TEACHER'S GUIDE

Terra Tempo: The Four Corners of Time

Lesson Plan

Grade Levels 4–7

CRAIGMORE CREATIONS

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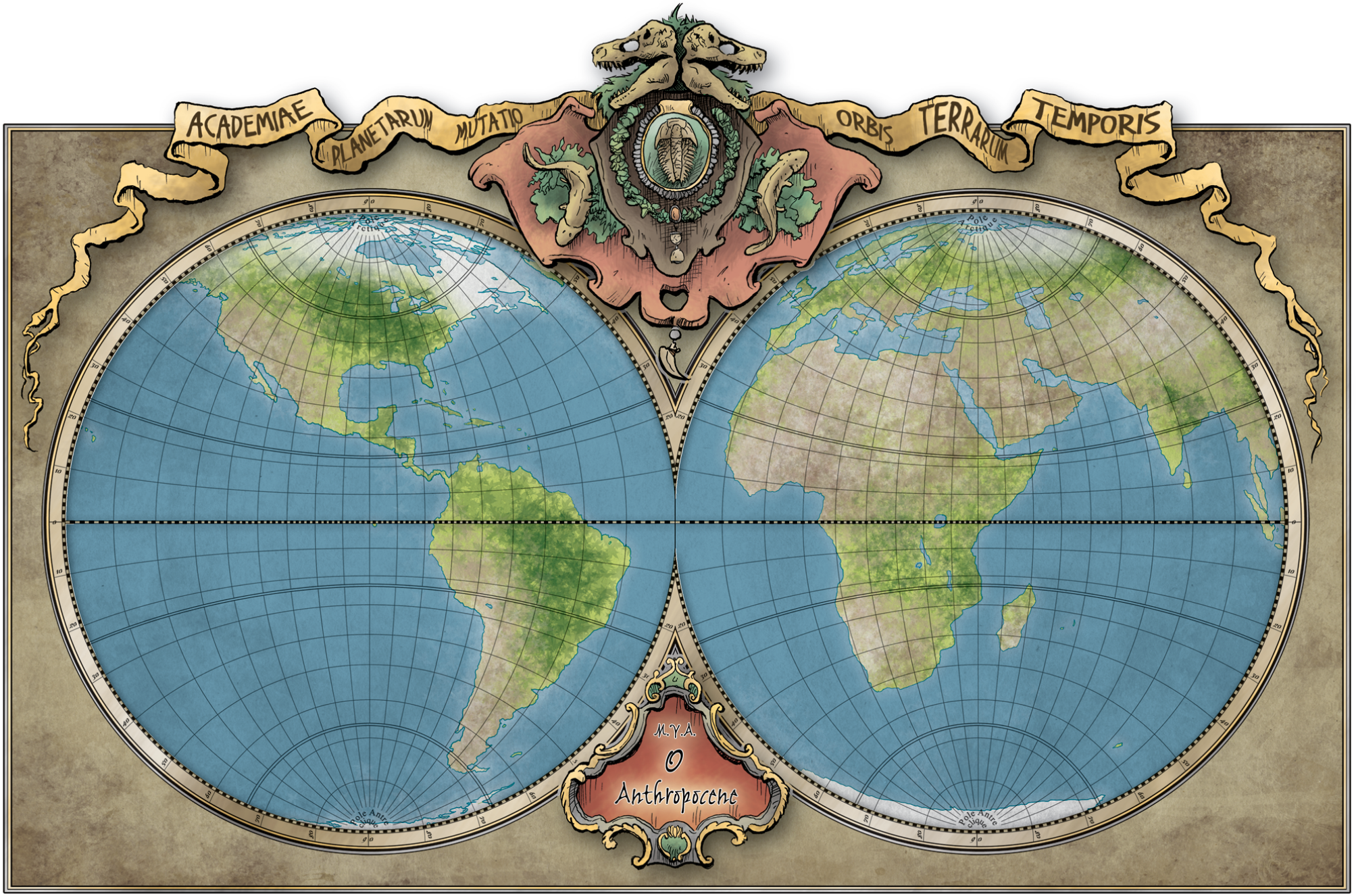

ACADEMIAE PLANETARUM MUTATIO ORBIS TERRARUM TEMPORIS
M.Y.A.
0
Anthropocene

Keep a time travel journal as you follow time travelers Jenna, Caleb, and Ari across the corners of time.

TABLE OF CONTENTS

LESSON 1
PRE-READING
UNDERSTANDING - GEOLOGIC TIME

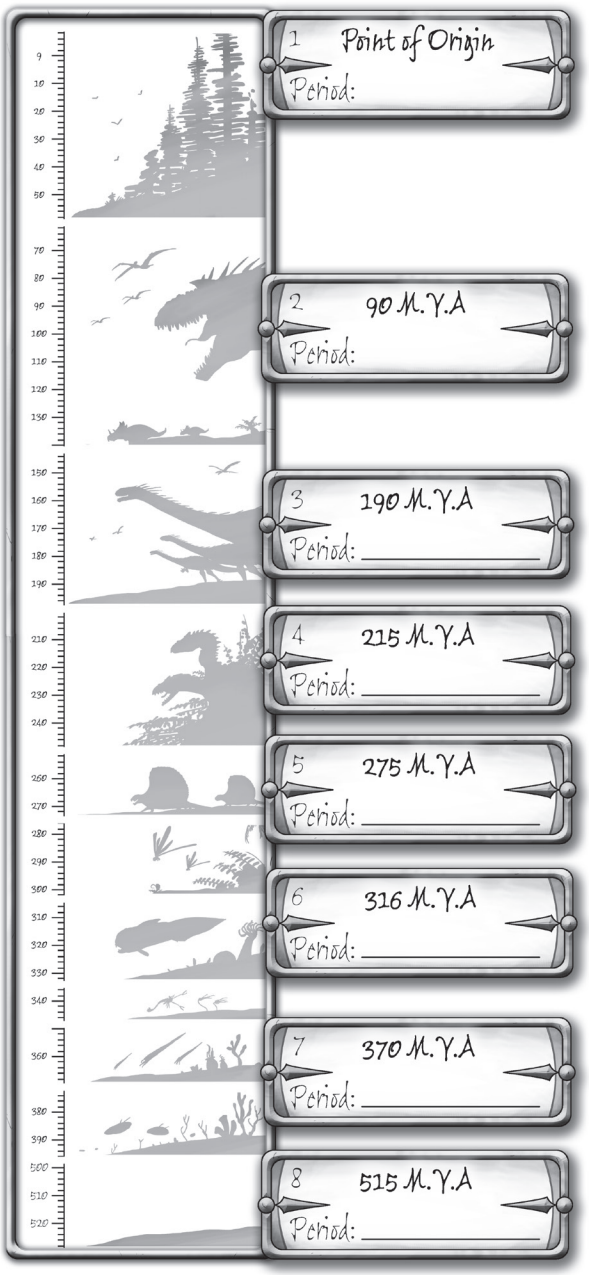
"True learning is in the dirt, found by rolling up the sleeves of your shirt."
-Uncle Al

Did you know that clues to the long past can be found in the dirt? Literally! Different habitats, ecosystems, and life forms long dead have left clues from their time locked in the Earth.

