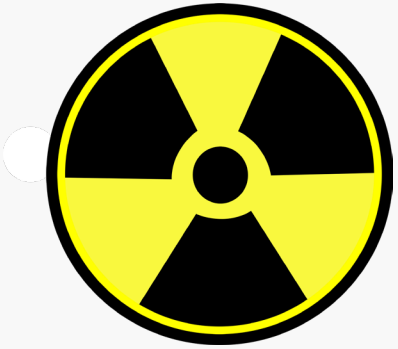
Radiation- What is it?

MODULE 2

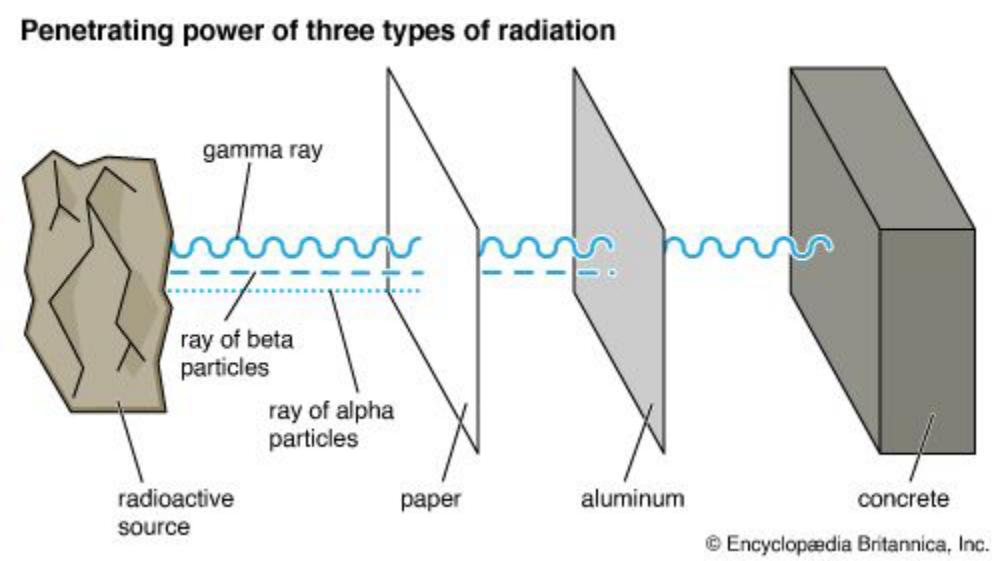
What is Radiation?

The transfer of energy in the form of particles or waves from one object to another though a medium.



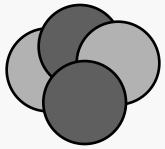
Types of Radiation

1. **Ionizing:** X-Ray, Gamma Rays; Alpha/Beta/Neutron particles
2. **Non-Ionizing**: Radiation that does not have enough energy to remove electrons from atoms, like radio waves, microwaves, and visible light.



