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BADAN RISET DAN INOVASI NASIONAL

BerAKHLAK
Berorientasi Pelayanan Akuntabel Kompeten Harmonis Loyal Adaptif Kolaboratif

#bangga melayani bangsa

Radiation Biology Effect

Srigading Dwi Lestari

Follow-up Training Course (FTC) on
Nuclear Radiological and Emergency Preparedness (NREP)
BRIN-JAEA
2025, 19th August

BIODATA

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Pengalaman Pelatihan:
Pelatihan Proteksi Radiasi
Pelatihan Hiperkes dan Keselamatan Kerja bagi Dokter
ToT : Teknik Mengajar
Training Course on Radiological Emergency Preparedness and Response

Pengalaman Mengajar:
Pelatihan Follow-Up Training Course (FTC) on Nuclear Radiological and Emergency Preparedness (NREP), 2024
Pelatihan Penyegaran Proteksi dan 3S, 2024
Pelatihan Petugas Proteksi Radiasi Instalasi Nuklir (PPR IN), 2023
Matkul K3 prodi elektromekanika PTNI, 2022-2024
Pelatihan Pekerja Irradiator, 2019-2021
BATAN Accelerator School, 2019
Pelatihan Pengenalan Kedaruratan Radiologik untuk First Responder, 2019
Matkul Anfisman prodi Elektronika Instrumentasi STTN, 2018-2019

WHY should know?

AWARE of radiation exposure risk in the work environment

Work safely, healthy, productively

GOALS(1)

Basic Competencies

At the end of the lesson, participants are able to describe the radiation interaction on biological material and explain the effects of radiation on humans

GOALS(2)

SUCCESS INDICATORS

- Mention the structure of human cells
- State the meaning of direct and indirect interactions
- Describes the radiation interaction of water molecule and biological materials
- Mention the classification of radiation effects

GOALS (3)

SUCCESS INDICATORS

- Explain stochastic and deterministic effects
- Explain the effects of radiation on body tissues and organs
- Explain the effects of radiation on the fetus
- Describe acute radiation syndrome

SUBJECTS

CELLS as The Smallest Unit of Life

INTERACTION OF RADIATION AND BIOLOGICAL MATERIALS

- **WATER MOLECULE**
- ***DNA***
- ***Chromosome***
- ***Cell***

Biological Effects of Radiation on Human Body

- ***Stochastic***
- ***Deterministic***

CELLS as THE SMALLEST UNIT OF LIFE (1 of 3)

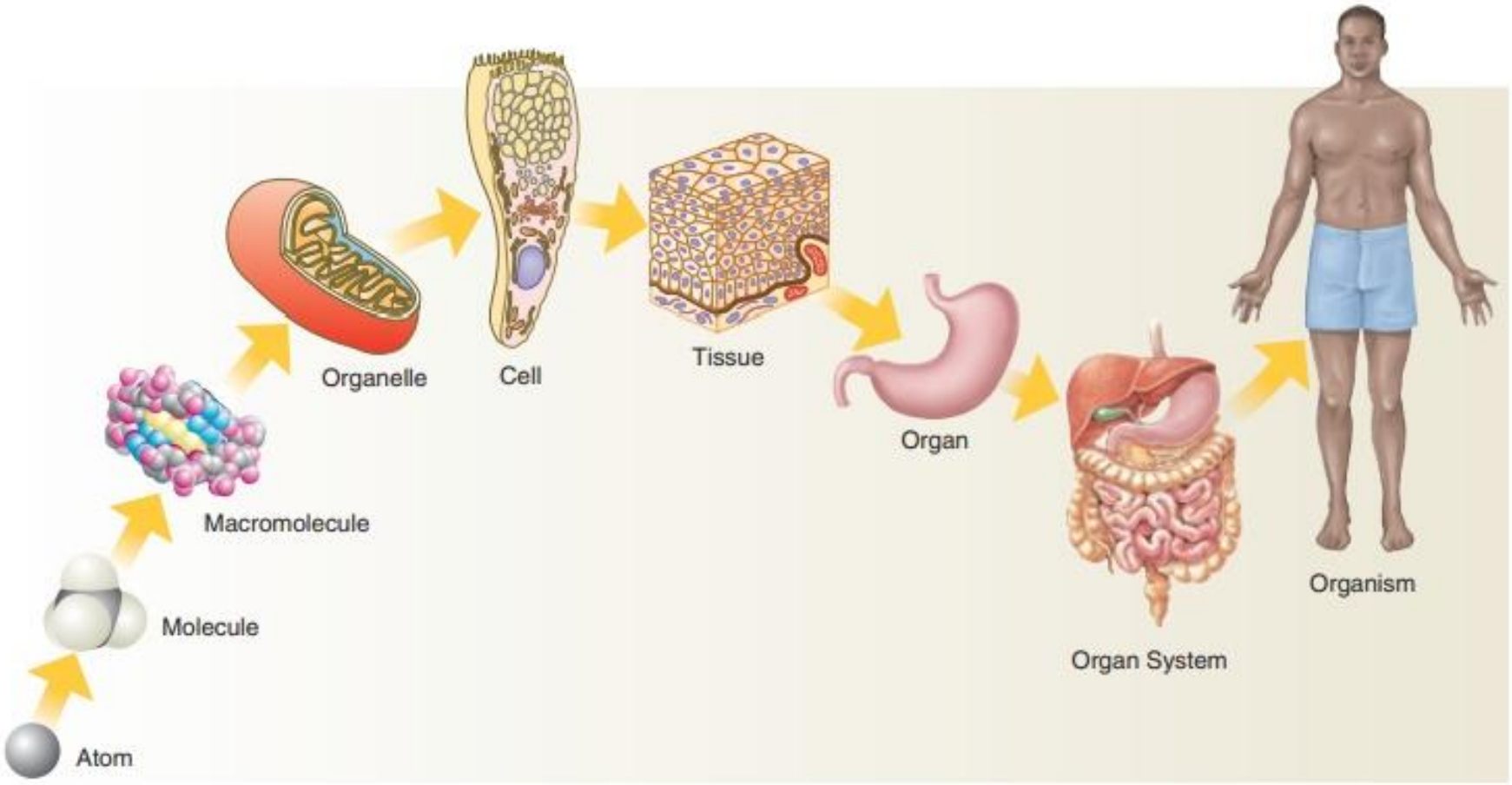


FIGURE 1-1 Organization levels of the body.

