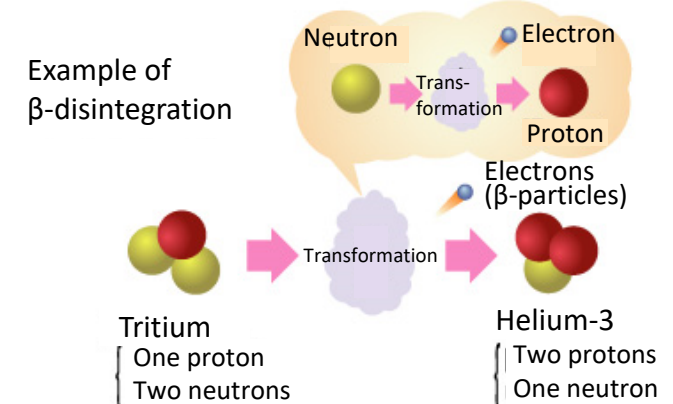
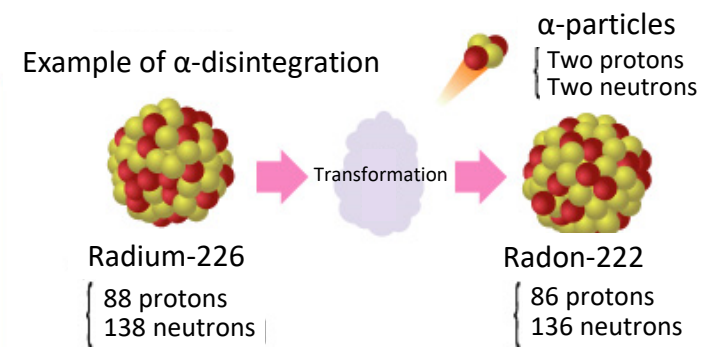
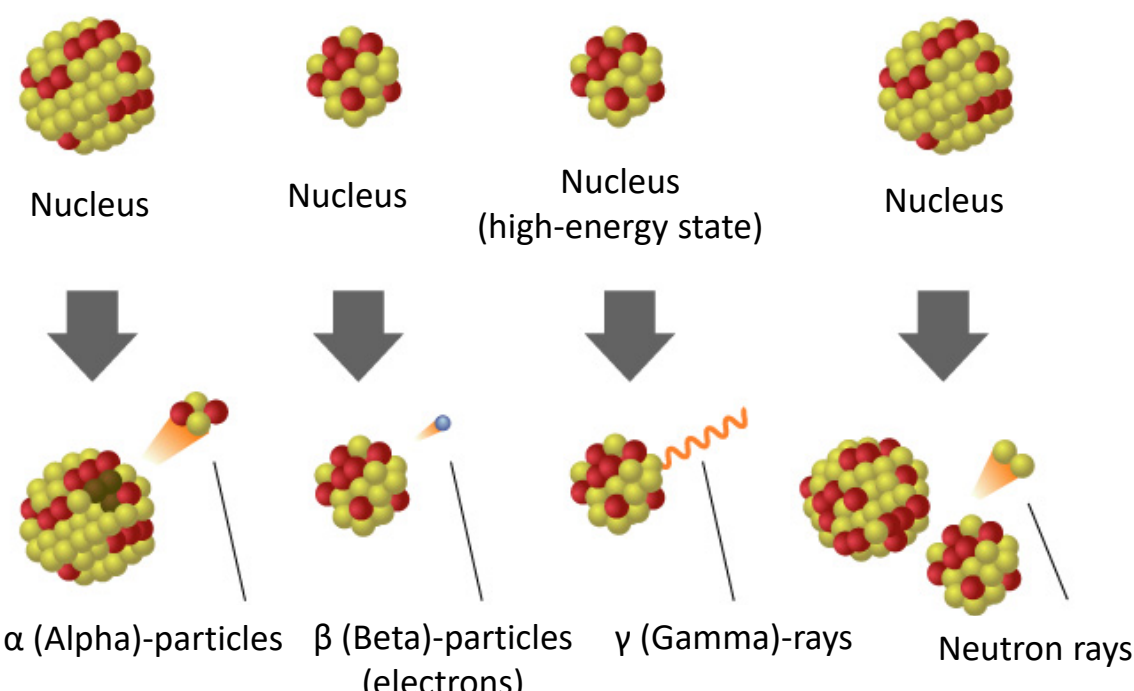
