SAWA UNIVERSITY

Biological Radiation Hazards

The Biological Effects Of Radiation

Sawa University — جامعـــــة ســـــــاوة الاهلية

College of health and medical techniques — كليـــــة التقنيـــات الصحيـة والطبيـة

Department of Radiology Tech. — قسم تقنيات الاشعة والسونار

. 3 Stage — المرحلـــــــــــة 3

الجانب النظري — محاضرة رقم 4

Theoretical — Lecture No. 4

تدريسي المادة : م.م خيرات رحيم لهمود

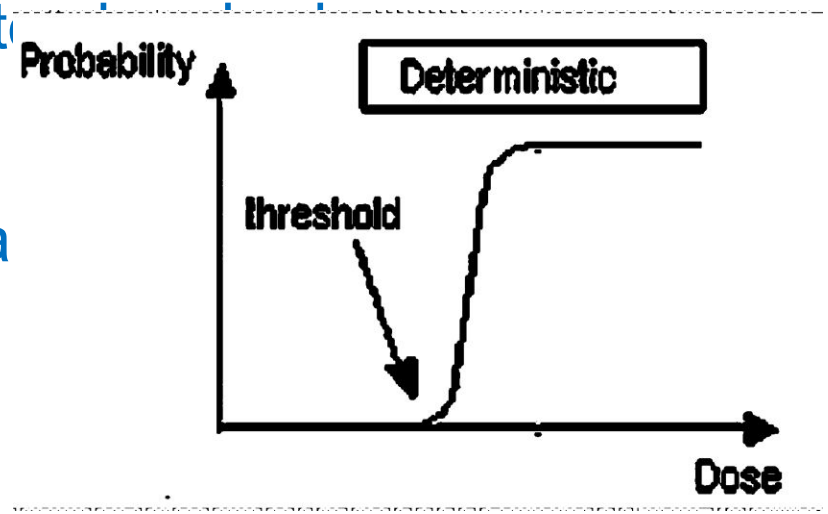
Types Of Biological Effects Of Radiation

1. Deterministic Effect
2. Stochastic Effect

1. Deterministic Effect

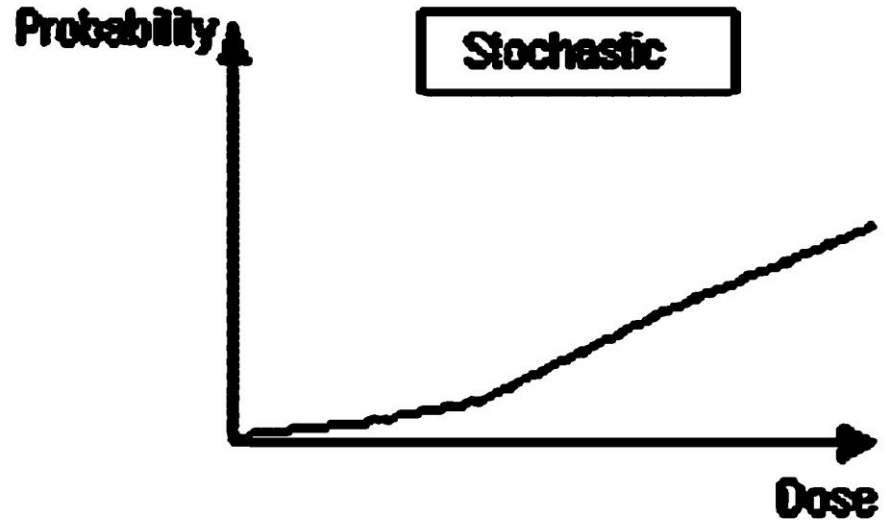
- ***Probability*** of this effects is not proportional to absorbed dose
- This effect has a ***threshold***, below which the effect will not occur.
- ***Severity*** of this effect is directly proportional to [illegible] absorbed dose.
- [illegible] a

Organs	Effects	Threshold (mSv)	
		Acute dose (single)	Chronic dose (multiple /year
Testis	Permanent infertility	> 3500	>2000
Ovary	Permanent infertility	>2500	>200
Eye	Cataract	>5000	>150



