Objectives
- Learn what the relative ages of rock layers reveal about Earth.
- Describe how index fossils are used to determine the ages of rock layers.
- Explain how the absolute ages of rocks are determined.
- Find the relative ages of rocks using cross-section images.

The BIG Idea
- Rocks, fossils, and other types of natural evidence tell Earth’s story.

Key Concept
- Rocks provide a timeline for Earth.

Layers of sedimentary rocks show relative age.
- ____________ are clues in the story of Earth’s past. But for the story to make sense, the clues needed to be arranged in order.
- Relative age is the age of an ____________ or ____________ in relation to other events or objects.
- You probably know relative ages for many things in your life. For example, if a friend tells you she has one older brother and one younger brother, you know the relative ages of her brothers even if you do not know their exact ages.
- Until the beginning of the 1900s, geologists didn’t have a way to determine the exact ages of objects that existed in Earth’s past.
- Instead, they reconstructed Earth’s story based on the relative age of different clues.
- Today there are still many parts of Earth’s history that cannot be given exact ages.
- Determining relative age continues to be an important way of piecing together the puzzle of Earth’s past.
- Sedimentary rock layers contain information about the relative ages of events and objects in Earth’s history. As we learned earlier, sedimentary rocks form from the sediments that fall to the bottom of lakes, rivers, and seas. Over time, the sediments pile up to form ________________ layers of sedimentary rocks. This formation of layers is very important to help determine relative age.
• The bottom layer of rock forms first, which means it is the ______________. Each layer above that is ______________, and the top layer is the youngest of all.
• This ordering is relative because you cannot be sure exactly when each layer formed, only that each layer is ______________ than the one ______________ it.
• When horizontal layers of sedimentary rock are undisturbed, the youngest layer is always on the _____ . But, over millions of years, the movement of ______________ ______ can disturb rock layers.
• A whole set of layers can get turned on its side. Rock layers can become ______ , or even folded over, like taco shells that begin as flat tortillas.
• If a set of rock layers has been disturbed, the youngest layer may no longer be on top. One way scientists determine the original order is to compare the disturbed rock layers with a similar but undisturbed stack of layers.

What is relative age? ________________________________
_________________________________________________

Igneous rock can disturb sedimentary layers
• So it’s not just the movement of tectonic plates that can disturb layers of sedimentary rock. Sedimentary rock layers can also be disturbed by igneous rock.
• __________ ________ from within Earth can force its way up through the layers above it, cooling and forming ______________ rock.
• Because the sedimentary rock layers have to be present before the molten rock cuts through them, the igneous rock must be ______________ than the layers it cuts through.
• If the molten rock erupts and flows onto the surface, it forms a layer of igneous rock on top of the layers of sedimentary rock. Over time, more sedimentary rock layers may form on top of the igneous rock layers.
• The igneous rock layer is ______________ than the sedimentary layers under it and ___________ than the sedimentary layers that form on top of it.

How can igneous rock disturb sedimentary rock layers? __________
_____________________________________________________
Index fossils help determine the age of rocks

- Fossils contained within ___________________ rock can offer clues about the age of the rock.
- An organism that was fossilized in a rock must have __________ during the same _______ span in which the rock formed. Using information from rocks and other natural evidence, scientists have determined when specific fossilized organisms existed. If people know how long ago a fossilized organism lived, then they can figure out the age of the rock in which the fossil was found.
- Fossils of organisms that were __________, that __________ in many ________, and that existed only during specific spans of ________ are called ________ ____________.
- These characteristics of index fossils make them especially useful for figuring out when rock layers formed.
- The mollusk *Inoceramus labiatus*, for example, is a kind of sea animal that appeared 144 million years ago and went extinct 65 million years ago. So, if you find a rock that contains a fossil of this mollusk, the rock must be between _______ million and _______ million years old because this mollusk lived during that time span.
- This chart shows a __________ ____________ of rock layers in which *Inoceramus labiatus* and two other index fossils are found. *Nerinea trinodosa* is a kind of sea animal that lived between ____ million and ____ million years ago. *Tropites subbullatus* is a kind of sea animal that lived between

Why is igneous rock always younger than any rock it cuts through?

______________________________
______________________________
In what type of rocks are index fossils found? ________________
What three characteristics must an index fossil have? ________________

Would you expect to find a fossil in igneous rock? Why or why not?

