

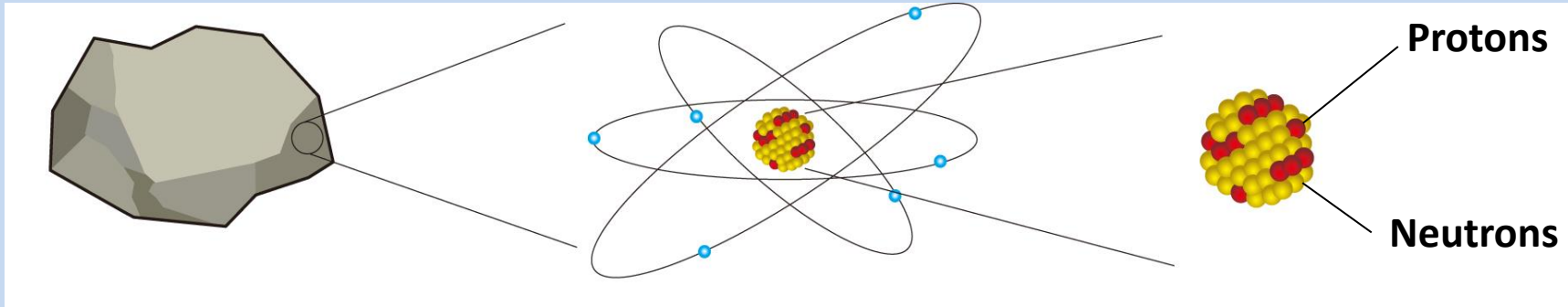
Radiation

Where does Radiation Come from?

Material

Atom

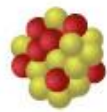
Nucleus



Nucleus



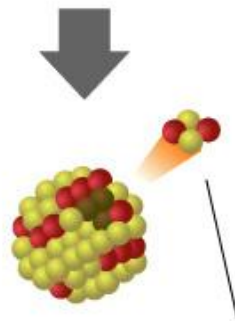
Nucleus



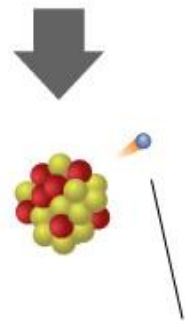
Nucleus
(high-energy state)



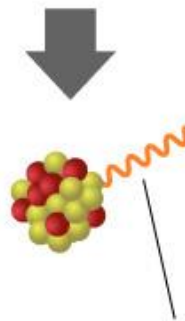
Nucleus



α (Alpha)-particles

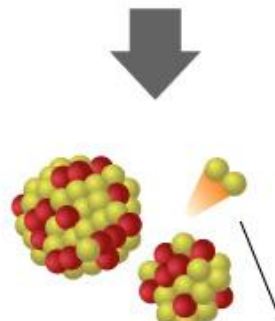


β (Beta)-particles
(electrons)



γ (Gamma)-rays

*X-rays are generated outside a nucleus.



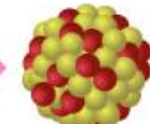
Neutron rays

Example of α -disintegration



Radium-226
{ 88 protons
138 neutrons }

Transformation



Radon-222
{ 86 protons
136 neutrons }

α -particles
{ Two protons
Two neutrons }

Example of β -disintegration



Tritium
{ One proton
Two neutrons }

Neutron

Electron

Proton

Electrons
(β -particles)

