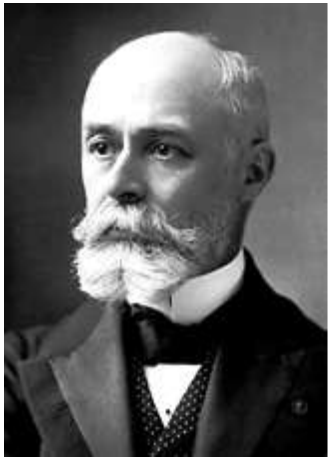
Discovery



Antoine Henri Becquerel
was born in Paris on
December 15, 1852

Discovery

- The early researchers also discovered that many other chemical elements besides uranium have radioactive isotopes. A systematic search for the total radioactivity in uranium ores also guided Marie Curie to isolate a new element polonium and to separate a new element radium from barium. The two elements' chemical similarity would otherwise have made them difficult to distinguish.

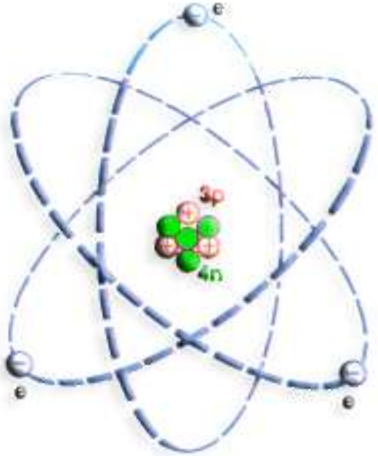
Discovery

Marie Curie, *née* Maria Sklodowska, was born in Warsaw on November 7, 1867

- All substance are made of atoms.

These have electrons (e) around the outside, and a nucleus in the middle. The nucleus consists of protons (p) and neutrons (n), and is extremely small. In some types of atom, the nucleus is unstable, and will decay into a more stable atom. This radioactive decay is completely spontaneous.

Most radioactive substances have many more particles in their nucleus.



Lithium atom

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What's an isotope?

- So isotopes of an atom have the same number of protons, but a different number of neutrons.

- Just because something is called an isotope doesn't necessarily mean it's radioactive.

- Radioactivity is the spontaneous disintegration of atomic nuclei. The nucleus emits alpha particles, ß particles, or *electromagnetic* rays during this process.

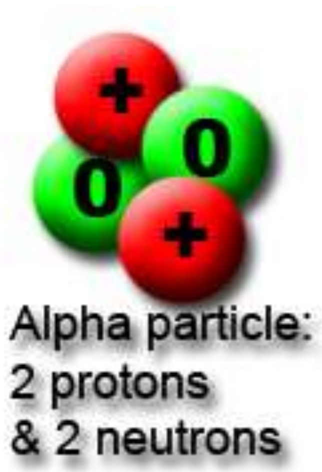
- There are three common types of radioactive decay, alpha, beta, and gamma. The difference between them is the particle emitted by the nucleus during the decay process

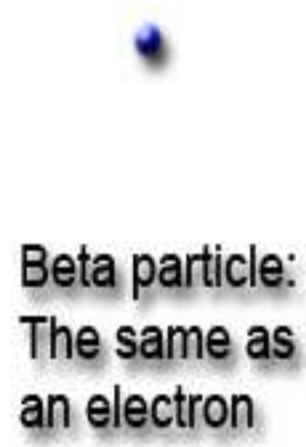
Alpha, Beta particles

- Alpha particles are made of 2 protons and 2 neutrons. We can write them as a helium nucleus .
- Because they have a large charge, alpha particles ionize other atoms strongly.

