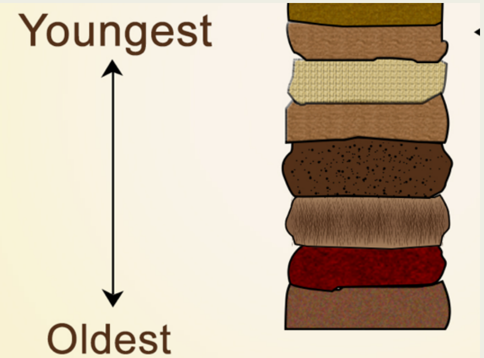
ESTABLISHING the age of ROCKS

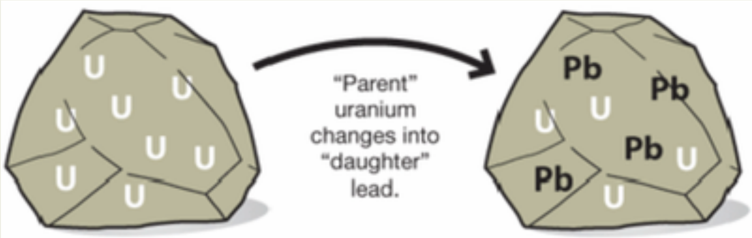
Relative Dating-aging rocks by comparison

Qualitative: *"this rock is older than that one"*

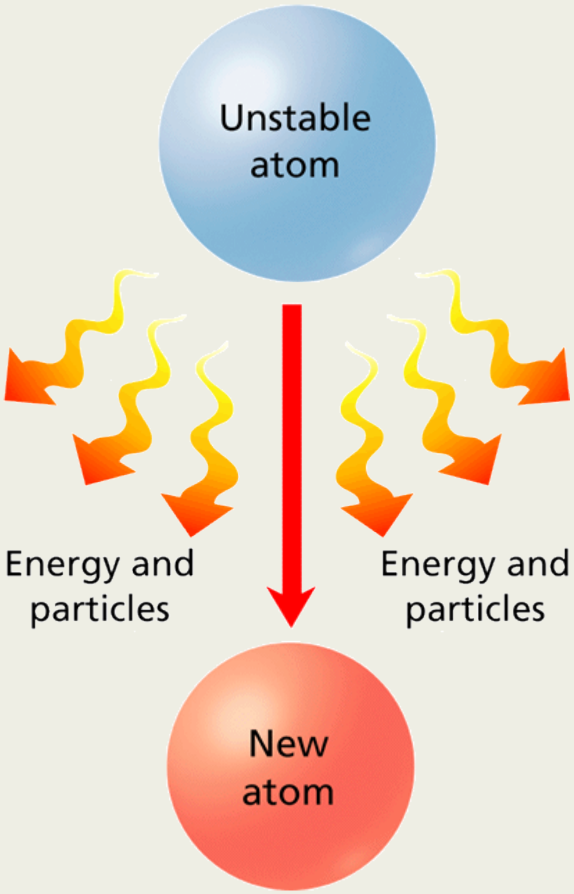


Absolute Dating-aging rocks by measuring the amount of radioactive decay

Quantitative: *"this rock is 280 million yrs old"*



ABSOLUTE DATING relies on RADIOACTIVE DECAY



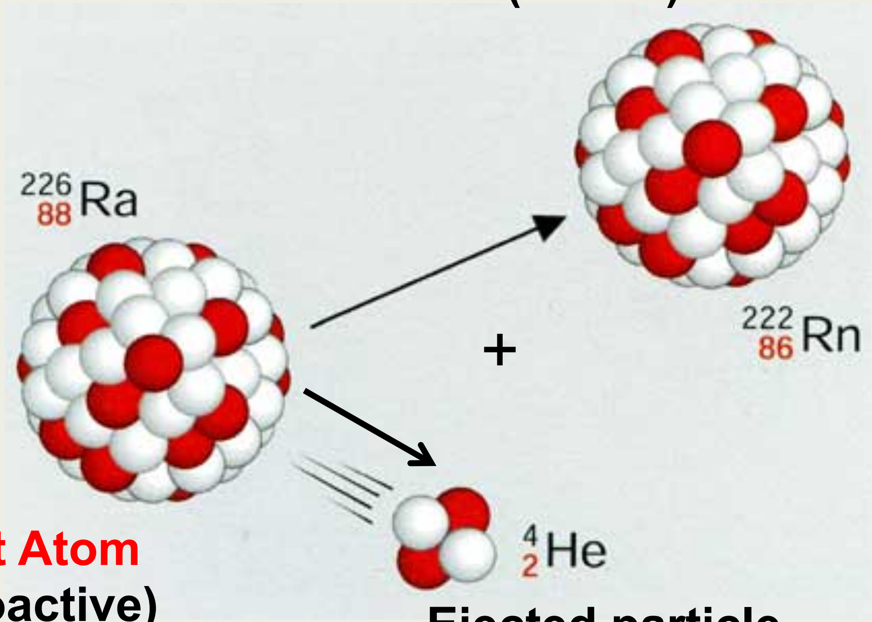
- Some isotopes are **radioactive** - have unstable nuclei
  - *radioactive elements occur naturally*
- They stabilize – **decay** - by ejecting particles, releasing energy
  - *The atom changes to a new atom with a different atomic number*
- The decay rate is constant and thus used to determine an absolute age
  - *found in volcanic rocks and once living tissues*

RADIOACTIVE DECAY

Parent atoms-radioactive & unstable atoms; give off particles spontaneously at a constant rate

Daughter atoms-stable product atoms produced by the decay of a radioactive atom

Daughter Atom
(Stable)



Parent Atom
(Radioactive)

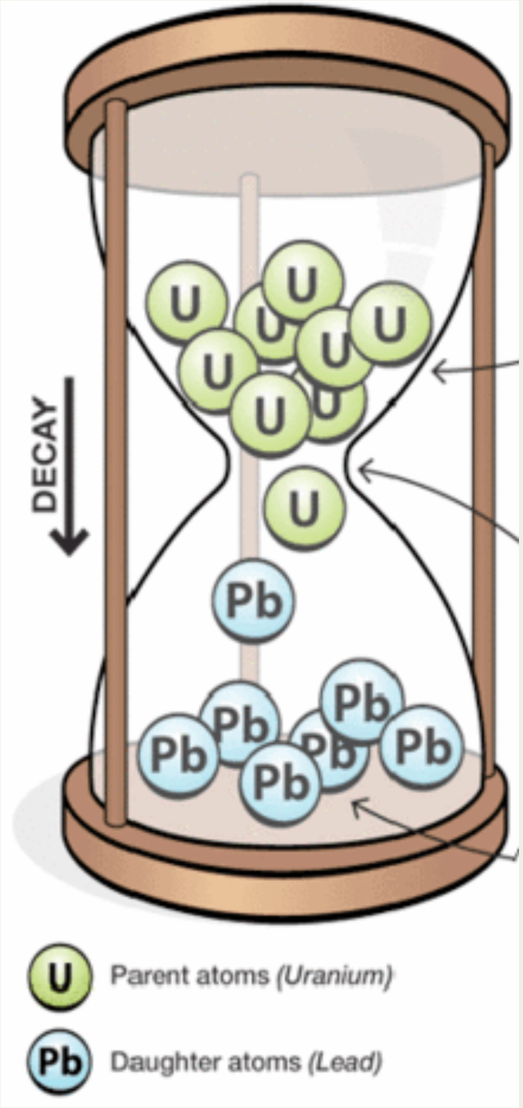
Ejected particle
(Radiation)

RATE of DECAY

- The rate of decay for a specific element is constant
  - *like a clock keeping perfect time*