Adapted from Shier, D.N., Butler, J.L., and Lewis, R. Hole's Essentials of Human Anatomy & Physiology, Tenth edition. McGraw Hill Higher Education, 2009.

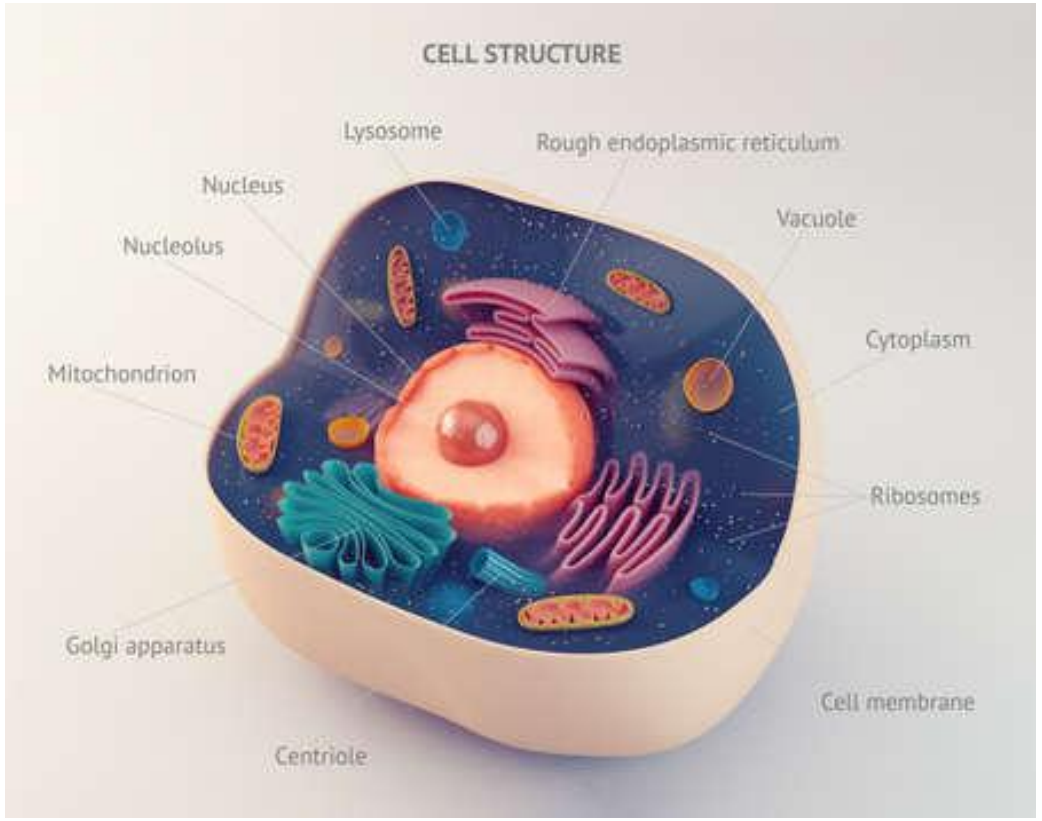
CELLS as THE SMALLEST UNIT OF LIFE (2 of 3)

Anatomy of cells

- Cell membrane

- Cytoplasm : liquid
  Cell organelles: solid,
carry out life function

- Nucleus:
Regulates cell activities
Chromosome contain DNA



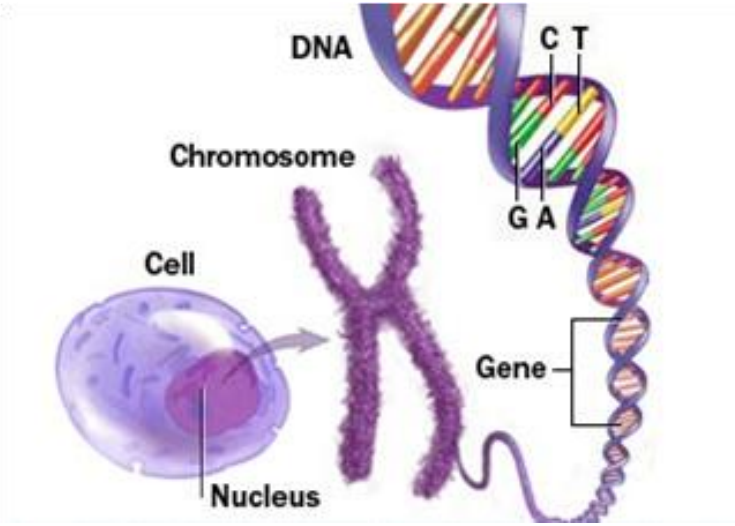
CELLS as THE SMALLEST UNIT OF LIFE(end)

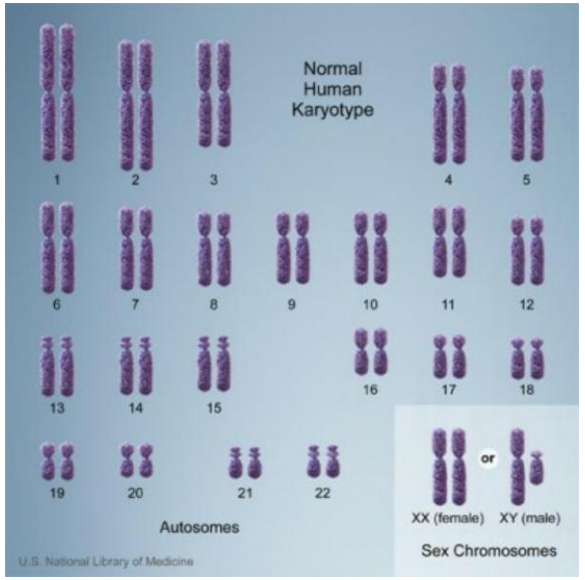
Chromosome → Store genetic information
→ 23 pairs: 44 autosome , 2 sex

DNA → a pair of long double helix polynucleotide connected by Hydrogen bonds.

