Radioactivity in everyday life

by Maja Grützmann

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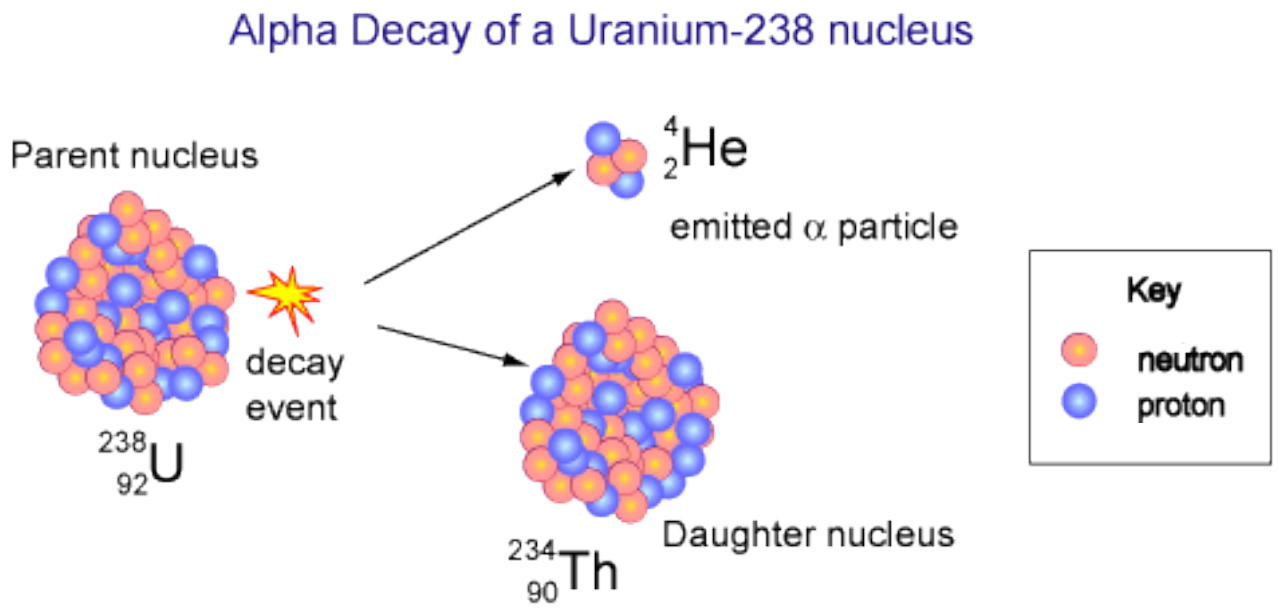
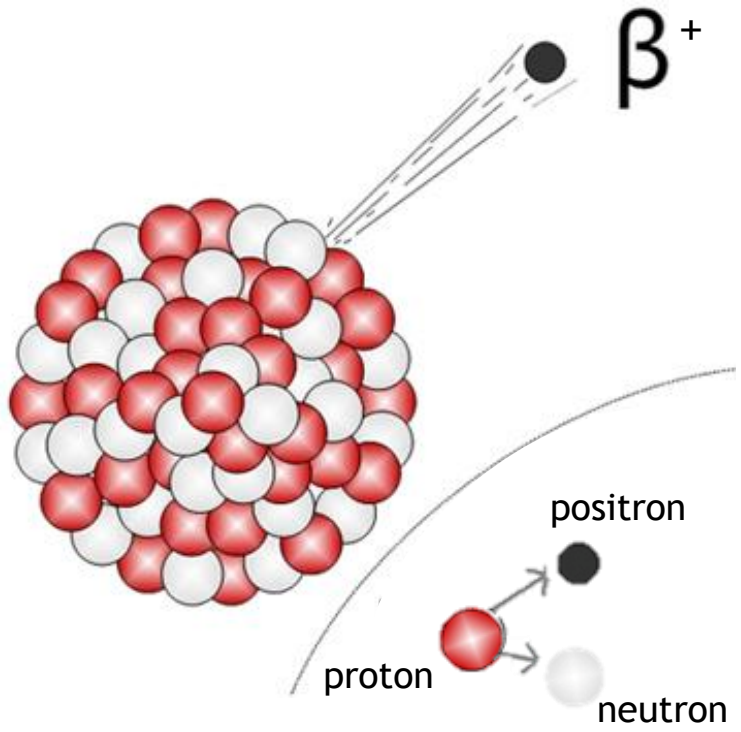
Alpha decay



$$^{A}_{Z}X \rightarrow ^{A-4}_{Z-2}Y + ^{4}_{2}He$$

Picture: http://study.com/cimages/multimages/16/alphadecay.gif

Beta decay

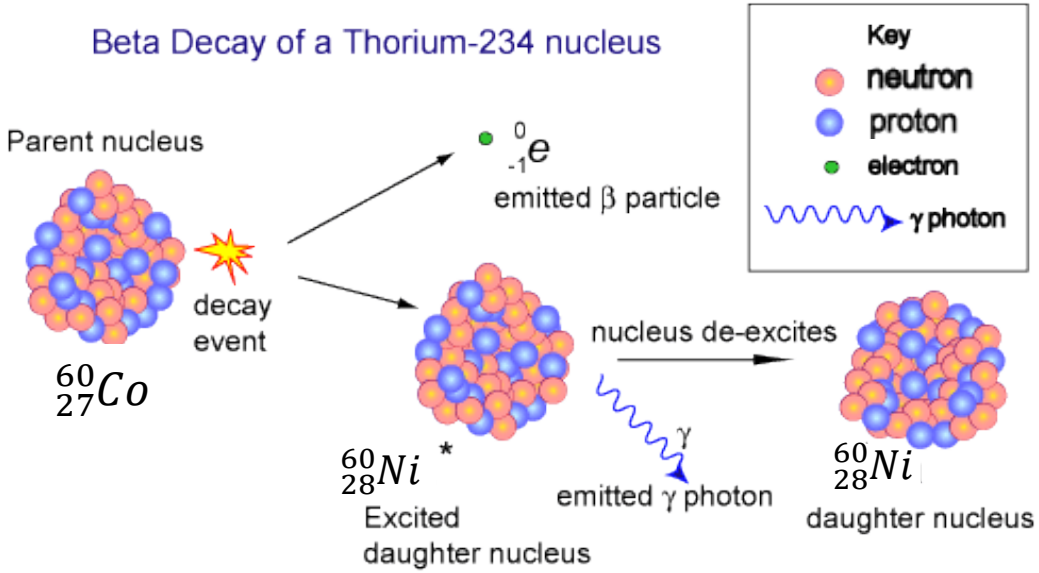


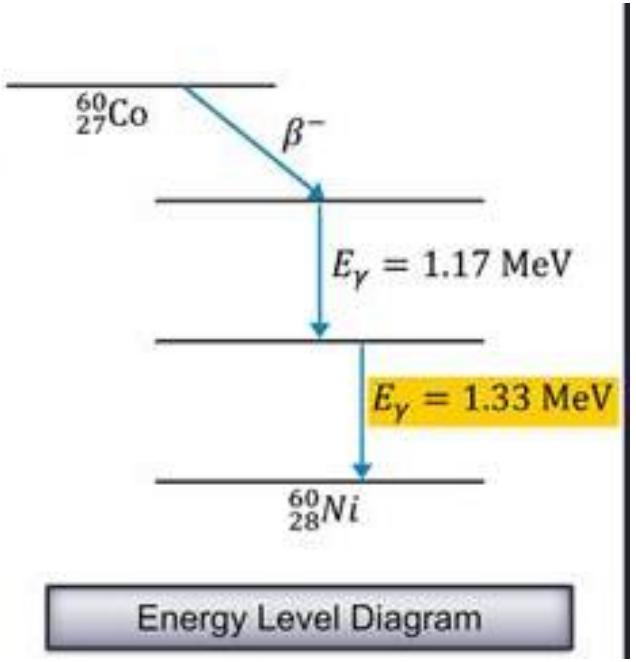
$$^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e + \bar{\nu}$$

$$^{1}_{1}p \rightarrow {}^{1}_{0}n + {}^{0}_{+1}e + \nu + \bar{\nu}$$

Picture: http://legacy.jefferson.kctcs.edu/techcenter/Classes/Physics/AtomicNuclearandModernPhysics/BetaMinusDecaySmall.jpg

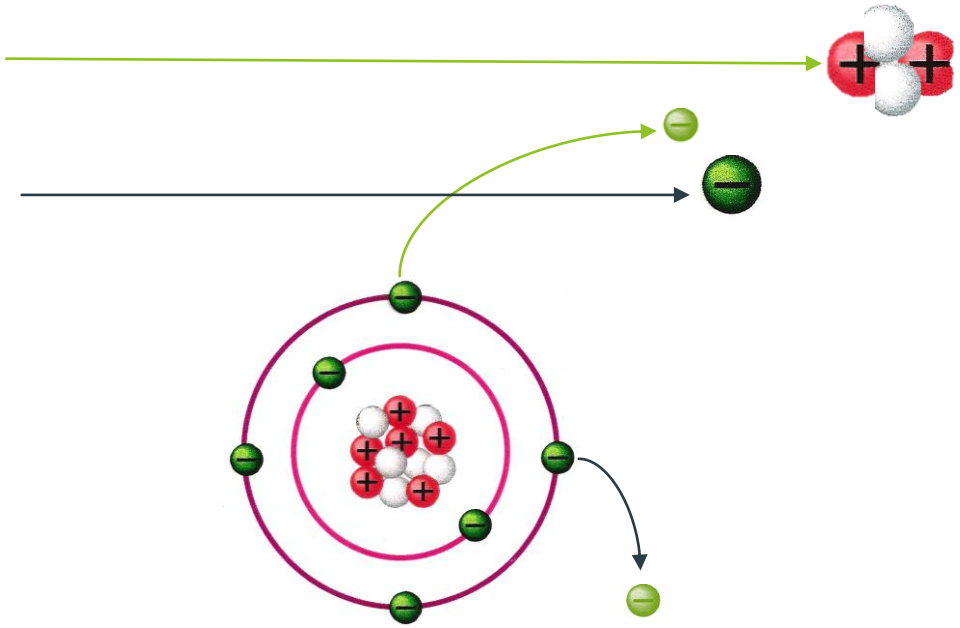
Gamma rays

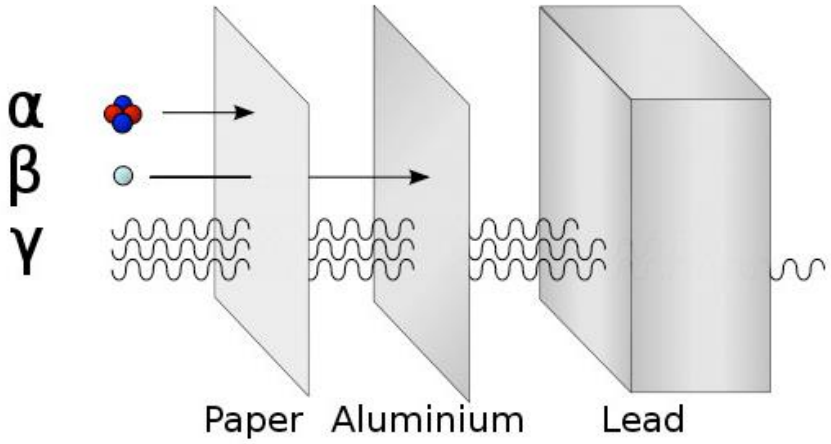




Pictures: https://d34h5de3fkci09.cloudfront.net/100000000082/data/lessonImg/Alpha__Beta__and_Gamma_Decay_files/image004.jpg
https://www.atnf.csiro.au/outreach//education/senior/cosmicengine/images/sun/betadecay.gif

Interaction of charged particles





Pictures: http://anguerde.com/TTF-227173-atom.html
http://ecuip.lib.uchicago.edu/multiwavelength-astronomy/images/gamma-ray/science/Alfa-beta-gamma-radiation-penetration.jpg

Interaction of photons

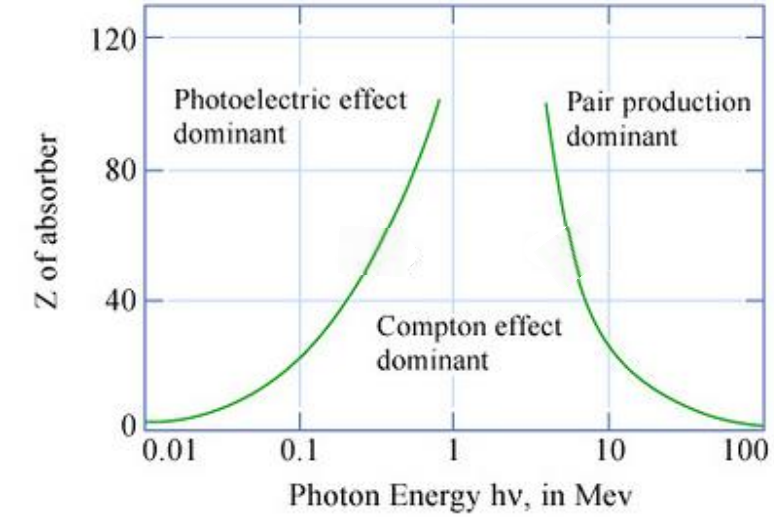
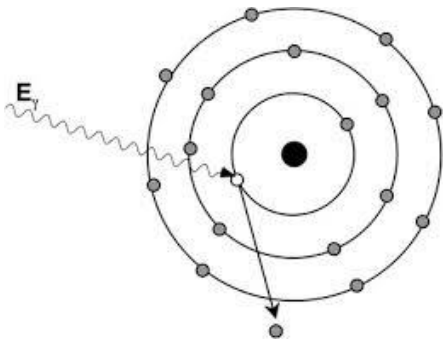
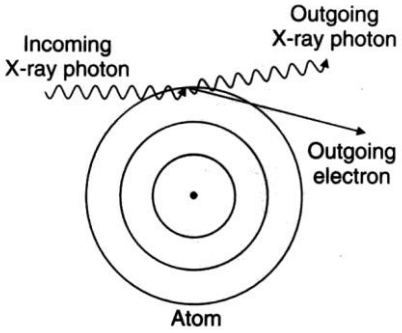


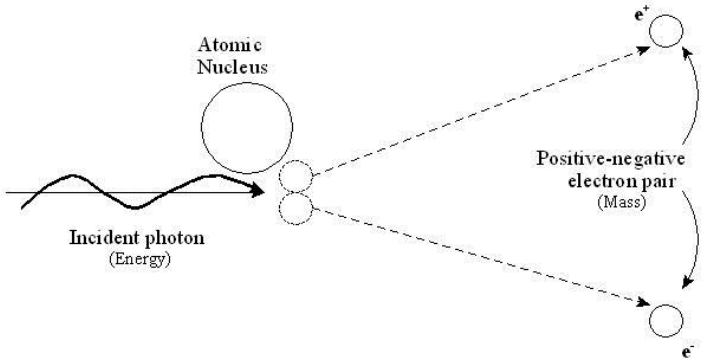
photo effect



Compton effect



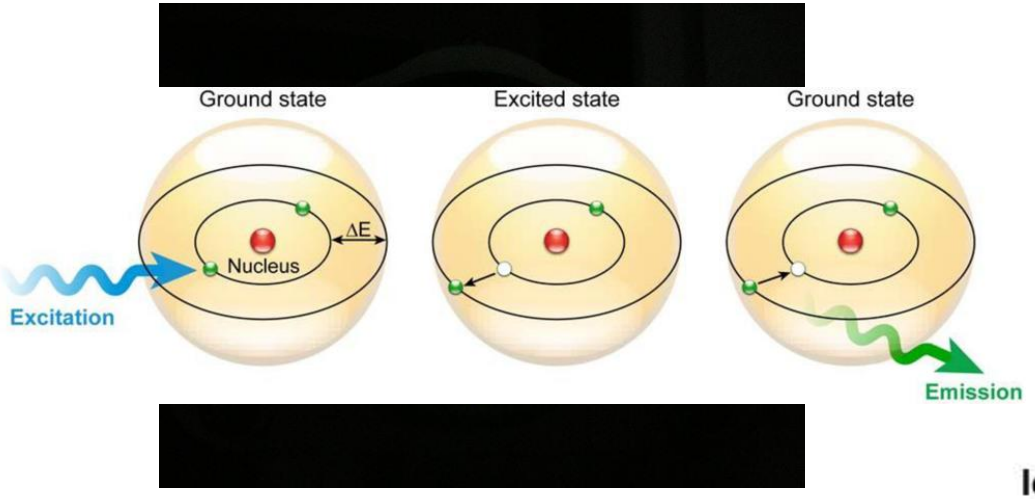
pair producing

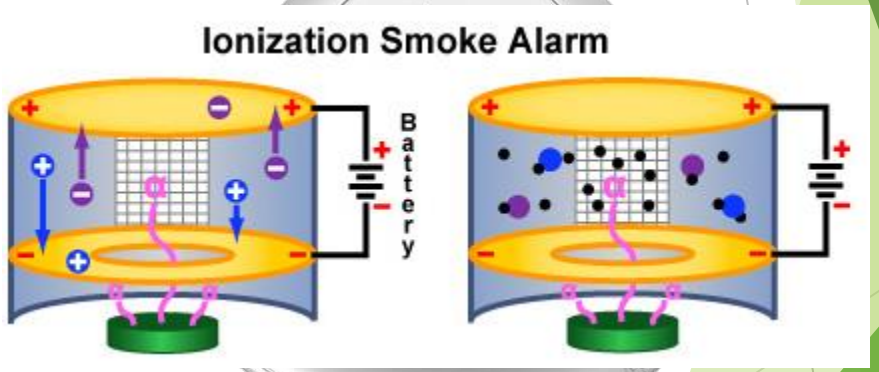


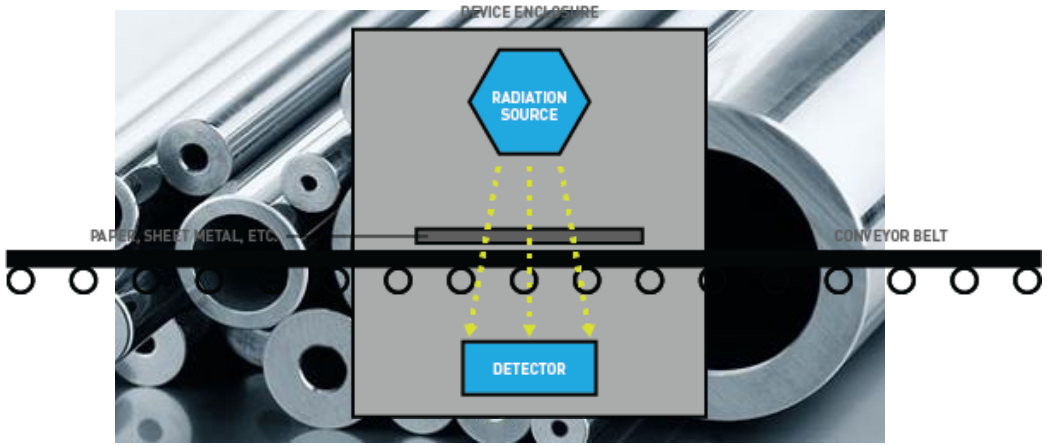
Pictures: https://c1.staticflickr.com/3/2446/3706466731_a60ff94037.jpg
https://www.researchgate.net/publication/278707900_Nuclear_Oncology
https://i.pinimg.com/originals/15/ec/8d/15ec8d1c8d7dded0592b39ebb9075289.jpg
http://ryuc.info/images/pair_production.JPG

Usage of ionizing radiation

Pictures: https://www.cantlawyers.vn/wp-content/uploads/2014/05/Seamless-Stainless-Steel-Tubes.jpg
https://www.i326.files.wordpress.com/2013/07/ionization.jpg
https://upload.wikimedia.org/wikipedia/commons/8/88/RadPTbEQBq.jpg
https://lh3.ggpht.com/-8qyFnE_Qq0/TbcPXgjy

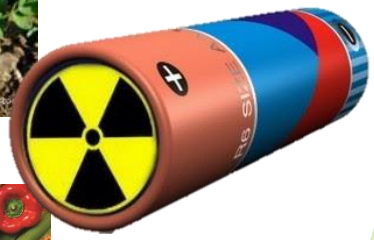






Usage of ionizing radiation

- Medicine
- Material inspection
- Energy
- Archaeology
- Agriculture
- Items of daily use
  - Ceramics and glass
  - Food
  - Package



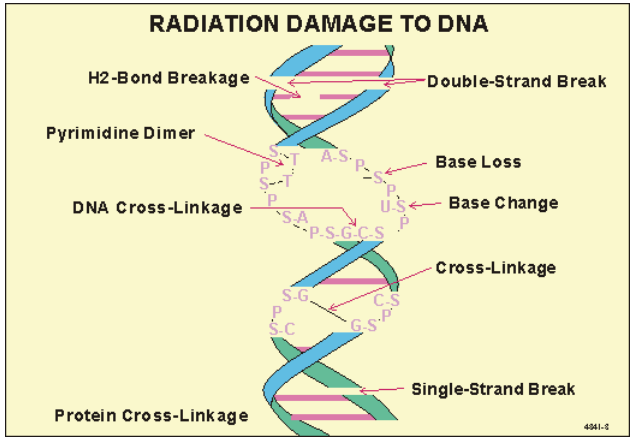
Pictures: http://www.youthareawesome.com/wp-content/uploads/2015/03/fruit.jpg http://i.imgur.com/NULmNuu.jpg http://www.clearviewbag.com/wpcontent/uploads/2015/10/polyethylene-roll.jpg http://2.bp.blogspot.com/ https://media.mercola.com/ImageServer/Public/2013/December/fertilizer.jpg http://www.councilchronicle.com/wp-content/uploads/2015/07/Fossil-Fuels-next-Victim-is-Carbon-Dating.jpg https://dingo.care2.com/pictures/causes/3159/3158812.large.jpg http://i3.ytimg.com/vi/fg6jYChQdTA/mqdefault.jpg https://www.nrc.gov/images/about-nrc/radiation/nuclear-medicine.jpg

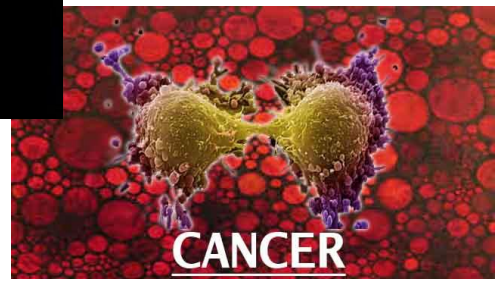
Effects on human body

- Ionization of atoms
- Destroys chemical bonding
- Leaves radicals

⇒

- Radiation sickness
- Cancer and other sicknesses
- Inherited defects





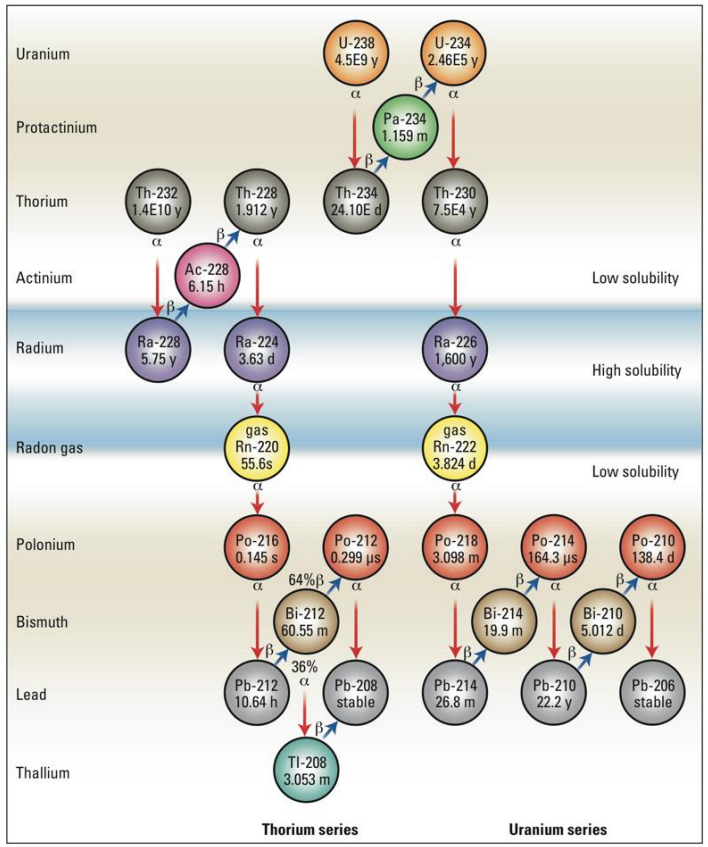
Pictures: http://i1-news.softpedia-static.com/images/news2/Specialists-Find-Ways-to-Counteract-Radiation-Poisoning-2.jpg http://3s9h7h3y0i6u2n9j4h5vgkf1-wpengine.netdna-ssl.com/4 wp-content/uploads/2013/10/cancer.jpg https://qph.ec.quoracdn.net/main-qimg-e73f4147d39995ee97a3f7631f92a8e1

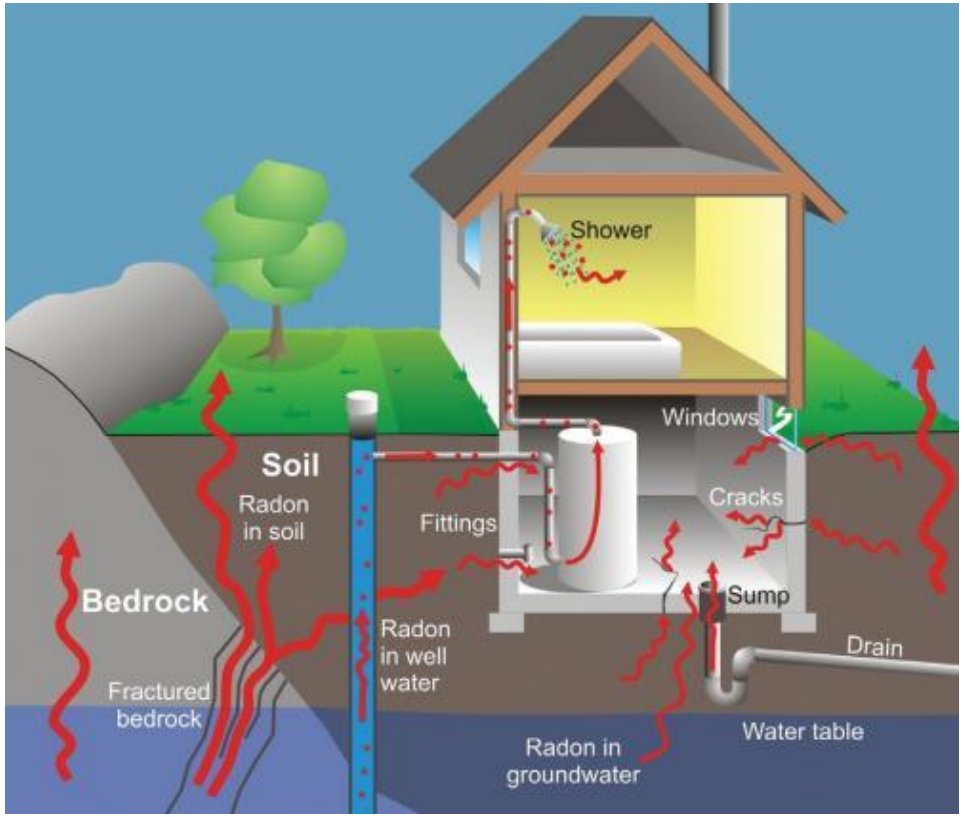
Sources of radiation

- **Man-made**
  - Medical treatment
  - Nuclear weapons testing
  - Already mentioned items
- **Cosmic radiation**
  - Originates from outer space
  - Interacts with atmosphere
  - Secondary particles
- **Cosmogenic radiation**
  - Radioisotopes formed in atmosphere
  - Cosmic rays interact with atoms in atmosphere
- **Terrestrial radiation**
  - Radioactive elements that have always been present on earth
  - Decay-products

Radon pollution

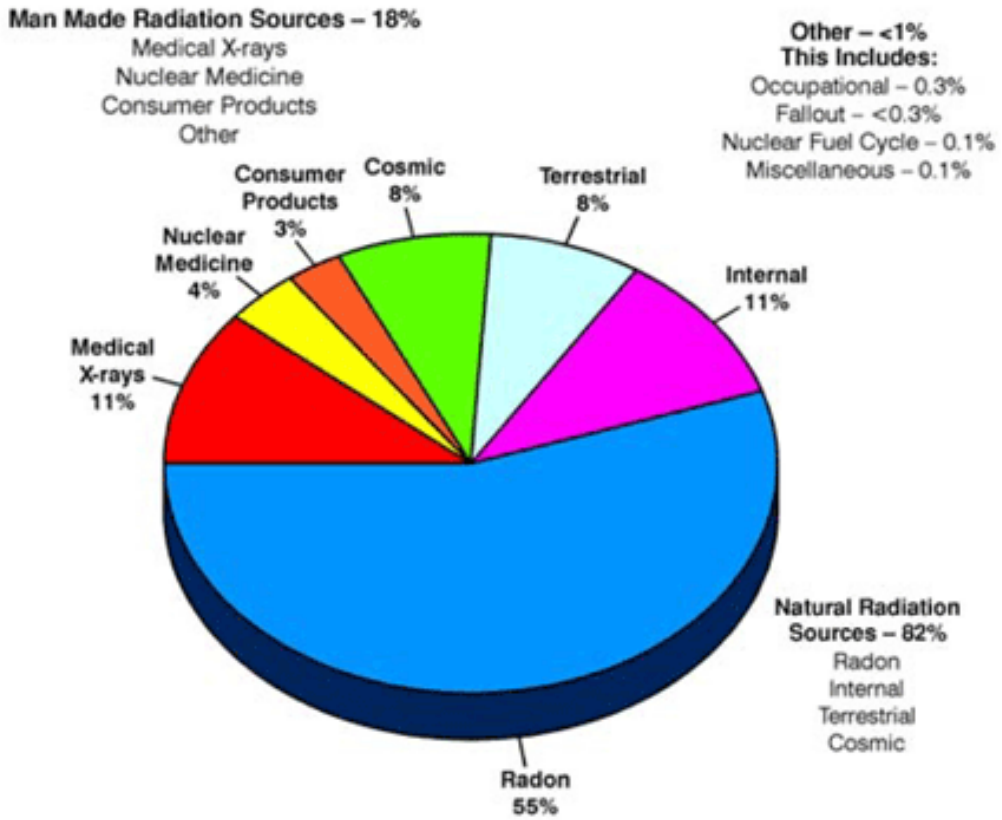
Thorium and Uranium series





Pictures: http://bracebridgerealty.ca/i/blog/54-how-does-radon-enter.jpg
https://ehp.niehs.nih.gov/wp-content/uploads/2015/07/ehp.1408855.g001.png

Ionizing Radiation Exposure to the Public



The above chart is taken from the National Council on Radiation Protection and Measurements (NCRP) Report No. 93, "Ionizing Radiation Exposure of the Population of the United States," 1987.

This chart shows that natural sources of radiation account for about 82% of all public exposure while man-made sources account for the remaining 18%.

Picture: http://azargauranium.com/wp-content/uploads/2014/06/ionizingradiation.gif

Conclusion

- Radioactivity is the **decay of atomic nuclei** combined with particle and energy emission (α: Helium nucleus, β: electron or positron, γ: EM wave)
- Radiation **ionizes** material, **changes** chemical and biological **characteristics**
- Very **useful in many fields** (medicine, energy, industry, archaeology, …)
- Greater dose **can be harmful**
- Naturally occurring radiation **everywhere** (cosmic, cosmogenic, terrestrial)
- Natural sources contribute much more than man-made ones

Further references

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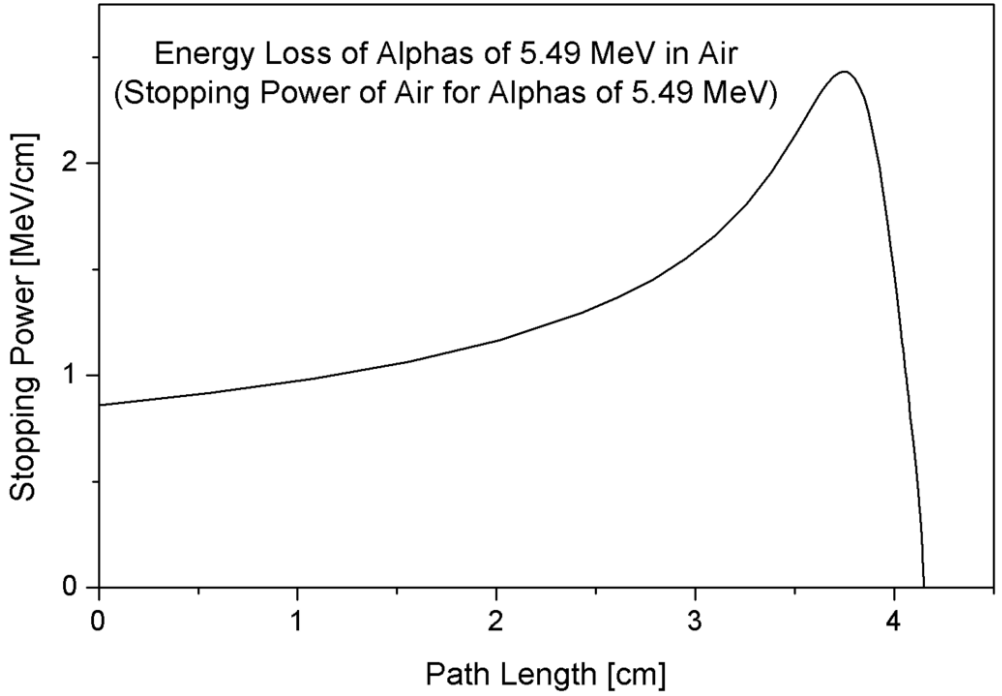
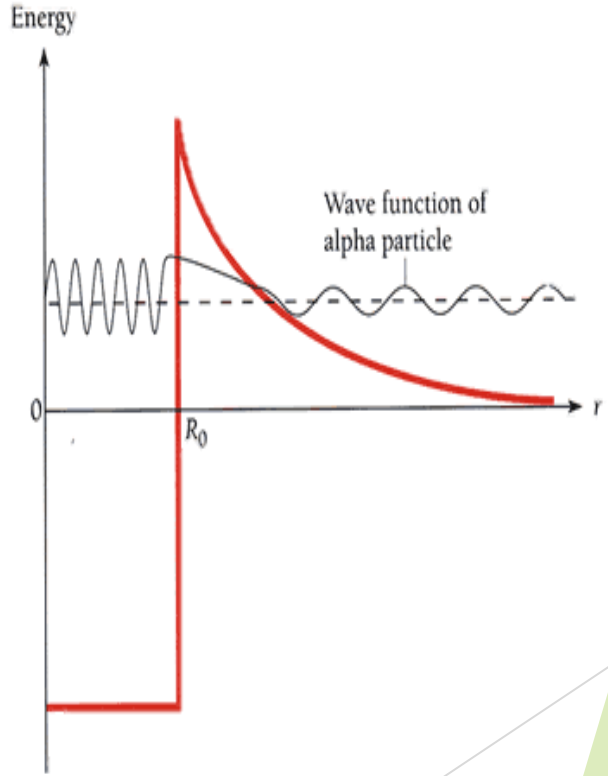
Alpha decay



Tunnel effect



Pictures: https://upload.wikimedia.org/wikipedia/commons/thumb/d/df/Bragg_Curve_for_Alphas_in_Air.png/1200pxBragg_Curve_for_Alphas_in_Air.png
http://sdsuphysics.org/physics197/p197_images/p197_classicalquantum.gif

Dosimetry

Activity	$A = \frac{dN}{dt}$	$[A] = Bq\ (Becquerel)$
Dose	$D = \frac{W}{m}$	$[D] = \frac{J}{kg} = Gy\ (Gray)$
Equivalent dose	$D_q = q * D$	$[D_q] = \frac{J}{kg} = Sv$ (Sievert)

Type of radiation, R	Energy range	Quality or weighting factor, w_R
Photons, electrons	All energies	1
Neutrons	<10 keV	5
	10–100 keV	10
	100 keV–2 MeV	20
	2–20 MeV	10
	>20 MeV	5
Protons	<20 MeV	5
Alpha particles, fission fragments, heavy nuclei		20

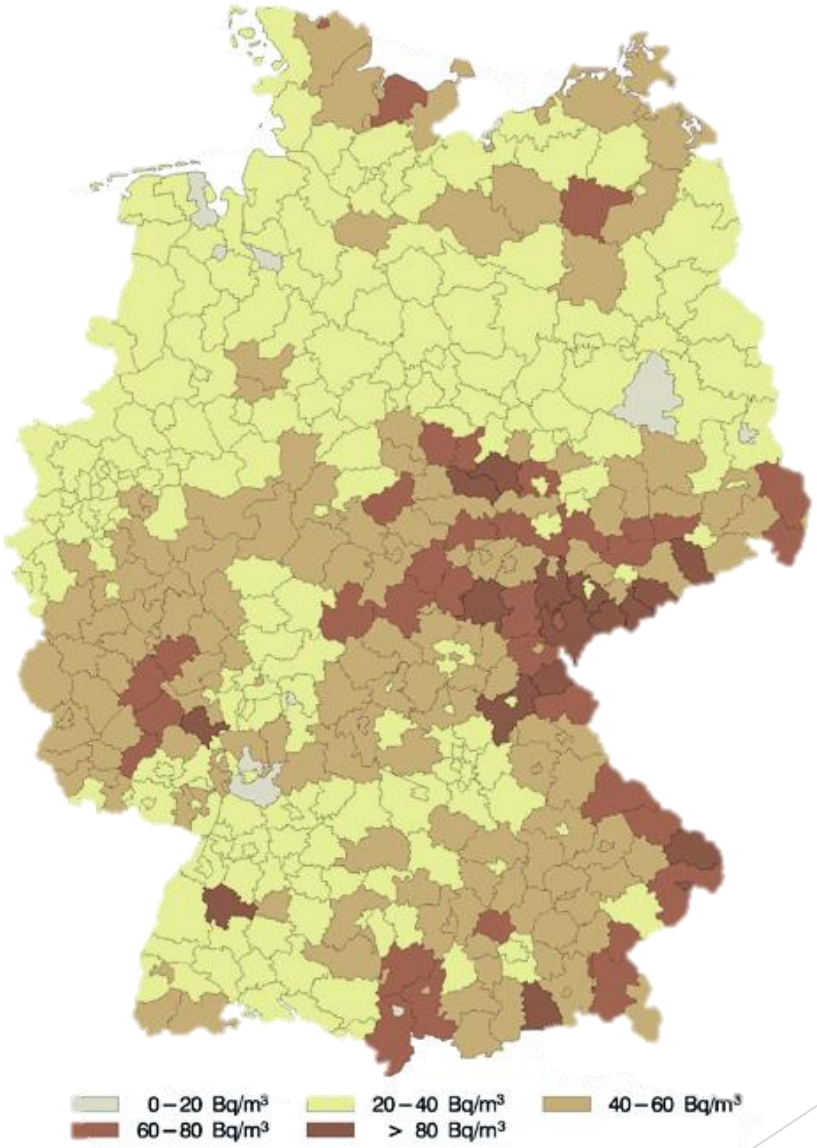
Picture: https://www.nucleonica.com/wiki/images/1/1f/Table_1.jpg

Interaction of charged particles

scattering	elastic	inelastic
with electron-shell	only small ΔE	excitation or ionization of the atom →deceleration
with nucleus	change of direction momentum transfer	Coulomb field →loss of velocity, emission of radiation

Radon pollution

Average	Bq/m³
Open air	15
Room air	60
Drinking water	6.000
Soil air in 1 m depth	5.000–500.000



Picture: http://www.bfs.de/SharedDocs/Bilder/BfS/DE/ion/umwelt/radon-gebaeude-landkreis.jpg?__blob=poster&v=3