RADIOBIOLOGY

RADIOBIOLOGY

OBJECTIVES:

At the end of this unit students should be able to:

1. Define the following terms; Radiation, Ionizing Radiation, Radiobiology, Exposure, Absorbed Dose, Dose Equivalent, Radioactivity.

2. Convert the conventional units of measurement of ionizing radiation to the S.I. Units.

3. Describe the types of interactions of radiation with matter.

4. Discuss radiation effects (Direct and Indirect), LET and RBE.

5. Use formulas to calculate X-ray Exposure.

RADIOBIOLOGY

Definition:

The study of the sequence of events that follows the absorption of energy from ionizing radiation, the efforts of the organism to compensate for the effects of this energy absorption, and the damage to the organism that may be produced.

RADIOBIOLOGY

Radiation:

When energy is emitted and transferred through matter, it is called Radiation. E.g. heat, light.

When any form of matter is struck by a form of radiant energy, it is described as being exposed or radiated.

In Radiology, the type of radiation used is Ionizing Radiation. Capable of creating +vely and –vely charged particles when interacted with matter.

Radiation In Perspective

Within the range of radiation frequencies, called the electromagnetic spectrum, cell phones fall between TVs and microwave ovens. At that level, many scientists believe the radiation from cell phones couldn't conceivably impair human health.

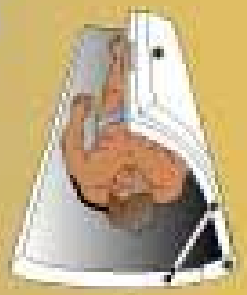
Infographic by Randie Gordon

power lines

TV

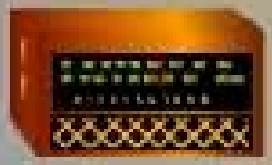
cell phone

heating lamp



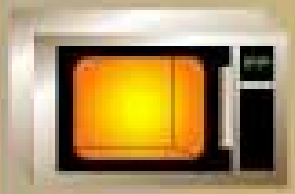
tanning booth

medical X-rays



AM radio

FM radio



microwave oven

Frequency, Hz

10^{2} 10^{4} 10^{6} 10^{8} 10^{10} 10^{12} 10^{14} 10^{16} 10^{18} 10^{20}

Radio

Microwave

Infrared

Ultraviolet

X-ray

Source: *IEEE Spectrum* magazine, August 2000

RADIATION UNITS

Exposure:

A measure of the ionization of air produced by x-radiation and gamma radiation below 3MeV.
Gradually being replaced with absorbed dose in air.

Unit- Roentgen (R) or coulombs per kilogram (C/kg).

Exposure Rate = C/Kg/s

A measure of Intensity of an x-ray beam of a given quality.

Intensity – Describes the quantity of radiation.

Quality – Describes the beams penetrating power.

RADIATION UNITS

Absorbed Dose:

This is the ratio E/m where E is the energy absorbed by the medium due to a beam of ionizing radiation in a small mass ‘m’.

Unit- J/Kg or Rad or Grey (Gy)

RADIATION UNITS

Dose Equivalent:

Occupational exposure. Unit used to measure the overall biological effect of different ionizing radiations.

Dose Equivalent = Q x Absorbed Dose x N

Q = Quality Factor

N = other factors e.g dose rate

Unit – REM or Sieverts (Sv)

RADIATION UNITS

Radioactivity:

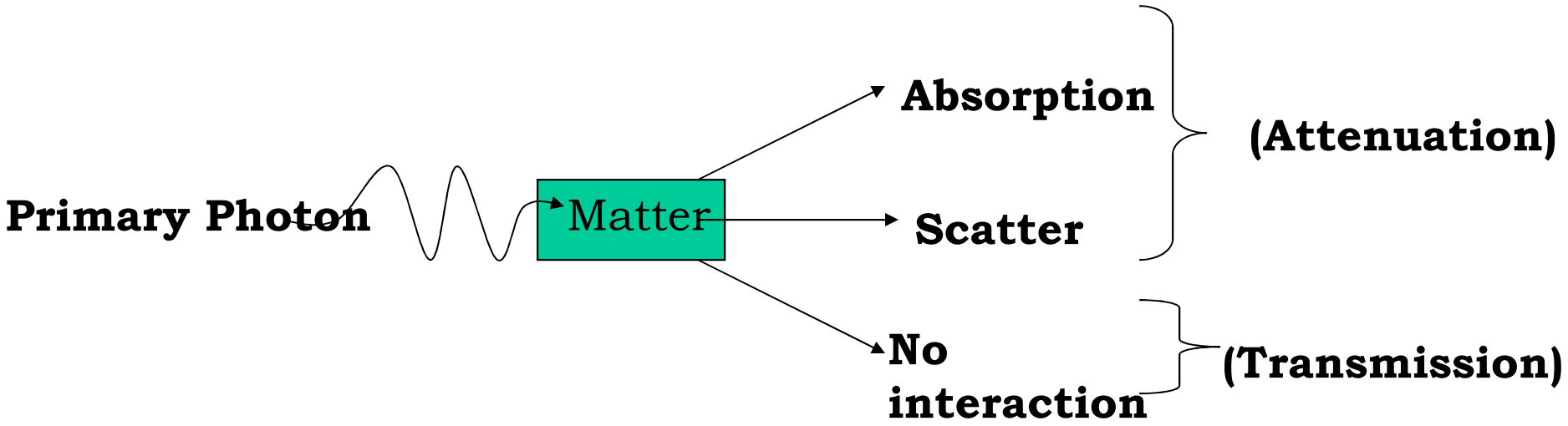
Not strictly a measure of radiation intensity but rather a measure of the rate of nuclear disintegration (decay) of a material.

Unit – Curie (Ci) or Becquerel (Bq)

RADIATION UNITS CONVERSION

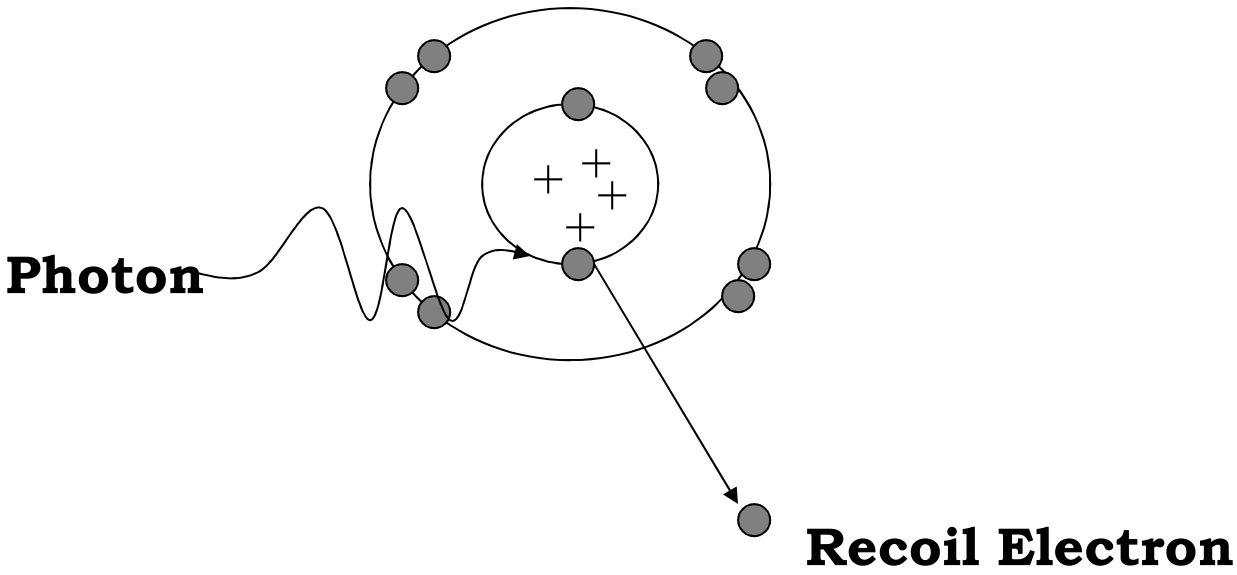
QUANTITY	S.I UNIT	CONVENTIONAL UNIT	
Exposure (X)	C/Kg	Roentgen (R)	$1R=2.58x10^{-4}$ C/Kg
Absorbed Dose	Grey (Gy)	Rad	1Gy=1J/Kg 1Gy=100Rad
Dose Equivalent	Sievert (Sv)	Rem	1Sv=100Rem
Radioactivity	Becquerel (Bq)	Curie (Ci)	$1Ci=3.7x10^{10}Bq$