Transformation

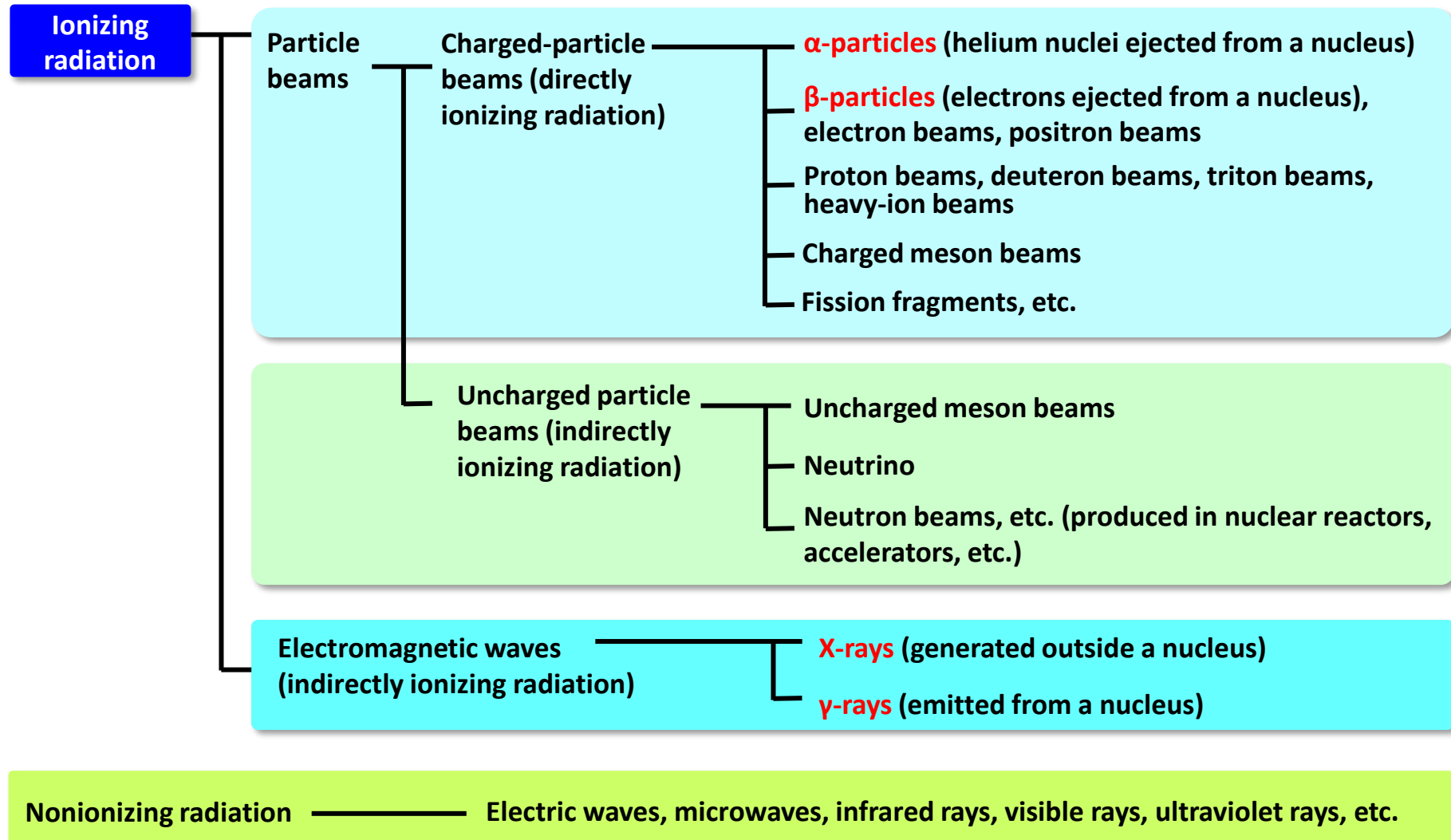
Transformation

Helium-3

{ Two protons
One neutron }

Radiation

Types of Radiation



While radiation includes ionizing radiation and nonionizing radiation, radiation usually means ionizing radiation.

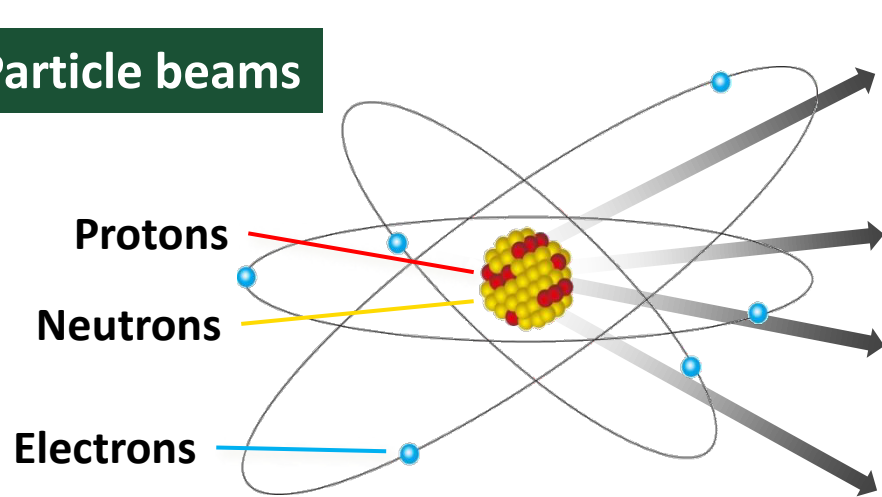
Source: Partially revised "Ionizing Radiation" in the Encyclopedia for Public Acceptance of Atomic Energy Accessible on the Internet, ATOMICA

