St. Louis Public Schools
Continuous Learning for Students
Middle School Science

Welcome to Distant Learning for Middle School Science for STUDENTS!

Students are encouraged to maintain contact with their home school and classroom teacher(s). If you have not already done so, please visit your child's school website to access individual teacher web pages for specific learning/assignment information. If you cannot reach your teacher and have elected to use these resources, please be mindful that some learning activities may require students to reply online, while others may require students to respond using paper and pencil. In the event online access is not available and the teacher cannot be reached, responses should be recorded on paper and completed work should be dropped off at your child's school. Please contact your child's school for the dates and times to drop off your child's work.

If you need additional resources to support virtual learning, please visit: https://www.slps.org/extendedresources

Overview of Week 6: Students engage with the performance task *Evolution of Andes* where they use what they know about the rock cycle and how earth systems interact (weeks 3-5 (April 6-24) of Continuous Learning plans) to create a model of how the growing Andes could have led to the sloths living in the Amazon and write an argument about how the Andes led to the sloths using their model as evidence. Students will present their final model and argument via PowerPoint slides, essay, or poster. To access **all instructional fillable pdf files, also available in print, for Week 6 go HERE**.

Overview of Week 7: Students use information on relative and absolute dating of rocks, slow and fast geologic changes of landforms to explain new phenomena such as the Great Unconformity and marine fossils found in the dry and arid areas of Grand Canyon, Arizona. Students work with Module F, Unit 2 as a primary resource. In any event that students cannot log in and access the work through their HMH account, they can type their answers in the editable pdf files hyperlinked and submit their responses via the platform established by their classroom science teacher. To access **all instructional fillable pdf files, also available in print, for Week 7 go HERE**.

Please keep in mind that daily breakdown of tasks is only a suggestion of pacing and resources.

For additional information on virtual learning go to https://www.slps.org/keeponlearning

For questions related to this instructional plan, please contact:

Valentina Bumbu
Science Curriculum Specialist
valentina.bumbu@slps.org

Daniel Bruce, Marvin Kopf
MS Science Teacher Leaders
daniel.bruce@slps.org, marvin.kopf@slps.org

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WEEK 6	**Lesson Objective** *What will you know and be able to do at the conclusion of this lesson?*	**Instructional Activities** *What needs to be done in order to teach the material?*	**Assessment / Assignment*** *How will you show your teacher that you learned the material? What needs to be turned in?*
Monday April 27	Obtain & evaluate information about the changes in the Andes mountains over time. Develop an initial model that shows life processes that formed Andes.	1. Follow the Slides up to Day 2 Tasks 2. Follow the instructions in the Student Instructions and complete Day 1 tasks shown in the slides	Write on a separate piece of paper or type in a word document the answer to Warm-Up Exercise questions. Write or type on the Evidence table. Draw/explain the initial model on paper or word document.
Tuesday April 28	Develop a model that explain changes and movement of matter (earth materials) in the Andes and how that led the sloths to live there	1. Follow the Slides Day 2 Tasks 2. Follow the instructions and complete Day 2 tasks shown in the slides **Additional support for modeling:** Animation of plate tectonic evolution of South America (Start at 2:45 to start at 80 million years ago. It takes a few viewings to see how the water recedes from South America, the Andes build eastward and rise, and the Amazon region fills in. You can also see how the Nazca Plate (the plates are shown in dark blue) begins to move very quickly toward South America at about 20 million years ago.) Video on background on plate boundary between Nazca and South America	Write or type on the Evidence table. Draw/explain the updated model (model 2) on paper or word document.

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Wednesday **April 29**		1. Follow the Slides Day 3 Tasks a. Write or type the answers to the questions 1-3 in Module F, Unit 2 Lesson 2 Engage and Exploration 1. b. Review Module F, Unit 2 Lesson 2, Explorations 2 and 3 2. Complete the rest of Day 3 tasks shown in the slides	Write or type the answers to the questions 1-3 in Module F, Unit 2 Lesson 2 Engage and Exploration 1. Draw/explain the updated model (model 3) on paper or word document.
Thursday **April 30**	Construct an argument to support a claim about one way that the Andes Mountains influenced the sloths living in the Amazon rainforest.	1. Follow the Slides Day 4 Tasks 2. Follow the instructions and complete Day 4 tasks shown in the slides	Draw/explain the updated model (model 3) on paper or word document. Write on paper (or type in a word document) questions for Day 4 that assess the most recent model.
Friday **May 1**	Create a presentation (PowerPoint slides, essay, or a poster) that includes your argument and model.	1. Follow the Slides Day 5 Tasks 2. Follow the instructions and complete Day 5 tasks shown in the slides 3. Use the Rubric for Students for guidance	Present your model and claim from evidence either via a powerpoint, essay, or poster.

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WEEK 7	**Lesson Objective** *What will you know and be able to do at the end of this lesson?*	**Instructional Activities** *What needs to be done in order to learn the material?*	**Assessment / Assignment*** *How will you show your teacher that you learned the material?*
Monday May 4	Explain how relative age of rocks (and fossils) can provide evidence of history of Earth	1. Engage with Module F, Unit 2 Lesson 1 Exploration 2 Relative Dating 2. Answer the questions 8-10 3. Complete the Performance Task *Grand Canyon Mystery* questions	Write or type the answers to questions 8-10 in Mod F, Unit 2, Lesson 1 Exploration 2 and questions in the performance task *Grand Canyon Mystery*.
Tuesday May 5	Explain how absolute age of rocks provides evidence of history of Earth	Read and answer the questions in Module F, Unit 2 Lesson 1 Exploration 3	Write or type the answers to questions 11-16 Mod F, Unit 2, Lesson 1 Exploration 3.
Wednesday May 6	Explain how data on rocks in Ashfall Fossil Bed National Park in Nebraska can provide evidence of history in that area	Read and answer the questions in Module F, Unit 2, Lesson 1 Continue Your Exploration, Lesson Check, and Interactive Review	Write or type the answers to Module F, Unit 2, Lesson 2 Continue Your Exploration questions 1-2 , Lesson Check questions, and Interactive Review questions.
Thursday May 7 **Friday May 8**	Construct an explanation for how marine fossils ended up in dry areas of Grand Canyon	1. Read the instructions in Module F Unit 2 Performance Task *How did marine fossils end up in the desert?* 2. Read and annotate Layers and Fossils in Grand Canyon and Fossils in Grand Canyon articles. 3. Answer the questions in the task sheet.	Write or type the answers to questions in Module F Unit 2 Performance Task *How did marine fossils end up in the desert?* using information from the 2 articles provided. !

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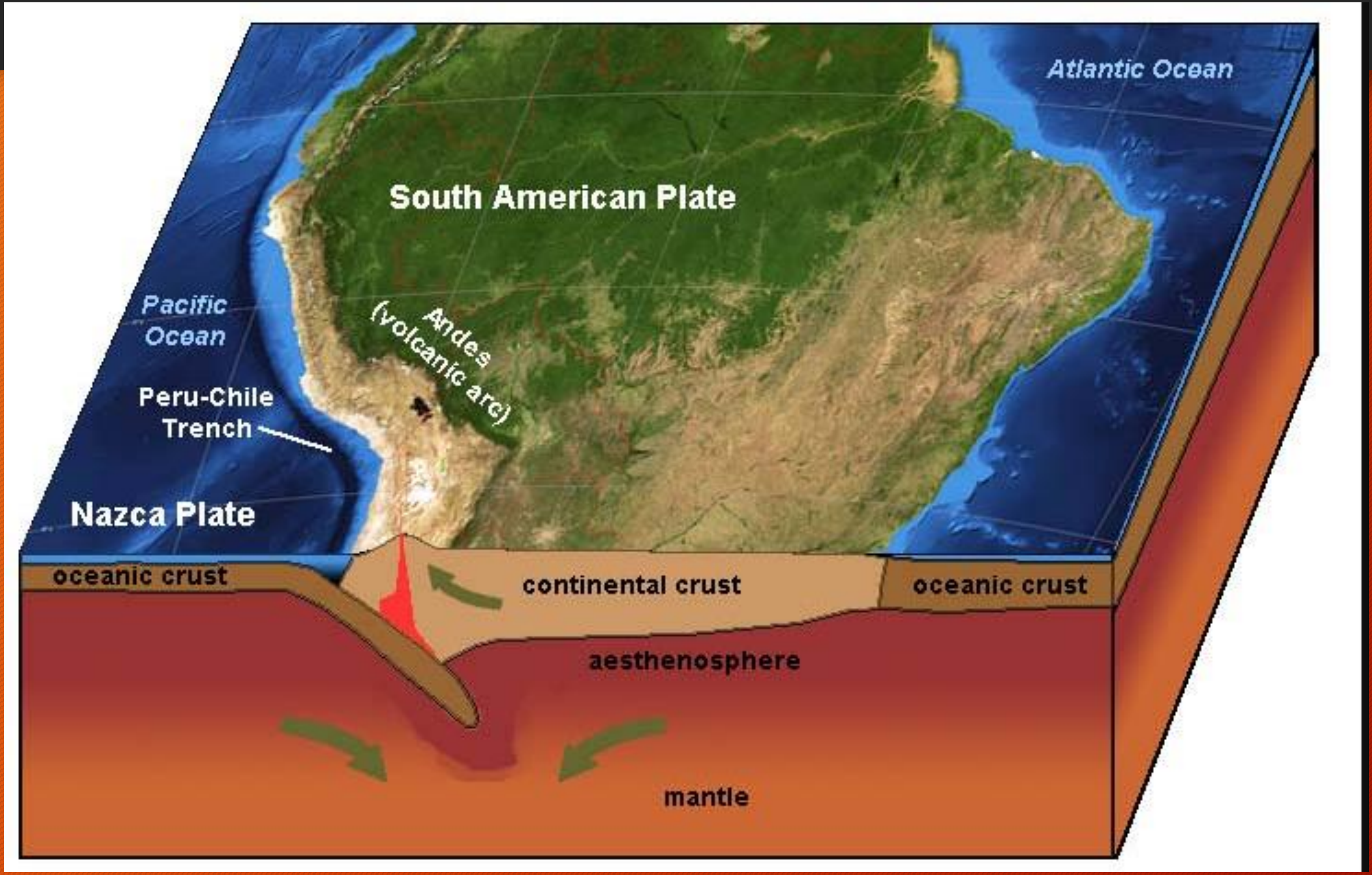
Evolution of Andes

POWER POINT SLIDES

How do mountains form? How do the growing mountains affect the areas around them?

Warm-Up Exercise

Where are the Andes Mountains are compared to the plate boundary?



Long History of Andes (Optional)

Video (1:53 min)

https://www.youtube.com/watch?v=VGsnGIRw0HY

Student Instructions Handout

- Read the Student Instructions

Student Instructions
Evolution of the Andes

INTRODUCTION
What does a sloth living in the Amazon rainforest have to do with the Andes Mountains more than 1,000 miles away?

Some scientists claim that when the Andes Mountains began growing they caused huge changes across South America, including changing the cycling of the water and atmosphere, which then influenced the ecosystems across the continent. They describe these interactions in terms of the movement of matter through the different systems.

This idea has caused a lot of controversy. Some people think that the mountains could not have caused so many changes to distant parts of the continent. Others agree, believing the mountains formed much earlier or later than these changes, so they could not have caused them. Some even argue that the climate helped the mountains to grow, not the reverse.