Activity: Point of Origin

Label the Periods on your timeline. As you keep your own time travel journal you will learn about the periods Jenna, Caleb, and Ari travel to.

As you read *Terra Tempo: The Four Corners of Time*, add a key fact and life form or symbol to each of the periods.



1 Key fact: _____

2 Key fact: _____

3 Key fact: _____

4 Key fact: _____

5 Key fact: _____

6 Key fact: _____

7 Key fact: _____

8 Key fact: _____

Background on Geologic Time:

The rock of the Earth's crust could tell us the history of Earth, but we know so little about rocks from more than 590 million years ago. Therefore, geologists call anything before this date Precambrian, even though the world is 4.6 billion years old.

More recent rocks tell the history of Earth since they were laid down on top of each other. Hence, the rocks on the bottom must be older than those on the top (although the sequence is often twisted, upturned, or broken). Fossils in the rock, and other signs are read to give a clearer picture of Earth's history.

Much of what we know comes from the study of fossils. And since certain fossils always appear before others in the sequence, regardless of rock type, one can say that one rock is older than another if it holds certain fossils. Fossils cannot give dates in years. For this scientists look for radioactive elements (such as uranium), which have a known rate of decay and can help determine dates.

The dates, or history, of Earth has been divided into time units: eons (longest), eras, periods, epochs, ages, and chrons. In this book, Jenna, Caleb, and Ari travel through periods of Earth's history starting with the Cambrian.

Further reading:

Check out the illustration of geologic time as a clock at wikipedia.org

http://paleobiology.si.edu/geotime/main/

http://www.nature.nps.gov/geology/usgsnps/gtime/gtime1.html

LESSON 2:
CHAPTER 1 – FOUND IN THE PAINTED DESERT

"The Last 550 million years of life on Earth have had some really intense time zones. We're gonna have to be really prepared for this one." -Ari

Your record of your travels begins here. As any good traveler knows, you need a good map to guide you.

Read Chapter 1.

On the next page is a map of the Colorado Plateau (present day).

Get oriented by labeling the points of the compass.

Teacher: Map is on page 7 in the student workbook. Answers on page 31 of *Terra Tempo: The Four Corners of Time*.

Label the states: Colorado, New Mexico, Arizona, Utah

Next, label the cities:

A: (Phoenix)
B: (Tuba City)
C: (Blanding)
D: (Grand Junction)
E: (Denver)
F: (Albuquerque)
G: (Santa Fe)

Label the key formations:
1: (Grand Canyon)
2: (Monument Valley)
3: (Rocky Mountains)
4: (Chaco Canyon)
5: (Petrified Forest)

Activity: Extinction Events

Ari's parents have taught him about different ways mass extinctions happen. Pick one of the five extinctions illustrated in the book and research it online. Be sure to make note of your sources. (Teacher: See page 19 in *Terra Tempo: The Four Corners of Time*)

Mass extinction caused by _____ can cause a massive extinction event because…

_____

_____

_____

Source(s):

_____

_____

_____

Further Reading:

Petrified Forest: http://www.scienceviews.com/parks/treestostone.html

Mass Extinctions:

http://www.endangeredspeciesinternational.org/overview.html

Changing ocean temperatures: http://marinebio.org/oceans/temperature.asp

Ice Ages: http://exhibits.museum.state.il.us/exhibits/larson/LP_extinction.html

Shifting land masses: http://www.news.wisc.edu/6138

Volcanic events: http://www.sciencedaily.com/releases/2011/01/110123131014.htm

Meteors: http://www.psi.edu/epo/ktimpact/ktimpact.html

LESSON 3
CHAPTER 2 AND 3 - GRAND IMPACT

"It is by learning to read the geologic record that a person can become a real-life time traveler." - Park Ranger

Read Chapters 2 and 3.

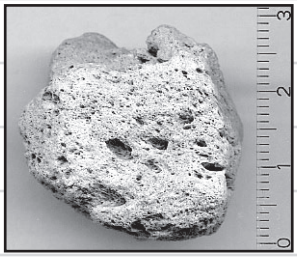
Understanding Rocks:

The three main types of rock are sedimentary, metamorphic, and igneous. The differences between them have to do with how they form.

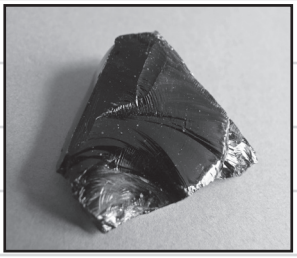
Igneous

Igneous rocks are formed when magma (molten rock deep within the earth) cools and hardens. Sometimes the magma cools inside the earth, and other times it erupts onto the surface from volcanoes as lava. When lava cools very quickly, the rock looks shiny and glasslike. Sometimes gas bubbles are trapped in the rock during the cooling process, leaving tiny holes and spaces in the rock.

Examples of this rock type include pumice and obsidian.



Pumice

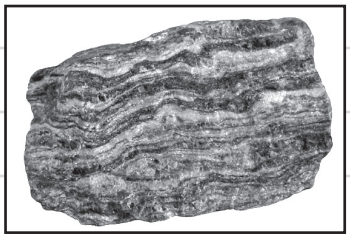


Obsidian

Go to http://geology.com and search "pumice" and "obsidian" for more information.

Metamorphic

Metamorphic rocks are formed under the surface of the earth from the metamorphosis (change) that occurs due to intense heat and pressure (squeezing). The rocks that result from these processes often have ribbon-like layers and may have shiny crystals, formed by minerals growing slowly over time, on their surface. Examples of this rock type include gneiss and marble.



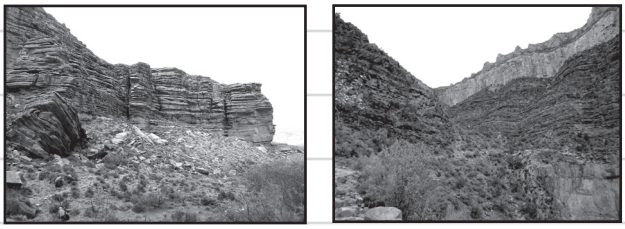
Gneiss

Marble

Go to http://geology.com and search "gneiss" and "marble" for more information.

Sedimentary

Sedimentary rocks are formed from fragments of other materials like sand, shells, and pebbles. Together, all these particles are called sediment. Over time sediment accumulates and hardens into rock. Generally, sedimentary rock is fairly soft and may break apart or crumble easily. It is usually the only type that contains fossils.



Sedimentary Rock

The layers of rock that Jenna, Caleb, and Ari see in the Grand Canyon with Uncle Al are all layers of sedimentary rocks. Let's take a look at the rock layers of the Grand Canyon.

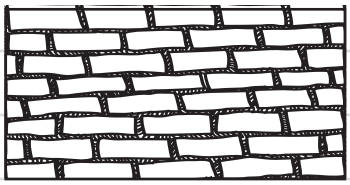
Activity: Rock Layers

Teacher: This Activity starts on page 10 in Student Workbook

Know The Canyon's History, Study Rocks Made By Time!