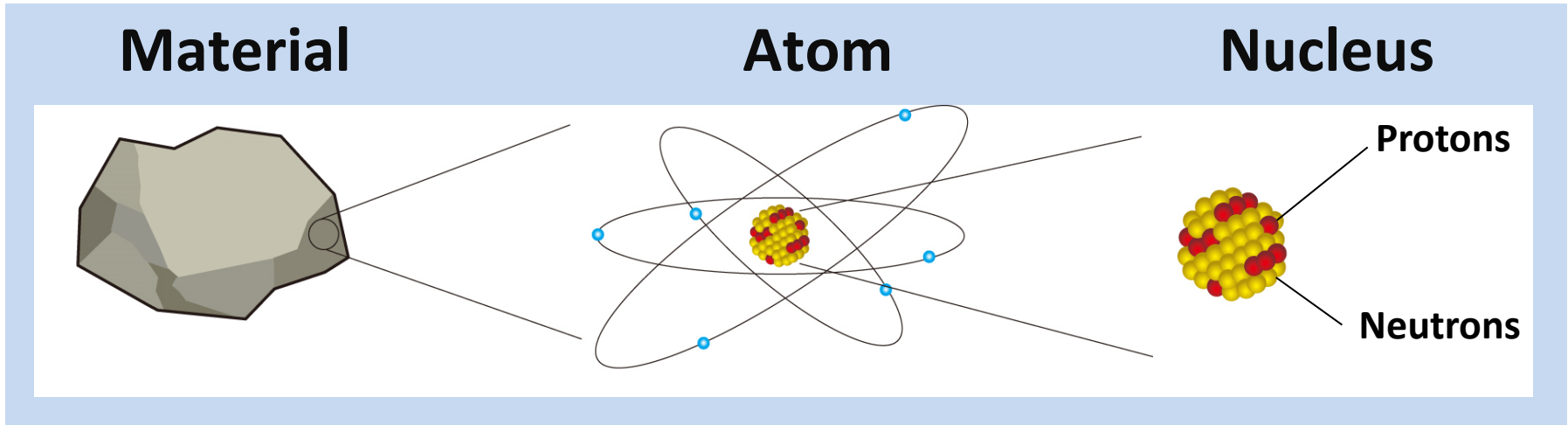
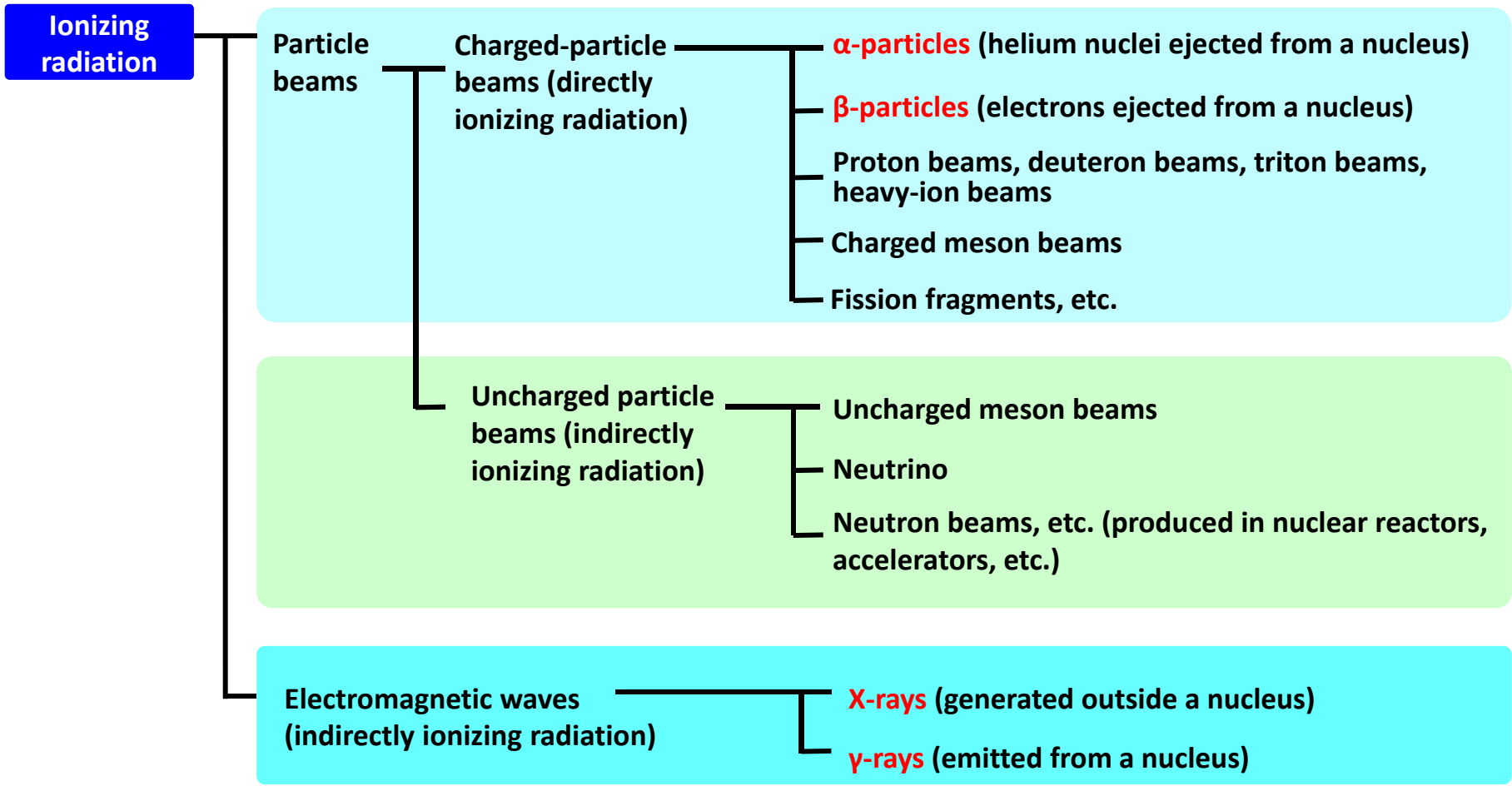


