Plate Tectonics and Continental Drift

Grade(s): High School 9th Grade
Lesson Duration: 7 Class Periods that are 58 minutes
Course Name(s): Earth Science
Lesson Author: Stephanie Archuleta, Center, Colorado

BIG IDEAS

By the end of this lesson students will understand the three main movement of tectonic plates and be able to describe how continents have moved in the past. Student's will be able to describe the evidence that Pangea existed and how continents are still moving today and will continue to move towards a new Super Continent that some scientists are calling Amasia.

EDUCATION STANDARDS

Science Performance Expectations (or state Science standard):

- **HS-ESS2-1: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.**

Science and Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	**Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Common Core State Standards:

Math
MP.2: Reason abstractly and quantitatively
HSN-Q.A.1: Use units as a way to understand problems and to guide the solutions of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and origin in graphs and data displays.
HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling
and
ELA:
SL.11-12.5: Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of finding, reasoning, and evidence and to add interest.

MEASURABLE STUDENT LEARNING OBJECTIVES

Day 1: Scientists will be able to describe evidence of fossils and rock formations that current continents were once connected, Pangea.
Day 2: Scientists will be able to describe the three types of plate boundaries.
Day 3: Scientists will be able to observe the land formations caused by the types of plate boundaries.
Day 4: Scientists will be able to describe Earth's Supercontinent Cycle.
Day 5: Scientists will be able to use evidence and puzzle piece Pangea together and label continents direct of movement to current day locations.
Day 6: Scientists will be able to predict continents future movements based on historic directional movements.
Day 7: Scientists will be able to create a short story about living conditions on the futuristic Supercontinent: Amasia

MATERIALS NEEDED

- http://piraterodgers.com/adventures/2008-10-Samuel-P-Taylor/page%206%20to%20earthquake%20trail.htm
  - San Francisco Earthquakes Fence Picture
- https://www.nasa.gov/wp-content/uploads/2021/06/703154main_earth_art-ebook.pdf?emrc=dd3cb5
  - Earth pictures from space.
- https://thinkingpathwayz.weebly.com/seethinkwonder.html
  - See-Think-Wonder Chart Ideas
    - Mix and match ideas for how to structure the class chart.
- https://earthquaketrack.com/r/colorado/recent
  - Recent earthquakes in Colorado
- https://app.discoveryeducation.com/learn/techbook/units/249c1bad-b405-4a11-9cc3-8cd128efbe7a/concepts/453a7f9c-ecf5-4014-afd7-3fe80375c311/tabs/759da9a7-2edf-4cde-9515-7081ca990764/pages/effe87bb-bf05-445e-b6af-07275d9d994b
  - Online Textbook I use for class. Students will take notes on "Tectonic Plate Interactions" and "Continental Drift Hypothesis".
- https://svs.gsfc.nasa.gov/2953
  - NASA resource describe Tectonic Plates and plate Boundaries
- https://spaceplace.nasa.gov/earthquakes/en/
  - NASA resource describing Earthquakes
- https://earthquake.usgs.gov/earthquakes/map/?extent=-89.96254,-428.90625&extent=89.96161,240.46875

    - Mapping current earthquakes worldwide in the past 24 hour
- https://pcapes.weebly.com/uploads/8/8/3/0/8830216/candy_bar_plate_activity.pdf S
    - Snickers Lab Resources: Snickers Fun Size Bars, Knife, and Lab Write Up Paper
        - Lab procedure modifications based on materials available and time modifications. I wanted my students to see all three tectonic plate movements together for comparisons.
- https://weissworldofscience.weebly.com/uploads/1/4/2/2/14227725/plate_boundaries_with_graham_crackers.pdf
    - Graham Cracker Lab Resources: Graham Crackers, Icing, Knife, and Lab Write Up Paper
        - Lab procedure modifications based on materials cost and time to complete lab.
- https://www.cnn.com/2022/10/07/world/pacific-ocean-supercontinent-scn
    - Article about Amasia