INTERACTIONS OF RADIATION WITH MATTER



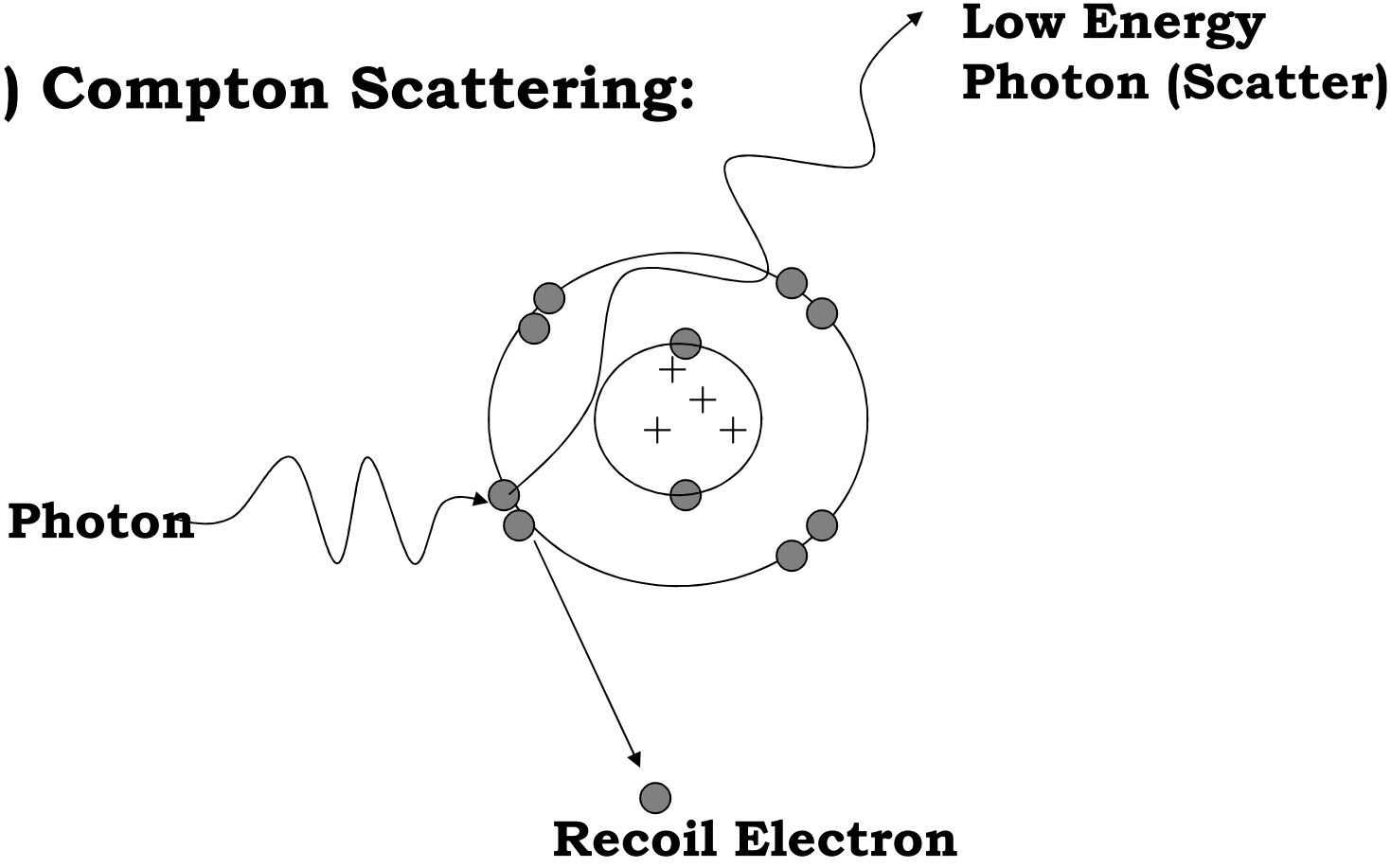
INTERACTIONS OF RADIATION WITH MATTER

1) Photoelectric Effect:



INTERACTIONS OF RADIATION WITH MATTER

2) Compton Scattering:



INTERACTIONS OF RADIATION WITH MATTER

3) Coherent Scattering:

Occurs below 10KeV. Makes only very small portion of scattering in diagnostic radiology.

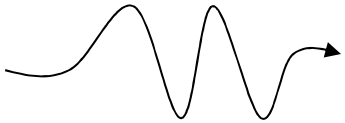
4) Pair Production:

Occurs above 1.03MeV.

5) Photodisintegration:

Occurs above 10MeV.

