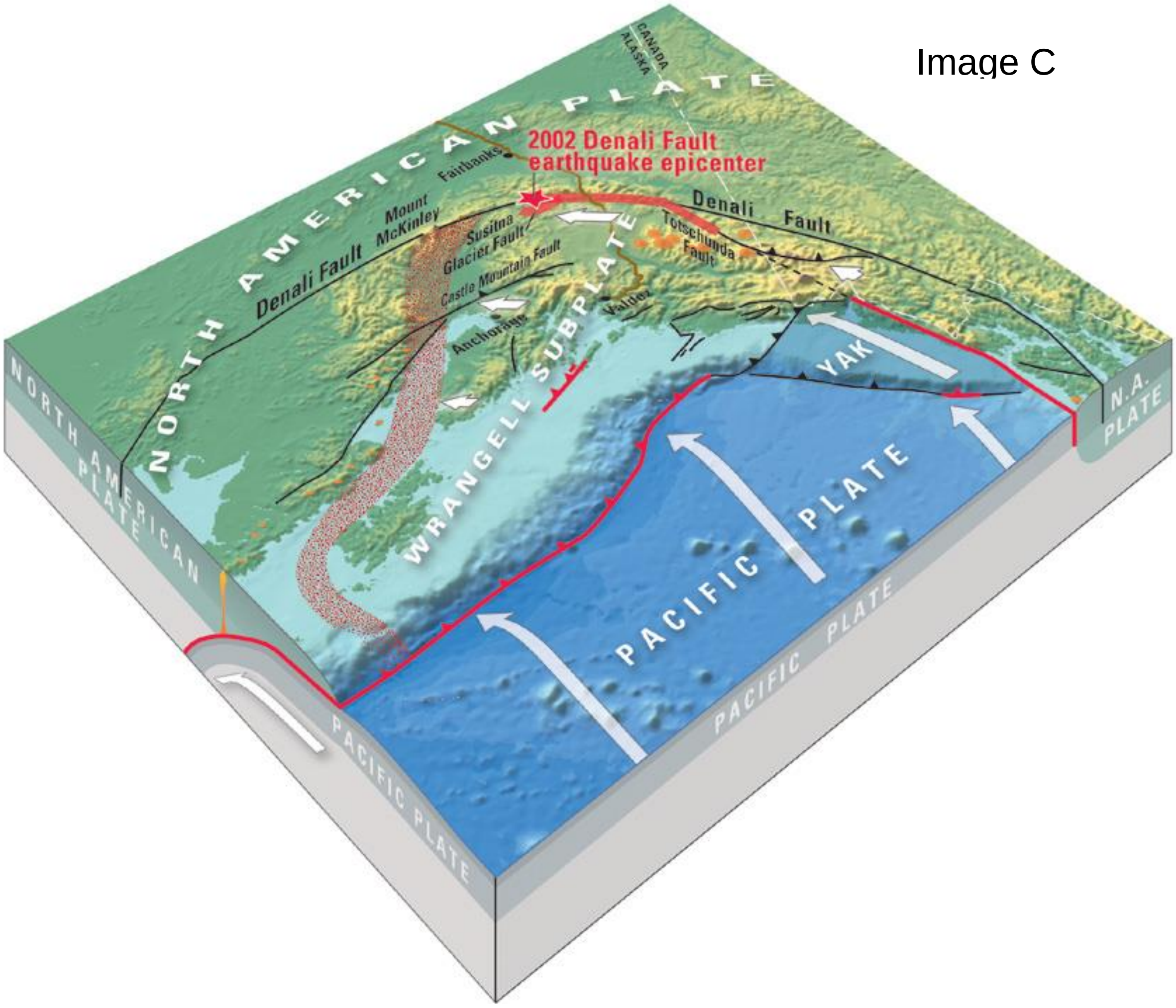


Image C



NORTH AMERICAN PLATE
CANADA
ALASKA
2002 Denali Fault
earthquake epicenter
Fairbanks
Mount
McKinley
Denali Fault
Susitna
Glacier Fault
Castle Mountain Fault
Anchorage
Valdez
Denali Fault
Totschunda
Fault
WRANGELL SUBPLATE
YAK
PACIFIC PLATE
N.A.
PLATE
NORTH AMERICAN
PLATE
PACIFIC PLATE
PACIFIC PLATE

Lesson Four: Earth's Changing Surface

Question: What changes on the Earth's surface have occurred throughout the planet's history?

Objective: MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed the Earth's surface at varying times and on varying spatial scales.

Phenomena: Weathering and erosion are natural forces that shape the Earth's surface. They are very common occurrences in Nevada, and massive erosion leads to destructive landslides.
Landslide Risks Always Exist in Nevada

Science 7 Knowledge Targets	***Science 7 Performance Targets***
• Know that the surface of the Earth has changed over time, and that the geological processes can occur slowly over millions of years.	• Students can use evidence from surface features to explain how the Earth has changed throughout its history.
Time	***Vocabulary***
Suggested: 2-3 periods (50-minute periods)	detect, discern, influence, geologic, crust, glaciers, erosion, tectonic plates, continents
Background Information	***Materials***
There are strange geological formations out there. Nancy, now 75 years old, remembers seeing a hill out in the field where she and her younger brother used to play tag. What happened? Where did that hill go? In this lesson, students will explore geologic features through an interactive activity from NOVA's *Making North America*. They will observe and gather evidence of how natural processes have changed our planet's surface and continue to do so.	• Computer • iPads/Chromebooks • Interactive board • Handouts
Lesson Overview (Activities)	***Advance Preparation***
Students will use an interactive lesson to learn about the different surface features of the Earth, and how they have changed throughout the planet's history.	• Teacher will make copies of student handouts. • Prepare the website for the interactive map. ***Options are****: a) write the URL on the board and have students type it on the web address bar on their iPad or Chromebook; OR b) teacher may use Google Classroom and post the link on the website.* • Create teacher account with PBS Learning Media by going to https://vegas.pbslearningmedia.org/. (It's free to sign up.)

Procedure

ENGAGE:
Begin the lesson by posing this question "Do you think that the natural landscape around you has always looked like it does today?" Give them examples of landscapes in your local area such as rivers and mountains. Give students about 1 minute to think of their responses. After the given time, have students share their thinking with a partner in the TTPS (timed think-pair-share). *Option: Teacher can ask 2-3 students to volunteer and share their own or their partner's thinking with the entire class.*

EXPLORE:

A. Instruct students to the Making North America | Interactive Map. Click the **Explore** option from the main menu. This will take you to a map of North America with many locator "pins." The videos included in the map describe how the geological features were formed over so many years. There are many pinned sites on the map, but tell the students to focus on the 10 areas, making sure to note how weathering, erosion, and deposition have contributed to the change.