ENGAGING CONTEXT/PHENOMENON

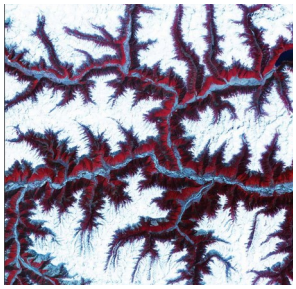
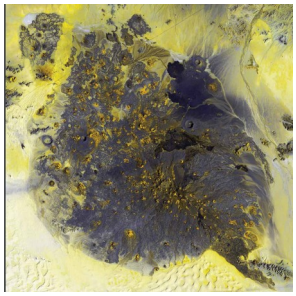
Real World Phenomena's: Discussing the power of continental drift and how a fence that moved 8.5 feet in an earthquake and showing satellite pictures of land formations caused by continental drift. Have a whole class discussion with a See-Think-Wonder Chart.

- Phenomenon: Fence along the San Andreas Fault in California that shifted 8.5 feet in the 1906 earthquake.

    - Picture from http://piraterodgers.com/adventures/2008-10-Samuel-P-Taylor/page%206%20to%20earthquake%20trail.htm

    - Picture from personal family vacation in 2001, pictures by Stephanie Burch (left picture) and Alice Burch (right picture)

- Phenomenon: Looking at Earth from satalite views of formations caused by plate tectonics
    - Pg 54: Himalayas, Central Asia
        -

- Pg 104: Pinacate Volcano Field, Mexico
  - 
- Pg 110: Rockey Mountains Trench, Canada
  - 
- Pg 150: Zagros Mountains, Iran
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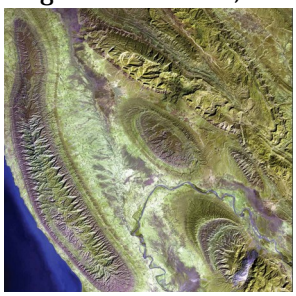
  - 
    - Pictures all taken from: https://www.nasa.gov/wp-content/uploads/2021/06/703154main_earth_art-ebook.pdf?emrc=dd3cb5

DATA INTEGRATION

Students will be analyzing data from various sights. Data will include similar fossil across oceans, rock formations, and tectonic plate land formations. This data will be combined and analyzed to support the continental drift hypothesis in creating Pangea, future Amasia, and describing well known land formations caused by plate tectonic interactions.

TEACHER BACKGROUND KNOWLEDGE

Background knowledge should include the evidence that supports the continental drift hypothesis and the three plate tectonic movements. The Continental Drift Hypothesis was created using fossil and rock evidence. This evidence is used to “piece” together Pangea. Pangea broke up with tectonic plate movements. These plates are continuing to move and current continents will eventually create another

supercontinent that is being called Amasia. Discover Ed textbook is a great resource to refresh content knowledge.

- https://app.discoveryeducation.com/learn/techbook/units/249c1bad-b405-4a11-9cc3-8cd128efbe7a/concepts/453a7f9c-ecf5-4014-afd7-3fe80375c311/tabs/759da9a7-2edf-4cde-9515-7081ca990764/pages/effe87bb-bf05-445e-b6af-07275d9d994b

DIFFERENTIATION OF INSTRUCTION

Differentiation for these lessons will include guided notes, multiple picture examples for the data analysis, and hands-on learning. The use of iPads for translation help and text to talk using the Google Translate App. I will confer with students that need support navigating websites or lab concepts.

REAL-WORLD CONNECTIONS FOR STUDENTS

Connections to student's lives include living in an area with mountains and extinct volcanoes. On the east side of our valley we have 14,000 foot mountains and the west side of the valley the mountains are volcanic based formations. We do not feel any earthquakes here but we do have small earthquakes about once a year typically along the east range. The east mountain range also has natural hot springs that have be utilized into local year-round swimming pools. The east range is part of the massive Rocky Mountain chain and the west range is part of the La Garita Caldera which is an extinct supervolcano. By understanding this lessons materials they will understand how the landscape was formed around them where they live.