Types of Ionizing Radiation

Ionizing radiation

Radiation that causes ionization

Particle beams



α -particles (helium nuclei ejected from a nucleus)



β -particles (electrons ejected from a nucleus)

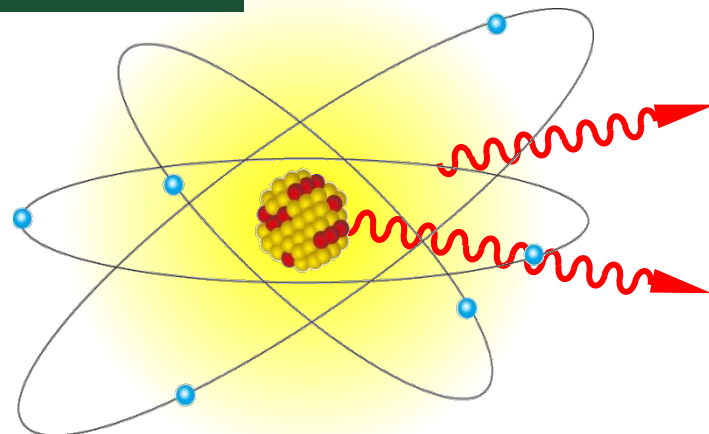


Neutron beams (produced in nuclear reactors, accelerators, etc.)



Proton beams (produced in accelerators, etc.)

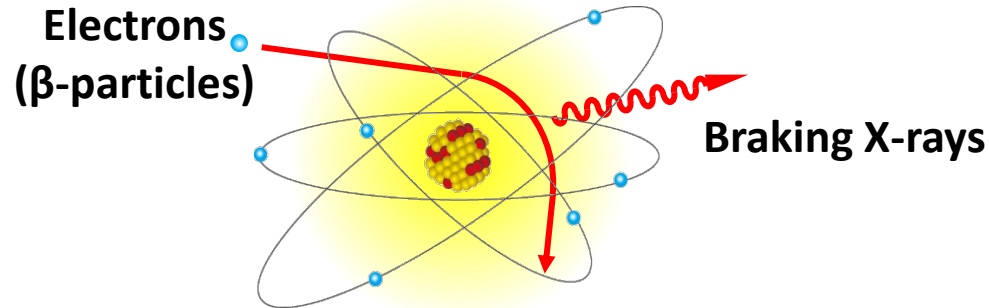
Electromagnetic waves



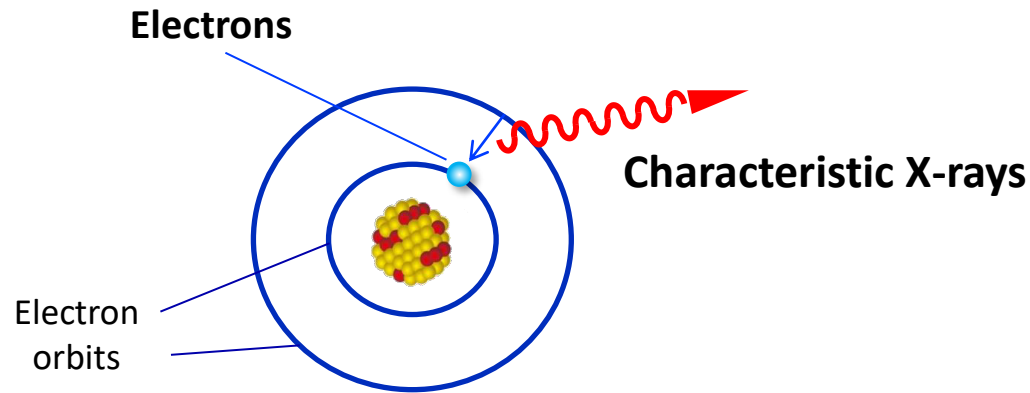
X-rays (generated outside a nucleus)

γ -rays (emitted from a nucleus)