1. Grand Canyon, Arizona
2. Joshua Tree National Park, CA
3. Flatirons, Colorado
4. Monument Rocks, Kansas
5. Acadia National Park, Maine
6. Caprock Canyons, Texas
7. Arches National Park, Utah
8. Grosvenor Arch, Utah
9. Monument Valley, Utah
10. Zion, Utah

B. Divide the class into small groups of four or five students. Have each group divide the 10 locations among its members, so each student explores two to three sites. You may wish to assign locations to students to facilitate the process.

C. Distribute the Evidence of Geological Processes handout. Tell students that their task is to observe the high-resolution images and/or videos available at these sites and to document evidence of past weathering, erosion, or deposition of each landscape. Students should review all of the media available for each particular location; some places have more images/videos than others. Point out that students can zoom in on the panoramic images in this interactive map

- For this part of the activity, students should explore their assigned locations individually and fill out the table in Part I of the handout with their observations.
- Next, encourage students to make connections about geoscience processes based on the evidence they have gathered and answer the questions in Part II of the handout.

EXPLAIN:
Have students come back together as a group to share their responses to Part II of the handout and reference observations of one site as evidence. They should discuss their explanations and evidence as a group**.** Use these questions to guide the students' discussion:

1. Describe how weathering, erosion, and deposition work together as an ongoing process over time to form a cycle, of sorts, which resulted in many of the landforms we see today.
2. Discuss the range of time scales that are represented at the 10 sites. How have weathering, erosion, and deposition played roles in forming the landscape over both long and short time periods?
3. Do you think these processes are still occurring today? Why or why not? What is your evidence?

Have students complete part III of the handout; they will do this part as a group.

EXTEND:
Challenge students to think of examples of similar processes (weathering, erosion, deposition) in their own neighborhoods or regions. Have students share their examples. Ask the following questions:
1. What is the geological feature? Where is it located?
2. What are the processes at work?
3. At what scale are the processes occurring?
4. Do you think that the geological feature will look the same thousands, millions, or billions of years from now? What is your reasoning?

EVALUATE:
Have students complete a short quiz: *Weird Geological Formations, What's the Story?* **OR** *The History of the Planet Earth Reading Comprehension* (***teacher needs to log-in to account to get the***

considerably, allowing for observations of great detail.	***reading selection and question set***).
Suggested Assessment	***Additional Resources and References***
• *The History of the Planet Earth Reading Comprehension (RC)* • *Weird Geological Formations, What's the Story?*	• "Interactive Map", PBS Learning Media Making North America | Interactive Map | PBS LearningMedia • "Evidence of Geological Process", PBS Learning Media Evidence of Geological Process Handout • "Weird Geological Formations", PBS Learning Media Weird Geological Formations, What's the Story Handout • "The History of the Planet Earth", Readworks.org The History of the Planet Earth

Answer Keys:

A) **Evidence of Geological Processes Part I** - answers will vary based on student observations.
B) **Evidence of Geological Processes Part II and III** - answers will vary based on student observations from Part I.
C) **Weird Geological Formations:** What's the Story?

DESCRIPTIONS:
Write the letter of the corresponding image to the left of the description.

Letter	Description
F	Moeraki Boulders (Otago, New Zealand). *A concretion is a hard mass of minerals that forms in sedimentary rock when sediment builds up gradually around a nucleus, such as a grain of sand or piece of shell. Concretions are generally harder than the rock around them. Formed originally in soft mud on the seafloor some 60 million years ago, these giant concretions have been eroded by wave action and exposed over time.*
B	Shilin Stone Forest (Kunming, China). *Covering a region that stretches hundreds of square kilometers, these limestone structures rise up to 30 meters (98 feet) tall. The limestone, which dissolves relatively easily in contact with slightly acidic rain and groundwater, has left behind various shapes as the rock has worn away and dissolved.*
A	Glacial Erratics (Yellowstone National Park, Wyoming, US). *Carried by glaciers and then left stranded when the ice melted, these formations look out of place in their surroundings. Glacial erratics can be quite large, sometimes bigger than a house!*
E	Sand Dunes (Sand to Snow National Monument, California, US). *Sand is moved by wind in different ways, depending on the size and weight of the grains. Crescent-shaped dunes form when the wind blows in one direction, with the gentle slope facing the wind; the "arms" point in the direction the wind is blowing. Dune shapes and patterns change constantly with altering wind conditions. When wind blows over sand from multiple directions, the resulting multi-armed dunes may even look like stars!*
D	Wave Rock (Hyden, Australia). *This structure is part of a granite hill that dates back over 2.6 billion years. About 14 meters (46 feet) high and 110 meters (360 feet) long, it is a product of processes that have exposed the once-buried granite bedrock. Through erosion, the top of the granite became exposed; as rainwater ran off and collected, intense weathering of the adjacent rock beneath surface resulted in the characteristic concave slope.*
C	Kannesteinen Rock (Vågsøy, Norway). *This oddly shaped rock along the coast was sculpted over thousands of years as it weathered heavy winds and breaking waves. The top of the rock has been eroded less than the portion below it, resulting in its unusual shape.*

Dynamic Earth | 7th Grade Science

Lesson Five: Earth's Geological Features

Question: What geographical features result when plate boundaries interact and how did the Earth's surface transform through natural processes such as weathering, erosion, and deposition?

Objective: MS-ESS2-2: Construct an explanation, based on evidence, for how geoscience processes have changed the Earth's surface at varying times and on varying spatial scales.

Phenomena: Tectonic Plate Movement**.** When Earth's tectonic plates move, new landforms are created. Geologists have discovered that the Sierra Nevada mountain range in California and Nevada continues to rise at a rate of half an inch every 10 years.
Sierra Nevada Mountain Range Rises Rapidly

Science 7 Knowledge Targets	***Science 7 Performance Targets***
• Know that interactions at plate boundaries result in specific geographical features, and that natural processes like weathering and erosion contribute to the formation of these landforms.	• Model how the movement of the Earth's lithospheric plates create predictable surface features. • Describe the role of water, ice, and wind play in altering surface features. • Use evidence to explain how weathering, erosion, and deposition are ongoing processes, causing minor changes over a short period of time, but forming new landforms over a large time scale.
Time	***Vocabulary***
Suggested: 5-6 periods (50-minute period)	Tension, compression, shearing, plate boundary, fault, weathering, erosion, deposition, rock formations
Background Information	***Materials***
One of the most beautiful places to go and explore is the Antelope Canyon in the American Southwest. Located on Navajo land, east of Page, Arizona, this amazing landscape was formed by the erosion of sandstone, mostly by flash flooding. Antelope Canyon is just one of the thousands of geological surface features that was formed by nature itself. So how did these wonders of nature come to be? How long did it take to shape them? As the Earth continues to age, and plates above the molten rock do not rest, these so-called geological features will change over time.	• Computer • Projector • iPads/Chromebooks • Candy bars • Handouts

Lesson Overview (Activities)	**_Advance Preparation_**
Students will learn about the types of stresses that shape the Earth, examine plate boundaries and faults using an inquiry-based activity, learn about rock formations, and explain how changes on the Earth's surface happen.	● Teacher will make copies of the handouts and prepare the materials required for the labs, as well as the videos that will be used in this lesson.

