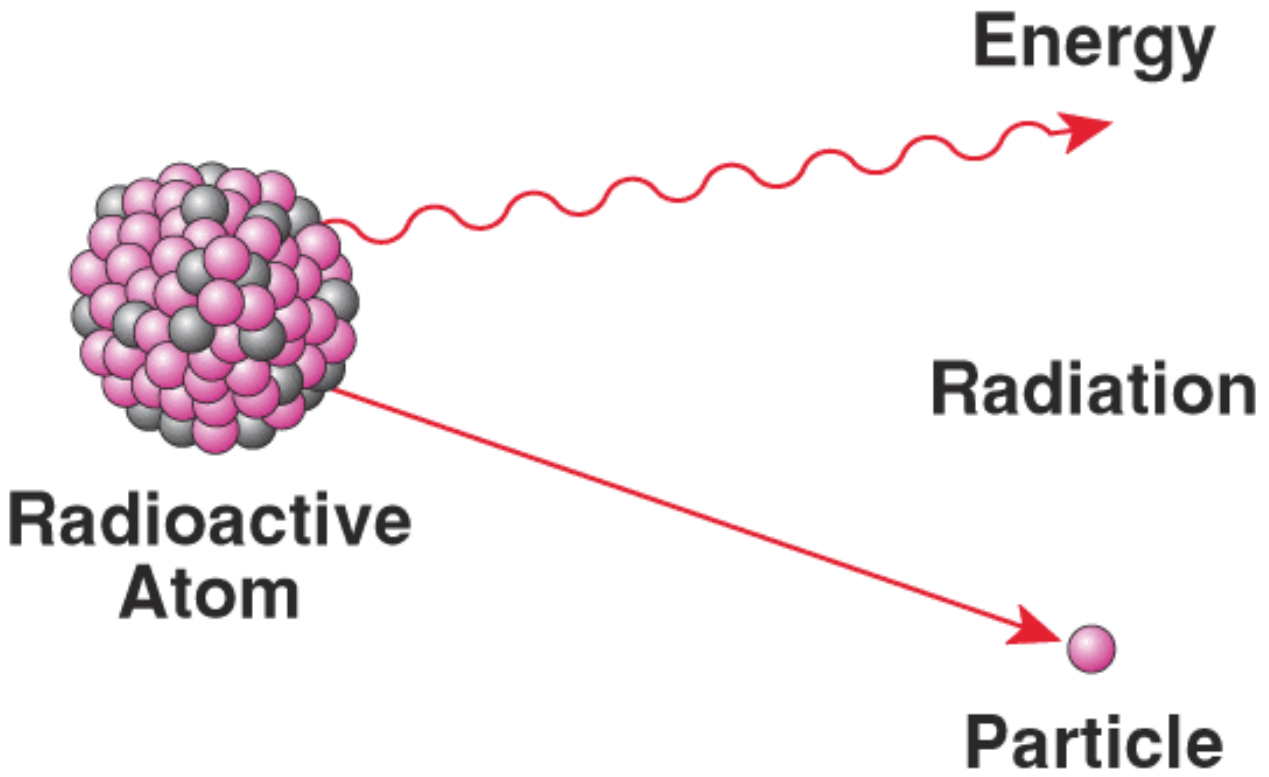
Radiometric Dating and Half Life

Radiometric Dating

Radiometric Dating is a method by which rocks and other objects can be dated by using the known ***decay rate*** of radioactive decay.

It compares the proportion of a naturally-occurring isotope in the object to the isotope's decay products.



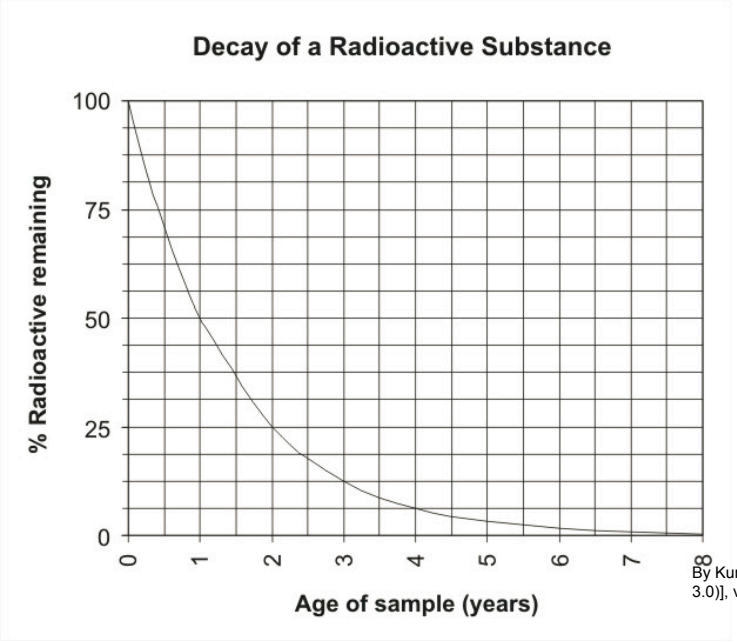
http://creationwiki.org/images/8/8a/Radioactive-atom.JPG

- ***Isotopes*** are versions of the same element with the *same* number of protons and *different* number of neutrons. For example, a radioactive isotope of ^{12}C is ^{14}C.
- Radioactive isotopes decay, or change, from “parent” into “daughter” spontaneously.

