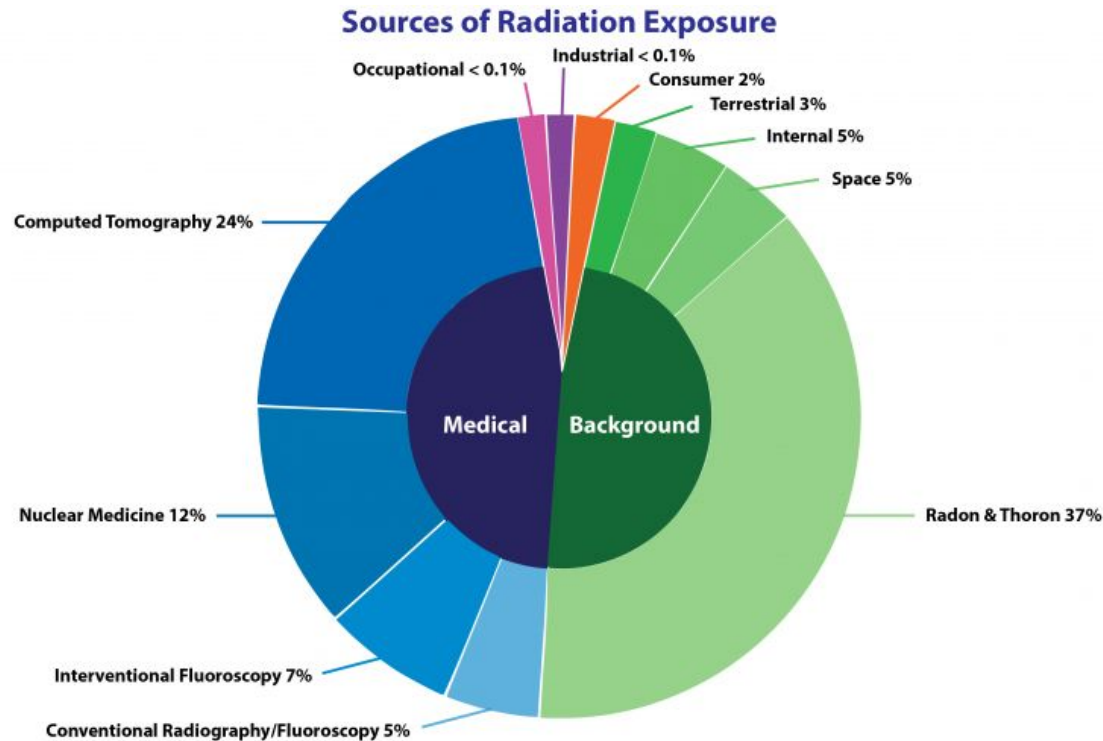


Half-Life

IB PHYSICS | UNIT 11 | ATOMIC PHYSICS

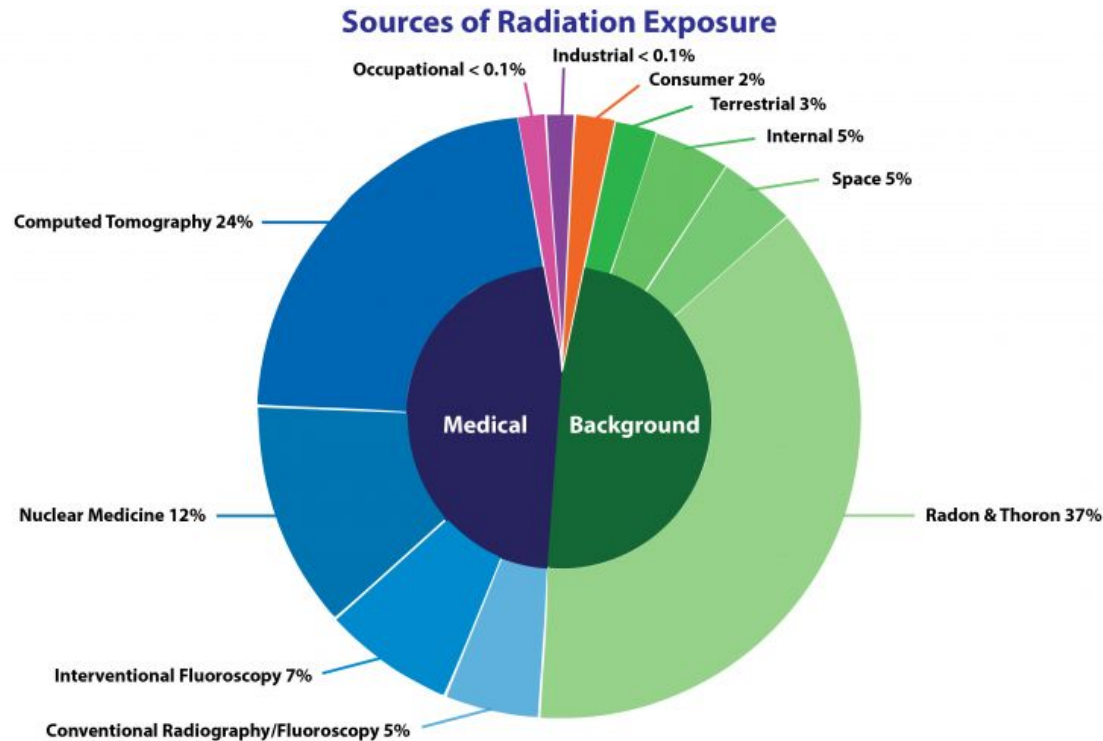
Where does Radiation Come From?



Average Annual Radiation Dose											
Sources	Radon & Thoron	Computed Tomography	Nuclear Medicine	Interventional Fluoroscopy	Space	Conventional Radiography/Fluoroscopy	Internal	Terrestrial	Consumer	Occupational	Industrial
Units											
mrem (United States)	228 mrem	147 mrem	77 mrem	43 mrem	33 mrem	33 mrem	29 mrem	21 mrem	13 mrem	0.5 mrem	0.3 mrem
