Rock Clocks

Middle School
NGGS: [MS-ESS1-4](), [4-ESS1-1]()
CCSS.Math: [6.RPA.3]()

Background

Read Pre-Lesson Preparation Before Class

Lesson Description

Investigate deep time and how scientists have deciphered the history of the Earth through geological information. Activities model geologist and paleontologist practices in a way that is accessible to those with limited understanding of Life and Earth Sciences. This lesson has been designed for middle school, but some activities offer ideas for scaffolding to make it appropriate for upper elementary students, too.

Driving Phenomenon

We live on an amazing planet. Out of thousands of planets discovered, Earth is the only planet known to support life. And, it is easy to take for granted that the Earth has always been here. The Earth has been around for a long time; 4.6 billion years is the current estimate. How could we possibly know this? Humans, comparatively, have only been around for a short time, so how can we know what we know about when the Earth formed.

To find answers to these questions we look for data in the Earth itself. By studying rocks from Earth's crust we can learn a great deal about the history of our planet.

Driving Questions

- How can we know about Earth's past before humans existed?
  - How do paleontologists and archaeologists know when a fossil is from?
  - How long were the dinosaurs around? How much of earth's history is that?

Learning Objectives

- Students use models to gain an understanding of collecting data and analyzing evidence from sources that are beyond the limit of direct human observation.
- Students will gain an understanding of the types of data used to substantiate the geological history of the Earth.

Time Requirements

- 120 minutes

Prerequisite Knowledge

- The Earth is formed of different types of rocks.
- Not all parts of the Earth's crust formed at the same time.

Teacher Resources

1. Earth From Space Image
2. Rock Cycle Diagram
3. Radiometric Dating Data
4. Radiometric Dating Supplement (optional)
5. Rock Layers Through Time
6. Earth's History Milestones

Student Resources

1. Rock Cycle Model
2. Particle Investigation
3. Fossil Puzzle
4. History of the Earth Timeline Project

How can we know about Earth's past before humans existed?

Full lesson procedures begin on page four.

Engage | 20 minutes	
Students will engage in building a model of the rock cycle to gain understanding of the three major types of rocks and how they transform from one to another.	Notes
Teacher Resources: 1 & 2 Student Resources: 1	

Explore | 25 minutes	
Students will work in groups to investigate samples of rock from around the world. By thinking about how they formed and analyzing data about their composition at the particle level students will determine how long ago they formed.	Notes
Teacher Resources: 3 & 4 *(optional)* Student Resources: 2	

Explain | 20 minutes	
By synthesizing the data known about how and when rocks formed, students will gain understanding of how geologists infer events in Earth's history before human existence.	Notes
Teacher Resources: 5 Student Resources:	

Elaborate | 25 minutes	
Students work through a puzzle modeling how paleontologists use fossils at various layers of rock gain deeper understanding of the history of Earth and history of life on Earth.	Notes
Teacher Resources: Student Resources: 3	

Evaluate | 40 minutes	
In a culminating project, students build a class model highlighting major events in the history of geology and/or life on Earth.	Notes
Teacher Resources: 6 Student Resources: 4	

Pre-Lesson Preparation

Review the Teacher Resources and decide which ones you will project on the board and which ones you will want to print and laminate. Each resource has suggested presentation guidelines. Student work is largely done in groups for this lesson, so you may print the Student Resources one per student or one per group. Gather a long piece of paper or several large pieces of paper for the timeline project. The timeline is designed to be 30 feet long.

Notes

Lesson Enrichment Ideas

DO

Plan a field trip to explore the history of life in the Griffin Halls of Evolving Planet and geological specimens from around the world at the Field Museum in Chicago.

Rent real specimens, and bring them to your classroom. If you live in the Chicago area, the *N. W. Harris Learning Collection* at the Field Museum offers numerous specimens that can be rented for study in the classroom.

- 300 Million Years Ago in Illinois
- Fossils From Rocks Near Chicago
- Fossils

READ

Older Than Dirt: A Wild But True History of Earth
by Don Brown and Dr. Mike Perfit
Two dirt-loving animals explore the major events in the history of the Earth in a graphic novel format.
http://worldcat.org/oclc/949922830

Rock Man Vs. Weather Man: The Magic School Bus Rides Again
by Samantha Brooke
This book offers an excellent scaffold for younger students being introduced to the rock cycle for the first time.
http://worldcat.org/oclc/1034931999

A History of Life in 100 Fossils
by Paul Taylor and Aaron O'Dea
More advanced in level of detail and reading level. It could be a helpful resource to have in the classroom during the final project of this lesson. Each story is only about a page of text and accompanied by rich photographs.
http://worldcat.org/oclc/951146948

WATCH

Radiometric Dating Video from the Griffin Halls of Evolving Planet
This video provides a little background of how a geochemist gets a sample from a rock specimen and prepares it to obtain data that students analyzed in the *Explore* portion of the lesson.

How can we know about Earth's past before humans existed?

Engage

1. Show an image of the Earth from space by projecting Teacher Resource 1: Earth from Space.

2. Ask students to identify what is in the picture, listen for them to respond that it is planet Earth, and add the following description.

   All the people you've ever known, and I've ever known, have lived here. All the people that came before us lived here, too. However, the Earth is much older than humans. The Earth formed billions of years ago when chunks of rock flying through space smashed together and joined into a planet. All of the planets in our solar system formed around the same time. Scientists estimate that the Earth is about 4.6 billion years old. Have you ever wondered how we know this? No humans were there to observe Earth when it began, but by studying the Earth we have found clues that have pointed to this number.

3. Ask the students if they can think of anything that could be studied to find evidence of the age of planet Earth? Elicit ideas from students on this question; listen for someone to bring up the idea that there are rocks on Earth that may have been around since the beginning of the planet, or that we can learn about Earth by studying rocks.

4. One thing that makes rocks on the planet Earth special is that they are many different ages. Some places in the solar system have not changed much since the solar system formed, but Earth's crust is different. Rocks on Earth are formed, recycled, and regenerated by different processes. Can you name any of the processes that form and reform rocks on Earth?

5. Listen for students to say things like erosion from wind and rain, or rock that is melted and turned to magma, or magma that cools after coming out of a volcano turning into igneous rock.

6. With all of these processes going on some of the rocks on Earth are newly formed, and some have been around for a very long time, possibly close to the time when Earth formed.

7. Break students into groups of three to four and pass out Student Resource 1: Rock Recycling to each group. Students should read and observe the images on the arrows, and then discuss with their group how they would place their arrows on the Rock Recycling diagram. There are multiple copies of each arrow because the cycle is not a simple circle. See Teacher Resource 2: Rock Cycle Data for the completed diagram to help you guide students in creating this model.

Engage

8 As groups are working through the model, you may need to show or explain that the arrows are showing the transition process that leads from one type of rock to the other. Another important hint might be that the cycle is not a simple circle; it is a cycle running in multiple directions at once.

9 Once each group has worked through the diagram, lead a discussion about their placement of the arrows and their understanding of the processes of going from one form of rock to the other.

10 Ask the students, “How can understanding the rock cycle help us understand how old the Earth is?” Listen for students to share ideas relating to the idea that knowing how a rock formed will give us clues to determine when it might have formed.

11 Reconfirm that understanding this earth system is one piece of the puzzle. Scientists found several additional methods that they employ to study the age of the Earth through clues found in the rocks. Students are going to get to use more of these methods in the following investigations to see how they all fit together to give scientists a clearer picture of Earth’s history.

Explore

1 Project Teacher Resource 3: Rocks and meteorites of unknown ages, and review the types of rocks and where they were found presented in the table. Ask for students to share ideas about how each one might have formed based on the information in the table and the understanding about rocks gained from building the rock cycle model.

2 Explain that we are going to analyze data taken from these samples in order to develop an idea of when each was formed.

3 Group students into to groups of two to four, and pass out a unique Sample Card from Teacher Resource 3: Radiometric Dating Data and Student Resource 2: Particle Sample Investigation to each group of students. Each sample is labeled according to the rock that it came from.

4 The first page of Student Resource 2: Particle Sample Investigation gives some background on the idea that matter is made of particles, and it may be advantageous to guide the students through this part of the activity depending on what their prior experience and knowledge is on this subject.

5 Explain to students that these sample cards represent the tiny particles that make up their rocks. Geologists must analyze rock samples at a very detailed level to determine the age of rocks. They use special equipment that helps them quantify or count the particles, so this sample card represents data similar to what a geologist would use.

6 Invite the students to look at the samples and make some observations about what they see in the sample. Encourage students to begin to analyze the sample for quantitative information.

7 Student Resource 2: Particle Investigation guides students in making observations about their rock sample and the particle specimen. However, you will want to be familiar with the resource in case you would like to scaffold some of the concepts for your class.

8 Once each group has found a date for their sample, invite them to create a timeline of the samples on the board or a bulletin board starting with the oldest sample at the bottom and working upward toward the youngest rock. A sample framework for the timeline is outlined in Teacher Resource 3: Radiometric Dating Data.

Optional Enrichment:

Explore

An optional way to enrich the lesson here would be to more deeply unpack the differences from sample to sample in comparison with the line graph used to determine age. If students are ready for this depth of conversation, it is an excellent springboard to a discussion of the concept of a half-life. Teacher Resource 4: Radiometric Dating Supplement can guide you in presenting the information and connecting it to the activity.

Exploring rocks of unknown ages activity was adapted from:
Flammer, L., J. Beard, C.E. Nelson, & M. Nickels. ENSIWEB. Evolution/Nature of Science Institutes "Virtual Age Dating Lesson" (1998) Retrieved [05.01.2018] from:
https://web.archive.org/web/20170710154400fw_/http://www.indiana.edu/~ensiweb/virt.age.html

9 Just before the end of the class session, have someone from each group state the age that they estimated, and explain which phase in the rock cycle their rock is in. If you have more than five groups it may be interesting to compare results from the groups that had the same sample, and determine if they had any margin of error.

10 Invite the students to think about why we would choose to display our timeline in this way before concluding this session of the lesson.

Explain

1 Ask each group to share some evidence that the rock cycle and/or radiometric dating provided for the formation of their rocks. Once everyone has shared, remind them that multiple types of data can help us better understand these big ideas like geological change.