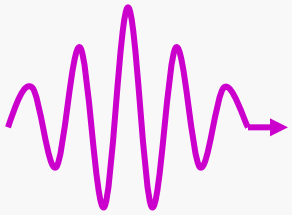
Types of Radiation

Charged vs. Uncharged



Alpha Particle

Beta Particle

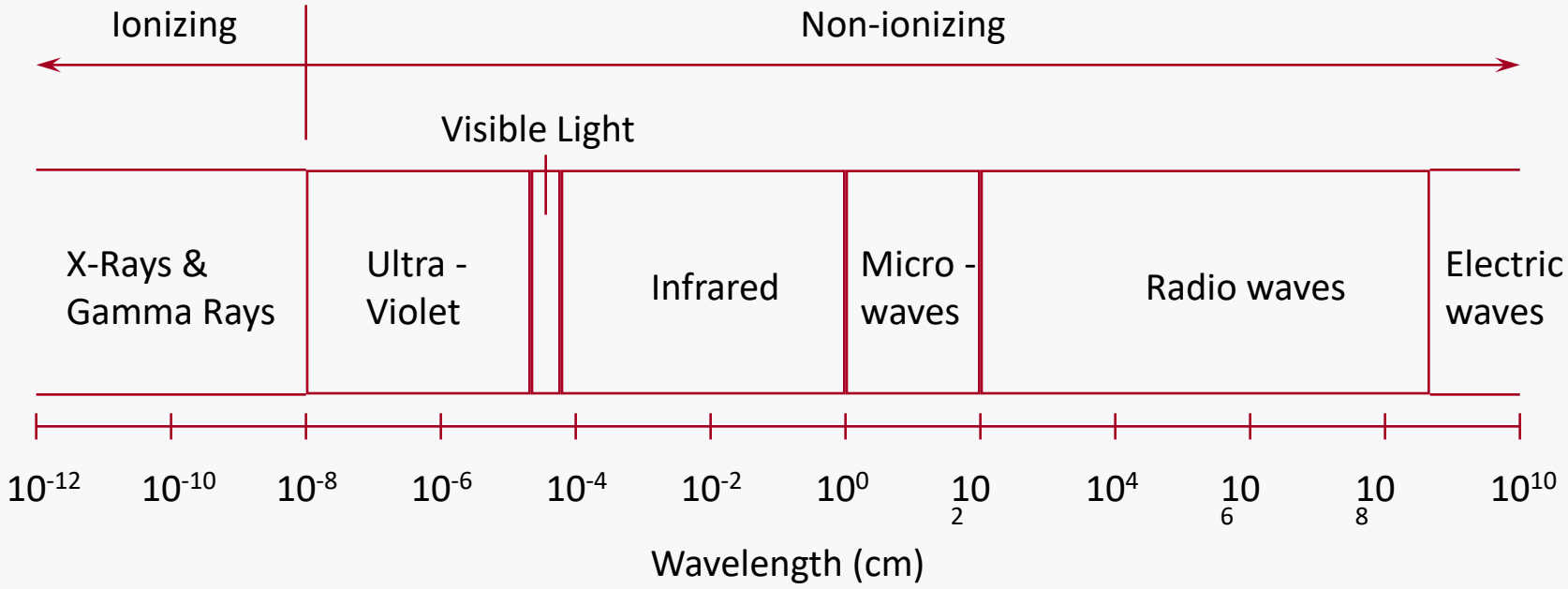


Photon

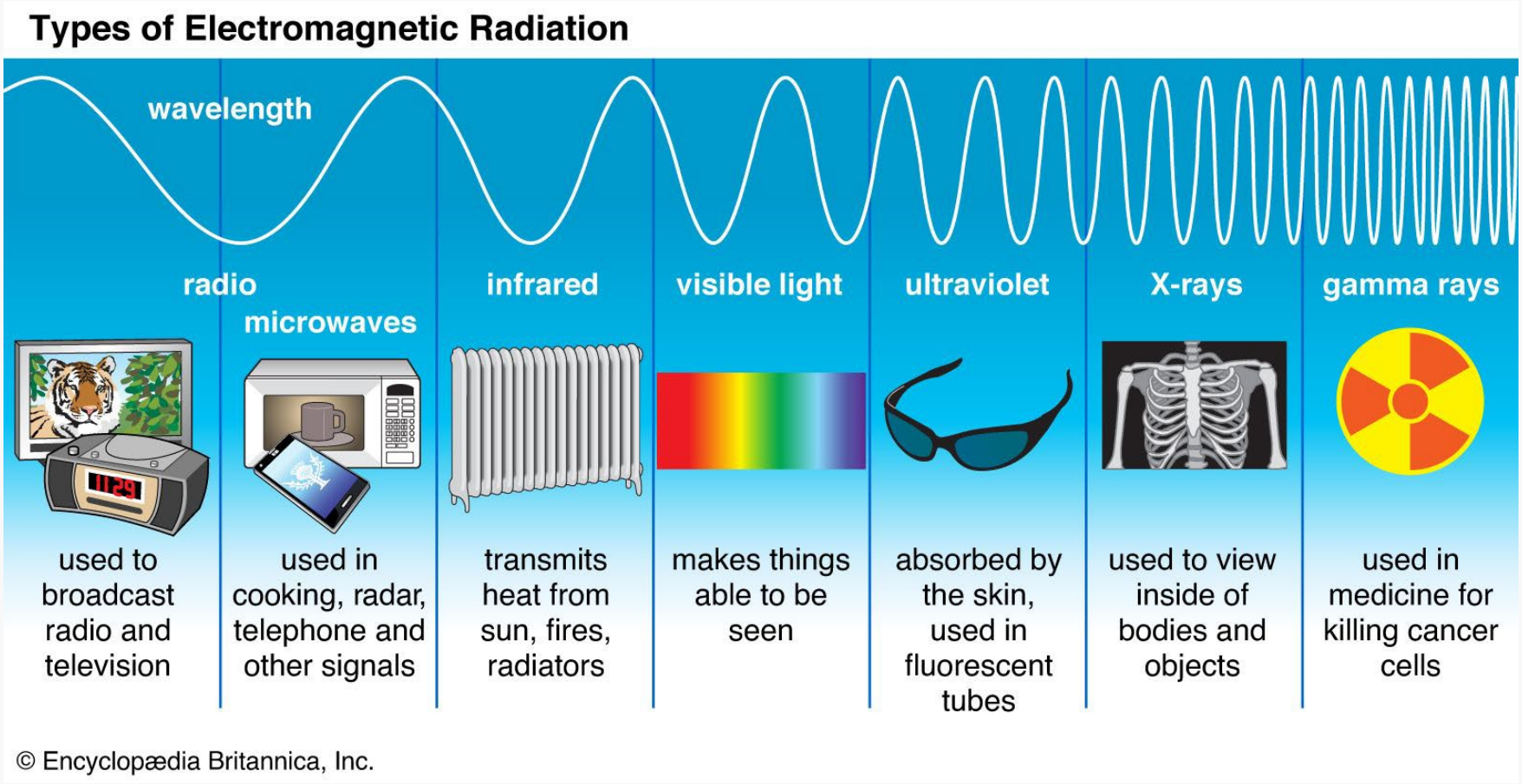
Neutron

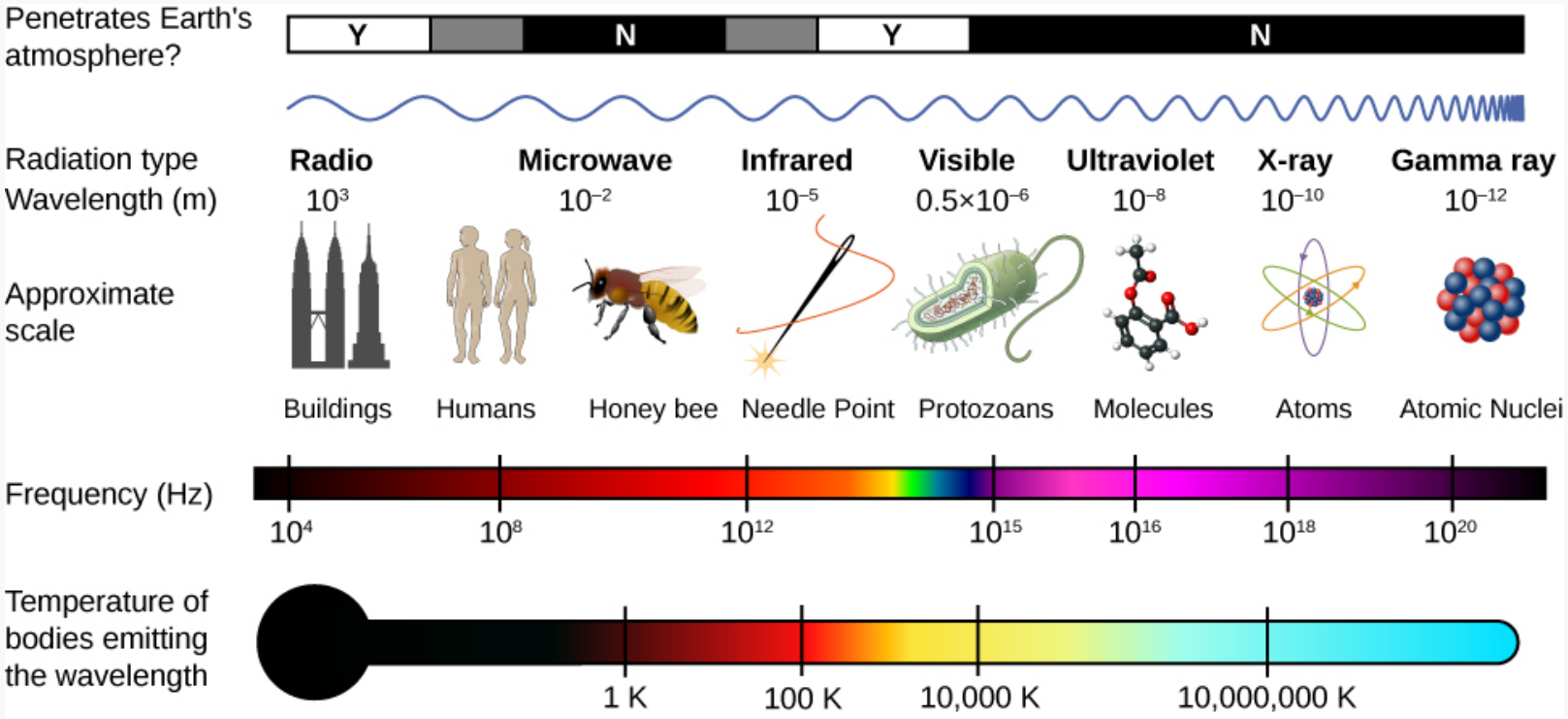
Electromagnetic Radiation

Oscillating electric and magnetic fields that transfer energy to matter via photon or wave interactions



Electromagnetic Radiation




Penetrates Earth's atmosphere?
Y
N
Y
N
Radiation type
Wavelength (m)
Radio
10^{3}
Microwave
10^{-2}
Infrared
10^{-5}
Visible
0.5×10^{-6}
Ultraviolet
10^{-8}
X-ray
10^{-10}
Gamma ray
10^{-12}
Approximate scale
Buildings
Humans
Honey bee
Needle Point
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
10^{4}
10^{8}
10^{12}
10^{15}
10^{16}
10^{18}
10^{20}
Temperature of bodies emitting the wavelength
1 K
100 K
10,000 K
10,000,000 K

Exposure

Absorption of ionizing radiation or the amount of a hazardous substance that has been ingested, inhaled, or in contact with the skin. Acute exposure occurs over a short period of time. Chronic exposure is exposure received over a long period of time, such as during a lifetime. See Occupational dose.

Radiation exposure is measured using various instruments like ionization chambers and Geiger counters, which detect the presence and intensity of radiation.

Units like becquerels (Bq), roentgens (R), rads, and sieverts (Sv) are used to quantify radiation exposure.

Understanding Radiation Units

mrem (millirem): A unit of radiation dose equivalent, used to measure the biological effect of radiation on the human body.

rem ('roentgen equivalent man'): A larger unit of radiation dose equivalent, equal to 1000 mrem.

mSv (millisievert): The international unit for radiation dose equivalent, equal to 100 mrem.

Sv (sievert): The international unit for radiation dose equivalent, equal to 100 rem.