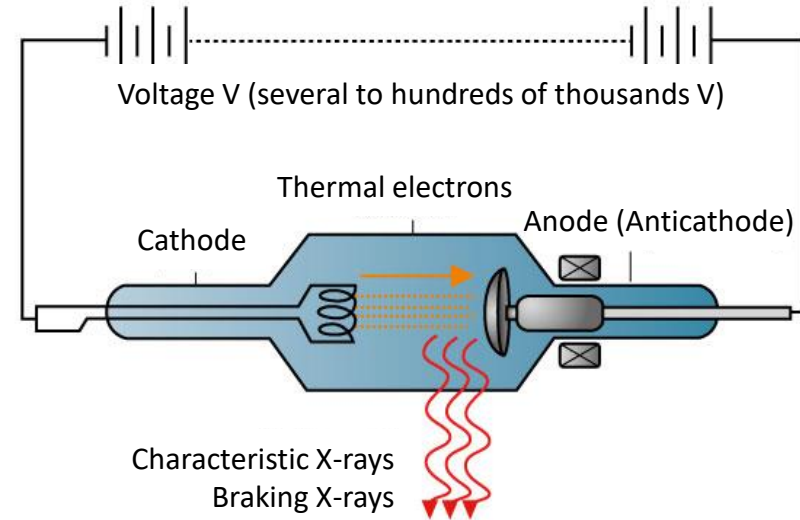
Braking X-rays



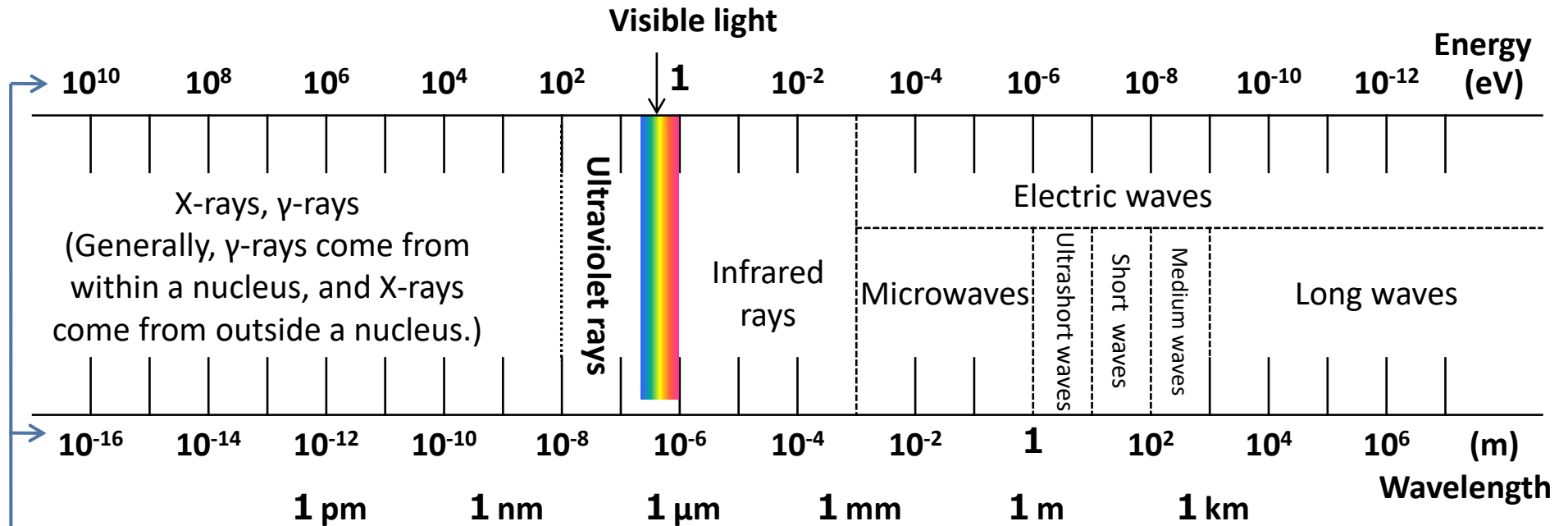
Characteristic X-rays



Structural drawing of an X-ray generator



Types of Electromagnetic Waves