Goals of the performance task

- Use what you know about the rock cycle and how earth systems interact to create a model of how the growing Andes could have led to the sloths living in the Amazon
- Write an argument about how the Andes led to the sloths using your model as evidence

Day 1 Tasks

1. **Gather evidence about the processes that built the Andes.**
   - Read **Evidence Card 1** and organize your ideas about each piece of evidence in the **Evidence Table**.
   - In the 1st column summarize each piece of evidence of a change that affected the Andes or the Amazon regions.
   - In the 2nd column describe what process(es) could have created each piece of evidence. Use the Rock Cycle Model (Resource 2) to describe the processes.
   - In the 3rd column write where (e.g., Andes region or Amazon region) and when the changes happened.
   - After you fill out the table for all the changes on your evidence card, write numbers in the 4th column to show the order in which the changes took place.
   - The first row is filled out with an example.

Day 1 Tasks, continued

2. Begin creating your model.

- Use information from your Evidence Table to make a model that shows the processes that built the Andes Mountains.
- The models should use words, color, symbols, and/or pictures to show:
  - The kinds of rocks that formed in the Andes Mountains
  - The processes that formed those rocks.
- Make sure you label the parts of your model and the arrows between the parts with the process that the arrow represents

3. Turn in your initial model to your teacher by labeling Day 1 Model

The goal of the model is to track the flow of matter and energy through the earth system from the Andes Mountains to the sloths living in the Amazon.

Day 2 Tasks

3. Gather more evidence about the Andes and the Amazon

- Read Evidence Card 2 and Evidence Card 3
- Write your ideas about each piece of evidence in your Evidence Table.

4. Add to your model

- Use information from updated Evidence Tables to add to your model to show how matter moved from the Andes Mountains to the sloths in the Amazon.

- The models should use words, color, symbols, and/or pictures to show:
  - The changes and movement of matter (earth materials) in the Andes and how that led changes and movement of matter in the Amazon that allowed the sloths to live there.
- Turn in the Evidence Table and the updated model labeled as Model 2 to your teacher

Day 3 Tasks

- Read and answer the questions 1-3 from Module F, Unit 2, Lesson 2 Engage and Exploration 1
- Review Module F, Unit 2, Lesson 2 Explorations 2 and 3

Day 3 Tasks, continued

- Now that you know more about slow and quick geologic processes and that your initial model shows how the movement of matter during the building of the Andes connects to the sloths in the Amazon, add some more information about the different ways matter is changing during these processes.
- Read the directions for parts A and B and **add the information to your model.**
  - **PART A: Timing of changes**. Using what you know about processes that change rocks, show which changes took millions of years, hundreds of years, or if they could have taken minutes.
    - Make sure you show some changes that would have happened very **slowly,** and
    - some changes that would have happened very **quickly**.
  - **PART B. Scale**. Using what you know about processes that change rocks, indicate the size of the changes and if they are microscopic, on the scale of inches or feet, or are miles long or high.
    - Make sure you show some changes that were very **small**, and
    - some changes that were very **large**.

Day 4 Tasks

- Update your model to show how you think energy drives the movement of matter between the Andes mountains, the climate, and the sloths. Your updated model needs to contain:
  - at least one way that energy from the **sun**, and
  - one way that energy from the **earth's interior** drives these processes.
- Evaluate your model by answering these questions:
- a. Find the components of the model that have information about each of the topics on the list below. Are any topics missing or unlabeled?
  - ❑ Changes to the earth's surface (development of the Andes Mountains)
  - ❑ Timing of the changes
  - ❑ The size of the changes
  - ❑ Changes to the climate
  - ❑ Changes to the organisms
  - ❑ How energy influences components of the model
- b. Find the processes that connect each component of the model. Are there any parts of the model are you having trouble understanding? Why?
- c. Which of the topics listed above does the model communicate well?
- d. What could be improved?

Day 5 Tasks

- Construct an argument to support a claim about one way that the Andes Mountains influenced the sloths living in the Amazon rainforest. This argument should use evidence from your model to support your claim.
- Create a presentation (PowerPoint slides, essay, or a poster) that includes your argument and model.

Sloths are mammals that live in tropical climates of Central and South America. They spend nearly all their time on tree branches, hanging on with their long claws. Sloths need the warm temperatures and the trees found in tropical rain and cloud forests to survive. Before the Amazon region had the warm, wet climate that allowed the rainforests to grow, sloths did not live in this region at all.

Day 5 Tasks, continued

The presentation should:

1. Include claim, evidence, and reasoning that together communicate an argument for how you think movement of matter in the Andes Mountains influenced the sloths in the Amazon.
   a) The argument should describe each step of the relationship beginning with the developing of the Andes Mountains.
   b) Refer to your model to help you describe each step and the process that caused it.
2. Your reasoning should describe ***how*** specific rock-changing processes and any other processes support your claim. (E.g., the breaking and moving of sediments by water caused _________ by _______.)
3. You are communicating an argument to an audience *at El Museo Nacional de Historia Natural* that includes people who have very different ideas about the relationship between the Andes Mountains and its environment. Be clear and convincing to your audience.

INTRODUCTION

What does a sloth living in the Amazon rainforest have to do with the Andes Mountains more than 1,000 miles away?

Some scientists claim that when the Andes Mountains began growing they caused huge changes across South America, including changing the cycling of the water and atmosphere, which then influenced the ecosystems across the continent. They describe these interactions in terms of the movement of matter through the different systems.

This idea has caused a lot of controversy. Some people think that the mountains could not have caused so many changes to distant parts of the continent. Others agree, believing the mountains formed much earlier or later than these changes, so they could not have caused them. Some even argue that the climate helped the mountains to grow, not the reverse.

A museum in Chile, *El Museo Nacional de Historia Natural*, is gathering all kinds of experts to discuss their evidence for each of these claims in a series of presentations. You are part of The Amazonia Research Group that has been studying how the development of the mountains could affect life in the Amazon. You have been asked to present an argument describing the relationship between the mountains and the sloths using evidence collected by your research group.

To make your argument very clear to the audience, you will create a model (diagram) to track the flow of matter and energy through the earth system all the way to the sloths. Follow the directions below to create and refine a model of this history, and to develop the presentation of your argument using that model.

In a separate packet you will find **resources** to help you develop your model including:

1. Diagrams showing the geologic history of the Andes Mountains
2. A model of the rock cycle
3. A description of evidence and interpretations from The Amazonia Research Group related to the Andes Mountains and the Amazon region.

KNOWLEDGE AND SCIENCE PRACTICES BEING ASSESSED:

In this assessment you will demonstrate your ability to:

- Develop a model that shows relationships between the earth and life processes that shape the earth.
- Support an argument using evidence about relationships between the processes that shape the earth and life
- Discuss how matter moves through these processes and how energy drives this movement

SCORING SYSTEM OR RUBRIC

Your presentation will be scored based on:

- The accuracy of the information in your model for each element (a-f) in Part A
- The clarity of the argument in showing how the mountains influenced the sloths.
- The strength of the reasoning in your presentation-- how well the reasoning explains how the evidence you cite supports your claim.

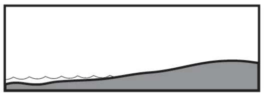
Evidence Table
Evolution of the Andes IEA

Evidence Table			
Evidence of changes in the earth system (short description)	Describe the processes that could cause the changes.	Where & when did the changes occur?	Order
Sedimentary rock formed on the western edge of South America	*Erosion and deposition: Water eroded rock in South America and the broken rocks were deposited and compacted until they formed new sedimentary rock.*	*65-80 million years ago*	1

Evidence card 1

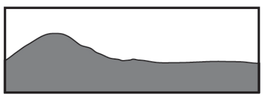
The History of the formation of the Andes Mountains

65-80 Million Years Ago



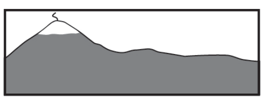
Water from the Pacific Ocean covered part of the west coast of South America. Sand that was carried in the water fell to the ground, was buried, and became sedimentary rock at the western edge of South America.

34-65 Million Years Ago



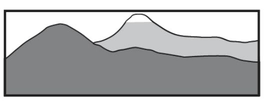
The Nazca Plate under the Pacific Ocean pushed into the South American Plate (see pictures at the bottom of the page).As the plates pushed together, the sedimentary rock at the edge of South America was compressed, deformed, faulted, folded, and a mountain range formed along the coastline.

10-34 Million Years Ago



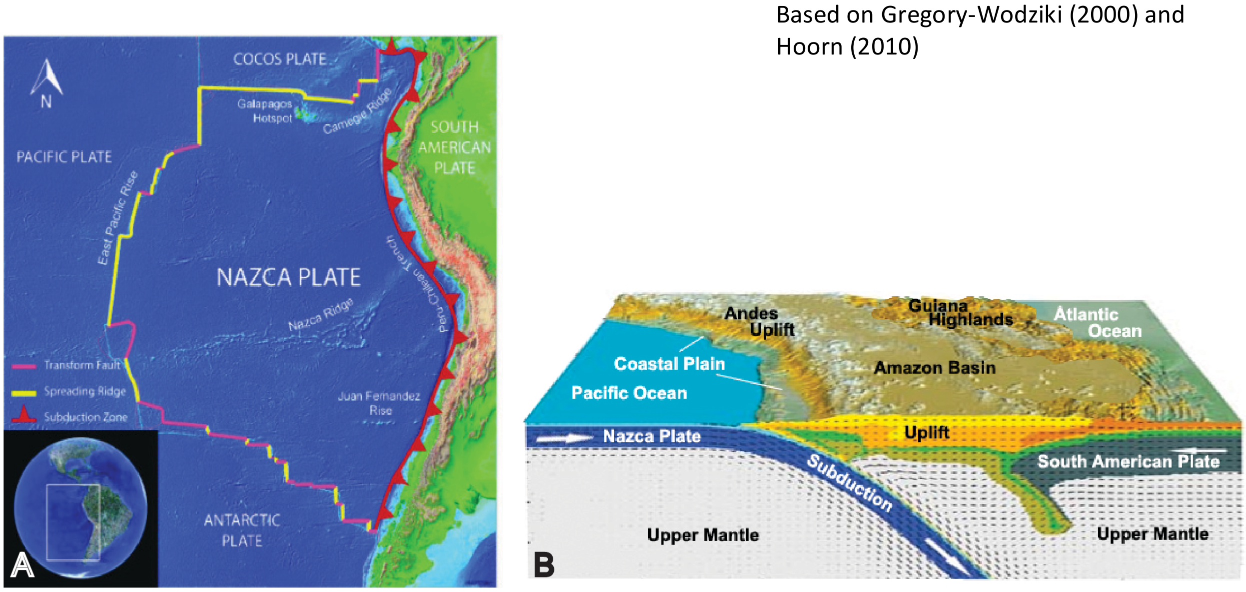
The Nazca Plate continued pushing into the South American Plate and it eventually caused volcanoes to form and erupt. The volcanoes and the continued compression from the plates pushing together built enormous mountains.

10 Million Years Ago to the present



The two plates continue pushing together, now faster, forming another set of huge mountains and volcanoes. Snow collected in the mountains and melted, carving rivers down the sides of the mountains and breaking and moving sediments away from the mountains.