POSSIBLE PRIOR or MISCONCEPTIONS

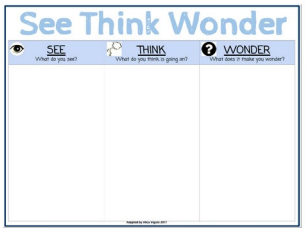
Misconceptions can include:

- Tectonic plates mark or follow the boundaries of continents or that each continent is located on its own tectonic plate.
- Tectonic plates move too slowly to be witnessed during a person's lifetime or that the positions of continents on Earth are unchanging.
- Deformation of Earth's lithosphere occurs only at plate boundaries.
- Students may think that the continental drift hypothesis and the theory of plate tectonics are the same idea.

LESSON PROCEDURE

5E	**Details of 5E Lesson Implementation** *(Visit BSCS to learn more about the 5E instructional model)*
Engage	**Lesson Objective** • Day 1: Scientists will be able to describe evidence of fossils and rock formations that current continents were once connected, Pangea. **Standards Addressed** • Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). **Materials & Resources** • http://piraterodgers.com/adventures/2008-10-Samuel-P-Taylor/page%206%20to%20earthquake%20trail.htm o San Francisco Earthquakes Fence Picture

- https://www.nasa.gov/wp-content/uploads/2021/06/703154main_earth_art-ebook.pdf?emrc=dd3cb5
  - Earth pictures from space.
- https://app.discoveryeducation.com/learn/techbook/units/249c1bad-b405-4a11-9cc3-8cd128efbe7a/concepts/453a7f9c-ecf5-4014-afd7-3fe80375c311/tabs/759da9a7-2edf-4cde-9515-7081ca990764/pages/effe87bb-bf05-445e-b6af-07275d9d994b
  - Discovery Ed: Online Textbook
- https://earthquaketrack.com/r/colorado/recent
  - Recent earthquakes in Colorado
- https://spaceplace.nasa.gov/earthquakes/en/
  - NASA resource describing Earthquakes
- https://thinkingpathwayz.weebly.com/seethinkwonder.html
  - See-Think-Wonder Chart Ideas



Procedure:

- Teacher will introduce the phenomenon using the fence picture and land formation pictures from space. While viewing this pictures the teacher will conduct a See-Think-Wonder about the pictures and ask for students to share their ideas. Then using Discover Ed Textbook lecture the Engage tab for Tectonic Plate Interactions and Continental Drift Hypothesis Chapters to start students thinking about chapter material. Class discussion about what are earthquakes from NASA Science website and if Colorado has earthquakes. After class is over group the See-Think-Wonder ideas together for future discussion/learning opportunities.
- Students will be analyzing the phenomenon pictures and write down their See-Think-Wonder ideas on sticky notes. They can share out if wanting to or just post sticky notes to the See-Think-Wonder chart. Students will then listen to the Engage tab lecture and NASA Science site and ask any questions. If any other wondering arise they can still be placed on the chart.

Formative/Summative Assessments

- Formative: List and describe 3 things that was new/interesting today.

Modifications

- Lots of picture examples and low risk listing of See-Think-Wonder sticky notes. Short clip videos have CC in Spanish and short answer formative assessment can be in home language.