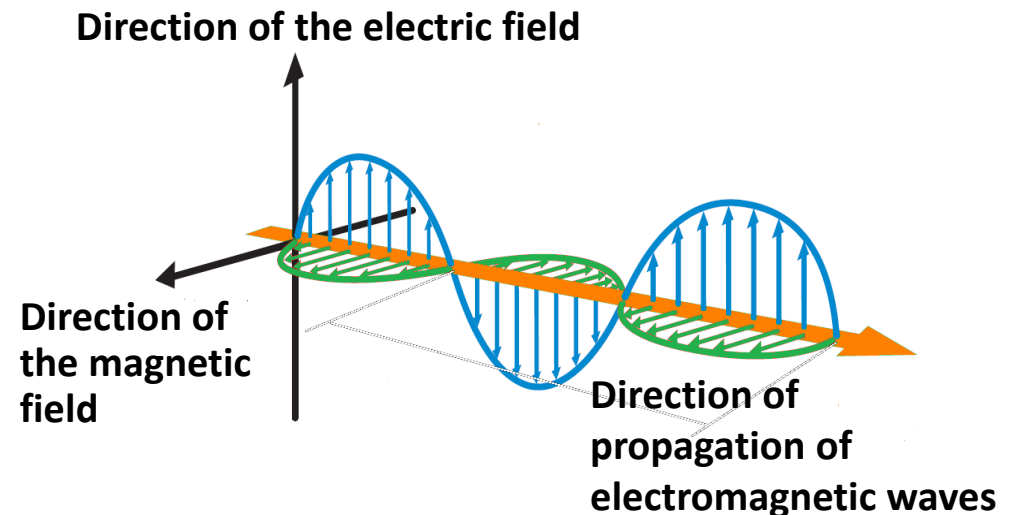


- Light has particle properties in addition to wave properties.
- Electromagnetic waves are called "photons" when they are considered as particles.

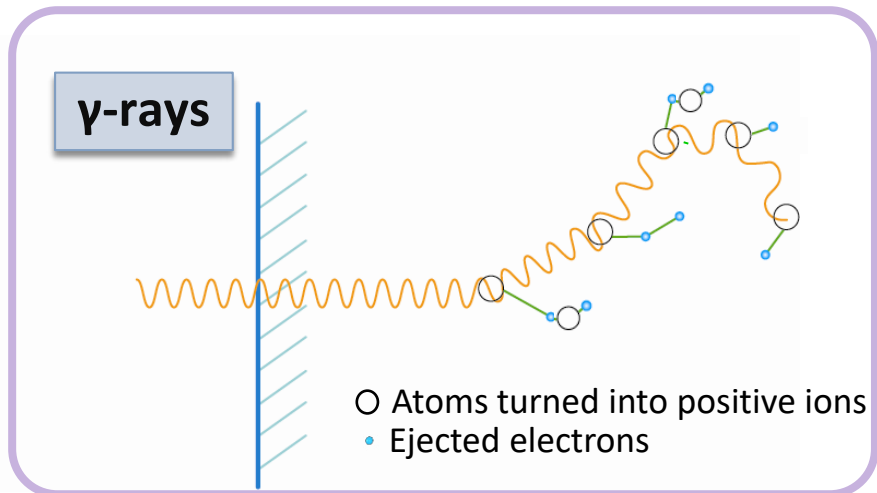