Procedure

Engage: Types of Stress.
Students will watch a short YouTube video on the types of stresses that changes the Earth's surface.

Explore: Candy Bar Tectonics
Students will apply the different types of stresses they saw on the video to learn more about the boundaries and geologic features created by the stress. Snickers or Milky Way candy bars are suggested.

WEBQUEST : How did these rock formations happen??
Students will use this webquest to learn more about the natural processes that shaped the Earth's surface. Teacher will provide the students the URL or link to get to the webquest assignment. All other resources are found in the webquest.

1. Start this lesson by showing the students the webquest assignment (projected on the Smartboard/Interactive Board)
2. Briefly explain the webquest by describing the lesson using the **Welcome** and **Introduction** pages (*tabs for the various pages are found on the left-hand side of each page*).
3. Click on the **Tasks** page and explain.
4. Then go to the **Process** page and clearly explain each of the processes that they need to go through, and give the students your expectations. ***Use models when needed.***
5. For the final output Thinglink, show them teacher made work, so that students will have a clear understanding of the product.

Explain:
Thinglink. Students will explain their work to a small group (option is to present in class) by describing the project created using Thinglink. Details on how to use the app will be explained by the teacher.

Option 2 is to print the pictures and have students paste the picture of their choice on a poster board; they write their notes and observations on the board to create a poster that they will share in their small groups or in class.

Extend: Changes on Earth.
Students will watch a short video from Discovery Education and complete a series of worksheets and inquiry-based activities. All student worksheets and answer key are available on the webpage, together with the video. A teacher account log-in is needed to access all resources.

Evaluate:
Quiz following the video from Discovery Education.

Suggested Assessment	**_Additional Resources_**
● Quizzes ● Lab Reports ● Candy Bar Tectonics Activity	● "Types of Stress", YouTube.com Types of Stress ● "Candy Bar Tectonics", sciencespot.net Candy Bar Tectonics

• Thinglink	• "How did these rock formations happen?" webquest by Megan Curley, zunal.com How did these rock formations happen?? • "Changes on Earth", visuallearningsys.com, 2012 (teacher needs to sign in to DiscoveryEd account) Changes on Earth Sign in: https://www.discoveryeducation.com

Candy Bar Tectonics Name ____________________________

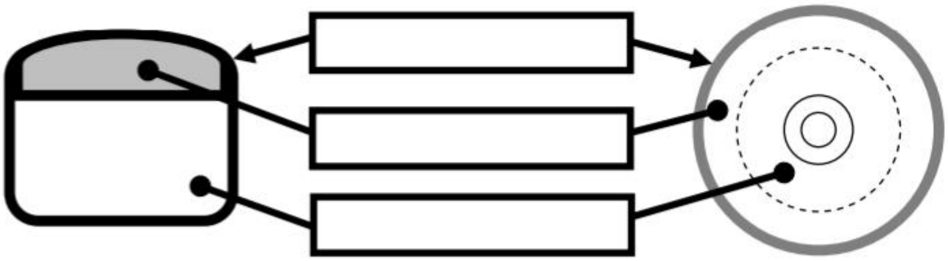
Part A: Getting Ready

1. Use your fingernail to make small cracks in the surface of your "Earth" or candy bar. Place on a paper towel.

What do we call the cracks in the Earth's surface? ________________

What do we call the large pieces of Earth's crust? ________________

2. Compare the candy bar to the Earth's structure. Label the parts of the candy bar to correspond to the layers of the Earth.



3. Which layer is "missing" in the candy bar? ___________________________

Part B: Observing Forces

COMPRESSION

What do you observe as you apply this force? ____

At what type of plate boundary would this force occur? _____________________________

At what type of fault would this force occur? ___________________________________

TENSION

What do you observe as you apply this force? ____

At what type of plate boundary would this force occur? _____________________________

At what type of fault would this force occur? ___________________________________

SHEARING

What do you observe as you apply this force? ____

At what type of plate boundary would this force occur? _____________________________

At what type of fault would this force occur? ___________________________________

Part C: Applications

Where else might we observe the three types of forces? Give at least three examples.

Candy Bar Tectonics **Answer Key**

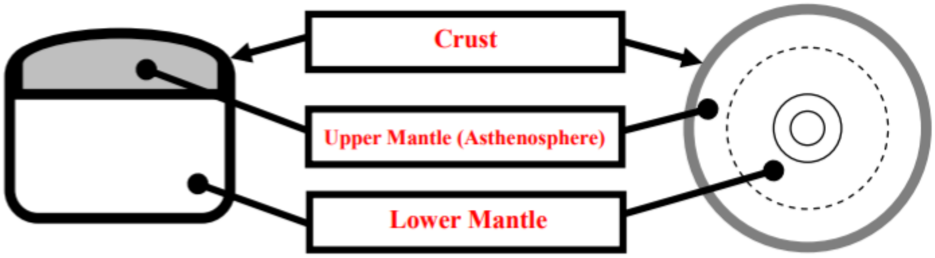
Part A: Getting Ready

1. Use your fingernail to make small cracks in the surface of your "Earth" or candy bar. Place on a paper towel.

What do we call the cracks in the Earth's surface? **Faults**

What do we call the large pieces of Earth's crust? **Plates**

2. Compare the candy bar to the Earth's structure. Label the parts of the candy bar to correspond to the layers of the Earth.



3. Which layer is "missing" in the candy bar? **Core**

Part B: Observing Forces

COMPRESSION

What do you observe as you apply this force? **The pieces of chocolate move together with some going over the others or two pieces push upwards together (arch)**
At what type of plate boundary would this force occur? **Convergent**
At what type of fault would this force occur? **Reverse (& thrust)**

TENSION

What do you observe as you apply this force? **The pieces of chocolate spread apart; some may "drop" into the caramel layer**
At what type of plate boundary would this force occur? **Divergent**
At what type of fault would this force occur? **Normal**

SHEARING

What do you observe as you apply this force? **The pieces of chocolate "slide" in different directions**
At what type of plate boundary would this force occur? **Transform (or lateral)**
At what type of fault would this force occur? **Strike-Slip**

Part C: Applications

Where else might we observe the three types of forces? Give at least three examples.
Answers will vary
Sample: Winds can cause shearing to occur on skyscrapers or the weight of the building might cause compression in the lower levels.

