Determining the Age of Earth

RCD Biology Unit 2

EQ: How do scientists know the age of Earth?

How Old is Earth and How do the Scientists Know?

The earth is about 4.6 billion years old. Arriving at this number wasn't easy but there are many lines of evidence that have allowed scientists to reach that conclusion.

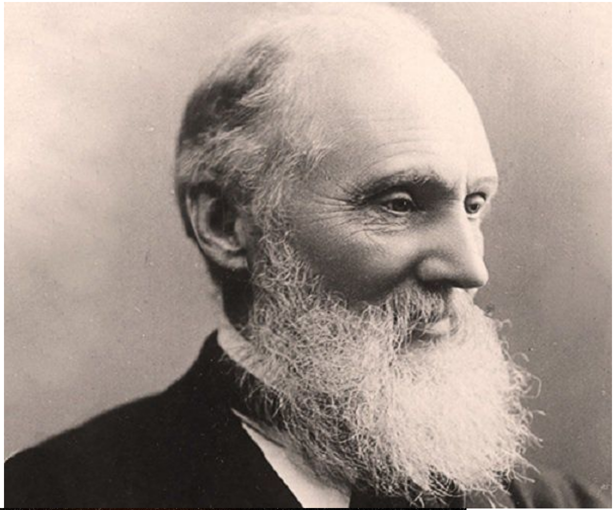
Indirect Estimates

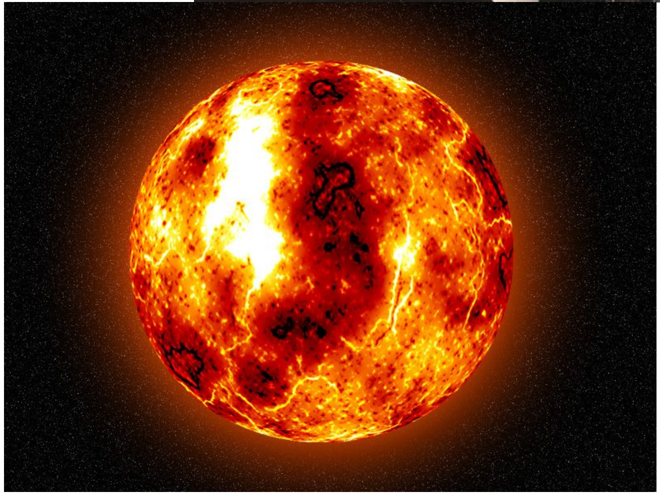
During the 18th and 19th centuries, geologists tried to estimate the age of Earth with indirect techniques.

One example is that by measuring how much sediment a stream deposited in a year, a geologist might try to determine how long it took for a stream to deposit an ancient sediment layer.

Indirect Estimates

In 1892, William Thomson (later known as Lord Kelvin) calculated that the Earth was 100 million years old, which he later lowered to 20 million years. He did this systematically assuming that the planet started off as a molten ball and calculating the time it would take for it to cool to its current temperature.





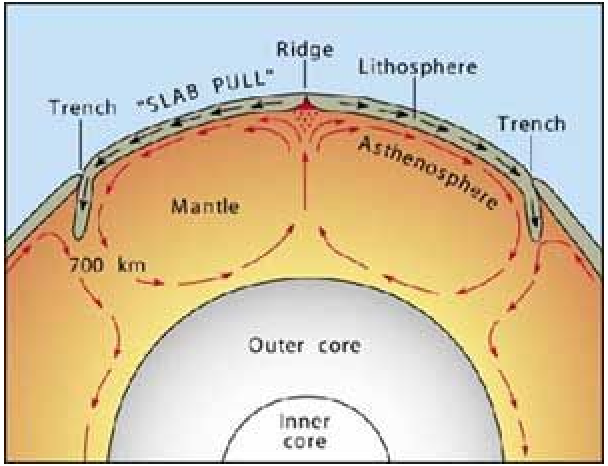
Kelvin's Calculation Flaw

Flawed when radioactivity was discovered in 1896.