Based on Gregory-Wodziki (2000) and Hoorn (2010)



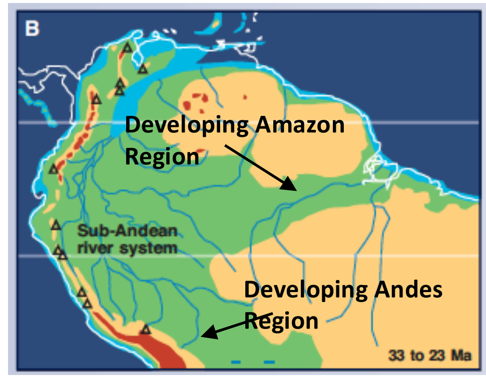
The Nazca Plate under the Pacific Ocean pushes into the South American Plate, which includes South America. The Andes form along the coastline where the two plates push together. A; A map of the Nazca Plate pushing into South America. B: A view beneath the surface of the earth of the Nazca Plate pushing under (subducting) the South American Plate.

http://4.bp.blogspot.com/-SlMrqBhlbCM/UGcsa-8Vwhl/AAAAAAAAFSk/ir2Sx-MikEw/s1600/229B-Image+Andes+Uplift.jpg
http://caribbeantectonics.weebly.com/uploads/2/5/8/3/25833890/769102.jpg?1389839103

Evidence Card 2

Evidence from rocks that are 5-12 million years old

1. There are large amounts of new metamorphic and volcanic rock that formed from 12 million years ago to 5 million years ago in the developing Andes Region.



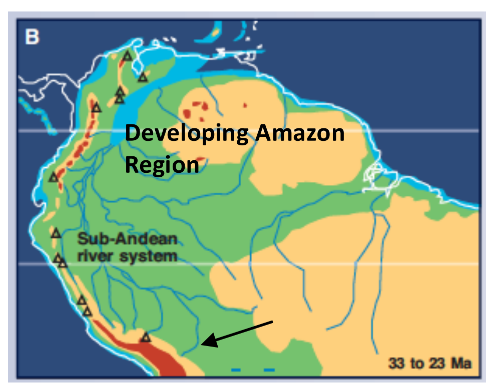
2. Fossils of tropical plants and insects, soil, and rock formations in the Amazon region show evidence of increased temperature and rainfall (a change in climate) beginning 5 million years ago.

3. Computer models of the atmosphere show that the warm, humid (wet) air that comes from the Atlantic Ocean started being blocked from moving across South America by growing mountains. By 5 million years ago this warm, wet air stayed in the Amazon Region.

4. Soil, sedimentary rocks, and fossils of plants and animals that live in wet environments show that shallow lakes and swamps formed in the Amazon region in this period.

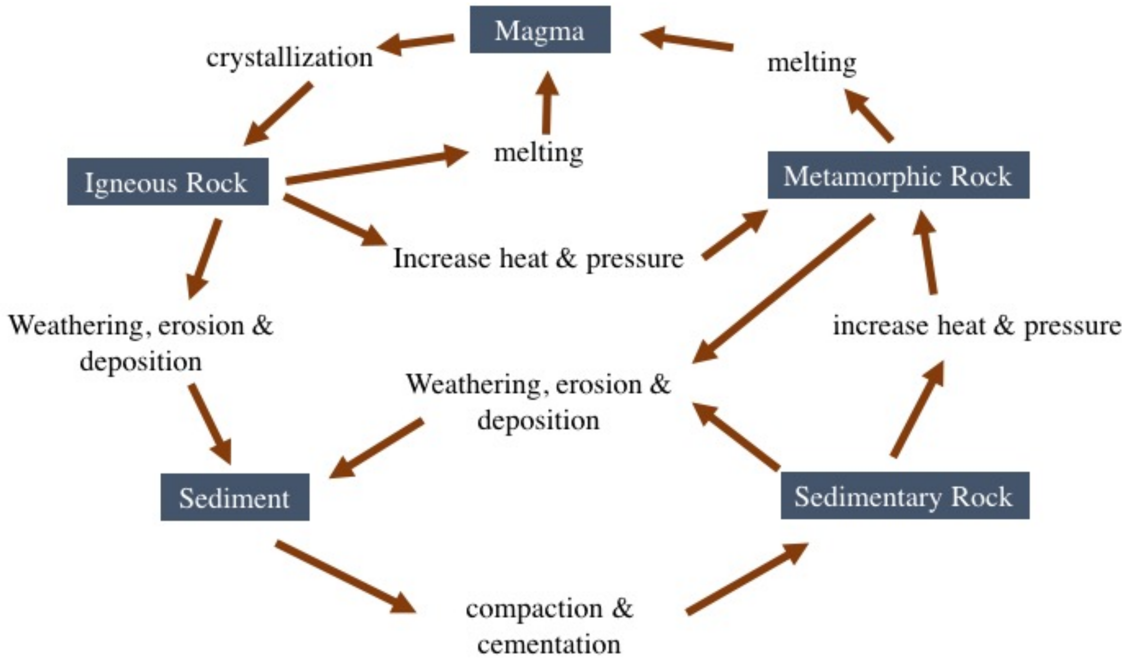
Evidence card 3

Evidence from rocks that are 5 million years old – now (rocks forming today)



1. Fossil plants and animals show changes to cooler climates around the world starting 10 million years ago.
2. Many fossils of plants and animals found in tropical rainforests are found across the Amazon region (including jaguars, toucans, poison dart frogs, cocoa trees, passion fruit trees, orchids, and thousands of kinds of butterflies). Fewer fossils of trees and animals from swamps and wetlands are found in the region.
3. The oldest fossil sloths in the Amazon region are about 10 million years old and in rocks that are 5 million years old and younger there are many species of sloths in the region.

The Rock Cycle



LESSON 2

Earth's History

This fossil of a tyrannosaur skeleton was found buried in a layer of sandstone, a sedimentary rock.

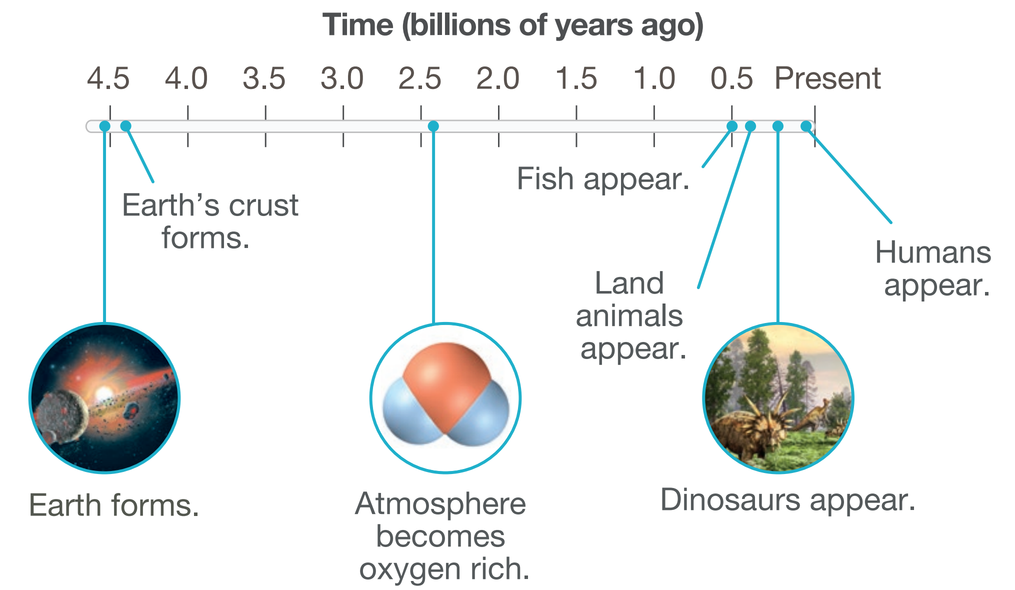
By the end of this lesson . . .

you will be able to explain how evidence is used to organize Earth's history into the geologic time scale.

Go online to view the digital version of the Hands-On Lab for this lesson and to download additional lab resources.

CAN YOU EXPLAIN IT?

What evidence is used to construct this timeline of Earth's history?



There is a growing body of evidence showing that the first known life forms appeared at least 3.5 billion years ago. Complex life did not evolve until more than a billion years later, and the first humans showed up only 200,000 years ago.

1. Review this geologic timeline of events in Earth's history. What kinds of evidence are used to make timelines like this one?

EVIDENCE NOTEBOOK As you explore the lesson, gather evidence to help you explain what kinds of evidence are used to construct geologic time scales.

Describing Geologic Change

You have likely changed a lot since you were born. Just imagine all the changes Earth has been through since it formed about 4.6 billion years ago! Geologic processes such as weathering, erosion, and tectonic plate motion constantly reshape Earth. Many landforms you see today—such as rugged mountains and steep canyons—formed from geologic processes over millions of years.

To learn about changes in Earth's past, we can look to the present. Many geologic processes that shape Earth today also shaped Earth in the past. For example, volcanoes erupted, glaciers carved valleys, and sediment was deposited to form sedimentary rock.

Glaciers are like slow-moving rivers of ice that scrape over land, picking up and moving rock. This glacier has been inching its way down this valley for thousands of years.

2. Discuss Analyze the two photos. About how long do you think it took the U-shaped valley to form? Explain.

This U-shaped valley was shaped by a glacier that flowed through the area in the past.

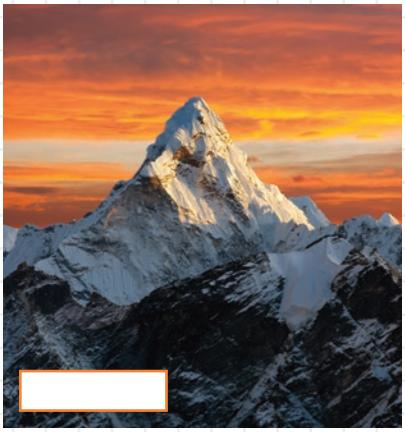
The Rate of Geologic Change

Most geologic processes change Earth's surface so slowly that you would not notice a difference in your lifetime. But over thousands to millions of years, geologic processes cause major changes to landscapes. For example, weathering and erosion are wearing down the Appalachian Mountains by about six meters (6 m) every million years. Over time, the rugged peaks have become rolling hills. The movement of tectonic plates is another example—they move at a rate of a few centimeters (cm) each year. Yet over millions of years, this motion builds tall mountain ranges and forms entire ocean basins.

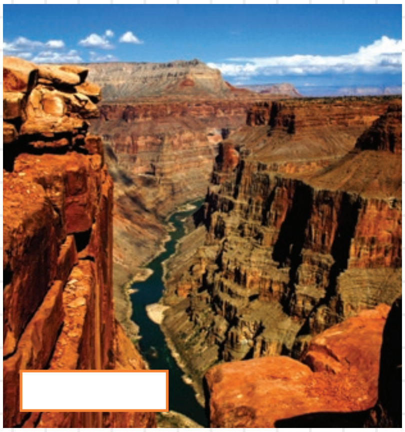
Not all geologic change is slow. Some processes can alter large areas or the whole planet within a short period. An example is the meteorite that struck the Yucatan Peninsula in Mexico about 65 million years ago. It sent debris into the atmosphere that blocked sunlight for years and likely contributed to a mass extinction.

The frequency of meteorite impacts, volcanic eruptions, and widespread glaciation have varied during different periods of Earth's history. Scientists take this information into account when they reconstruct Earth's geologic past.

3. Geologic change is shown in each photo. Read each description, and then label the images to tell whether you think the change is relatively fast or slow.



For millions of years, two tectonic plates have been pushing up the Himalayan Mountains. The mountains are still growing today at about 1 centimeter per year.



The Colorado River has been carving a path through the Grand Canyon for at least 5 million years. In some spots, the canyon is 1,620 meters (m) deep and continues to get deeper today.

This landslide happened when rocks and soil suddenly slid down the side of this mountain as a result of the force of gravity.

Do the Math

Describe Scales of Time

How long is one million years? It helps to think about this in terms of numbers that are more familiar to us. For example, how many human lifetimes are in one million years?

STEP 1 Assume the average human lifetime is 80 years. The question asks how many human lifetimes are in 1 million years, so we need to find out how many times 80 divides into 1,000,000. Let *h* represent the number of human lifetimes.