2 Tell students that they will now solve a puzzle about the order in which different animals lived on Earth based upon the fossil record. Paleontologists call this puzzle of 'what lived when' relative dating, and they combine evidence that we have from the Earth's history with evidence from the history of life to help solve the puzzle.

3 Tell them that in order to solve the unknown parts of the puzzle, we will need to abide by certain rules or things we know to be true about the way that rock layers occur in nature.

4 Revisit the timeline on the board created from their previous samples, and again ask the students if they have any ideas why this timeline would be vertical rather than horizontal.

5 To support their reasoning, also present students with the Image A provided in Teacher Resource 5: Rock Layers Through Time. Bring their attention to the arrow and the star marking two layers of rock and ask, "which of these layers was formed first, which rocks are the oldest?" Listen for students to remember from the previous discussion that the star layer is lower, so it is older. On the board, write, **KNOWN: Newer layers of rock form on top of older layers.**

Explain

6 Revisit image A on Teacher Resource 5: Rock Layers Through Time and tell students that a certain type of fossil was found in layers of rock below the Star layer, but not in the Star layer. Ask students if they think it will reappear above the arrow layer. Listen for them to realize that once this fossil disappears from the record, it means it has gone extinct and it will not be back. Then write, **KNOWN: Once a fossil disappears from the fossil record it does not appear in younger layers.**

7 Now ask students to wonder how it is that we can even see the layers of rock in this mountain. They were under the ground at one point, buried deep below the surface, but now they rise high in the air. What could have happened to make this mountain? Encourage students to think back to the rock cycle at some of the forces that occur in metamorphic rock formation. Listen to see if anyone can remember that strong tectonic forces push, fold, and even invert sedimentary layers. Add to this idea by explaining that sometimes mountain ranges get pushed up this way, and sometimes these forces fold and invert the original order of the sedimentary layers of rock.

8 Show Image B from Teacher Resource 5: Rock Layers Through Time to illustrate what folding and inversion can look like in nature, and write, **KNOWN: Metamorphic forces can invert, twist, and fold sedimentary rocks, interrupting the layers.**

9 Now show Image C from Teacher Resource 5: Rock Layers Through Time and tell the students that we have reached the final rule for our puzzle. Explain that scientists use certain types of fossils that only show up for very short and specific periods in the fossil record and nowhere else. These are called Index Fossils. Write the last rule on the board, **KNOWN: Certain fossils, called index fossils, are found in specific rock layers that are consistent across the Earth can be used to give more specific times for when something lived.**

10 Looking at this image, see if you can determine what are the index fossils here. Turn to a partner and talk to share what you think it might be. Finally, ask for a volunteer to share their thoughts with the class.

RULES FOR THE PUZZLE:

Explore | Steps 5-9

- **KNOWN:** Newer layers of rock form on top of older layers during the formation of sedimentary rocks.
- **KNOWN:** Metamorphic forces can invert, twist, and fold sedimentary rocks interrupting the layers.
- **KNOWN:** Once a fossil disappears from the fossil record it does not appear in younger layers.
- **KNOWN:** Certain fossils, called index fossils, are found in specific rock layers that are consistent across the Earth can be used to give more specific times for when something lived.

Elaborate

1 Invite students to reassemble with their working groups.

2 Pass out Student Resource 3: Fossil Puzzle one per group. The Student Resource contains the instructions set in the margin to the right.

3 Once groups have determined the order and answered the questions bring everyone back together for a concluding discussion. Check-in to see if all groups came to similar conclusions about the order and the culminating questions.

Evaluate

1 Now that they have practiced the ways that scientists study rocks and fossils to recreate the history of the earth, students will create a timeline that shows some of the key moments in Earth's history that have been determined in the ways we have just practiced.

2 Ask students, based upon our oldest rocks from the Radiometric Dating Simulation, what is our conclusion about how old Earth might be? Listen for them to respond that it is at least 4.4 billion years old. The oldest known rocks on Earth are 4.4 billion years, so does that mean Earth is older or younger than this? Listen for students to confirm that it is older. Then state that scientists currently estimate Earth's age at 4.57 billion years old.

3 Share with students that they are going to build a timeline of Earth's history to summarize and communicate some of the events they have learned about in the prior investigations.

4 Introduce students to the idea that our timeline will be 9.14 meters long *(approximately 30 feet)*. One end of the timeline will be today, and the other end of the timeline will be the formation of the Earth.

5 Student Resource 4: History of Earth will guide each group in determining where to place a particular event on the timeline using proportional computations. Once each group has determined the place on the timeline for their event, they can also create drawings, collages or other graphics to help illustrate what they learned about the event.

6 Another culminating activity could be to display the timeline in a hallway or other public space and allow students to share what they learned with other students.

FROM STUDENT RESOURCE 3:

Elaborate | Step 2

1. Cut out the fossil cards on the resource.
2. Spread the cards out on your desk facing up so everyone can see.
3. Find the card that is labeled "R" - this is the first card in your sequence
4. Order the cards knowing that "R" is first in the sequence order.
5. After you have created your sequence, write down the order of letters that appear in the left hand corner of each card.

ELEMENTARY DIFFERENTIATION

Evaluate

If students do not have the experience in mathematics to be able to perform proportional computations, the timeline building activity can be about measurement rather than proportions. A measurement guide to a 30 foot timeline can be found in Teacher Resource 6: History of Earth Milestones.

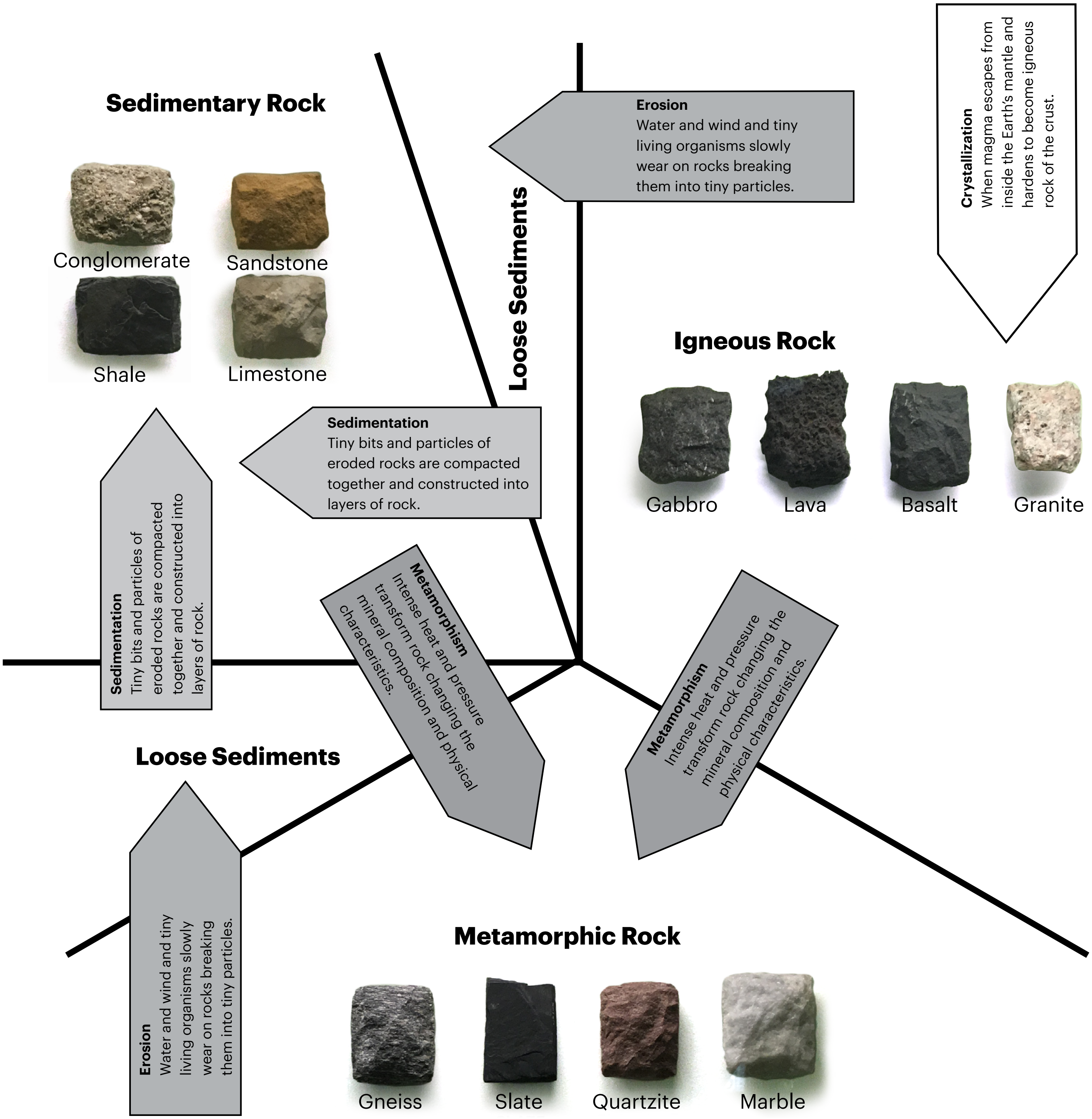
Teacher Resource 1.0

Earth from Space

Image Courtesy of NASA

Rock Cycle Diagram

Teacher Resource 2.0



Teacher Resources

Radiometric Dating Data

Teacher Resource 3.0

Resource Contents
Overview of Samples — Image for Projection
Student Data Cards — Print and laminate one copy each
Data Key (for teacher reference only) — Do not print