→ 1 nucleotide = deoxyribose
sugar+base+phosphate group

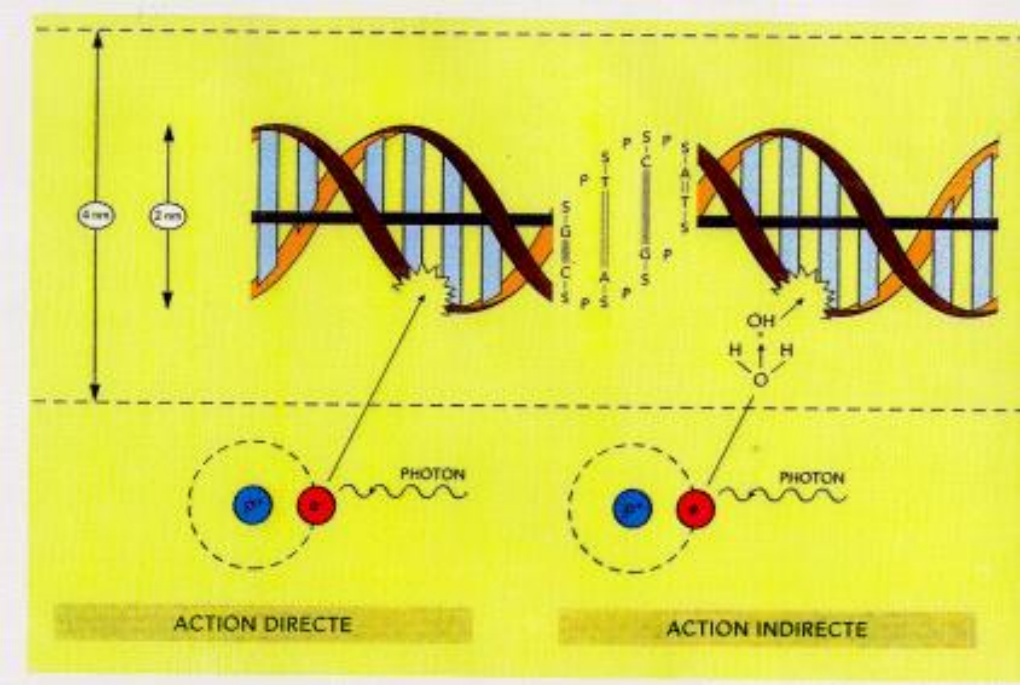
→ Genetic material carries INHERITED information and protein synthesis





INTERACTION OF RADIATION AND BIOLOGICAL MATERIALS

- Radiation exposure → Ionization → produce electrons →
- DIRECT or INDIRECT interaction



INTERACTION OF RADIATION AND BIOLOGICAL MATERIALS

(Interaction of Radiation and H_2O molecule)

H_2O Radiolysis Scheme

spontan : $H_2O \Longleftrightarrow H^+ + OH^-$

radiation : $H_2O \Rightarrow H_2O^+ + e^-$

radical ion (10^{-10} detik)

$H_2O^+ \Rightarrow H^+ + {}^{\bullet}OH$

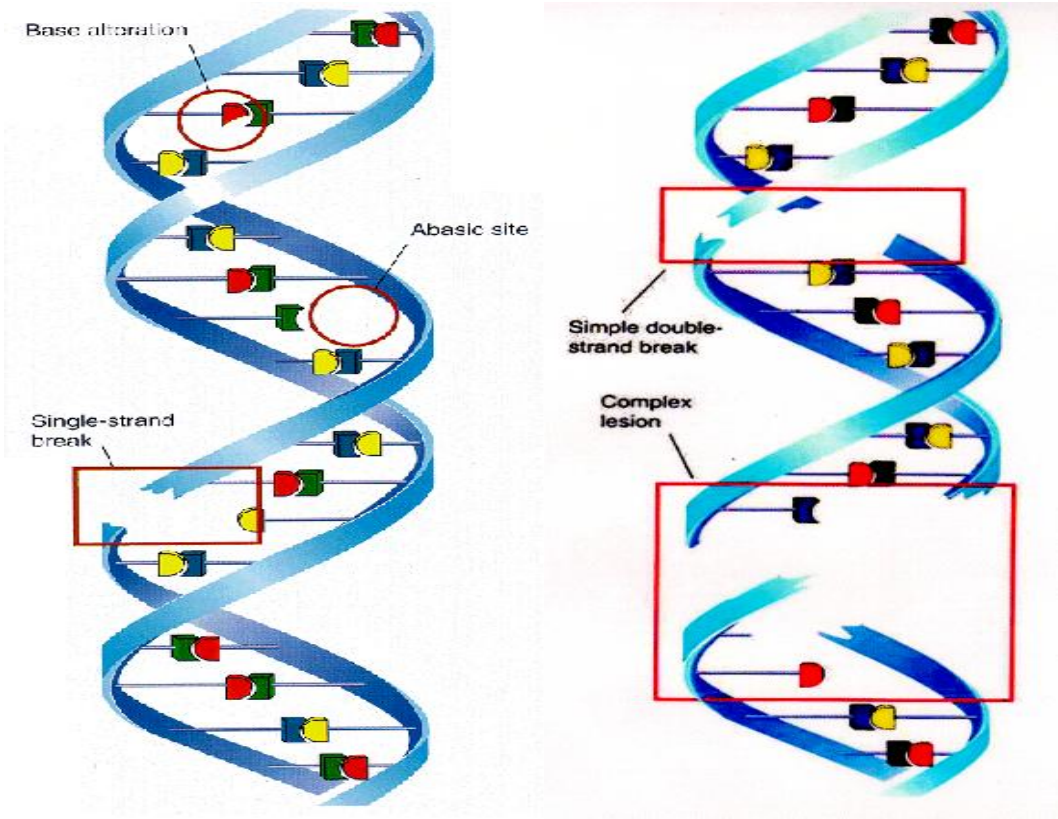
free radical(10^{-5} detik)

$e^- + H_2O \Rightarrow OH^- + H^{\bullet}$

INTERACTION OF RADIATION AND BIOLOGICAL MATERIALS

(Interaction of Radiation and DNA)