Look up the rock layers and give a brief description. Also draw a small picture or symbol to represent each rock.

Kaibab Limestone



Ex: The layer at the top of the canyon that is made up of sedimentary rock found at the bottom of seas and often includes fossils of sea critters.

Toroweap Limestone

Coconino Sandstone

Hermit Shale

Supai Group

Redwall Limestone

Muav Limestone

Bright Angel Shale

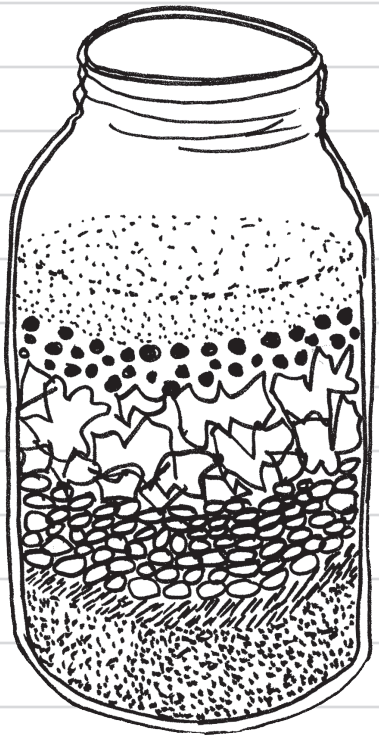
Tapeats Sandstone

Make a Mini-Canyon of Your Own!

Find materials to represent each rock layer (keep in mind color and composition). For the example given, Kaibab limestone, try using rice. It could have small shells or beads mixed in to represent the fossils!

Suggested materials: colored sand, dirt, pine needles, crumpled dried leaves, flour, small beans, beads, etc.

In a mason jar, or other clear container layer the materials in the same order they occur in the Grand Canyon to create a mini canyon of your own.



Further Reading:

http://www.nps.gov/grca/naturescience/geologicformations.htm

"Nowhere on Earth is the book of time complete."- Uncle Al

After observing the kids' travels through geologic time, complete the notes:

Period: Cambrian **Formation:** Bright Angel Shale

Describe the characteristic plants and animals (3). *You may have to do some additional research!*

1 _____

2 _____

3 _____

Describe the environment (climate/landscape):

_____

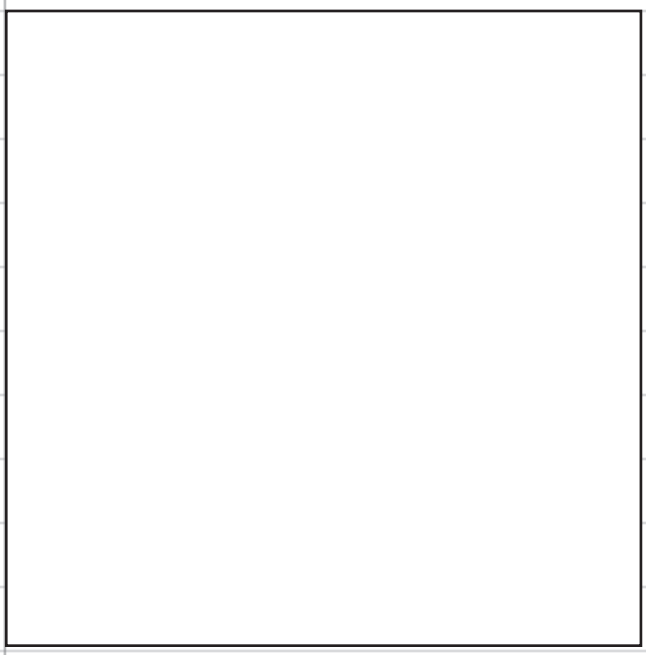
_____

Identify a key fact after reading:

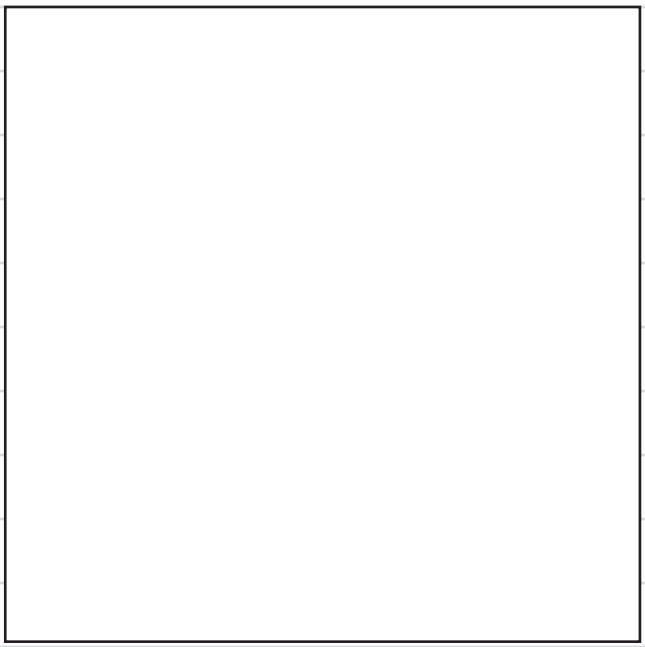
_____

Sketchbook: Then/Now

Draw the Cambrian as it was and the Bright Angel Shale as it is now.

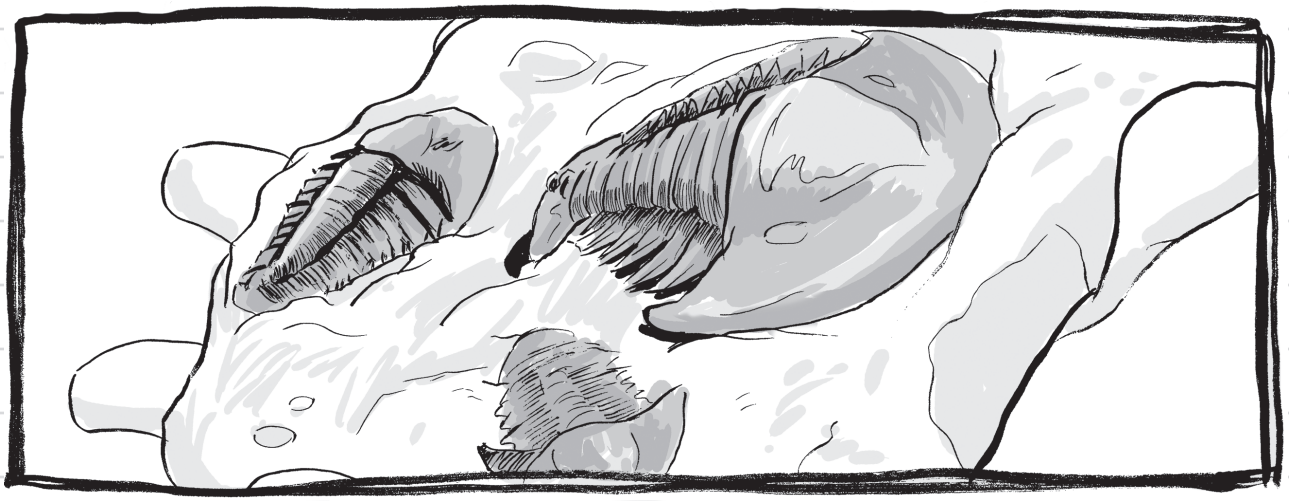


Cambrian Then



Bright Angel Shale Now

Activity: Make Your Own Fossils



Uncle Al points out a trilobite fossil. Its body was covered by a layer of mineral-rich sediment on the bottom of a shallow sea. Its shell was slowly replaced by the minerals encasing it until a cast, or impression, remained. These outlines can remain in or on rock for millions of year and preserve clues to the past.