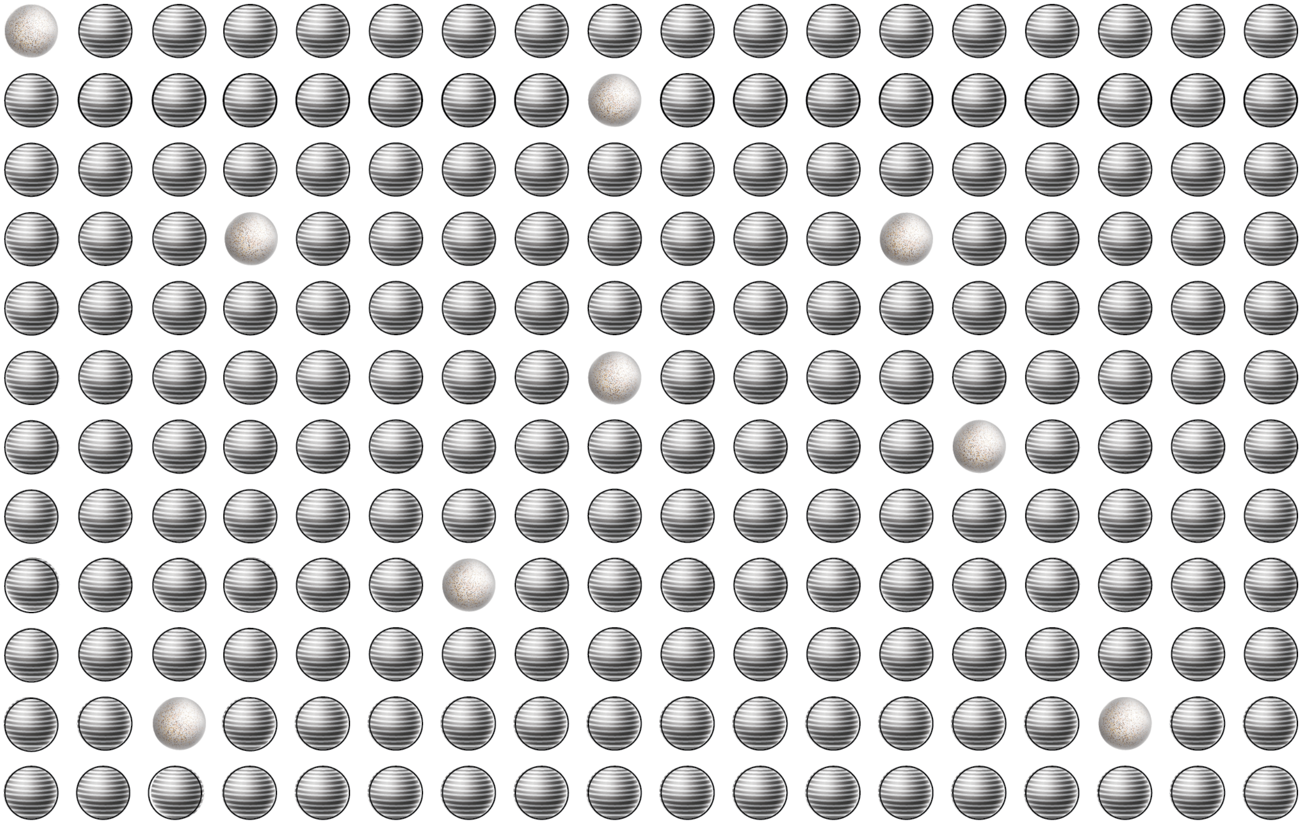
Stromatolite fossils	Máximo's fossil	Trilobite fossil	Crystals from metamorphic rocks	Ancient Ocean Floor
United States	Argentina	Morocco	Australia	Canada
				

Stromatolite Fossil © The Field Museum, PE39247
Patagotitan mayorum Femur Fossil © The Field Musem, Photographer John Weinstein
Trilobite Fossil © The Field Museum, GEO86418_06d, Photographer John Weinstein.
Brown zircon © Science Stock Photography/Science Source
Ancient Sea Floor Fossil © The Field Museum, E20070

Teacher Resource 3.0: Radiometric Dating Data

Particle Sample Of Crystals From Metamorphic Rocks Found Near Jack Hills, Australia

This sample of rocks was collected from a small cluster of hills in Western Australia. The rocks show signs of having been exposed to geologic processes of heat and pressure. Some crystals found in the rock are known to be very durable and resistant to destruction even through metamorphic processes, so we are testing them to determine their age.



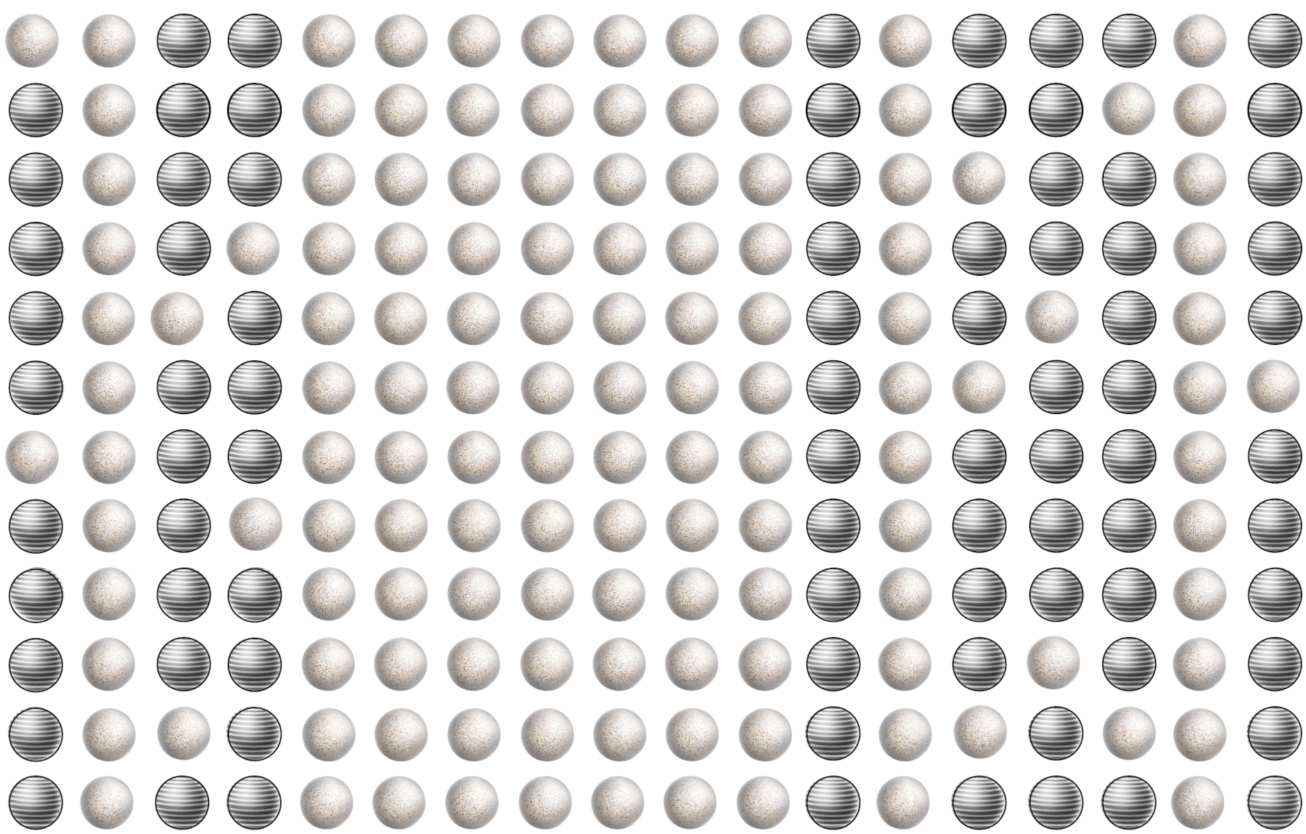
Teacher Resources

Teacher Resource 3.0: Radiometric Dating Data

Teacher Resources

Particle Sample from Trilobite Fossils found in Morocco

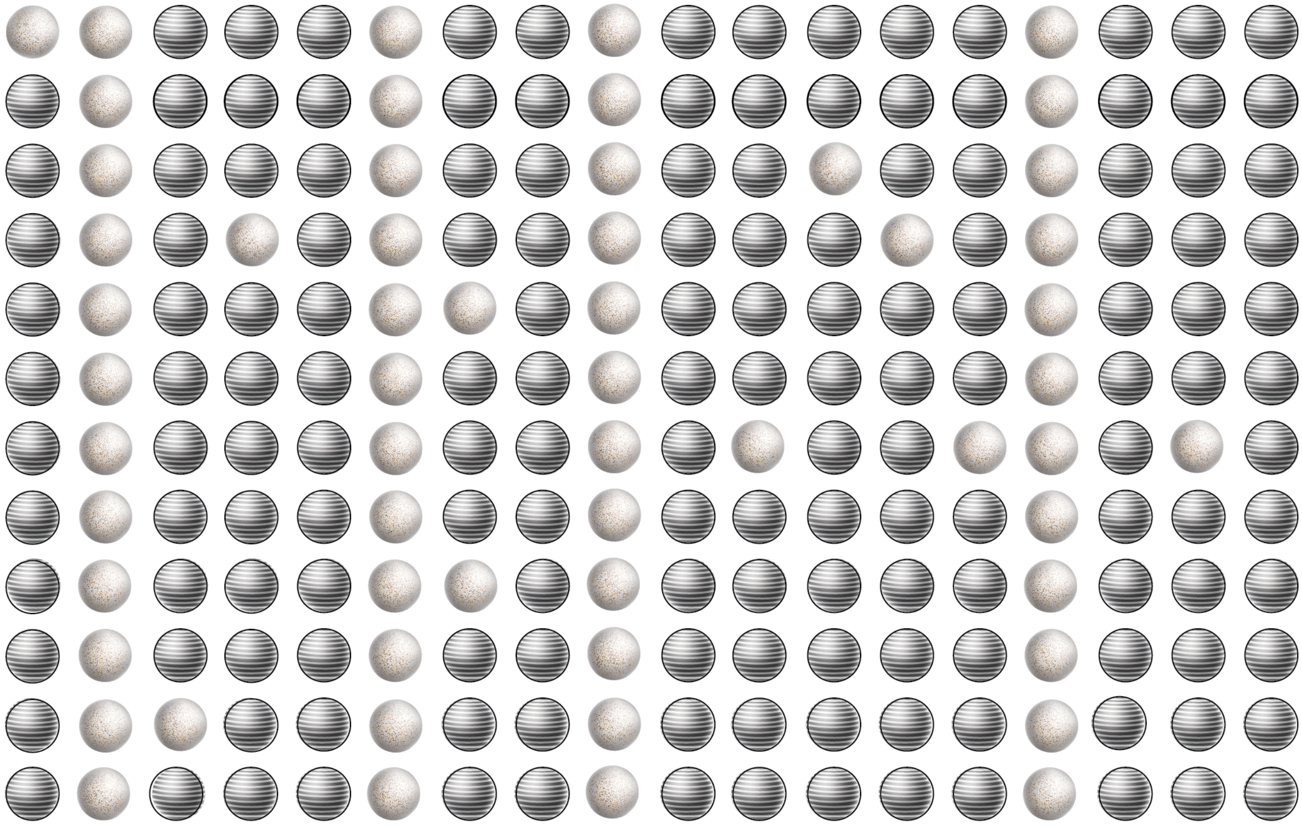
Trilobites are a diverse group of animals that inhabited the ocean floor. They have been found throughout the world, yet they always seemed to live in ancient saltwater seas. They were the first animals to have eyes, and they ranged in size from 1 mm to 72 cm.