Unconformities help find the relative age of rocks

• Look at this cross section.
• We know that the oldest layer is layer ____ and the youngest is layer ____. We know that this is true from what we have learned. This idea, that older layers are on the bottom and younger layers are on the top is ______, ___________, and explains one ________. Therefore, it can be a scientific _____. In fact, it is known as the Law of Superposition!
• This is one principle that scientists use to find the relative age of rocks. Now, this is great and all, but as we know, Earth does not exist is perfectly horizontal layers everywhere. There are many places where Earth looks like this:
• We can see that there are horizontal layers but not all the layers are horizontal to other horizontal layers. These are known as ____________________. We can use unconformities to find the age of rocks.

• There are three types of unconformities we will learn about: faults, intrusions and extrusions.

• **Faults**
  
  o Whenever a rock __________ or __________, it is known as a fault. The line marked H in the above image is an example of a fault.
  
  o A fault can only form in a rock that already exists. (After all, it’s hard to break a rock that isn’t there). Therefore, all faults are ______________ than the rock in which they break.

• **Intrusions**
  
  o When molten rock cools and forms igneous rock in pre-existing rock, it is called an intrusion. The large area marked A in the image above is an intrusion.
  
  o We already talked about intrusions and known that they are ______________ than the rock that they form in. Again, just like a fault, an intrusion must have a rock to intrude into.

• **Extrusions**
  
  o If molten rock reaches the ______________ of Earth and cools, it is known as an extrusion.
Again, an extrusion can only form on previously existing rock. Therefore it is always ___________ than the rock below it.

- So, in short, all unconformities are younger than the rock that they form in.

Radioactive dating can show absolute age

- Think again about the friend who tells you that she has two brothers, one older than she is and one younger. You know the order in which they were born—that is, their relative ages.
- The older brother, however, might be 1 year older or 20 years older. The exact age of the younger brother is still a mystery.
- To find out how much older or younger your friend’s brothers are, you need to know their actual ages.
- The actual age of an _________ or __________ is called its ________________ age.

Half-life helps find the absolute age of rocks

- Because scientists can’t ask a rock its age (that’d be scary), they have had to find a different way of determining the absolute ages of rocks.
- The solution lies in the smallest unit of matter, the ____________.
- Atoms make up everything on Earth, including you and rocks (who though you’d have so much in common!).
- The atoms of many chemical elements exist in various forms. Some of these forms are ____________ and break down over time into another form. This
breakdown—called __________________—is a very useful clock because a particular unstable form of an element always breaks down at the same rate into the same other form.

- The rate of change of a radioactive element is measured in half-lives.
- A half-life is the length of ______ it takes for half of the __________ in a sample of a radioactive element to change from an unstable form into another ______.
- Different elements have different half-lives, ranging from fractions of a second to billions of years. Just as a ruler is not a very useful tool for measuring the distance between planets, elements with very short half-lives are not very useful for measuring the ages of rocks. Instead, elements with half-lives of millions to billions of years are used to date rocks.
- For example, uranium 235 has a half-life of 704 million years. Uranium 235 is an unstable element found in some igneous rocks. Over time, uranium 235 breaks down into lead 207. Using information from radioactive dating of rocks, scientists estimate that Earth is about ______ billion years old.
- Radioactive dating works best with ___________________ rocks. Sedimentary rocks are formed from material that came from other rocks. For this reason, any measurements would show when the original rocks (the sediments) were formed, not when the sedimentary rock itself formed.
- Just as uranium 235 can be used to date igneous rocks, carbon 14 can be used to find the ages of the remains of some things that were once alive.
- Carbon 14 is an unstable form of carbon, an element found in all __________________.
- Carbon 14 has a half-life of 5730 years. It is useful for dating objects between about 100 and 70,000 years old, such as the wood from an ancient tool or the remains of an animal from the Ice Age.

Scientists use both absolute and relative age to learn about the past

- Scientists must piece together information from all methods of determining age to figure out the story of Earth’s past:
  - Radioactive dating of ____________ rocks reveals their ________________ age.
• Interpreting layers of _______________ rock shows the _______________ order of events.

• _______________ help to sort out the _______________ record.

You have learned that it is not possible to date sedimentary rocks with radioactivity directly. Geologists, however, can date any igneous rock that might have cut through or formed a layer between sedimentary layers.

Then, using the absolute age of igneous rocks, geologists can estimate the ages of nearby sedimentary layers.

**Check Your Notes**

What is absolute age? ____________________________________________________________

What is a half-life? ____________________________________________________________

If you tell someone you are 12 years old, are you giving your relative or absolute age? __________________________________________

What is the difference between relative age and absolute age? Use an example in your explanation. ____________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

How might the absolute age of an igneous rock layer help scientists determine the relative ages of nearby sedimentary rock?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

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