Explore	**Lesson Objective** • Day 2: Scientists will be able to describe the three types of plate boundaries. • Day 3: Scientists will be able to observe the land formations caused by the types of plate boundaries. **Standards Addressed** • **Developing and Using Models** Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Develop a model based on evidence to illustrate the relationships between systems or between components of a system. • **ESS2.B: Plate Tectonics and Large-Scale System Interactions** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. **Materials & Resources** • https://app.discoveryeducation.com/learn/techbook/units/249c1bad-b405-4a11-9cc3-8cd128efbe7a/concepts/453a7f9c-ecf5-4014-afd7-3fe80375c311/tabs/759da9a7-2edf-4cde-9515-7081ca990764/pages/effe87bb-bf05-445e-b6af-07275d9d994b o Online Textbook I use for class. Students will take notes on "Tectonic Plate Interactions" and "Continental Drift Hypothesis". • https://svs.gsfc.nasa.gov/2953 o NASA resource describe Tectonic Plates and plate Boundaries • https://earthquake.usgs.gov/earthquakes/map/?extent=-89.96254,-428.90625&extent=89.96161,240.46875 o Mapping current earthquakes worldwide in the past 24 hour • https://pcapes.weebly.com/uploads/8/8/3/0/8830216/candy_bar_plate_activity.pdf o Snickers Lab Resources: Snickers Fun Size Bars, Knife, and Lab Write Up Paper • https://weissworldofscience.weebly.com/uploads/1/4/2/2/14227725/plate_boundaries_with_graham_crackers.pdf o Graham Cracker Lab Resources: Graham Crackers, Icing, Knife, Cupcake Lines, and Lab Write Up Pape **Procedure:** • Day 2: Teacher is lecturing about the three types of plate boundaries: Divergent, Convergent, and Transform. Lecture taken from Discovery Ed Textbook. After lecture the teacher will introduce the 24 hour earthquake website and discuss boundaries and compare with NASA: Tectonic Plates website. This should lead to discussion about current activity and the size of the plates having both continental and oceanic crust involved in movement.

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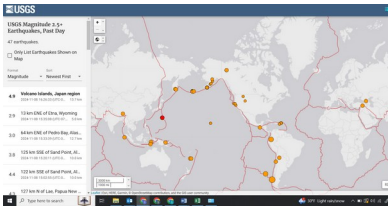
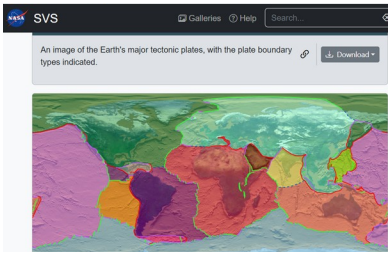

Day 2: Students are taking Cornell Style notes about the plate boundaries and drawing pictures of plate boundaries in notebook. Actively listening and answering and asking questions about the plate boundaries website.
Day 3: Teacher is prepping lab material and describing/demonstrating lab procedure. Walking around conferring with students as they demonstrate what types of plate movements cause different land formations. (Snickers and Graham Cracker labs can happen in one day)
Day 3: Students are gathering needed lab materials and following lab procedures. They will then conduct lab and be able to describe what lab is showing (Divergent: forms rift valleys, Convergent: forms mountains, and Transform: forms a land shift)

Formative/Summative Assessments

Day 2 Formative: Cornell Notes Completed
Day 3 Summative: Completed Lab Write-Up

Modifications

Students can have textbook in Spanish or lower Lexile reading score. Notes that are expected to be taken in notebook are highlighted throughout lecture on the front of classroom board. Use of iPad for google translate when needed.

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<td><u>Explain</u></td>
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Lesson Objective

Day 4: Scientists will be able to describe Earth's Supercontinent Cycle.
Day 5: Scientists will be able to use evidence and puzzle piece Pangea together and label continents direct of movement to current day locations.

Standards Addressed

<u>ESS2.B: Plate Tectonics and Large-Scale System Interactions</u>
<u>Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.</u>
<u>Stability and Change</u>
<u>Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</u>

