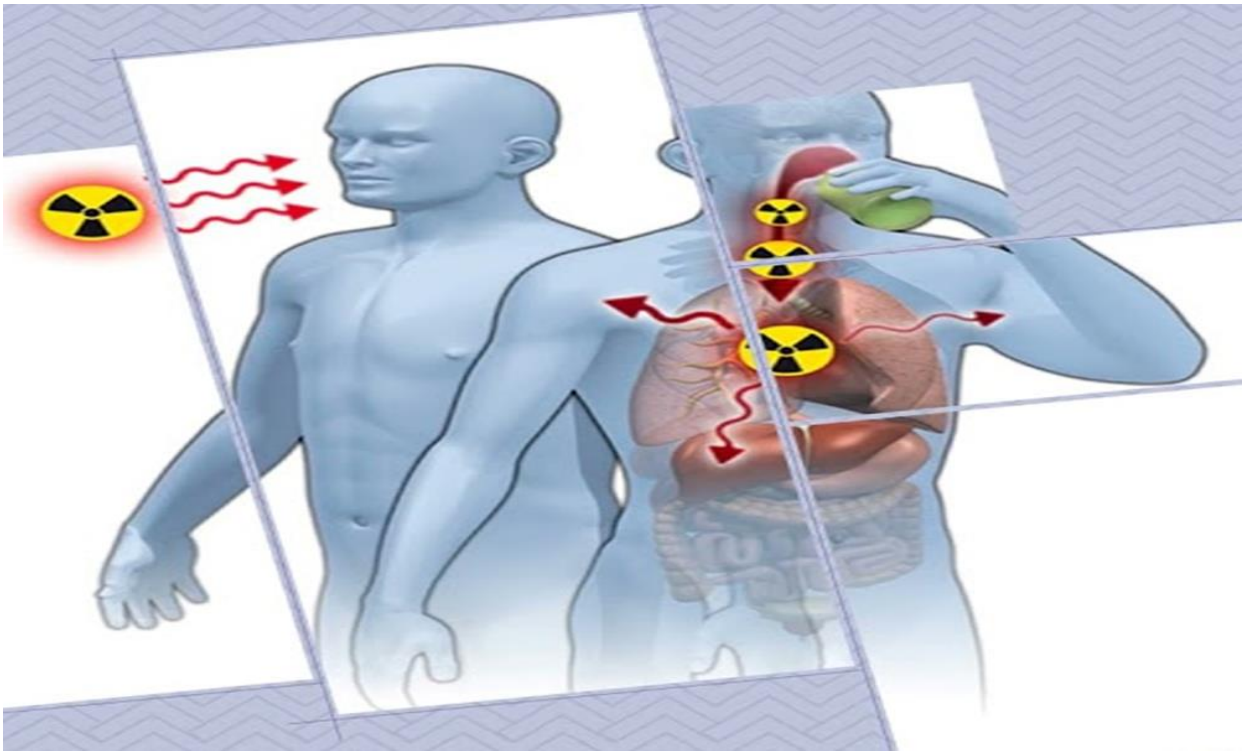
Stochastic effects on ionizing radiation
7th Lecture



Prepared and Presented by:

Lecturer Dr/ Arshed Shaker
Lecturer Dr/ Ayad Abdelsalam
Assist. Lecturer Dr/ Noor sabah

3rd year, 1st course

Teaching of Biological Radiation hazards

College of Technology & Health Sciences
Radiology Techniques Department

Stochastic Effects of Ionizing Radiation

Stochastic effects are harmful biological effects of ionizing radiation that occur by chance. They do not have a threshold—any dose, even very small, has the possibility of causing an effect. However, the severity does not increase with dose; instead, the probability of occurrence increases as the dose increases.

Key Characteristics

- Random (probabilistic): Occur by chance due to mutations in cells.
- No threshold: Even the smallest dose carries some risk.
- Probability ↑ with dose: Higher dose = higher chance of effect.
- Severity independent of dose: If the effect happens, its severity is not related to how much dose was received.
- Caused mainly by DNA damage and gene mutations.

Main Stochastic Effects

1. Cancer induction

Radiation may damage DNA, possibly resulting in:

- Leukemia
- Thyroid cancer
- Breast cancer
- Lung cancer
- Skin cancer
- Other solid tumors

The risk increases with dose**,** but no dose guarantees cancer**.**

2. Hereditary (genetic) effects

Radiation damage to **gametes (sperm or ova)** can cause mutations passed to offspring:

- Congenital abnormalities

- Genetic diseases

Note: In humans, hereditary effects from radiation have not been conclusively proven, but they are well demonstrated in animal studies.

Mechanism

Ionizing radiation → DNA damage → misrepair or mutation →

- If in somatic cells → cancer
- If in germ cells → hereditary effects

Effects may take years or decades to appear—called late effects.

Local Tissue Effects of Ionizing Radiation

Local tissue effects are radiation-induced changes that occur only in the specific part of the body that receives the dose. These effects are mostly deterministic (non-stochastic), meaning they have a threshold dose, and their severity increases with dose.

1. Skin Effects

The skin is one of the most radiosensitive tissues locally.

- Early transient erythema
- Main erythema
- Dry desquamation (dry peeling)
- Moist desquamation (wet peeling)
- Epilation (hair loss)
- Ulceration
- Skin necrosis (very high doses)
- Chronic radiation dermatitis

2. Eye Effects

Especially the lens of the eye:

- Cataract formation

- A classic deterministic effect
- Lens damage has a clear threshold dose

3. Gonadal Effects

Damage to reproductive organs:

- Temporary sterility
- Permanent sterility
- Reduced fertility

4. Bone Marrow (Hematopoietic Tissue)

If a large bone region is irradiated:

- Suppression of blood cell production
- Anemia, leukopenia, thrombocytopenia

5. Gastrointestinal Tract

When abdominal tissues are exposed:

- Inflammation of the intestinal mucosa
- Nausea, vomiting, diarrhea
- Ulceration at high doses

6. Lungs

Local irradiation of the thorax may cause:

- Radiation pneumonitis (early)
- Pulmonary fibrosis (late)

7. Thyroid and Other Endocrine Organs

- Hypothyroidism after neck irradiation
- Glandular atrophy

Key Features of Local Tissue Effects

- Localized to the exposed body region
- Deterministic with a threshold
- Severity increases as dose increases
- Can be early or late effects depending on tissue type