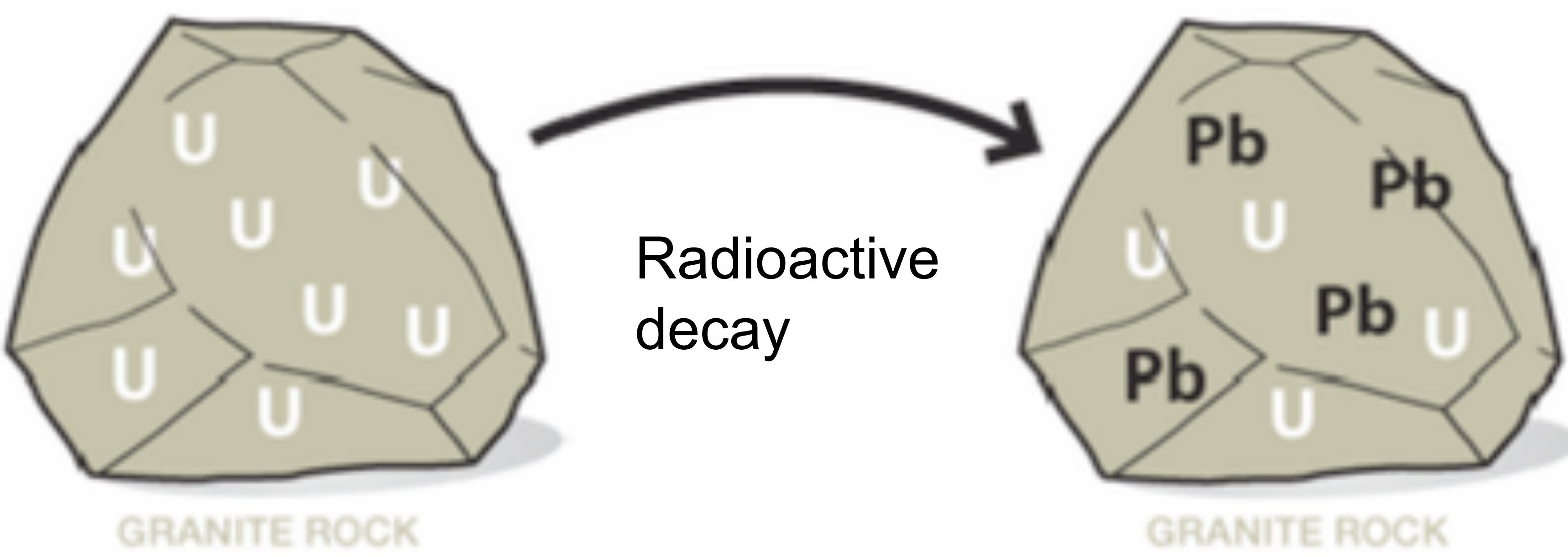
- The rate is measured as the **half-life =** the time it takes for *half* of the radioactive atoms to decay

- The more **parent** radioactive atoms that decay to stable **daughter** atoms; the older the sample.



Practice:

What is the parent atom? Daughter? Which is stable? Radioactive? How much has decayed? How many half lives have passed? How old is the rock?*

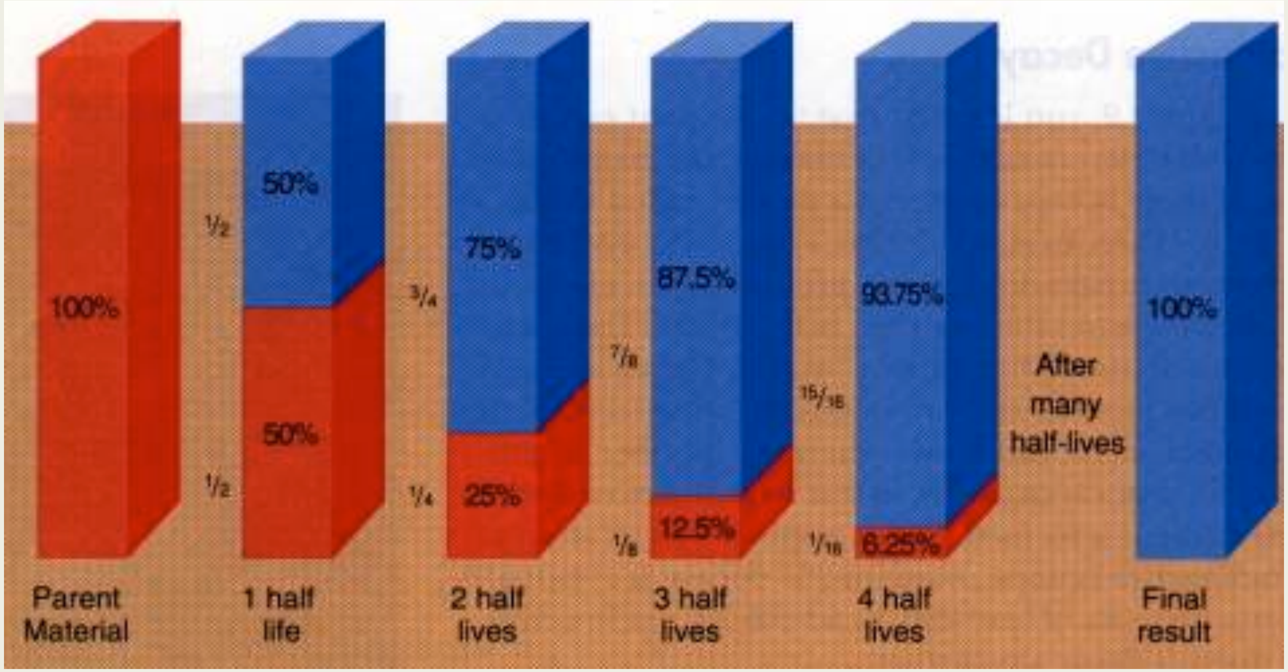


*Half-life of Uranium (U-238) is 4.5 billion years old.

RATE of DECAY

- As decay occurs, the composition of rock changes
  - *The amount of radioactive element goes down while the amount of decay product goes up*

Parent Atom



Daughter Atom

HALF-LIFE of RADIOACTIVE ISOTOPES

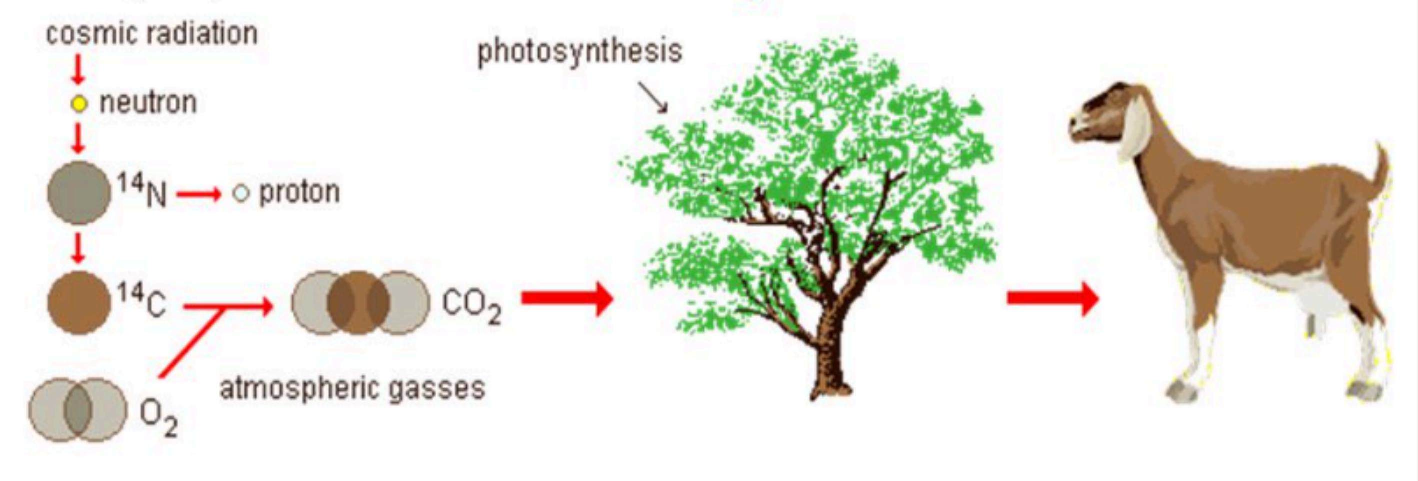
Table 10.1 Radioactive isotopes frequently used in radiometric dating.