Radioactive Decay

- ***Radioactive decay*** means that the unstable nucleus of the ***parent*** isotope changes in some way -- by emitting energetic particles and/or energy -- in order to become a more stable ***daughter***.
- This ***radioactive decay*** occurs a constant rate independent of any physical variables (i.e. pressure, temperature, weathering, chemical environment, presence of EM fields).
- Each isotope has a unique decay rate, and likewise, its own ***half-life***.

Half-Life

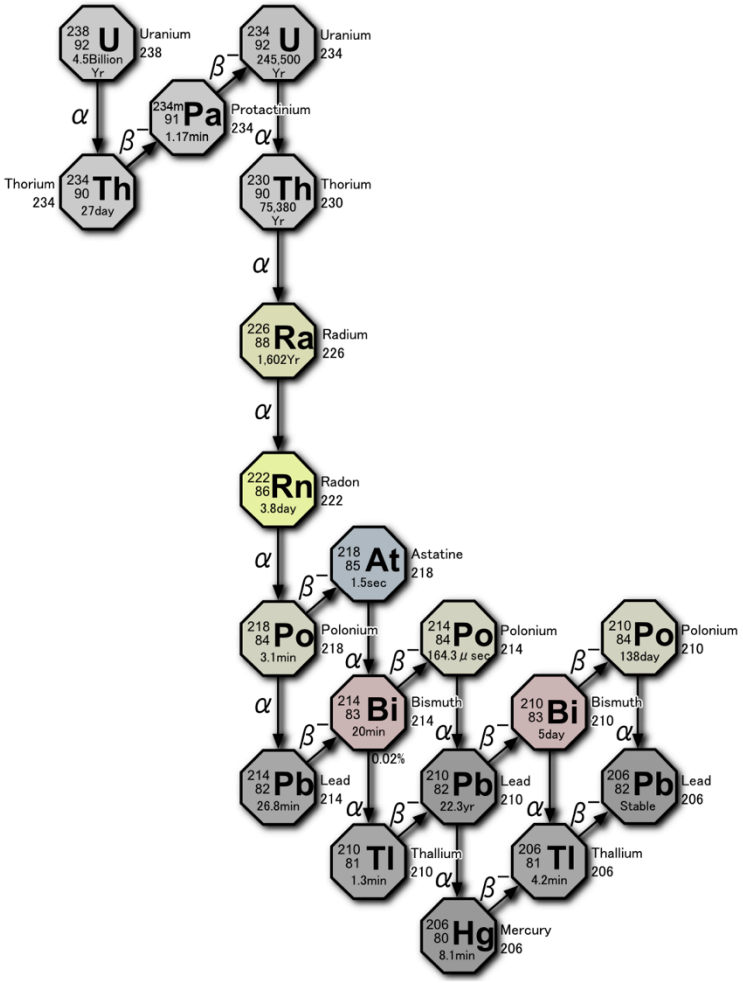


- The ***half-life*** is the time required for the original amount of parent isotope to fall to half its initial value ($T_{1/2}$).
- The daughter isotope will likewise increase.
- i.e. after 1 half-life, the ratio of parent:daughter will be 1:1, but after 2 half-lives it will be 1:3.