mSv (International)	2.28 mSv	1.47 mSv	0.77 mSv	0.43 mSv	0.33 mSv	0.33 mSv	0.29 mSv	0.21 mSv	0.13 mSv	0.005 mSv	0.003 mSv

(Source: National Council on Radiation Protection & Measurements, Report No. 160)

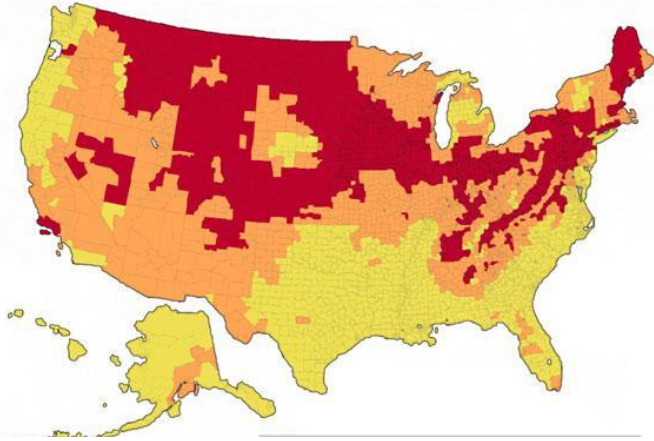
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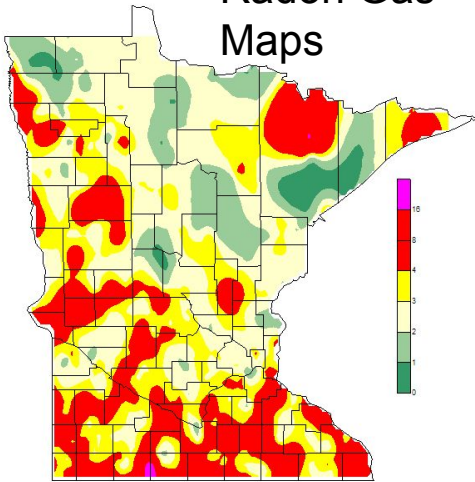
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Background Radiation



