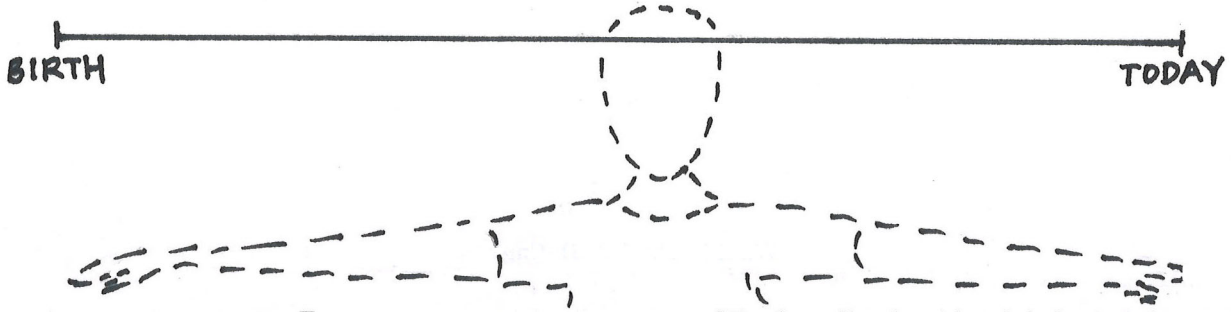
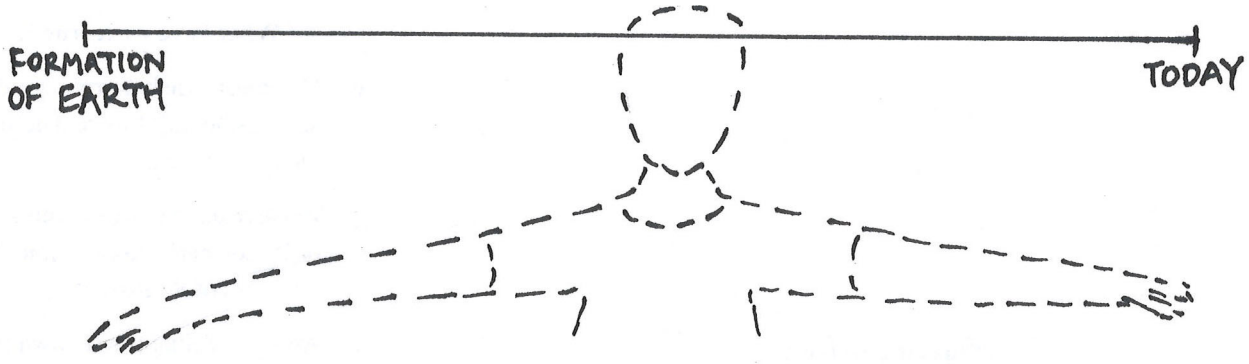
USGS
science for a changing world

Introduction to Geologic Time

Think about measuring a timeline of your life with your arms outstretched. Your birth happened at the tip of one hand and today is the tip of your other hand. What major events and milestones (such as learning to walk, starting school, the birth of a sibling, your favorite vacation, etc.) have happened in your life and in what order did they happen? How do you know when these events happened? From a parents? Photographs? Draw a timeline of your life and label as many events and dates as you can.



Now, picture your arm span as Earth History from the formation of Earth until today (sketch below). What major events and milestones (such as the first land plants, the first simple animals, dinosaurs, glacial periods, human civilization, etc.) have happened on Earth and when did they happen? How do **geologists** (scientists who study Earth) know when events Earth history happened? Draw a timeline of Earth and label as many events as you can.

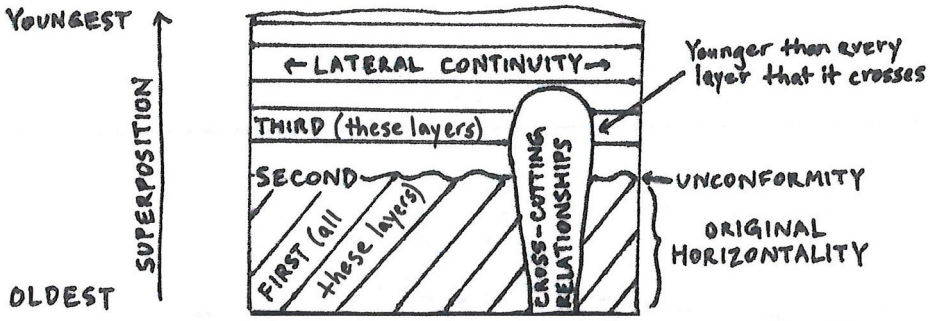


Understanding geologic time can be challenging because instead of seconds, minutes, or hours, geologists measure time in terms of **millions** of years ago (Ma) or **billions** of years ago (Ga)! Many geologic processes happen very slowly, at about the rate at which your fingernails grow, so they are very hard to see within our lifetimes.