Materials:

½ cup cold coffee - for coloring. Water may be substituted. Can add coffee grounds or sand for texture.
1 ½ cup flour
½ cup salt
mixing bowl and spoon
objects

Directions:

Mix ingredients together, adding the flour slowly (more flour can be used if the dough is too sticky). Roll dough into small rounds or sections. An object can be pressed into each section. Sample objects: leaves, shells, plastic play animals, or any object from

the present day that signifies what would be laid down in our own geologic time for future geologists and archaeologists to ponder.

Remove the object, leaving an impression. Let the dough dry overnight.

Teacher: As an additional activity, bury the objects in shoeboxes with sand. Students can then dig them out using spoons and brushes.

If you were discovering this for the first time; what could your discovery tell you about the past?

LESSON 4
CHAPTER 4 – PALEOZOIC PURSUIT

"You are well on your way to being geologic time travelers!"- Uncle Al

Read Chapter 4, then complete the notes.

Period: _____ **Formation:** Temple Butte

Describe the characteristic plants and animals (3):

1 _____

2 _____

3 _____

Describe the environment (climate/landscape):

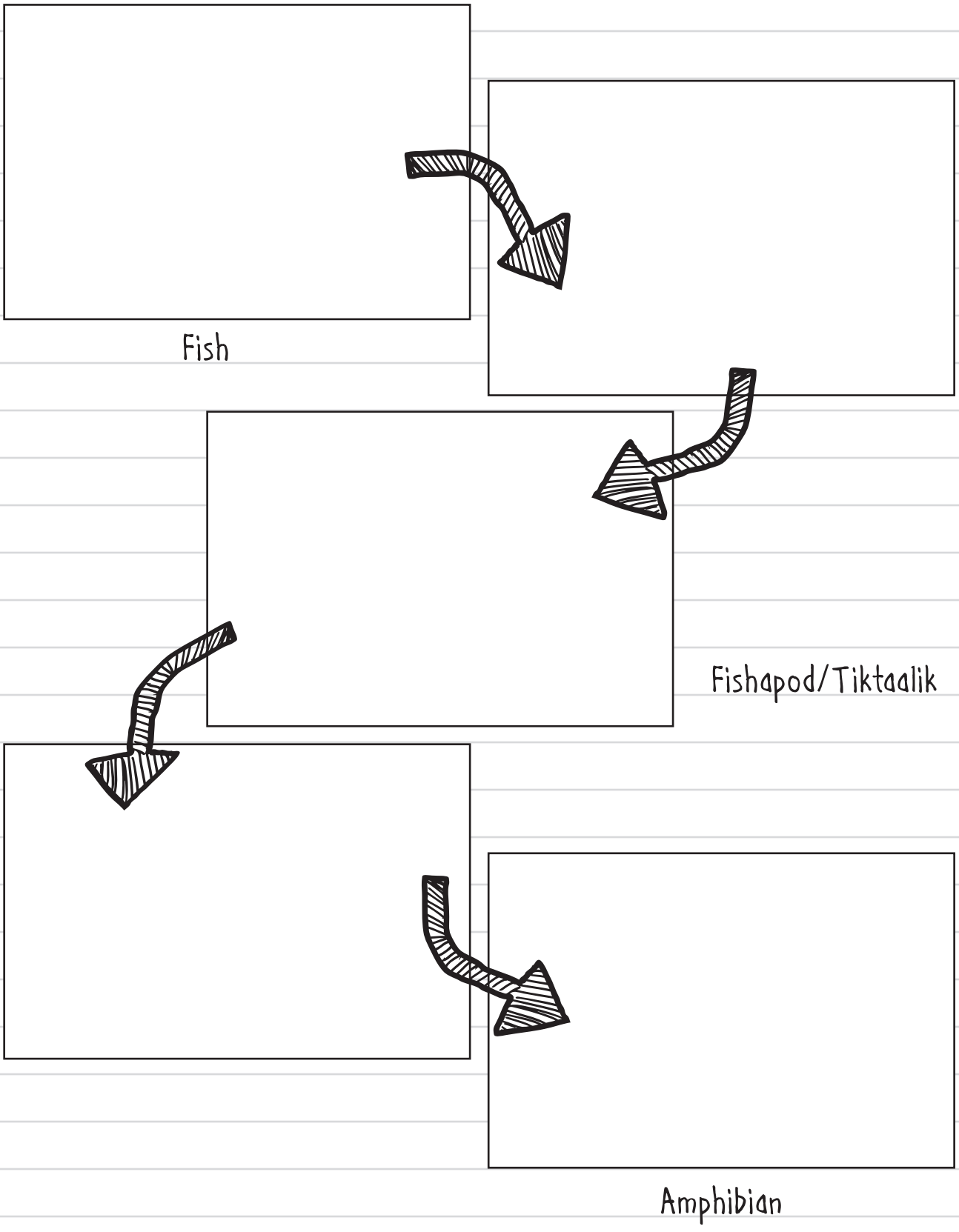
_____

_____

Identify a key fact after reading:

_____

Activity: Illustrate the transition from Fish to Amphibian



Fish

Fishapod/Tiktaalik

Amphibian

Period: _____ **Formation:** Honaker Trail

Describe the characteristic plants and animals (3). You may want to look some names up!

1 _____

2 _____

3 _____

Describe the environment (climate/landscape):

_____

_____

Identify a key fact after reading (also write this on your geologic timeline):

_____

Activity: Illustrating the Pennsylvanian Carboniferous

Now: Honaker Trail Formation

Deposited in the Pennsylvanian Carboniferous Period by shallow seas. Comprised of dark grey limestone with fossils forming rugged slopes and ledges.

Then: Pennsylvanian Carboniferous

After reading, illustrate how you imagine this area looked in your time travel journal; keep in mind what you have learned about this period.