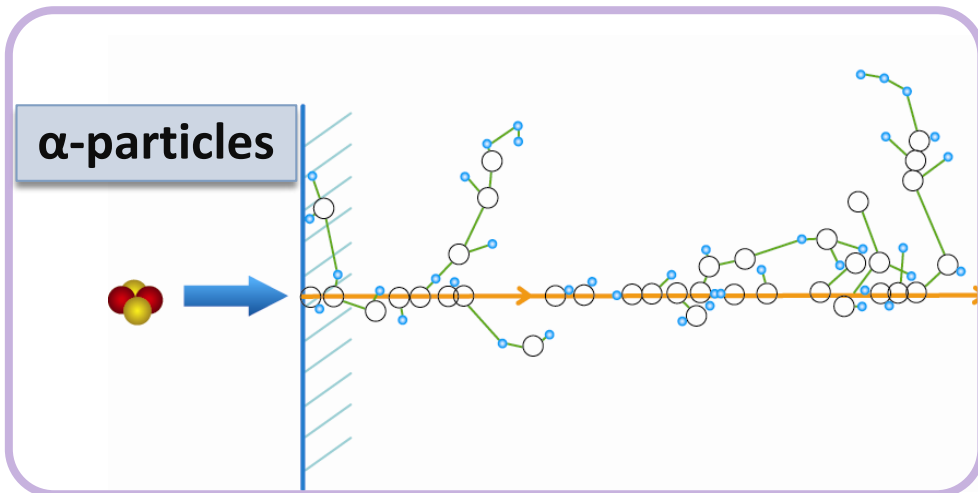
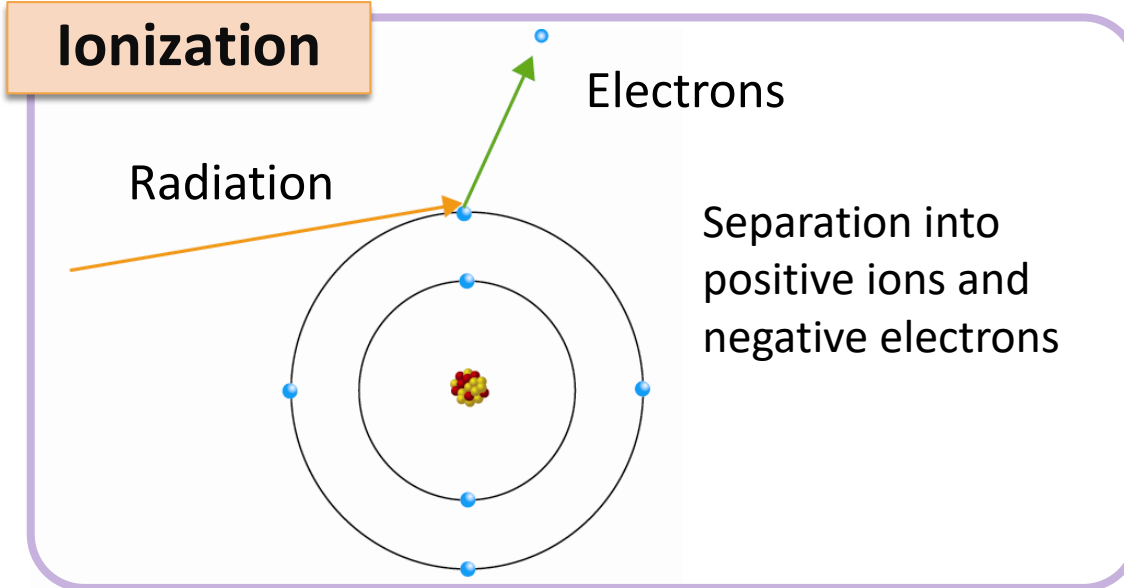
The values indicated above show photons' energy (eV) and those indicated below show their wavelengths (m) as wave motions.