RADIATION EFFECTS



Incident X-Ray Photon

Fast Electron

Ion Radical

H^+ OH^-

(10^{-11Sec})

Free Radical

(10^{-4Sec})

Chemical Change

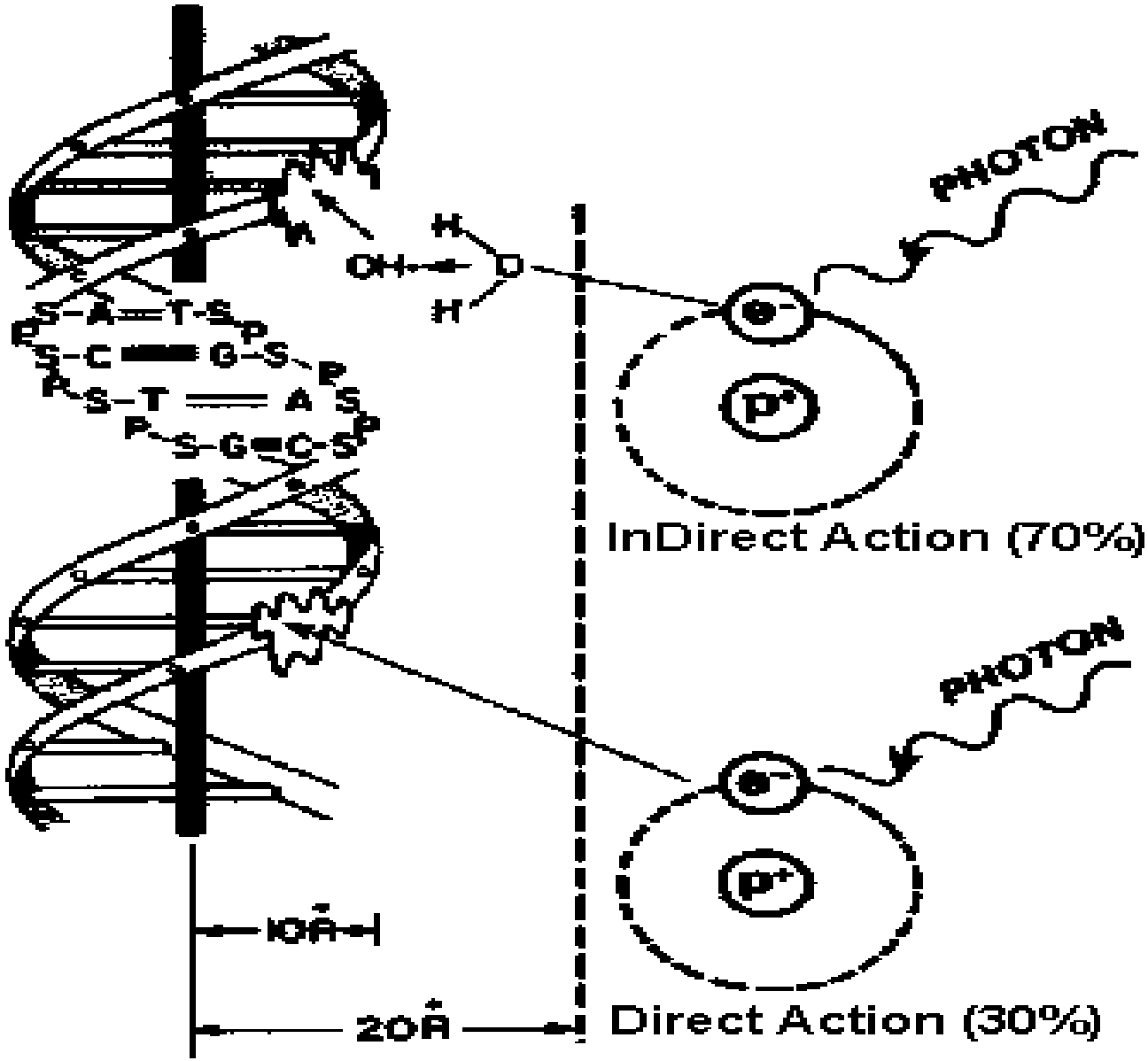
H_2O_2

Breakage of Bonds

(Hours – Years)

Biological Effect

RADIATION EFFECTS



RADIATION EFFECTS

LET- Defined as the rate at which the energy of radiation was transferred to tissue.