Radioactive Parent	Stable Daughter Product	Currently Accepted Half-Life Values
* Uranium-238	Lead-206	4.5 billion years
* Uranium-235	Lead-207	713 million years
Thorium-232	Lead-208	14.1 billion years
Rubidium-87	Strontium-87	47.0 billion years
* Potassium-40	Argon-40	1.3 billion years

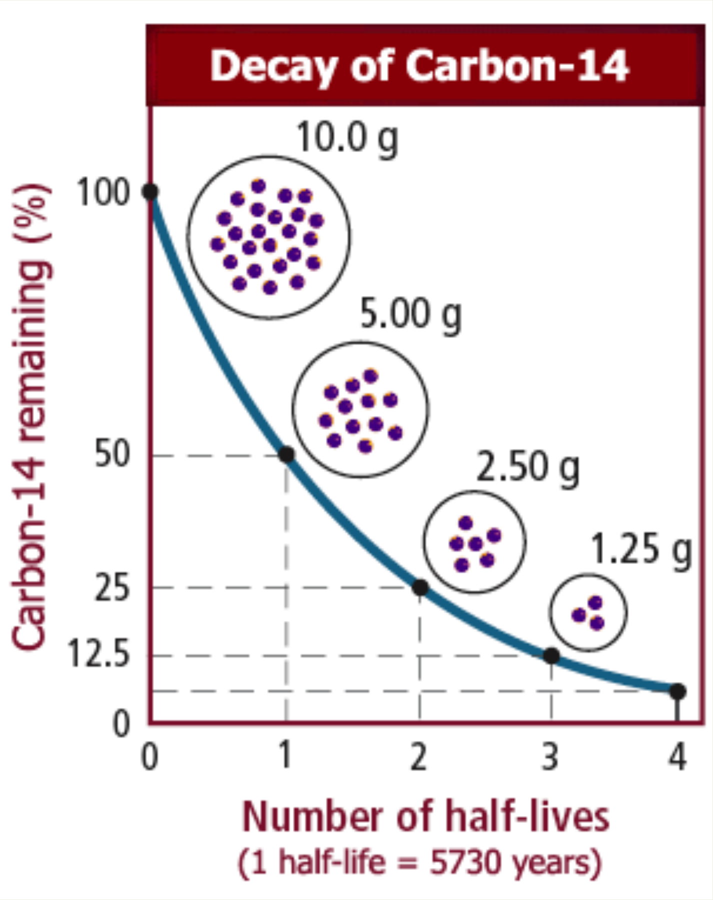
useful isotopes for rocks, but too slow to use on organic tissues

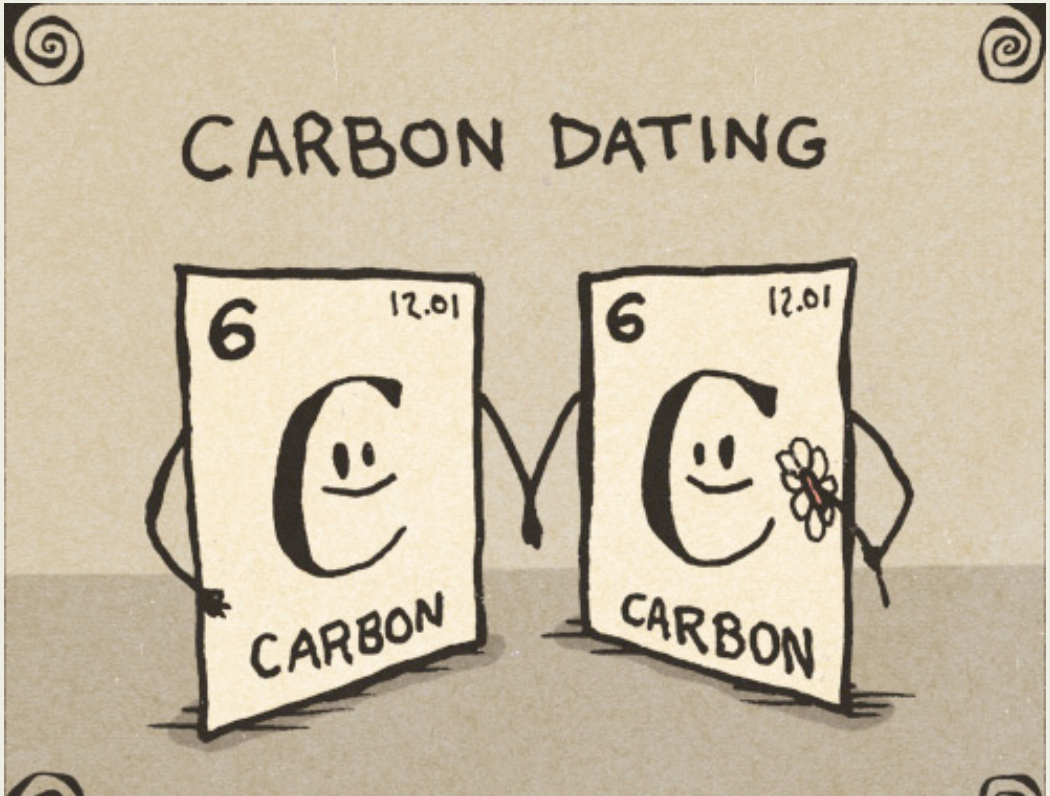
CARBON 14 DATING

- C-14 Half-life is 5730years
- Useful for dating plant and animal remains from 500 to 50,000 years old *soft tissue, wood, bone, cloth*
- C-14 in atmosphere absorbed by plants photosynthesis
- When the organism dies, no more C-14 taken in;
  C-14 in organism decays into N-14