- *Single strand break*
- *Double strand break*
- *Base damage*



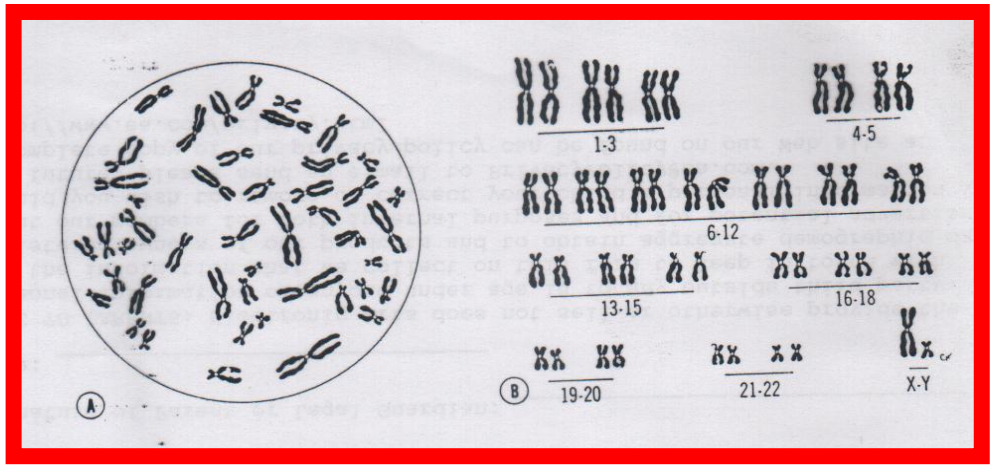
INTERACTION OF RADIATION AND BIOLOGICAL MATERIALS

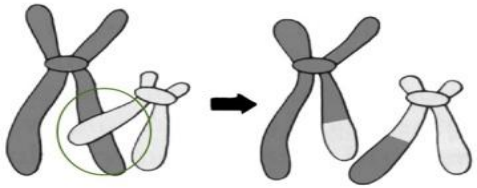
(Interaction of Radiation and Chromosome)

Exposure to radiation → changes in **the number** ataupun **structure** of chromosome *(Chromosome aberation)*

A B

A. Normal; B. Dicentric





Kromosom yang mengalami translokasi mengalami perpindahan fragmen.

INTERACTION OF RADIATION AND BIOLOGICAL MATERIALS

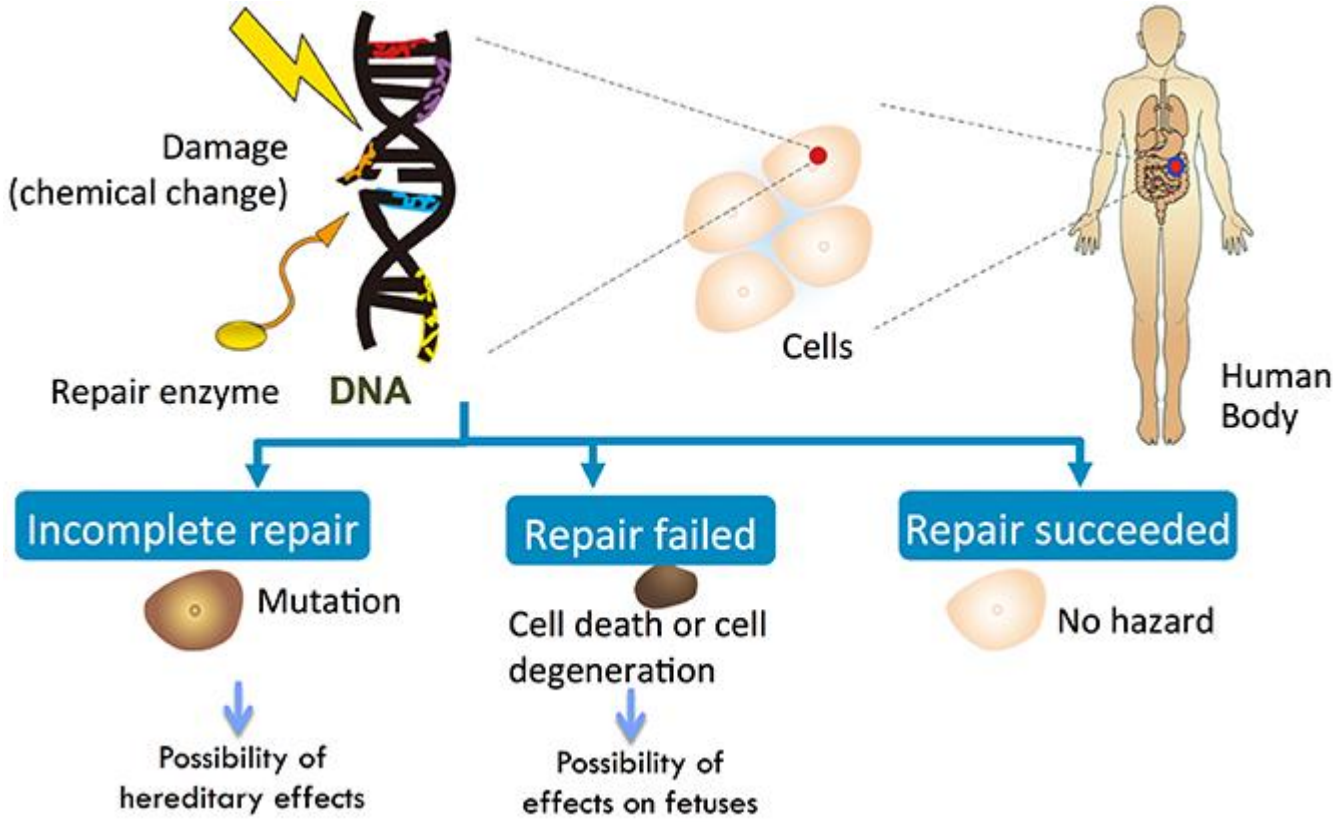
(Interaction of Radiation and DNA)

TYPE OF DAMAGE	POSSIBLE OCCURANCE
Change of Base	Complete repair
Loss of base	Complete repair
Single strand break	Complete repair
Double strand break	Complete repair Mutation Death of cell
Severe damage	Death of cell

