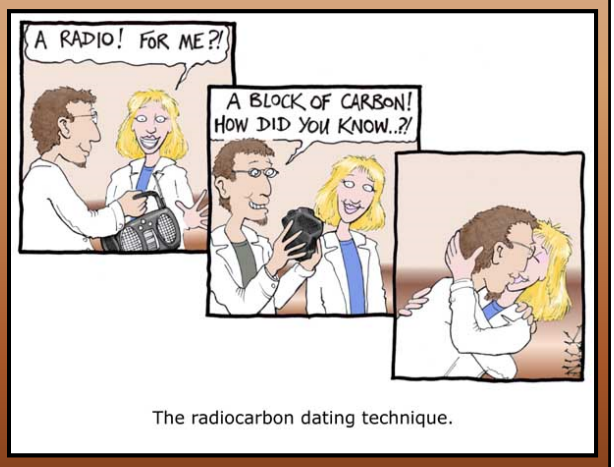
7.2 Half-life

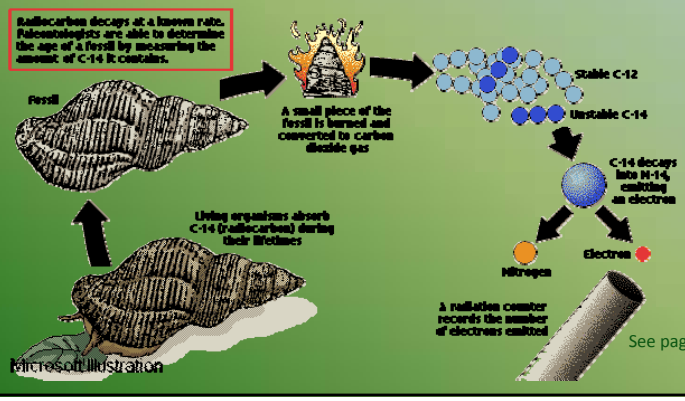
Vocabulary

- Daughter isotope
- Decay curve
- Half-life
- Parent isotope
- Radiocarbon dating



7.2 Half-life

- It can be difficult to determine the ages of objects by sight alone.
  - Radioactivity provides a method to determine age by measuring relative amounts of remaining radioactive material to stable products formed.



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7.2 Half-life

- Carbon dating measures the ratio of carbon-12 and carbon-14.
  - Stable carbon-12 and radioactive carbon-14 exist naturally in a constant ratio.
  - When an organism dies, carbon-14 stops being created and slowly decays.
    - Carbon dating only works for organisms less than 50 000 years old.

Using carbon dating, these cave paintings of horses, from France, were drawn 30 000 years ago.

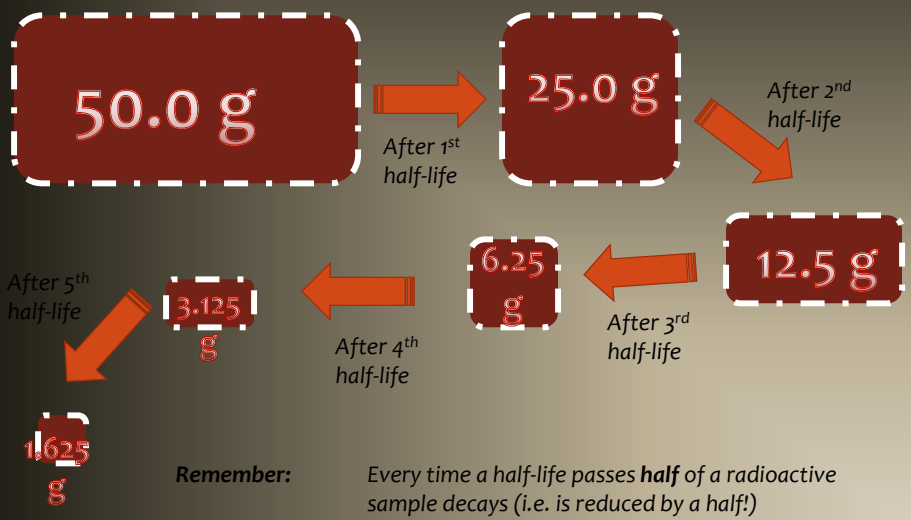
See pages 302 - 304

The Rate of Radioactive Decay

- Half-life measures the rate of radioactive decay.
  - Half-life = time required for half of the radioactive sample to decay.
  - The half-life for a radioactive element is a constant rate of decay.
  - Strontium-90 has a half-life of 29 years. If you have 10 g of strontium-90 today, there will be 5.0 g remaining in 29 years.