pm: picometers
nm: nanometers

μ m: micrometers
eV: electron volts

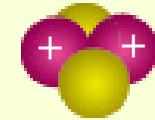


Ionization of Radiation - Property of Ionizing Radiation



- **α -particles**

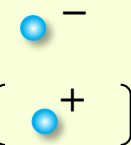
- Two protons plus two neutrons
- Helium (He) nuclei
- Charged particles (2+)



High ionization density

- **β -particles**

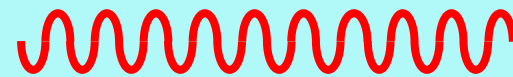
- Electrons (or positrons)
- Charged particles (- or +)



Low ionization density

- **γ -rays and X-rays**

- Electromagnetic waves (photons)



Low ionization density/high penetrating power

- **Neutron beams**

- Neutrons
- Uncharged particles

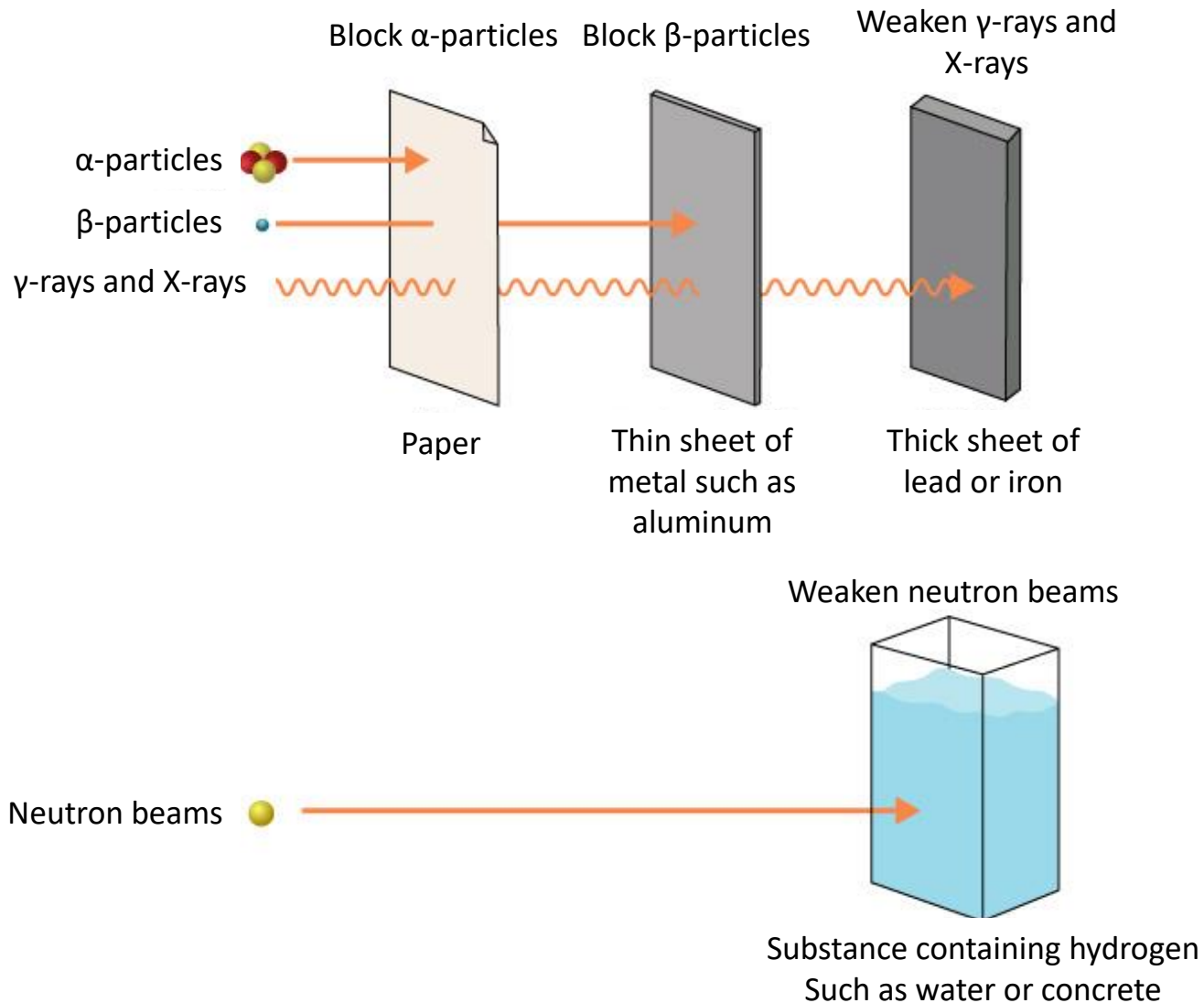


High ionization density

When the ionization number is the same, the higher the ionization density is, the larger the biological effects are.