Radioactive decay of elements inside Earth's interior provides a steady source of heat.

The mantle is able to flow and so convection moves heat from the interior to the surface of the planet.

Thomson (Lord Kelvin) had grossly underestimated Earth's age.

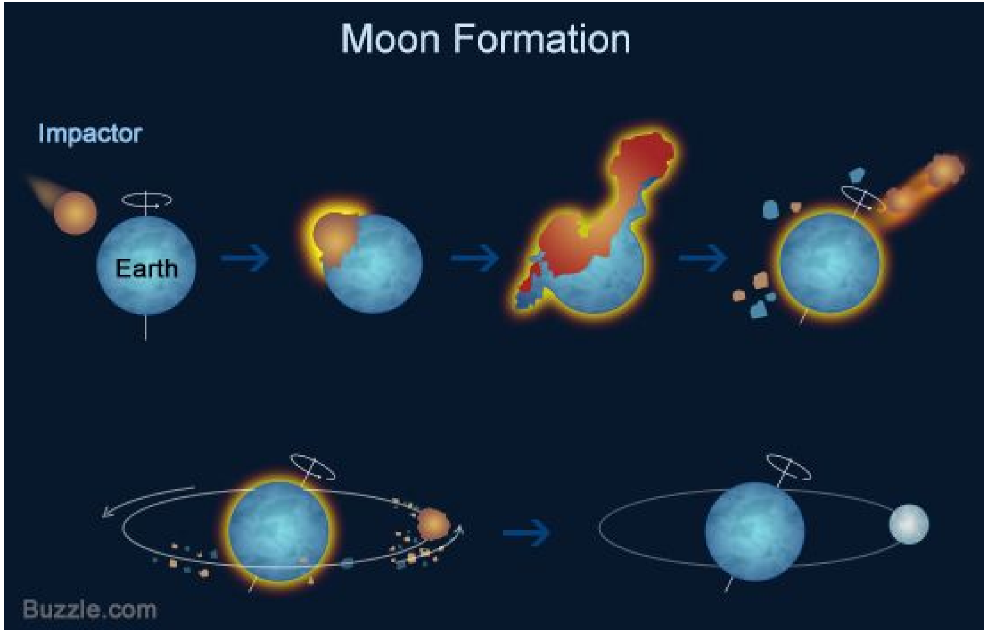


Radioactivity

Radioactivity turned out to be useful for dating Earth materials and for coming up with a quantitative age for Earth.

Scientists not only date ancient rocks from Earth's crust, they also date meteorites that formed at the same time Earth and the rest of the solar system were forming.

Moon rocks also have been radiometrically dated.