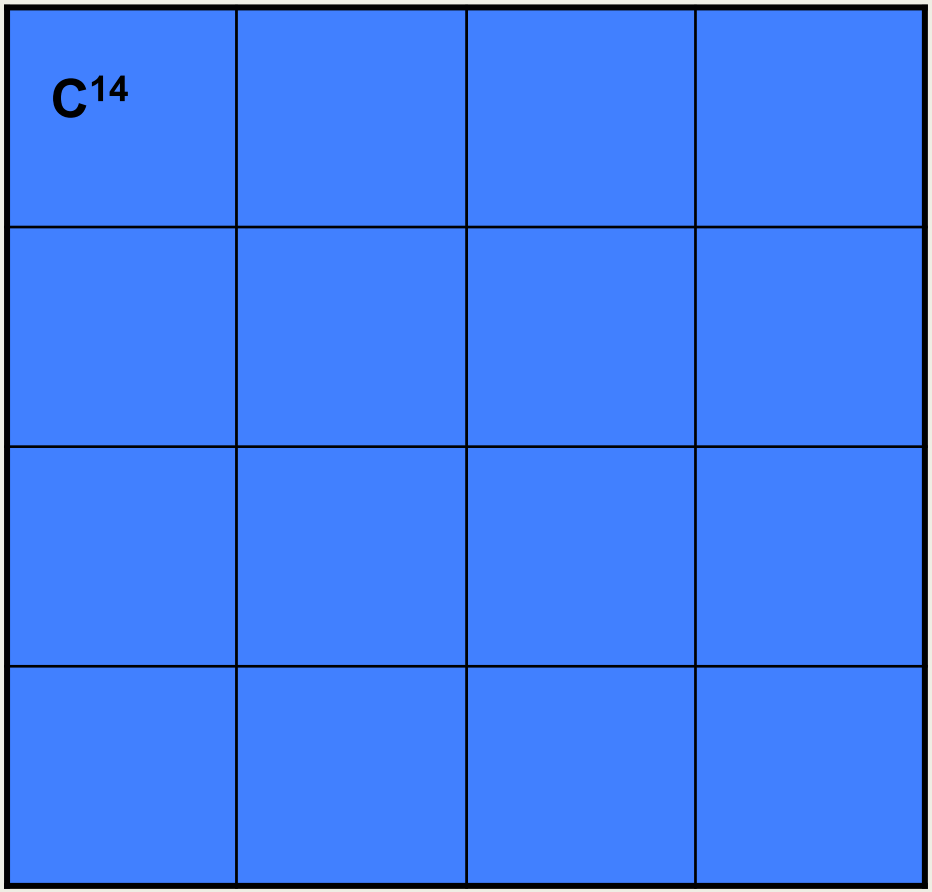
C-14 HALF LIFE = 5,730YRS





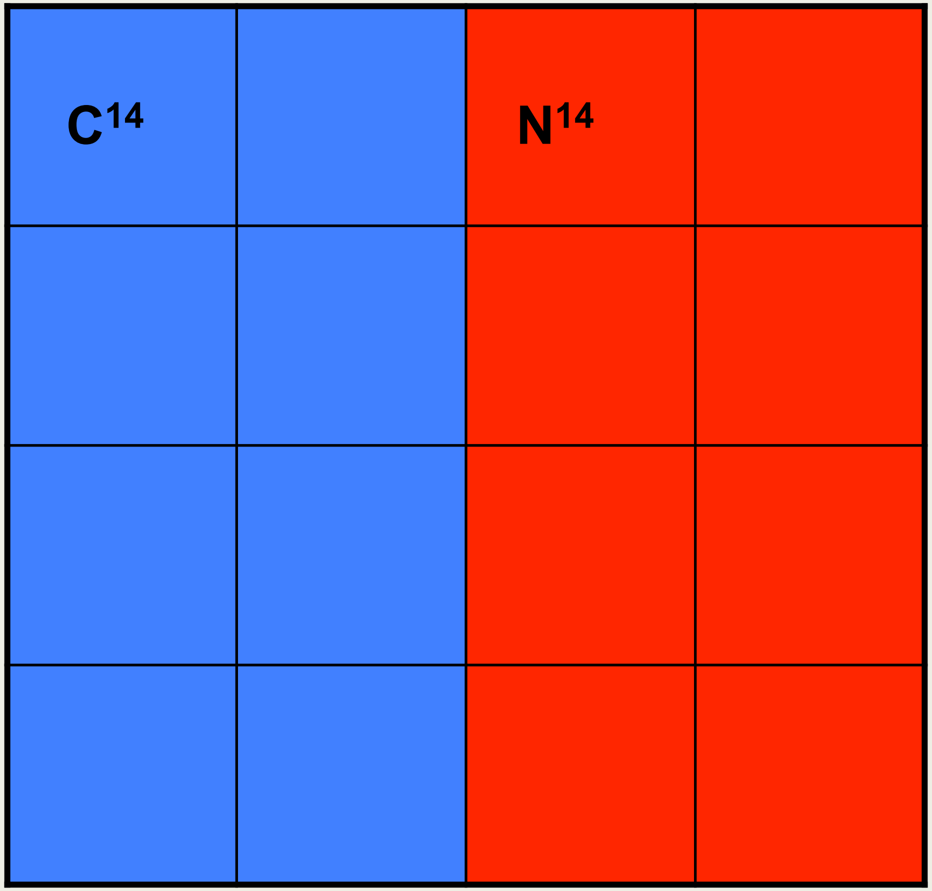
C-14 Video Review

- **The grid below represents the ratio of C^{14} : N^{14}**
  - *To start, 100% of the material is C^{14}*



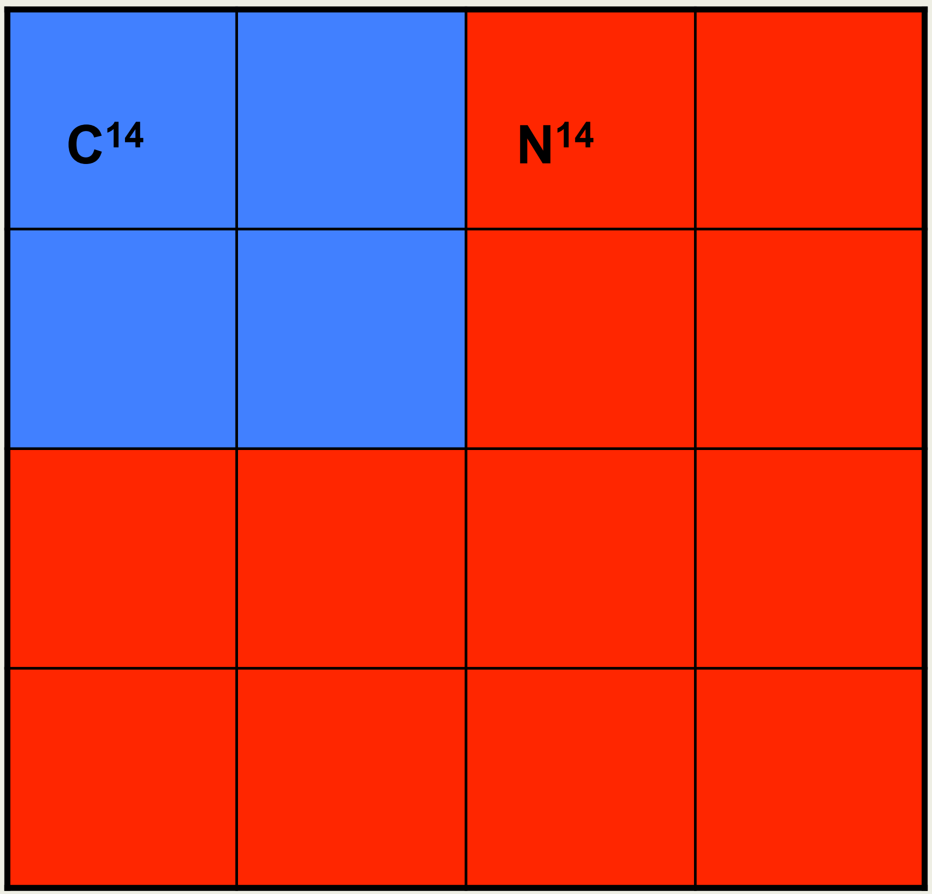
Half lives	% C^{14}	% N^{14}	Ratio of C^{14} to N^{14}
0	100%	0%	no ratio

- *After 1 half-life, 5740 years, 50% of the C^{14} has decayed to N^{14}*



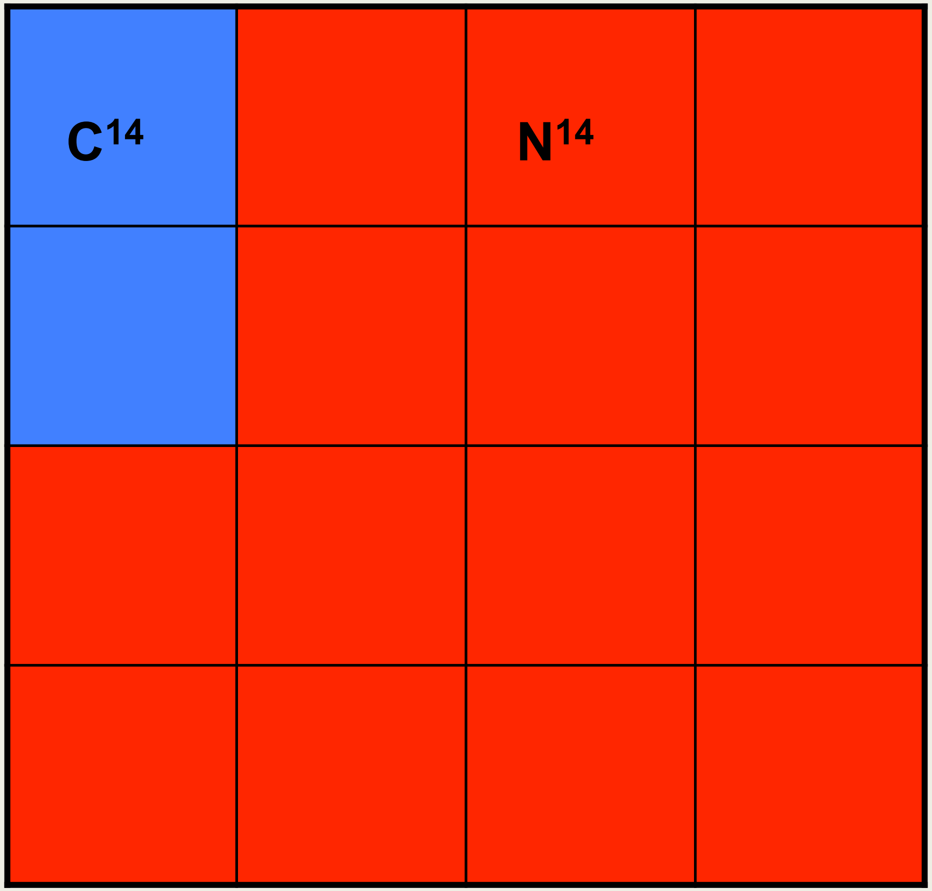
Half lives	**% C^{14}**	**%N^{14}**	**Ratio of C^{14} to N^{14}**
0	100%	0%	no ratio
1	**50%**	**50%**	**1:1**