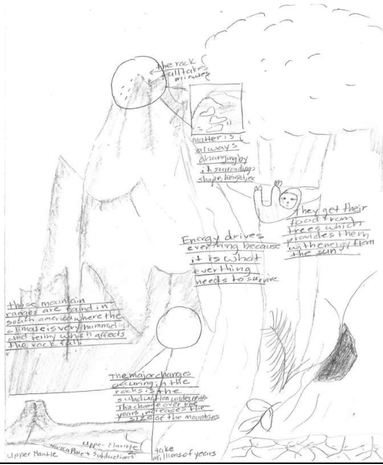
STEP 2 $h = \frac{1{,}000{,}000}{80} = 12{,}500$. There are 12,500 human lifetimes in 1 million years.

4. The Himalayan Mountains have been growing slowly for about 50 million years. Using the same method, find out how many human lifetimes have passed since the Himalayan Mountains began to grow.

STEP 1 I need to find out how many times ____________ divides into ____________

STEP 2

Sample Scoring Rubric
Evolution of the Andes

	Emerging[1]	Developing	Approaching Proficiency	Excelling
Description of Performance	The claim is supported by **no relevant** evidence from the model to explain how the movement of matter between systems impacted the sloths. AND uses **inaccurate**, **incomplete, or no reasoning** to show how the evidence supports the claim about how the building of the mountains.	The claim is supported by **relevant** evidence from the model **for at least one system** to explain how the movement of matter between systems impacted the sloths. AND uses **incomplete and/or inaccurate reasoning** to show how the evidence supports the claim about how the building of the mountains. 	The claim is supported by **relevant** evidence from the model **for more than one system** to explain how the movement of matter between systems impacted the sloths. AND uses **incomplete and/or vague reasoning** to show how the evidence supports the claim about how the building of the mountains.	The claim is supported by **relevant** evidence from the model to explain how the movement of matter between systems impacted the sloths. AND uses **accurate and explicit** reasoning to show how the evidence cited supports the claim about how the building of the mountains.

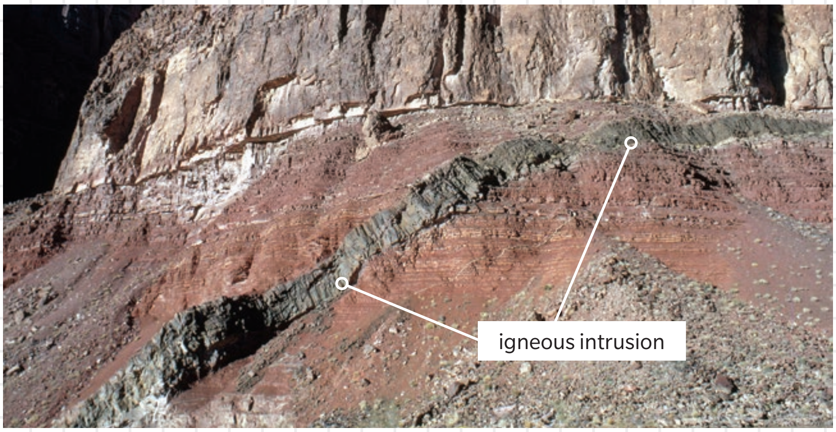
[1] If student provides no assessable evidence (e.g., "I don't know" or leaves answer blank), then that student response cannot be evaluated using the rubric.

Relative Dating

Think about the stack of pancakes. The oldest pancake is the one that was made first and placed at the bottom of the stack. The last pancake made ended up on top of the stack. It is the youngest. This is like a stack of sedimentary rock layers; the oldest layer is at the bottom and the youngest is at the top. This is true as long as rock layers are undisturbed. That is, the rock layers have not been greatly deformed by geologic processes.

When you determined the relative ages of the pancakes, you used relative dating. **Relative dating** is any method of determining whether something is older or younger than something else. Geologists use relative dating to determine the relative ages of rocks, fossils, and features such as faults. What if you cut the stack of pancakes in half? The cut happened after the pancakes were made, so the cut is younger than the pancakes. The same is true for a fault or an igneous intrusion that cuts across rock layers. That is, the feature is younger than the rocks it cuts across.

Scientists find the relative ages of rocks to compile the rock record. The *rock record* is all of Earth's known rocks and the information they contain. The rock record allows scientists to piece together some of Earth's past environments and events.



7. Magma intruded into these sedimentary rocks, cooled, and formed a diagonal band of igneous rock. The intrusion is older / younger than the sedimentary rocks it cuts through.

Fossils

In most cases, fossils are the same age as the rock in which they are found. An *index fossil* is the remains of an organism that was common and widespread, but only existed for about 1 million years or less. The age of an index fossil can help establish the ages of rocks and other fossils. For example, specific ammonite fossils are found in Dinosaur Provincial Park. They are marine index fossils that are about 75 million years old. The rocks in which they are found, and any other fossils in those rocks, are also likely about 75 million years old.

Organizing all of Earth's known fossils from oldest to youngest shows how life on Earth has changed over time. All of Earth's known fossils and the information they provide is known as the *fossil record*. The fossil record grows as fossils are continually discovered.

EVIDENCE NOTEBOOK

8. Explain how undisturbed sedimentary rock layers and index fossils in Dinosaur Provincial Park can provide information about the ages of the park's ancient animals.

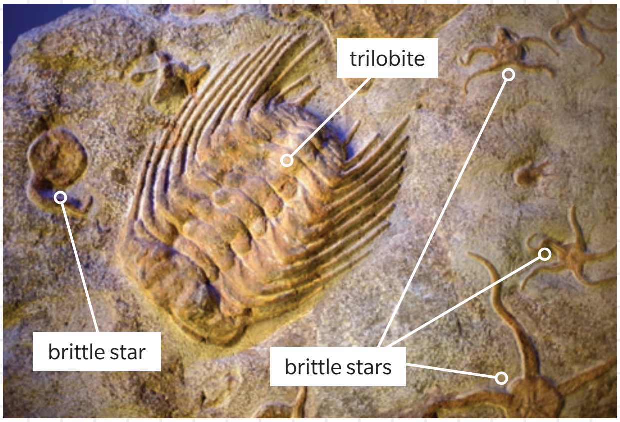
9. This type of trilobite is an index fossil that lived about 440 million years ago. Fossils of the trilobite and the brittle star were found in the same rock layer. What can you infer about these two organisms?

A. They likely lived at the same time.

B. They are likely closely related.

C. They likely lived in different habitats.

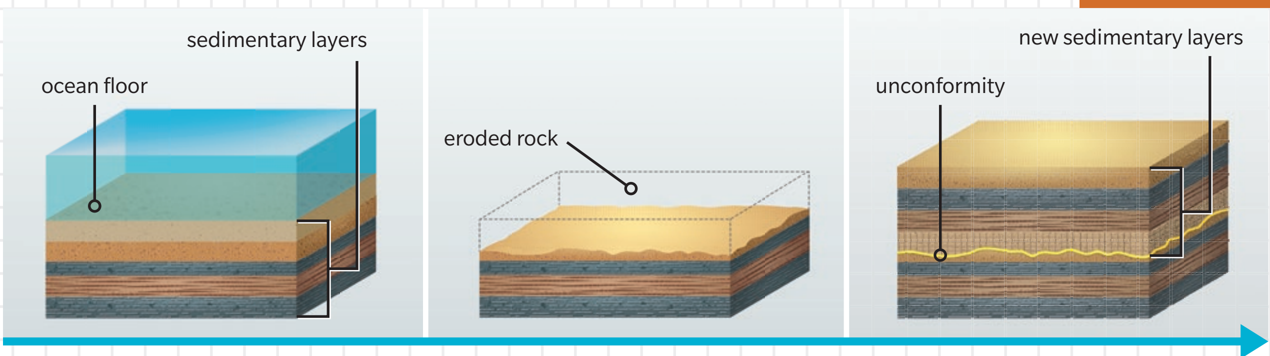
D. They are likely younger than the rock layer.



Unconformities

Some rock layers are missing, forming gaps in the rock record. Such a gap is called an *unconformity*. These gaps can occur when rock layers are eroded or when sediment is not deposited for a period of time. In this way, rock layers are like pages in a book of Earth's history—only some pages were torn out or never written in the first place!

Explore ONLINE!



Over millions of years, sediment settles on the sea floor, forming layers.

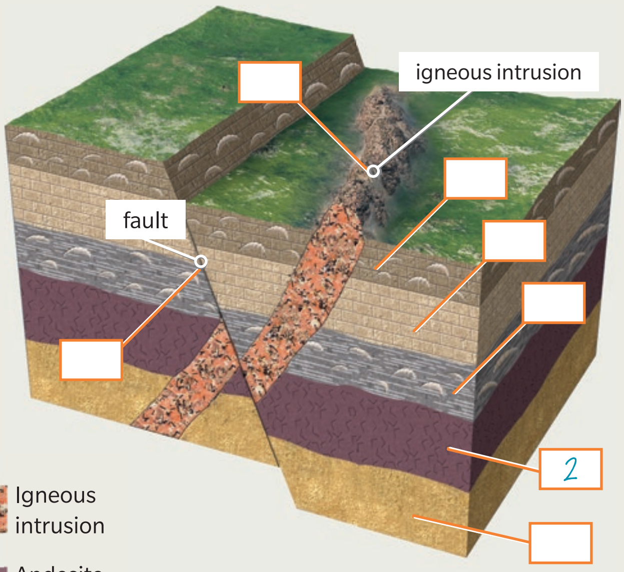
Sea level drops and exposes the sediment. Some layers are eroded.

New layers form over the old set of layers—an unconformity now exists.

Determine Relative Age

The positions of rock layers, fossils, faults, and intrusions can be used to determine their relative ages. Scientists use relative dating to piece together Earth's history. Look at the rock layers and features in the diagram.

10. Number the diagram to show the relative ages of the rocks and features. Use the number 1 for the first (oldest) rock layer or feature. Use the number 7 for the most recent (youngest) rock layer or feature.