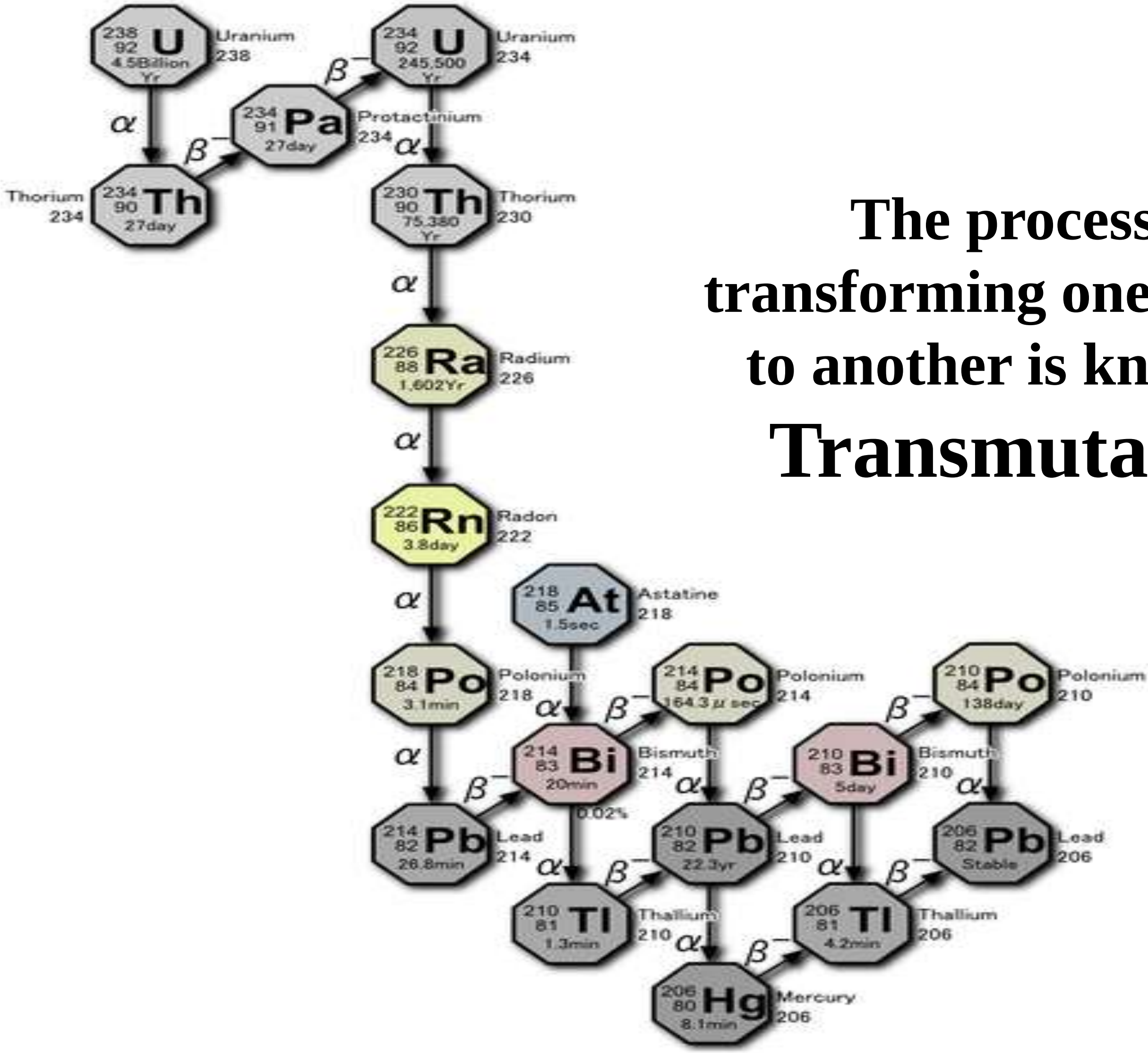
- Beta particles is often an electron. If an electron is involved the number of neutrons in the nucleus decreases by one and the number of protons increases by one.

Alpha and Beta particles





- **Alpha**
- **Beta**



The process of transforming one element to another is known as

Transmutation.

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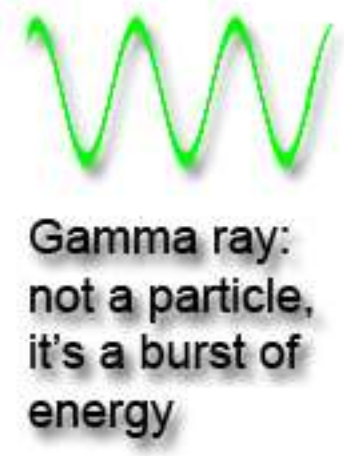
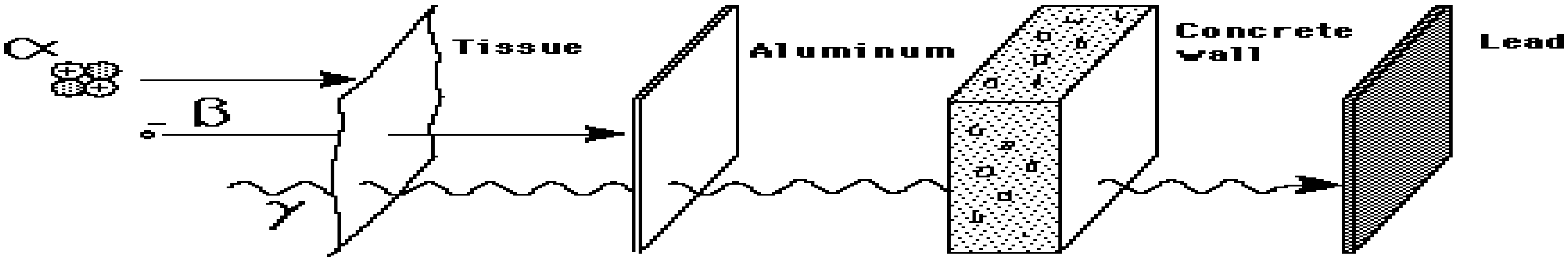
Gamma rays