After 2 half-life, 11460 years, 75% of the C^{14} has decayed to N^{14}



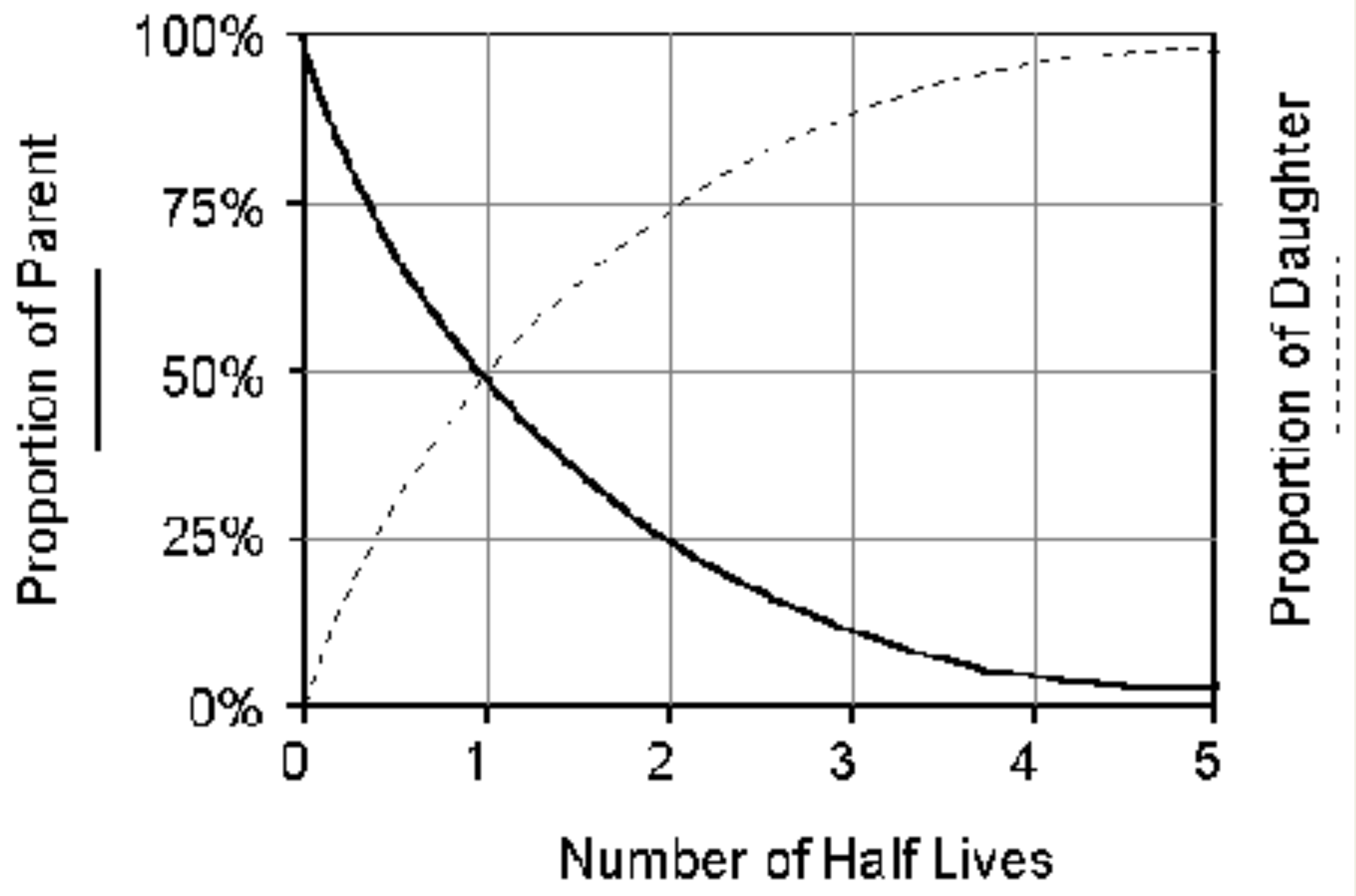
Half lives	**% C^{14}**	**%N^{14}**	**Ratio of C^{14} to N^{14}**
0	100%	0%	no ratio
1	50%	50%	1:1
2	**25%**	**75%**	**1:3**

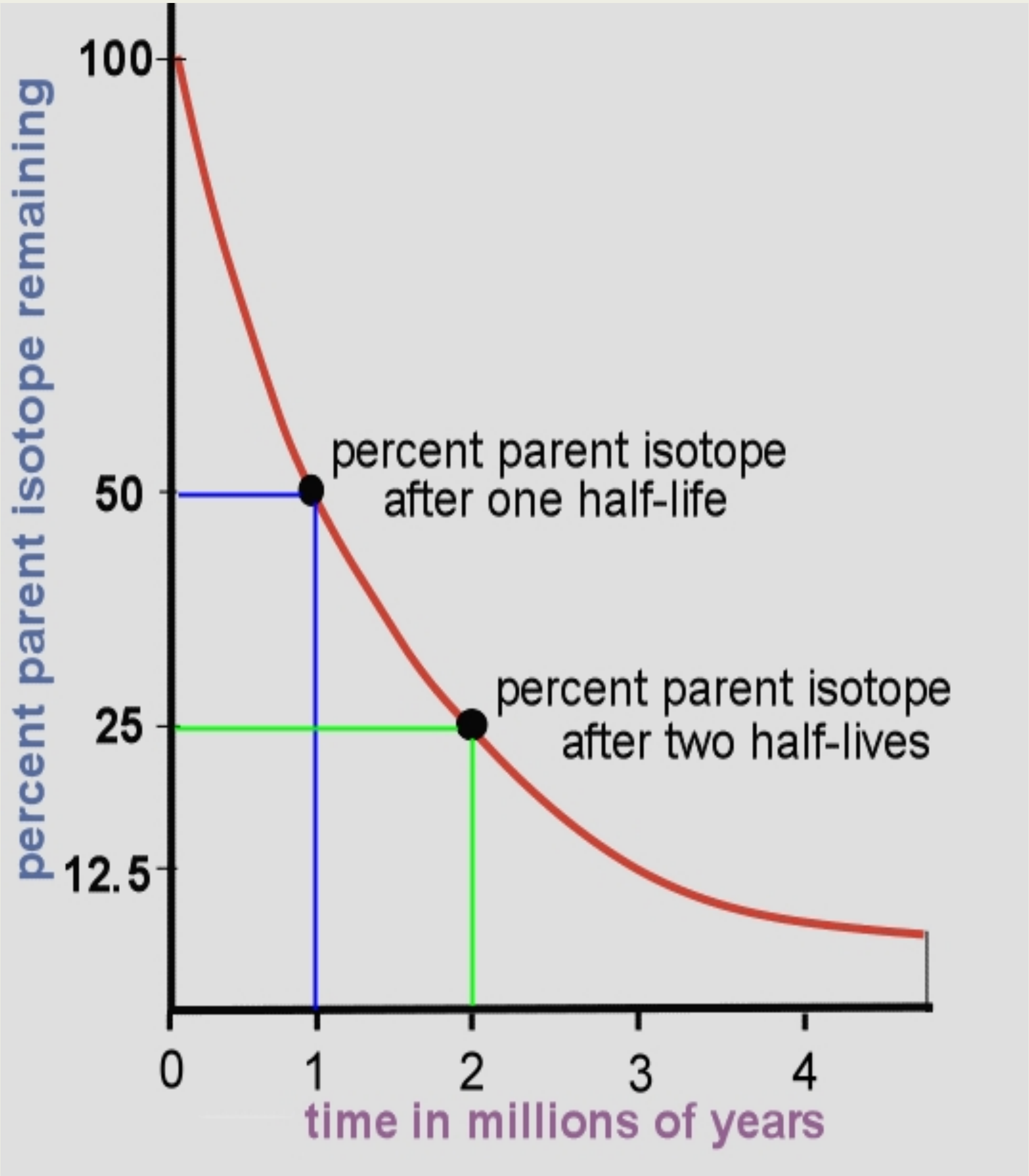
After 3 half-life, 17190 years, 87.5% of the C^{14} has decayed to N^{14}



Half lives	% C^{14}	%N^{14}	Ratio of C^{14} to N^{14}
0	100%	0%	no ratio
1	50%	50%	1:1
2	**25%**	**75%**	**1:3**
3	**12.5%**	**87.5%**	**1:7**

STOP HERE


100%
75%
50%
25%
0%
0
1
2
3
4
5
Proportion of Parent
Proportion of Daughter
Number of Half Lives