See pages 305 - 306

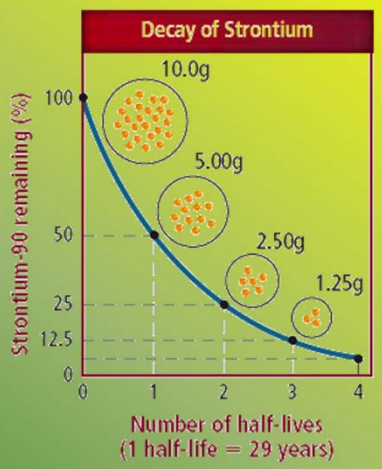
Example: Watch the decay of a 50.0 g radioactive sample of C-14



Remember: *Every time a half-life passes **half** of a radioactive sample decays (i.e. is reduced by a half!)*

The Rate of Radioactive Decay

- Decay curves show the rate of decay for radioactive elements.
  - The curve shows the relationship between half-life and percentage of original substance remaining.



The decay curve for strontium-90

See pages 305 - 306

Common Isotope Pairs

- There are many radioisotopes that can be used for dating.
  - Parent isotope = the original, radioactive material
  - Daughter isotope = the stable product of the radioactive decay

Isotope		Half-life of parent (years)	Useful range (years)
Parent	Daughter		
Carbon 14	Nitrogen 14	5,730	100 - 30,000
Potassium 40	Argon 40	1.3 billion	100,000 - 4.5 billion
Rubidium 87	Strontium 87	47 billion	10 million - 4.5 billion
Uranium 238 Uranium 235	Lead 206 Lead 207	4.5 billion 710 million	10 million - 4.6 billion

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Common Isotope Pairs

- The rate of decay remains constant, but some elements require one step to decay while others decay over many steps before reaching a stable daughter isotope.
  - Carbon-14 decays into nitrogen-14 in one step.
  - Uranium-235 decays into lead-207 in 15 steps.
  - Thorium-235 decays into lead-208 in 10 steps.

Table 7.6 Common Isotope Pairs Chart

Isotope		Half-Life of Parent (y)	Effective Dating Range (y)
Parent	Daughter		
carbon-14	nitrogen-14	5730	up to 50 000
uranium-235	lead-207	710 million	> 10 million
potassium-40	argon-40	1.3 billion	10 000 to 3 billion
uranium-238	lead-206	4.5 billion	> 10 million
thorium-235	lead-208	14 billion	> 10 million
rubidium-87	strontium-87	47 billion	> 10 million

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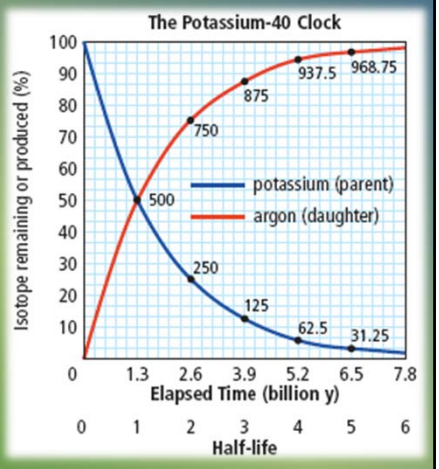
The Potassium-40 Clock

- Radioisotopes with very long half-lives can help determine the age of very old things.
  - The potassium-40/argon-40 clock has a half-life of 1.3 billion years.
  - Argon-40 produced by the decay of potassium-40 becomes trapped in rock.
  - Ratio of potassium-40 : argon-40 shows age of rock.



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The Potassium-40 Clock

Table 7.7 The Decay of Potassium-40

Number of Half-lives	Elapsed Time (billions of years)	Amount of Potassium-40 Present	Amount of Argon-40 Present	Ratio of Argon-40 to Potassium-40
0	0	1000 g	0	0
1	1.3	500 g	500 g	1:1
2	2.6	250 g	750 g	3:1
3	3.9	125 g	875 g	7:1
4	5.2	62.5 g	937.5 g	15:1

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Summary

A half-life is the length of time required for half the nuclei in a sample of a radioactive isotope to decay into its products.