Introduction to radiation biophysics, types of radiation and dose concept

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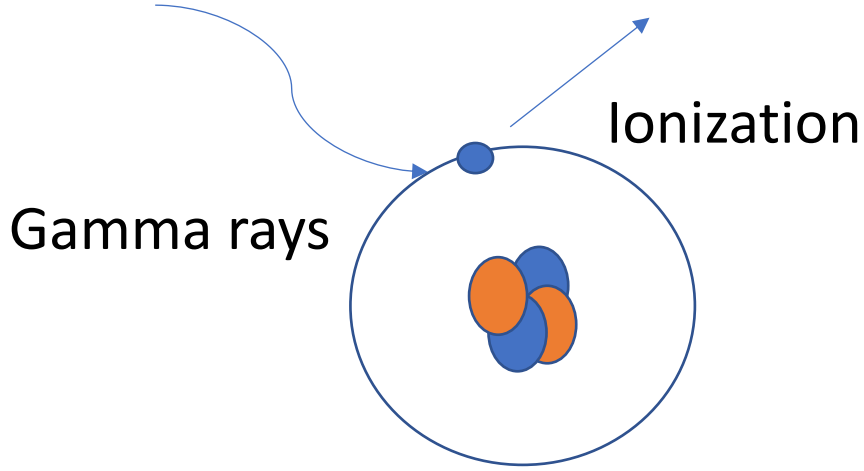
Ionizing effect of radiation

- Radiation is a general term defining energy propagation from a source
- This source can be man made (x-rays) or can be an unstable (radioactive) nucleus.
- Radiation could exist either in particle (alpha, beta) or in electromagnetic (EM) wave (gamma) forms.
- Ionizing meaning; Radiation has enough energy to remove electrons from the orbit of atoms
- Radioactive nucleus origin all particles, are ionizing