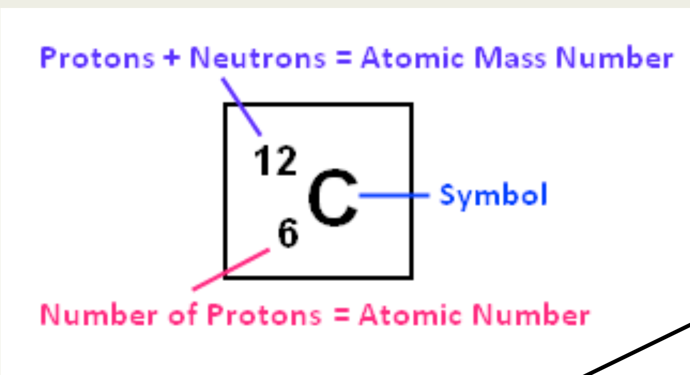


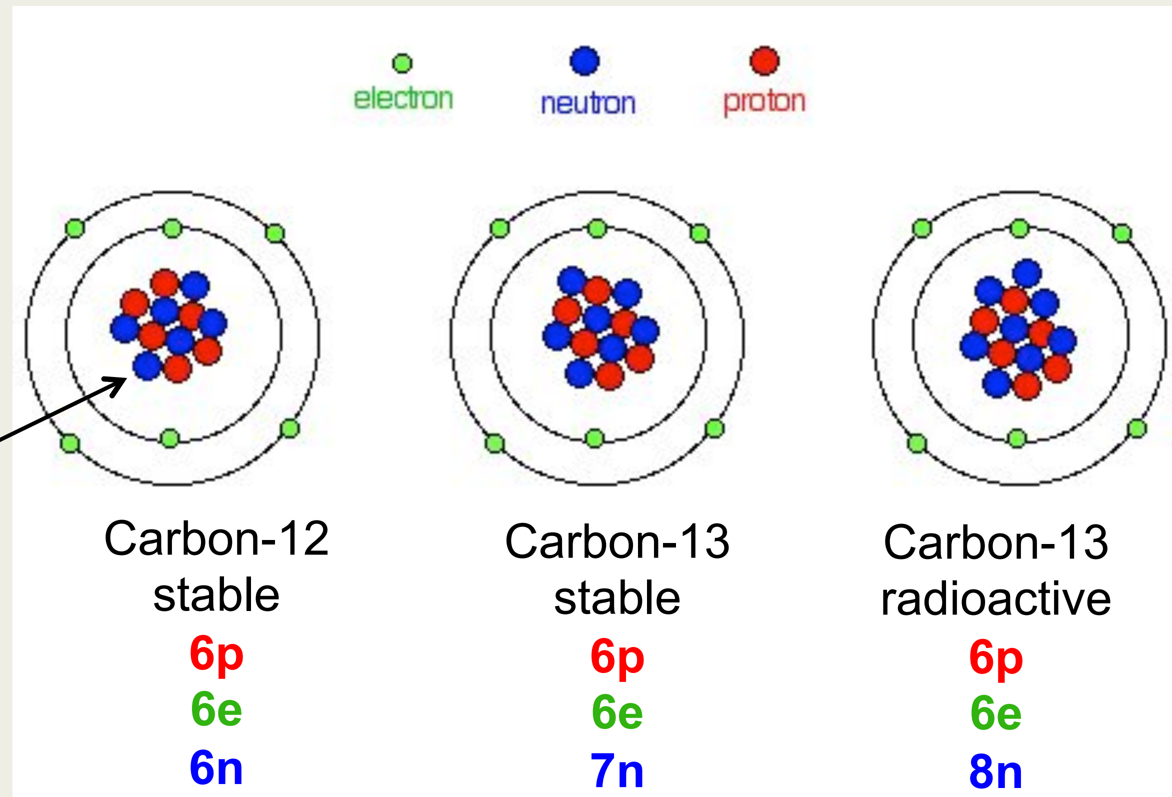
What is the half life represented in this graph?

If 4 half-lives have passed, what % of radioactive material would remain?

ISOTOPES

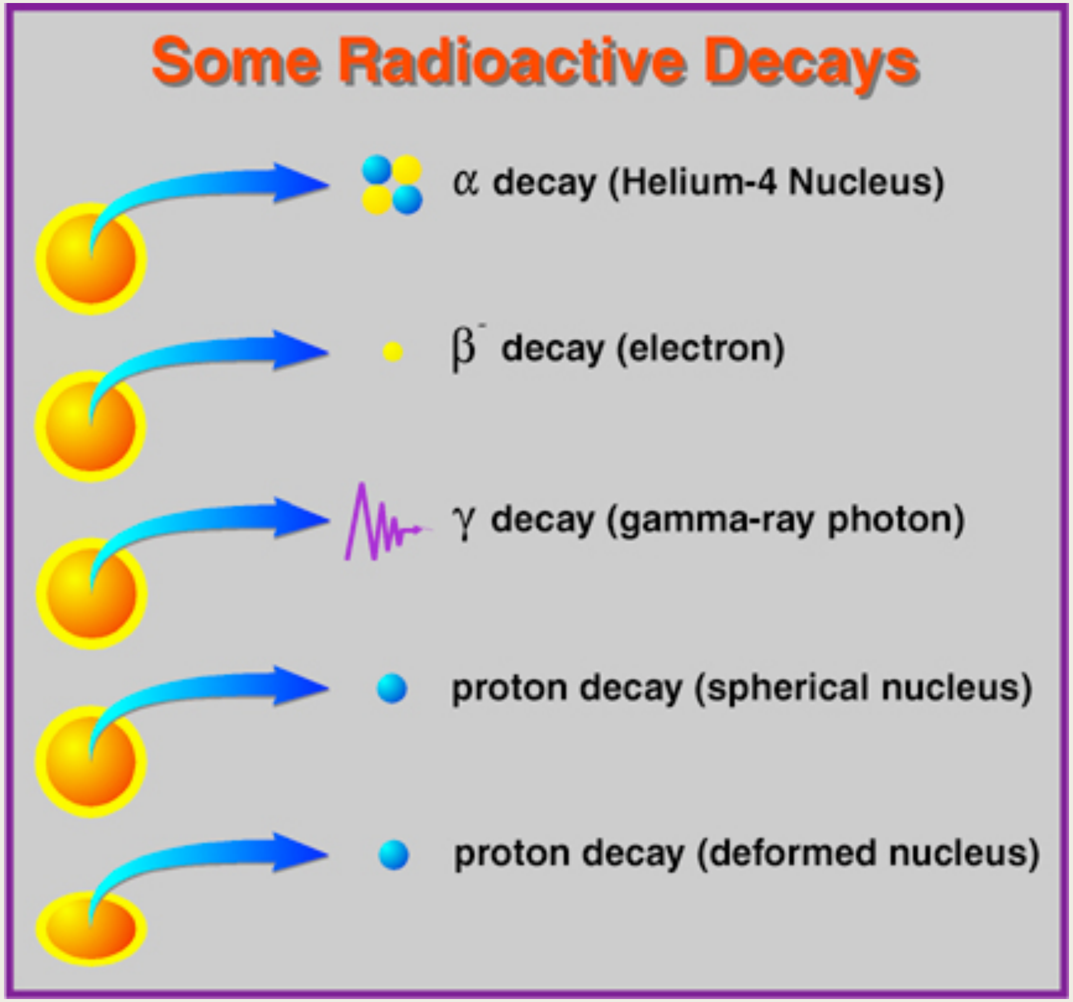
- Different forms of the same element
- Same chemical properties (# protons)
- Different mass (more or less neutrons-makes nucleus unstable)





Mass in nucleus

DIFFERENT TYPES OF DECAY PRODUCTS



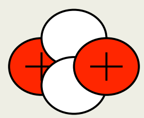
- Each with a measureable rate

Examples

- Carbon-Nitrogen 5,730years
- Potassium-Argon 1.3 billion years
- Uranium-Lead 4.5 billion years

ALPHA DECAY

- Unstable nucleus ejects an alpha particle
  - *= 2 protons, 2 neutrons*

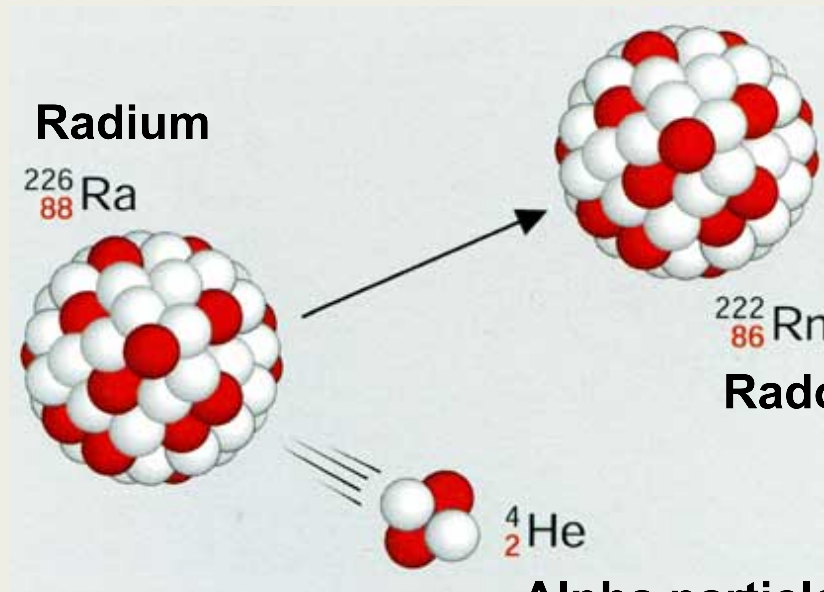


- Net effect

mass reduced by 4

Atomic # by 2

- Damaging to tissues but does not cross skin
- *Polonium 210 in cigarette smoke decays IN the lung to cause cancer. Don't smoke!*