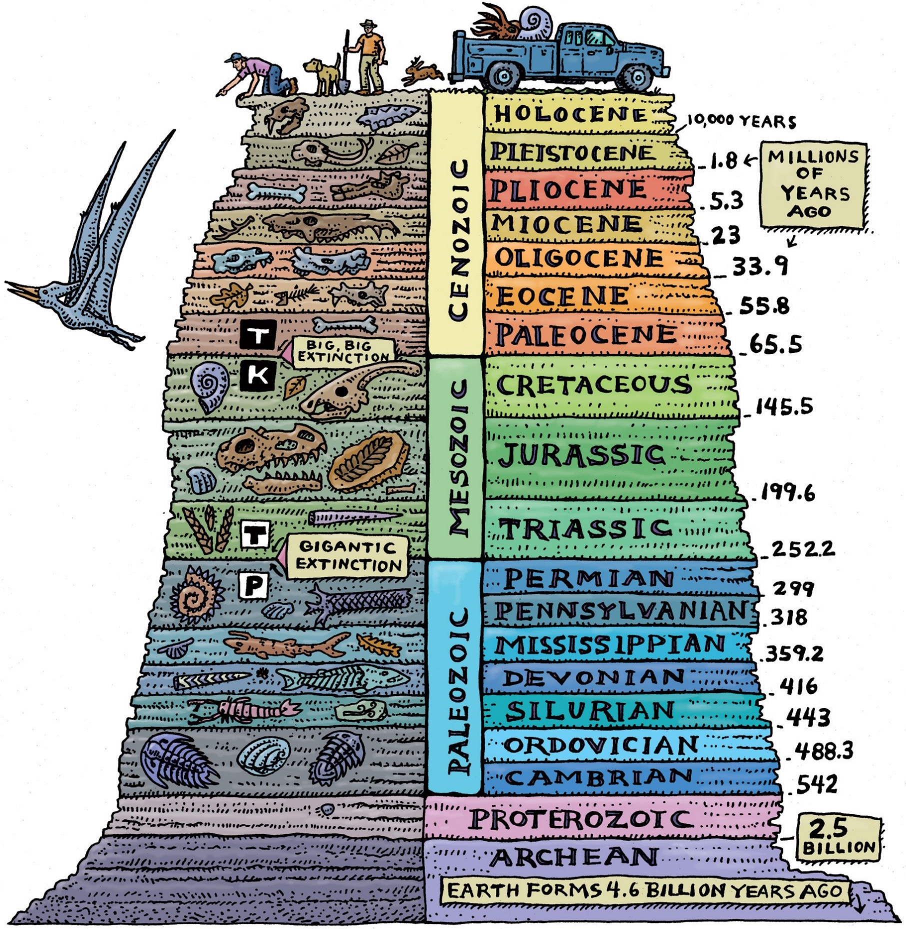


Radioactivity

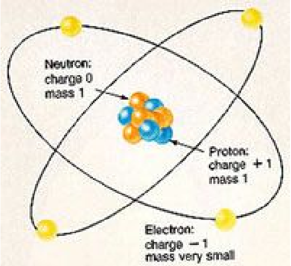
Using a combination of radiometric dating, index fossils, and superposition, geologists have constructed a well-defined timeline of Earth history.

With information gathered from all over the world, estimates of rock and fossil ages have become increasingly accurate.

This is the modern geologic time scale with all of the ages.



How does Radioactive Dating Work?

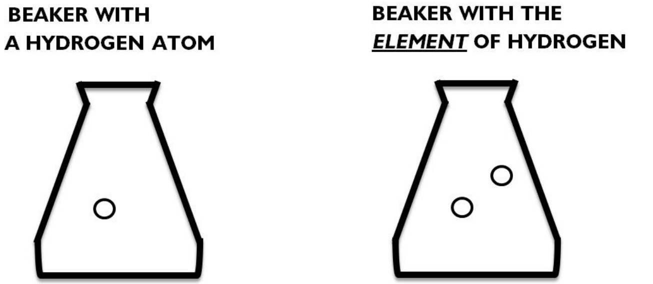


Radiometric Dating: A method for estimating the absolute age of rocks.

Basic atomic chemistry

Element: the simplest kind of chemical; it cannot be broken down into simpler forms by any physical or chemical process.

Atoms: the smallest particle of an element that retains the characteristics of elements.