Further Reading:

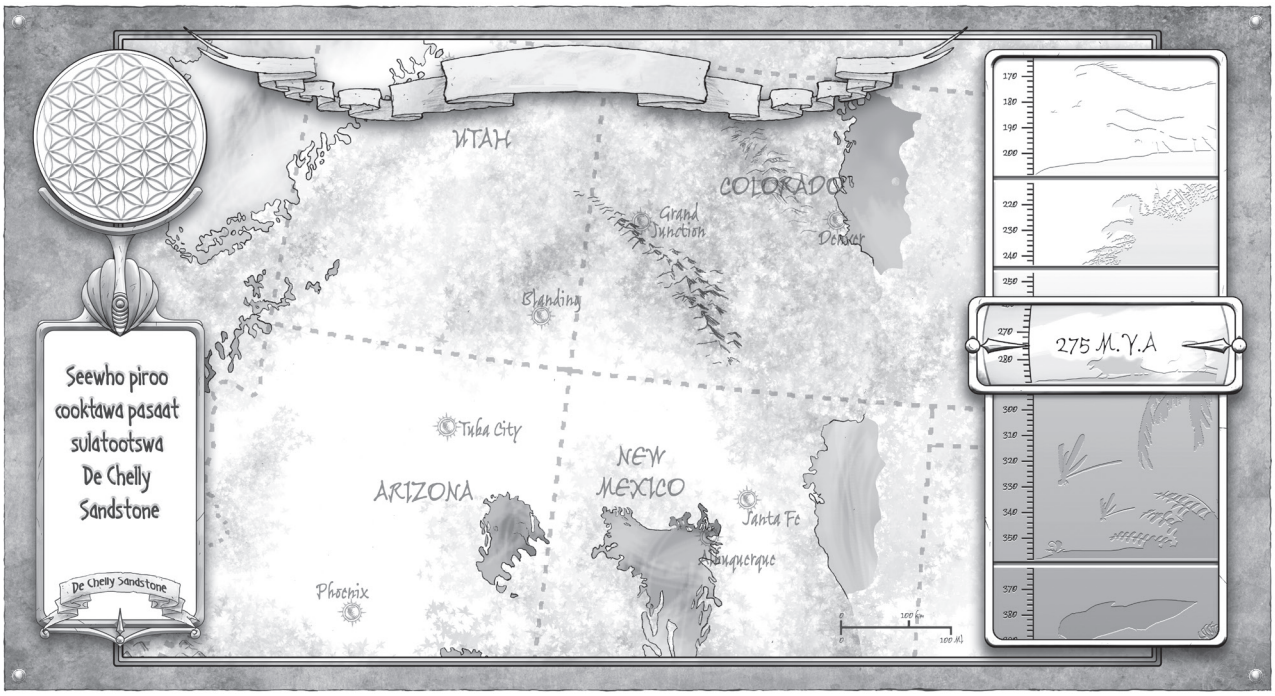
Honaker Trail Formation: http://www.searchanddiscovery.com/documents/2011/50510helms/ndx_helms.pdf

http://www.ucmp.berkeley.edu/carboniferous/carboniferous.php

Image searches on Google turn up a variety of artistic drawings that are very interesting to compare.

LESSON 5
CHAPTER 5 – THE PERMIAN POST

"The landscapes of time are a puzzle that I am dedicated to solve."- Levi Wilson



Read Chapter 5, then complete the notes

Period: _____ **Formation:** De Chelly Sandstone, Monument Valley

Describe the characteristic plants and animals (3). *You may want to look up some additional creatures!*

1 _____

2 _____

3 _____

Describe the environment (climate/landscape):

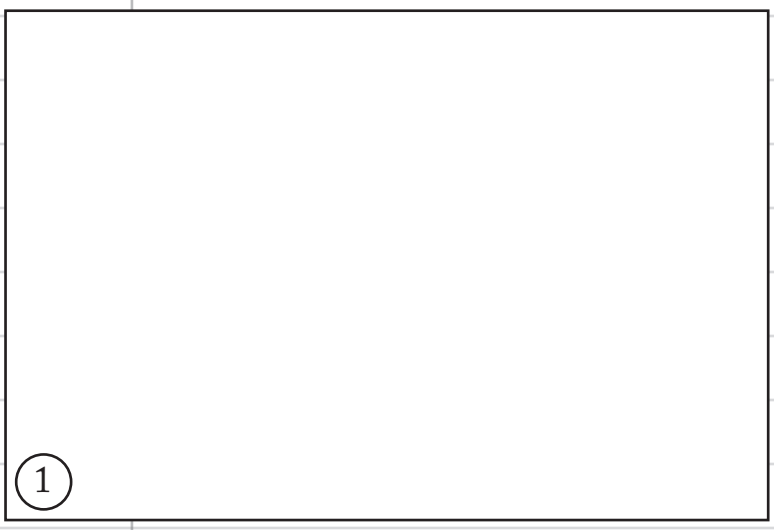
_____

_____

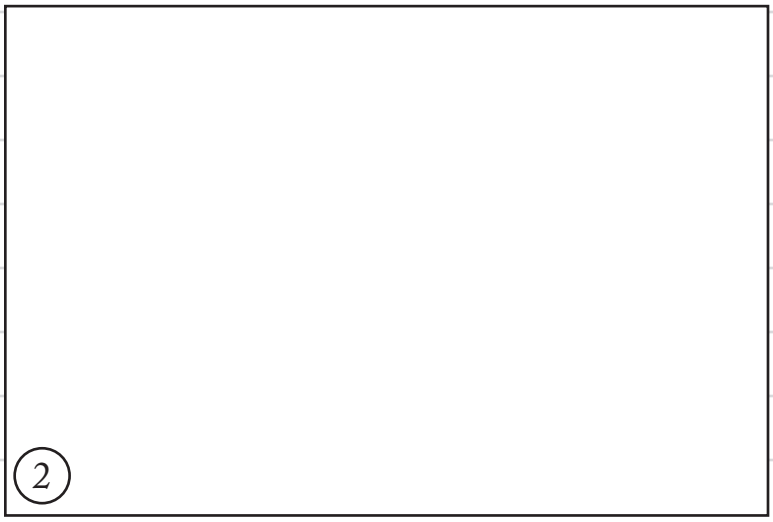
Identify a key fact after reading:

_____

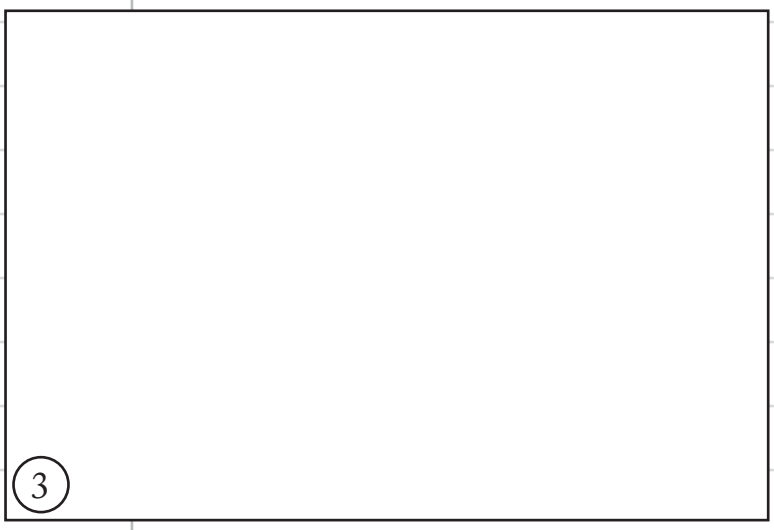
Make a mini graphic novel illustrating the "Great Dying" in the frames provided.



Pangea Supercontinent break-up.



Volcanic eruptions: huge lava flows occurred in Siberia erupting for hundreds of years; there was lava for miles!



Ash from the volcanoes blocked out sunlight – like a cloud – and the temperature dropped.