Teacher Resource 3.0: Radiometric Dating Data

Particle Sample of Ancient Ocean Floor Rocks Found in Canada

This sample of rocks was collected from a cluster of sedimentary rocks that are known to have once been at the bottom of the ocean. The red color represents sediment that had a high iron content. Long ago the iron interacted with oxygen in the air and the ocean. It marks a time in Earth's history when photosynthetic bacteria were releasing a lot of oxygen.

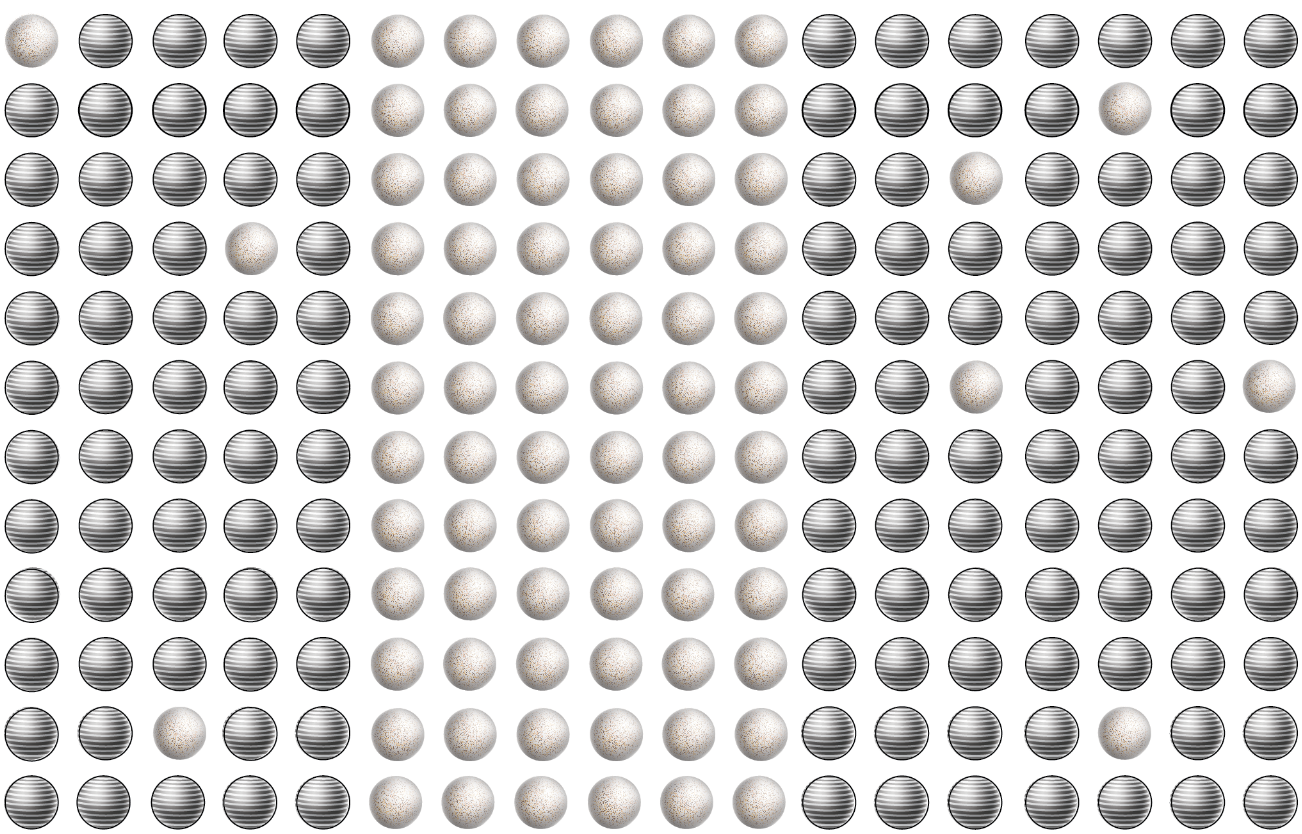


Teacher Resources

Teacher Resource 3.0: Radiometric Dating Data

Particle Sample from Stromatolite Fossils from Texas, United States

This sample of rocks was collected from Texas in the western United States. Formations such as these can be found throughout the world, and they were created by the activities of photosynthetic bacteria. The bacteria secrete a glue-like substance which traps tiny sand particles and binds layer after layer into mounds or columns. The stromtatolite fossils are signs of the earliest form of life on Earth, and yet, there are still living stromatolite colonies in present day shallow seas. Let's investigate this sample so that we can see when this particular stromatolite colony lived.

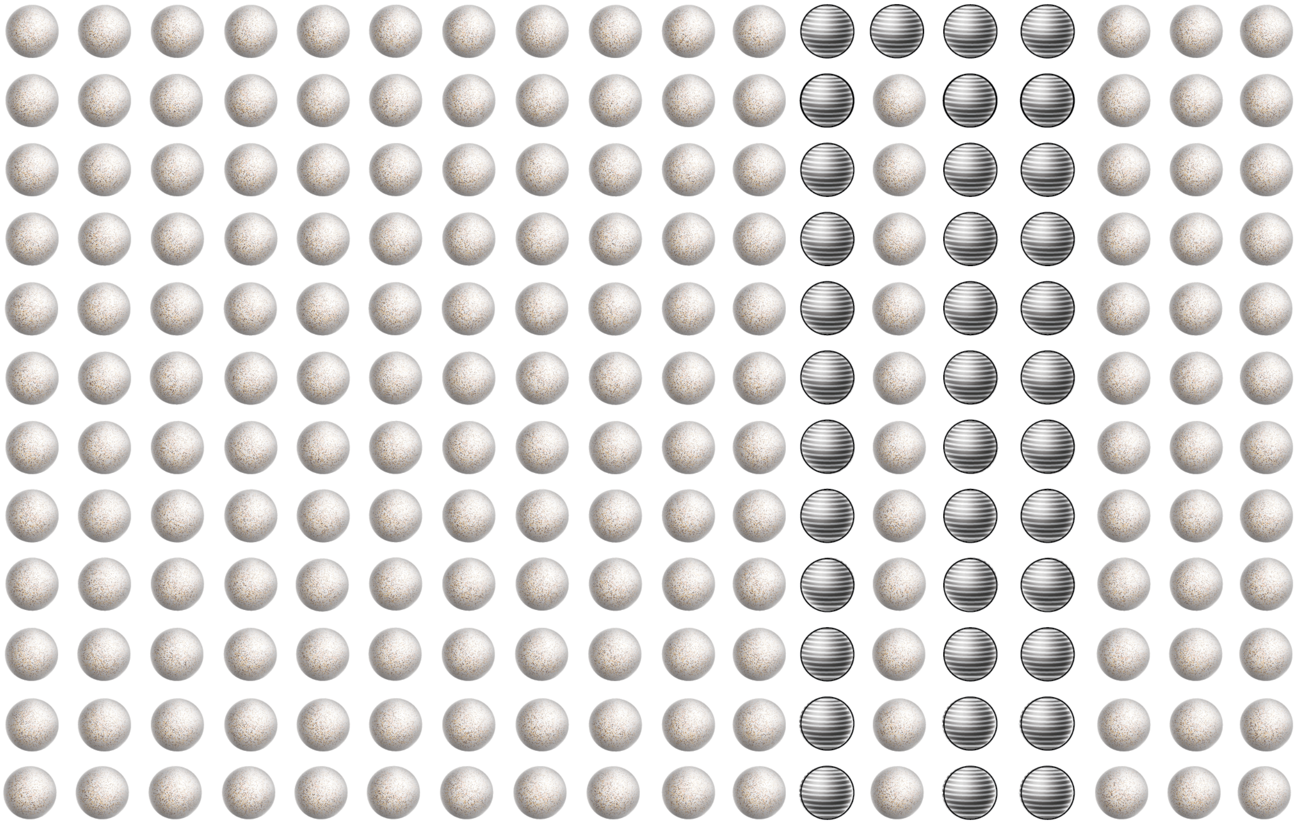


Teacher Resource 3.0: Radiometric Dating Data

Particle Sample from *Patagotitan mayorum* Fossil from Argentina (Máximo)

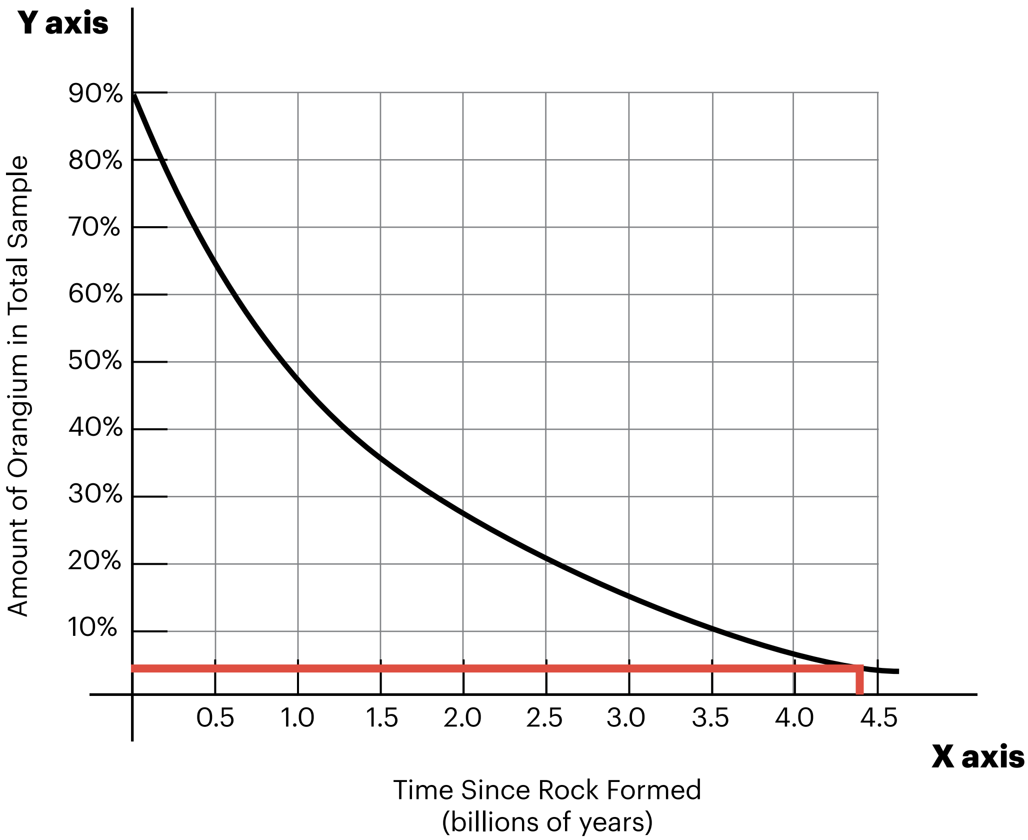
This is the largest leg bone ever discovered. It belonged to the largest animal that is known to have walked the Earth. This bone is nearly 8 feet long, and it belonged to a dinosaur named *Patagotitan mayorum* which was found in southern Argentina in a region called Patagonia. By dating this bone, we can determine approximately when this animal lived, and died.