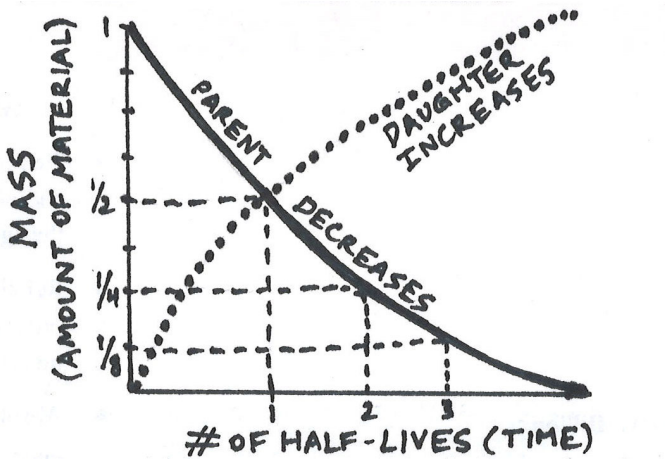
Geologists use both **relative dating** and **absolute dating** methods to create a geologic timeline, called the **Geologic Time Scale.** The Geologic Time Scale is updated every few years by an international committee to include new discoveries and technological advances as they are understood. To learn more about the Geologic Time Scale, read “Introduction to the Geologic Time Scale” and https://pubs.er.usgs.gov/publication/fs20183054

What is Relative Dating? Relative dating teaches us how old a rock layer is when compared to another rock layer. The Laws of **Stratigraphy** (the study of geologic layers) are used to understand the relative ages of rocks and can be used to tell the geologic story of a place on Earth. 1) S**uperposition:** Older layers are on the bottom and younger layers are on the top. 2) **Original Horizontality**: Sedimentary rocks pile up in horizontal (flat) layers. If the layers aren't flat, they have been altered by faulting and/or folding. 3) **Lateral continuity:** Horizontal sedimentary layers are continuous, they stretch out sideways in the same direction. 4) **Cross-cutting relationships:** A feature (fault, igneous (magma/lava) intrusion, etc.) that cuts across another layer is *younger* than the layer that it cuts across. 5) **Unconformities:** Gaps in time in the geologic record, shown by a buried erosional feature.

One great example of a geologic story is Grand Canyon National Park in Arizona, where all three rock types and all the laws of stratigraphy can be seen. To learn more, read, "The Geology of the Grand Canyon." Look at the diagram below to see examples of the laws of stratigraphy. To learn more about relative dating and the Laws of Stratigraphy, read "Introduction to Relative Dating."



What is Absolute Dating? Absolute dating provides geologists with more precise ages for rocks by using certain **isotopes** (elements with the same number of protons but a different number of neutrons) to give more precise ages in millions (Mya) or billions (Gya) of years ago. While some isotopes are stable, radioactive isotopes spontaneously **decay** (break down) from a parent (original) isotope to a daughter (new) isotope at a predictable rate, known as a **half-life**. A half-life is how long it takes for half of the parent isotope to decay to a daughter isotope. The accepted age of Earth is about 4.6 billion years old!



What is a Billion? You have probably heard the word "billion" when someone is talking about *a lot* of money or when they are exaggerating. One billion is 1,000,000,000. In other words, 1 billion is equal to **1000 million**.

Can you count to 4.6 billion? If you started counting at one count per second on January 1st, never stopping to eat, sleep, or talk, and never slowing down (not to mention saying all of those long numbers each second), you would reach 31,536,000 at the end of the year. You would reach one billion in just under 32 years. If you wanted to count all the way to 4.6 billion, that would take you about 146 years of non-stop counting!

What have we learned?

- Geologists use both **relative dating** and **absolute dating** to determine the ages of rocks.
- Relative dating places events in order compared to each other using the Laws of Stratigraphy.
- Absolute dating uses known rates of half-lives to give more precise geologic ages in millions or billions of years.
- Understanding geologic time is challenging because the numbers are so huge!
- Most geologic processes happen very slowly and are hard to see on human timescales.
- Earth is ~4.6 billion years old.
- 1 billion = 1000 million