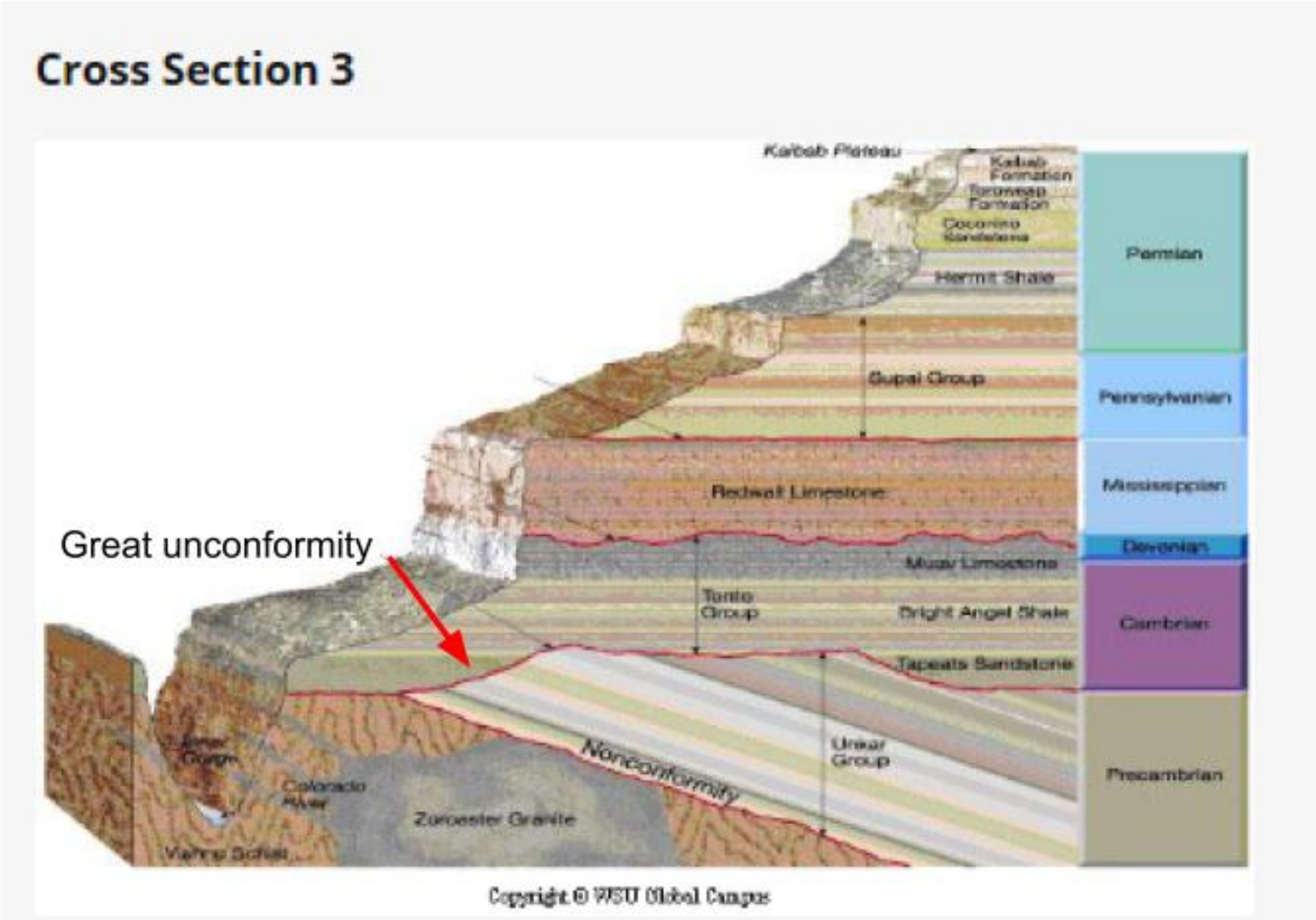


Scientist Name________________________________

Grand Canyon Mystery Task

The Grand Canyon is an ancient land form, over 1.2 billion years old. We can see the layers of the rock as we travel down into the canyon, and there is one big question that has baffled scientists for years. At the bottom of the layers of rock, there is a 1.2 billion year gap in the rock record that has been called the “Great Unconformity”. The rock that should be there is simply missing, and scientists have been working on understanding the missing pieces of “time” in Earth’s geologic record. (https://www.forbes.com/sites/trevornace/2016/08/10/grand-canyons-1-2-billion-year-old-secret/#1b3bdf1267d7)

You can see the unconformity between two rock groups: the Vishnu schist and the Tonto formation. Read more about these rock groups below.



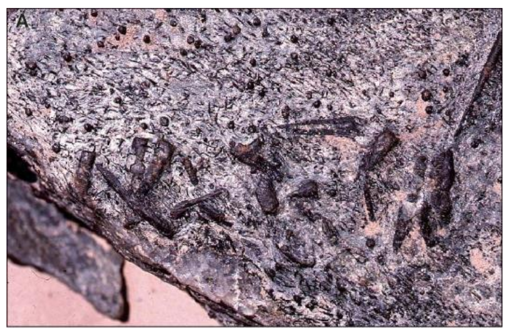
The Vishnu Schist

This rock group is metamorphic and is the oldest rock group in the Grand Canyon. It includes the remains of an ancient mountain chain that eroded away starting 1.8 billion years ago.

(https://utahgeology.com/the-vishnu-schist-of-the-grand-canyon/)

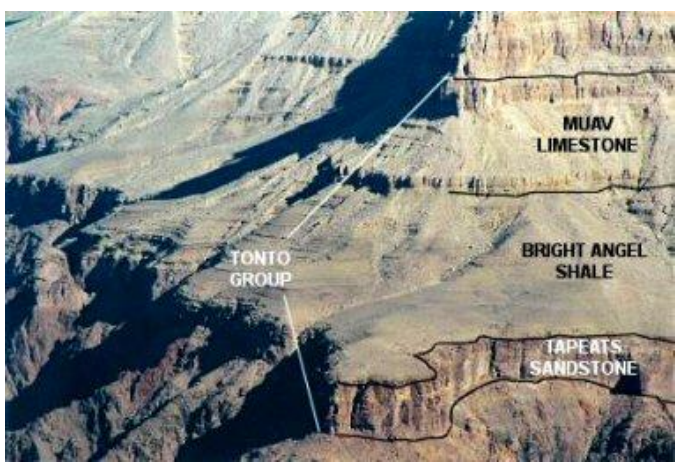
Mineral crystals found in the Vishnu Schist that have been dated to the Pre-Cambrian era.

(https://www.researchgate.net/figure/A-Staurolite-crystals-near-river-mile-94-in-the-Vishnu-Schist-large-black-grains_fig2_296058495)



Tonto Group

This rock group are layers of various sedimentary rocks that were deposited during the Cambrian Period, 500-520 million years ago.



(http://www.grandcanyonnaturalhistory.com/pages_nature/geology/tonto-group.html)

These fossils were found in the Tonto Group at the Grand Canyon.

(http://archive.fossweb.com/resources/pictures/199374584.html) https://www.flickr.com/photos/paleo_bear/7991988514

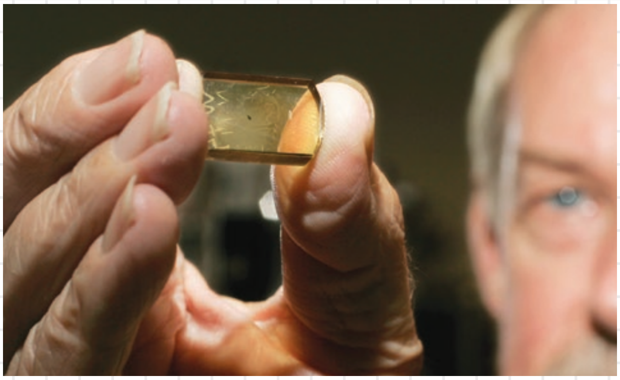
1. How does the great unconformity provide evidence of the history of the earth?

Claim			
Evidence		Science Principle	
Reasoning			

2. The Great Unconformity can also be seen at Siccar Point in Scotland. What evidence would you need to gather in order to prove this?

Using Absolute and Relative Age

Relative age is described in terms of whether an object is older or younger than other objects. *Absolute age* identifies how old an object is, as expressed in units of time. In other words, absolute age is the actual age of something.



This tiny black speck is a crystal that was found in a sandstone rock in Australia. It's about 4.2 billion years old. The person holding it is Simon Wilde, who discovered it in 1984.

11. Discuss How do you think scientists figured out the absolute age of this zircon crystal?

12. Write an A next to statements that describe absolute age. Write an R next to those that describe relative age.

R	I am younger than my cousin.
	I am 14 years old.
	That is the oldest bicycle I've ever seen.

	My cat lived to be 15 years old.
	This coin is the newest in my collection.
	This is the last book in the series.

Absolute Dating and Relative Dating

In the 1950s, technology made it possible to find the absolute ages of some rocks. **Absolute dating** is any method of measuring the actual age of something in years. Absolute dating is typically used to find the ages of igneous rocks. Igneous rocks form when molten rock cools and forms new crystals. The new crystals contain unstable particles that begin to break down as soon as the crystal forms. Scientists measure the relative amounts of unstable particles and the more stable particles they become. This ratio is used to calculate how long ago the unstable particles began breaking down, which is when the rock formed.

Different types of unstable particles exist in rocks, and each type breaks down at a specific rate. For example, unstable potassium breaks down into argon. It takes 1.3 billion years for half of the potassium to break down into argon. It takes another 1.3 billion years for half of the remaining potassium to break down. This pattern repeats as long as some of the unstable material exists.

Absolute dating and relative dating are used together to provide a more complete understanding of Earth's history. For example, weathered volcanic ash is found within rock in Dinosaur Provincial Park. The absolute age of the ash allows scientists to conclude that some of the rock layers in the park formed 76 million years ago. Fossils found in these same rock layers must also be 76 million years old.

Do the Math
Determine Absolute Age

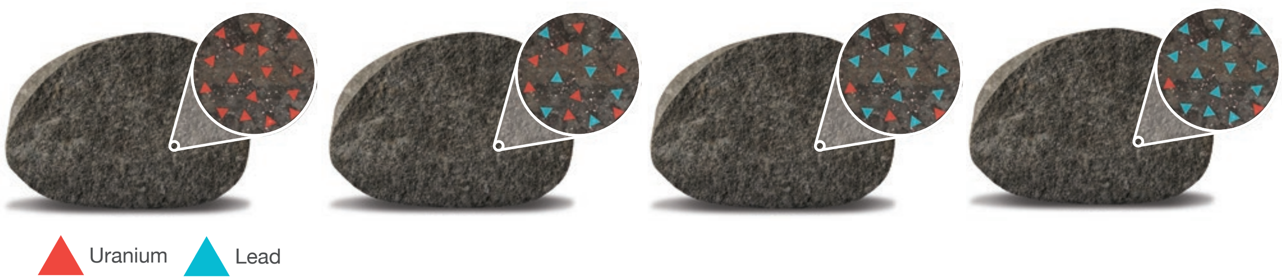
The first step in finding a rock's absolute age is to measure the amounts of unstable particles and the stable particles they form. Next, the rate at which the unstable particles break down must be found. This rate of change is called half-life. *Half-life* is the amount of time needed for half the amount of unstable particles to change into more stable particles.

$A = n \times h$

A = Age of rock
n = number of half-lives passed
h = half-life of unstable particle

The rock below formed when molten rock cooled. It contains unstable uranium particles that break down into more stable lead particles. It takes 704 million years for half the rock's uranium to change to lead. That is, the half-life is 704 million years. At any point in time, the amounts of uranium and lead can be measured to find the rock's age.

The Breakdown of Uranium to Lead over Three Half-Lives



Igneous rock forms This igneous rock just formed. It contains unstable uranium particles. At this time, none of the uranium has changed into lead.

704 million years later One half-life has passed. Half of the unstable uranium has changed into a more stable form of lead. The rock is 704 million years old.

1.4 billion years later Another half-life has passed, so half of the remaining uranium has changed into lead. The rock is now 1,408 million years old.

2.1 billion years later The pattern continues. For every half-life, half of the remaining uranium changes to lead.

13. Fill in the table as you explore the half-life diagram.

Half-Lives Passed	Unstable Particles in the Rock	Stable Form of the Particle	Time Passed (Millions of Years)
0	16	0	0
1	8	8	704
2	4	12	1,408
3		14	

EVIDENCE NOTEBOOK

14. How can absolute dating be used to describe when the fossil organisms in Dinosaur Provincial Park lived? Explain.

The Absolute Age of Earth

Absolute dating can be used to find the age of Earth, but not by using rocks from Earth. This is because the first rocks that formed on Earth had been eroded, melted, or buried under younger rocks long ago. Therefore, most rocks on Earth are younger than Earth itself—with one exception: meteorites.

Meteorites are small, rocky bodies that have traveled through space and fallen to Earth's surface. The absolute ages of meteorites can be determined. Because Earth formed at the same time as other bodies in our solar system, meteorites should be the same age as Earth. Absolute dating of meteorites and moon rocks suggests that, like these other bodies, Earth is about 4.6 billion years old.