- **Gamma rays do not directly ionize other atoms, although they may cause atoms to emit other particles which will then cause ionization.**

Penetration of Matter



Penetrating power	**Low** **Alpha**	**Medium** **Beta**	**High** **Gamma**

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Half Life

- Radioactive decay rates are normally stated in terms of their half-lives, and the half-life of a given nuclear species is related to its radiation risk.
- The original term, dating to 1907, was "half-life period", which was later shortened to "half-life" in the early 1950s.

The half-lives for some nuclides of interest

Symbol	Element	Radiation	Half-Life
U-238	Uranium-238	alpha	4,460,000,000 years
Th-234	Thorium-234	beta	24.1 days
Pa-234	Protactinium-234	beta	1.17 minutes
U-234	Uranium-234	alpha	247,000 years
Th-230	Thorium-230	alpha	80,000 years
Ra-226	Radium-226	alpha	1,602 years
Rn-222	Radon-222	alpha	3.82 days
Po-218	Polonium-218	alpha	3.05 minutes
Pb-214	Lead-214	beta	27 minutes
Bi-214	Bismuth-214	beta	19.7 minutes
Po-214	Polonium-214	alpha	1 microsecond
Pb-210	Lead-210	beta	22.3 years
Bi-210	Bismuth-210	beta	5.01 days
Po-210	Polonium-210	alpha	138.4 days
Pb-206	Lead-206	none	stable

- ***Radioactivity* in drinking water is not a new phenomenon, having been present to some extent for thousands of years.**

- Radioactivity in drinking water comes from two sources, naturally occurring… and man made.

  Man made radioactivity is usually found in surface waters… while **naturally occurring** radioactivity comes from bedrock.

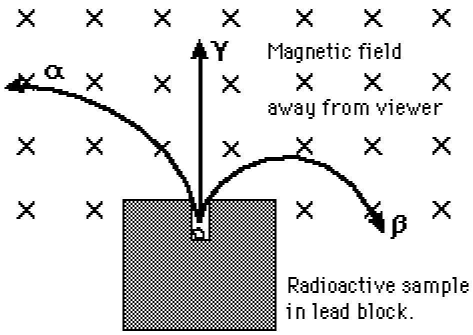
- Radium-226 and radium-228 are natural groundwater contaminants that usually occur in trace quantities. At high exposure levels, radium-226 and radium-228 can cause bone cancer in humans and are believed to cause stomach, lung, and other cancers as well.

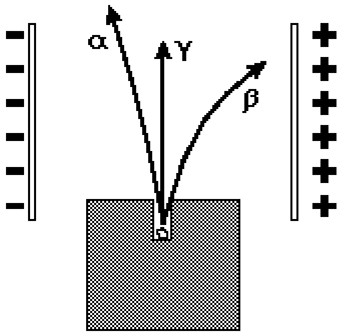
- Uranium is a naturally occurring radioactive contaminant found in both groundwater and surface water. At high exposure levels, uranium is believed to cause bone cancer and other cancers in humans.

- Gross Alpha emitters occur naturally as radioactive contaminants, but several come from manmade sources. They may occur in either groundwater or surface water. At high exposure levels, alpha emitters are believed to cause cancer in humans.

- Beta and photon emitters are primarily manmade radioactive contaminants associated with operating nuclear power plants, facilities that use radioactive material for research or manufacturing, or facilities that dispose of radioactive material. Some beta emitters occur naturally. Beta and photon emitters primarily occur in surface water. At high exposure levels, beta and photon emitters are believed to cause cancer in humans.