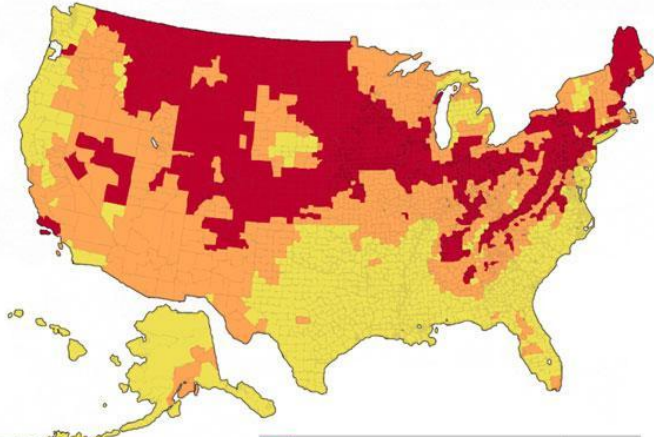
Radon Gas
Maps



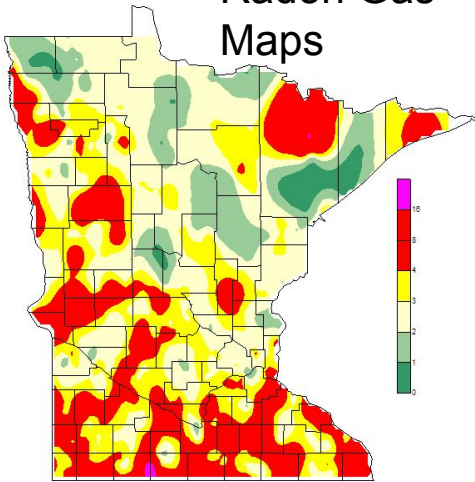
A person would receive a dose equivalent of 1 mrem from any of the following activities:

- 3 days of living in Atlanta
- 2 days of living in Denver
- 1 year of watching television (on average)
- 1 year of wearing a watch with a luminous dial
- 1 coast-to-coast airline flight
- 1 year living next door to a normally operating nuclear power plant

Background Radiation



Radon Gas
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Is Radiation Dangerous?

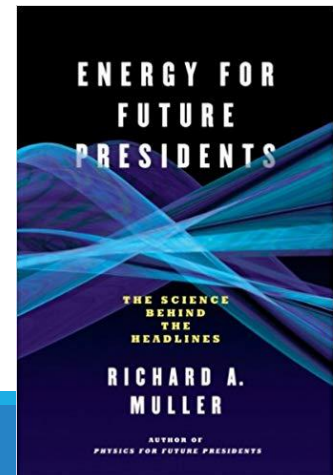
Radiation Sickness – 100 rem or more

Symptoms: Nausea and vomiting

Other Radiation Effects

Likelihood of cancer increases by 1%* for every radiation dose of 25 rem

**Note: This percent likelihood is added to the 20% chance from natural causes*



*Values taken from the book **Energy for Future Presidents** □

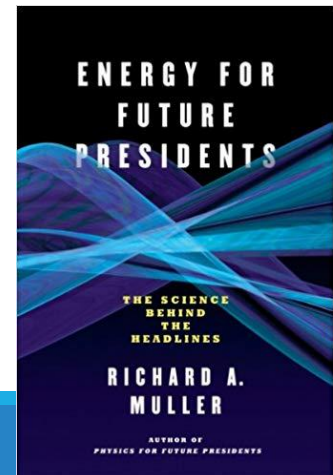
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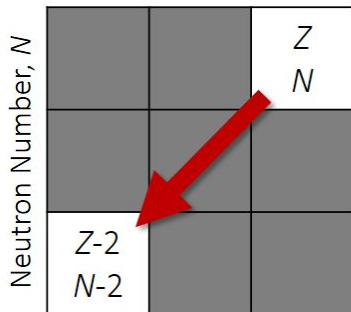
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Radioactive Decay