15. Recall the zircon crystal found in the sandstone in Australia. The zircon formed long before the sandstone. It was part of an igneous rock before it became part of the sandstone. Complete each statement to make it true.

__________ dating was used to determine the age of the sandstone rock compared to the ages of the rocks around it. __________ dating was used to calculate the actual age of the zircon mineral.

Use Relative and Absolute Dating Together

Scientists use both relative and absolute dating to find the ages of rocks and fossils. A field geologist modeled a rock sequence to help determine their ages.

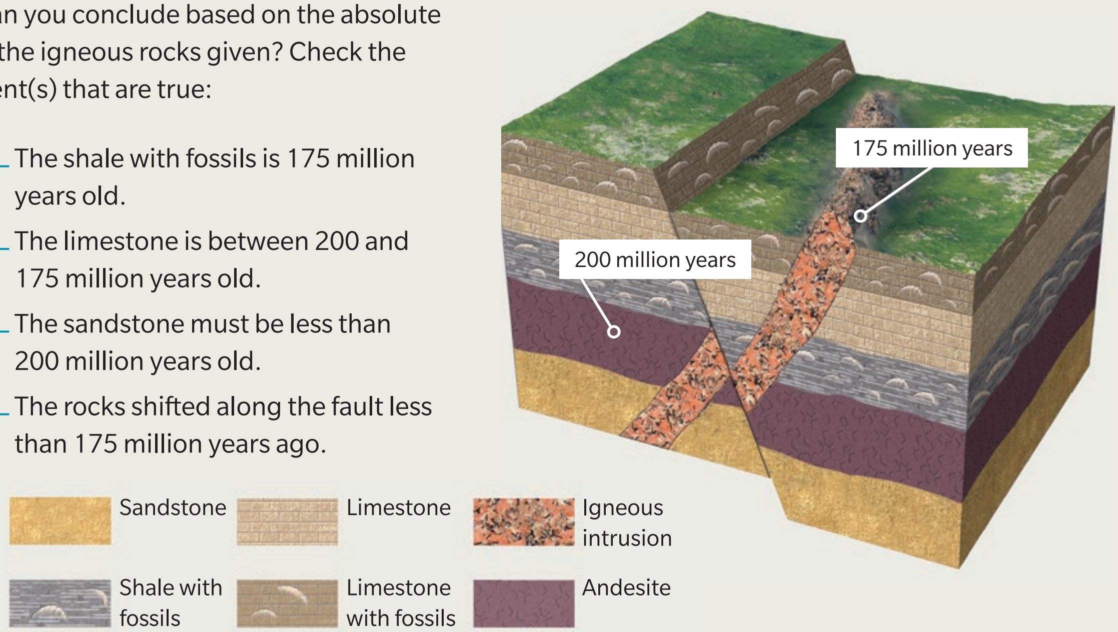
16. What can you conclude based on the absolute ages of the igneous rocks given? Check the statement(s) that are true:

______ The shale with fossils is 175 million years old.

______ The limestone is between 200 and 175 million years old.

______ The sandstone must be less than 200 million years old.

______ The rocks shifted along the fault less than 175 million years ago.



Continue Your Exploration

Name: **Date:**

Check out the path below or go online to choose one of the other paths shown.

Exploring the Ashfall Fossil Beds

- **Hands-on Labs**
- **Exploring Local Geology**
- **Propose Your Own Path**

Go online to choose one of these other paths.

Although most fossils are preserved by sedimentary rock, some are preserved by igneous rock. Look at these fossils of ancient animals from the Ashfall Fossil Beds in Nebraska. The animals were killed by hot volcanic ash that covered the area during an eruption. As the ash settled into thick layers, it cooled and hardened into rock. Volcanic ash can fall from the sky or flow downhill during an eruption. Ash flows can burn everything in their path, but sometimes they will preserve animals such as these.

These rocks contain fossils of rhinos and horses that died in a volcanic ash flow.

- (green) young adult male rhino "Tusker"
- (blue) large three-toed horse "Cormo"
- (yellow) adult female rhino "Sandy" with baby "Justin"
- (red) rhino calf
- (purple) rhino calves (possibly twins) "T.L." and "R.G.C."

Continue Your Exploration

The following field notes were recorded in the area:

Date: October 9
Location: Ashfall Fossil Beds State Historical Park, Nebraska
Observations and Notes:

- The fossils in the photo were uncovered in the ash layer.
- Other fossils exist above and below the ash layer as shown in the table.
- The ash layer is as thick as three meters in some places.
- Absolute dating shows that the ash layer formed 12 million years ago.

Rocks and Fossils from the Ashfall Fossil Beds State Historical Park

Rock Layers	Fossils Found
loose sand and gravel	zebras, lemmings, giant camels, muskrats, giant beavers
sandstone layer	barrel-bodied rhinos, giant land tortoises, camels, rodents, horses
ash layer	
sandstone layer	
sandy and silty sedimentary rock layers	alligators, fish, hornless rhinos, giant salamanders

Source: The University of Nebraska State Museum and Nebraska Game and Parks Commission, "Geologic Setting of Ashfall Fossil Beds and Vicinity," 2015

1. The ash layer is igneous rock. Absolute dating shows the ash layer is 12 million years old. What can you infer about the animals found in the ash layer?

2. Language SmArts Write a short informative report applying what you've learned to explain the history of the area.

- Use the observations and notes to explain what happened in the area over time.
- How old are the fossils in the ash layer? What was the area like before the ash flow that formed the fossil beds?
- How can absolute and relative dating help you explain how the area changed?

3. Collaborate Many articles about the Ashfall Fossil Beds are available in magazines and on the Internet. Find several articles. In a group discussion, cite specific evidence that could help you identify the article that provides the most accurate and thorough information. Discuss the evidence with the group.

Can You Explain It?

Name: **Date:**

How do we know when these ancient animals lived?

EVIDENCE NOTEBOOK

Refer to the notes in your Evidence Notebook to help you construct an explanation for when these ancient animals lived.

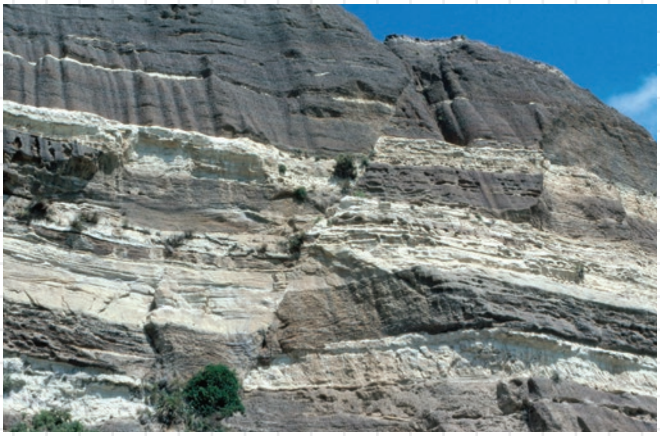
1. State your claim. Make sure your claim fully explains how the ages of the animals shown above were determined.

2. Summarize the evidence you have gathered to support your claim and explain your reasoning.

Checkpoints

Answer the following questions to check your understanding of the lesson.

Use the photo to answer Questions 3 and 4.



3. Which rock layer or feature of the cliff formed most recently?

A. the thick black rock layer at the top

B. the fault running through the center

C. the white rock layer near the bottom

D. the gray rock layer at the very bottom

4. Which of the following questions could be answered from the information in the photo? Choose all that apply.

A. Which is the oldest rock layer?

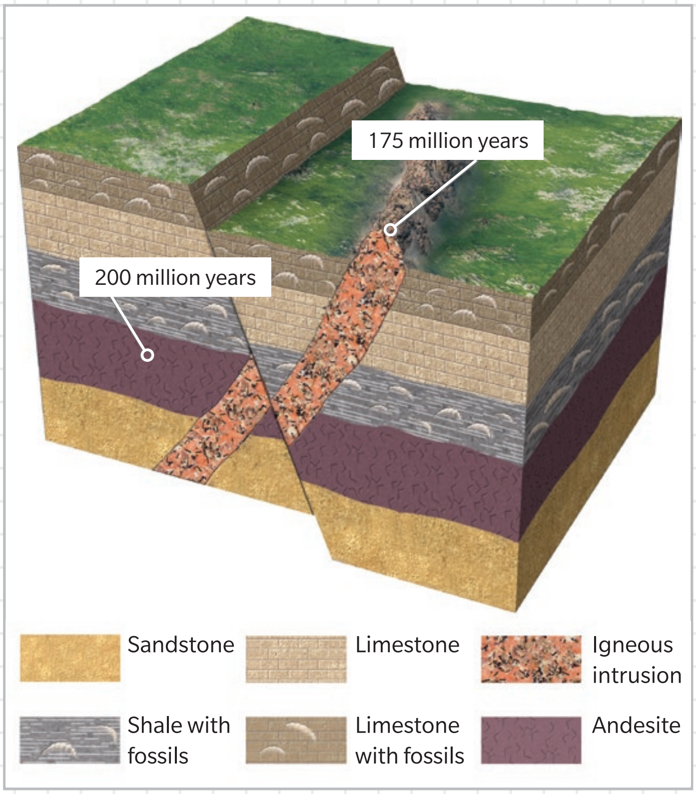
B. When did the oldest rock layer form?

C. What are the relative ages of the rocks?

D. What is the absolute age of the most recent layer?

E. What year did the fault form?

Use the diagram of undisturbed rock layers and features to answer Questions 5 and 6.



5. Which of the following statements are true? Choose all that apply.

A. All fossils are over 175 million years old.

B. The fault shifted the rocks more than 175 million years ago.

C. All fossils formed between 175 and 200 million years ago.

D. The sandstone is older than 200 million years old.

E. The sandstone is 201 million years old.

6. Circle the correct term to complete each statement.

The igneous intrusion is younger / older than the fault.

The fossils found in the shale are from animals that lived before / after the animals that formed fossils in the limestone.

Interactive Review

Complete this interactive study guide to review the lesson.

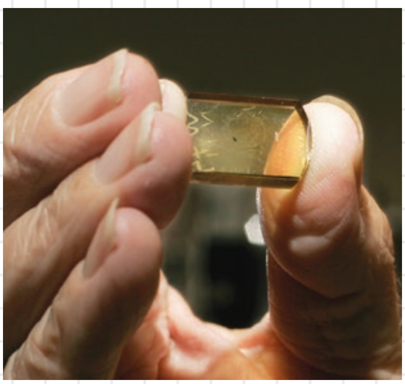
Sedimentary rock layers—and the fossils in those rock layers—help us to understand Earth's history.

A. Summarize how sedimentary rock and fossils form.

Geologists use relative dating to compare the ages of different rock layers and the fossils in those layers.

B. A student makes a sandwich with several layers of bread and cheese. Then the student cuts the sandwich and says it models how a fault cut through rock layers after the rock layers formed. Explain how the example of the sandwich relates to relative dating.

The combination of absolute and relative dating allows scientists to determine the ages of rocks and fossils. Absolute dating provides evidence that helps us estimate the age of Earth.



C. How can scientists find the absolute ages of igneous rocks?

Name: **Date:**

How did marine fossils end up in the desert?

Imagine that you were hiking at the Grand Canyon in Arizona and you discovered a fossil of a cephalopod embedded within limestone rock. You asked the tour guide about the fossil and learned that a cephalopod was a marine organism that is closely related to a squid. You began to wonder how a marine fossil ended up in the dry, hot desert region. You decided to learn more about this fossil and the environment in which this organism thrived. In order to do this, you need to research the area and its geologic history. Construct an explanation of how the cephalopod fossil ended up in the Arizona desert.