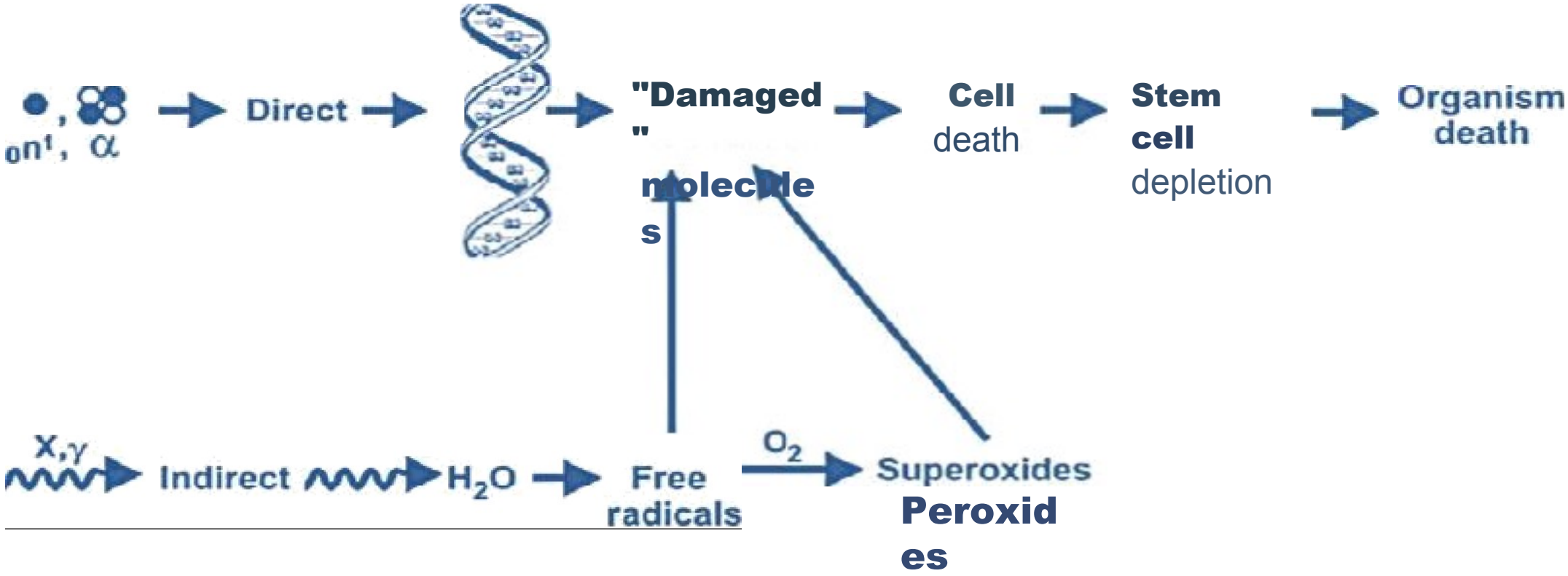
2. Stochastic Effect

- ***Probability*** of this effect is directly proportional to absorbed dose.
- There is no ***threshold***, so any dose may or may not produce this effect
- ***Severity*** of this effect is independent on the absorbed dose.
- Stochastic effect of r enetic modifications.