Teacher Resources



Teacher Resource 3.0: Radiometric Dating Data

Data Key - Crystals From Rocks Found Near Jack Hills, Australia

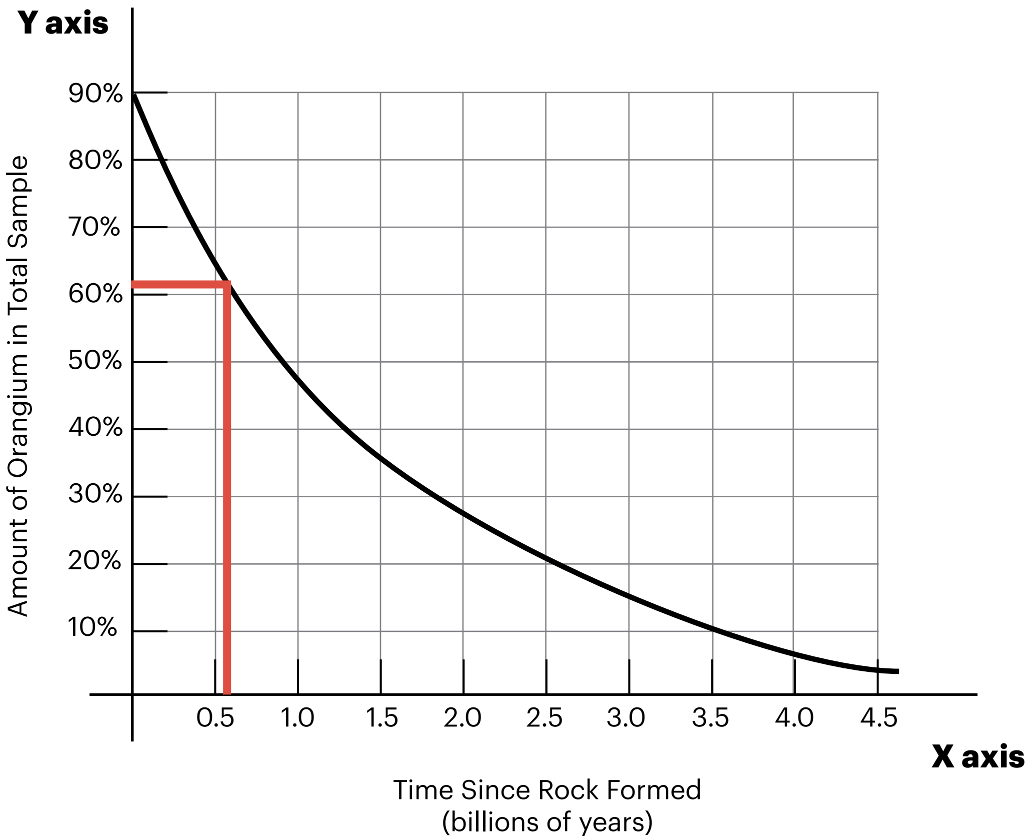


Total Particles:	216
Grittium Particles:	9 (4%)
Bandium Particles	207 (96%)

Teacher Resources

Teacher Resource 3.0: Radiometric Dating Data

Data Key - Trilobite Fossils found in Morocco

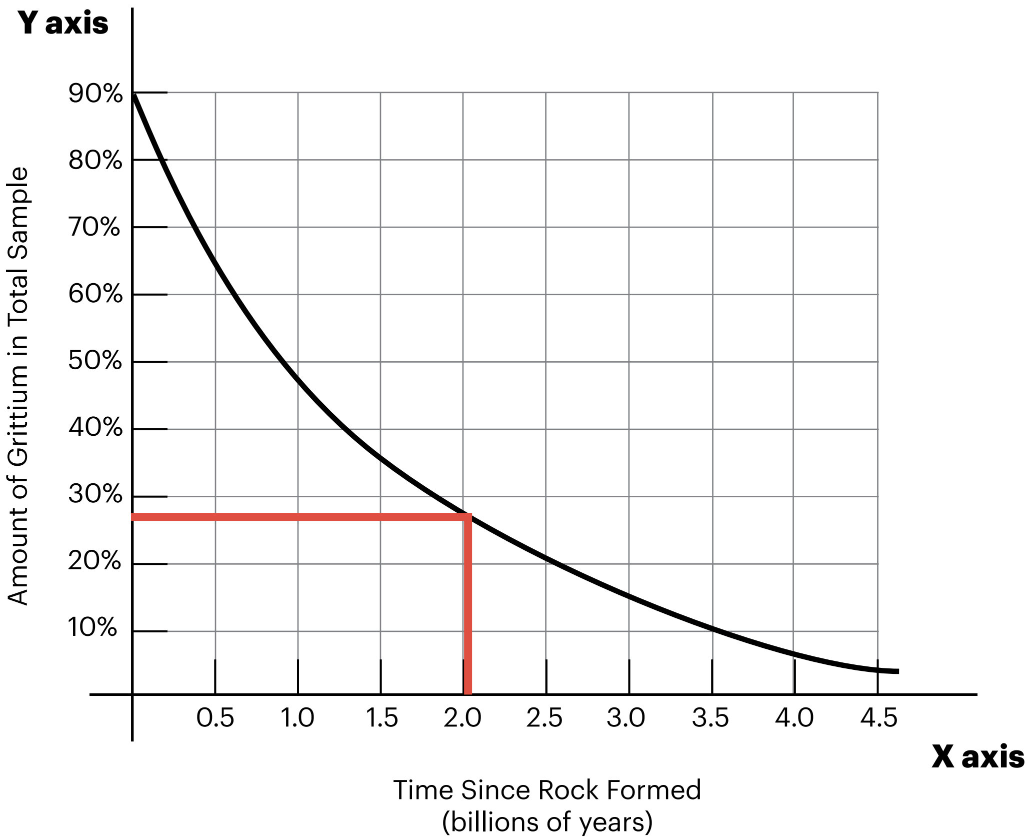


Total Particles:	216
Grittium Particles:	134 (62%)
Bandium Particles	82 (38%)

Teacher Resources

Teacher Resource 3.0: Radiometric Dating Data

Data Key - Ancient Ocean Floor Rocks Found in Canada

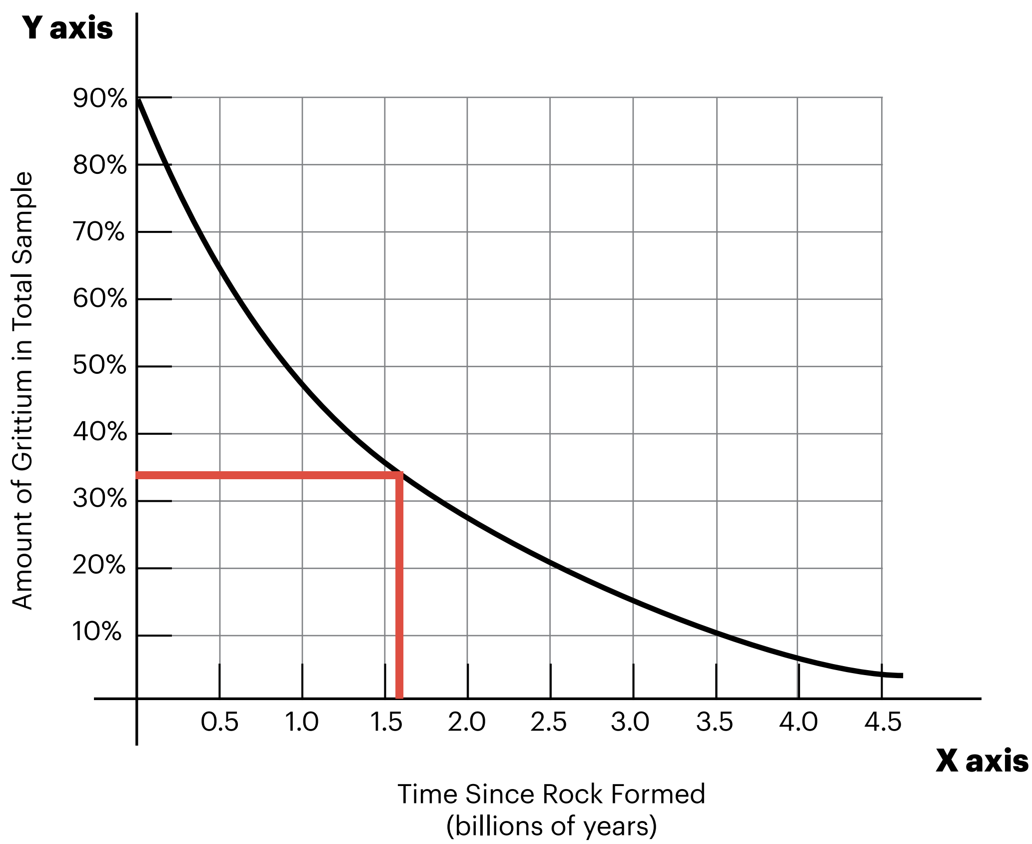


Total Particles:	216
Grittium Particles:	58 (27%)
Bandium Particles	158 (63%)