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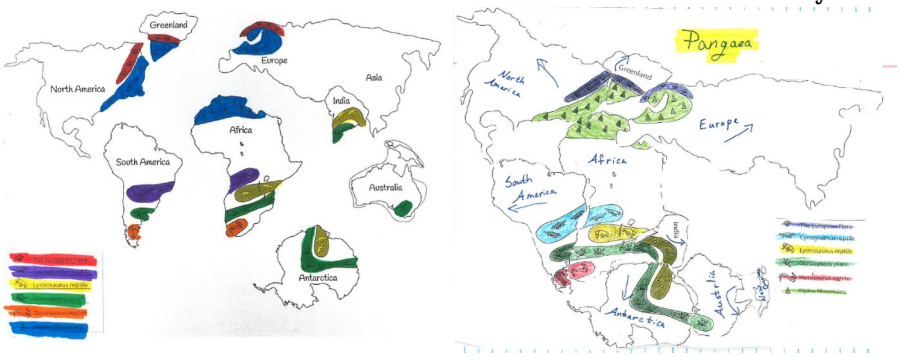
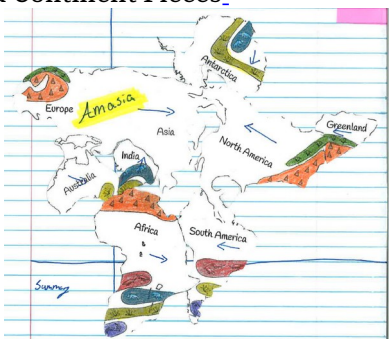
	Materials & Resources • https://app.discoveryeducation.com/learn/techbook/units/249c1bad-b405-4a11-9cc3-8cd128efbe7a/concepts/453a7f9c-ecf5-4014-afd7-3fe80375c311/tabs/759da9a7-2edf-4cde-9515-7081ca990764/pages/effe87bb-bf05-445e-b6af-07275d9d994b o Online Textbook I use for class. Students will take notes on "Tectonic Plate Interactions" and "Continental Drift Hypothesis". o Continents Evidence worksheet found on Discovery Ed  **Procedure:** • Day 4: Teacher is lecturing about supercontinents and the Earth's Supercontinents Cycle and the evidence we have that supports the idea of the supercontinent Pangea, pass out evidence worksheet. • Day 4: Students are taking Cornell Style notes about supercontinents and the evidence that supports Pangea. Then they will color the evidence on the different continents and cut out the continents (CUT INDIA OUT BY ITSELF). • Day 5: Teacher will remind students about using the colored evidence to recreated Pangea. Once Pangea is created continents will go through continental drift to the continents current locations paying attention to the direct the continents are moving. • Day 5: Students are creating Pangea then drifting the continents to their current day locations. Draw an arrow on the continent to show the drift direct going from Pangea to current location. **Formative/Summative Assessments** • Day 4 Formative: Color and Cut out Continents • Day 5 Summative: Creating Pangea and Current Continent Locations **Modifications** • Students can have textbook in Spanish or lower Lexile reading score. Notes that are expected to be taken in notebook are highlighted throughout lecture on the front of classroom board. Use of iPad for google translate when needed.
Elaborate	**Lesson Objective** • Day 6: Scientists will be able to predict continents future movements based on historic directional movements.

Standards Addressed

- **Stability and Change**
  Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
- **Math**
  MP.2: Reason abstractly and quantitatively
  HSN-Q.A.1: Use units as a way to understand problems and to guide the solutions of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and origin in graphs and data displays.

Materials & Resources

- Balloon
- Colored Continent Pieces
  - 

- Article about Amasia
  - https://www.cnn.com/2022/10/07/world/pacific-ocean-supercontinent-scn

Procedure:

- Teacher is instruction students to create Pangea on a balloon. (MUST WORK IN GROUPS OF 2-3). Then move the continents to current locations and then keep moving them until the combine again. Remind students that movement need to be at the same pace. Pass out Amasia reading.
- Students will blow up a balloon and create Pangea on the balloon, then while working in groups move the continents to current locations and then continue the movements across the balloon until they create a new supercontinent. Class discussion about what to call this new Supercontinent. Discuss that America and Asia are the main continents combine so some scientists are calling the new futuristic supercontinent: Amasia. Students will then annotate a reading about Amasia. Annotations can include: Asking Questions, Evoking Sensory Images, Determining Importance, Drawing Inferences, or Using and Creating Schema.