Alpha, Beta, and Gamma





- **Alpha ,Beta, and Gamma could be analyzed into three distinct species by either a magnetic field or an electric field.**

Instruments used by Summit Labs

- Gas-Proportional Counter

  (gross alpha/gross beta,Ra-226, Ra-28, U)

- Scintillation Counter (Ra-226)

- Liquid-Scintillation Counter (Radon)

Units:

- 1) Disintegration - count per second
- 2) Becquerel – one disintegration per second (Bq)
- 3) Curie– 37billion disintegrations per second (pCi)
- 4) pCi/l

Required Detection Limits and MCL

Contaminant	Detection Limit	MCL
Gross Alpha	3 pCi/l	(except U and Radon) 15 pCi/l
Gross Beta	4 pCi/l	(Beta and photon emitters) 4mrem/year
Ra-226	1 pCi/l	
Ra-228	1 pCi/l	
Ra-226+Ra-228		5 pCi/l
Uranium	2 pCi/l	30 pCi/l

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Dose:

- Rad- energy absorbed by tissue that is exposed to radioactivity.
- Rem combines the amount of radiation exposure (Rad) with its alleged impact on health.

- Concentration=4mrem/yer

4mrem/yr/(2L/d x 365.25d/yr x2.29x10(-5)mrem/pCi)=239 pCi/L

Sample Collection, Preservation and Handling

- Collect samples in 1 gallon plastic containers.
- It is recommended that samples be preserved at the time of collection by adding…
- Enough 1N HNO3 to the sample to bring it to pH 2

  If samples are to be collected without preservation, they should be brought to the laboratory within 5 days, then preserved and held in the original container for a minimum of 16 hours before analysis.

Holding time

- The correct holding time for gross alpha, Ra-226 and Ra-228, and uranium is 6 months (see Manual for the Certification of Laboratories Analyzing Drinking Water EPA 815-B-97-001, March 1997 Criteria and Procedures Quality Assurance); however, for annual compositing of 3 radionuclide samples, the holding time is 12 months. This confusion was the result of a mismatch between the certification manual and the regulation. A footnote was added to the March 1997 edition of the certification manual, which acknowledged the conflict and stipulated a 12 month holding time for a composite. Therefore, systems can composite radionuclide samples during the initial monitoring period for up to one year.

Methods For Analysis of Drinking Water

- Gross Alpha (EPA 900.0)
- Gross Beta (EPA 900.0)
- Radium 226 (EPA 903.0)
- Radium 228 (EPA 904.0)
- Uranium (EPA 908.0)

Methods Summary

- 900.0 Method Summary
- 1) Gross Alpha/Beta (evaporation) 100 ml acidified sample evaporated to 20 ml and quantitatively transfer on the pre-weight planchet.
- 903.0 Method Summary
- 1)1 L acidified sample. Ra-226 is co-precipitated with Ba as Sulfate
- 2) Precipitate is separated from sample matrix and supernate is discarded
- 904.0 Method Summary
- 1) 1 L acidified sample. Ra-228 is co-precipitated with Ba and Pb as Sulfate
- 2) The (Ba-Ra)SO4 precipitate is dissolved in basic EDTA. The progeny, Ac-228, is chemically separated from its parent by repeatedly forming the (Ba-Ra)SO4
- 3) Ac-228 is then separated from Ra-228 by precipitation as a OH.(save supernate)
- 4)This is the end of ingrowth and beginning of Ac-228 decay.
- 5)Ac-228 is co-precipitated with Y as Ac-Y2(c2O4)3
- Counted on a low-background Alpha/Beta gas proportional counter.

DATA EVALUATION

- RANDOM Uncertainties: Includes the radioactive decay process itself, random timing uncertainties, variations in collection, sample preparation, positioning of the sample at the detector, etc. The list is nearly endless.
- SYSTMATIC Uncertainties: can be considered to be conceivable sources of inaccuracy which are biased and not subject to random fluctuations and those which may be due to random cause but cannot be or are not assessed by statistical methods.
- QA /QC data are key in defining the level of uncertainty.

QA /QC

- Blank- Instrument Background Trip blank
- Method Blank

- 1) Duplicates – Extra sample taken from same place, analyzed independently to document sampling precision.
- 2) Matrix Duplicate – Intralaboratory split sample used to document method precision in a given matrix.
- 3) LCS- Spike- Known activity/nuclide addition to deionized water.
- 4) Matrix Spike- Known activity/nuclide addition to sample aliquot prior to preparation to document bias in a given matrix. (Matrix interference)
- 5) Matrix Spike Duplicate- Intralaboratory split sample with known additions prior to preparation to document precision and bias.

Conclusion

- A gross alpha test is the first step in determining the level of radioactivity in drinking water.
- If gross alpha activity is less than 5 pCi/l no further action is required.
- If gross alpha activity is greater than 5 but less than 15 pCi/l testing for Radium 226 and 228 is required.
- If gross alpha activity is greater than 15 pCi/l testing for Uranium is required.
- If gross beta activity is greater than 50 pCi/l than testing for the individual nuclides is required.

- **Thank you for your attention!**

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