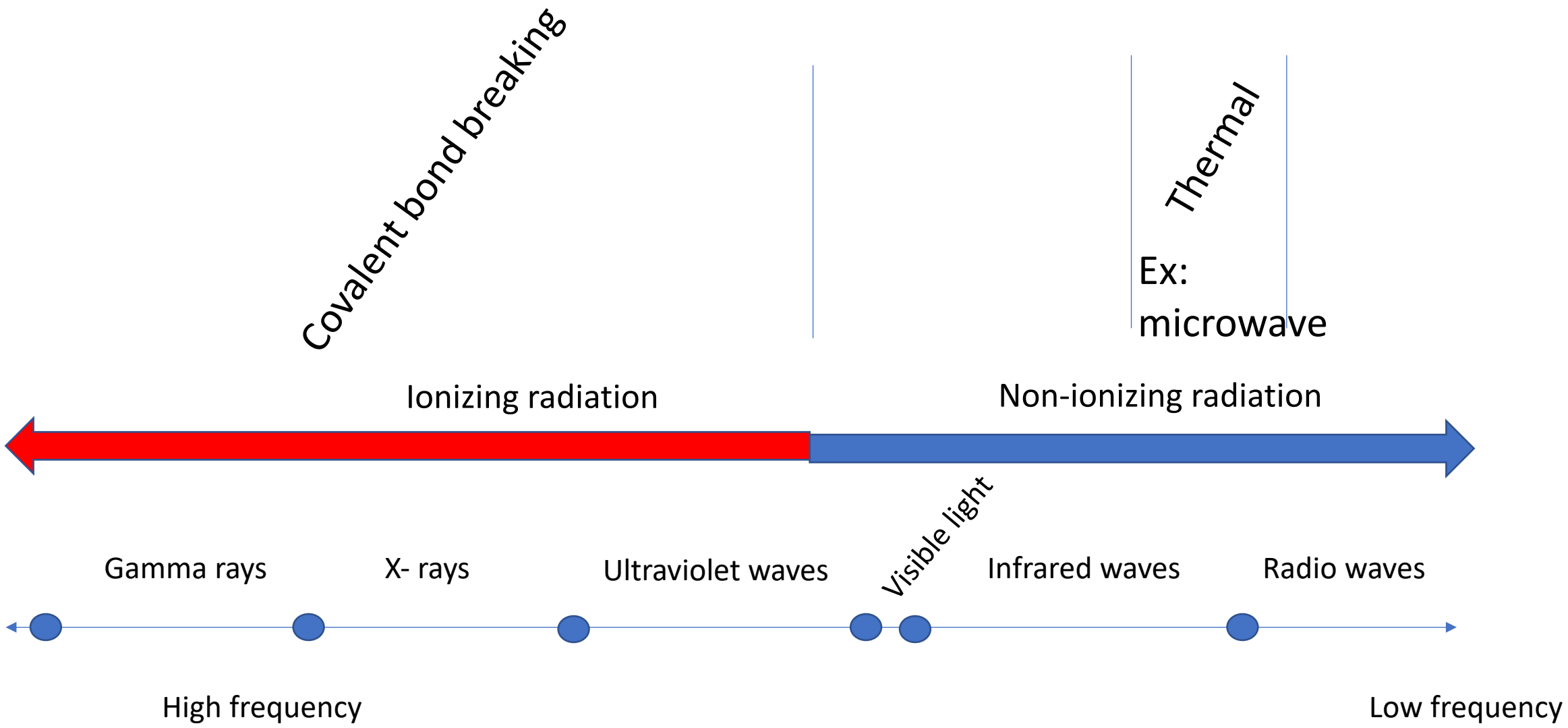


Energy of radiation

For EM waves: Energy=Planck constant (h: $6{,}62.10^{-34}$ Joule.sec) X frequency

For particle radiation: Kinetic energy**=**$1/2mv^2$

Electromagnetic spectrum



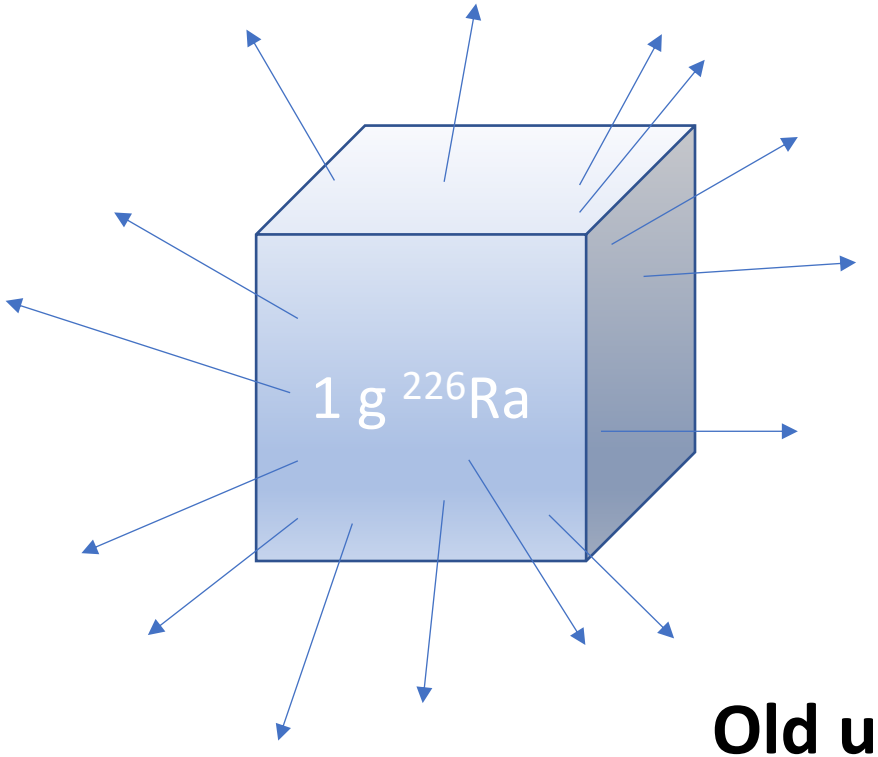
Radiation dose and measurement (dosimetry)

- Radiation dose is a concept that is developed in order to establish a link between the amount of radiation measured and the chemical/biological effects of it.

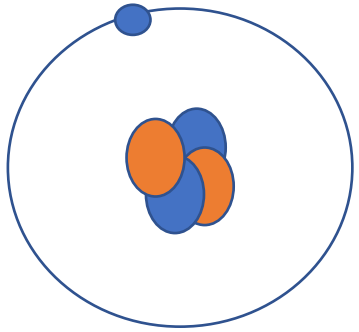
- Dosimetry is required for the quantitative expression of biological effects of radiation.