Alpha particle

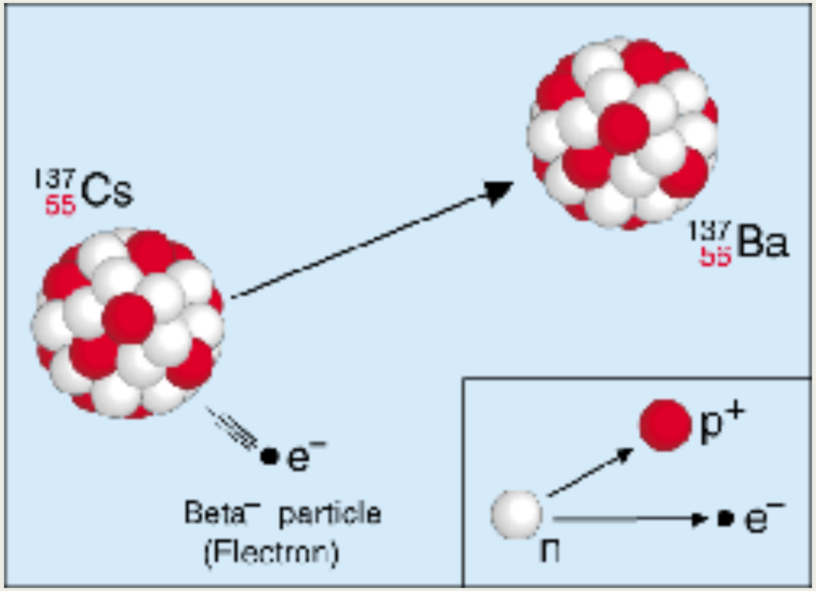
$^{226}Ra \rightarrow {}^{4}He + {}^{222}Rn$

88 2 86

$$^{222}_{88}\mathrm{Ra} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{218}_{86}\mathrm{Rn}$$

BETA DECAY

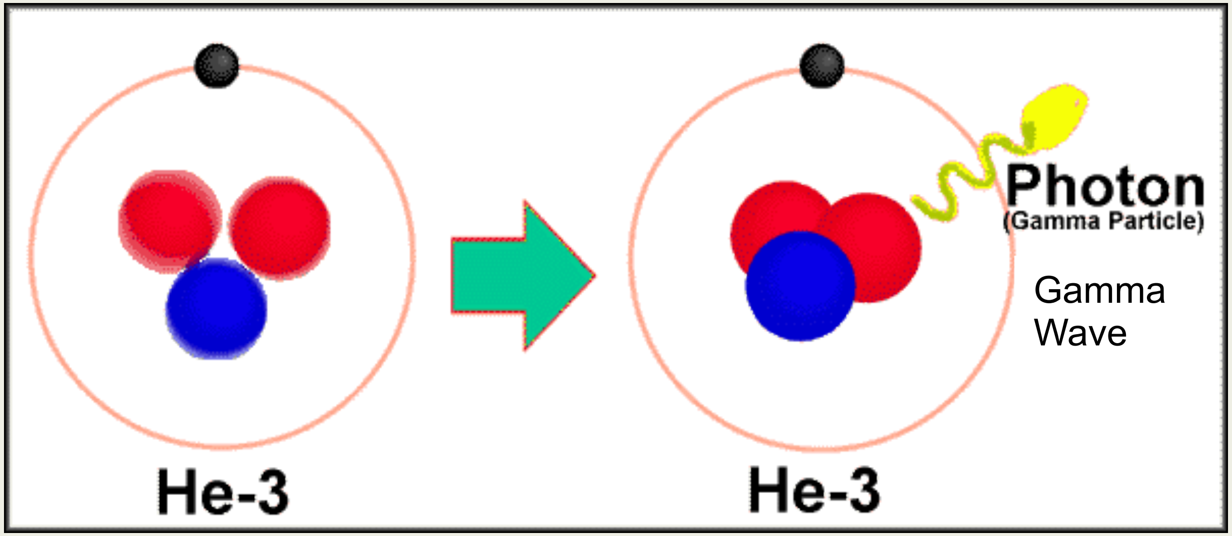
- Loss of a beta particle (electron)
  - *A neutron splits into an electron (ejected), and proton (remains behind)*
- Net effect neutron lost & proton gained
  - *no mass change*
  - *+1 atomic number*
- Penetrates skin, damaging to cells



$$^{131}_{53}\mathrm{I} \rightarrow {}^{0}_{-1}\mathrm{e} + {}^{131}_{54}\mathrm{Xe}$$

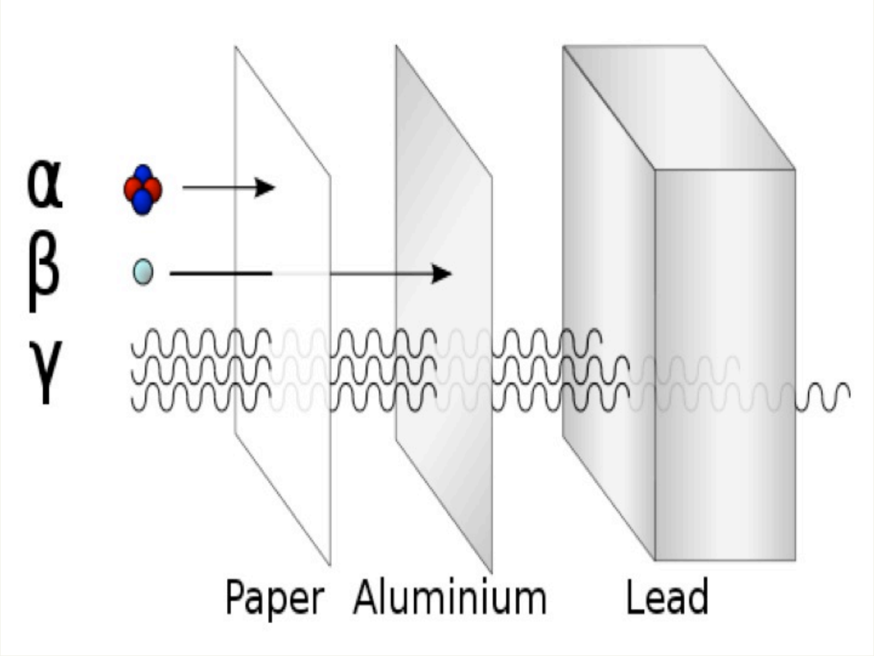
GAMMA DECAY

- Gamma energy released often after alpha or beta decay w/ too much energy to be stable
  - *but no change to atomic mass or number*



  - *Short wavelength gamma penetrates deep into tissues*
  - *Stopped only by thick concrete, lead barriers*

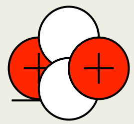
RADIOACTIVE ENERGY



- Smaller; more energetic and dangerous

EXAMPLES | *YOU TRY*

- Alpha decay



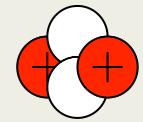
$^{238}U_{92} \rightarrow$

$^{234}Th_{90} + {}^{4}He_{2}$

- Beta decay

$${}^{131}_{53}I \rightarrow {}^{131}_{54}Xe + \underset{\textit{beta particle}}{{}^{0}_{-1}e}$$