Teacher Resources

Teacher Resource 3.0: Radiometric Dating Data

Data Key - Stromatolite Fossils from Montana, United States

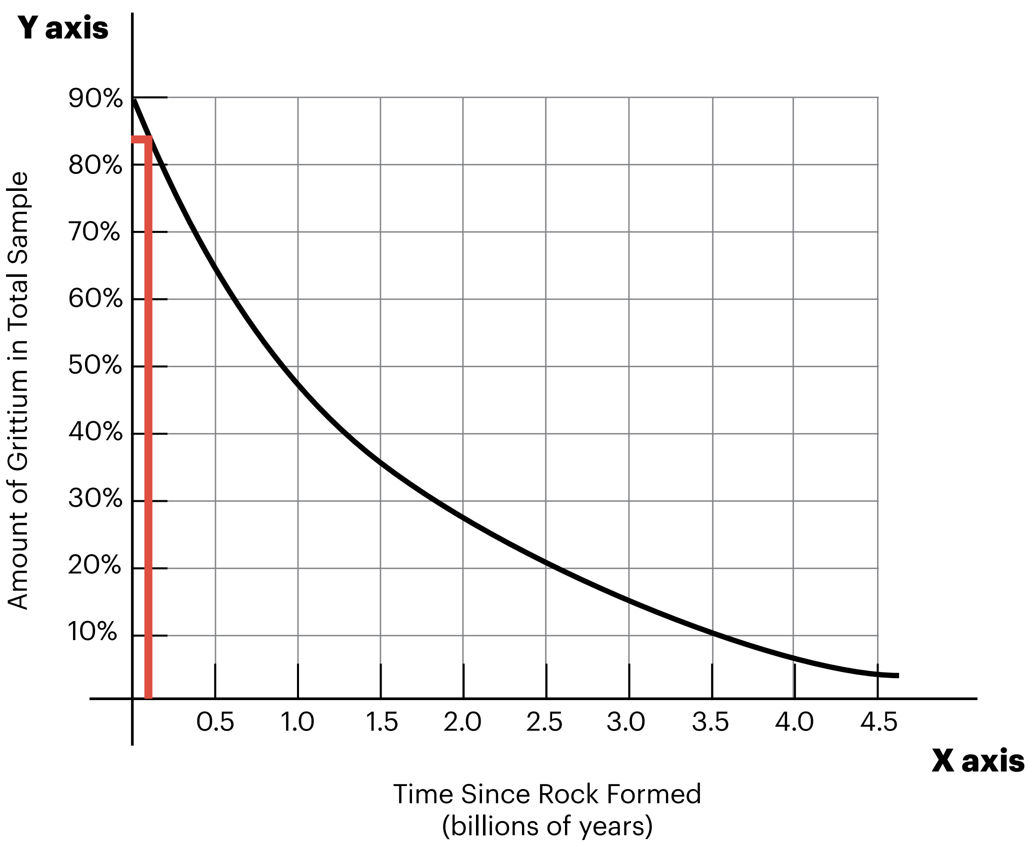


Total Particles:	216
Grittium Particles:	80 (37%)
Bandium Particles	136 (63%)

Teacher Resources

Teacher Resource 3.0: Radiometric Dating Data

Data Key - *Patagotitan mayorum* Fossil from Argentina (Máximo)



Total Particles:	216
Grittium Particles:	179 (83%)
Bandium Particles	37 (17%)

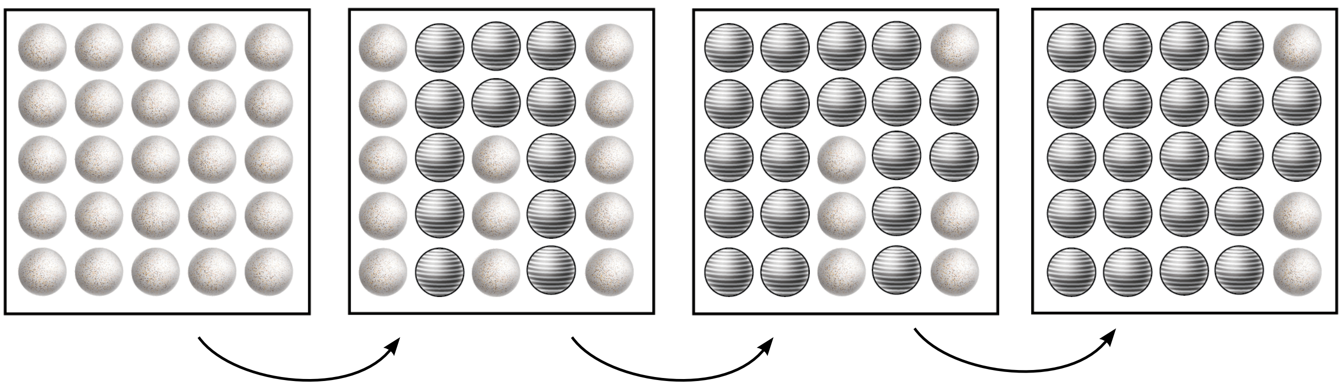
Teacher Resources

Radiometric Dating Supplement *(optional)*

Teacher Resource 4.0

Use this resource only if you would like to cover the concept of half-life with your students. This is a term that students may have heard in association with Radiometric Dating. This supplement helps to explain how half-life connects to the other concepts in this investigation.

Half lives are defined by the amount of time it takes for one half of the atoms in a sample to go from the parent element to the daughter element.



Half-lives are used as a guideline for different types of elements that are used in radiometric dating. In nature different elements have different half-lives, so they are often used for specific lengths of dating.