INTERACTION OF RADIATION AND BIOLOGICAL MATERIALS

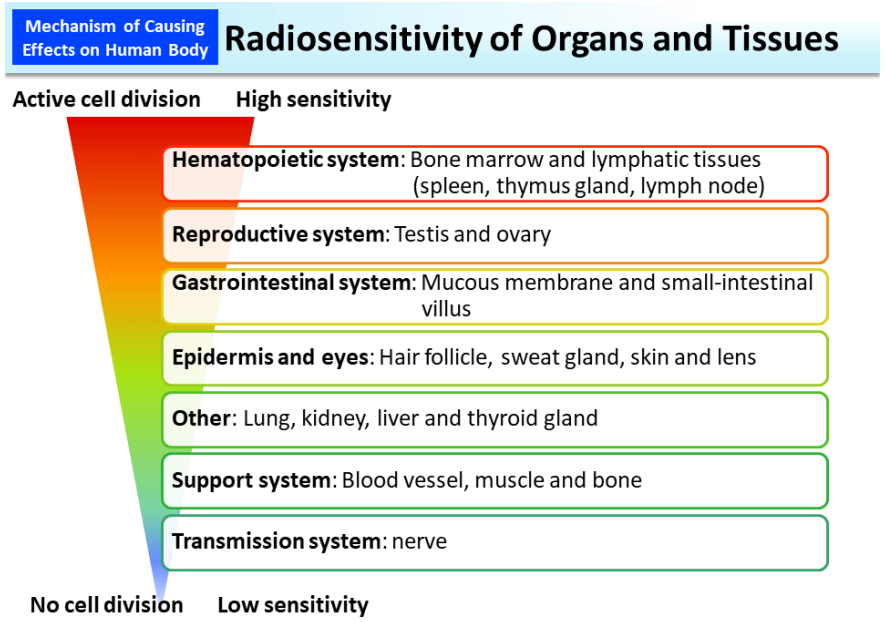
(Interaction of Radiation and Cell)

Effect of Radiation on Human Cells



INTERACTION OF RADIATION AND BIOLOGICAL MATERIALS
(Interaction of Radiation and Cell)

THEORY of CELL RADIOSENSITIVTY



Cell sensitivity affects the sensitivity of organs and tissues.

RADIATION BIOLOGY EFFECT TO HUMAN BODY

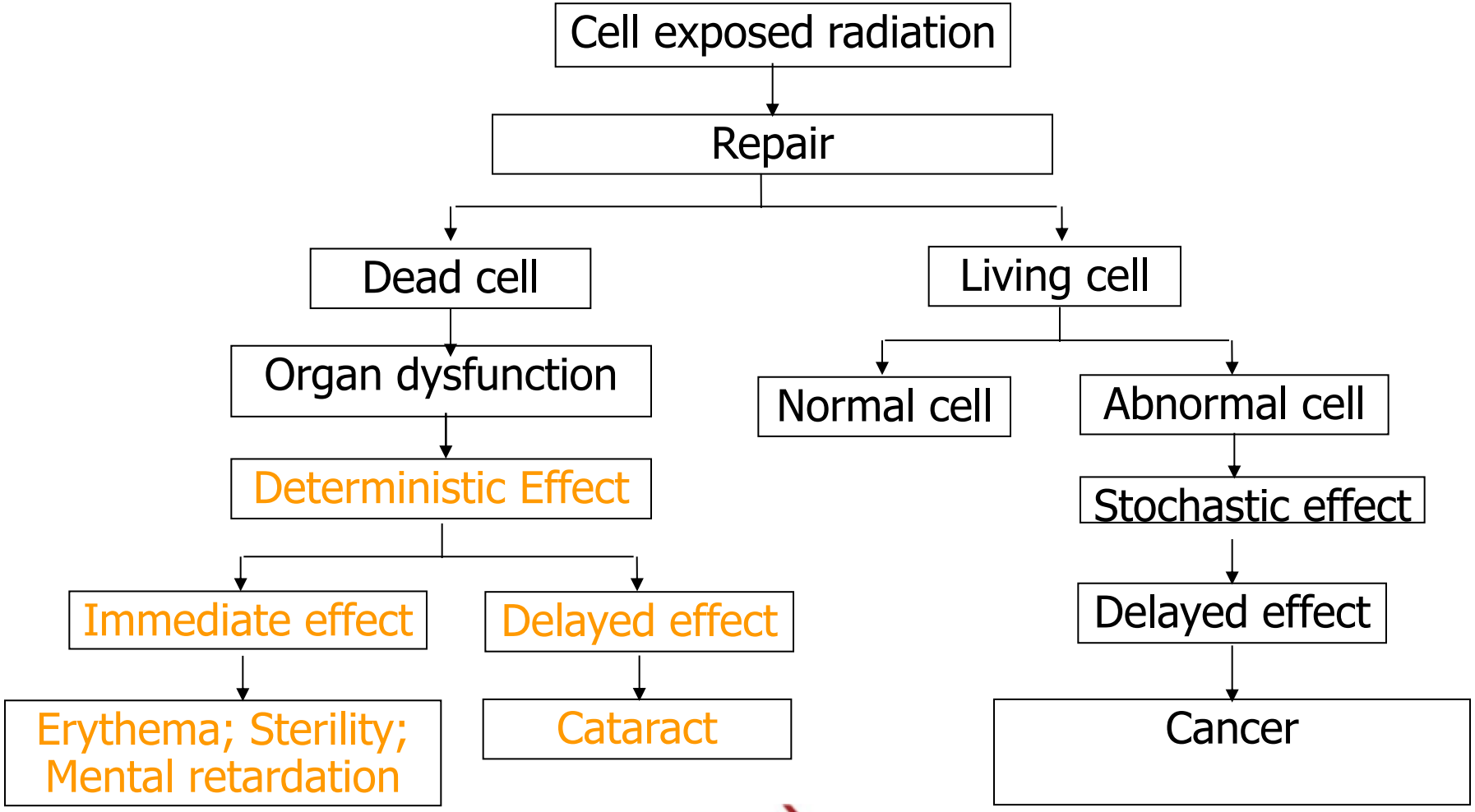
Classification of Radiation Effect(1)

- Target cell:
  - Genetic (inherited, gonade cell)
  - Somatic (somatic cell)