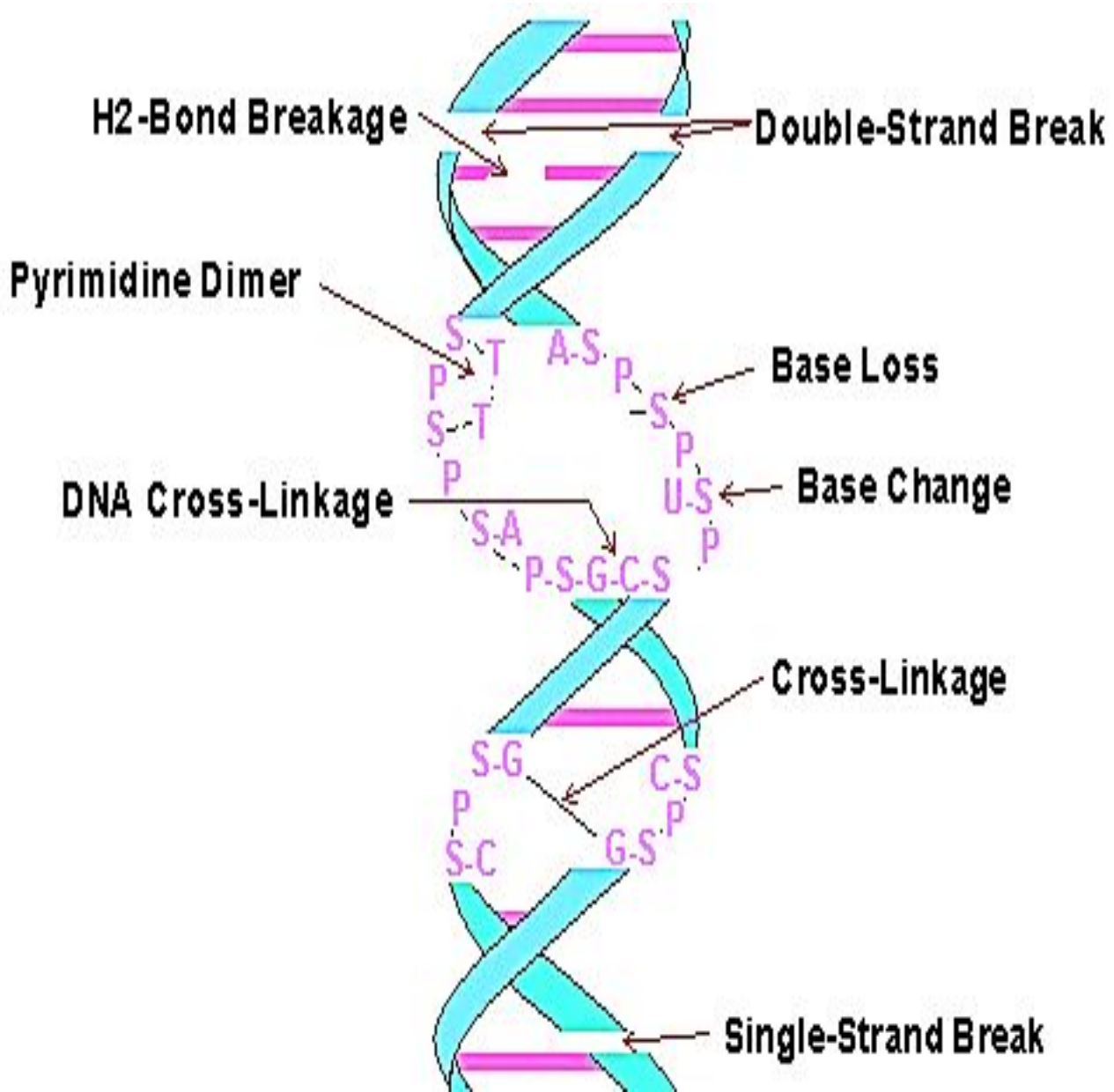


Mechanisms Of Damage

1. **Direct mechanism:** Radiation directly hit atoms of macromolecules (DNA, RNA, proteins, lipids & carbohydrates)
2. **Indirect mechanism:** Radiation hit water to form ***free radicals*** in a process called ***radiolysis*** which can contribute to the destruction of the cell.


●, ❀
on¹, α
Direct
"Damaged "
molecules
Cell death
Stem cell depletion
Organism death
X,γ
Indirect
H2O
Free radicals
O2
Superoxides
Peroxides

Cellular Damage Of Radiation



•Transfer radiation energy to atoms and molecules in the cellular structure (DNA) lead to ***genomic instability*** due to:

1. **Single-strand break**
2. **Double-strand break**
3. **Hydrogen bond breakage**
4. **DNA cross-linkage**
5. **Pyrimidine Dimer**
6. **Base change**
7. **Base loss**

Types Of Cellular Damage

- within seconds (physical & biochemical effects)
- within few minutes (**Cell death or Cell repair)**
- **Within** hours-days-weeks or months *(*clinical symptoms):

a) **Somatic damages** arise from genomic instability in somatic cells of irradiated person either appear **early** after exposure (hair loss, infertility), or appear **late** after exposure (cataract & cancer)

b) **Genetic damages** arise from genomic instability in germ cells of irradiated parents and seen in their **offspring** as genetic malformations.