Then, the temperature rose from all the gas caused by the eruptions.

5

The changing weather patterns caused species to die-off on land.

6

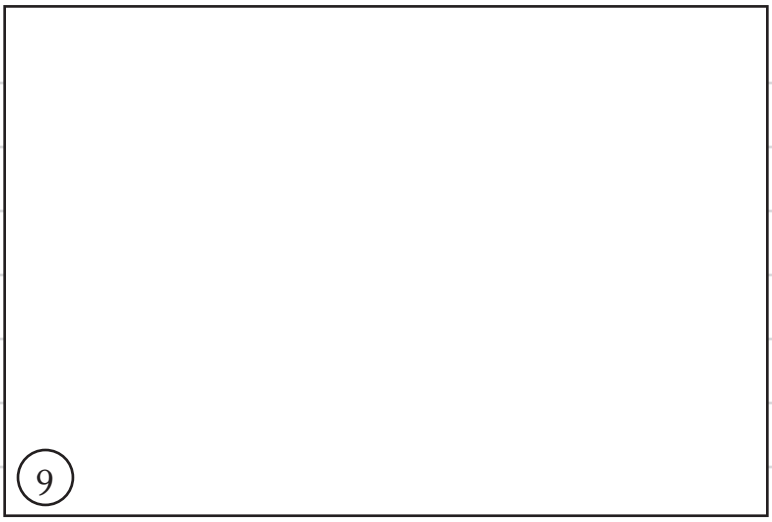
…And in the sea.

7

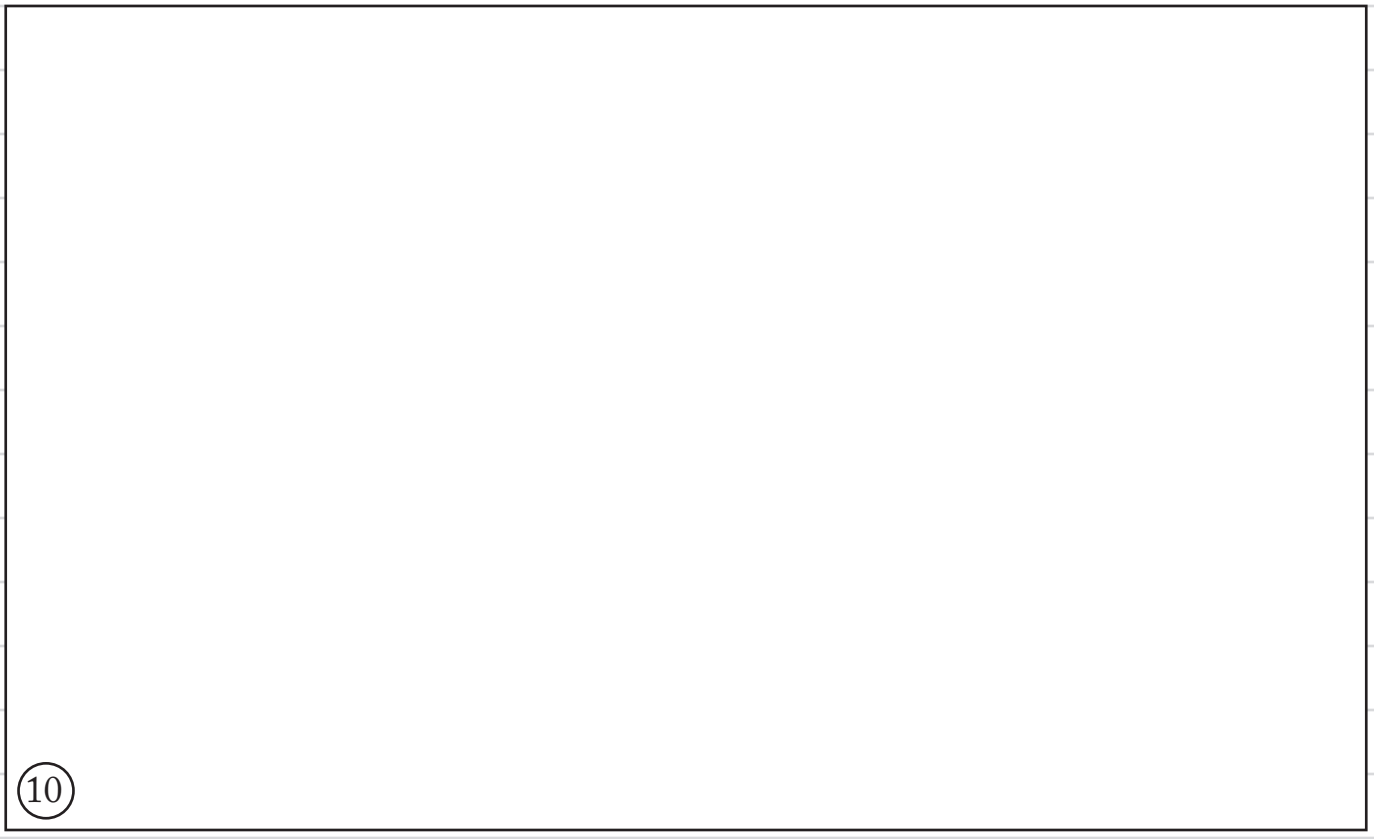
When the oceans warmed up, the chemistry of the sea was disrupted, killing many organisms that supported life.

8

Every change affected life on Earth and occurred over a period of time – maybe 100,000 years.



The most severe of all the extinctions killed 90% of existing life – it took over ten million years for the planet to recover and give rise to the reign of the…



Dinosaurs!

Debate Activity: Conflicting Mottos (This activity can be done now or later on.)

The Geosophists vs. the Treasure Hunters

Discover the curious nature of things and the curious things in nature vs.
First discover, first claim

By understanding the land and the processes of change the land undergoes through time, the time travelers could make money in the present day by locating mineral wealth (mining), oil, coal, water, and dinosaur bones deposited in the past. Some time travelers seek this wealth, but others are after understanding the Earth and the Earth's history. Those who travel to understand the Earth's puzzles and gain knowledge are out to "Discover the curious nature of things and the curious things in nature." Those who travel to locate material wealth say, "First discover, first claim!"

Divide into 2 groups. Some students represent the geosophists and others the treasure hunters. (Teachers choice: scaffold the debate according to students' abilities and maturity. Ex: Small groups, divided class, fishbowl).

After arguments are presented and both sides have had a chance to respond ask students to vote with their feet. Those who would time travel as treasure hunters move to one area. Those who see themselves as geosophists at heart go to another area. A third area may be created for those who are unsure.

Further Reading:

Rough Riders:
http://www.loc.gov/rr/hispanic/1898/roughriders.html
http://en.wikipedia.org/wiki/Rough_Riders
Spanish American War:
http://www.spanamwar.com/rrhist.html

LESSON 6
CHAPTER 6 – TSE'BII'NDZISGAII

"The Landscape is not just a place to live, it's a story we become a part of."
- Robbie

Read Chapter 6, then complete the notes.