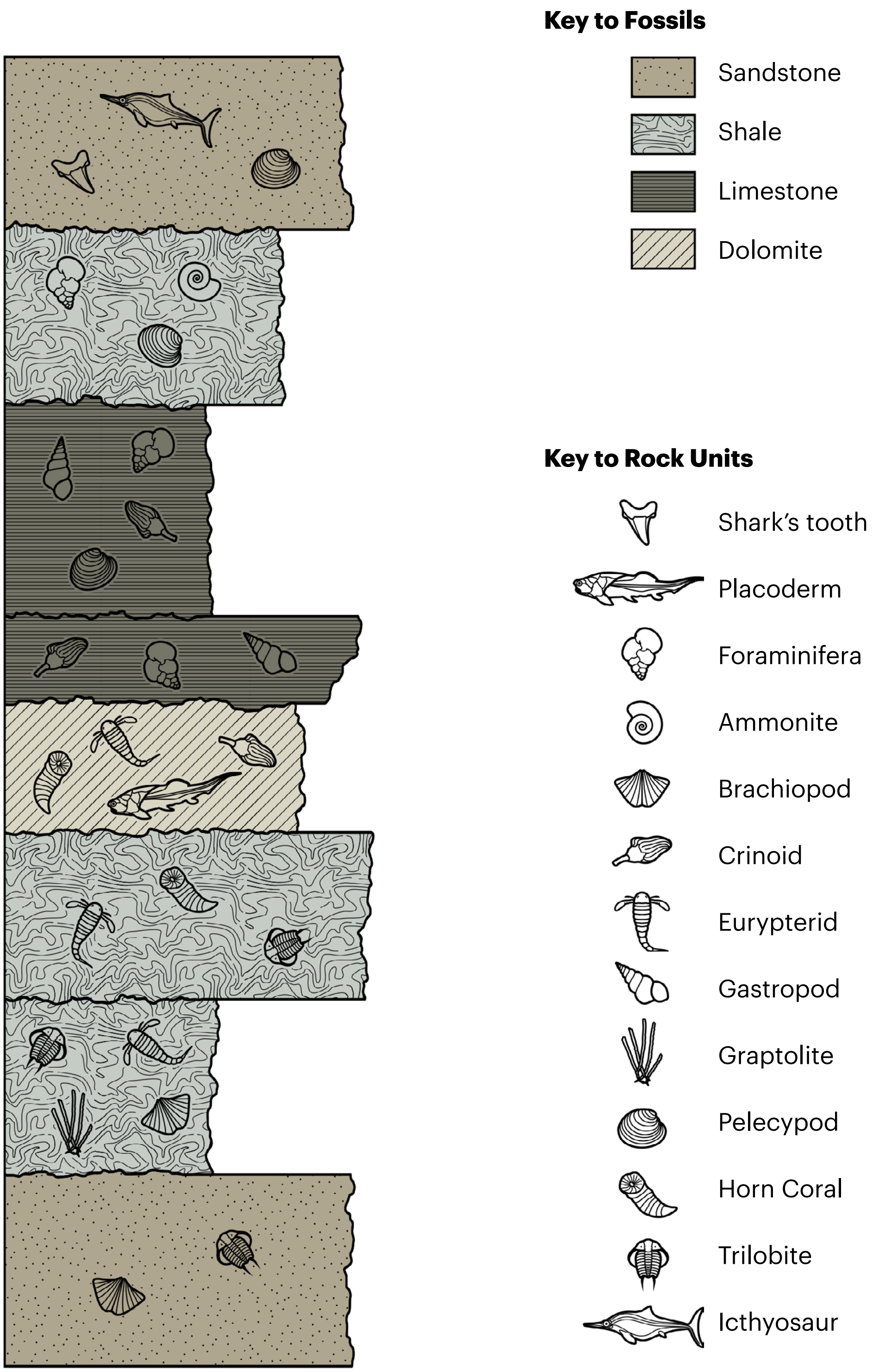
Teacher Resource 5.0

Image A: Sedimentary Rock Layers Exposed

Image B: Layered Rock Folded Near Fault

Teacher Resource 5.0: Rock Layers Through Time

Image C: Rock Units Each Containing Different Fossils



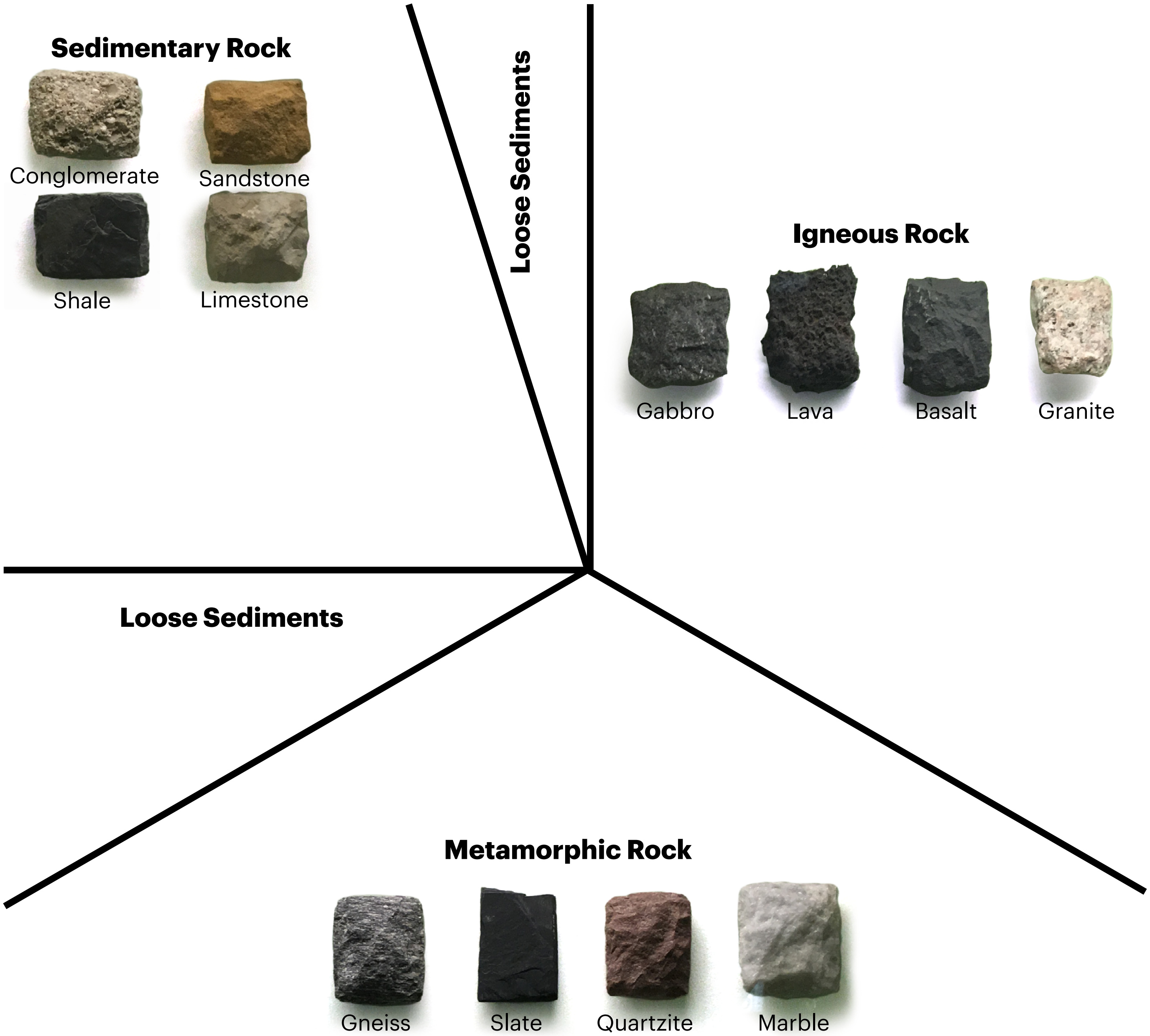
Milestones in Earth's History

Teacher Resource 6.0

Event	Age (billions of years ago)	Distance on Timeline (meters)	(feet - inches)
Earth forms	4.57	9.14	30 - 0
Life begins	3.8	7.60	25 - 0
Bacteria, algae, and fungi abundant	3.0	6.10	20 - 0
Sponges, worms, and jellyfish abundant	0.54	1.10	3 - 6
First fish appear	0.48	0.98	3 - 2
First four-legged animals	0.40	0.79	2 - 7
First animals laying eggs on land (amniotes)	0.33	0.67	2 - 1
First dinosaurs appear	0.23	0.46	1 - 6
First mammals appear	0.21	0.44	1 - 5
Dinosaurs become abundant and birds appear	0.16	0.30	1 - 0
Flowering plants appear	0.014	0.27	0 - 11
Dinosaurs go extinct	0.066	0.13	0 - 5
Mammals become abundant	0.050	0.10	0 - 4
First humans appear	0.003	0.05	0 - 2

Rock Cycle Model

Student Resource 1.0



Student Resource 1.0: Rock Cycle Model

Crystallization
When magma escapes from inside the Earth's mantle and hardens to become igneous rock of the crust.

Metamorphism
Intense heat and pressure transform rock changing the mineral composition and physical characteristics.

Sedimentation
Tiny bits and particles of eroded rocks are compacted together and constructed into layers of rock.

Metamorphism
Intense heat and pressure transform rock changing the mineral composition and physical characteristics.

Erosion
Water and wind and tiny living organisms slowly wear on rocks breaking them into tiny particles.

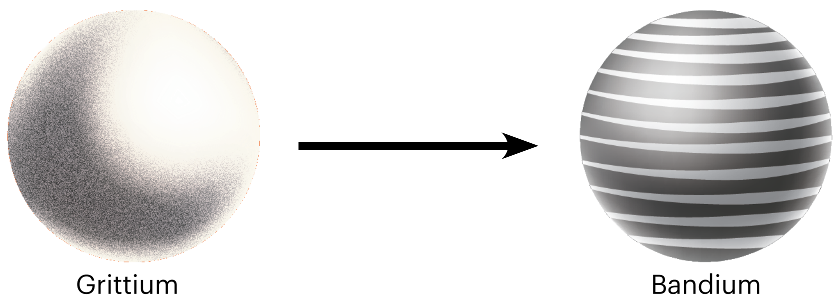
Sedimentation
Tiny bits and particles of eroded rocks are compacted together and constructed into layers of rock.

Erosion
Water and wind and tiny living organisms slowly wear on rocks breaking them into tiny particles.

Particle Investigation

Student Resource 2.0

All matter — all the stuff in the universe including Earth's rocks — is made up of very small particles called atoms. We cannot see the atoms with our eyes, but we can observe them indirectly using scientific instruments. Today we will be working with some fictional elements called *Bandium* [BAND-ee-uhm] and *Grittium* [GRIT-ee-uhm] to help us understand how the particles behave.



Scientists recognize that some types of matter change over time eventually transforming into a different type of matter completely; these changing elements are called radioactive elements. When they change, they transform into a more stable element. The initial element is often referred to as the parent element, and the element they transform into is called the daughter element.

In the image above...
What is the name and texture of the Parent Element? ________________________________

What is the name of the Daughter Element?_____________________________

These changes happen to the individual particles of the element (the atoms), but not every particle makes the change at the same time. By studying many samples, scientists have learned that the amount of time it takes for half of particles to switch to the new element is very regular, like the ticking of the hands of a clock.

Student Resource 2.0 Particle Investigation

In order to determine how old our rock samples are we need to investigate how many particles have changed at this atomic level. Luckily, for us our samples have been prepared ahead of time by a scientist called a geochemist using special equipment so we can focus on making observations at the particle level.

Before analyzing the data provided by the geochemists, look at your group's sample and record your observations and questions in the boxes below.

Rock observations of physical appearance	Particle sample observations

Student Resource 2.0 Particle Investigation

Sample Label:	Sample Location:

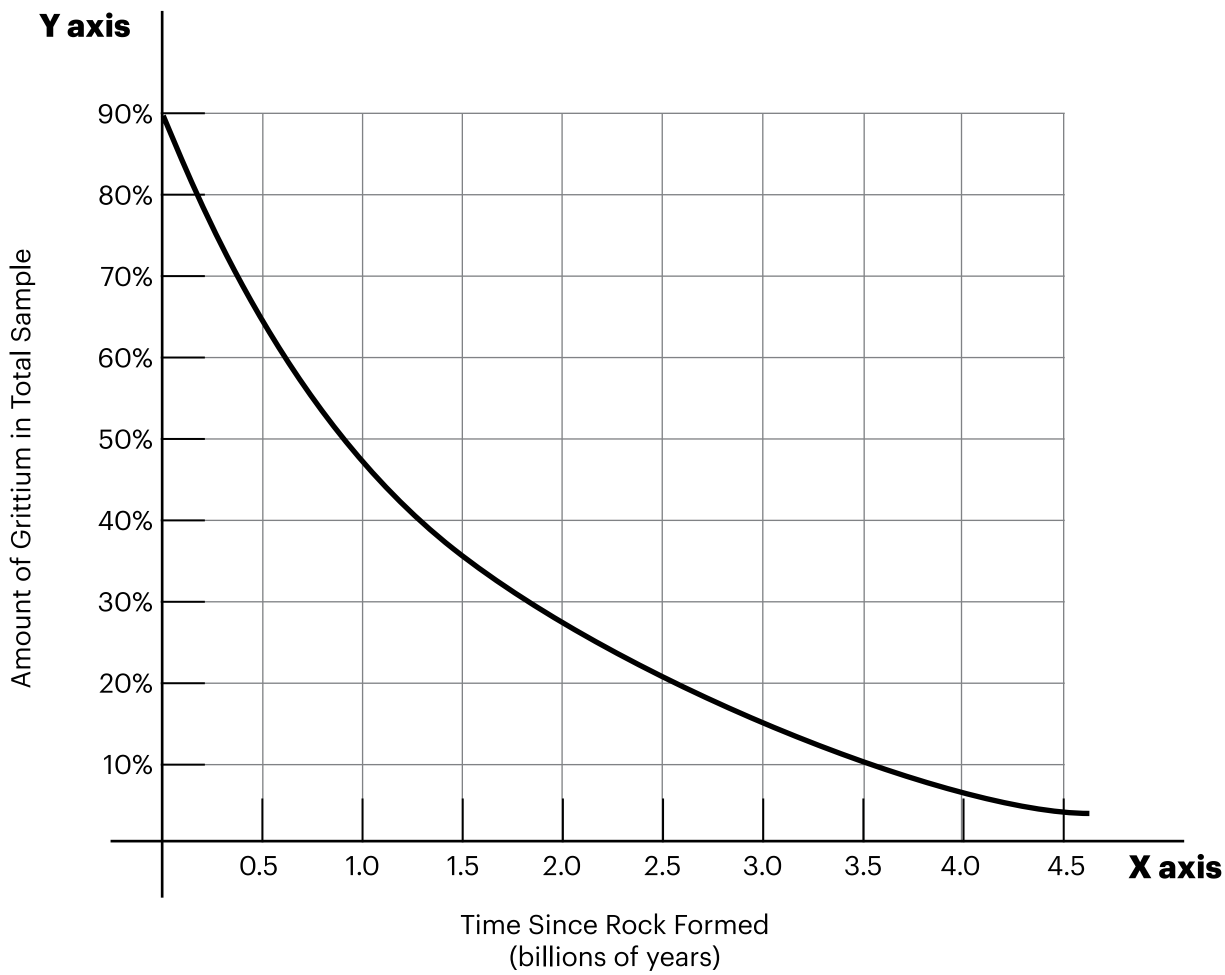
Total Particles in the Sample:	
Particles of Grittium in Sample:	Particles of Bandium:
Percentage of Grittium in the total sample *(show your work in the space below)*:	

Student Resource

Student Resource 2.0 Particle Investigation

Scientists that have studied how the amount of Bandium and Grittium change over time have created a reference for us to use as we analyze our samples. Based on your calculations above, follow the three steps below to plot where your sample falls on the line graph.

