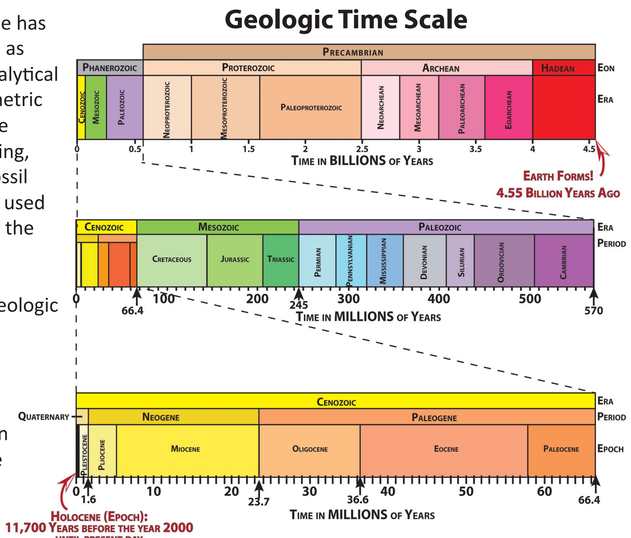
# Geologic Time: Unraveling the age and history of the Earth

## What is the Geologic Time Scale?

The Geologic Time Scale is a system of measuring the passing of time throughout the entire history of the earth. It measures time by dividing all of earth's history into smaller chronological (like events arranged in order based on time they happened) sections. Geologic time is vast, so instead of units of time that we use in our daily lives, like minutes, hours, days, or even years, time is often expressed as billions of years, millions of years, and sometimes thousands or tens of thousands years when describing events that happened in earth's past.

The Geologic Time Scale has been refined over time as technology, such as analytical instruments for radiometric dating techniques, have improved. Relative dating, absolute dating, and fossil evidence were and are used to construct and refine the time scale.

Boundaries between geologic time units are typically determined based on important geologic or paleontologic events, like dinosaur extinction (Cretaceous-Paleogene boundary) or the explosion of animal life (Precambrian-Cambrian boundary).




After United States Geologic Survey, "Putting Time into Proportion" http://geomaps.wr.usgs.gov/parks/gtime/gtime2.html

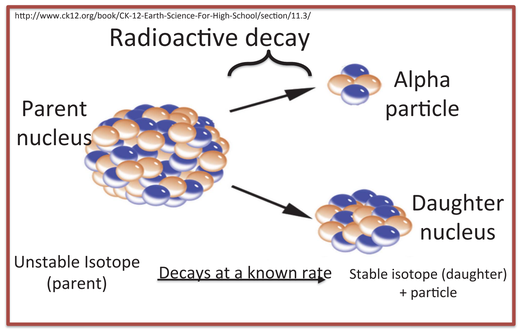
## How do we know how old the earth is?

A large body of evidence points to the earth being 4.55 billion years old. Much of the evidence for the absolute age of the earth comes from ***radiometric dating,*** also known as ***absolute dating.*** The most well-studied isotope system (Uranium-Lead, or U-Pb) has been used to date meteorites from asteroids that formed when the solar system formed and give us the **4.55 billion year (Ga) old age of the earth.**


*Over 70 meteorites were dated as of 2007, this number is likely much higher with advancement of technology over the last 9 years

Collection: Dr. Phil Plait
Image: Chris Setter

### How does radiometric dating work?



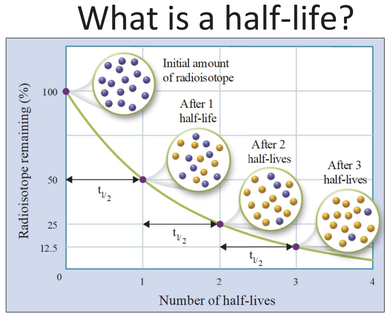

Elements can have multiple *isotopes*– different forms of the same element that contain the same number of protons but a different number of neutrons within the nucleus. Some *isotopes* are stable, and do not spontaneously decay, while other *isotopes* are unstable and *do experience radioactive decay*. Radio active decay occurs at rates that are directly measureable and known to scientists through over 50 years (even hundreds for some isotope systems like Uranium-Lead!) of experiments.

### Isotope decay systems

Minerals like Zircon (above) are VERY resistant to chemical change, and can record extremely old isotopic histories that can be unraveled using $^{238}U$-$^{206}Pb$, $^{176}Lu$-$^{176}Hf$, and other techniques. Methods have been developed and tested to account for possible contamination in minerals and the possibility of really hot (100s of degrees C) geologic events 'resetting' the decay scheme of an isotope.

| Parent-Daughter | Half-life |
|---|---|
| $^{176}Lu$-$^{176}Hf$ | 37.2 billion years |
| $^{238}U$-$^{206}Pb$ | 4.47 billion years |
| $^{40}K$-$^{40}Ar$ ($^{40}Ar$-$^{39}Ar$) | 1.248 billion years |
| $^{235}U$-$^{207}Pb$ | 710 million years |
| $^{10}Be$-$^{10}B$ | 1.387 million |
| $^{234}U$-$^{230}Th$ | 248 thousand years |
| $^{14}C$-$^{14}N$ | 5730 years |