Lesson Six: Natural Disasters

Question: What catastrophic events have led to the rapid transformation of the Earth's surface?

Objective: MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed the Earth's surface at varying times and on varying spatial scales.

Phenomena: Catastrophic events such as earthquakes and landslides. Volcanic eruptions also play a major role in changing the Earth's surface, and it does not take long. The process is quick, and the change is instant. Is Nevada at risk for these natural hazards?
What would happen if an earthquake strikes Las Vegas? The Dormant and Extinct Volcanoes of Nevada

Science 7 Knowledge Targets	***Science 7 Performance Targets***
• Know the different catastrophic events resulting from geological processes that rapidly transformed the surface of the Earth.	• Students can provide examples of catastrophic events that rapidly change the Earth's surface and describe the process of change.
Time	***Vocabulary***
Suggested: 5-6 periods (50-minute period)	Landslides, fault, volcano, earthquake, erosion, natural hazards
Background Information	***Materials***
A **natural disaster** is a major catastrophic event resulting from the natural processes of the Earth; examples of these are floods, hurricanes, tornadoes, volcanic eruptions, earthquakes, tsunamis, and other geologic processes. A natural disaster can cause severe loss of life and/or damage to property, and typically leaves some economic damage in its wake. When the affected area is densely populated, this will influence the ability of the area and people to recover. Especially when damage to infrastructure is severe, often the city or state will have to seek help from other agencies or places.	• Computer • Projector • iPads/Chromebooks • Handouts
Lesson Overview (Activities)	***Advance Preparation***
• Students will learn about the different natural events that lead to rapid changes of Earth's surface features. • They will start by reading a short selection. • Then they will conduct an investigation on mini-landslides. • They will also create a Powerpoint presentation after completing a webquest on natural disasters. • They will complete a self-assessment	• Teacher makes copies of handouts and reading materials, as well as the lab activity requirements. • Send request to Tech Trekker 2-3 weeks in advance for the construction of the Stream table.

<table>
<tr><td>worksheet called the 3-2-1 countdown.
● As an extension, they can perform a hands-on activity, Investigating Erosion Control.</td><td></td></tr>
<tr><td colspan="2">Procedure</td></tr>
<tr><td>Engage:
Day 1: Rapid Change to Landforms.
Students will read a short selection on what causes the Earth's surface to change rapidly.

Explore:
Day 1: Mini-Landslides.
Students will conduct an investigation on landslides in order to describe the dynamics of landslides and how they relate to the effects on people and property.

Day 2 to 4: Natural Disasters.
Students will familiarize themselves, by creative methods, on how they can help lives touched by disaster. Teacher will provide the URL for the webquest assignment that students will use to learn more about natural disasters. All resources are available on the webpage for this specific webquest.</td><td>Explain:
Day 5: PowerPoint Presentation.
Students will describe natural disasters: how they happen; when they are most likely to occur; and other important information about these natural events.

Extend:
Day 6: Investigating Erosion Control.
Students will conduct an investigation on erosion control. Teacher will make copies of the student worksheet ahead of time. Stream table will be provided by Tech Trekker.

Evaluate:
Day 6: 3-2-1 Countdown.
Using this formative assessment tool, students will be able to reflect on their own learning processes.</td></tr>
<tr><td>Suggested Assessment</td><td>Additional Resources</td></tr>
<tr><td>● Lab Report

● Formative Assessment using 3-2-1 Countdown</td><td>● "Lesson 4: What Causes Rapid Changes to Landforms?", Pearson Education, Inc.
What Causes Rapid Changes to Landforms?

● "Hands-on Activity: Mini-Landslide" by Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder,TeachEngineering.org

● "Natural Disasters: Lesson 5, Mini-Landslide", TeachEngineering.org
Mini-Landslide worksheet

● "Natural Disasters" webquest by Michael Estrada, zunal.com
Natural Disasters

● "Activity 15: Using a Stream Table to Investigate Erosion Control", www.maine.gov
Investigating Erosion Control

● "3-2-1 Countdown" formative assessment tool by Mignon Penalosa
https://docs.google.com/document/d/1ooPOSpqx9KVmur47ZJFArwxQ9MAAjPve40-Dj65CZko/edit</td></tr>
</table>

Handouts/Worksheets:

Name: ______________________________ **Date:** ________________

Mini-Landslide Worksheet

Sand Trial	Building	Prediction Will the building be damaged or moved? (circle)	Observations What actually happened?
No water	1	Yes No	
	2	Yes No	
	3	Yes No	
Little water	1	Yes No	
	2	Yes No	
	3	Yes No	
More water	1	Yes No	
	2	Yes No	
	3	Yes No	

Gravel Trial	Building	Prediction Will the building be damaged or moved? (circle)	Observations What actually happened?
No water	1	Yes No	
	2	Yes No	
	3	Yes No	
Little water	1	Yes No	
	2	Yes No	
	3	Yes No	
More water	1	Yes No	
	2	Yes No	
	3	Yes No	

Lava Rock Trial	Building	Prediction Will the building be damaged or moved? (circle)	Observations What actually happened?
No water	1	Yes No	
	2	Yes No	
	3	Yes No	
Little water	1	Yes No	
	2	Yes No	
	3	Yes No	
More water	1	Yes No	
	2	Yes No	
	3	Yes No	

(Answers will vary depending on student observation.)

NAME ______________________ DATE ________PERIOD ________

3-2-1 COUNTDOWN

3 NEW FACTS I LEARNED		
1.	2.	3.
2 AH-HA'S THAT POPPED INTO MY MIND		
1.	2.	
1 BIG QUESTION I STILL HAVE		
1.		

Dynamic Earth | 7th Grade Science

Lesson Seven: Natural Hazards and Technology

Question: What are some of the effects of natural hazards? How does technology help mitigate the effects of these geological events?

Objective: MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed the Earth's surface at varying times and on varying spatial scales.