1. Make a mark on the Y-axis as close as you can to the spot that corresponds to the percent of Grittium that you calculated on the previous page.
2. Draw a horizontal line from the point you marked on the Y-axis to the curve and mark a point or dot on the curve.
3. Now, draw a vertical line from the point on the curve down to the X-axis.
4. Estimate the age of the sample based upon where the vertical line hits the X-axis.



Student Resource

Fossil Puzzle

Student Resource 3.0

Instructions:

1 Cut out the fossil cards from pages 2 -3 .
2 Spread the cards out on your desk facing up
3 Find the card that is labeled "R" - this is the oldest card in your sequence.
4 Order the cards knowing that the oldest fossil card is first in the sequence (it belongs on the bottom). Each card represents a new rock layer in a timeline of the fossils in different rock layers. .
5 After you have answered the questions on the next page, return your cards to the envelope.

Questions:

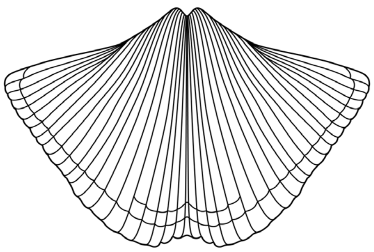
1. Write the sequence of letters (that appear in the lower left hand corner), from oldest rock layer to youngest.

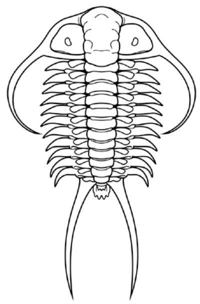
2. Which fossils could be index fossils? Why?

3. Which fossils would not be used as index fossils? Why?

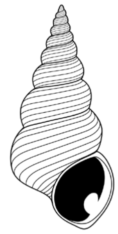
Student Resource

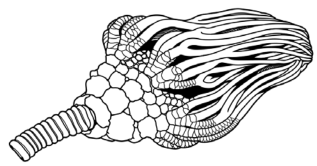
Student Resource 3.0: Fossil Puzzle

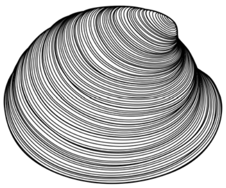

Brachiopod

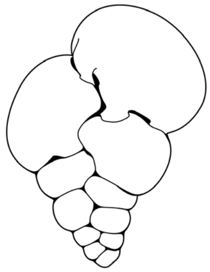

Trilobite

R

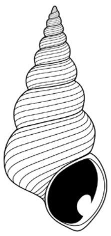

Gastropod


Crinoid


Pelecypod


Foraminifera

W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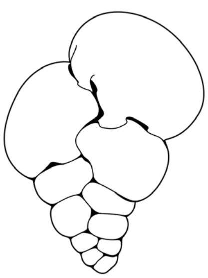
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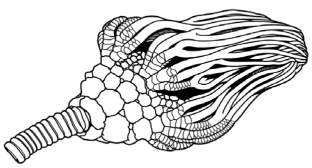
Crinoid

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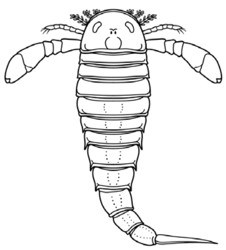
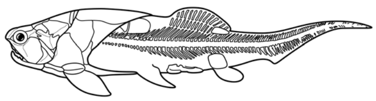
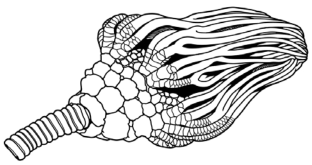
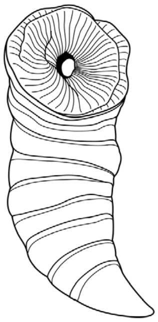

Eurypterid

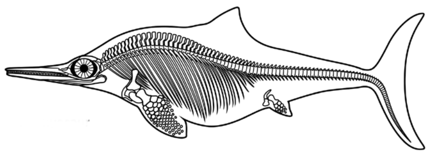

Placoderm


Crinoid

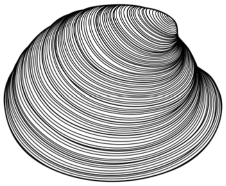

Horn Coral

U

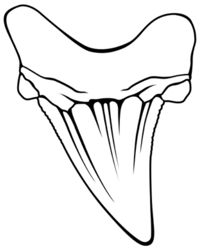
Student Resource 3.0: Fossil Puzzle



Ichthyosaur

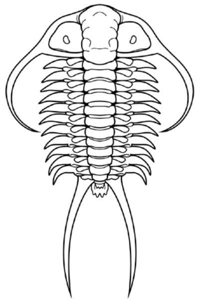


Pelecypod

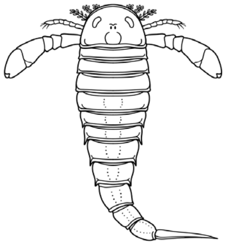


Shark's tooth

L



Trilobite



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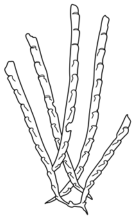
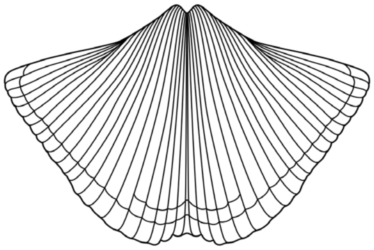
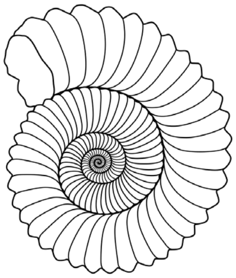


Graptolite

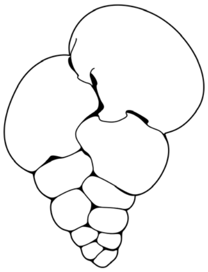


Brachiopod

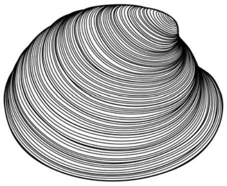
E



Ammonite

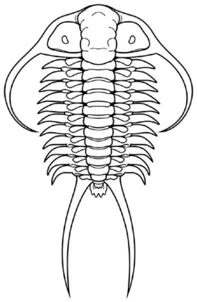


Foraminifera

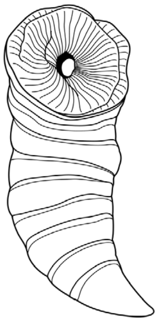


Pelecypod

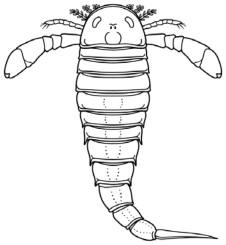
A



Trilobite



Horn Coral



Eurypterid

P

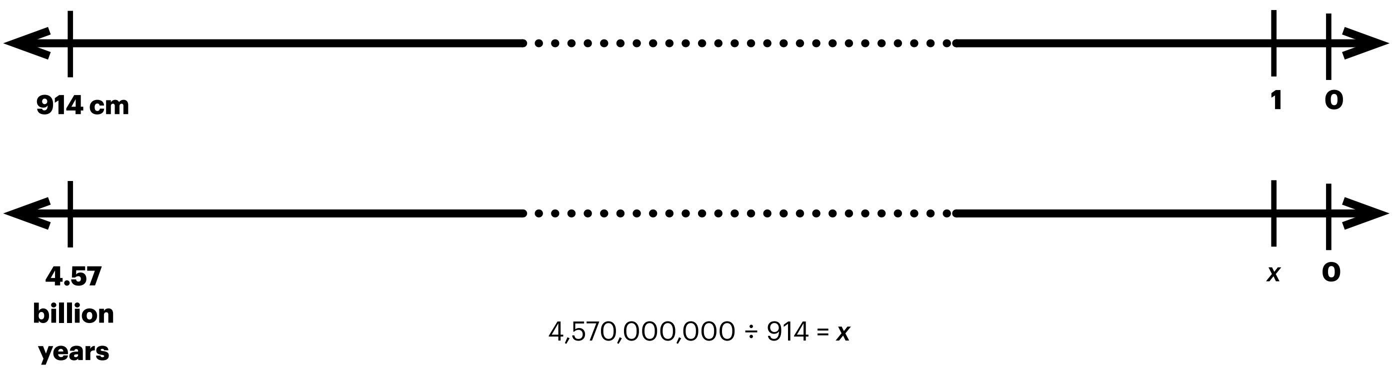
History of the Earth Timeline Project

Student Resource 4.0

The timeline is 9.14 meters long. How many centimeters are in the timeline? Show your work below.
(Hint: there are 100 centimeters in 1 meter)

The timeline spans 4.57 billions of years. How many millions of years is that? Show your work below.
(Hint: 4.57 billion can also be written as 4,570,000,000.)

To find out the relationship between centimeters and years in our timeline we can use a dual number line to help us see the relationship between the two scales.



4,570,000,000 ÷ 914 = ***x***

1 cm = 5,000,000 years

How far from present day (0 meters) should you place the event that you studied in the particle investigation?
Show your work below.

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