- Alpha



$^{185}Au_{79} \rightarrow$

$^{181}Ir_{77} + {}^{4}He_{2}$

- Beta

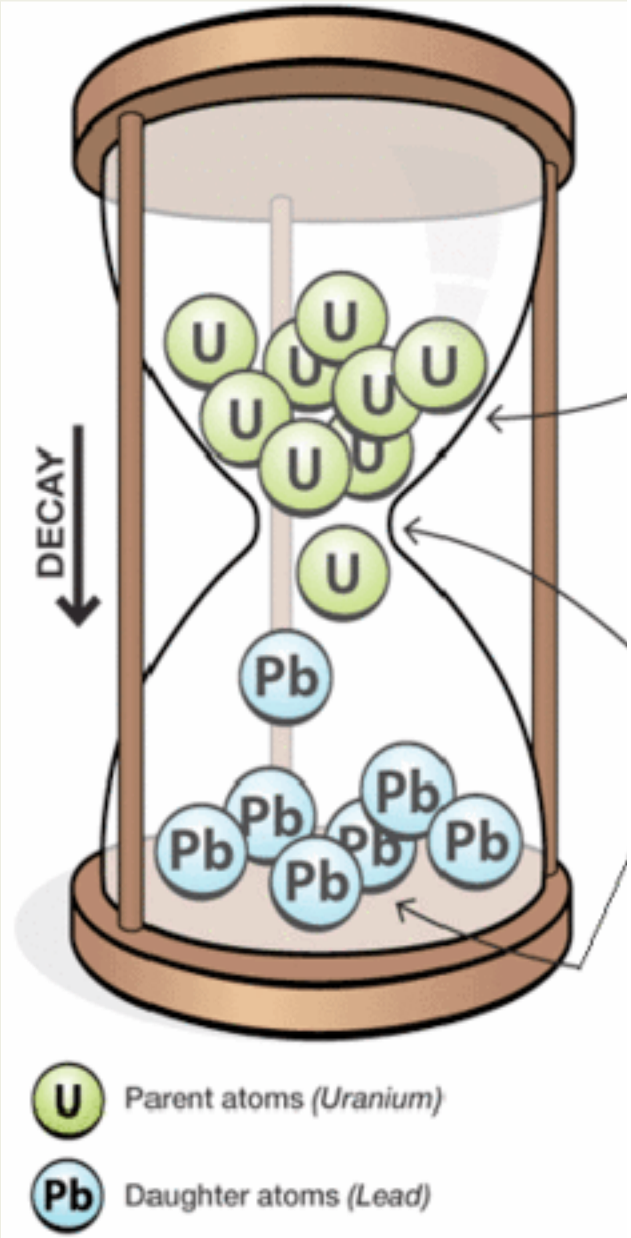
$^{14}C_{6} \rightarrow$

$^{14}N_{7} + e^{-}$

PRACTICE

- $^{56}Cr_{24}$ -> e^- + __________ **α or β?**
- $^{208}Po_{84}$ -> $^{4}He_{2}$ + ________ **α or β?**
- $^{131}I_{53}$ -> $^{131}Xe_{54}$ + ________ **α or β?**
- $^{241}A_{95}$ –> $^{237}Np_{93}$ + ______ **α or β?**
- $^{238}Ur_{92}$ undergoes an α decay – write the complete equation


"--AND I WAS THE FIRST TO LOCATE THE ISOTOPE!"
HEY, MAN! IT'S--IT'S GLOWIN'!



We don't observe all the atoms decaying –rely on assumptions

#1: The original number of atoms were consistent with environmental levels today.

#2: The rate of decay is constant.

#3: The daughter atoms were all made by decay and none were lost

The more daughter accumulated the older the sample.

Dating Sedimentary Layers

Inaccurate b/c the age of a layer reflects when the particles were deposited; the particles themselves were formed earlier

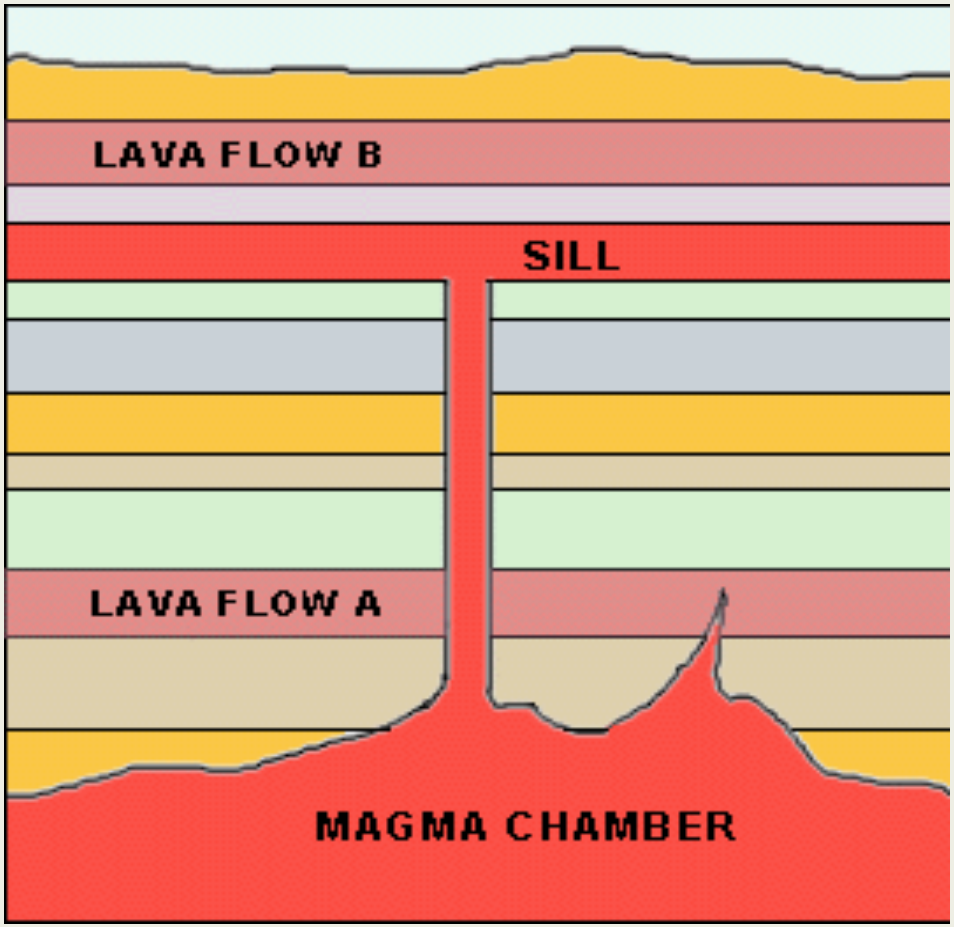
100mya

2mya

2mya

A layer formed 2mya could contain rock bits formed 100mya

Date the igneous intrusions to date the layers



Youngest

Older

Oldest

Use radiometric* dating of the igneous as ‘bookmarks’ to date the sedimentary layers

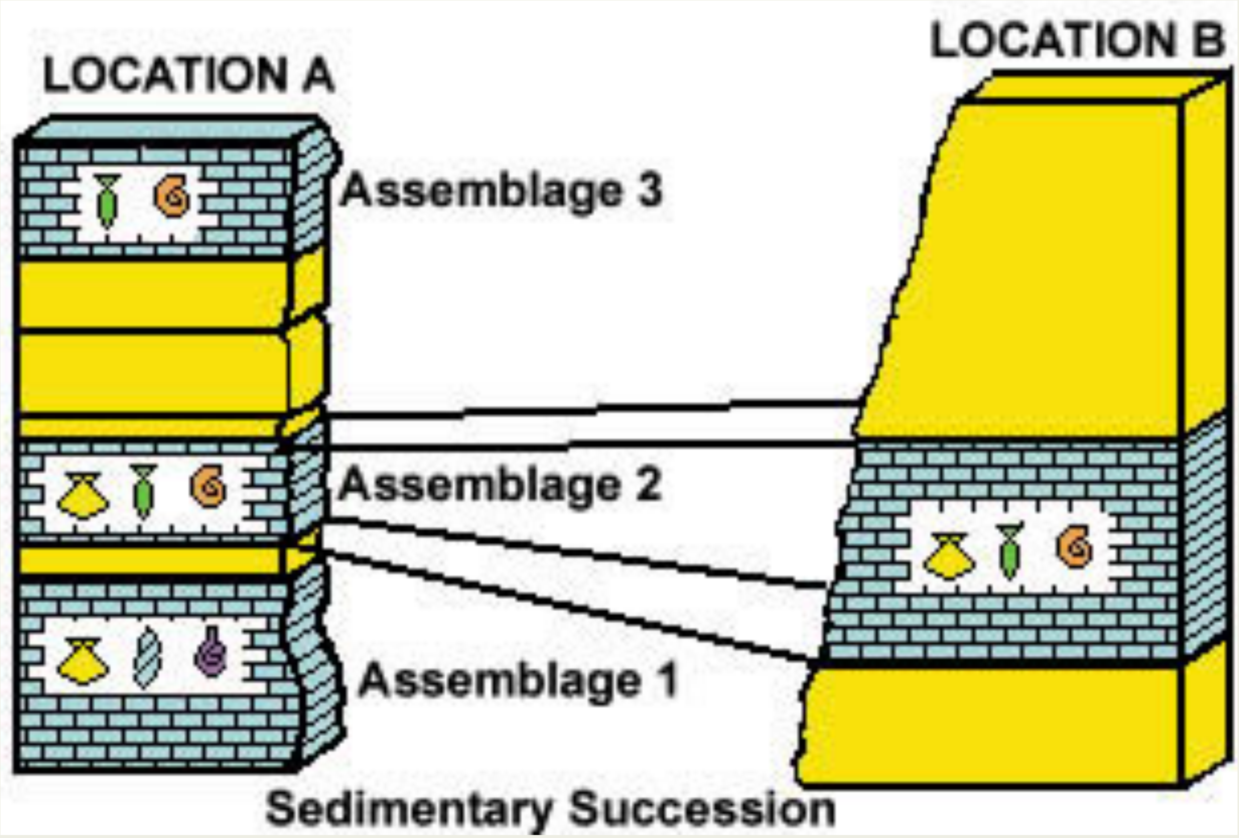
**radioisotope; absolute age*

Date the igneous intrusions to date the layers

< 65my

65-95my

>95my



Igneous

65my

Sedimentary

igneous

95my

Dating Sedimentary Layers