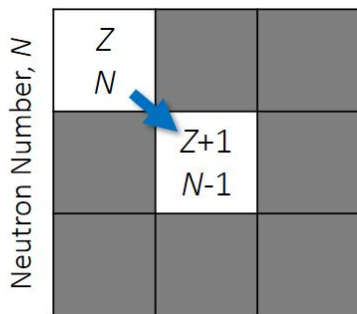
82	83	84	85	86	87	88	89	90	91	92
Pb	Bi	Po	At	Rn	Fr	Ra	Ac	Th	Pa	U
Lead	Bismuth	Polonium	Astatine	Radon	Francium	Radium	Actinium	Thorium	Protactinium	Uranium



α Decay

Mass #

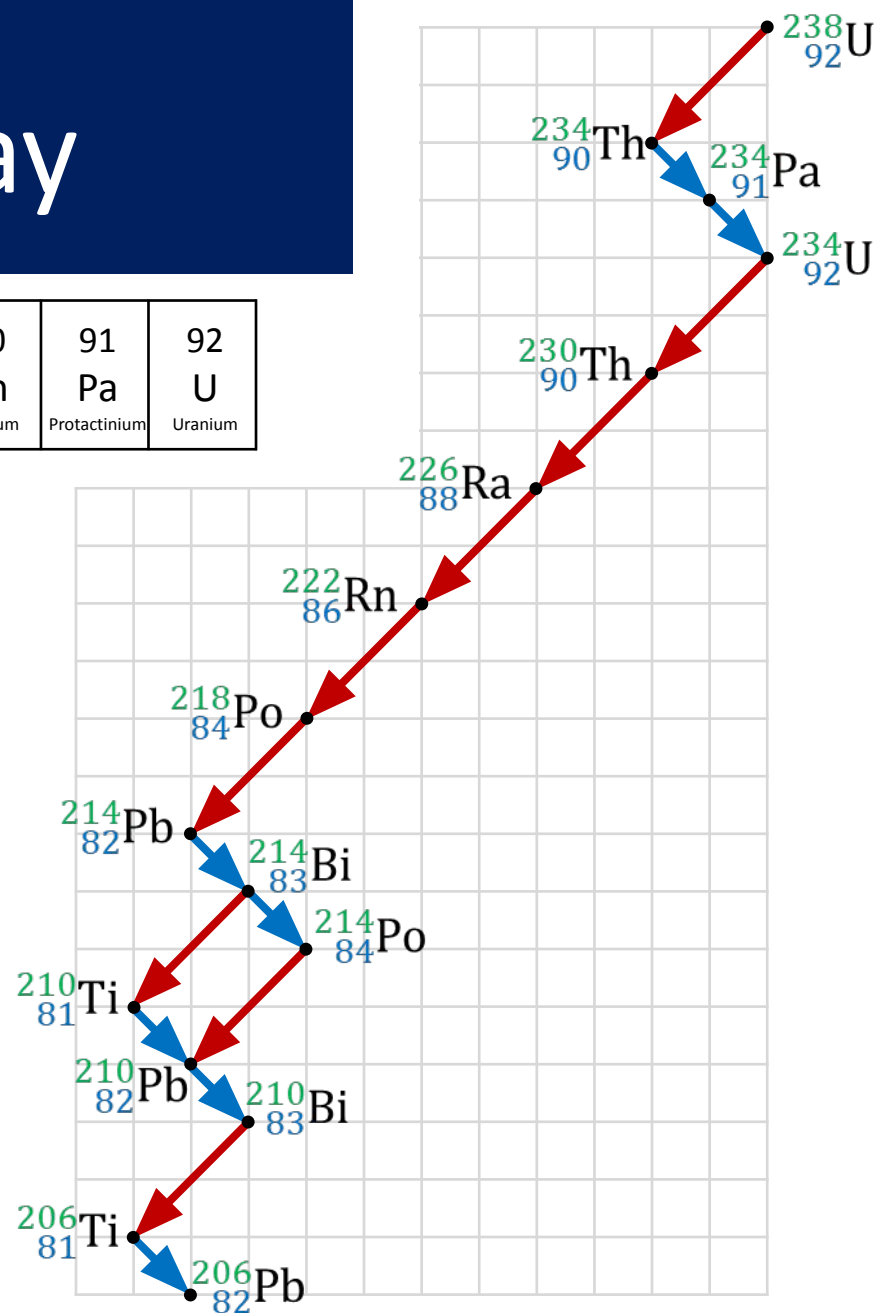
- 4



β^- Decay

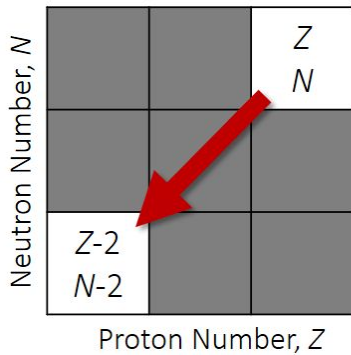
Mass #

Same



Radioactive Decay

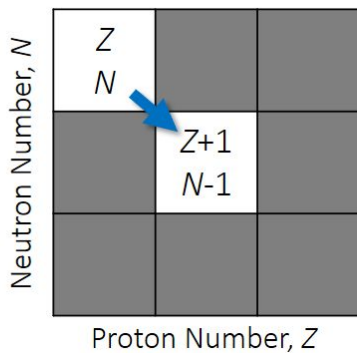
82	83	84	85	86	87	88	89	90	91	92
Pb	Bi	Po	At	Rn	Fr	Ra	Ac	Th	Pa	U
Lead	Bismuth	Polonium	Astatine	Radon	Francium	Radium	Actinium	Thorium	Protactinium	Uranium