Where does Radiation Come from?



Types of Radiation



Nonionizing radiation ————— Electric waves, microwaves, infrared rays, visible rays, ultraviolet rays, etc.

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

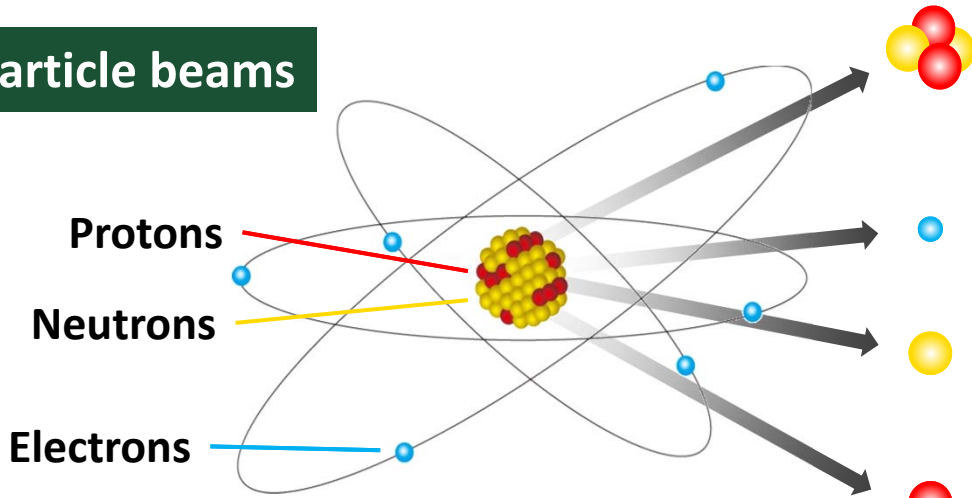
Partially revised "Ionizing Radiation" in the Encyclopedia for Public Acceptance of Atomic Energy Accessible on the Internet, ATOMICA

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)

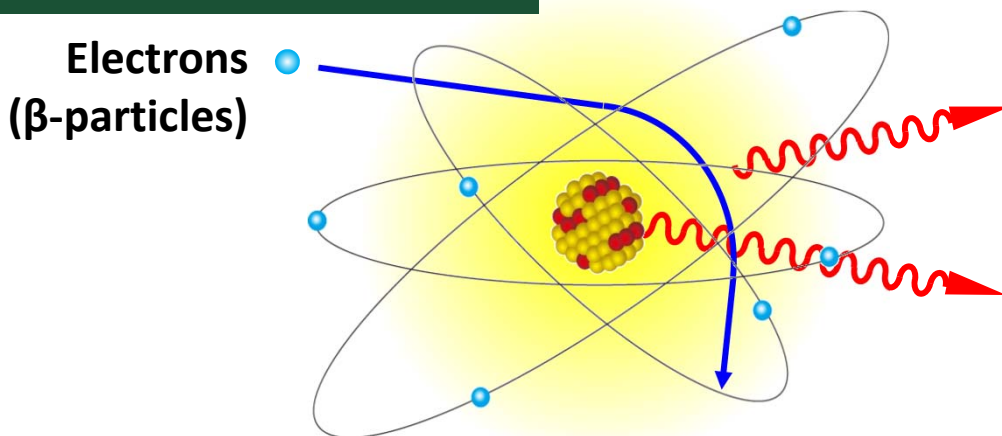


Neutron beams (produced in nuclear reactors, accelerators, etc.)



Proton beams (produced in accelerators, etc.)

Electromagnetic waves



X-rays (generated outside a nucleus)

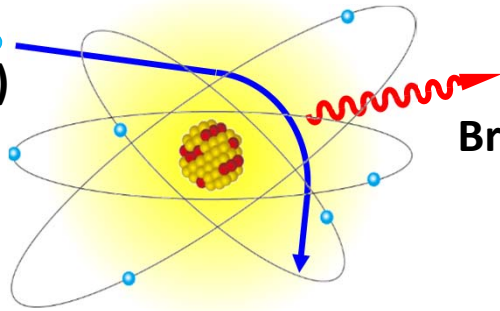
* X-rays generated when electrons within an atom are caused to travel between orbits by incident electrons are called characteristic X-rays.