Location: Monument Valley, 1986 CE (Common Era)

Period: _____

Formation: Chinle Formation; Monument Valley

Describe the characteristic plants and animals (3):

1 _____

2 _____

3 _____

Describe the environment (climate/landscape):

_____

_____

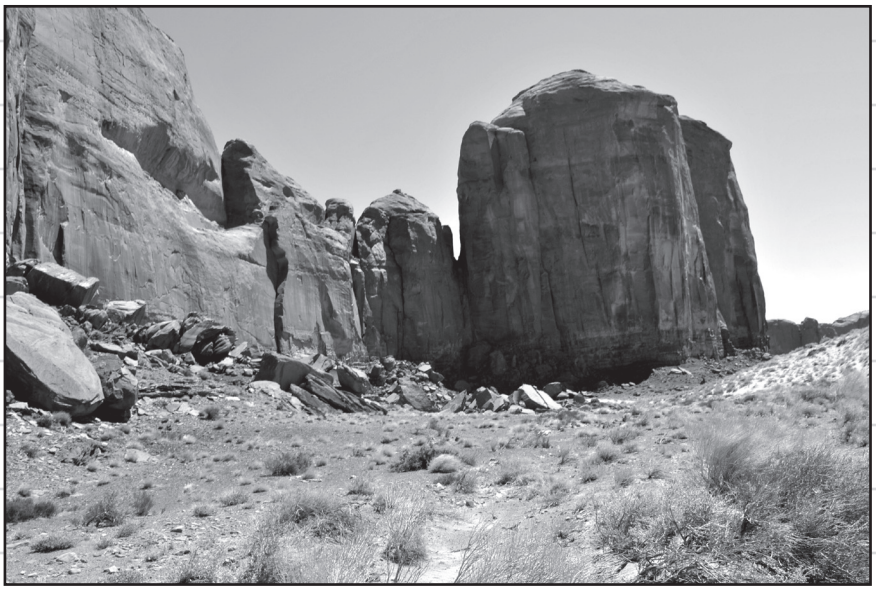
Identify a key fact after reading:

_____

Ye Bi Chei

Monument Valley is characterized by its iconic rock formations. These formations are colored red by iron oxide and are clearly stratified into three different layers, and were formed by weathering and erosion. The Ye Bi Chei and other landforms have significance to the Navajo People that relate both to their mythological history as well as their modern history. Today Monument Valley is a Tribal Park and the interior is only accessible with an official Navajo guide.

Reference: http://monumentvalley.org/geology/



Monument Valley, AZ

Activity: Weathering and Erosion

Materials:

Sugar cubes (recommended variety brown and white sugar!)

glue

eye dropper, squeeze bottles like those used for contact solution, spray bottles, etc

plastic base (tupperware lid)

Create a landscape inspired by the formations of Monument Valley by stacking and arranging your sugar cubes. Experiment with different shapes, groupings, and levels. See the pictures above for inspiration!

Question: What will happen to your (sugar) landscape when water is introduced?

Hypothesis:

_____

_____

_____

Fill the eye dropper with water and focus the droplets on a few places in your sugar landscape.

What is happening? Record your observations.

_____

_____

_____

Now experiment by introducing the water by way of different containers. Formulate a new hypothesis:

If… _____

_____

Then… _____

_____

Conclusion:

Using the experiment above explain how you think weathering and erosion agents like water have shaped the landscape in places like Monument Valley.

_____

_____

_____

_____

_____

Further Reading:

http://monumentvalley.org/geology/

http://navajonationparks.org/htm/monumentvalley.htm

http://www.monumentvalley.com/Pages/english_homepage.html

LESSON 7
CHAPTER 7 – TRIASSIC TIMES

"It's most dangerous to have the map and not understand it."- Peregrina Sandoval

Read Chapter 7, then complete the notes.

Period: Mesozoic – Late Triassic **Formation:** Chinle Formation

Describe the characteristic plants and animals (3).

1 _____

2 _____

3 _____

Describe the environment (climate/landscape):

_____

_____

Identify a key fact after reading:

_____

Early Mammals: Divergent Evolution

Connect these life forms of the past to their decendants in the present:

Diapsid – Vertebrates that possess skulls with two major fenestrae, or openings near the temple.

(Teacher: examples include snakes, lizards, birds, dinosaurs)

Synapsid – Vertebrates that possess skulls with one major fenestra in the region of the temporal bone

(Teacher: examples: mammals)

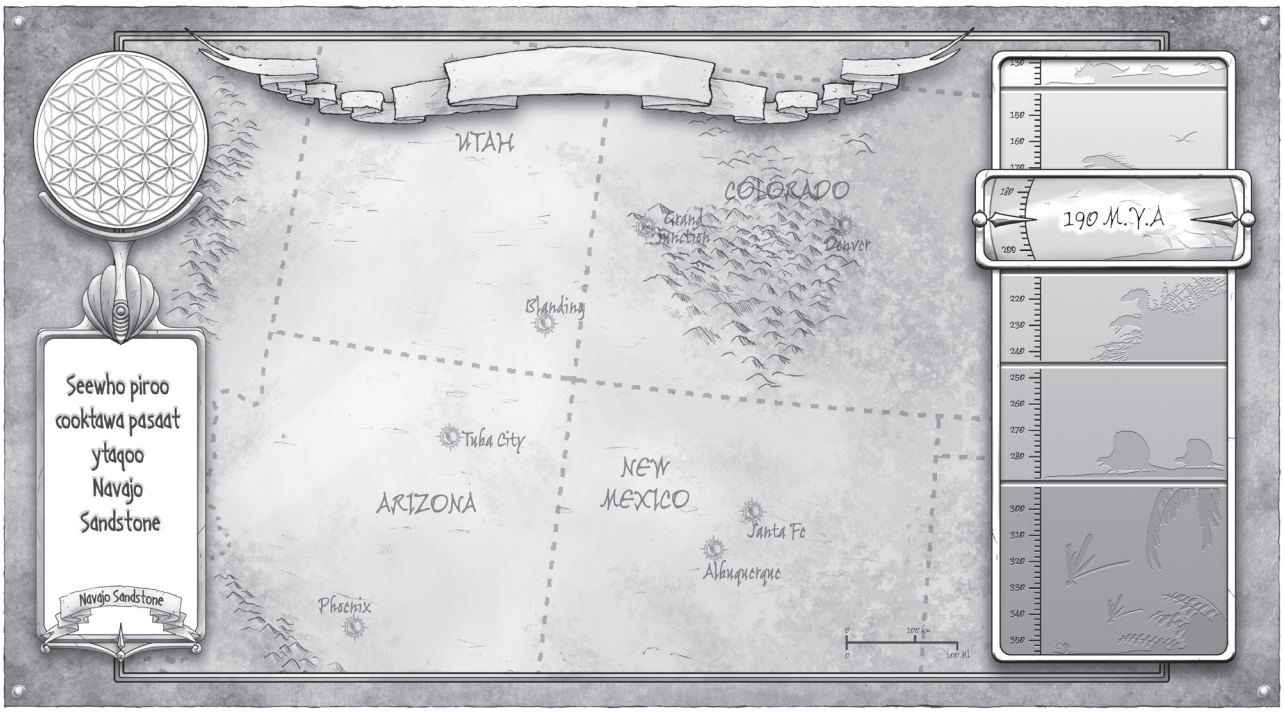
Anapsid –Vertebrates that possess skulls with no major fenestrae

(Teacher: example: turtles)

Research each type of animal above. Choose an animal for each and draw their skulls. Be sure to label your drawing with the animal's name.

