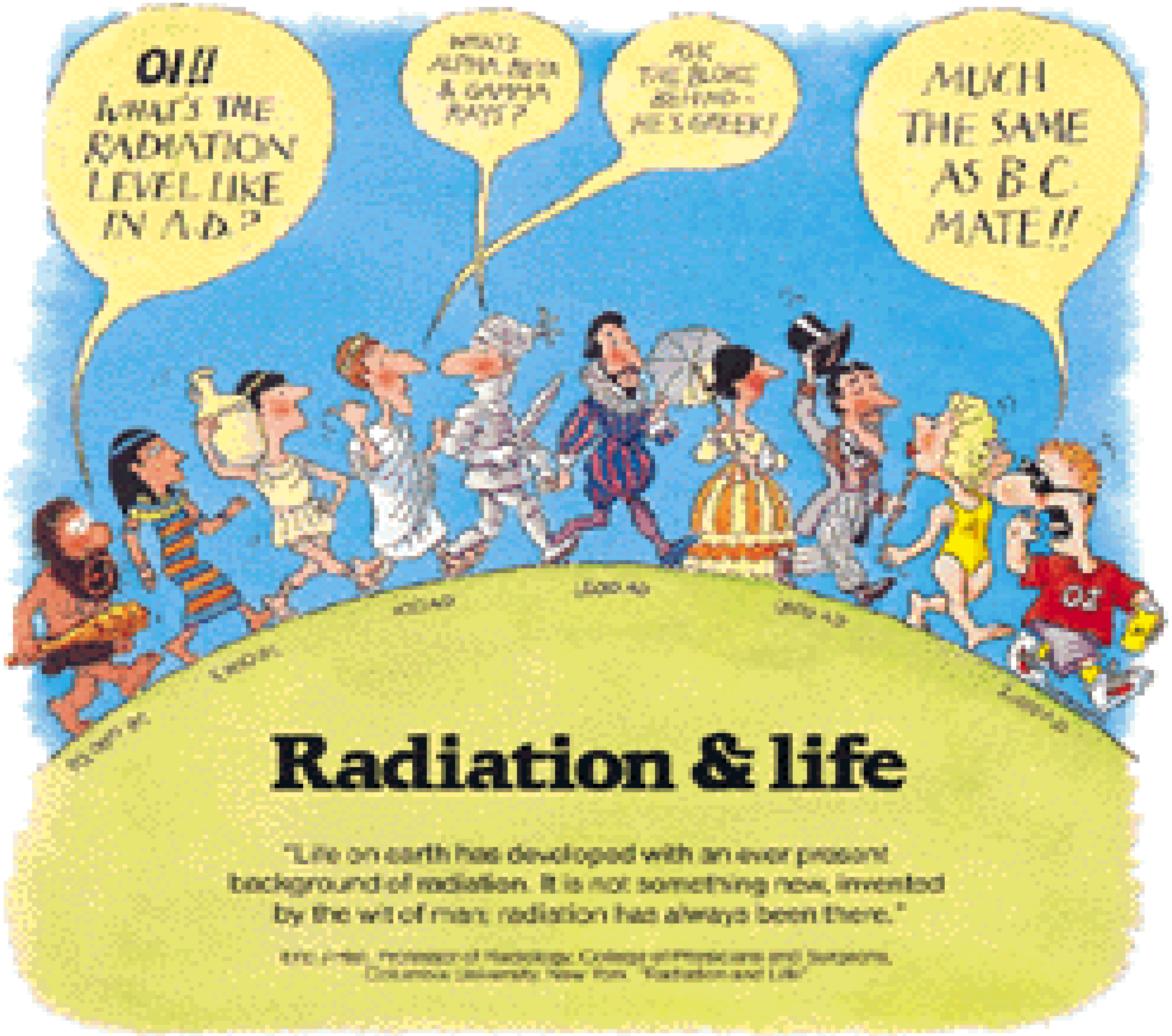
Dosimetry



Sanja Dolanski Babić
May, 2018.

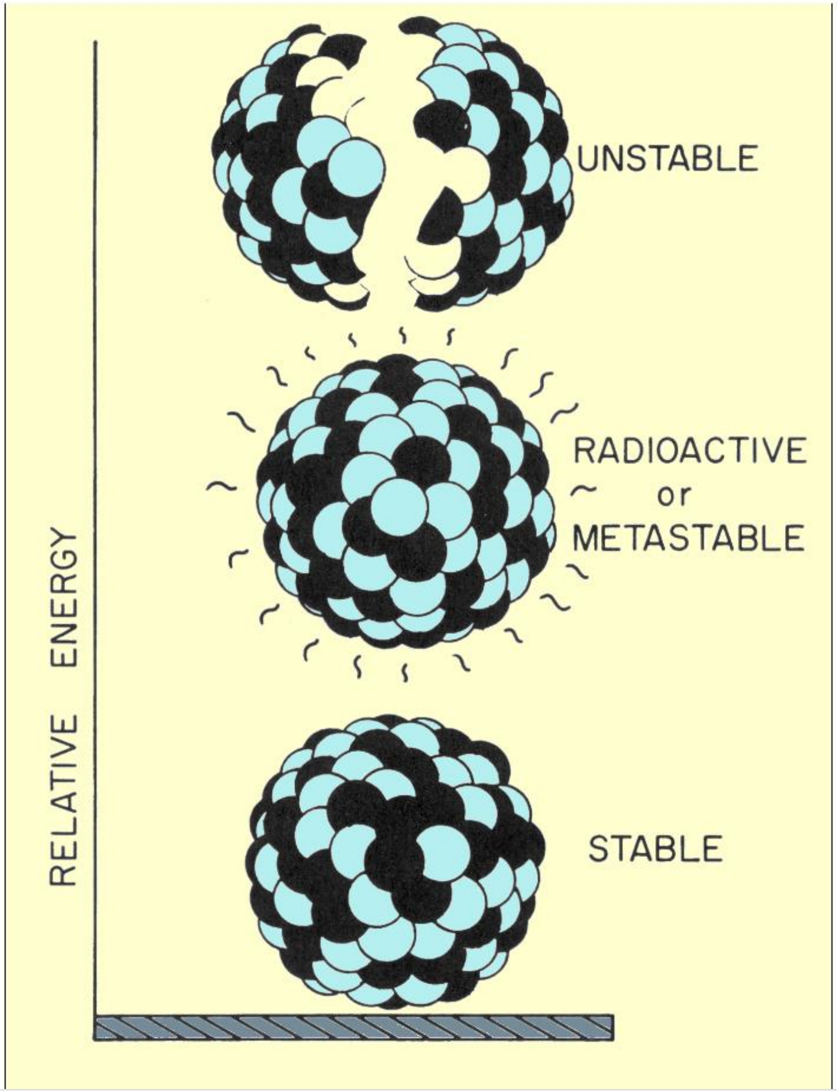
What’s the difference between radiation and radioactivity?

Radiation - the process of emitting energy as waves or particles, and the radiated energy

Radioactivity - the property of radionuclides of spontaneously emitting ionizing radiation

Sources of radiation – natural and artificial

Radionuclide – radioactive nucleus



The three levels of nuclear stability

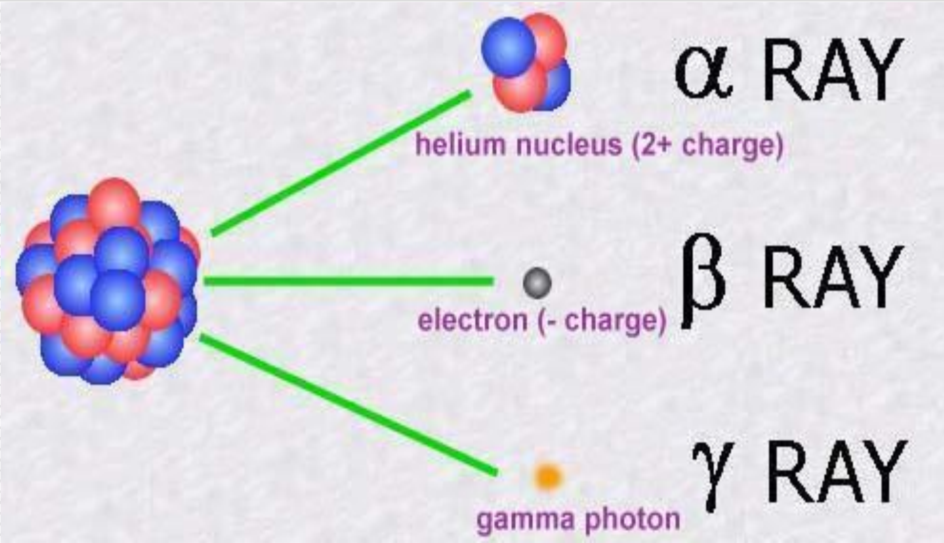
Radioactive isotopes

- Radioactive isotopes (radionuclides) of some elements (^{14}C, ^{15}N, ^{133}I,...) have unstable nuclei which decay in the process of transmutation to more stable nuclei.

- These new formed nuclei are usually in the excited state and relax to the ground state by the emission of radiation: in the form of particles (α, β) or photons (γ).

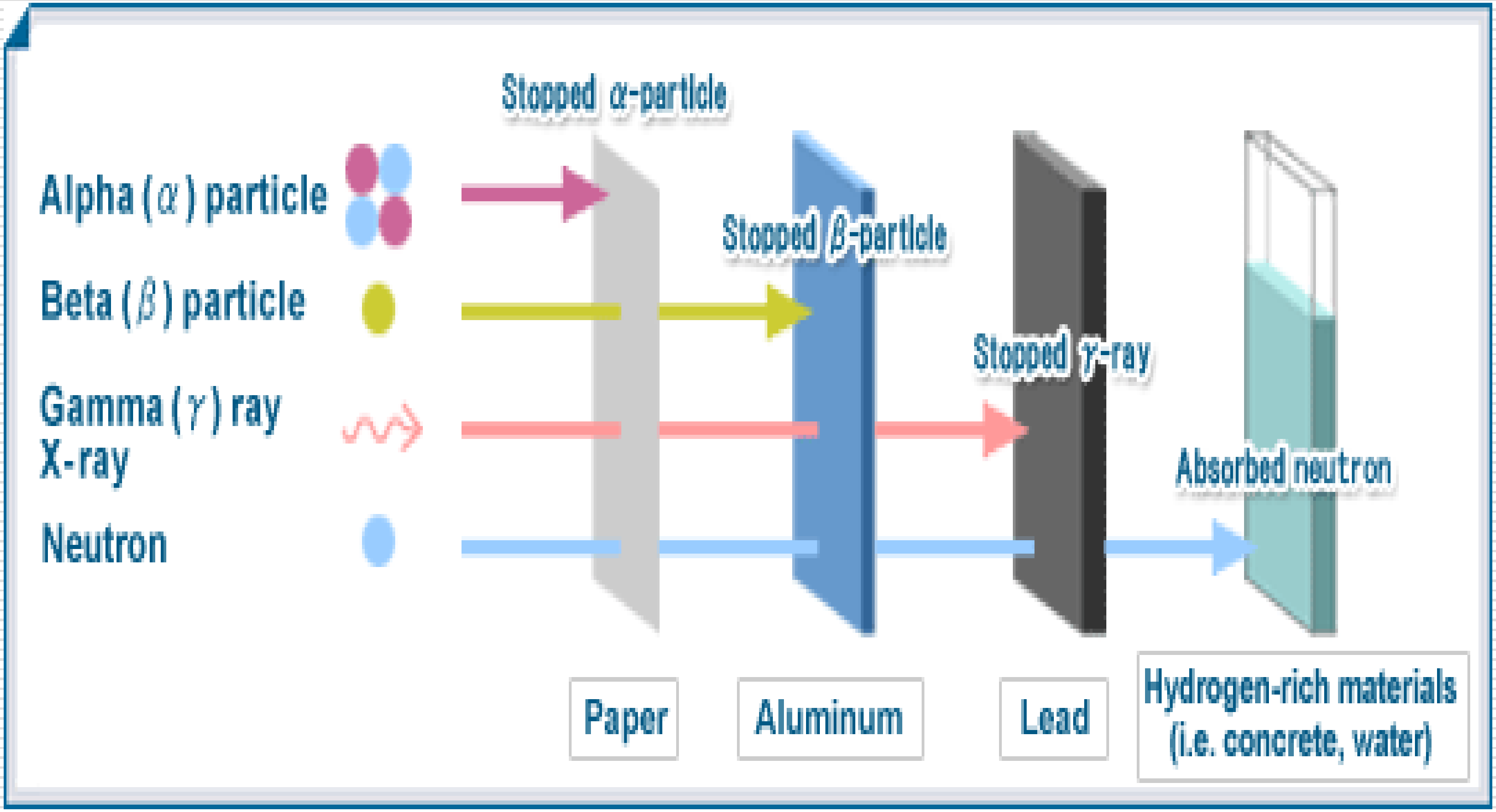
Types of ionizing radiation

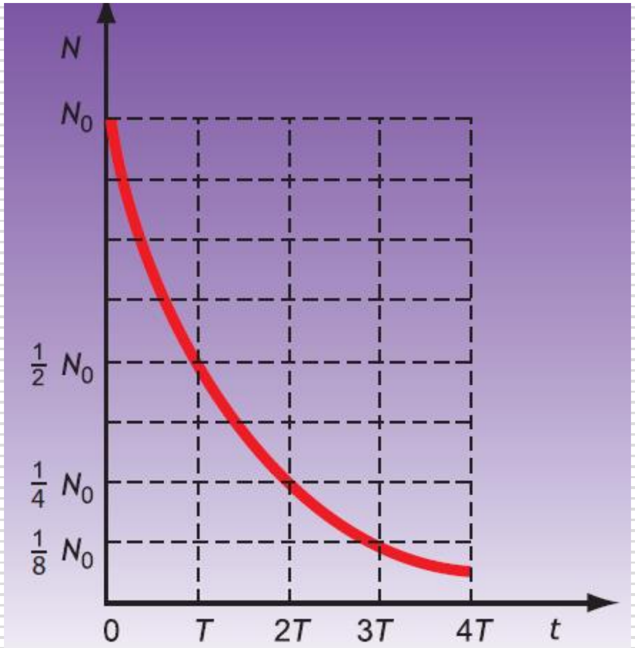
Radioactivity is a spontaneous transmutation of an atom into another atom with the emission of radiation.

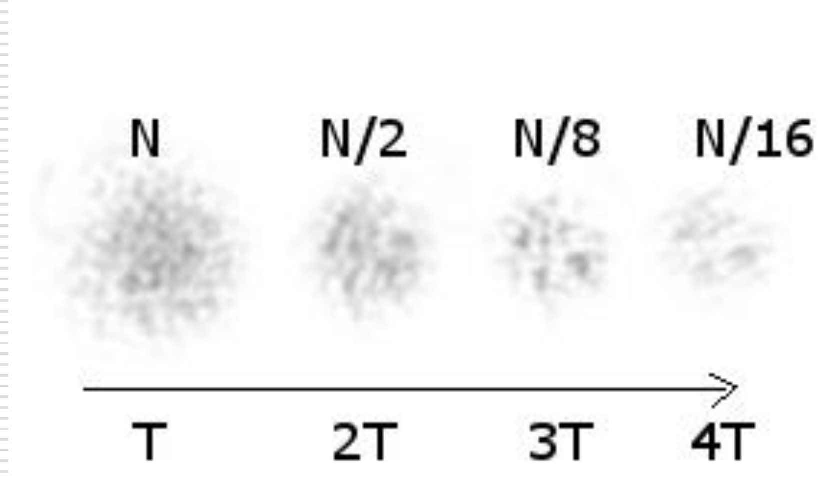


http://www.youtube.com/watch?v=o-9yt7OAYmE&feature=related

Types of ionizing radiation







$$N = N_0 \cdot 2^{-t/T_{1/2}}$$

The half-life is the time taken for half of the atoms of a radioactive substance to decay.

the half-life time

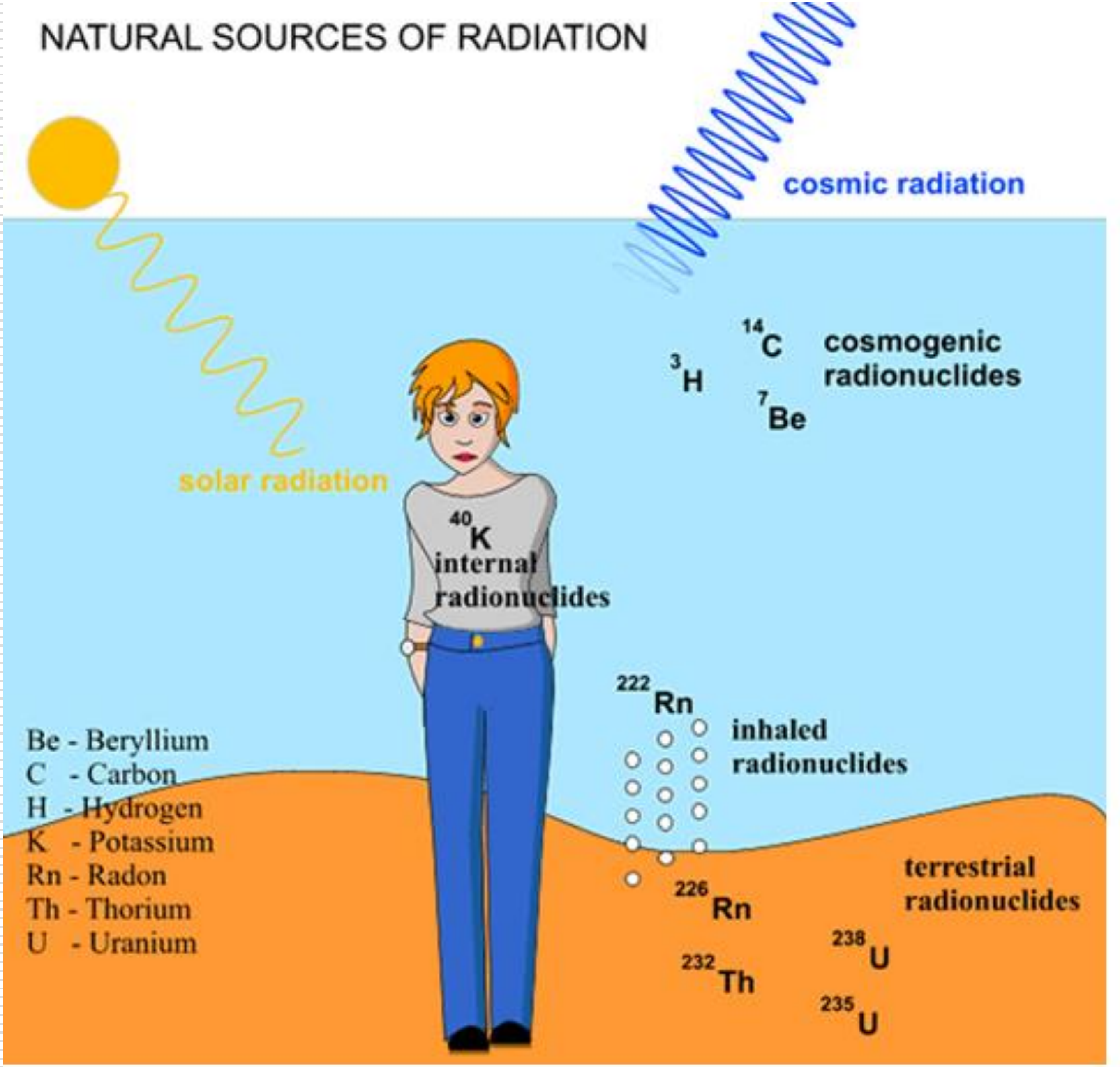
$$A = A_0\, e^{-T_{1/2}/t}$$

$$\lambda = \frac{\ln 2}{T_{1/2}}$$

activity – the number of decays in 1 s

radioactive decay constant

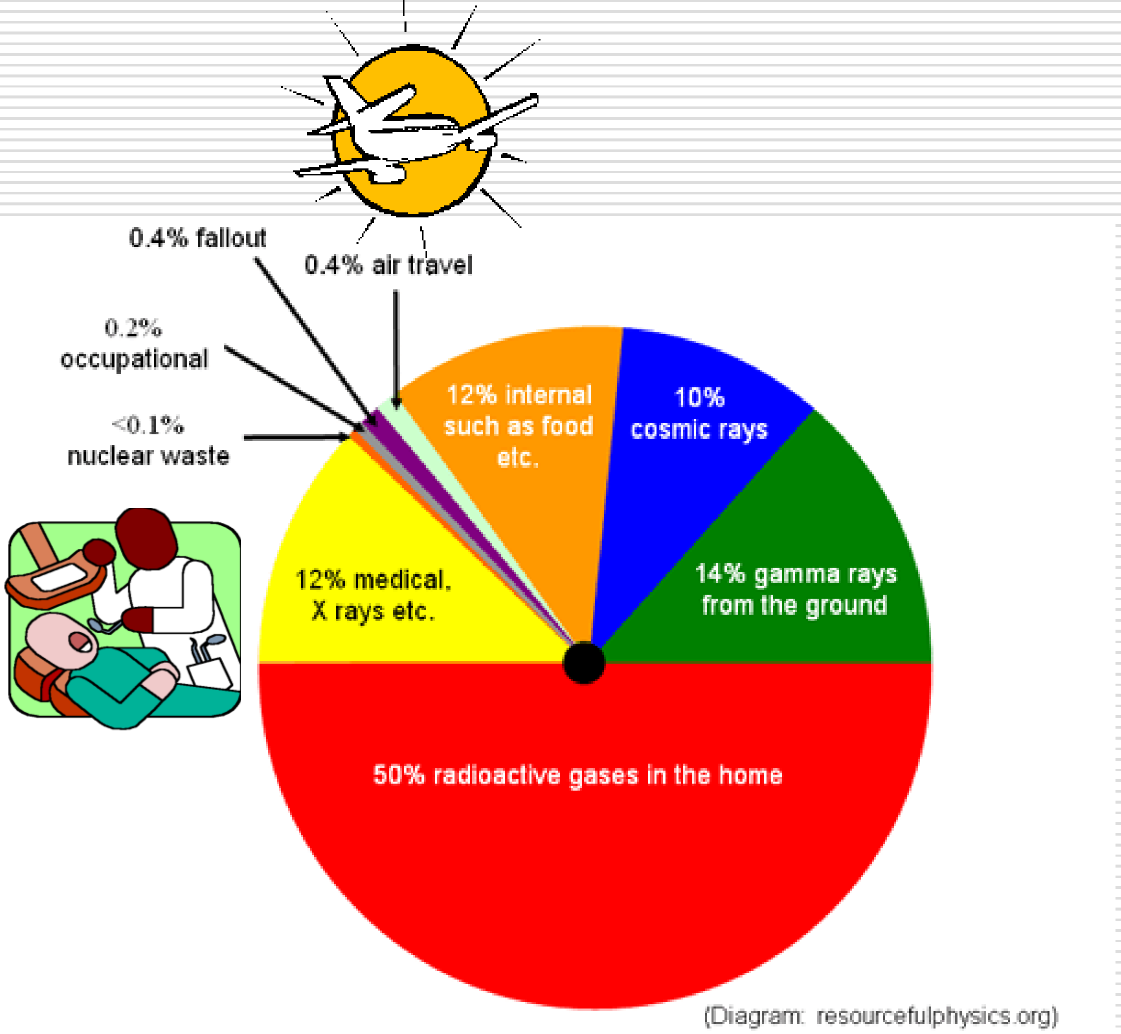
http://www.splung.com/content/sid/5/page/radioactivity


NATURAL SOURCES OF RADIATION
cosmic radiation
solar radiation
14C
3H
7Be
cosmogenic radionuclides
40K
internal radionuclides
222Rn
inhaled radionuclides
226Rn
232Th
238U
235U
terrestrial radionuclides
Be - Beryllium
C - Carbon
H - Hydrogen
K - Potassium
Rn - Radon
Th - Thorium
U - Uranium

Radionuclides used in medicine

radionuclides	half time
cesium - 137	30.1 years
cobalt - 58	71.3 days
iodine - 124	4.17 days
iodine - 130	12.4 hours
iodine - 131	8.041 days
iron - 52	8.3 hours
molybdenum - 99	66.02 hours
technetium – 99m	6.02 hours

Pie chart for background radiations



Standard warning sign for a possible radioactive hazard

Devices for detecting and measuring of radiation:

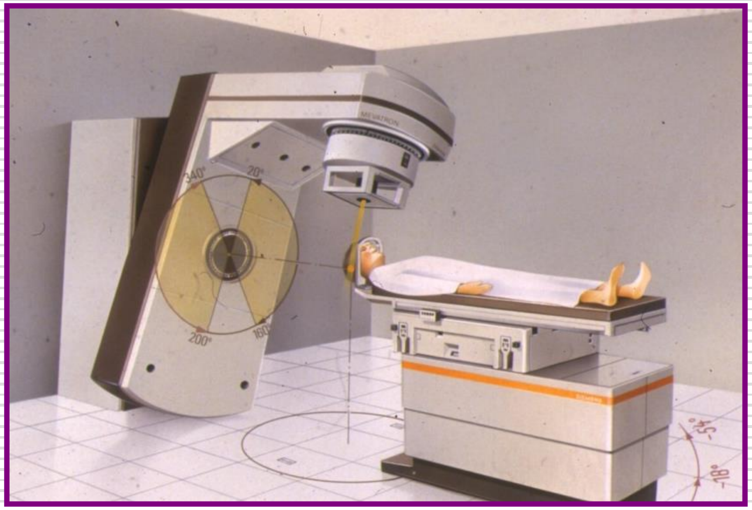
1. Devices for track visualisation of radioactive particles – radiographic track and Wilson cloud chamber

2. Counters (detectors) – Geiger counter, scintillation detector, semiconductor detector, gamma-camera etc.

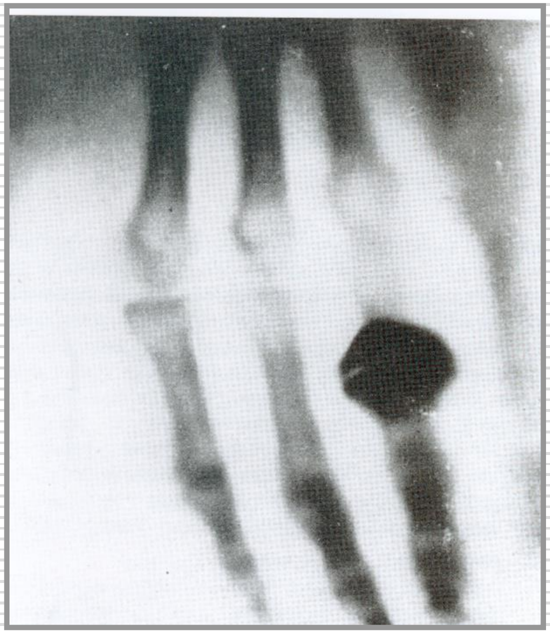
3. Dosimeter is a small portable instrument for measuring and recording the total accumulated dose of ionizing radiation a person receives – such as a film badge, thermoluminescent or pocket dosimeter

Radiation detectors are used in: nuclear physics, medicine, particle physics, astronomy and industry

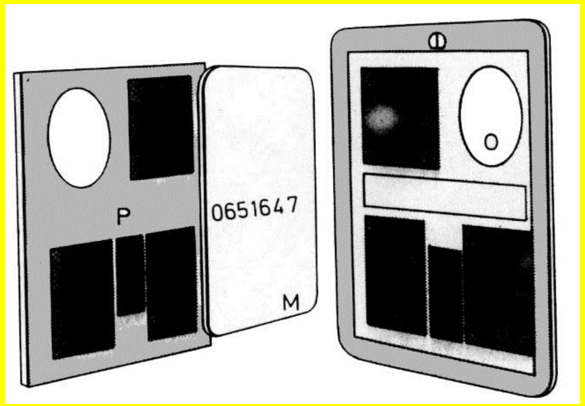
Radiographic track



Radiotherapy



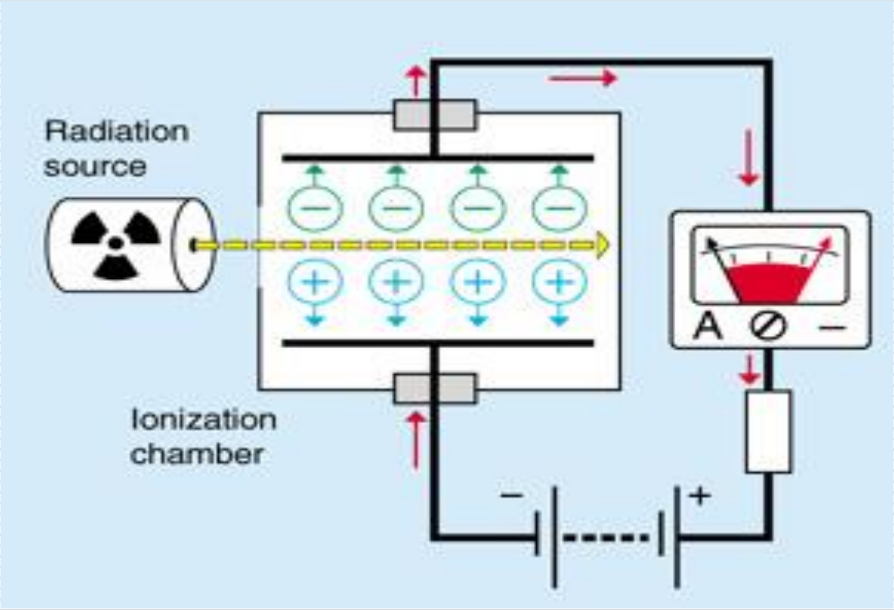
Diagnostics



Protection from radiation

Ionization Chamber

- device used for two major purposes: detecting charged particles in the air and for detecting or measuring of ionizing radiation
- device measures the electric current generated when radiation ionizes the gas in the chamber and therefore makes it electrically conductive

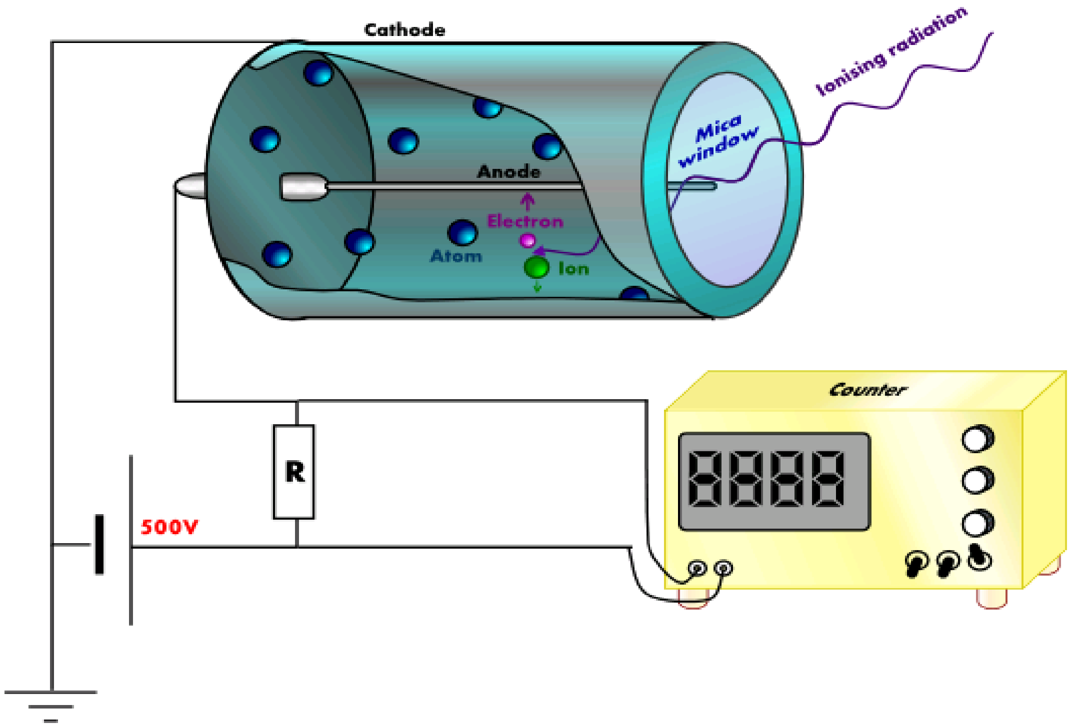


Principle of an ionization chamber

- electric currents are very low: around 10^{-15} A
- dosimetry in medicine measures very low doses X and γ radiation

Geiger-Müller Counter

- detects a single particle of ionizing radiation and produce an audible click for each



GM tube – simply gas detector

– higher voltage at the source of current

– imediate “chain” ionization of the gas

– electric current is 10^{10} times higher than primary electric current

– GM counter is used to detect usually alpha and beta radiation

Chest X ray examination

That’s how it used to be…

Deep therapy was the first use of X-ray to treat cancer, and the Hospital was among the first to secure the equipment, here in use in 1947.

https://www.youtube.com/watch?v=jN7oqMw6ipo

Radiotherapy: http://www.cchosp.com/cchhist.asp?p=510

EXPOSURE (X)–

measure for ionization of the air mass of 1kg

$X = \Delta Q/\Delta m$ $[X]=C/kg$ $1\ R = 2.58 \times 10^{-4}\ C/kg$

- **defined only for electromagnetic radiations which energies are smaller than 3 MeV**

RADIATION ABSORBED DOSE (D)–

measure of increasing internal energy (ΔU) in a mass of 1 kg tissue (ΔU) caused by absorption of ionizing radiations

$D = \Delta U/\Delta m$ [D]=Gy=J/kg 1Gy = 100 rad

- defined for all ionizing radiations

- measuring of absorbed doses are not possible in living tissues

dose in gray = energy deposited per kg

↓

dose equivalent in sievert = dose in gray × quality factor

- EQUIVALENT DOSE is calculated: $D_{eq} = D \times H$;

H is radiation quality factor $[D_{eq}] = Sv$; 1 Sv = 100 rem

Radiation quality factors

radiation	**factor**	**dose equivalent of 1 gray**
alpha	20	20 Sv
beta	1	1 Sv
gamma	1	1 Sv
x-rays	1	1 Sv
neutrons	10	10 Sv

EFFECTIVE EQUIVALENT DOSE: $D_{eq} \times f$

- each body part has its own weight factor, f

Whole body	1 (100%)
Ovaries, testes	0.25 (25%)
Bone marrow	0.12 (12%)
Bone surface	0.03 (3%)
Thyroid	0.03 (3%)
Lungs	0.15 (15%)
Breasts	0.12 (12%)
Other tissues	0.30 (30%)

X ray examination

0.02- 0.05 mSv

0.03 mSv

Radiation levels and their effects

Upper limit for Radiation Workers	50 mSv per year
Upper limit for general population	5 mSv per year
Visible blood changes	0.5 mSv per year
Lethal dose for 50% of individuals	500 mSv
Lethal dose for all	1 500 mSv
Radiation dose by one chest X ray examination	0.2 mSv
Radiation dose by one head CT scanning	11 mSv
Natural radiation in Croatia	2 mSv per year
Smoking	13 mSv per year

--- DOSE SPEED – radiation doses during 1sec

- very important to biological damages

Radiation by the Numbers

Certain kinds of imaging diagnostics use ionizing radiation, which is associated with an increased risk of cancer. Here are estimated radiation levels for some procedures:

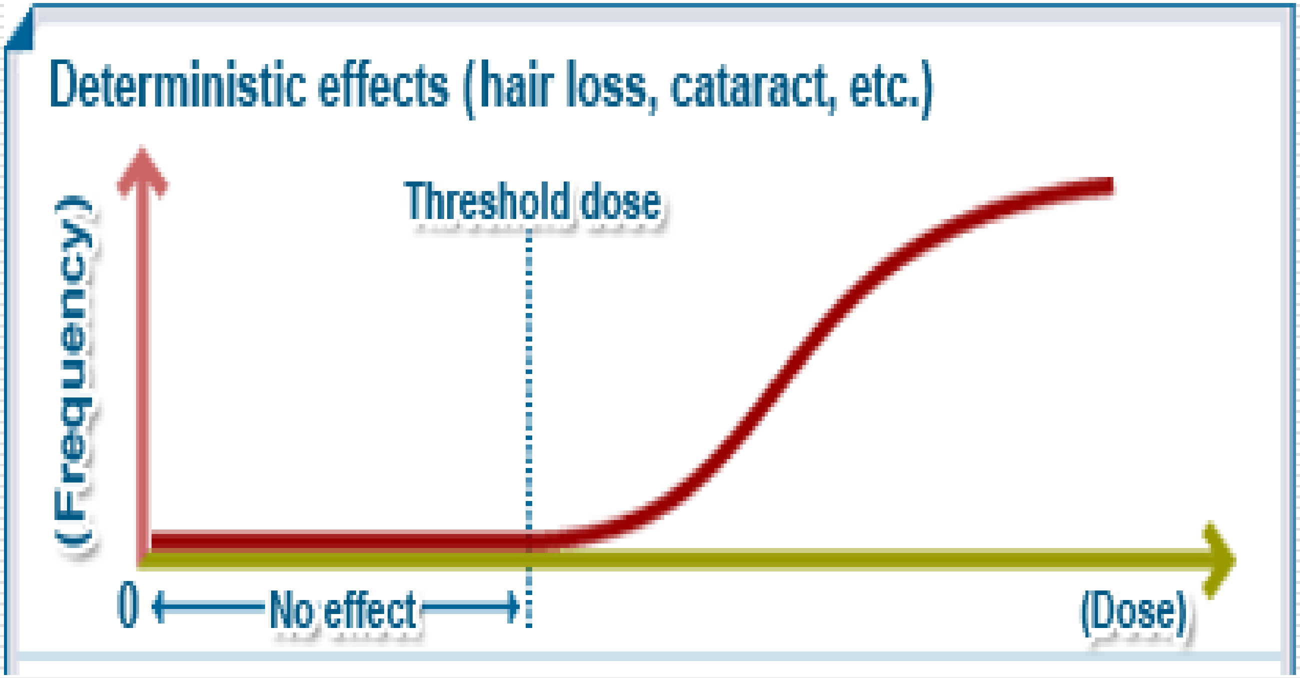
SOURCE	ESTIMATED DOSE (MILLISIEVERTS)
Chest X-ray	0.01-0.1 mSv
Mammogram	0.8 mSv
Head CT	2 mSv
Chest CT	8-10 mSv
Abdomen-pelvis CT	10mSv
Full-body screening CT	12-25 mSv
World War II atom bomb (mean)	20 mSv

Source: WSJ research

Biological effects of ionizing radiation

Deterministic (nonstochastic) effects

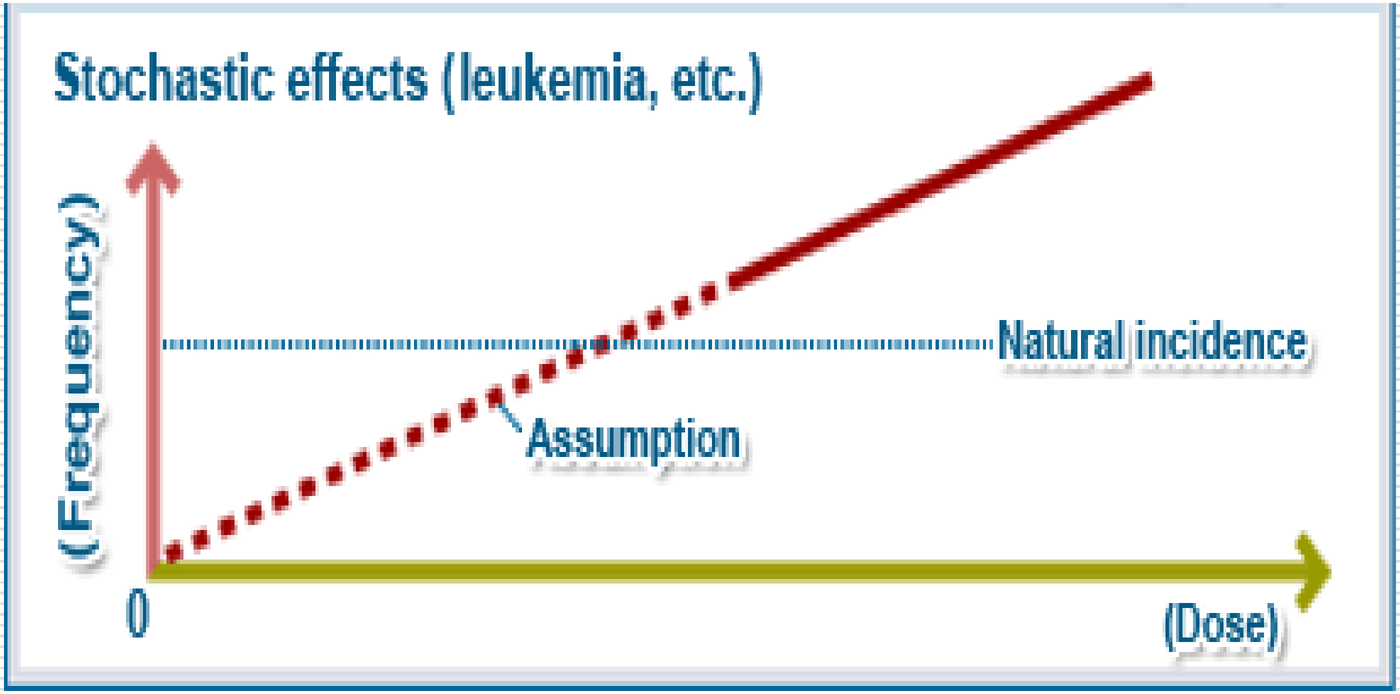
- the probability for damage depends on dose
- there is treshold dose
- somatic effects (appear only in irradiated person) - development of radiation sickness



Biological effects of ionizing radiation

Stochastic effects

- are biological effectts, of which the probability to occur is the function of the dose;
- A treshold for such effect cannot be quantified!!!The damage appears for any dose.
- genetic effects (transfered to next generations) and development of cancer




COUNTERTHINK
WHICH BUTTON DO I PUSH?
USUALLY WE JUST PUNCH 'EM BOTH.
DETECT CANCER
CAUSE CANCER
MAMMOGRAM 5000 CONTROL PANEL
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