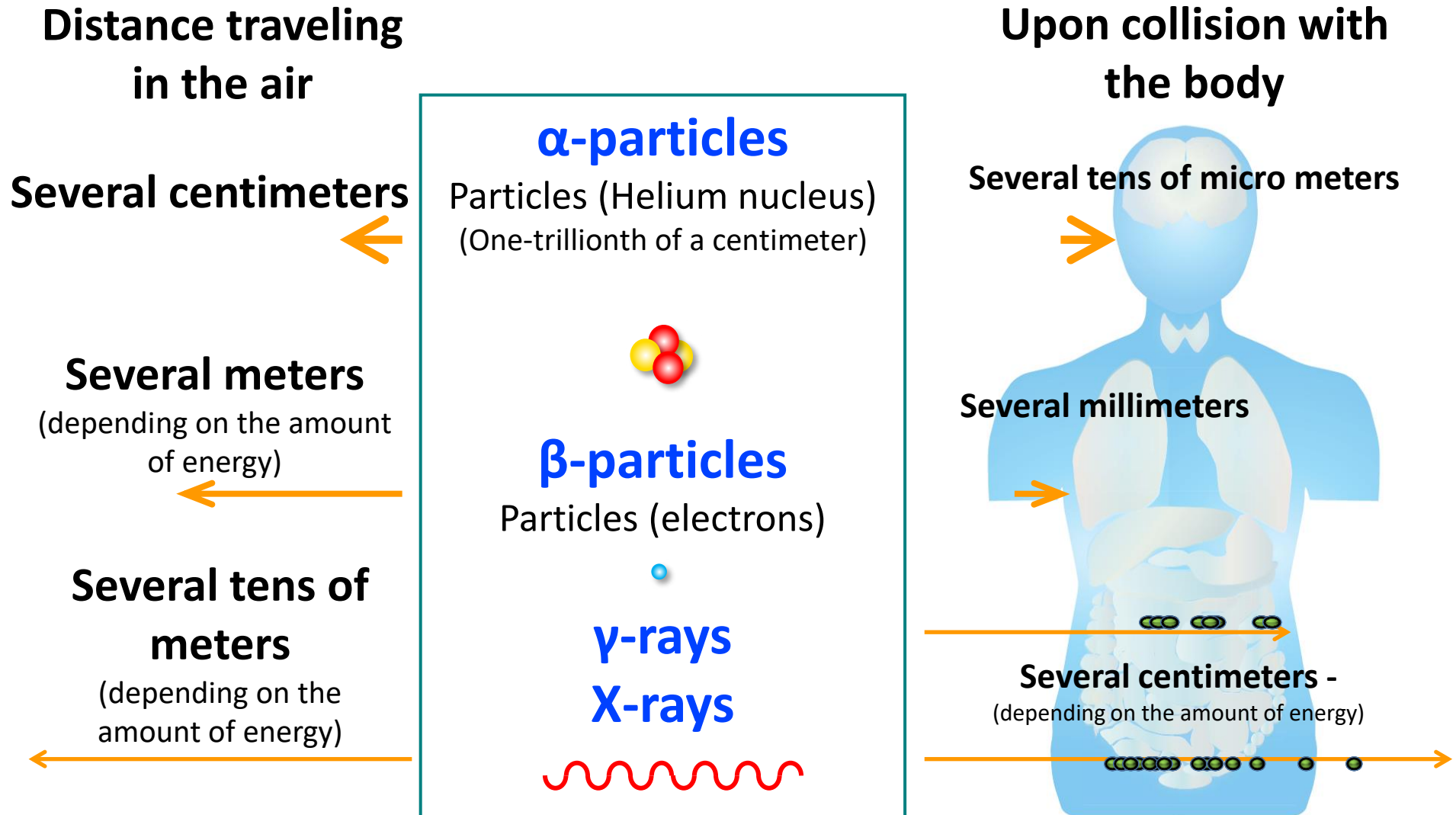
Penetrating Power of Radiation

Radiation can be blocked by various substances.



Radiation

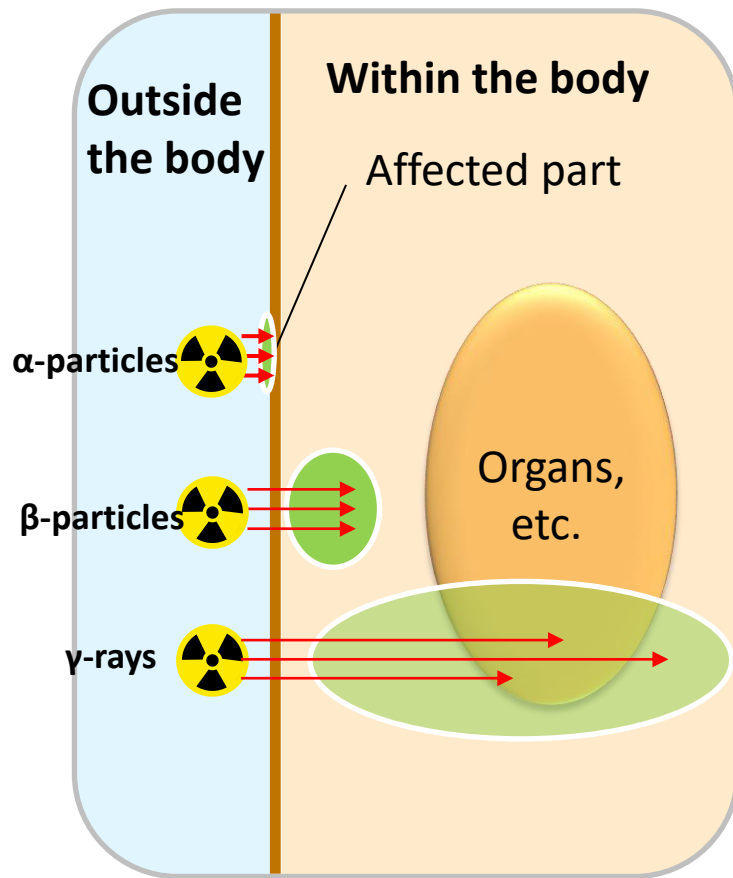
Penetrating Power of Radiation within the Body



Radiation

Penetrating Power and Range of Effects on the Human Body

When radioactive materials are located outside the body



When radioactive materials are located within the body