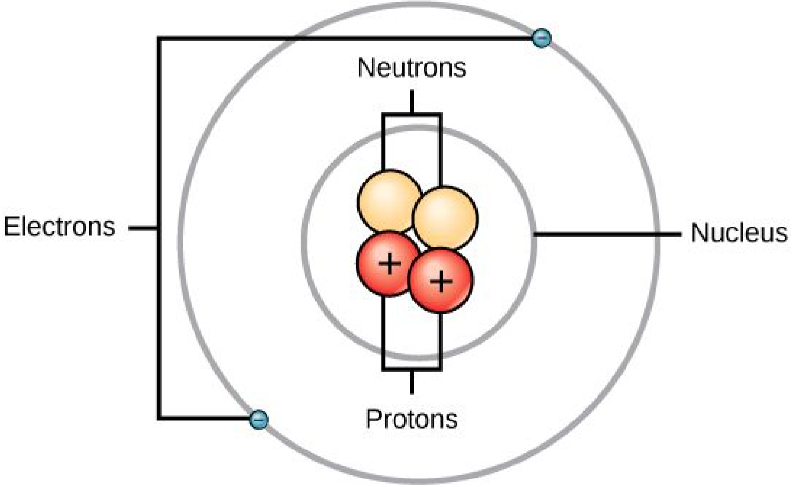


Basic Chemistry

Atoms are made up of:

- Protons: Positive charge, Mass = 1
- Neutrons: No charge,

  Mass = 1
- Electrons: Negative Charge, No Mass

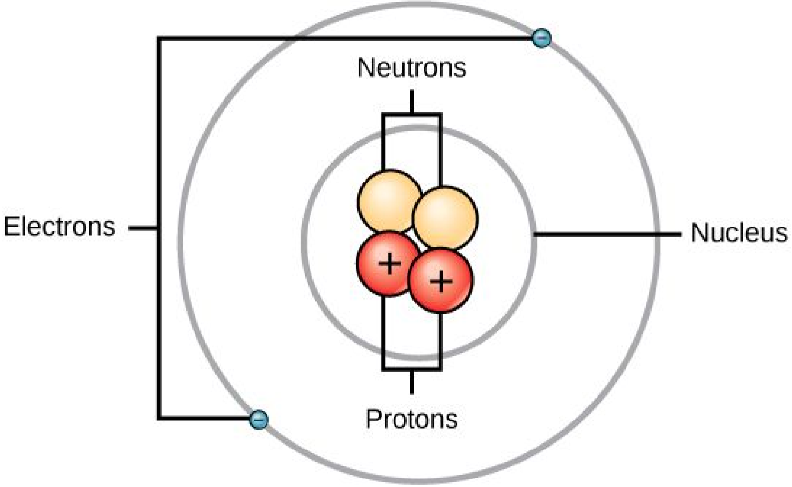


Basic Chemistry

Nucleus of an atom has protons and neutrons. The electrons orbit around the nucleus forming the electron cloud.

#protons = #electrons

#protons ≠ #neutrons



Basic Chemistry

Atomic Number: total number of protons in the nucleus of the atoms of an element.

Defines the element; if atomic number changes then the element changes.

Atomic mass: total mass of all protons and neutrons (electrons have negligible mass)

Notation:

e.g. $^{8}O^{16}$

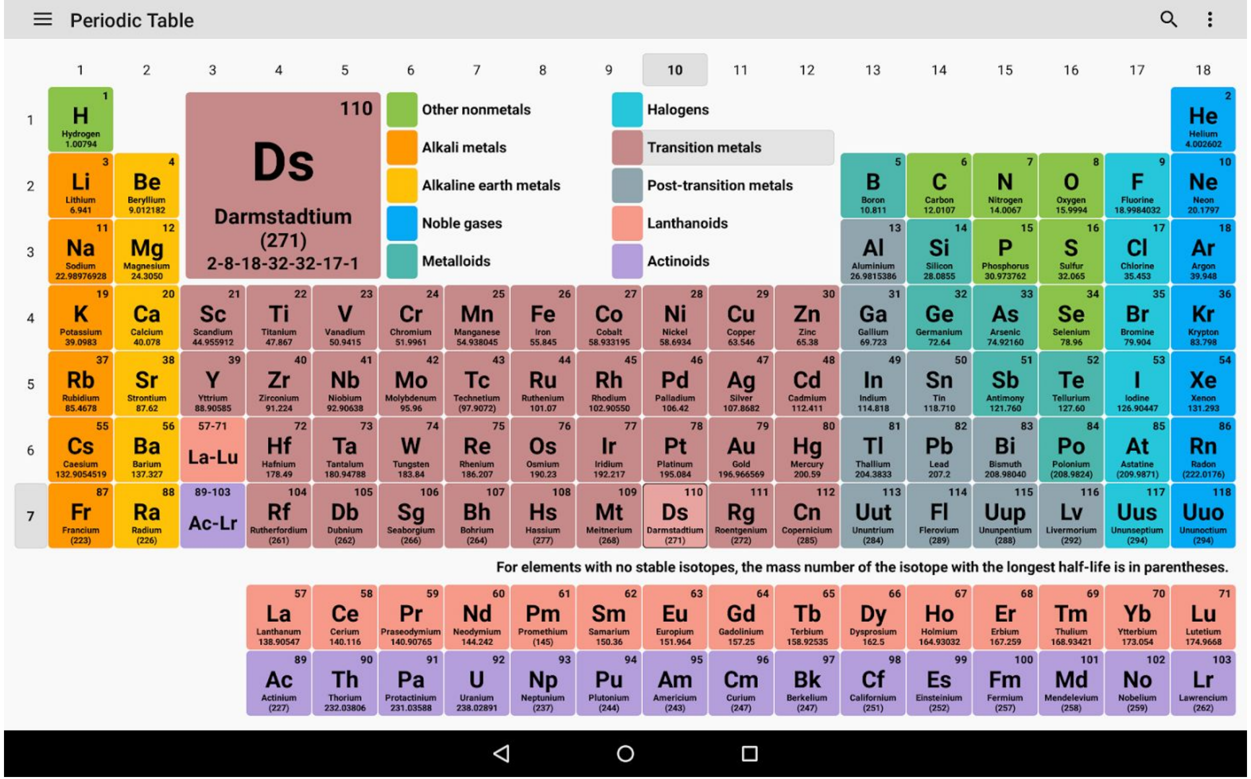
O = oxygen

8 = atomic number (8 protons)

16=atomic mass (8 protons + 8 neutrons = 16)

Basic Chemistry

Periodic Table: the list of all known elements in order of increasing atomic number.



Isotopes

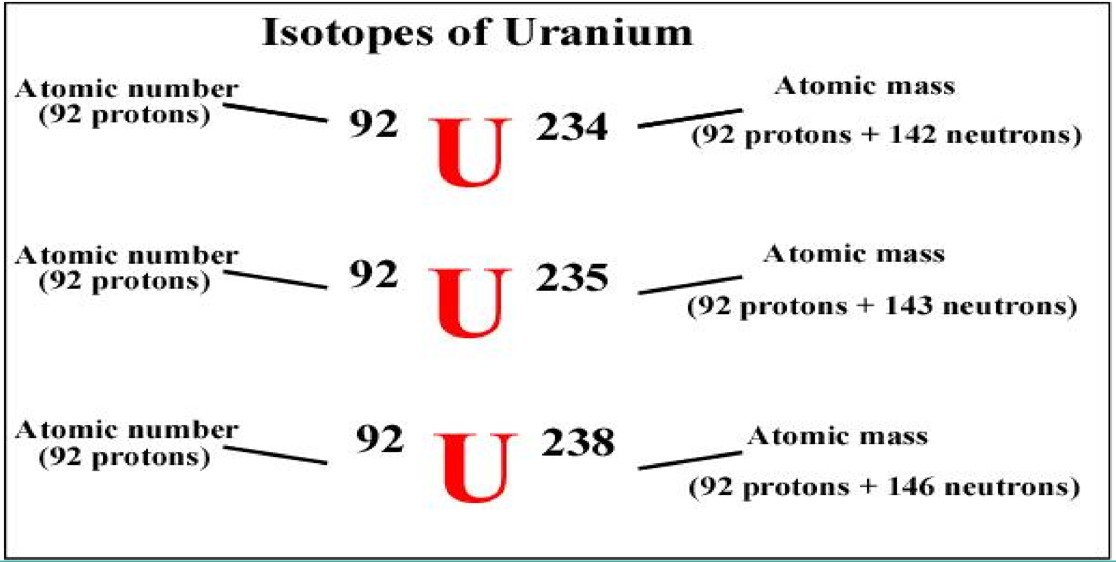
Isotopes: forms of elements with different atomic mass.