Formative/Summative Assessments

- Summative: Creating Amasia
- Formative: Annotating Amasia Reading

Modifications

- Class discussions can be in home language. Use of iPad for google

	translating the Amasia reading.
Evaluate	**Lesson Objective** • Day 7: Scientists will be able to create a short story about living conditions on the futuristic Supercontinent: Amasia **Standards Addressed** • **HS-ESS2-1:** Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. • **Math** HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling • **ELA:** SL.11-12.5: Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of finding, reasoning, and evidence and to add interest. **Materials & Resources** • Combination of any or all materials from past days to support the short story assignment. **Procedure:** • Teacher is assigning short story assignment. Short story needs to include information about weather/climate, plants, and animals. o Think about what life forms are on current continents and what will mix when continents are combined. What continents are now closer to the equator/poles? Confer with students during the writing process. • Students are creating a short story about the living conditions of futuristic Amasia. **Formative/Summative Assessments** • Summative: Short story **Modifications** • Use of iPad for translation and if needed short story can be in home language.

REFERENCES

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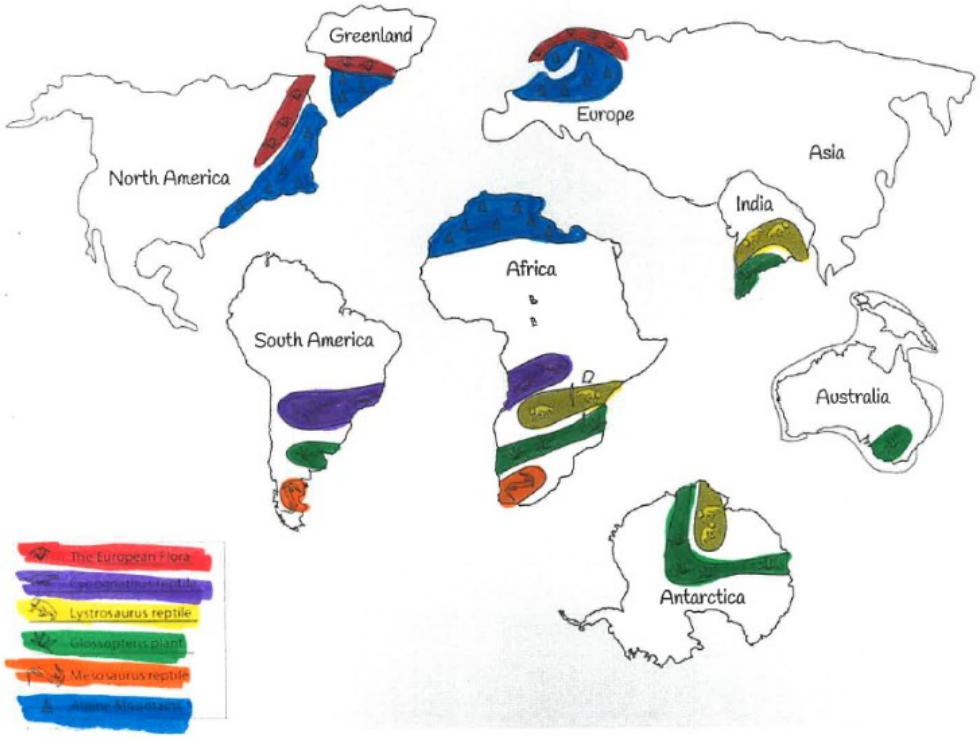
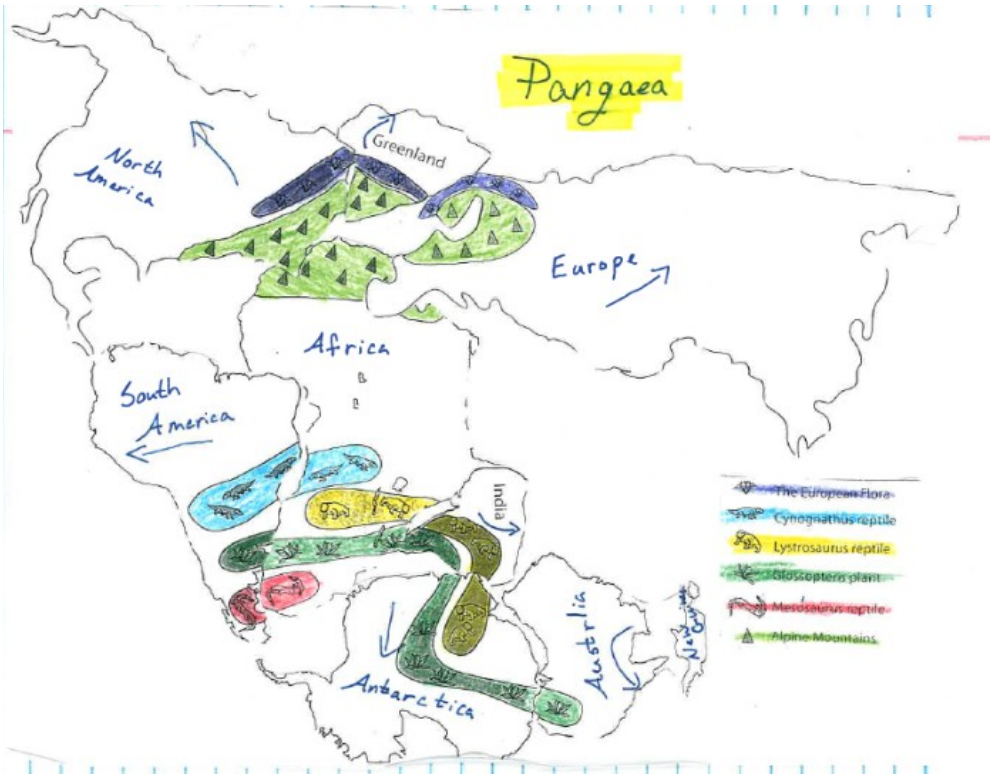
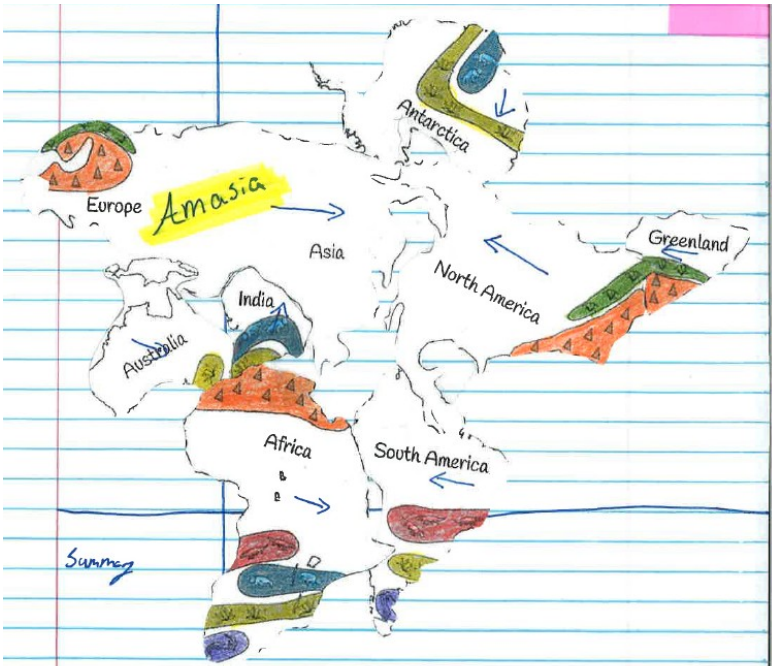


- Above worksheet taken from Discovery Education Textbook and modified to "piece together" Pangea and Amasia





Name _____

Title: Milky Way Boundaries

Objective/Hypothesis: observe 3 plate boundary movements

Materials: Milky Way
Paper Towel

Procedure:

- Place Milky Way on paper towel
- Perform boundary movements with Milky Way
  - Transform – Convergent – Divergent
- Observe, record, & compare formations

Data/Observations:

Discussion:

Name _____

Title: Graham Cracker Icing Lab

Objective/Hypothesis: Observe plate tectonic movements & interaction.

Materials: Graham Crackers
Icing
Knife

Procedure:
- Break cracker into small rectangle
- Piece rectangles together & add icing
- Conduct plate tectonics movements
  - Divergent – Convergent – Transform boundaries
- Observe formations created in the icing & correlate to Earth formations

Data/Observations:

Discussion: