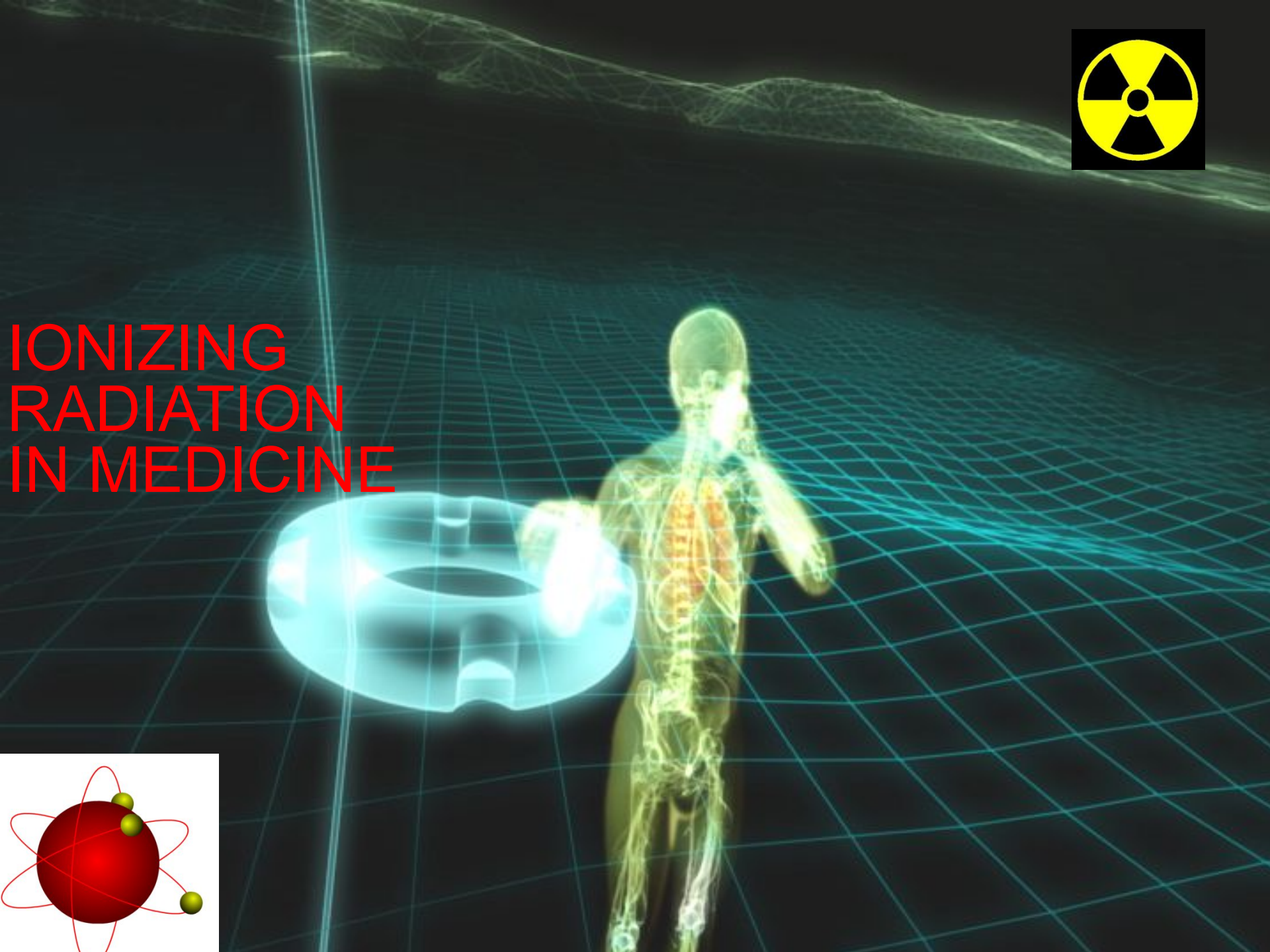
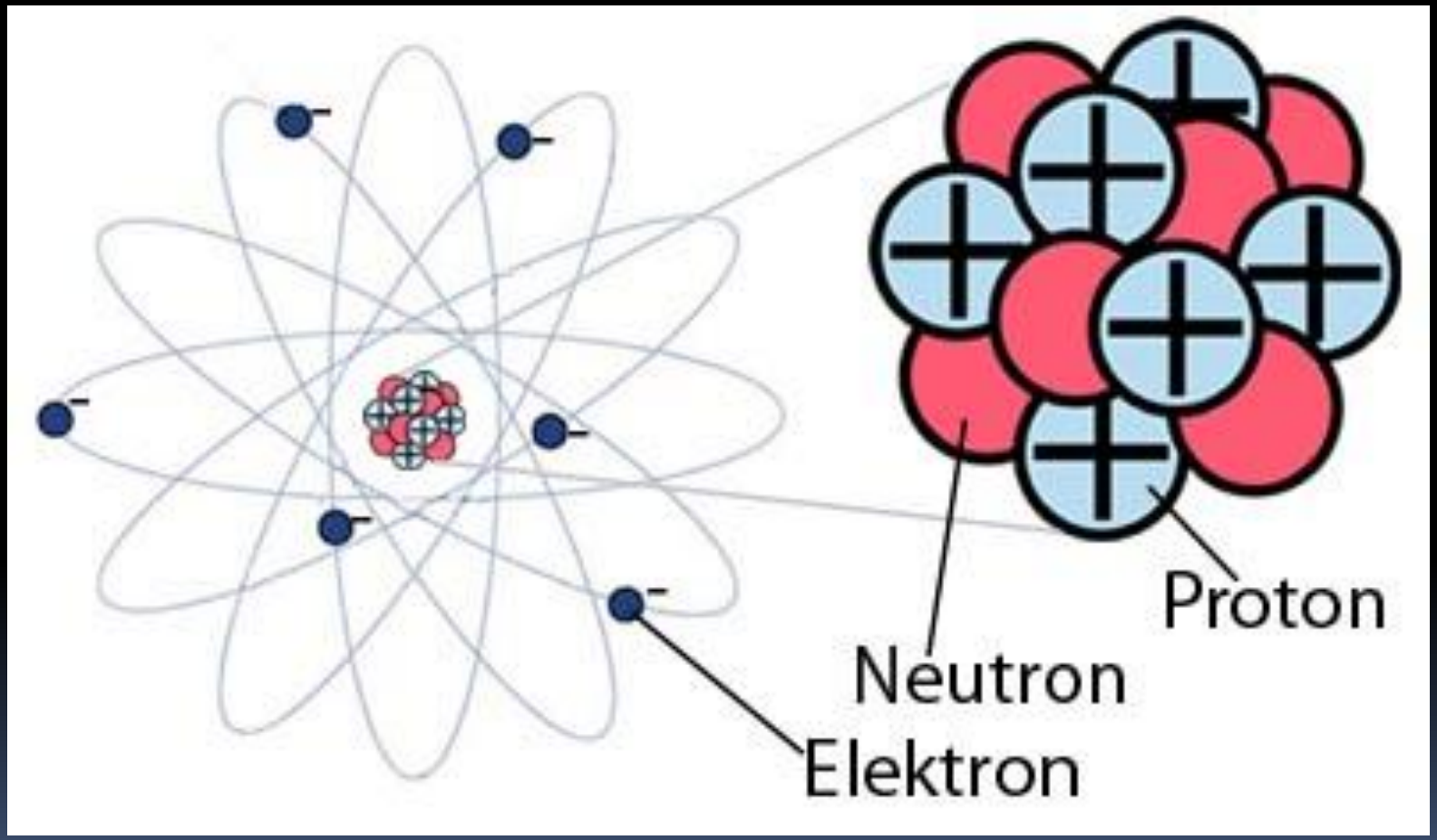
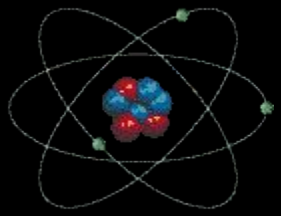

IONIZING
RADIATION
IN MEDICINE

NUCLEUS. ATOM.



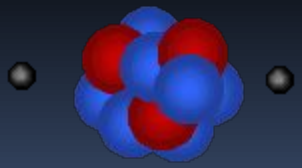
NUCLEUS. ATOM.



PROTON

NEUTRON

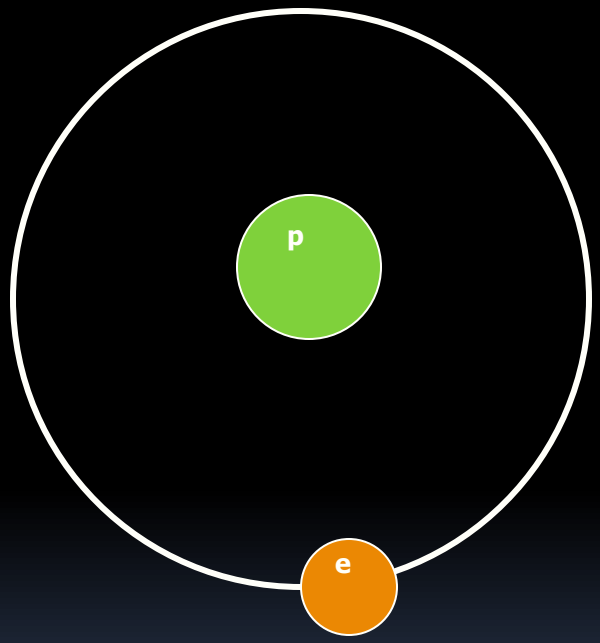
ELECTRON



Parts of an Atom

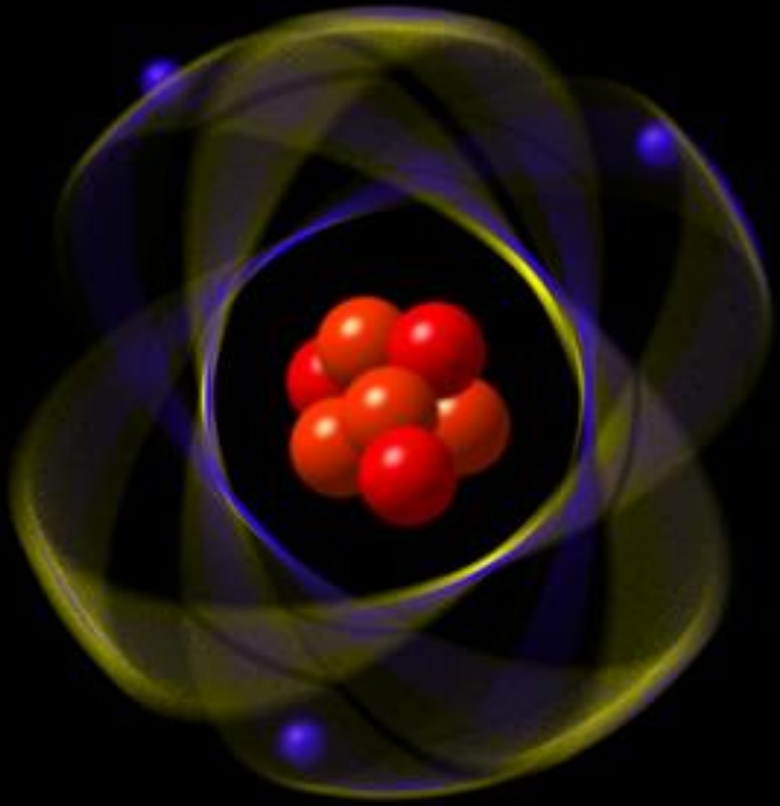
- Each element in the Periodic Table has a different number of protons in its nucleus
  - Protons have positive charge
  - Change the number of protons change elements
  - This is called nuclear physics
- The element also has the same number of electrons
  - Electrons have negative charge
  - Change the number of electrons ionize the element
  - This is called chemistry
- Some elements also have neutrons
  - Neutrons have no charge
  - They are in the nuclei of atoms

The Hydrogen Atom



^{1}H

- One electron orbiting a nucleus
- 1 proton = Z = atomic number
- 0 neutrons = N
- Total mass = A = Z+N =1
- Singly ionized Hydrogen is missing one electron = $^{1}H^{+}$
- Add a neutron and you have Deuterium = ^{2}H = D



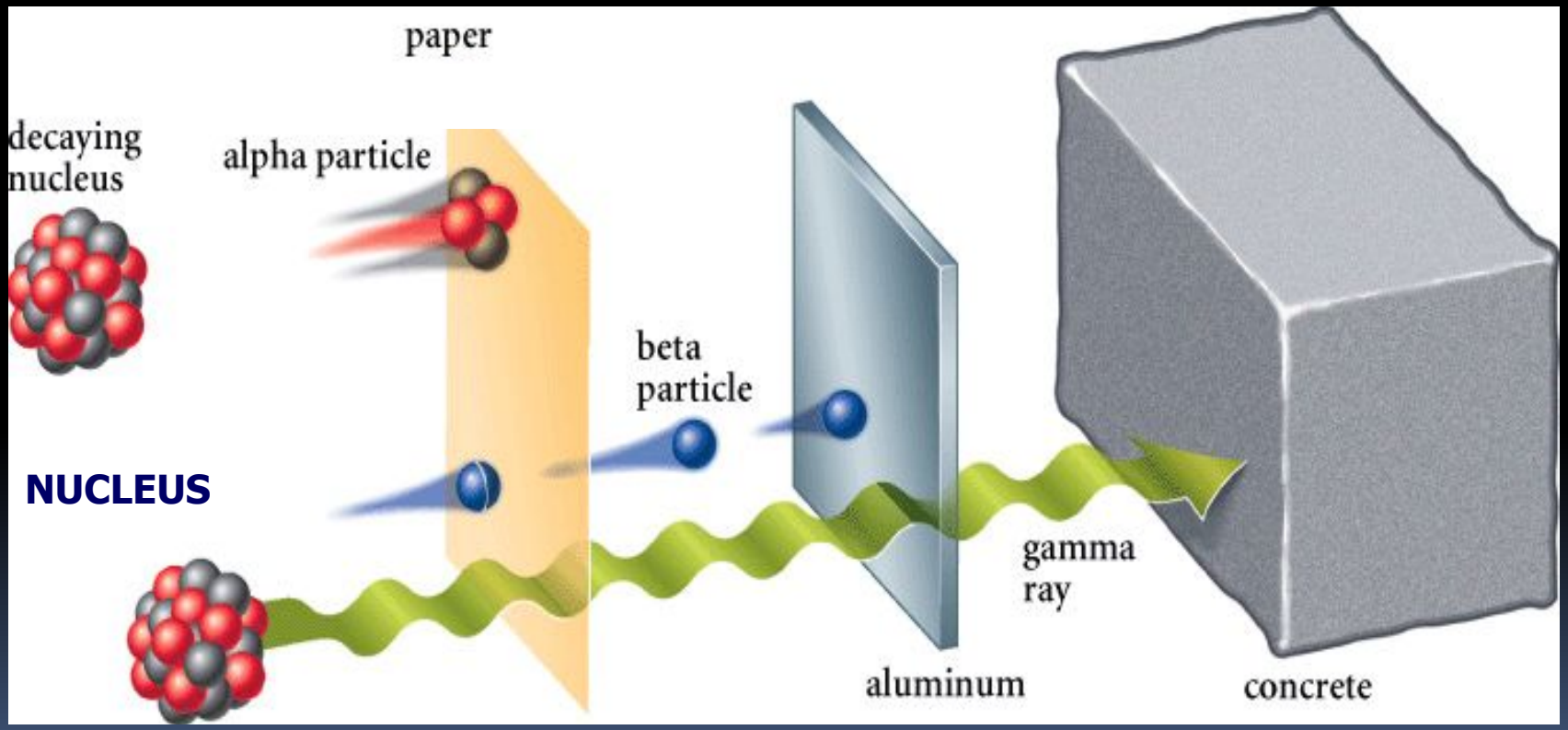
Thinking deeper: The forces in the atom

- Electrons are bound to nucleus by the Coulomb (electromagnetic) force
- Protons in nucleus are held together by the *strong* nuclear force
- Neutrons can decay into protons by weak nuclear force, emitting an electron and an anti-neutrino. The weak force is also responsible for radioactivity.

$$F = \frac{k\, q_1\, q_2}{r^2}$$

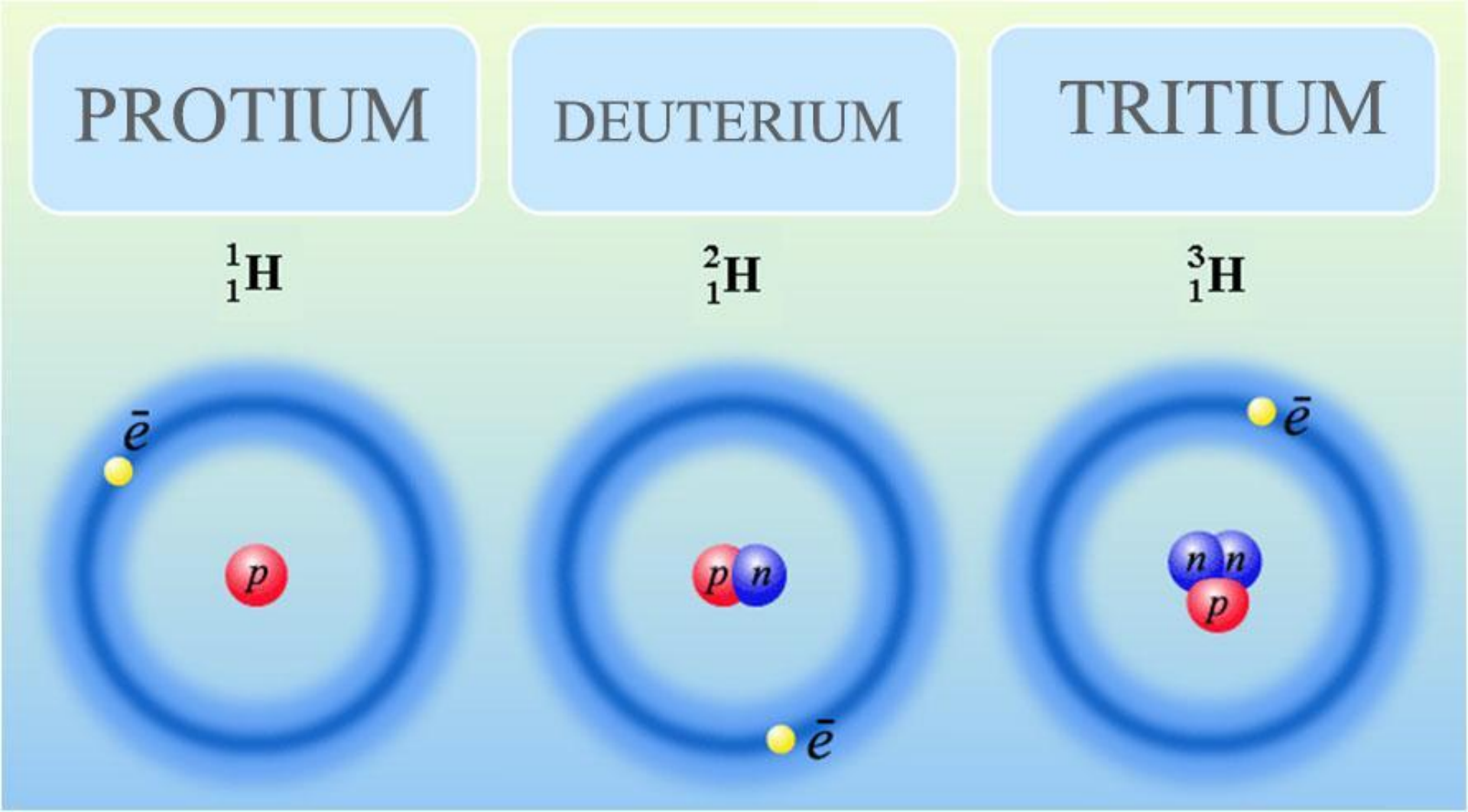
$$n = p + e + \bar{\nu}$$

PENETRATION ABILITY OF DIFFERENT KINDS OF RADIATION



ISOTOPES

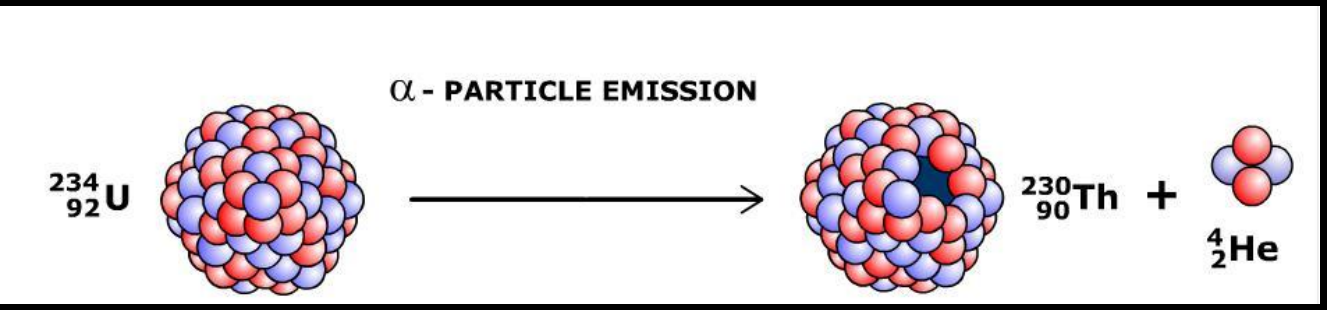
Hydrogen isotopes

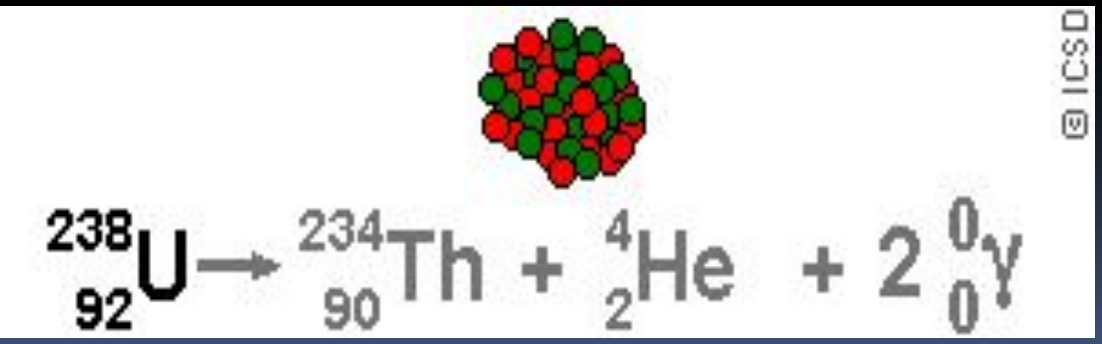


ALPHA DECAY

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

$$ {}_{2}\alpha^{4} = {}_{2}He^{4} $$

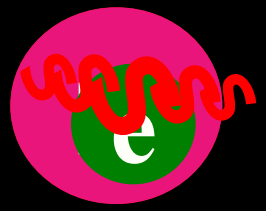




GAMMA-RAYS

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

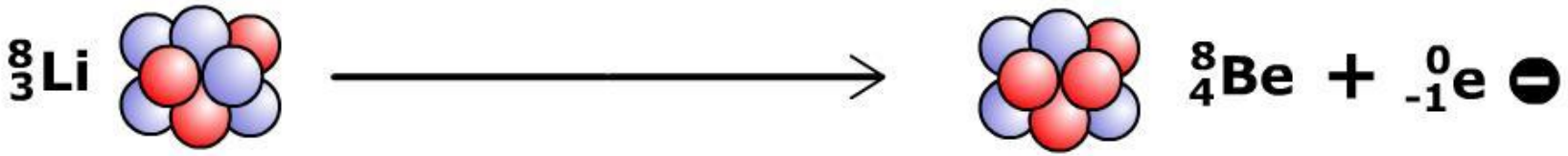
β - DECAY



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

β MINUS DECAY – ELECTRON AND ANTINEUTRIO RELEASE

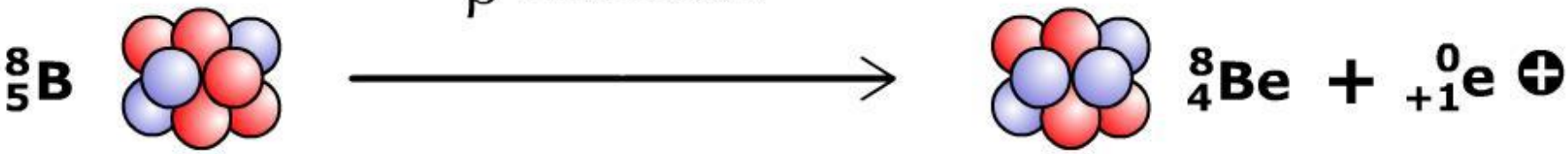
β^- EMISSION



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

β PLUS DECAY – POSITRON AND NEUTRINO RELEASE

β^+ EMISSION



ELECTRON CAPTURE

$$ {}_{z}X^{A} + {}_{-1}e^{0} = {}_{z-1}Y^{A} + \nu . $$

RADIOACTIVITY LAW

Radioactive decay law

***dN* – number of nuclides in radioactive decay per infinitely small period of time *dt*.**

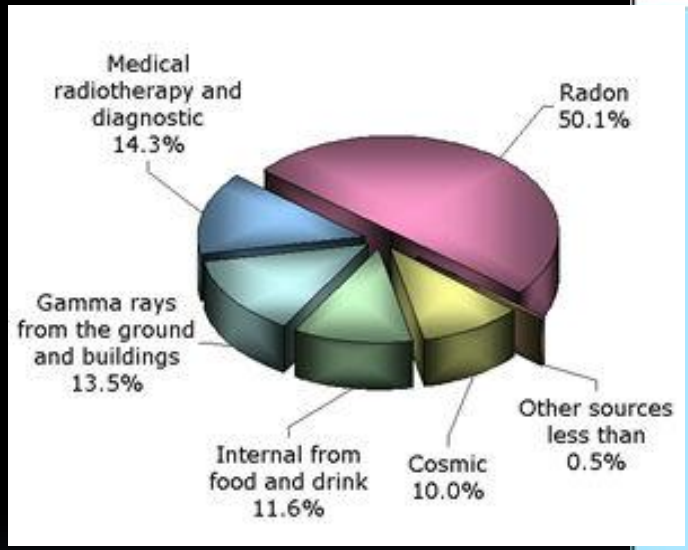
$\frac{dN}{dt}$ **- decay rate**

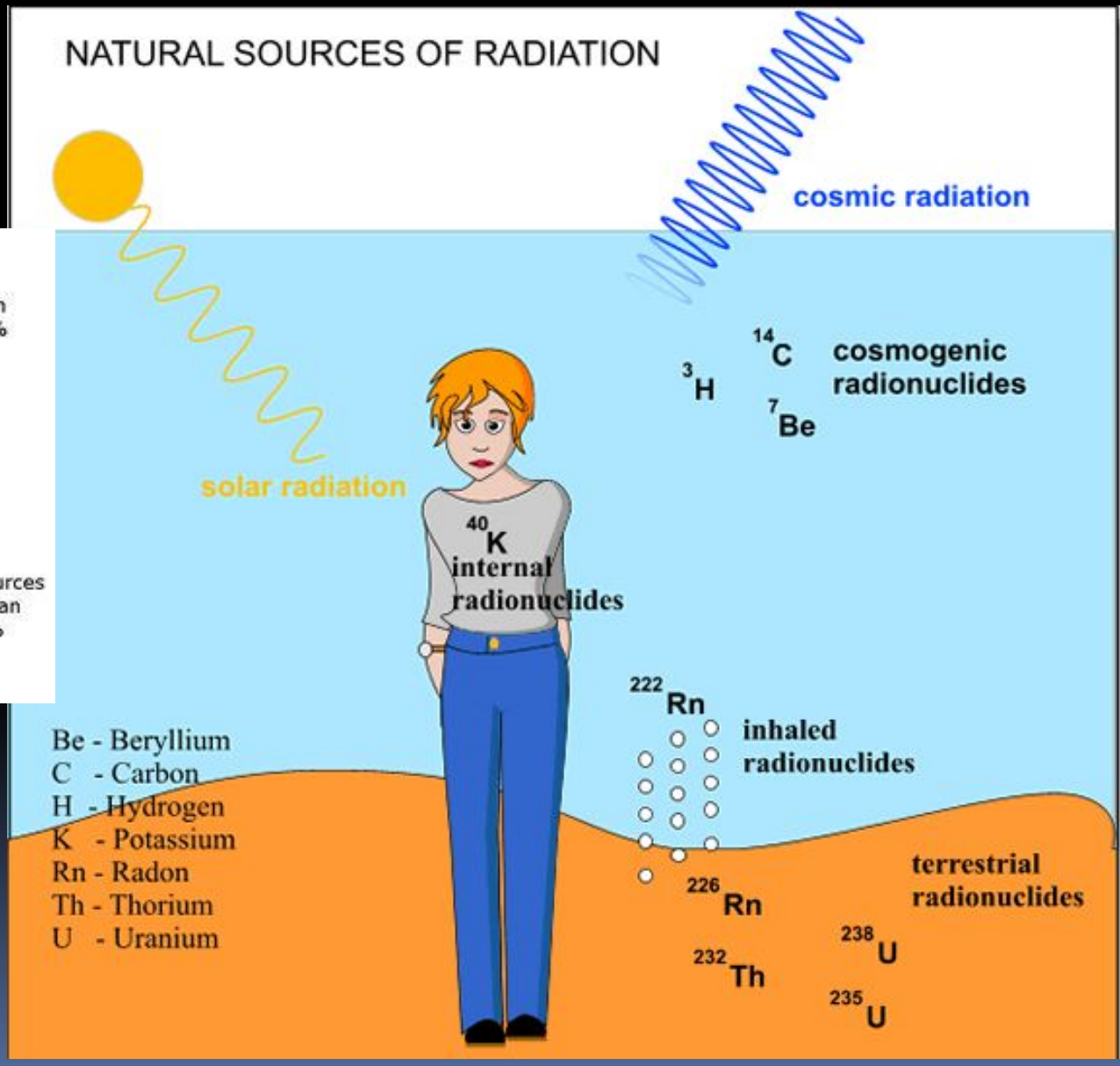
Radionuclide initial quantity N_0
Radioactive decay constant λ, it characterizes radionuclide of this kind decay probability

$$\frac{dN}{dt} = -\lambda \cdot N_0 \cdot \rightarrow N = N_0 \cdot e^{-\lambda \cdot t}.$$

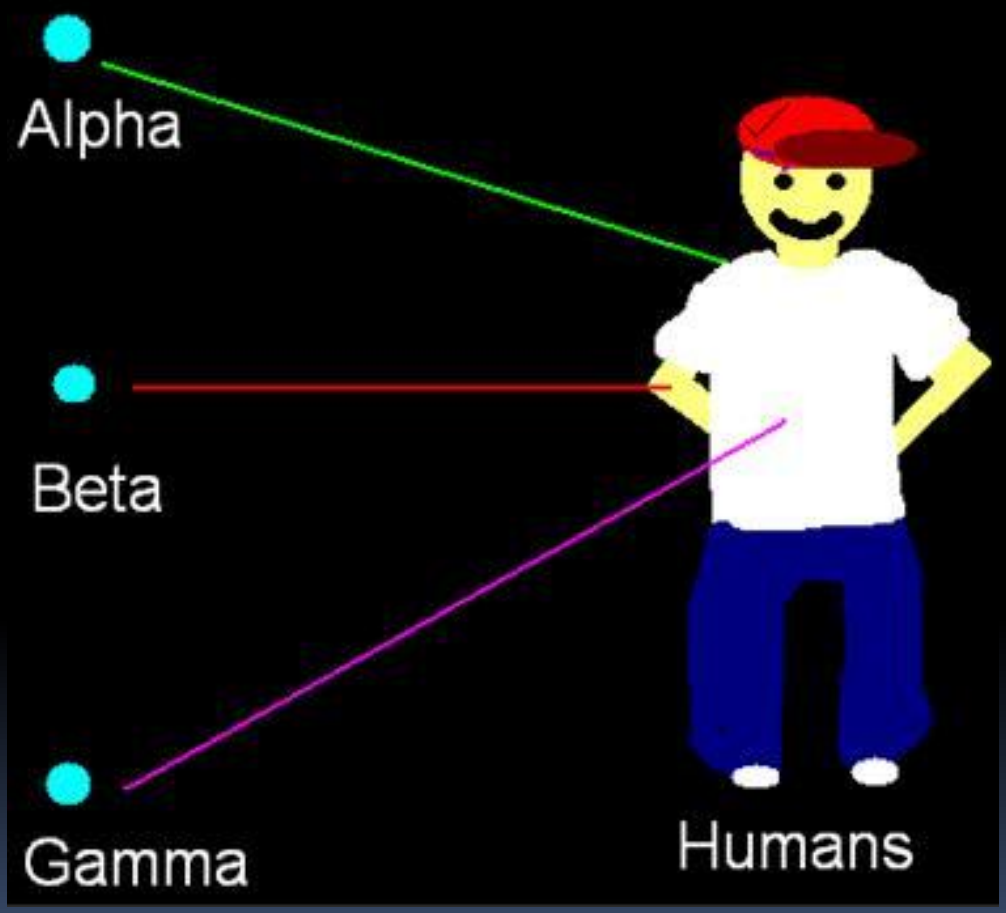
If in initial period of time ($t = 0$) there are N_0 number of nuclides after then the time t the number of nuclides left is N.

EXTERNAL AND INTERNAL IRRADIATION





BIOLOGICAL ACTION OF RADIATION



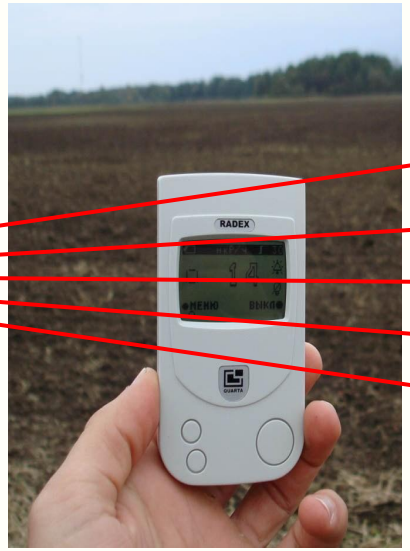
DOSIMETRY

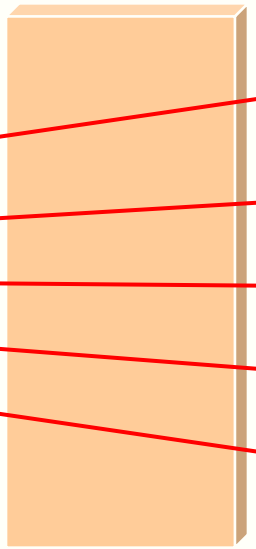
Source of radiation

Exposure dose

absorbed radiation dose

Equivalent dose

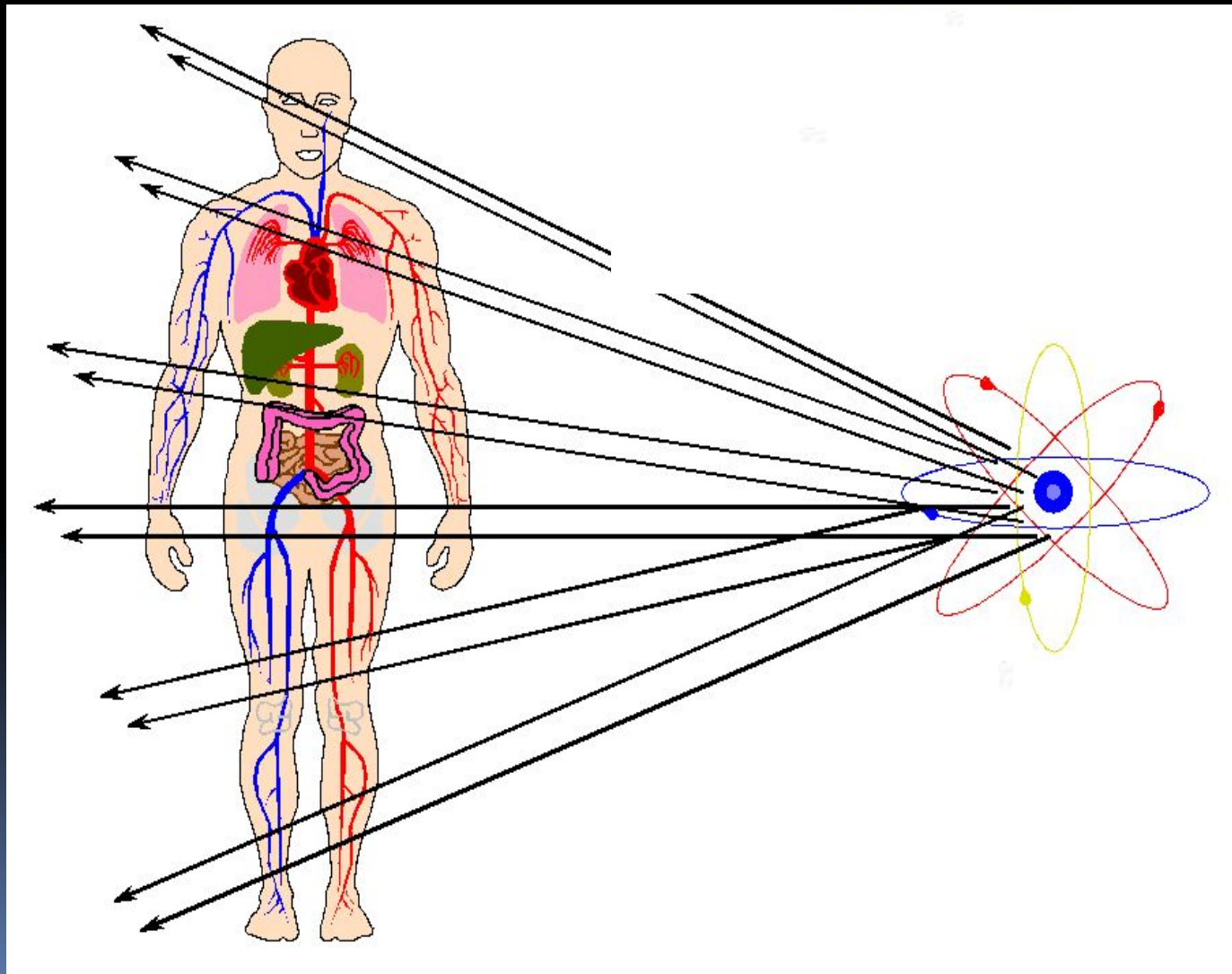




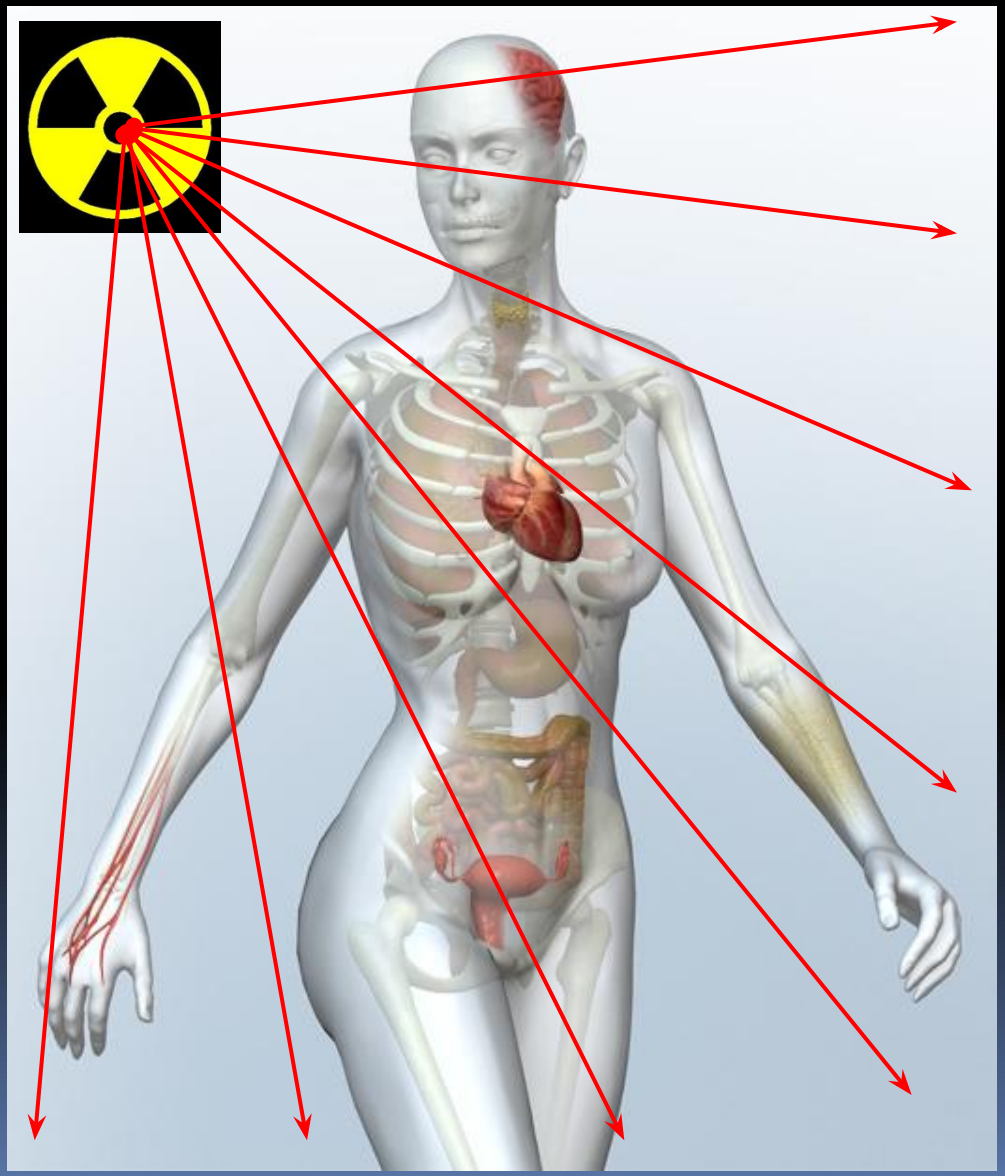
RADIATION UNITS

Becquerel, Bq Curie, Cu	1 Bq = 1decay in sec 1 Cu = 3,7 x 10^{10}Bq	**Radionuclide activity** – decays quantity per unit of time
Cl/kg (coulomb per kilogram) Rontgen, R	1 Cl/kg = 6,24 x 10^{24} ion pairs/kg 1 R = 2,08 x 10^{15} ion pairs /м^3	**Exposure dose –** quantity of charges, produced in unit of volume or mass of air due to its ionization radiation
Grey, Gy Rad, rad	1 Gy = 1 J/kg 1 rad = 0.01 Gy	**Absorbed radiation dose** – quantity of ionizing radiation energy, absorbed with unit of mass of some physical body, i.e. organism tissues
Sievert, Sv REM, roentgen equivalent man	1 Sv = 1Gy = 1J/kg (for β and γ radiation) 1 rem = 0.01 Sv = 10mSv	**Equivalent dose** – absorbed dose multiplied on coefficient of different radiation danger rate

EQUIVALENT DOSE



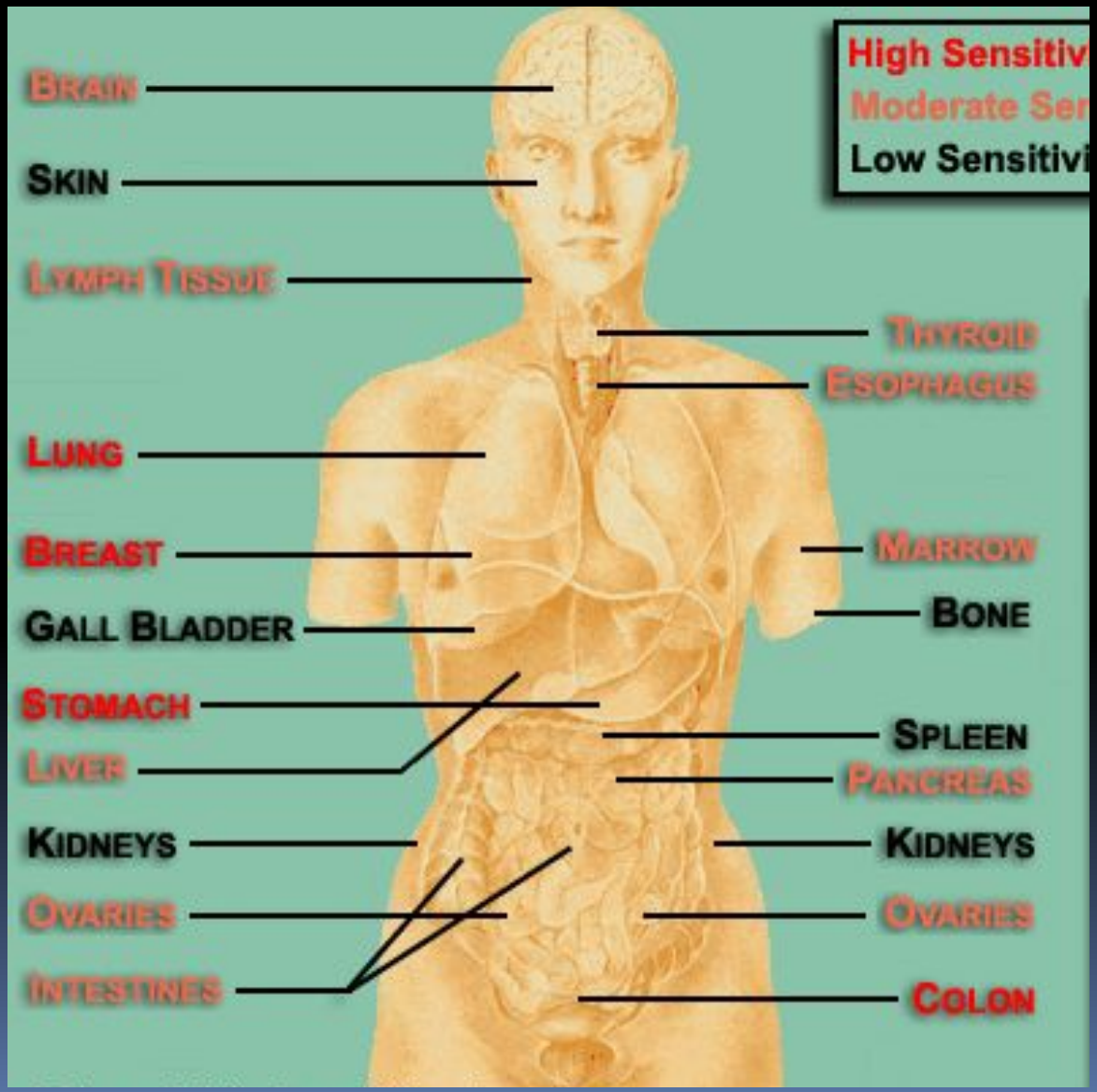
EFFECTIVE EQUIVALENT DOSE



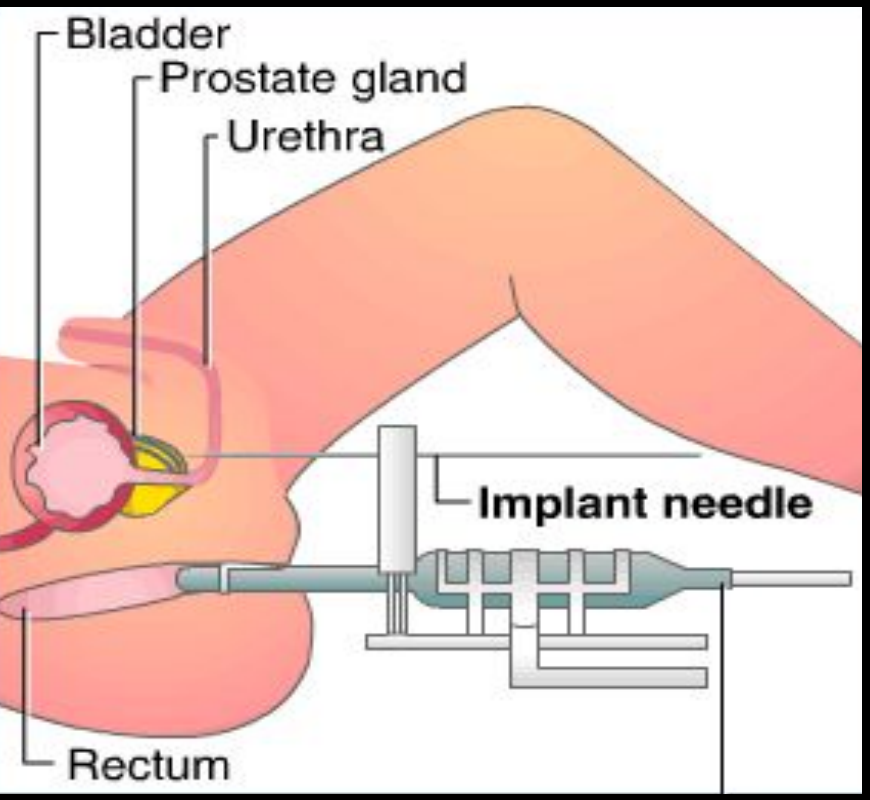
EED – equivalent dose calculated with different tissues radiation sensitivity taken into account. The whole organism dose equal: 1. Separate organs have their own values:

Red bone marrow – 0,12
Bones – 0,03
Mammary gland – 0,15
thyroid gland – 0,05
Lungs – 0,12
Stomach – 0,12
Intestine – 0,12
genital gland – 0,01

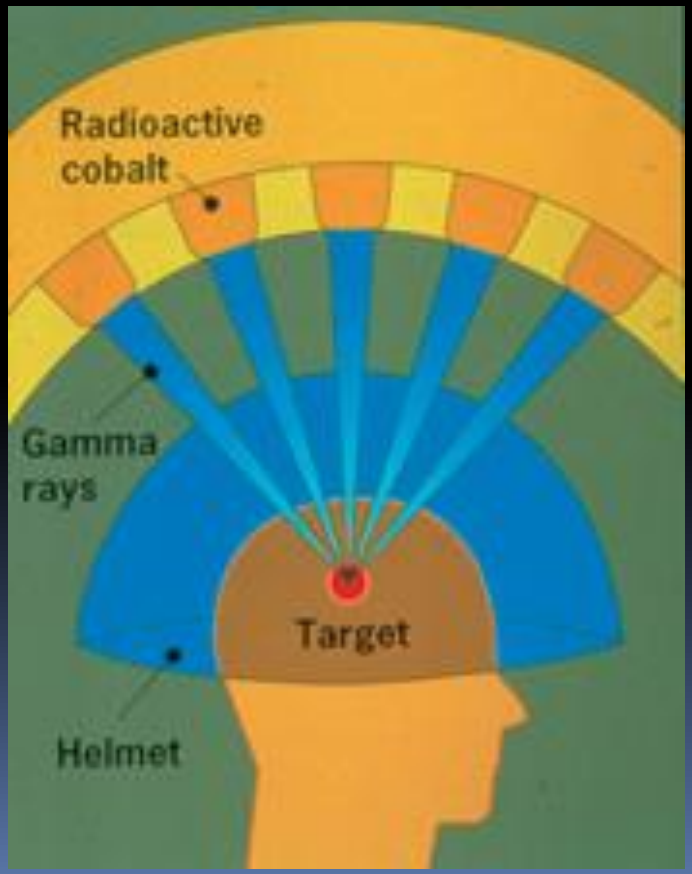
Different organs radiation sensitivity

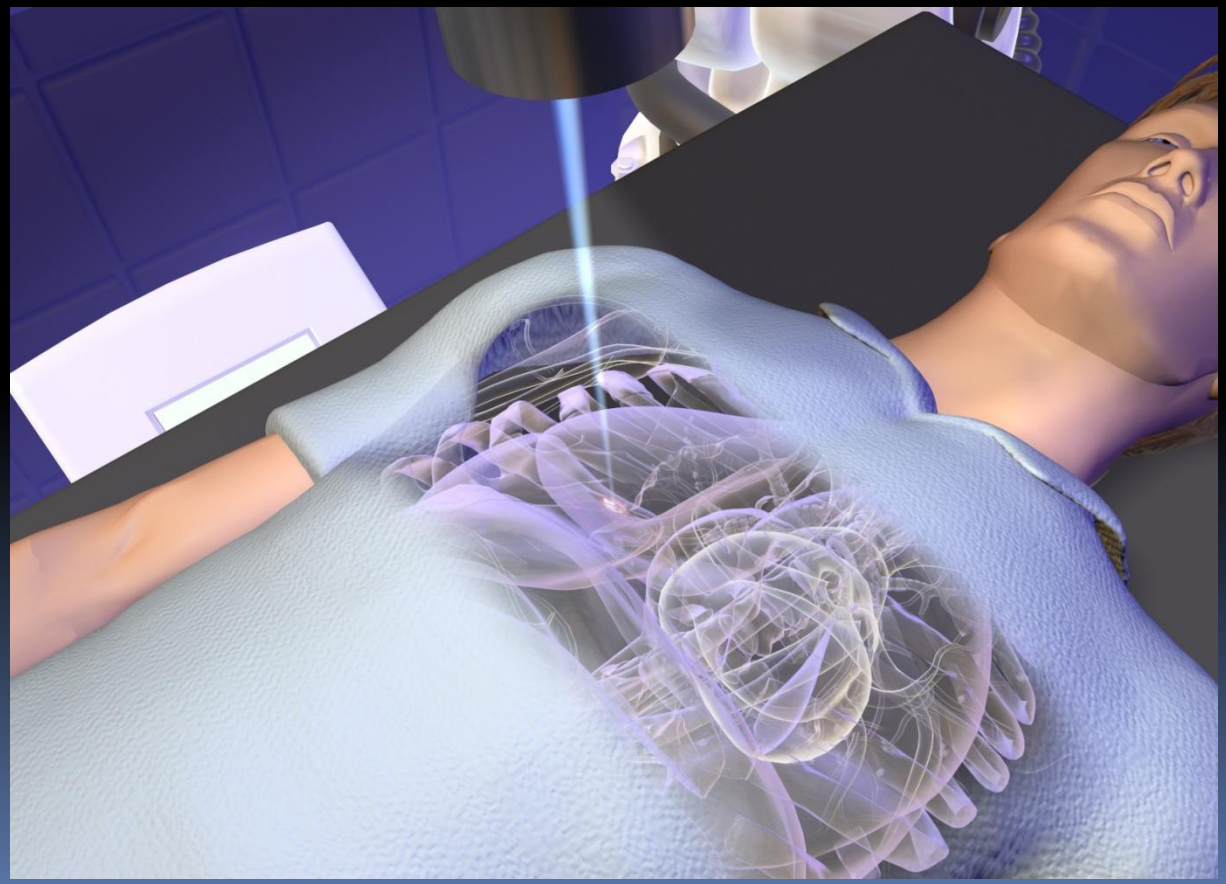


INTERNAL RADIOTHERAPY

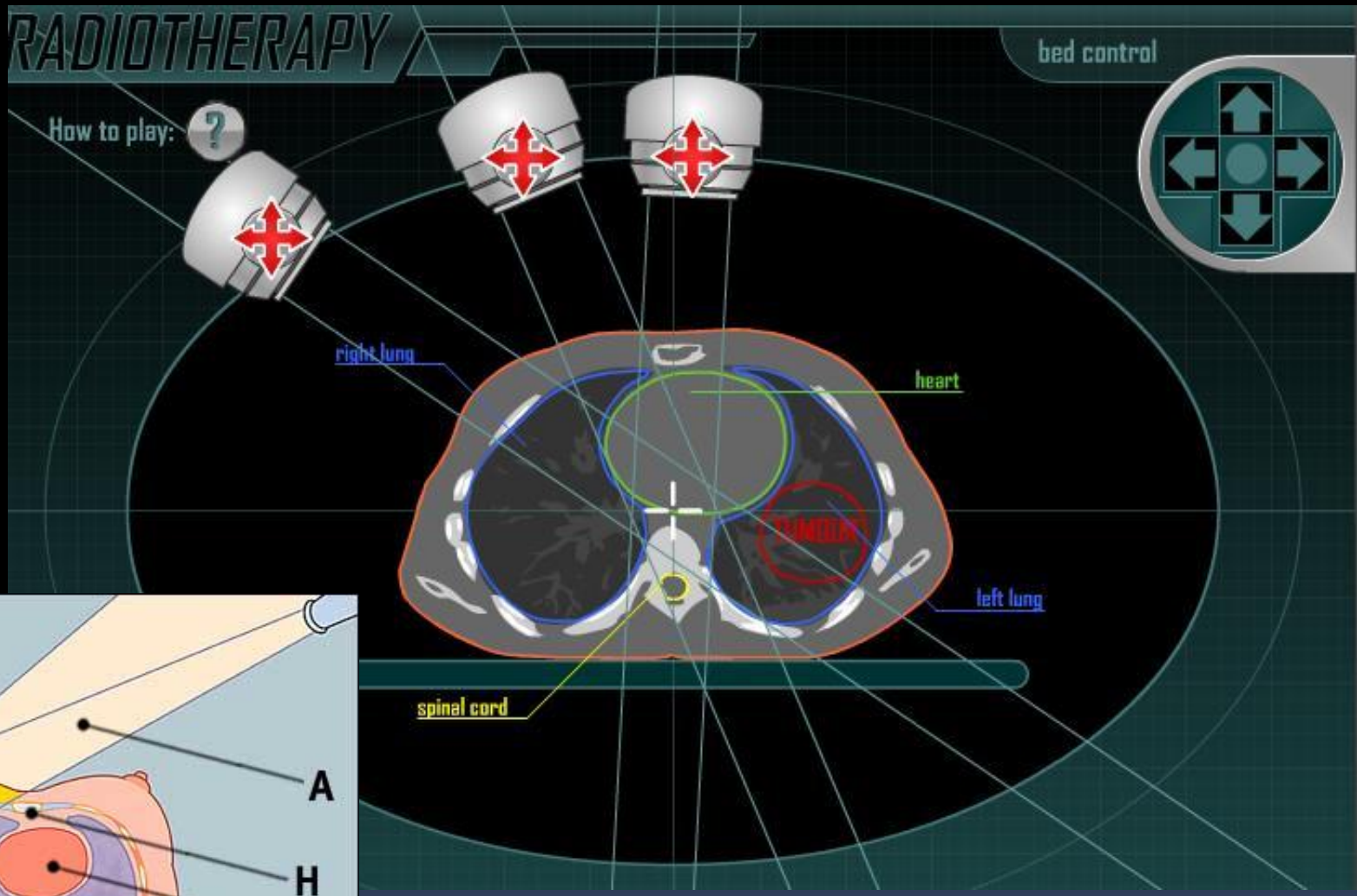


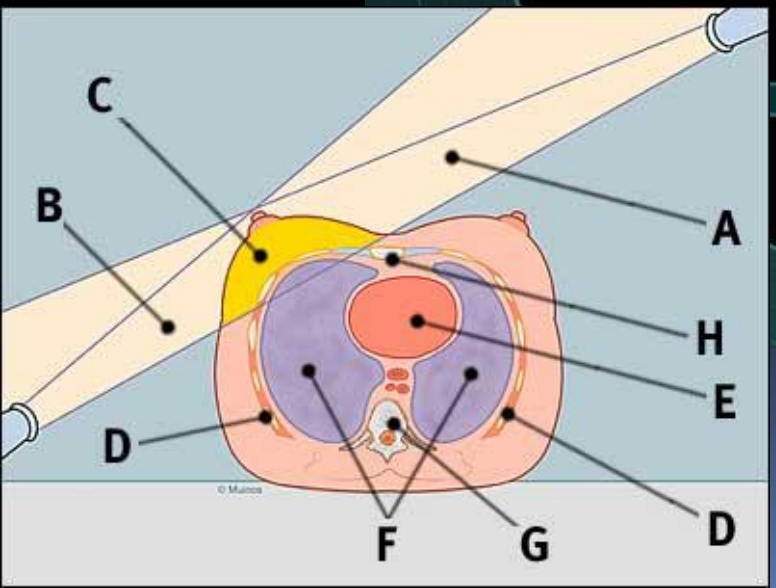
EXTERNAL RADIOTHERAPY

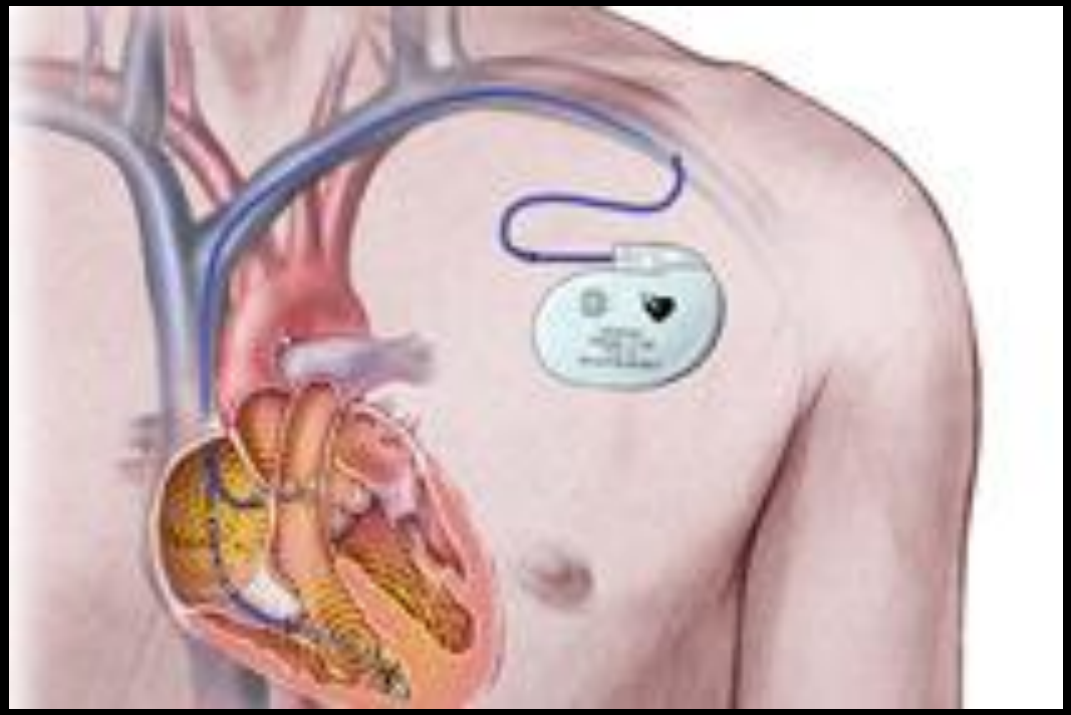




EXTERNAL RADIOTHERAPY







Cardio stimulator with plutonium battery have been working already for 34 years and had only one slight correction. The doctor described case history in New England Journal of Medicine, nuclear cardiostimulator will live longer, then its owner.