Cephalopod fossil

The Grand Canyon in Arizona

The steps below will help guide your research and help you construct your explanation.

1. **Define the Problem** Investigate to learn more about cephalopods and other marine fossils found in the Arizona desert. Define the problem you are trying to solve.

2. **Conduct Research** Do research to identify the rock layers in the Grand Canyon and the types of fossils found in each layer.

3. **Analyze Data** What is the name of the rock layer in which cephalopod fossils are commonly found? What type of rock is this layer? Explain your answer.

4. **Interpret Data** Using the data you collected in Steps 1–3, what can you infer about the past environments of this area? Describe any events in Earth's history or geologic processes that may have contributed to the changing environment.

5. **Construct an Explanation** What is the age of the cephalopod fossil you found? What was the environment like in the area at that time? Provide evidence to support your claim.

Self-Check

	I identified the rock layer and type of rock in which the fossil was found.
✔	I researched how geologic processes could have contributed to the Grand Canyon's past environments.
	I analyzed data to estimate an age of the cephalopod fossil.
	I provided evidence to identify the environment of the cephalopod.

Fossils in Grand Canyon

This article has been modified and printed from the website: https://www.nps.gov/grca/learn/nature/fossils.htm

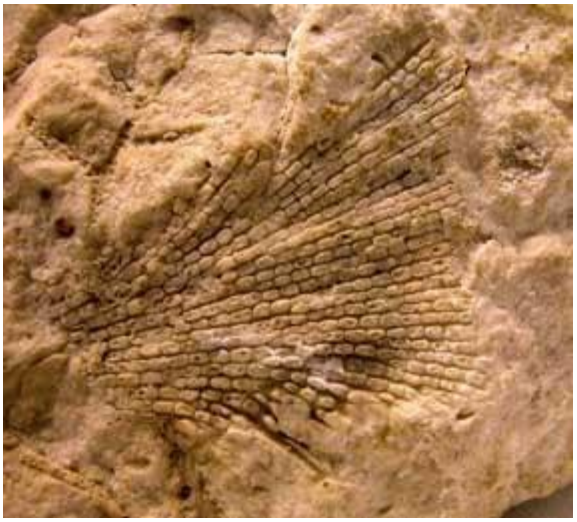
Introduction

Grand Canyon has so much more than pretty scenery. It contains an amazing diversity of rock formations with an abundance of fossils hidden within.

- The sedimentary rocks exposed throughout the canyon are rich with marine fossils such as crinoids, brachiopods, and sponges with several layers containing terrestrial fossils such as leaf and dragonfly wing impressions, and footprints of scorpions, centipedes, and reptiles.

- Ancient fossils preserved in the rock layers range from algal mats and microfossils from Precambrian Time 1,200 million to 740 million years ago to a multitude of body and trace fossils from the Paleozoic Era 525-270 million years ago.

What about dinosaur fossils? Not at Grand Canyon! The rocks of the canyon are older than the oldest known dinosaurs. To see dinosaur fossils, the Triassic-aged Chinle Formation on the Navajo Reservation and at **Petrified Forest National Park** is the nearest place to go.



Fossils are the preserved remains of ancient life, such as bones, teeth, wood, and shells. Trace fossils represent the presence or behavior of ancient life, without body parts being present. Footprints, worm burrows, and insect nests are examples of trace fossils. Sedimentary rock contains fossils because it was built up layer upon layer, often trapping and preserving animals, plants, footprints, and more within the layers of sediment. If all the conditions are right, fossils are formed as the layers of sediment turn into rock.

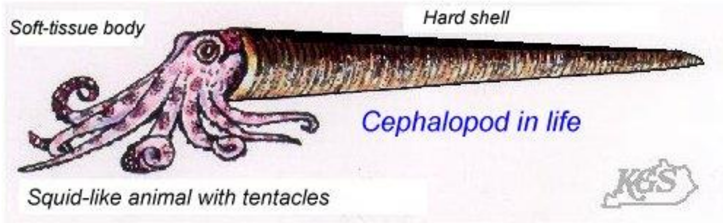
With 32% of Earth's geologic history and one billion years of fossil life found at Grand Canyon, this is a great place to study ancient environments, climate changes, life zones, and the geologic processes that formed the landscape as we see it today. The following are the most common and well known groups of fossils found at the canyon. Many more await our discovery.

Marine Fossils

With marine environments creating many of the sedimentary rock layers in the canyon over the past 525 million years, marine fossils are quite common. Species changed over time, but similar fossils can be found in most of the marine-based rocks at Grand Canyon.

Cephalopods
Cephalopods are molluscan animals that live in the sea. The group includes the modern octopi and squids as well as many fossil forms. The name cephalopod means "head foot" and it looks

as though its feet (actually tentacles) are growing out of its head. The soft parts of the cephalopod animals are not fossilized, but the shell fossils are common in some strata. The inside of the fossil cephalopod shells are very similar to the internal parts of the modern Nautilus, a squid-like animal with a coiled shell. Because the shell structure is similar, we infer that the fossil cephalopods animals were similar to Nautilus when they were alive.



Stromatolites

The oldest fossils at Grand Canyon are 1,200 million to 740 million years old. Stromatolites are the limestone structures formed by photosynthesizing bacteria called cyanobacteria. They created layers of alternating slimy bacteria and sediment in very shallow water, dominating shallow seas until predators, such as trilobites, came into the picture. Today stromatolites only live in a few shallow ocean areas with high salinity. The salinity deters predation and allows the stromatolites to survive.

Trilobites

Grand Canyon’s oldest trilobites are found in the Tonto Group, which is between 525 and 505 million years old. It includes the Tapeats Sandstone, Bright Angel Shale, and Muav Limestone. These fossils are arthropods, or joint-footed animals, with a segmented body of hinged plates and shields. They could curl up into a ball for protection, sometimes fossilizing as a "rolled" trilobite. Like arthropods today, trilobites molted as they grew, shedding their old exoskeleton. These molts could fossilize, so one animal could leave several different sized fossils behind. Even though trilobites were relatively primitive animals, they had amazingly complex eyes. Many species had faceted eyes like an insect, using up to 15,000 lenses in one eye.

Crinoids

Though plant-like in appearance, crinoids, or sea lilies, were animals, sometimes described as seastars on a stick. They had structures like “roots” that could hold them in place, collect food, circulate fluid, and even act like feet in some species so they could walk across the sea floor. They had a “stem” or column shaped body created by a series of discs stacked together with a central nerve running through. At the top of the body was a cup-like head with feeding structures radiating out from each. These feathery arms had some structural support and could be used in some species for crawling or swimming, though they were primarily used for filtering and capturing food from the water.

In the ancient seas these crinoids were so plentiful they formed "gardens" on the sea floor. Discs, individually or sometimes still stacked together, can be found in all the marine layers of in *Kaibab Limestone* at Grand Canyon. These were the hardest parts of the animal and most readily preserved as fossils.

Brachiopods

The most common shelled animal in the ancient seas was the brachiopod. From about 20,000 species of brachiopods, only about 300 species exist today. They are found in every Paleozoic marine layer at the canyon. Brachiopods had two asymmetrical shells, or valves, with one larger than the other. They often fossilized whole because when their muscles were relaxed, as in death, the valves were closed. They contracted their muscles to open the valves and filter feed. They lived on the ocean floor attaching themselves with strong threads or using the shape of the shell and/or ridges on top of the shell to stabilize them in soft mud or sand. A few species had long spines on either side that helped them to remain stable in faster currents or wave action.

Two different brachiopods, Meekella (left) and Productus (right). Also a small crinoid disc in lower right corner.

Bryozoans

Lacy and stick bryozoans similar to those in our oceans today, were also found in ancient seas. These colonial animals produce “lacy” structures on hard surfaces or “stick” structures that stood up into the water column. Each animal has its own chamber within the colonial structure from which it can extend feeding arms into the water column or retract them for protection.

Bryozoans are passive filter feeders, collecting organic material and plankton from the water. Scientists sometimes refer to bryozoans as “moss animals” because when their arms are out feeding, they sometimes look like moss covering a surface.

Corals

Corals secrete a hard skeleton of calcium carbonate which readily fossilizes under the right conditions. One type of coral found in the ancient marine layers of the canyon, such as layers of *Kaibab Limestone,* is the horn coral. This solitary coral lived on the sea floor, with the pointed end of its “horn” embedded in the soft sediment for stability and the wider end with a cup-like depression in which the animal lived.

Corals have a polyp shape, similar to its relative the jellyfish. It tucks its body into its skeleton and extends tentacles into the water column for feeding. Corals have a spiral of tentacles lined with nematocysts, or stinging cells, which can capture plankton floating by within reach.

Sponges

Living attached to the sea floor, sponges are a colony of single-celled animals that act like a multi-cellular animal. Each individual animal has a specific job, from filtering water for food to protection. Fossil sponges exist because of a unique skeletal structure. Microscopic silica or calcium carbonate spicules, or interlocking spines, provided structural support. When the sponge died, the spicules clumped together and formed a silica mass. When hardened into rock the mass became a chert nodule. Chert is harder than the limestone rock it is embedded in, causing the nodules to protrude from the rock as erosion occurs. With so many sponges in the ancient seas, layers like the Kaibab Limestone are actually more resistant to erosion because of the chert nodules.

Burrows

Trace fossils are left behind by the activities of ancient organisms. Burrows are a classic example of a trace fossil. Animals burrowed through the soft sediment at the bottom of the ancient seas. Under the right conditions, these burrows were preserved when they filled in with sediment. The animals are not usually present, but evidence of their behavior or activities is represented in the trace fossil, found in the Bright Angel Shale.

Layers in Time: Geology of Grand Canyon

How did Grand Canyon form? By studying **geology** we learn about the Earth's history and how places change over time. What plants or animals lived in your town 150 million years ago? The ancient remains of plants and animals preserved in the rock, called **fossils**, tell stories about the past. Take a look at the chart of common fossils at Grand Canyon on the back page.

Vocabulary:

Fossils: the hardened remains or imprints of plants or animals preserved in rock

Geology: the study of the origin, history and structure of the earth

Think About It

THE OLDEST PANCAKE IN A STACK IS ALWAYS AT THE BOTTOM. THE ROCKS AT GRAND CANYON ARE A LOT LIKE PANCAKES. WHERE DO YOU FIND THE OLDEST ROCKS AT GRAND CANYON?

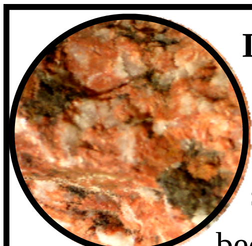
Cool Canyon Facts

River length: 277 miles

Canyon width: 10 miles

Canyon depth: 1 mile

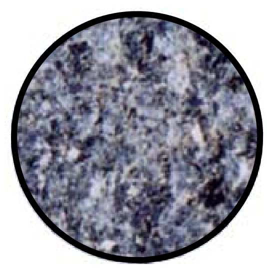
Rocks come in all colors, shapes, and sizes. They can be very different, but to make sense of what is around us, **geologists** put rocks in groups according to how they form. The three families of rock are: **igneous, sedimentary** and **metamorphic**. Natural forces create and destroy rock, changing them over time in the rock cycle.



Igneous rocks are formed when rock is super-heated and becomes **molten** (liquid). There are two kinds of molten rock: magma (found beneath the Earth's surface) and lava (found on the Earth's surface). The **molten rock cools and hardens** on or beneath the Earth's surface forming a variety of igneous rock. Two examples are granite and basalt.

Sedimentary rocks are made of smaller pieces (like **sand or mud**), called sediments, that pile into layers. As pressure on the sediment increases over time, minerals act like glue, cementing them into solid rock. The three main types of sedimentary rocks at Grand Canyon are **sandstone, shale (or mudstone), and limestone**.