### What is a half-life?

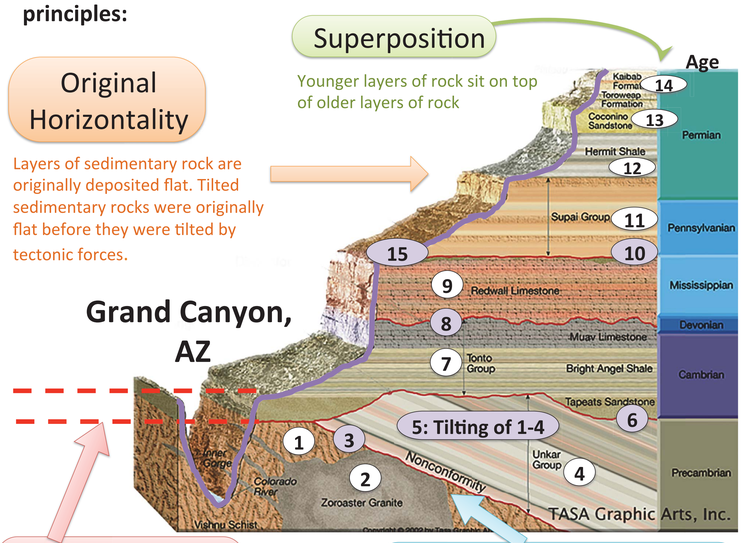



A half life is the amount of time it takes for the amount of a parent isotope to decay to half of its original amount. The length of half-lives can vary from millions to billions of years depending on the isotope.

## What about rocks that don't have the right minerals to be dated radiometrically?

A method called ***relative dating*** is used for these types of rocks.

Relative dating uses the relationships between different rock units to tell the order of events in which the rocks were formed. This method is based underlying, well-tested principles described first by Danish scientist, Nicolas Steno in 1669. These are now known as **Steno's principles:**

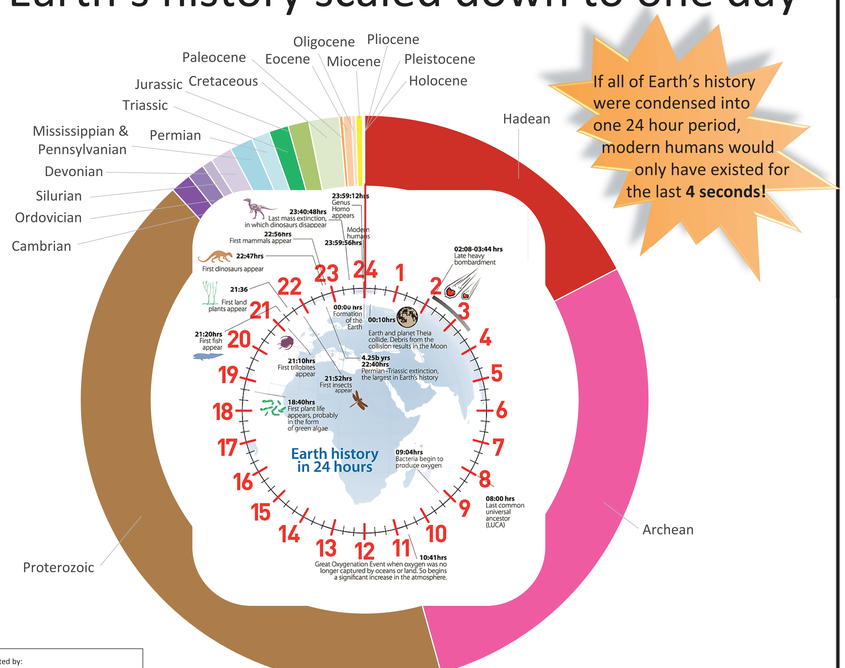



These principles are used to determine the relative order of the rock units shown above. Units and events are labeled with 1 being the oldest and 15 being the youngest. Purple= tectonic event or erosion, White = rock unit

## Where can I learn more?

- **BBC: 25 Biggest Turning Points in Earth's History** http://www.bbc.com/earth/bespoke/story/20150123-earths-25-biggest-turning-points/
- **USGS: Geologic Time Online Edition** http://pubs.usgs.gov/gip/geotime/
- **University of California Museum of Paleontology Understanding Geologic Time (Interactive)** http://www.ucmp.berkeley.edu/education/explorations/tours/geotime/index.html
- **Radiometric Dating: A Christian Perspective** http://www.asa3.org/ASA/resources/Wiens.html#page 19

## Earth's history scaled down to one day




If all of Earth's history were condensed into one 24 hour period, modern humans would only have existed for the last **4 seconds!**

http://www.sciencemagpie.com/2012/10/02/geological-time-piece/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For Darwin Day 2016


### To get the age of a rock... Measure the amount of parent and daughter isotopes in the rock using mass spectrometry and use the equation:

$$amount\ of\ daughter\ /amount\ of\ parent = e\hat{}half-life\ of\ parent \times \boldsymbol{time} - 1$$

The only unknown is time, so the equation is solved for time to get the age of the rock.