LESSON 8
CHAPTER 8 - MOBILIS IN MOBILI

"I move within movement and I get where I need to go." -Everett Ruess



Read Chapter 8, then complete the notes.

Formation: Navajo Sandstone; Monument Valley

Period: _____

Describe the characteristic plants and animals (3):

1 _____

2 _____

3 _____

Describe the environment (climate/landscape):

_____

_____

Identify a key fact after reading:

_____

Pantoum Activity

A pantoum in an ancient form of poetry originating in southeast Asia. It is often used in poems describing nature.

Instructions:

1. Number eight lines on a separate piece of paper (1–8.)
2. Think about the kids' time travel experience, especially in the Jurassic.
3. Brainstorm and write down eight things that come to mind (on lines 1–8.) These can be words, phrases, or sentences.
4. Transfer your words onto your pantoum form on the next page, matching the numbered lines on the brainstorm to the numbered lines on the form. (Note, there are repeating lines!)
5. You can revise, add, or take away.
6. Read your Jurassic Time Travel Pantoum aloud!

Pantoum sequence:

1 _____

2 _____

3 _____

4 _____

2 _____

5 _____

4 _____

6 _____

5 _____

7 _____

6 _____

8 _____

7 _____

3 _____

8 _____

1 _____

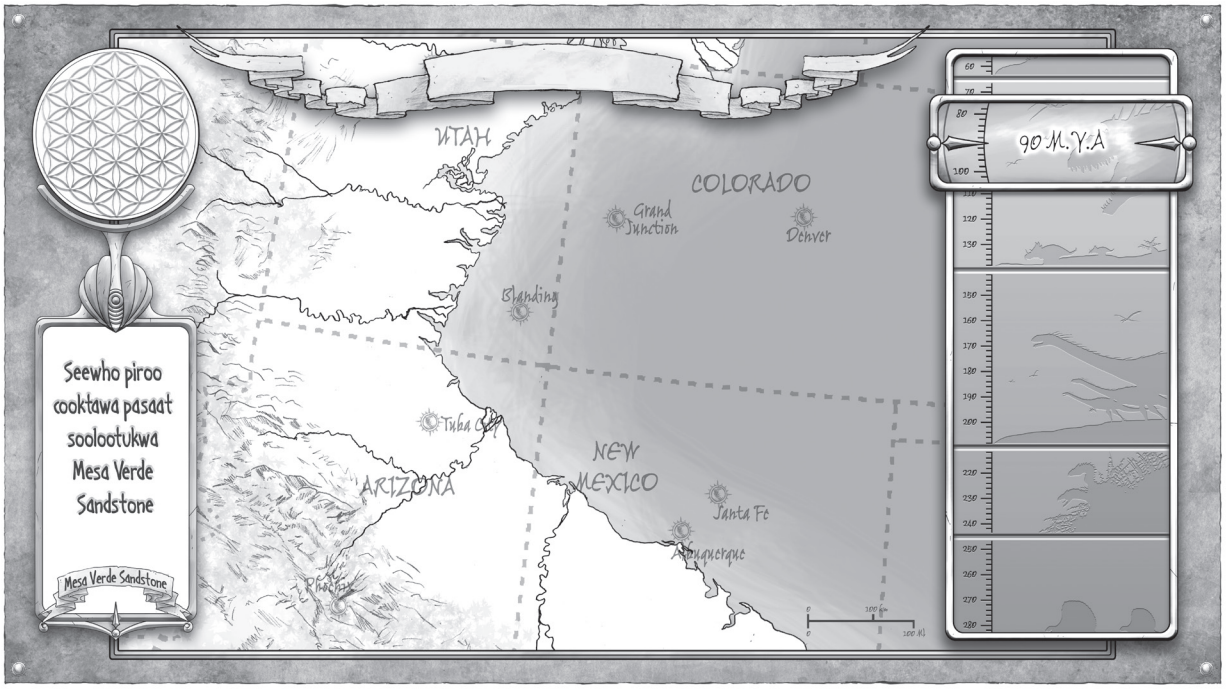
Further Reading:

Everett Ruess: http://everettruess.net

About Pantoum Poetry: http://www.poets.org/viewmedia.php/prmMID/5786

LESSON 9
CHAPTER 9 - CREEPY CRETACEOUS

"We need to know the territory if we are to understand the map." -Jenna



Read Chapter 9, then complete the notes.

Period: _____

Formation: Mesa Verde Sandstone; Monument Valley

Describe the characteristic plants and animals (3):

1 _____

2 _____

3 _____

Describe the environment (climate/landscape):

_____

_____

Identify a key fact after reading:

_____

Ponder: Why can't Jenna, Caleb and Ari make it back to Monument Valley from the Cretaceous?

How do you think the kids will get back to Uncle Al and Aunt Maddie?

Fulfill Jenna's wish and draw a scene from the Cretaceous. Be sure to label the plants and animals in your scene for future time travelers.

LESSON 10
CHAPTER 10 – HOME FROM THE RANGE

Read Chapter 10. Go through your time travel journal and be sure you have a completed timeline with a key fact and symbol (Lesson 1) before you begin the final activity.

Research Project

Discover the curious nature of things and the curious things in nature

vs.

First discover, first claim

(Can be done in groups, pairs, or individually)

There is a key conflict in this book regarding the reasons for time travel and exploration. Both groups of time travelers, the treasure hunters and geosophists are after knowledge and understanding of the processes of change. The key difference is in what they intend to do with their knowledge.

The present day Colorado Plateau holds resources that were laid down and formed by the Earth's geologic past. These are important natural resources that people use in our society and important for study to better understand the Earth's history. These resources, which hold the key to understanding, can also be the key to wealth.

The conflict spills off the page and into real life and it is up to you – just like Jenna, Caleb and Ari – to think about what we do with "the curious things in nature."

Lookup each of the resources below and mark at least one location on the map on the next page where that resource can be found. Be sure to complete a key for your map. You may choose to use different colors or different symbols for each resource.

Resources:

1. Uranium – Atlas Uranium Mill and/or Denison mines
2. Dinosaur bones – Morrison Formation
3. Coal – Black Mesa (Peabody Western Coal Company)
4. Water – Navajo aquifer (Black Mesa) or Colorado River (Hoover Dam)
5. Natural gas/shale gas – Manning Canyon Shale
6. Petroleum

Resource maps for reference:

http://energy.usgs.gov/OilGas/AssessmentsData/NationalOilGasAssessment/AssessmentUpdates.aspx

http://pubs.usgs.gov/dds/dds-069/dds-069-b/REPORTS/Chapter_7.pdf

More maps from the USGS:

http://energy.usgs.gov/Tools/EnVisionSplash.aspx

Map Key

- Uranium
- Dinosaur Bones
- Coal
- Water
- Natural Gas/Shale Gas
- Petroleum

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