γ -rays (emitted from a nucleus)

X-rays for Medical Use and Generators

Braking X-rays

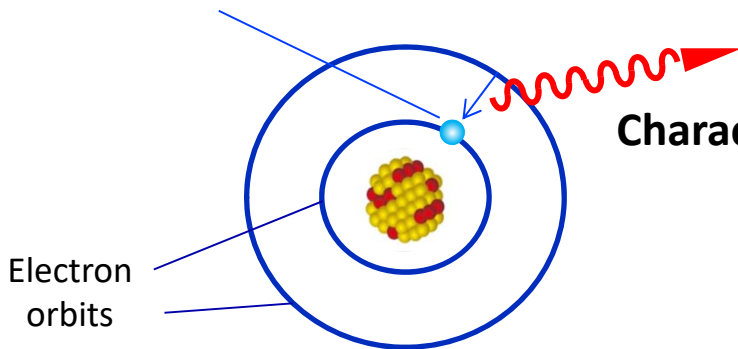
Electrons
(β -particles)



Braking X-rays

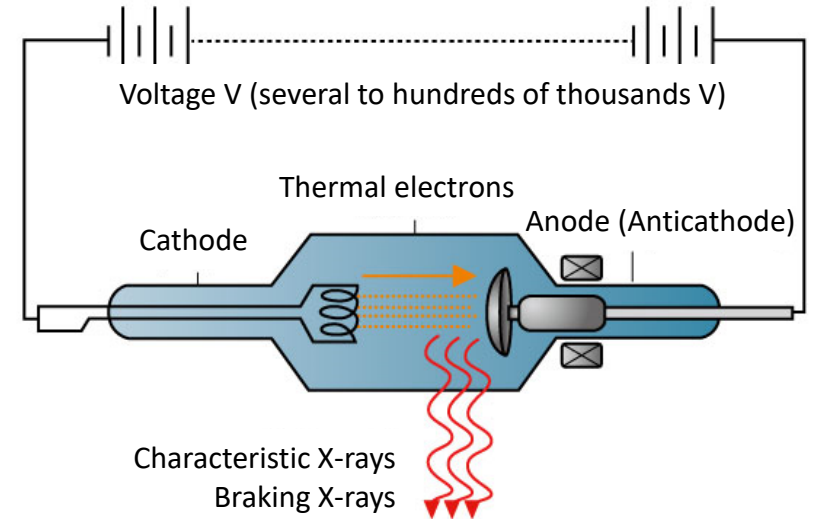
Characteristic X-rays

Electrons

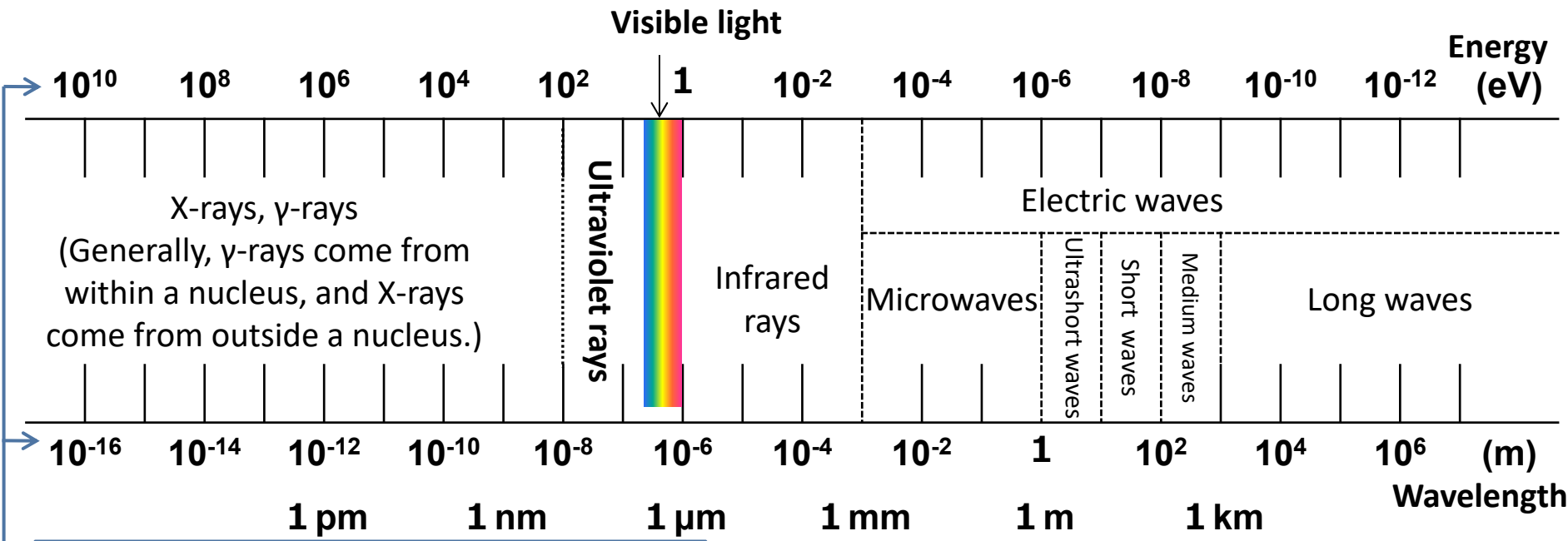


Characteristic X-rays

Structural drawing of an X-ray generator

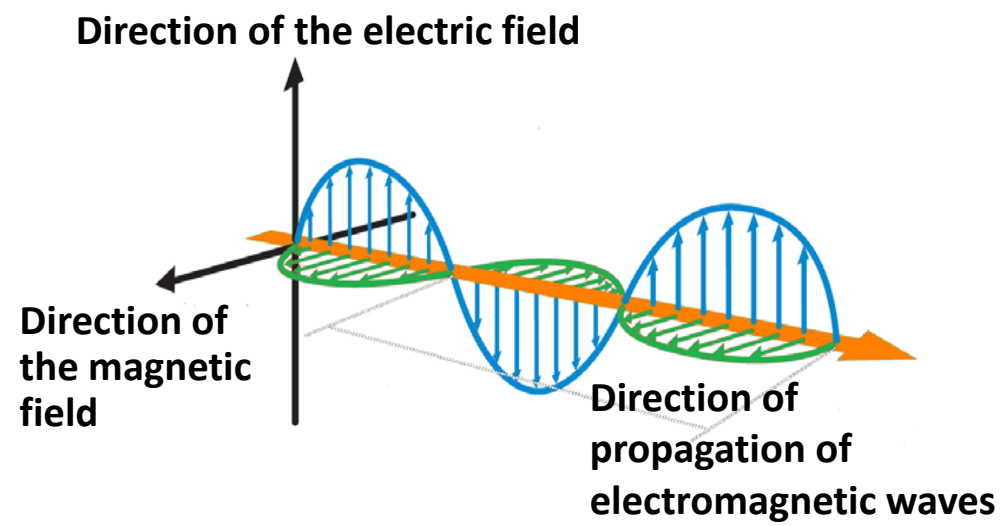


Types of Electromagnetic Waves

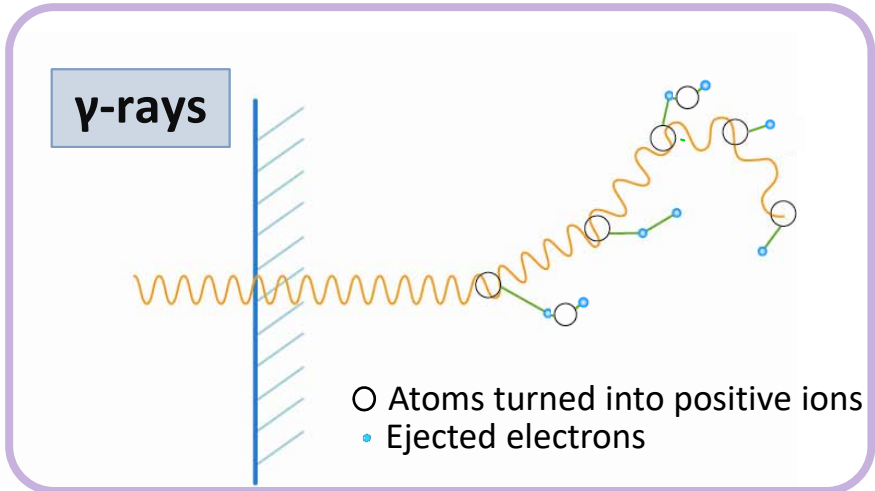
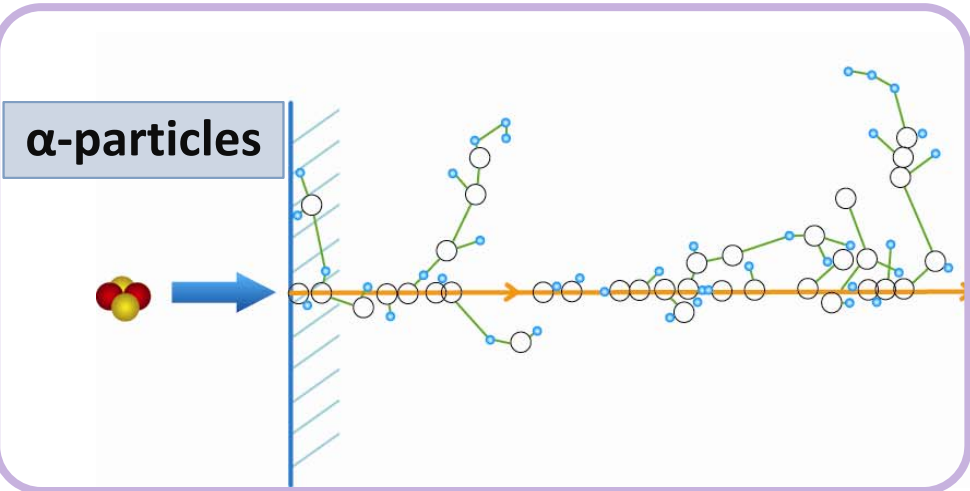