- There are SI and old units used in radiation measurement

Activity units

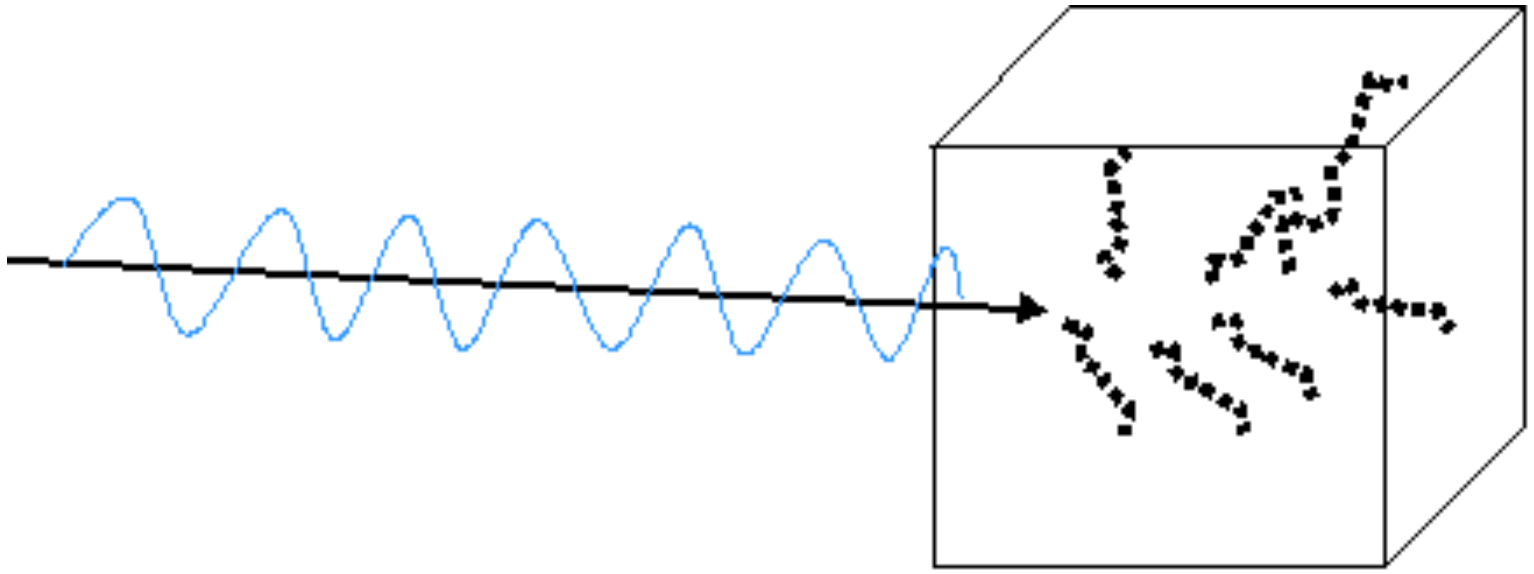


Old unit: Curie (Ci) = 37.000.000.000 disintegration/sec



SI unit: Becquerel (Bq) = 1 disintegration/sec

Exposure units



- The amount of ionization as charge in a unit dry air at standart pressure and temperature is defined as exposure.

- This measurement of exposure applies only to ionizing electromagnetic radiation, such as gamma and x rays, not to particulate radiation (e.g., alpha or beta particles).

- **SI unit: Coulomb/kg (C/kg**). Radiation mediated total ion charge generation is measured in coulombs per 1 kg of air.

- **Old unit(cgs, cm-gram-sec): Roentgen (R)** Radiation mediated total ion charge generation is measured in electrostatic charge (esu) per 1 cm^3 of air.

- 1 esu charge in 1 cm^3 air = 1 R

- 1 esu = 3.335 x 10^{-10}Coulomb (C)

- Air density at standard conditions: 0.001293 g/cm^3

- 1 kg air= 7.734 x 10^5 cm^3

- 1 R = 3.335 x 10^{-10} C/cm^3 = **2.58 x 10^{-4}C/kg**

Radiation absorbed dose

- **Radiation absorbed dose (rad):**
  Any kind of radiation energy absorbed by any kind of material in its unit mass.

- **SI unit: gray (Gy),** (Joule/kg)

- **Old unit (cgs): rad,** (100 erg/g)

- 1 Gy = 1 J/kg

- 1 J = 10^7 erg

- 1 Gy = 10^7 erg/10^3g = 10^4 erg/g = 100 rad

What is the absorbed dose in air when the exposure is 1 R?