α Decay

Mass #

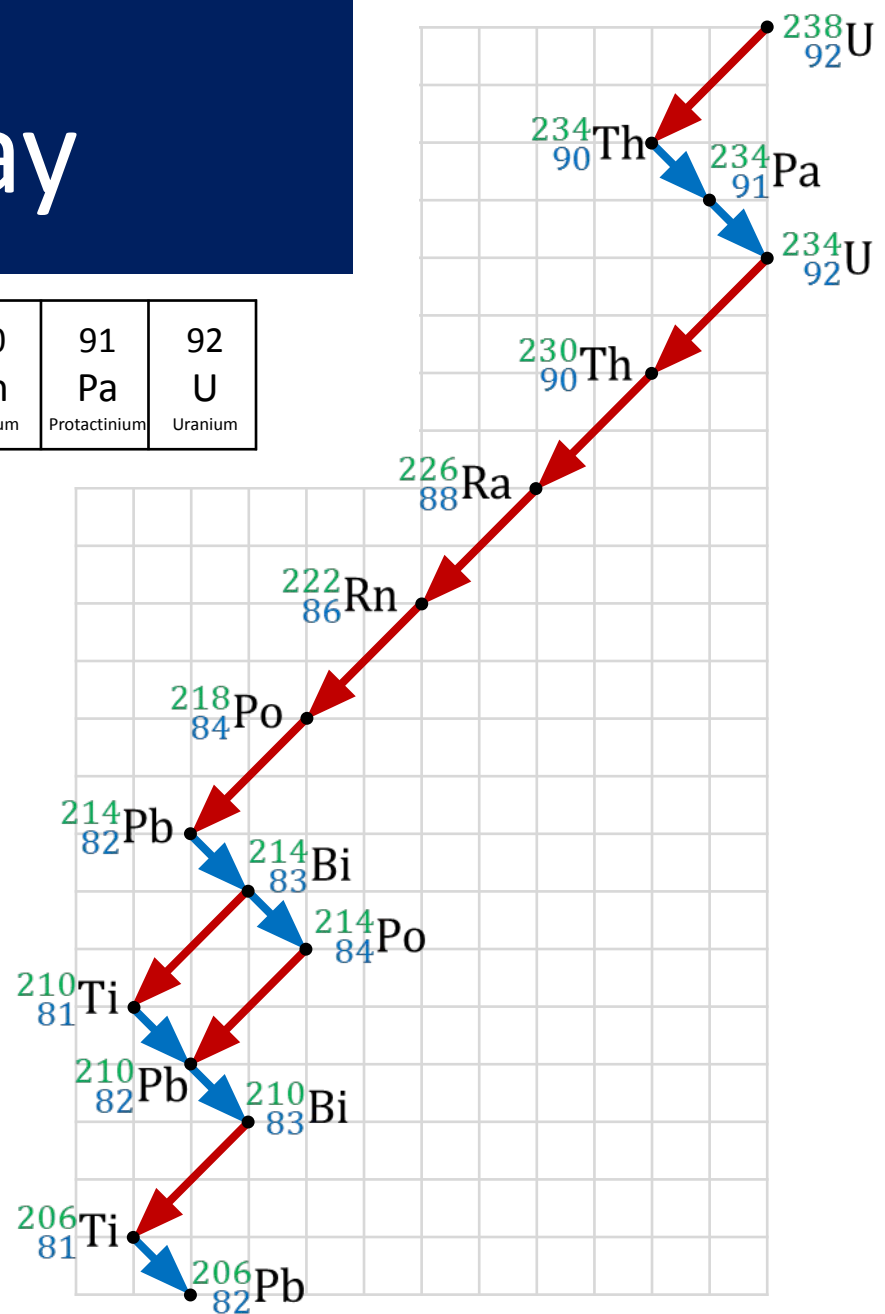
- 4



β^- Decay

Mass #

Same

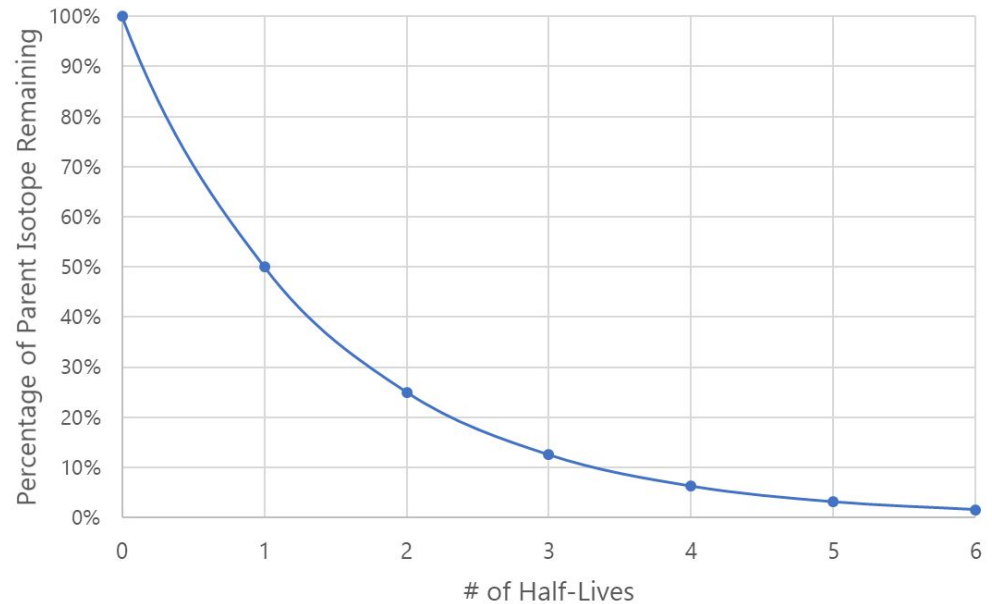


Half-Life

The amount of time it takes for one half of the original sample to **decay**

Radioactive Nuclide	Half-life
Uranium-238	4.5×10^9 years
Radium-226	1,600 years
Radon-222	3.8 days
Francium-221	4.8 minutes
Astatine-217	0.03 seconds

This can be in the scale of seconds, minutes, days or even years!