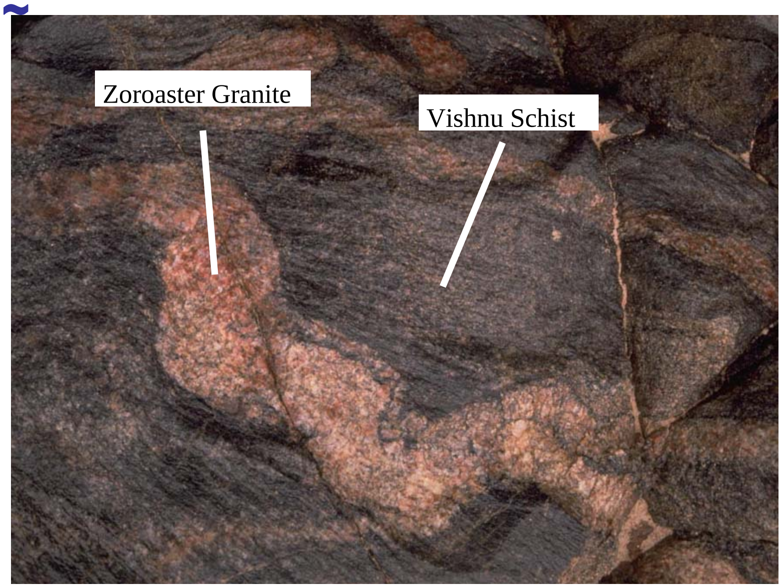
Metamorphic rocks are rocks that have been **changed under great heat and pressure**. The original rock can be sedimentary, igneous, or even metamorphic. The original rock is changed into something new, just as a caterpillar "metamorphoses" into a butterfly.



Rock layers tell stories of the past

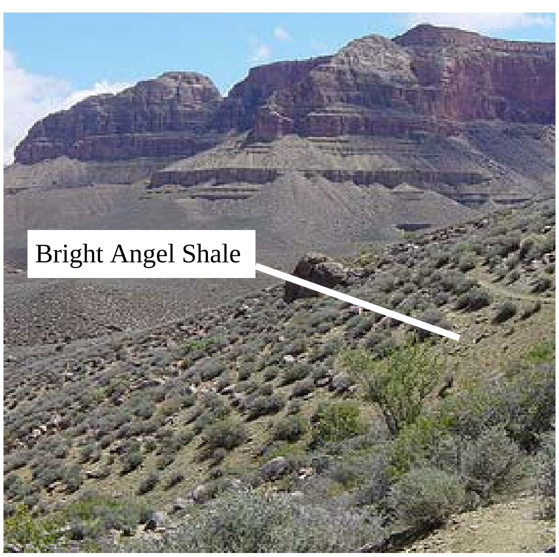
Each rock layer in Grand Canyon has a story to tell. Preserved within each layer are the clues that help us unravel these stories. Fossils give us a snapshot of past plant and animal life; sand, mud, and other sediments in the rock tell of ancient rivers, beaches, swamps and sand dunes; sparkly crystals can tell of ancient mountain building events and volcanic eruptions.

Precambrian Basement Rocks



The basement rock formed 1.8 billion years ago when the North American continent collided with an ancient chain of volcanic islands, much like today's Hawaiian Islands. Intense **heat and pressure** from the collision formed rock called Vishnu Schist. From deep under the earth's surface, molten rock flowed up as magma between the cracks of the Vishnu Schist. As the **flowing magma cooled and hardened**, it formed veins of pinkish rock called Zoroaster Granite. Because of the extreme heat and pressure that folded and changed the rock, any fossils in the original rock were destroyed.

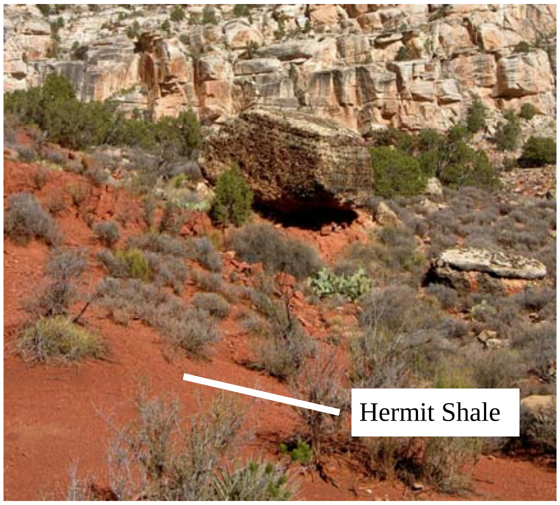
Circle which rock family(ies) these rocks belong to : Sedimentary Igneous Metamorphic



Bright Angel Shale

If you came to Grand Canyon area 515 million years ago when the Bright Angel Shale was forming, everything was covered by a very **muddy, warm, shallow sea**. Trilobites, brachiopods, crinoids and worm-like creatures that burrowed in the sea-floor thrived in the nutrient-rich water. This greenish-colored **shale** forms the broad, flat area known as the Tonto Platform in Grand Canyon.

Rock Family: Sedimentary Igneous Metamorphic



Hermit Shale

Are you ready to go wading through the mud? About 280 million years ago the Grand Canyon area was covered by a broad coastal plain that had many slowly **meandering streams**. The environment was excellent habitat for an abundance of ferns and conifers, along with reptiles and insects, including dragonflies with 12-inch wingspans. This layer consists of **siltstones, mudstones, and fine grained sandstones** rich in iron that create a gentle, red slope in most parts of Grand Canyon National Park.

Rock Family: *Sedimentary* *Igneous* *Metamorphic*

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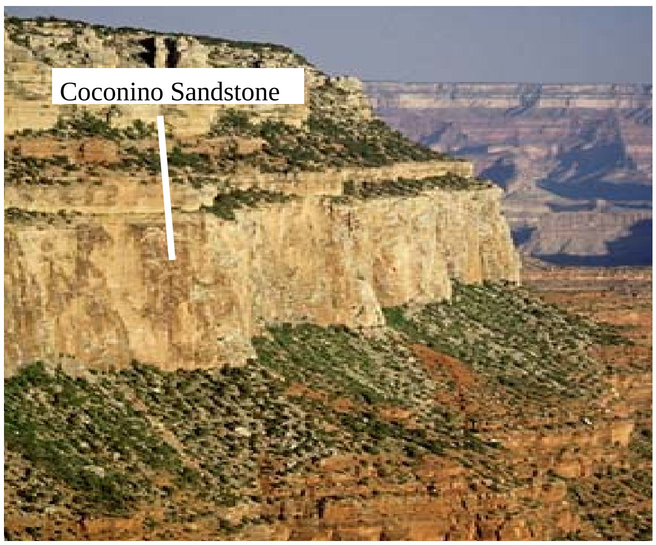
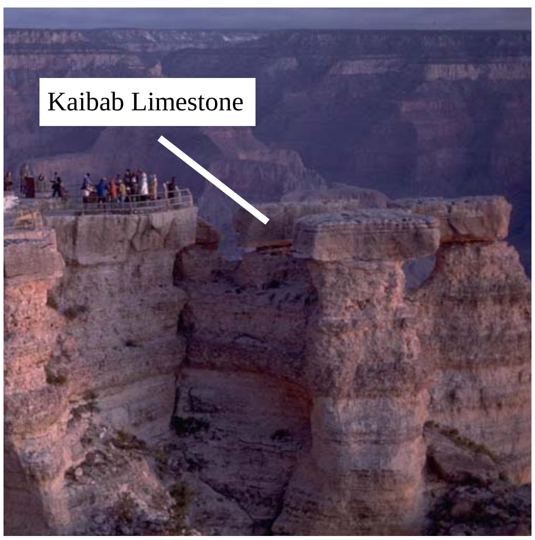
Coconino Sandstone



Have you ever wanted to visit the Sahara desert? About 275 million years ago the Grand Canyon area was covered with large dune-fields. The ocean lay to the west. Reptiles, spiders, scorpions, and other insects dwelled on the **sand dunes** of this extensive desert, leaving their tracks fossilized in the sandstone. This **sandstone** layer creates a broad, light-colored cliff a few hundred feet below the rim of Grand Canyon. Cross-bedding (lines that run at steep angles to one-another) can be seen in the rock, giving evidence to the wind-blown sand dunes that once covered the area. *Rock Family:* *Sedimentary* *Igneous* *Metamorphic*



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Kaibab Limestone

About 270 million years ago North America was the western part of the super-continent Pangaea. The Grand Canyon region was once again covered by a **shallow, warm, and well-lit clear sea with a sandy/muddy floor.** Brachiopods, sponges, and other sea creatures dominated these waters. Other species in-cluded crinoids, corals, bryozoans, cephalopods, sharks and fish. This **limestone** is the youngest, and therefore the top-most, rock layer found at Grand Canyon National Park.

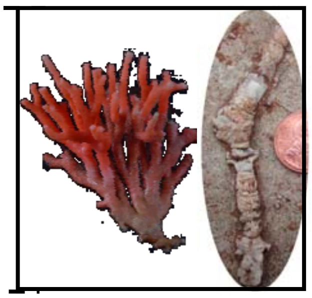
Rock Family: *Sedimentary* *Igneous* *Metamorphic*

Fossils of Grand Canyon

Here are some of the more common fossils found in the sedimentary rock layers of Grand Canyon.

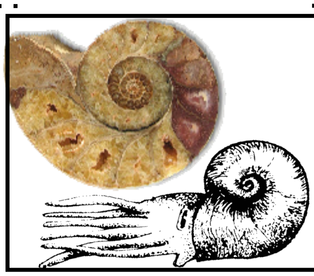
Brachiopods– A variety of shells lived in clear ocean waters.

Bryozoans– These are apartment complexes for microscopic (that's really small!) animals.

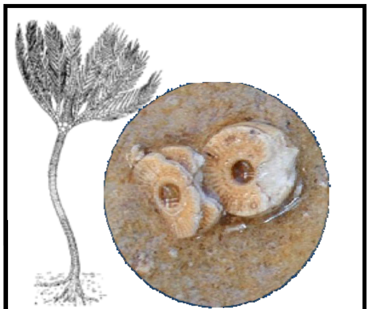


Burrows of animals– Worms and trilobites dug tunnels in the soft muddy sediment under the sea floor.

Cephalopods– These creatures roamed the sea and are related to the squid in today's oceans.



Coral– This predator was rooted to the sea floor. Descendents of this animal still live

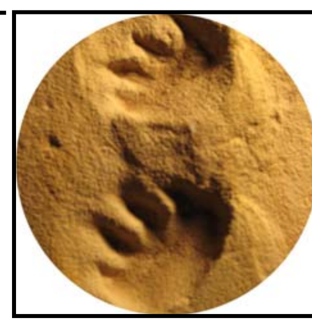


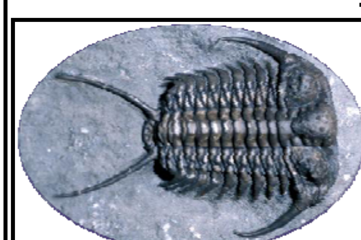
Crinoids– Tiny disks made the stem and arms of this animal, that was rooted to the sea floor.

Ferns– These fossils are the imprints of where leaves fell into the mud thousands of years ago.

Sponges– Sea sponges are one of the most common fossils in the youngest layer at Grand Canyon.

Tracks– Reptiles and other animals left their mark in the mud and sand where they lived.





Trilobites– These segmented animals vary in size from that of a dime to a dinner plate.