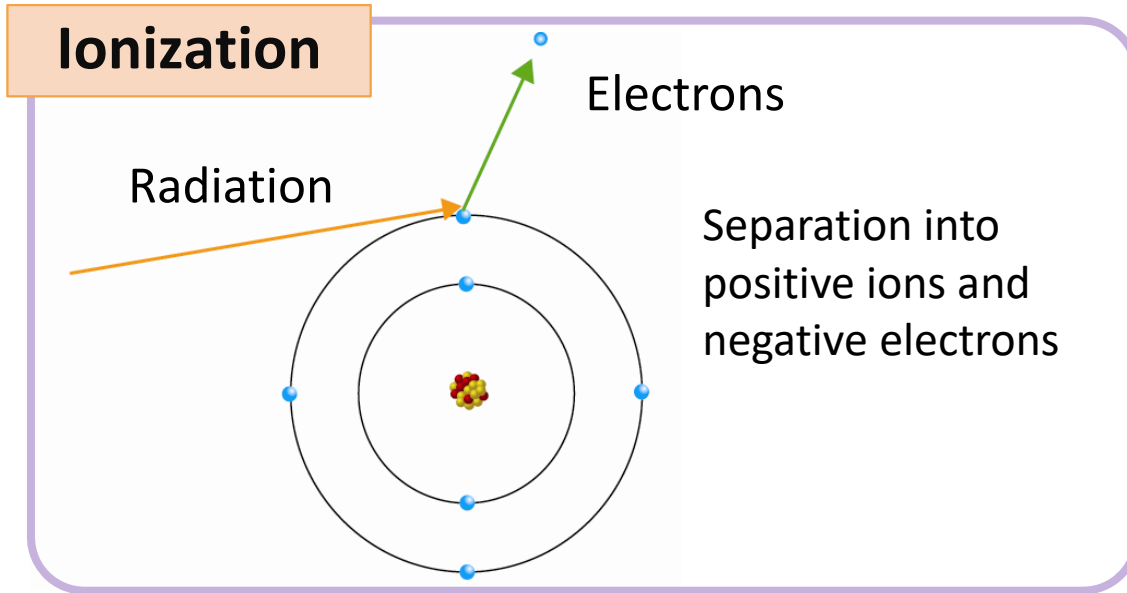


- Light has particle properties in addition to wave properties.
 - Electromagnetic waves are called "photons" when they are considered as particles.
- The values indicated above show photons' energy (eV) and those indicated below show their wavelengths (m) as wave motions.

pm: picometers μm : micrometers
 nm: nanometers eV: electron volts



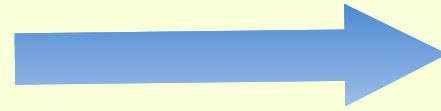
Ionization of Radiation - Property of Ionizing Radiation



Types of Radiation and Biological Effects

- **α -particles**

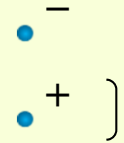
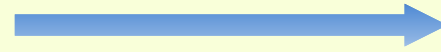
- Two protons plus two neutrons
- Helium (He) nuclei
- Charged particles (2+)



High ionization density

- **β -particles**

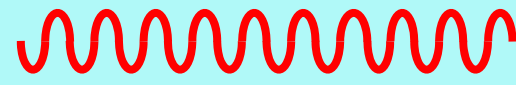
- Electrons (or positrons)
- Charged particles (- or +)



Low ionization density

- **γ -rays and X-rays**

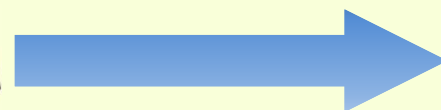
- Electromagnetic waves (photons)



Low ionization density/high
penetrating power

- **Neutron beams**

- Neutrons
- Uncharged particles

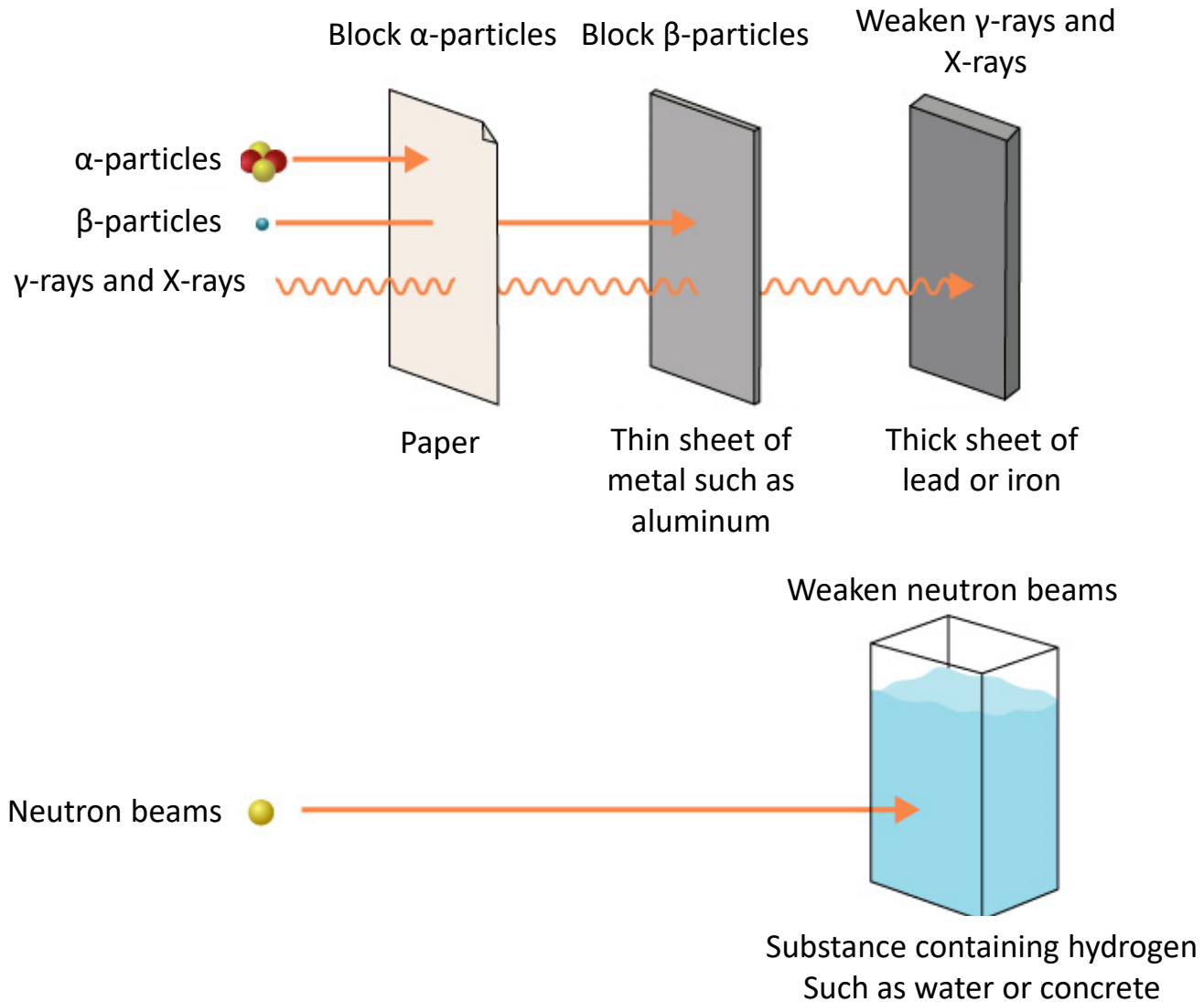


High ionization density

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.



Penetrating Power of Radiation within the Body

Distance traveling
in the air

1 to 10 cm



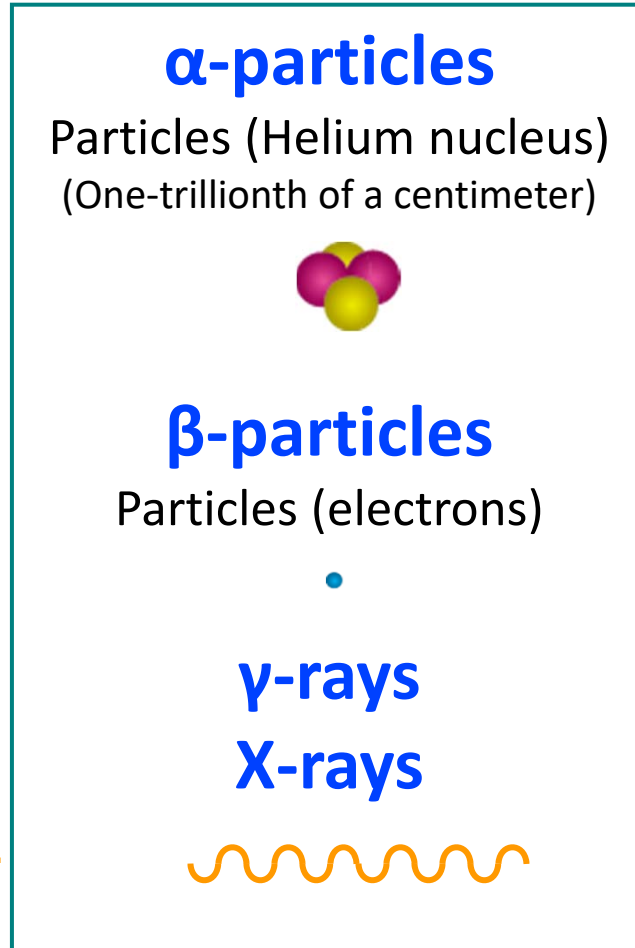
Several meters

(depending on the amount
of energy)



Several tens of
meters

(depending on the
amount of energy)



Upon collision with
the body

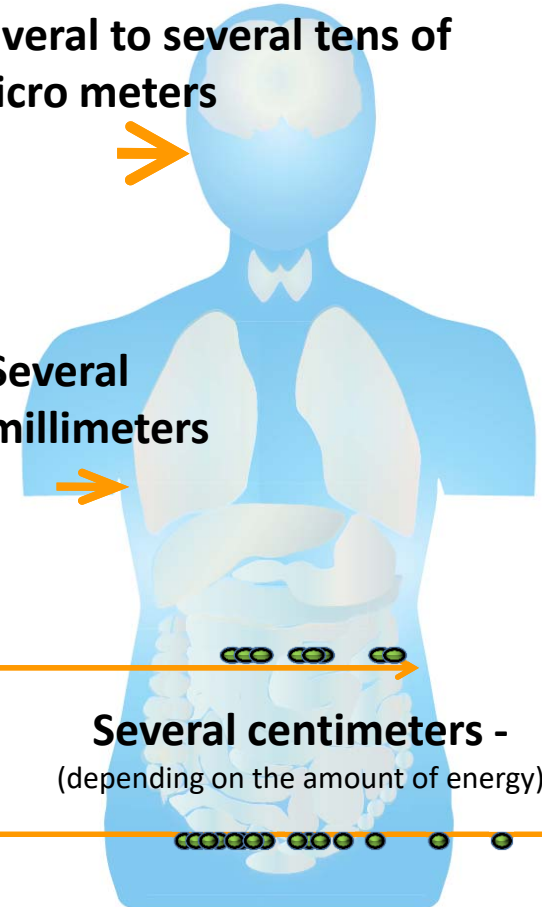
Several to several tens of
micro meters



Several
millimeters

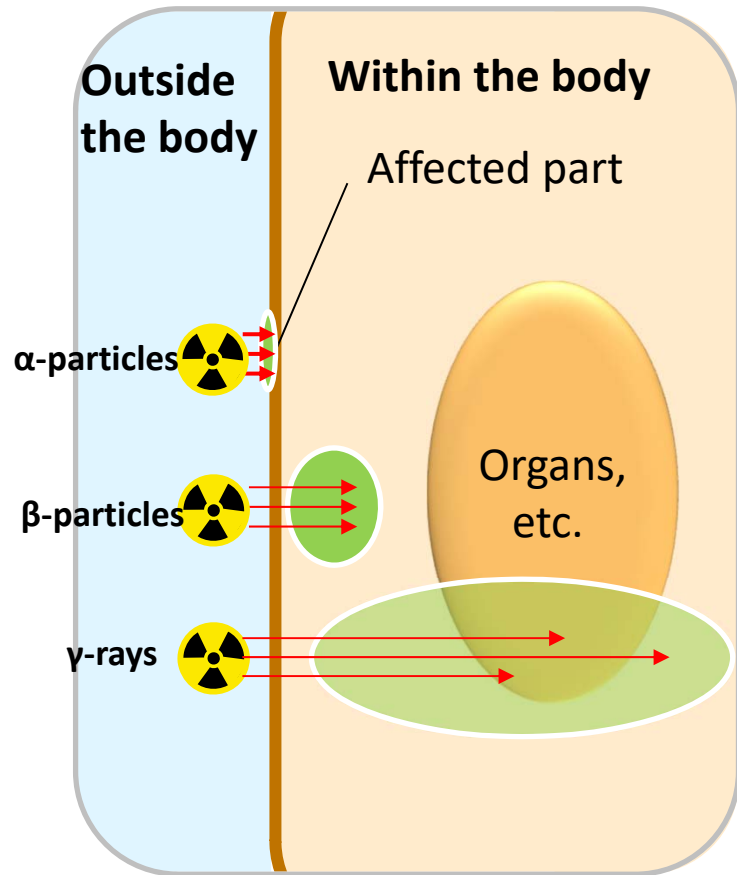


Several centimeters -
(depending on the amount of energy)



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