Half-Life

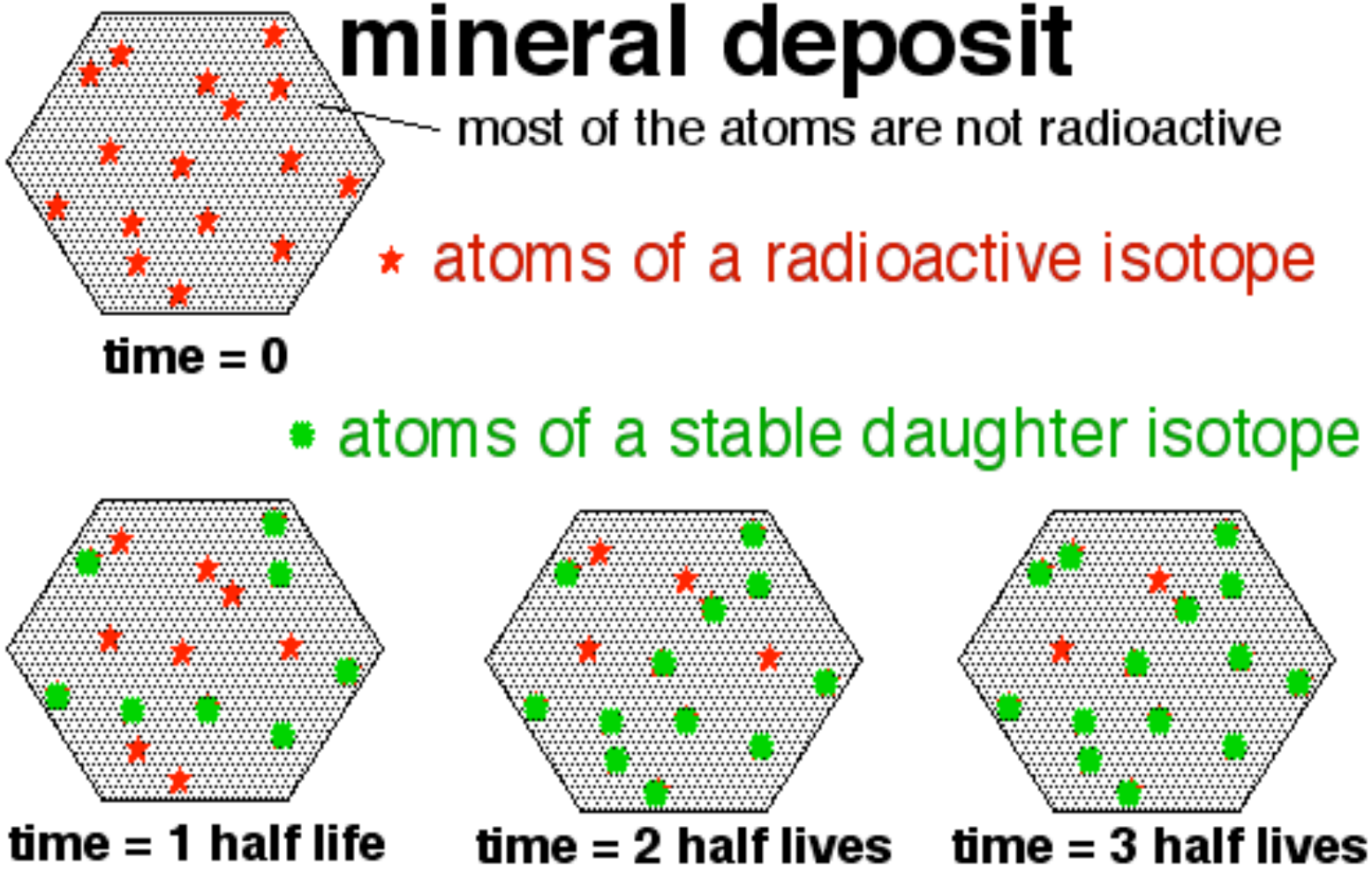
Number of Half-Lives	Percent of Parent	Percent of Daughter
0	100	0
1	50	50
2	25	75
3	12.5	87.5
4	6.25	93.75
5	3.125	96.875
6	1.5625	99.4375
7	0.78125	99.21875

Uranium Decay



By Tosaka (Own work) [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

- For example, ^{238}U is a commonly used isotope in radiometric dating. Its final decay product is ^{206}Pb.
- In 4.5 billion years, half of a sample of ^{238}U will have been converted to ^{206}Pb (i.e. it's half-life is 4.5 billion years).
- Scientists can determine the age of a rock that contains ^{238}U from the ratio of ^{238}U to ^{206}Pb in the rock. The age can be calculated more accurately by measuring all the products in the series.



https://upload.wikimedia.org/wikiversity/en/thumb/4/4b/Radiometricdatingmineral.png/400px-Radiometricdatingmineral.png

Other Isotopes used in dating rocks

Parent	Daughter	Half-Life (years)	Types of Rock
^{238}U	^{206}Pb	4.5 billion	mineral zircon, baddeleyite.
^{40}K	^{40}Ar	1.3 billion	micas, feldspars, and hornblendes,
^{87}Rb	^{87}Sr	49 billion	old igneous and metamorphic rocks, lunar samples
^{234}U	^{230}Th	80,000	ocean-floor sediments

Radiocarbon Dating

- While ^{12}C is commonly found in all living things, ^{14}C is produced when cosmic rays hit nitrogen in the atmosphere.
- Living organisms contain trace amounts of ^{14}C.
- Radioactive decay of ^{14}C starts only when an organism dies and decays into ^{14}N.
  - ^{14}C's half life is significantly shorter than other radioactive parent isotopes (~ 5730 years)
  - Samples older than 50 000 years have undetectable levels of 14C and other isotopes must be used.

Radiocarbon Dating

Scientists can calculate how long ago a piece of organic material was part of a living plant or animal by comparing the amount of ^{14}C that remains in the material to the amount of ^{14}C that exists in similar material in a living plant or animal (with some correction). They can determine this either by measuring the radioactivity in the sample or by measuring the amount of ^{14}C using a mass spectrometer.

Absolute Dating

Radiometric dating is ***absolute dating*** because it provides an actual numerical age or range as opposed to ***relative dating*** which can only provide a chronological order to events.