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cell

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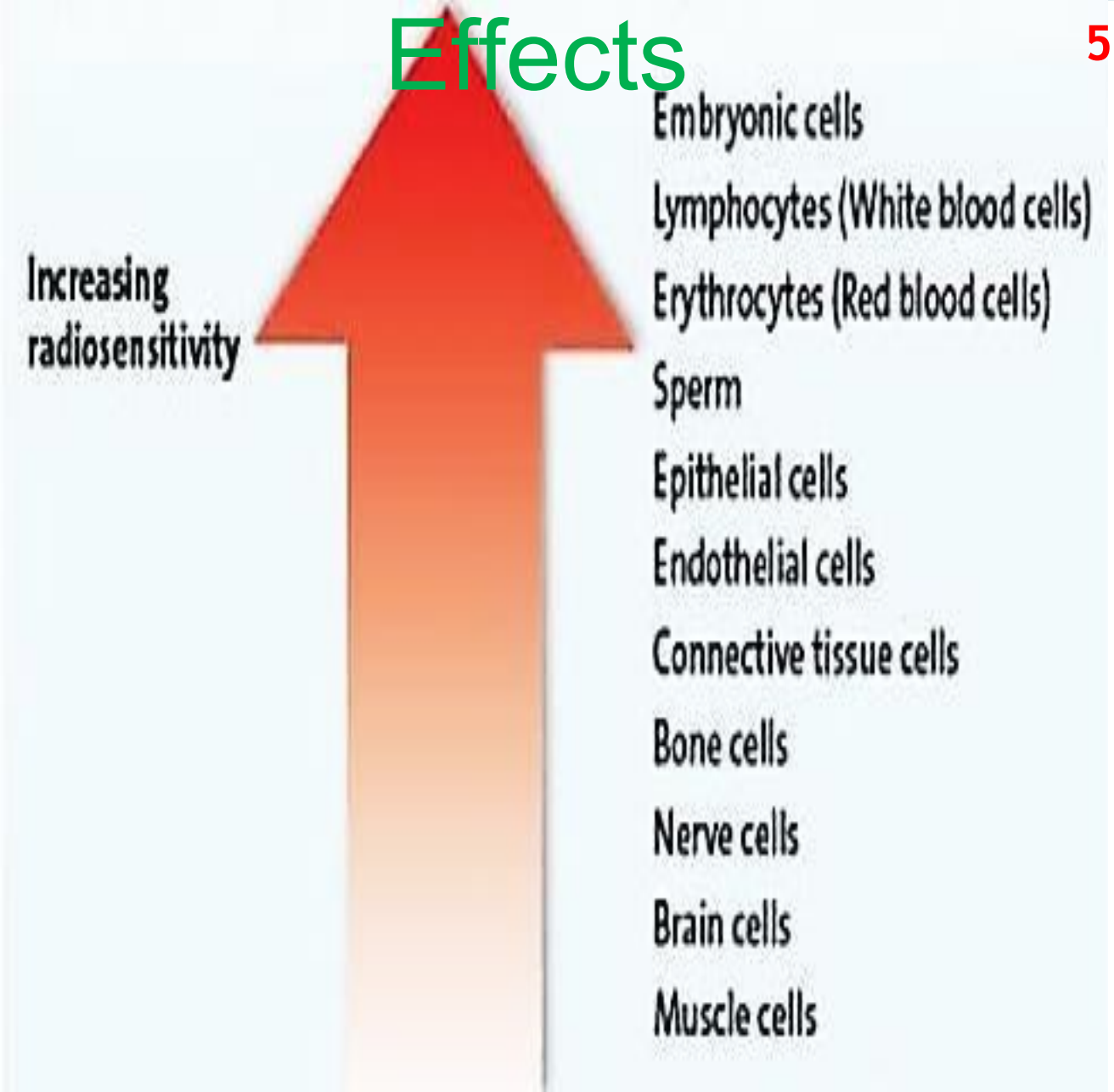
Determinants Of Radiation Effects

1. **Type of radiation** (alpha, beta, neutron, x and gamma rays)
2. **The radiation dose** (amount of radiation)
3. **The dose rate of radiation** (amount of radiation/time)
4. **Species Sensitivity (*LD50/30)*** (the dose of radiation that kills 50% of population within 30 days)

Organism	LD_{50} (rad)	Organism	LD_{50} (rad)
Dogs, pigs	300	Cattle, rats, horses	630
Goats	350	Rabbits	800
MAN	400	Chickens	1000
Mice, monkeys	450	Insects	5000
Sheep	540	Turtles	15000
Fish	550	Bacteria/viruses	100000

Determinants Of Radiation Effects



5. **Cell Sensitivity *(Bergonie & Tribondeau Law*)** Radio-sensitivity of a tissueis

directly

proportional to the ***rate of proliferation*** of its cells, and *inversely* proportional to the degree of ***cell differentiation***.

- Cells with high proliferation rate (division) and low differentiation (non-specialized) are highly sensitive to radiation such as embryonic cells and tumor cells so killed by radiotherapy treatment.
- Cells with low proliferation (or non-dividing) and high differentiation

Determinants Of Radiation Effects

6. **Part of the body exposed**

   Extremities (hands or feet) are able to receive a greater amount of radiation with less resulting damage than blood forming tissues found in the bone marrow.

7. **Age of individual**

   As a person ages, cell division slows and body is less sensitive to effects of radiation.

8. **Area exposed**

   The larger the area exposed, the greater the overall damage. Therefore, radiation therapy doses should be delivered to very limited areas (to tumor sites) rather than whole-body irradiation of the same dose.

QUIZ

Q1. What are the two main types of biological effects of radiation?
Q2. Describe the key characteristics of a Deterministic Effect.
Q3. Give three examples of Deterministic Effects.
Q4. According to the provided table, what is the acute (single) radiation dose threshold for causing permanent infertility in the Testis?
Q5. Describe the key characteristics of a Stochastic Effect.
Q6. What are the common outcomes of Stochastic Effects of radiation?
Q7. What are the two mechanisms by which radiation causes damage to cells?
Q8. Briefly explain the Indirect mechanism of cellular damage.

Any questions?