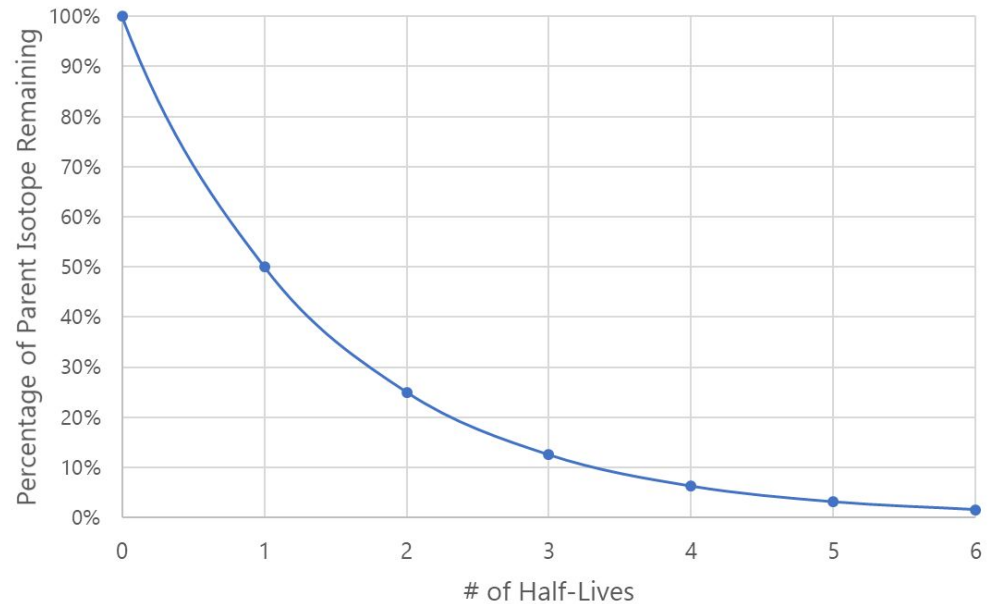


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Half-Life of Dice



The Rules that are rolled a 6 have decayed into a new isotope and are removed from the sample

Half-Life =

# of Rolls	# of Dice
0	120
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Half-Life of Dice



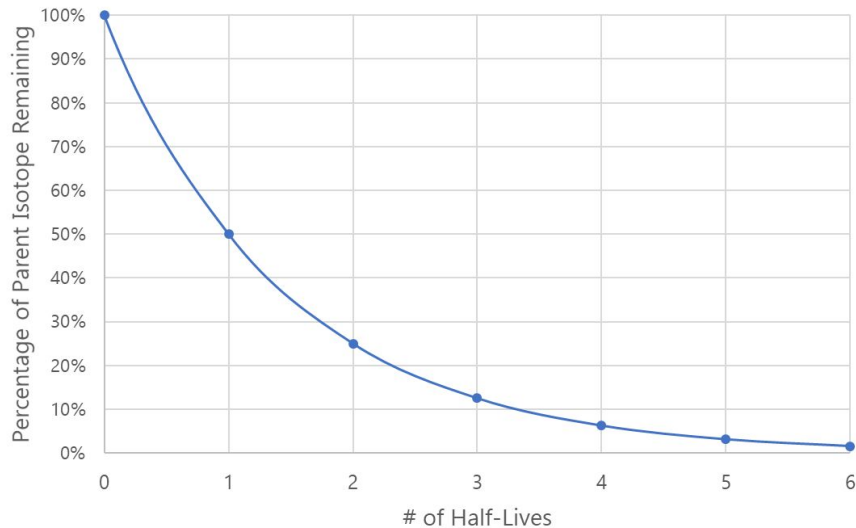
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Half-Life =

# of Rolls	# of Dice
0	120
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Half-Life Example

How many half-lives does it take for there to only be ___% of the original sample remaining?