Phenomena: Earthquakes, tsunamis, and landslides are catastrophic events that occur naturally. These types of episodes happen instantly, and a lot of times without warning, leading to some of the worst destruction of human life and property. Events like these cannot be prevented. The ONLY other option is to get back on your feet and start over. People and organizations always come to survivors' aid, but bringing supplies to extremely ravaged areas may be challenging. Vehicles such as FEROX's ANT (advanced necessities transporter) are designed to bring the supplies to those places where ordinary trucks can't go.
A.N.T. Aid Necessities Transporter

Science 7 Knowledge Targets	***Science 7 Performance Targets***
• Students know technology has been engineered to help mitigate the effects of geological events on human life and property.	• Students identify the effects of natural hazards to human life and property. • Students can provide examples of technologies invented that help to mitigate the effects of geological events.
Time	***Vocabulary***
Suggested: 2-3 periods (50-minute periods)	Earthquake, seismic waves, prototype, redesign
Background Information	***Materials***
One of the most dangerous natural disasters that most people hope will never happen is an earthquake. This phenomenon results when energy in the Earth's lithosphere is suddenly released, creating seismic waves and resulting in the Earth's surface shaking forcefully. Destruction to property and deaths are inevitable. Our ability to monitor and warn people of a possible occurrence is essential. The aftermath is a different story, but technology has made it so that people can get back up on their feet and start over again.	• Computer • Projector • Handouts • Lab materials
Lesson Overview (Activities)	***Advance Preparation***
• Students will start by reading about natural disasters: "Landslides: On the Road to Destruction." • Using the reading selection, students will write about emergency preparation. • During the Exploration part of the lesson, students will learn more about earthquakes	• Teacher prepares all required student handouts, videos and slides for presentations, and all lab materials needed.

and build a structure that is earthquake-proof. ● They will use the engineering design process as they build the structure. ● Teacher will then lead a discussion on the building that was constructed and using guide questions, ask students the following questions: *1. When did we do some of the steps in this cycle in our lesson?* 2. *Discuss what worked and what didn't with the structures.* ● Students will write a paragraph that describes their new design to improve their building. ● As an extension, students will read the "Six Amazing Disaster Relief Inventions." This will lead to the creation of **Project DiRT, lesson nine**.	
Procedure	
Engage: Natural Hazards & Disasters. Students will read a selection about landslides and then write about preparation for an emergency. **Explore: Earthquake Proof Home.** Students will explain what an earthquake is, what causes them, and why they occur. Then students will build an earthquake-proof home. Teacher will prepare all the materials and resources for student use, which are available in the document for this activity. Resources for this activity are available by clicking on the hyperlinks in Additional Resources.	**Explain: Recap/Closing.** Teacher led discussion on the engineering design process used in the construction of an earthquake proof home. **Extend: Six Amazing Disaster Relief Inventions.** Students will read a short informational text describing 6 different inventions that help reduce the effects of natural disasters. **Evaluate: REDESIGN**. Students will write a paragraph explaining how they will improve their design.
Suggested Assessment	***Additional Resources***
● EDP (engineering design process) and the earthquake-proof home.	● "Landslides: On the Road to Destruction", adapted from edhelper.com Landslides: On the Road to Destruction ● "Earthquake Proof Home", adapted from Natural Hazards and the Science & Engineering Practices of Human by Jessica Catson and Deanna Pinomaki https://docs.google.com/document/d/1qgI3T7WD6PU7ApS6KTkaqd719soboC70NA1Lg2wr2QA/edit# ● "6 Amazing Disaster Relief Inventions" by Rebecca Goldfarb, blog esurance.com Amazing Disaster Relief Inventions

Name:____ Adapted from Edhelper.com

Landslides: On the Road of Destruction

Landslides happen often and can be one of the most destructive forces on earth. In Washington state, the Nile Valley landslide occurred on October 11, 2009. Later that month, a landslide occurred in North Carolina on October 25. Two more occurred in Tennessee on November 10, 2009. All of these landslides caused road closures and severe road damage. The worst landslide in history occurred in China on December 10, 1920. Over 180,000 lives were lost in this landslide.

A landslide is a natural disaster. Most landslides take place when part of a mountain breaks away and slides down its slope. Landslides usually happen as a result of gravity. Landslides occur when something changes the stability of the slope. A landslide can cause serious damage to the area around it. It can cause rivers to change course and cause flooding. A landslide can cover sections of roadway cutting off access. Roads buckle under the stress of the ground deformation.

What causes these changes? An increase in underground water can put pressure on a slope from deep beneath the soil. The pressure causes the slope to become unstable. Simple erosion can also cause a slope to become unstable. Erosion happens more often where there are no plants to keep the soil in place. Other times, heavy rains, snow, or snow melts can cause the soil to loosen. In the winter of 1996-97, severe storms brought heavy rain and snow to Seattle, Washington. The soils became saturated and over one hundred landslides were reported in the area. Many people lost their homes in these slides.

Serious events such as earthquakes and the eruption of volcanoes can also cause landslides. Earthquakes can destroy entire cities and are not easily predicted. Human activities can also create unstable conditions on a slope. Vibrations from machinery, blasting, construction, and de-forestation activities can also cause landslides. Landslides are divided into five basic categories. A debris flow is usually a quick, mass movement in which a combination of loose soil, rock, organic matter, air, and water flow down slope. A debris avalanche is the same as a debris flow, only faster. An earthflow is when the material at the top of a slope either becomes so fine or so saturated with water that it moves downhill. This leaves an empty "bowl" at the top of the flow, creating an hourglass shape to the flow. A mudflow is created when the dirt on a slope gets so saturated that it slips away. They are often called mudslides.

Finally, a creep is a slow, steady, downward movement of the soil or rock that forms the slope. This generally happens over a period of time and often, measures can be taken to protect these areas from further erosion. Landslides are dangerous natural disasters. It is important for geologists to understand the causes of a landslide so they can try to prevent them from occurring wherever they can.

Name: ____

Think! Write!

A) Have there been any landslides reported in your state? How about natural disasters? With little or no warning, it would be difficult to prepare for a landslide. Natural disasters can occur anywhere, however. Write a preparedness plan for your family. Include the preparations you would need to make to stay at home for at least two weeks without water or electricity.

____

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____

B) If you needed to evacuate, what things would you consider the most important items to save? How quickly could your family locate these items in an emergency? Make a short list of the ten most important things you think you would want to take if you should ever need to leave home quickly.

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(Student answers will vary.)

Lesson Eight: Seismic Raspberry Shake

Question: What geological events are difficult to prevent? How can past events help prevent future events?

Objective: Explain how data from catastrophic events can predict future events based on patterns or trends.

Phenomena: Elephants warn tourists of a Tsunami prior to its occurrence, allowing them to get to the safest locations available.

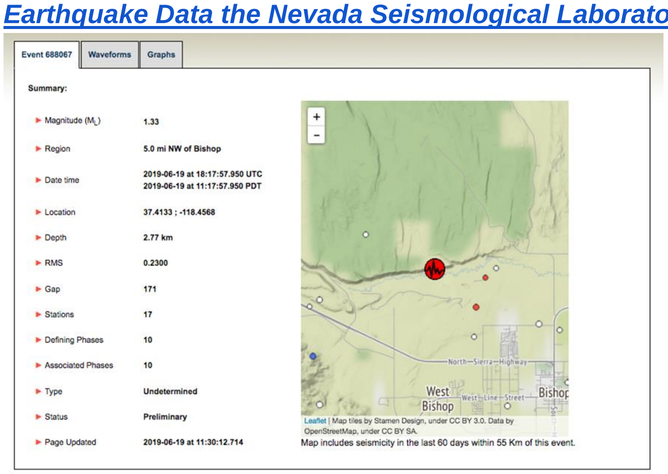
For more information and video, visit: Elephants Warn Tourists of Tsunami from the Wonder of Science.

