



Radioactivity: a steady but unpredictable process

- *Spontaneous transformation of one element to another*



(kind of like popping popcorn...)



To measure the time it takes for radioactive decay, we look at **half-lives**.

**Half-life** is the time it takes for half the atoms of the parent isotope to decay into the daughter isotope.

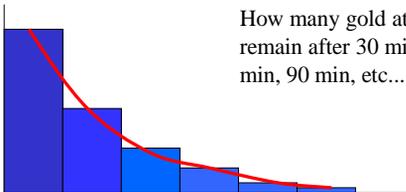


## Half-Life

Notice that half-life occurs at an exponential rate (not a linear rate)

Let's say that you start with one-billion atoms of Au-189. Gold-189 has a half-life of 30 minutes.

How many gold atoms remain after 30 min, 60 min, 90 min, etc...



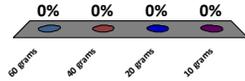
Let's do an activity to simulate half life:

- You will need: 1 coin

**Question:**

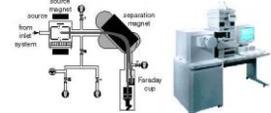
The isotope Einsteinium-253 has a half-life of 20 days. If you began an experiment with an 80-gram sample of Einsteinium-253, how much would remain after 60 days?

1. 60 grams
2. 40 grams
3. 20 grams
- ✓ 4. 10 grams



### How do geologists get a numerical age on a rock?

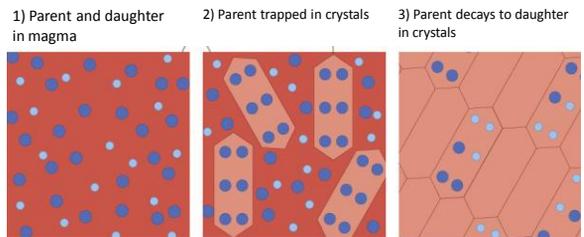
- 1) Collect a rock sample that contains a radioactive isotope
- 2) Measure the parent-daughter ratio using a mass spectrometer



### Common isotopes used to date minerals...

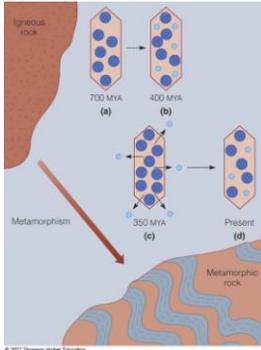
Parent Isotope	Parent Isotope	Daughter Isotope	Daughter Isotope	Half-life ( $t_{1/2}$ )
Uranium-238	$^{238}\text{U}$	Lead-206	$^{206}\text{Pb}$	4400 million years
Potassium-40	$^{40}\text{K}$	Argon-40	$^{40}\text{Ar}$	1300 million years
Rubidium-87	$^{87}\text{Rb}$	Strontium-87	$^{87}\text{Sr}$	48800 million years

### What do numerical ages mean: igneous rocks?



Dates on igneous rocks = time of crystallization

### What do numerical ages mean: metamorphic rocks



**Metamorphic rocks = time of metamorphism**

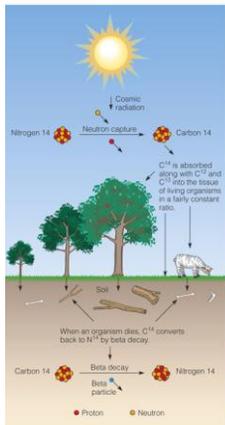
### What do numerical ages mean: sedimentary rocks



Does dating this class give the age of this sedimentary rock?

**No.** It would give us the age of crystallization.

**Sedimentary rocks cannot be accurately dated.**



### Radiocarbon (<sup>14</sup>C) dating

- Only for organic material (i.e. bones, shells, charcoal)
- Half life 5730 years, not good for material > 70,000 years
- Uses: ancient cultures, sediments from last ice age

### 4.6 billion year age for Earth

- Moon rocks 4.4-4.5 byr
- Meteorites 4.6 byr
- Oldest mineral on Earth 4.4 byr



Cs-137 has a half life of 30 years. How long will it take to decay to 1/16 its original amount?

1. 60 years
2. 90 years
3. 120 years
- ✓ 4. 150 years