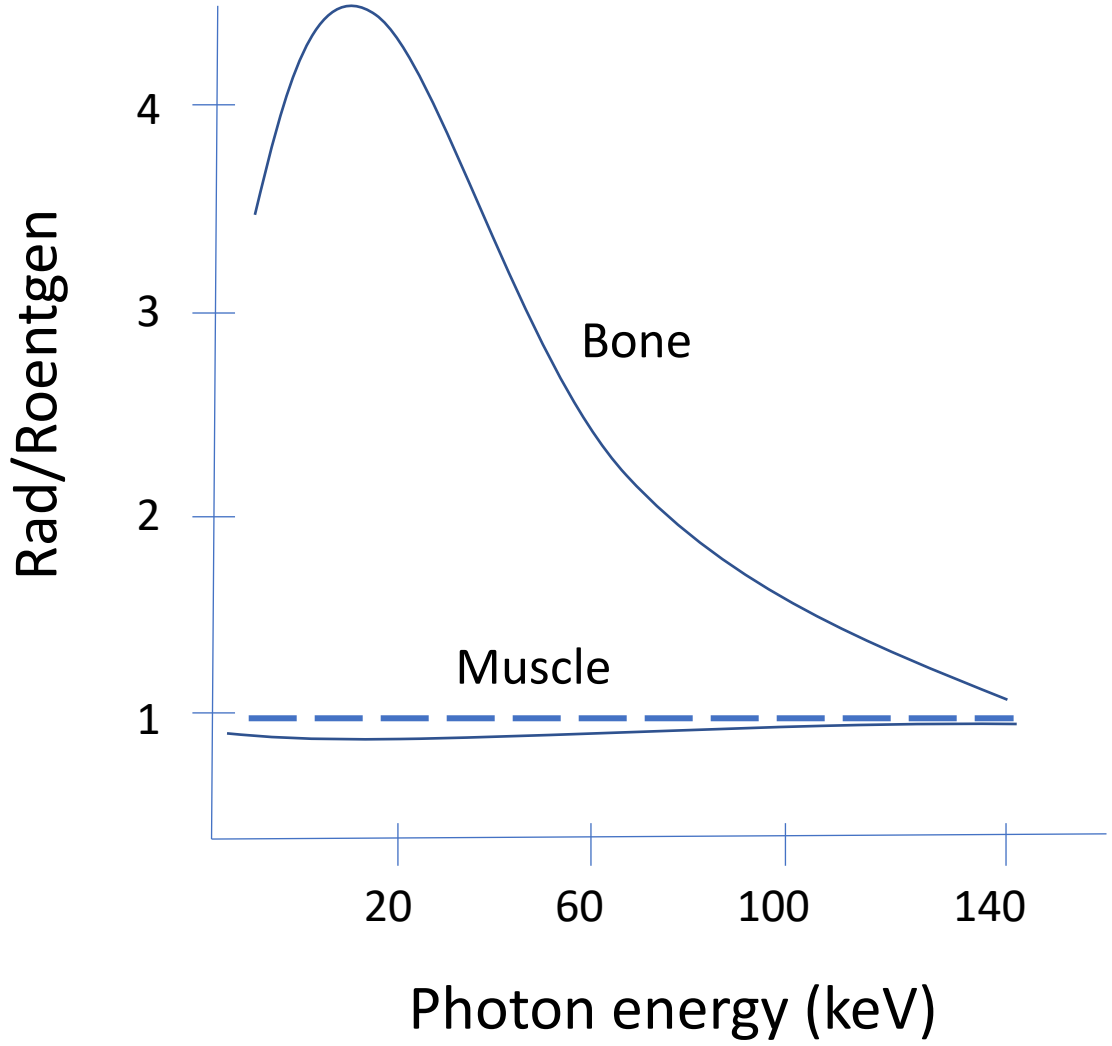
- Amount of radiation that must be absorbed by air molecules to produce 1 Coulomb of charge in 1 kg of air is 33.7 joules.

- $2.58 \times 10^{-4} C/kg$ (1R) x 33.7 J/C = 8.8×10^{-3} J/kg = 8.8×10^{-3} Gy (0.88 rad)

- Therefore, 1R would produce a dose of 0.88 rad in air.

How to measure absorbed dose in tissue?

- To measure dose directly from tissue is not easy, instead measuring ionisation in air is preferred
- Absorption properties of air and soft tissue are similar. Therefore 1R exposure deposits roughly 1 rad (0.95 rad) in soft tissue.
- Absorption in bone is more than in soft tissue or air.
- Therefore, while 1 R x-ray exposure produces ~ 1 rad dose in soft tissue, in bones however, same exposure dose will produce ~3 rads of absorption dose



Quality factor

- Same absorbed doses of radiation will not be equally harmful to tissues
- Considering this fact, a quality factor is assigned to each radiation type
- Quality factor concept gives us the advantage of comparing different kind of radiation mediated biological effects

Radyasyon	Kalite faktörü (Q)
Alpha radiation	20
Beta radiation	1
Gamma radiation	1

Quality factors (Q) of different radiation types.

Equivalent dose

- **SI unit: sievert (Sv)**
- **Old unit (cgs): rem**
- **Equivalent dose (Sv)** = Absorbed dose (Gy) x quality factor
- **Equivalent dose (rem)** = Absorbed dose (rad) x quality factor