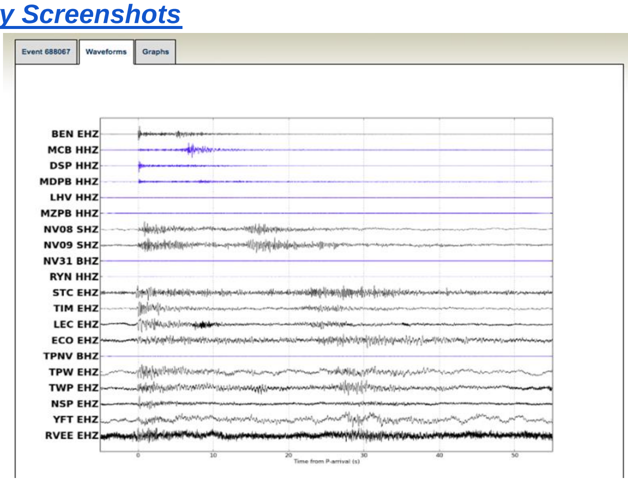
Science 7 Knowledge Targets	***Science 7 Performance Targets***
• Know that some geological events are difficult to predict because they occur suddenly and with no warning signs. • Know that scientists use technologies and historical data to predict catastrophic geological events.	• Explain that there are regions of the world more susceptible to specific types of catastrophic geological events, compared to other regions. • Analyze data from past geological events to predict the locations of hazardous areas on Earth. • Identify a variety of technologies used to monitor and detect the occurrence of geological events.
Time	***Vocabulary***
Suggested: 3-4 periods (50-minute periods) ******You will need to reserve the Raspberry Pi Shake from Tech Trekker* ***at least one week*** *in advance to collect local data from your school for a week before you reach* ***activity three****.*	Flood, hurricane, reservoirs, tornado, earthquake, tsunami, severe weather warning, severe weather watch, prepare, predict, magnitude, P and S waves
Background Information	***Materials***
Predicting some severe weather is not an easy task for meteorologists, and hasn't been in the past. Certain natural disasters like hurricanes and tornadoes can be monitored by devices that can detect a change in the atmosphere, relative to the disaster's specifics. These can help a community, to aid in their evacuation to safety. However, when it comes to earthquakes, these devices do not provide a warning before an earthquake occurs. Earthquakes generate seismic waves that radiate from the rupture point, similar to waves in water from a stone dropped. Seismic waves not only travel outward from the center, but also down through the Earth. These waves can be	• iPad or Chromebooks • Webquest Student Guide • Raspberry Shake* ** Provided through UNLV Tech Trekker. Must reserve and setup at least one week prior to data comparison activity.* *When an earthquake occurs it generates seismic waves, which radiate away from the rupture point like waves in a pond, but also travel downwards through the Earth. Scientists can detect and measure these vibrational waves at great distances.*

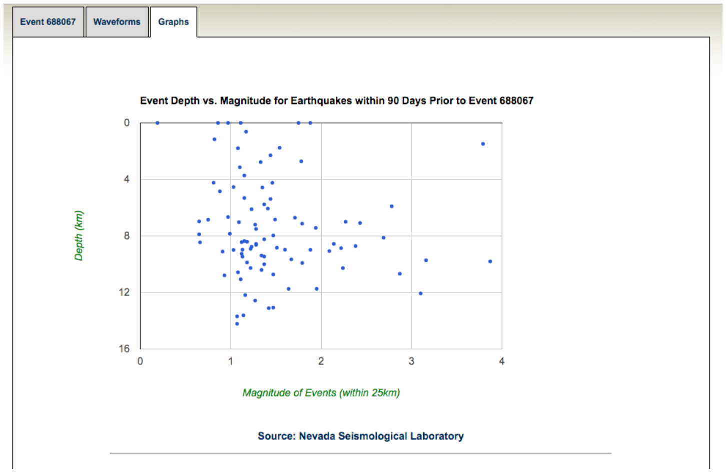
detected and measured at vast distances. There are two types of waves: P waves are primary compressional waves; and S waves are secondary transverse waves. *For more information and diagrams, visit: Seismic Waves and Earth's Interior.*	
Lesson Overview (Activities)	***Advance Preparation***
• **Activity One** What is a Raspberry Shake and how does it collect information/data? • **Activity Two** Our World in Data, Data Dive *Can be split and set up as stations for rotations within partners or as a Webquest. • **Activity Three** Raspberry Shake Data Geological Comparison • **Activity Four - Extension if time permits** Seismology in the Classroom • **Activity Five - Extension if time permits** Unawaria: Saving the city	• You will need to reserve the Raspberry Shake from Tech Trekker **one week** in advance to collect local data from your school for a week before you reach **activity three**. • Print out the graphs from ourworldindata.org in case the internet doesn't cooperate for data dive. Otherwise, post in Google Classroom, or whichever class platform you prefer, for students to access the guide digitally for the link: https://ourworldindata.org/natural-disasters#empirical-view
Procedure	
Engage: Show students the elephants and tsunami video. Ask students how the elephants could know that a tsunami was coming. (Responses of felt vibrations and change of weather could have caused the elephants to know.) After this, display examples of different tools used for predicting natural disasters: tornadoes, hurricanes, and tsunamis. (Students may ask what about tools for earthquakes or wildfires.) Discuss that these events are much more challenging to predict, but this is exactly why meteorologists examine past data patterns/trends to help predict possible future events. Show students PBS Earthquake Prediction video. Display examples of seismic waves over the past years to present. Without informing students what the waves are measuring, ask them. Show students the PBS Seismograph video of how seismographs came to become the tool to record seismic activity. Share with students that the Raspberry Shake will be set up in our classroom to record the seismic activity in our location for a week. Share video of how the Raspberry Shake works and what is inside a geophone video. Allow students to generate questions as a table team or within pairs. These questions can be clarified when the Tech Trekker	After collecting data for one week at school site, students should compare the data collected to another set of data. Students should be looking to see if there are similar patterns in the waves that would help them to predict if an earthquake could occur at or close to their school. **Explain:** *Data Dive* Through the data dive, the analysis of frequency and severity will allow for a discussion about how to utilize the data in the future. Have a discussion of what was occurring in the world of humans that may have coincided with some major catastrophic natural disasters (pulling from their learning of human impact in sixth grade). *Raspberry Shake Analysis* The probability of getting solid P and S wave data from the week long report from the Raspberry Shake is slim. You and/or students can visit the The Nevada Seismological Laboratory to view recent event data, waveforms, and graphs. *(Screenshots below are examples of the data available, collected from June 19, 2019).*

team returns, after the data has been collected for a week. **Explore:** *Data Dive* Working in pairs or groups of three, students will answer a series of questions pertaining to the data displayed in graphical form. By using the Our World in Data live, some graphs are interactive. They show the data as a time lapse, and students can move their cursors over spots on the graph to provide a more accurate interpretations of the analysis. Allowing students to work in partners will allow for collaboration and foster discourse related to their interpretations of the data. *Raspberry Shake* Review P and S waves with students. Reiterate that P waves travel the fastest, making them the first waves that arrive to the seismograph. S waves travel slower and only in solids, arriving to the seismograph after P waves. Watch the seismograph analysis video, and answer any follow up questions.	**Extend:** *Seismology in the Classroom* Create a classroom seismograph using basic classroom supplies. Students can simulate different magnitude earthquakes and identify them on the readout. *Unawaria: Preventing Natural Disasters* After studying natural disasters, students will determine the best locations to place the warning sensors. **Evaluate:** Use the scenario that students are the leaders of a country that is at risk for multiple natural disasters. As the leaders, students need to evaluate the natural disaster risk and how it could impact their country. Students create a plan that decreases the effects on their community. *You could also have students to complete the Stanford Earth Science Short Performance Assessment that utilizes more data.*
Suggested Assessment	***Additional Resources & References***
• The Wonder of Science Assessment Task Natural Disaster Preparedness Plan • Stanford Short Performance Assessment (includes a rubric) Natural Hazards Plan utilizes data more	• Unawaria: Saving the city • Can we cause earthquakes? USGS • Seismology in the Classroom • Seismic Signals Reading & Discussion • Raspberry Pi Teacher Guide • Raspberry Pi: Geophone • Raspberry Pi: Reading Seismographs • Nevada Seismology Laboratory Preparedness • USGS Nevada Data

Earthquake Data the Nevada Seismological Laboratory Screenshots






Event 688067
Waveforms
Graphs
Event Depth vs. Magnitude for Earthquakes within 90 Days Prior to Event 688067
Depth (km)
Magnitude of Events (within 25km)
Source: Nevada Seismological Laboratory

Name ____ P _____ Date ________

Natural Disasters: Our World in Data, Data Dive Guide

Directions: *Follow the guide below, and answer a series of questions that align with each graph. Each graph is hyperlinked and will take you to the graph you need. Record responses in complete sentences.*
Note: Some graphs are interactive to demonstrate the changes over time. Other graphs allow you to hover your cursor over a plot on the graph to identify it with accuracy.

Number of Reported Natural Disasters

What is the overall trend in data from 1900 to 2018?

Determine the year range of when the most natural disasters occurred.

In what year did the most natural disasters occur? How many occurred?

At which point, from 1900 to 2018, did natural disasters begin to continually rise? Explain what factors could have influenced their increase.

Number of Disasters by Type

Pick one year from 2006 through 2018 and determine the most occurring to least occurring natural disaster. List the natural disasters, how many occurred, and the name of the country.

Which natural disasters did not occur every year from 1970 through 2018?

Which natural disasters tend to occur the most, regardless of the year?

Explain the overall trend in natural disasters from 1970 through 1986 and 1989 through 2006. How are these trends similar or different?

Number of Known Significant Earthquakes *Use the slider in the bottom left hand corner to alter the year. You can also hover your cursor over a country to identify the data.*

What was the first year that more than two earthquakes occurred? In what country did this occur?

In what year did Italy experience eight to ten significant earthquakes?

How many times in one year has the United States experienced four to six significant earthquakes? In what years did they occur?

Where have eight to ten (or more) significant earthquakes occurred in a year? *Include the year and how many occurred.*

Significant Volcanic Eruptions

What is the most volcanic eruptions a country has experienced? In what country and year did they occur?

What countries have active volcanoes but no eruptions?

Droughts

There are two different sets of data plotted on the interactive graph. What does each of them indicate?

In what year was the first most severe drought in the United States? *Bonus: What US event may have had an influence on the drought during this timeframe?*

What is the difference between the index and average for each of these years: 1988, 2000, and 2011?

Hurricanes, Tornados, and Cyclones

*Use the **Frequency of North Atlantic hurricanes** line graph.*

In what year did North Atlantic hurricanes surpass 14 occurrences? In this year, how many US hurricanes occurred?

What year had the more US hurricanes? What is the difference between US hurricanes and the North Atlantic hurricanes within the same year?

*Use the **Hurricane Landfalls in the United States** bar graph.*

In what year(s) did category 5 hurricanes occur? *List in chronological order.*

What year had the most landed hurricanes?

What is the average amount of hurricanes that landed from 1851 to 2017?

Use the **Power Disposition Index (*PDI) of North Atlantic Cyclones*** *line graph.*

What is the Power Disposition Index?

What is the trend of the data in PDI of North Atlantic Cyclones?

What year had the highest PDI? What was the value? Look at the same year on the ***Frequency of North Atlantic hurricanes*** line graph, what was the most severe hurricane that occurred this year?

Extreme Precipitation and Flooding

Use the **Global Precipitation Anomaly** *line graph.*

What is a synonym for anomaly?

In order to collect this data set, what data was collected?

Calculate the average rainfall/snowfall for 2000 through 2015.

What years had the most precipitation fall? *List in chronological order, with the amount in inches.*

What years had the least precipitation fall? *List in chronological order, with the amount in inches.*

Use the **Precipitation Extremes (One Day)** *line graph.*

Compare the data for *extreme on-day precipitation* to the *9-year average* for the year 1917.

Compare the data for *extreme on-day precipitation* to the *9-year average* for the year 1943.

Compare the data for *extreme on-day precipitation* to the *9-year average* for the year 2010.

After comparing the data for *extreme on-day precipitation* to the *9-year average* for years 1917, 1943, and 2010, compare the data from each year together.