- Treshold dose:
  - stochastic & deterministic

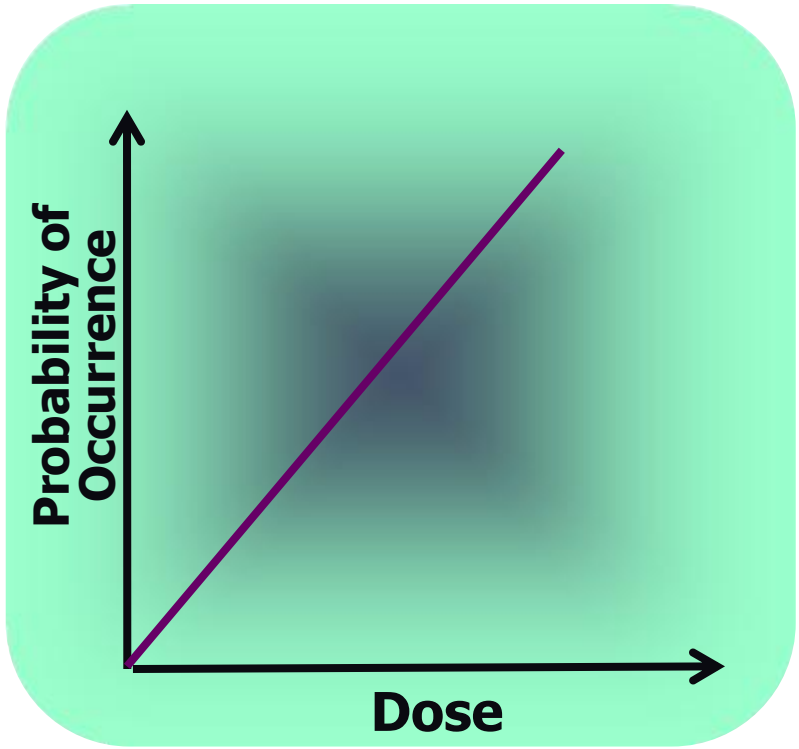
RADIATION BIOLOGY EFFECT TO HUMAN BODY

Classification of Radiation Effect (2)



RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Stochastic Effect) 1 of 2

→ Occur to gene mutations/modifications



Characteristic of stochastic effect:

- Random
- NO Treshold dose
- The Probability of effect is dose dependent
- Affect the exposed individu and descendant

RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Stochastic Effect) end

Exposed individu:

- Target : somatic cell-- carsinogenesis
- Cancer due to radiation is not specific

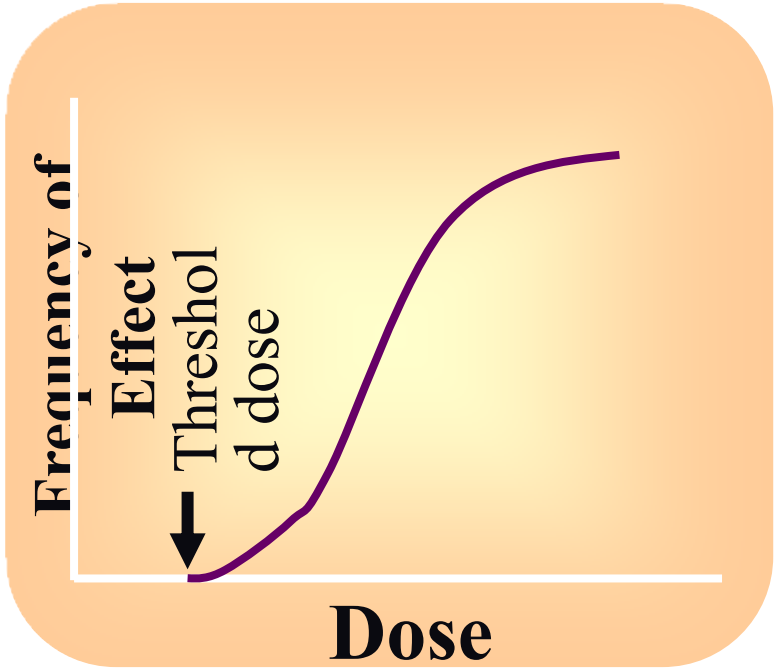
Descendant of exposed individu:

- Target : genetic cell-- inheritable

RADIATION BIOLOGY EFFECT TO HUMAN BODY

(Deterministic Effect) 1 of 14

→ Occur in deal cell due to radiation exposure of part or whole body



Characteristic of deterministic effect :

- Have threshold dose
- The severity of affect is dose dependant
- Affect the exposed individu

RADIATION BIOLOGY EFFECT TO HUMAN BODY

(Deterministic Effect) 2 of 14

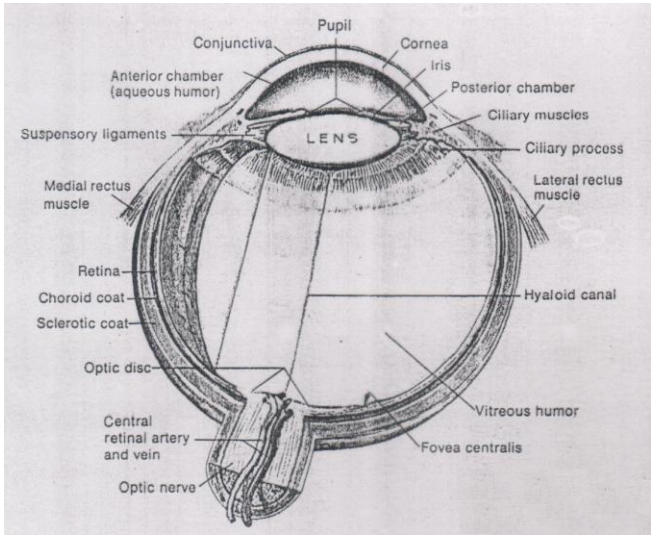
Radiation Effect on SKIN

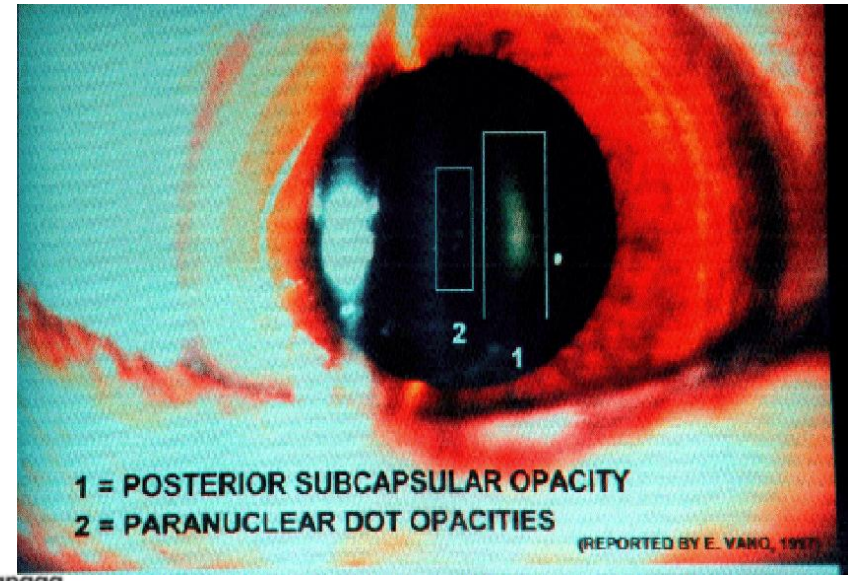
RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 3 of 14