$$100\% / 2 = 50\%$$

remains after 1 half-life

$$50\% / 2 = 25\%$$

remains after 2 half-lives

$$25\% / 2 =$$

remains after 3 half-lives

$$\underline{\hspace{2cm}} / 2 =$$

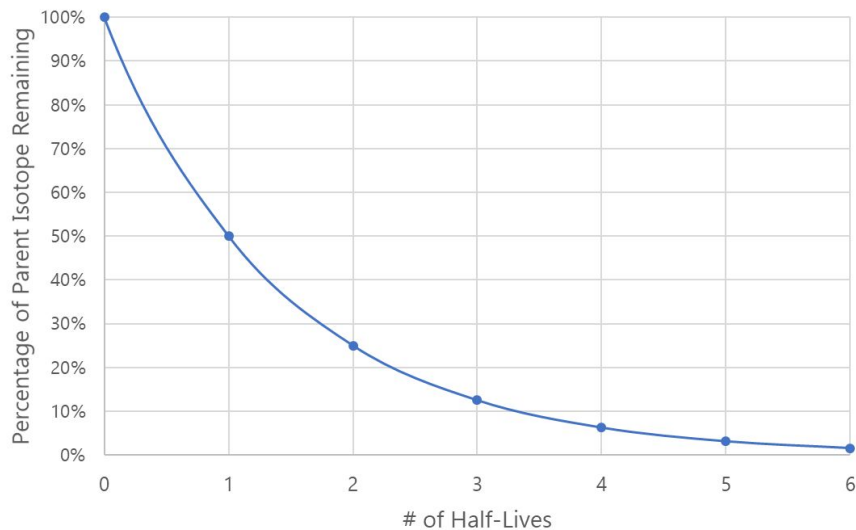
remains after 4 half-lives

$$\underline{\hspace{2cm}} / 2 =$$

remains after 5 half-lives

Half-Life Example

How many half-lives does it take for there to only be ___% of the original sample remaining?



$$100\% / 2 = 50\%$$

remains after 1 half-life

$$50\% / 2 = 25\%$$

remains after 2 half-lives

$$25\% / 2 = 12.5\%$$

remains after 3 half-lives

$$12.5\% / 2 = 6.25\%$$

remains after 4 half-lives

$$6.25\% / 2 = 3.125\%$$

remains after 5 half-lives

Half Life Problem:

How many half-lives does it take for 100 g of a radioactive sample to decay to 12.5 g?

If the half-life of the sample is 7 years, how long will this take?

The half-life of radium-226 is 1601 years. What percentage remains undecayed after 4804 years?

Half Life Problem:

How many half-lives does it take for 100 g of a radioactive sample to decay to 12.5 g?

$$100 \text{ g} \overset{1}{\square} 50 \text{ g} \overset{2}{\square} 25 \text{ g} \overset{3}{\square} 12.5 \text{ g} \quad \boxed{3} \\ \text{Half-Lives}$$

If the half-life of the sample is 7 years, how long will this take?

$$(\mathbf{3 \text{ half-lives}}) \times (\mathbf{7 \text{ years}}) = \boxed{21} \\ \text{years}$$

The half-life of radium-226 is 1601 years. What percentage remains undecayed after 6404 years?

$$(\mathbf{4 \text{ half-lives}}) \times (\mathbf{1601 \text{ years}}) = 4 \\ \text{Half-Lives} \\ 100\% \overset{1}{\square} 50\% \overset{2}{\square} 25\% \overset{3}{\square} 12.5\% \overset{4}{\square} \mathbf{6.25\%}$$

Radiocarbon Dating

How old is a sample of rock that has 6.25% of its original C-14. The half-life of C-14 is 5,730 years.

Radiocarbon Dating

How old is a sample of rock that has 6.25% of its original C-14. The half-life of C-14 is 5,730 years.

100% 50% 25% 12.5% **6.25%**

1 2 3 4

(3 half-lives) × (5730 years) =

22,920

years

Half-Life Examples



How does a PET scan work?



Half-Life Examples



How does a PET scan work?