For a given element the atomic number remains the same, therefore the number of neutrons is different.

Uranium has 3 common isotopes:

$^{92}U^{234}$

50 excess neutrons



$^{92}U^{238}$

54 excess neutrons

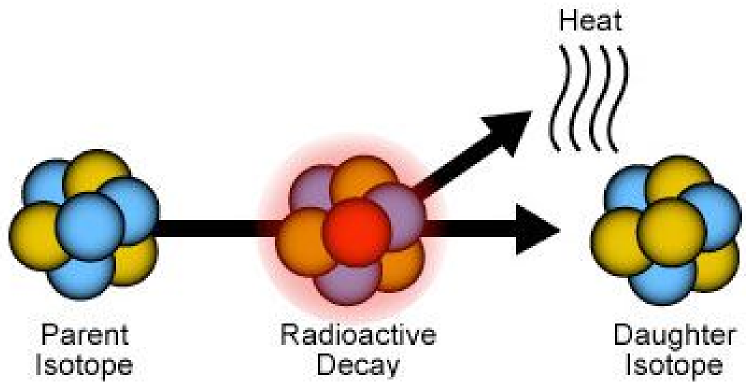
$^{92}U^{235}$

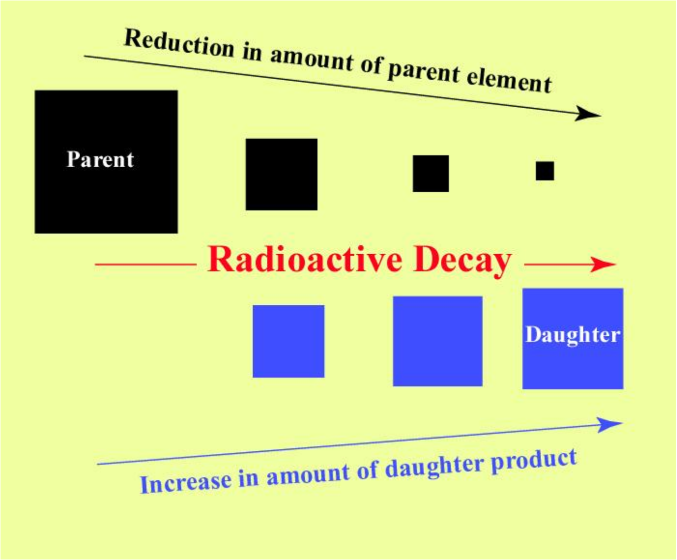
51 excess neutrons

Radioactive Isotopes

Radioactive isotopes: isotopes of elements that change spontaneously by losing or gaining subatomic particles.

Radioactive decay takes place at a constant rate and has done so over all of geologic time.





Half Life of Radioactive Isotopes

Half-life of an isotope: the time taken for the amount of parent to be reduced by ½.

Over multiple half lives the parent is constantly reduced in amount and the daughter increases in amount.

The half-life of uranium^{238} is 4.5 billion years:

> **Starting with 1000 atoms of U^{238}, after 4.5 billion years there will be 500 atoms of U^{238} and 500 atoms of Pb^{206} the daughter isotope.**

Review Questions

WRITE & ANSWER THE FOLLOWING QUESTIONS

1) About how old is planet Earth?
2) How have scientists tried to calculate the age of Earth?

Use the following $^{8}O^{16}$

3) How can you tell how many protons are present?
4) How can you tell how many neutrons are present?
5) How can you tell how many electrons are present?

6) What is an isotope?
7) What is the half-life of an isotope? (what does it mean?)