- Radiation Effect on Eye

Most sensitive→ eye lens → catarac

- Dose 0,5 Gy → observed lens opafication
- Dose 2–10 Gy → cataract in 6 months - 35 years
- The higher dose→ the shorter latency period





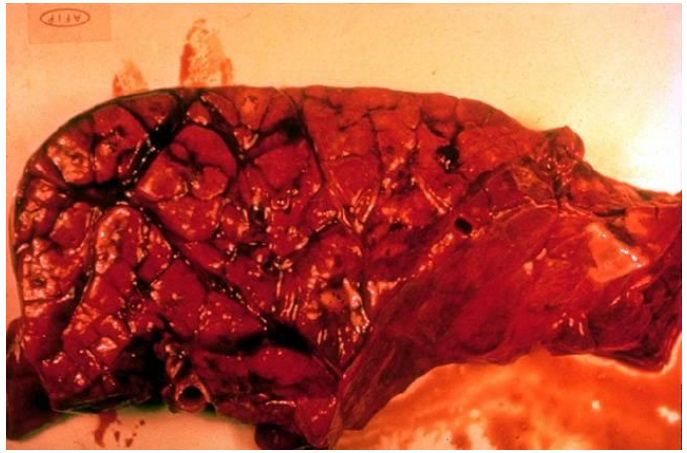
RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 4 of 14

- Radiation Effect on Lung

  Treshold Dose: 3 – 5 Gy

Radiation effect	Time
Pneumonities	3 – 12 weeks
Pulmonary fibrosis	6 months ~

Irradiated lung tissue



RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 5 of 14

Radiation Effect on testis

Radiation Effect	Dose Range (Gy)
Oligosperma	0.15
Temporary sterile (months)	<1
Temporary sterile (1-2 years)	1-3
Permanent sterile	3.5-6

RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 6 of 14

Radiation Effect on Ovarium

Radiation Effect	Range Dose (Gy)
Temporary sterile	0.65
Sterile in 40 years old women	5-7
Sterile in 20 years old women	12-15

RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 7 of 14

- Radiation Effect on Hematopoiesis

Treshold dose: 0,5 Gy

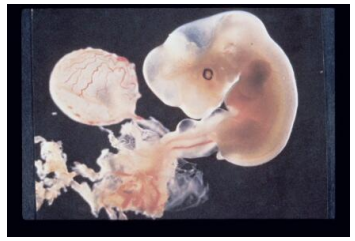
Immediate decrease in blood components

TYPE OF BLOOD CELL	FUNCTION	TIME
Erythrocyte	O2 and CO2 transportation	Weeks
Leukocyte (Lymphocyte)	Immune system	Hours
Leukocyte (Granulocyte)	Immune system	Days-weeks
Platelets	Blood clotting	Days-weeks

RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 8 of 14

Radiation Effect on Fetus (1)

Treshold dose: 0,05 – 0,1 Gy



Stages of Pregnancy	Gestation Age (weeks)	Radiation Effect
Pre-implantation	0-2	Death
Organogenesis	2-7	Organ malformation, neonatal death
Fetus	8-25	Mental retardation

RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 9 of 14

- Radiation Effect on Fetus (2)

Table of Relationship between Gestational Age and Treshold Dose that can Cause mental retardation

Gestation Age (weeks)	Treshold Dose (Gy)
8-15	0.1
16-25	0.4-0.6

RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 10 of 14

ACUTE RADIATION SYNDROME

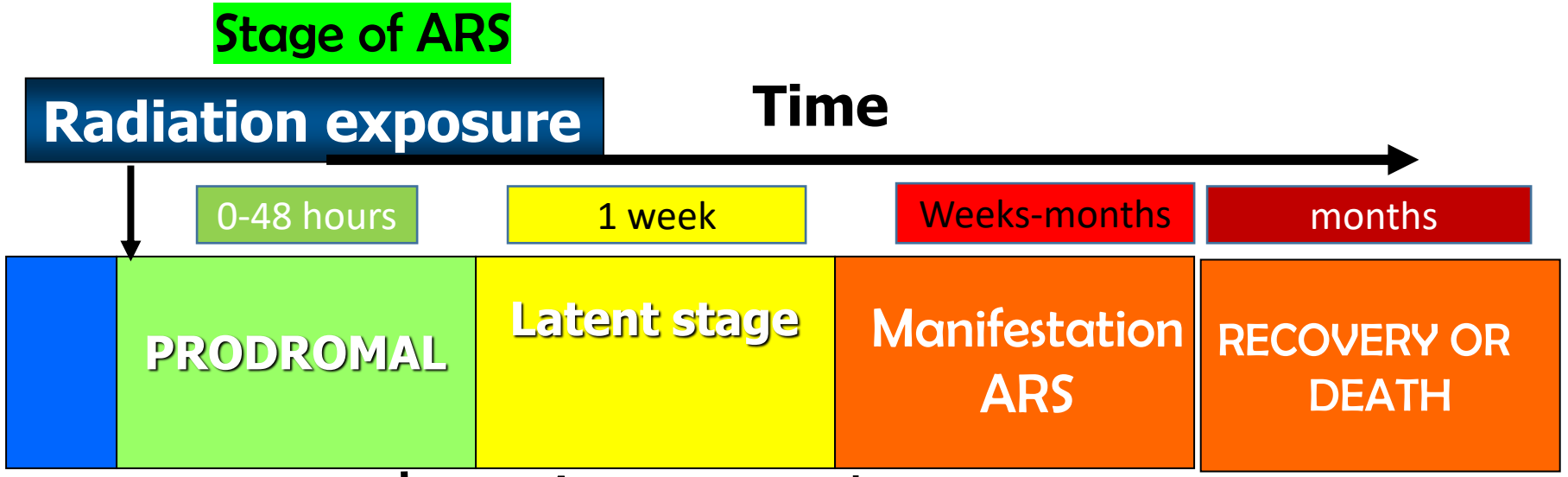
→ an acute illness caused by radiation exposure (or irradiation) of the entire body by a high dose of penetrating radiation in a very short period of time (usually a matter of minutes)