Examples of Radiation Units and Conversions

Quantity	Unit	Description	Approximate Conversions	Notes
Exposure	Roentgen (R)	Ionization in air	1 R ≈ 2.58×10^{-4} C/kg (SI unit)	Measures charge in air, not absorbed dose
Absorbed Dose	Rad (radiation absorbed dose)	Energy deposited per mass	1 rad = 0.01 Gray (Gy)	1 rad = 100 erg/g
	Gray (Gy)	SI unit of absorbed dose	1 Gy = 100 rad	1 Gy = 1 joule/kg
Dose Equivalent	Rem (roentgen equivalent man)	Absorbed dose × radiation weighting factor	1 rem = 0.01 Sievert (Sv)	Reflects biological effect
	Sievert (Sv)	SI unit of dose equivalent	1 Sv = 100 rem	Used for radiation protection standards

Quantity	Unit (Traditional)	Unit (SI)	Definition / Purpose	Conversion	Notes
Exposure	Roentgen (R)	Coulomb/kg (C/kg)	Measure of ionization in air	1 R = 2.58×10^{-4} C/kg	Used mostly for X-rays and gamma rays
Absorbed Dose	rad	Gray (Gy)	Energy absorbed per unit mass	1 rad = 0.01 Gy	1 Gy = 100 rad
Dose Equivalent	rem	Sievert (Sv)	Absorbed dose × radiation weighting factor (WR)	1 rem = 0.01 Sv	Accounts for biological effects of radiation
Radiation Weighting Factor (WR)	—	—	Factor to convert absorbed dose to dose equivalent	Depends on radiation type	X-rays/gamma: 1; Alpha: 20; Neutrons: 5-20

Conversions

- For purpose of radiation protection, it is often *assumed* that **1R = 1rad = 1rem**.
- For photons, since R is only defined for photons and the quality factor is 1 for photons; 1R is actually less than 1rad so this is a conservative assumption.
- The actual “conversion” factor is dependent on the absorber (1R = 0.96rad for tissue).

Absorbed Dose

The amount of energy absorbed by an object or person per unit mass. Known as the "absorbed dose," this reflects the amount of energy that ionizing radiation sources deposit in materials through which they pass, and is measured in units of radiation-absorbed dose (rad). The related international system unit is the gray (Gy), where 1 Gy is equivalent to 100 rad. For additional information, see Doses in Our Daily Lives and Measuring Radiation.

Dose Equivalents

- A measure of the biological damage to living tissue as a result of radiation exposure. Also known as the " biological dose," the dose equivalent is calculated as the product of absorbed dose in tissue multiplied by a quality factor and then sometimes multiplied by other necessary modifying factors at the location of interest. The dose equivalent is expressed numerically in rems or sieverts (Sv) (see 10 CFR 20.1003). For additional information, see Doses in Our Daily Lives and Measuring Radiation.

- 100 rem = 1 Sv

Dose Equivalents

Dose Equivalent Type	Definition	Units	Purpose / Use	Notes
Deep Dose Equivalent (DDE)	Dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2)	rem or Sv	Estimates dose to whole body from external radiation penetrating deep	Used for monitoring occupational exposure to penetrating radiation like gamma rays, X-rays
Shallow Dose Equivalent (SDE)	Dose equivalent at 0.007 cm depth (7 mg/cm^2)	rem or Sv	Dose to skin or extremities	Relevant for low-energy beta radiation or skin dose assessments
Eye Dose Equivalent (EDE)	Dose equivalent at 0.3 cm depth in the lens of the eye	rem or Sv	Evaluates dose to lens of the eye	Important for cataract risk in radiation workers
Committed Dose Equivalent (CDE)	Dose equivalent to a specific organ/tissue over 50 years after intake of radioactive material	rem or Sv	Assesses internal exposure from inhalation or ingestion	Used in nuclear medicine, radiation protection for internal emitters
Committed Effective Dose Equivalent (CEDE)	Weighted sum of committed doses to all organs considering tissue sensitivities	rem or Sv	Estimates overall health risk from internal exposure	Combines organ doses with tissue weighting factors
Effective Dose Equivalent (EDE)	Weighted sum of external doses to all organs using tissue weighting factors	rem or Sv	Estimates overall health risk from external exposure	Accounts for variation in organ radiosensitivity
Total Effective Dose Equivalent (TEDE)	Sum of Deep Dose Equivalent (external) and Committed Effective Dose Equivalent (internal)	rem or Sv	Overall radiation dose to individual (external + internal)	Used in occupational dose monitoring