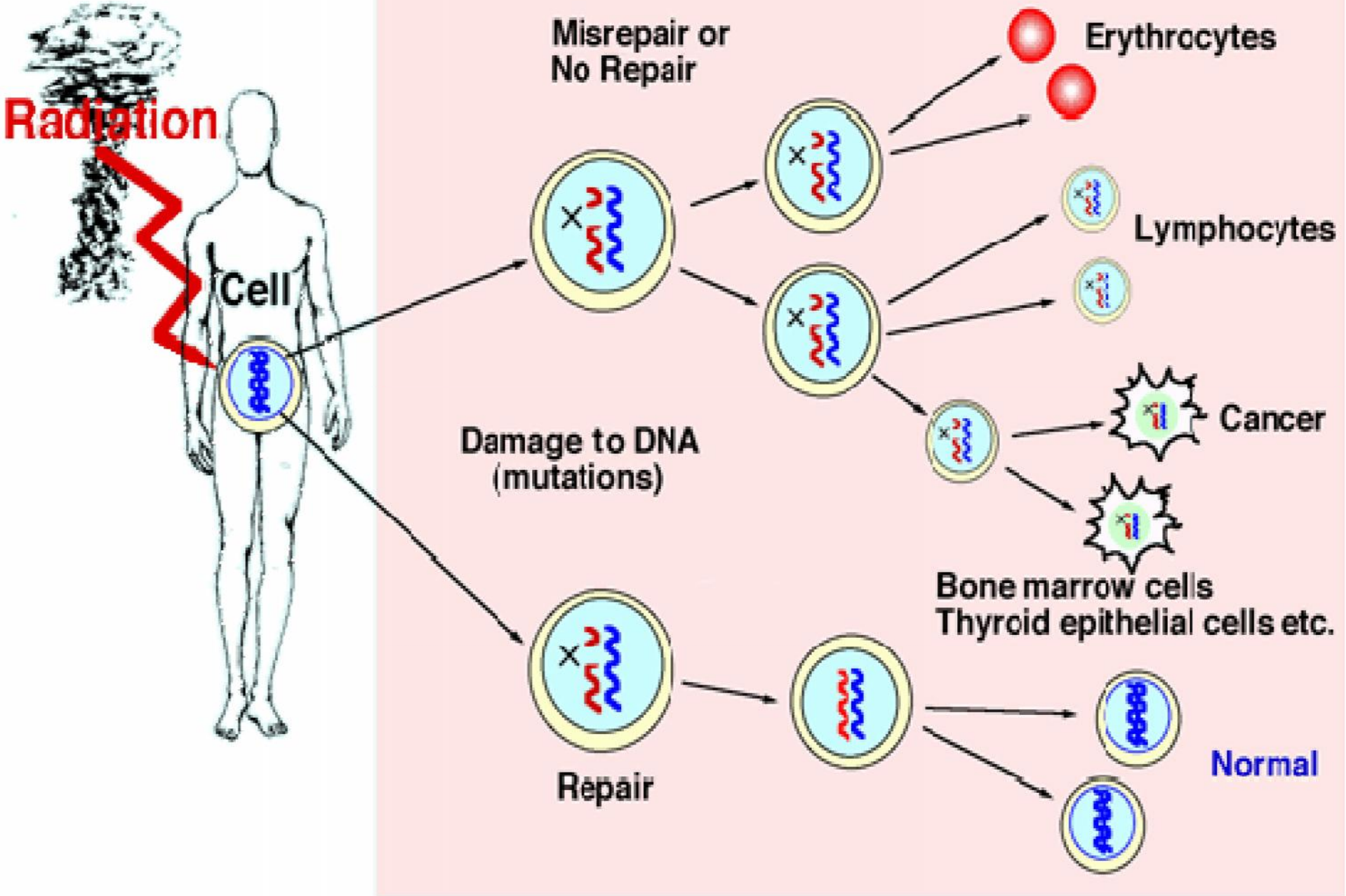
Relative Biological Effectiveness (RBE)- The unit of measurement of biologic damage.

RADIATION EFFECTS

Law of Bergonie and Tribondeau:

The radiosensitivity (how much damage radiation does to a particular cell) is a function of the metabolic state of the cell being irradiated. The level of metabolism is **directly** related to the reproductive (mitotic) rate and **indirectly** related to the specialisation of the cell.

RADIATION EFFECTS



CALCULATING X-RAY EXPOSURE

Output Intensity = $\frac{K(mAs)kVp^2}{d^2}$

K = Measures value at 70kVp and 100cm (40 inches).

Output Intensity (mR) = $K(mAs_2)\frac{(kVp_2)^2}{(70)^2}\frac{(100)}{(d_2)}$

If K is not known use : $15 \times \frac{kVp_2 \times mAs_2}{D^2}$