Dynamic Earth | 7th Grade Science	
Lesson Nine: Project DiRt (Disaster Relief Transporter) Engineering Design	
Question: How does terrain caused by natural disasters influence emergency vehicle wheel/tire design?	
Objective: Design a wheel/tire that can transport a load across a specific modeled terrain: a: flood (smooth & slippery/not rough) b: earthquake (moderately rough & different levels) c: landslide (extremely rough)	
Phenomena: Flooding, earthquakes, and landslides are catastrophic events that occur along the west coast of the country, and are therefore relevant to students in CCSD. *To demonstrate to students the aftermath terrains for the challenge, visit the sites below:* Las Vegas Flooding post Drought Recent 3.7 Valley Earthquake CA/NV Earthquake Extreme Landslides	
NGSS Engineering Design	***NGSS Science: Earth Systems & Human Activity***
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-ETS1-3:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. **MS-ETS1-4** Develop a model to generate for iterative testing and modification of a proposed object, tool. Or process such that an optimal design can be achieved.	**MS-ESS2-2:** Construct an explanation of the Earth based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. ** Focus on CCSD Knowledge Target #5: Students know water, ice, and wind transform the Earth's surface through weathering, erosion, and deposition.* ** Focus on CCSD Performance Target #5: Students can use evidence to explain how weathering, erosion, and deposition are ongoing forming processes causing relatively minor changes to landscapes over a short period of time and forming new landforms over a large time scale.* **MS-ESS3-2:** Analyze and interpret data on a natural hazard to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
Time	***Vocabulary***
Suggested: 3-4 periods (50-minute periods) *This design challenge will depend on the length of your class periods.*	Natural disasters, geological events, terrain, transporter, flood, landslide, earthquake, design process, criteria, constraints, define problem/ask questions, model, prototype, solutions, optimal design

Background Information	***Materials***
This is a concluding activity, after building student background knowledge by analyzing and interpreting data on the distribution of evidence to determine: how the Earth once was; the relationships of tectonic plates to one another; how the Earth's surface has changed over time from geological processes; and the development of technologies to understand and predict catastrophic events. Students will take their understanding of how the world works and apply their knowledge to design wheels best suited for terrain after a natural disaster. By using the design process, students will utilize specific criteria and constraints to develop solutions, while considering the problem at hand. Through collaboration, students will brainstorm possible solutions to design a model, build a prototype, and then test it. Testing will allow them to determine how to make alterations or adjustments to design, to best meet the criteria and constraints, with an optimal design. After using basic materials to develop and test their prototypes, and using the battery-operated car frames, the best wheel designs will be 3D printed. Through the Tech Trekker Program at UNLV, student designs can be 3D printed prior to the visit from the Tech Trekker team. *Want to know more about teaching engineering and the design process? Visit the sites below:* Teach Engineering STEM curriculum for k-12 NGSS Framework Engineering & Technology	*It is suggested that students work in groups of 3-4. All amounts of materials will vary depending on your class sizes/groupings and availability of materials.* • Bottle caps • Foam • Cardboard • Popsicles sticks or coffee stir sticks • Pipecleaners • Rubberbands • Hot glue guns • Scissors • Masking tape • Terrain surfaces (*see advance preparations below)* a: flood (smooth & slippery/not rough) b: earthquake (moderately rough & multi-level) c: landslide (extremely rough) • Battery operated car frames* * Provided through UNLV Tech Trekker
Lesson Overview (Activities/Agenda)	***Advance Preparation***
• **Activity One** Introduce phenomena and All Terrain Vehicles Research • **Activity Two** Review Design Process • **Activity Three** Brainstorm and Plan • **Activity Four** Develop Prototype • **Activity Five** Test and Revise	• To make the **terrain surfaces,** use materials you have available to you. We suggest the following on pieces of cardboard: ○ Use wax paper, water, and/or shaving cream on cardboard for the flood board. ○ b: Use sandpaper (various grits) and perhaps split the board to have a variance in levels. • Schedule availability to pick-up terrain boards for classroom model testing. Coordinate at least three weeks in advance.

	• Communicate and schedule with UNLV Tech Trekker to ensure that students' designs are submitted to create the wheels ahead of their visit to test after printed with 3D printer and visits from UNLV to support lesson.
Procedure	
Engage: Introduce the challenge by recapping all that students have learned up to this point. Then, show them the videos (*linked above*). Students can record their observations of each catastrophic event in their notebooks. After each event, have students turn and talk to one another about their observations. This should be considered as part of their research for building their transporters. Have a class discussion about how the Earth changed in each catastrophic event. Ask students why it is important to have a transporter that can go through different terrains. Show students a video of all-terrain vehicles. Provide students with the design process guide (*found below*) and review the design process with them. **Explore:** Identify the criteria and constraints for students to update on their guides. ***Criteria:*** 1) Determine what catastrophic event your wheel design is ideal for. 2) Wheel design must move the transporter from point A to point B on the terrain boards. ***Constraints***: 1) Design must utilize both axles of the model car. 2) Materials must be approved with design by teacher. *(This is typically done to ensure students have thought through the use of available materials).* To ***identify the problem***, students should decide within their groups what catastrophic event they prefer to design for. They should frame the problem as citizens needing supplies Then students should conduct research around wheel design and all-terrain vehicles. *Here are some helpful links to share with students: Ferox's ANT CEW Engineering Tire Review Ward's Auto Hankook Tire*	Students will work together in their groups to share the research they've done that impacts their design choices. Students will then **brainstorm** their ideas in a group. Here, students should be fully collaborating with their groups. Students should then begin the **planning** stage. Students should sketch and label what they intend their vehicles to look like and how they will use the materials. There are two different perspectives, a top and side; help students think through all angles of design. **Explain:** Within the design process guide, students will need to explain how they built their prototypes. This should be in a step-by-step process. It may also be considered that students explain their revisions and the reasons why they altered their designs to be more successful. **Extend:** By placing the terrain boards at an incline, students will be able to determine if their wheels provide enough grip (friction) to reach point B, which is now elevated. Students can stack universal textbooks underneath after successful trials to determine how steep an incline their terrain vehicle can successfully climb. **Evaluate:** Students will evaluate their designs based on testing the prototype with revisions and their collaborations within their groups.
Suggested Assessment	
A rubric *(may need modification for grade level). Suggestion: you may also want to survey your students on their collaboration throughout this challenge.*	

Design Process Student Guide (next page)

Name ______________________ Period __________ Date ______________ Group Members ______________________

Design Challenge ____

Directions: Make sure you're completing your work in ***complete sentences*** for parts 1, 4, & 5.

The Design Process

Criteria

Constraints

1: ASK

What is the **problem**? What have you learned through research?

2: BRAINSTORM

What are possible **solutions**? After researching, what are some components you'd like to include?

3: PLAN

Draw your design from the top and side perspectives. You could also consider a second design as well. **ON THE BACK SIDE.**

4: BUILD

What steps did you take to build your prototype?

5: IMPROVE

What went well? What could've worked better? How did you make adjustments to your original design?

3: PLAN

Draw your design from the top and side perspectives. You could also consider a second design as well..

PROTOTYPE #1

PROTOTYPE #2

TOP VIEW

SIDE VIEW