The four stage of ARS:

- Prodromal: The classic symptoms appear from minutes to days following exposure.
- Latent stage: no symptom
- Manifest illness stage: syndrome appears on hematopoietic, digestion, dan central nerve system
- Recovery or death

RADIATION BIOLOGY EFFECT TO HUMAN BODY

(Deterministic Effect) 11 of 14



- Asymptomatic

- Nausea
- Vomiting
- Diarrhea

- Infection
- Hemorrhage

Decrease
Absolute Lymphocyte

RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) 12 of 14

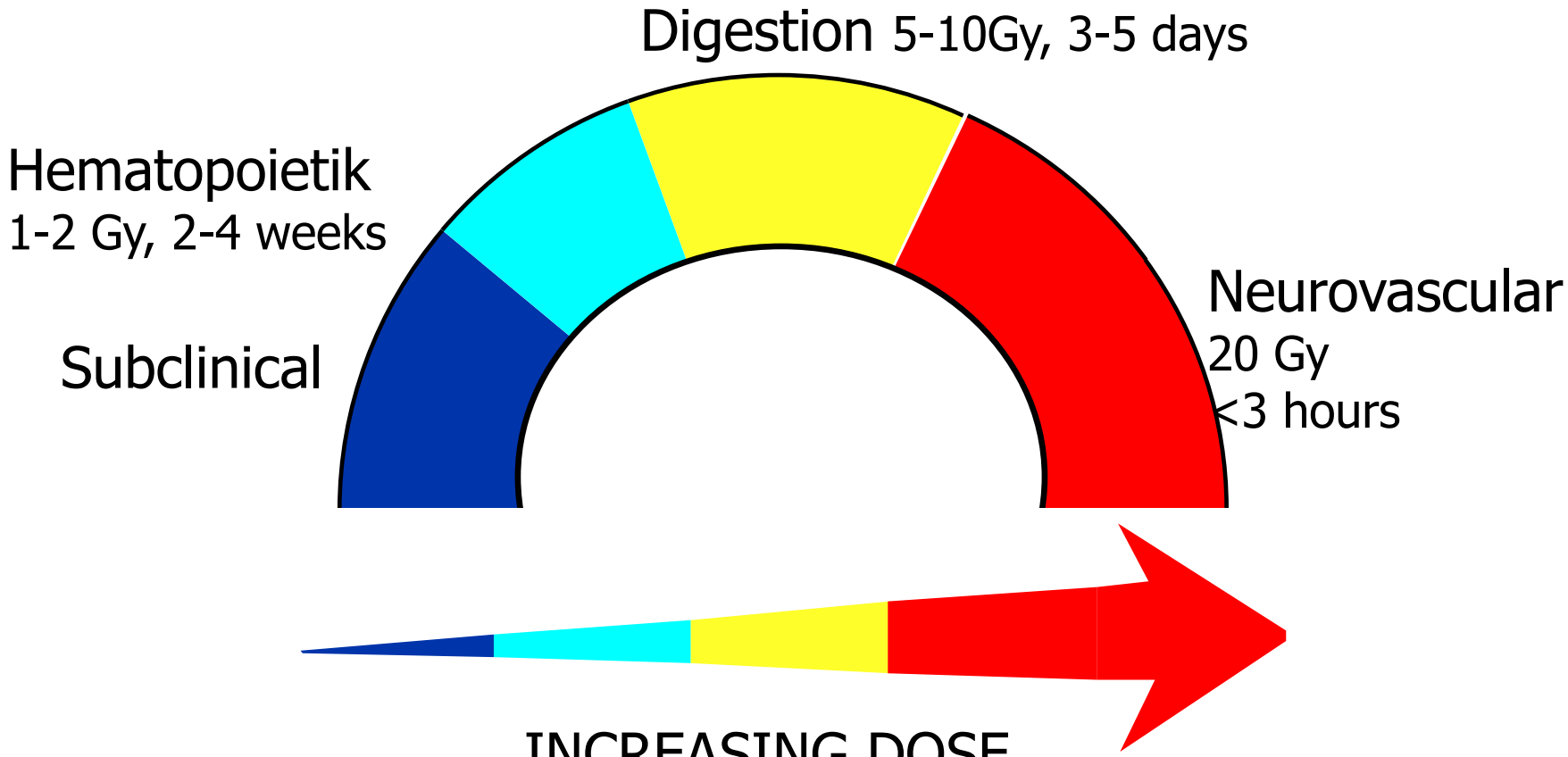
Prognosis based on absolute lymphocyte

Absolute Lmphocyte (/μl)	Estimated Dose	Degree of ARS	Prognosis
1000-3000 Normal	0-0.4	No damage	Complete healing
700-1000	0.5-1.9	Mild	Healing
400-700	2.0-3.9	Moderate	Probably healed
100-400	4.0-7.9	Severe	Probably healed by specific treatment
<100	≥8.0	Very severe	Very hard to be healed

RADIATION BIOLOGY EFFECT TO HUMAN BODY

(Deterministic Effect) 13 of 14

Manifestation of ARS



RADIATION BIOLOGY EFFECT TO HUMAN BODY
(Deterministic Effect) end

MEAN LETHAL DOSE or LD 50/60

- The dose of radiation expected to cause death to 50 percent of an exposed population, whole body, within 60 days

- Healthy adult: dose 2,5-5Gy, average dose 3,5Gy

If medical treatment is appropriate and adequate, LD 50/60 increase until 4-5 Gy

QUIZ

https://wordwall.net/resource/76237240/efek-biologi-radiasi

Resume (1)

1. Structure cell consist of cell membrane, cytoplasm and cell organel, nuckleus (chromosome/DNA).

2. Interaction radiation and biologic material occur DIRECTly or INDIRECTly .

3. Classification of radiation effect divided by target cell (somatic dan genetic effect), dose (stochastic dan deterministic effect).

Resume (2)

4. Stochastic effects occurs in mutation/abnormal cell.
5. Characteristic of stochastic effect : random, no threshold dose, relationship between probability and dose
6. Deterministic effects due to death of cell
7. Characteristic of deterministic effect : have treshold dose, severity depends on dose.
8. Acute radiation syndrome occurs if high radiation exposure in entire body on very short periode time

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THANK YOU

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