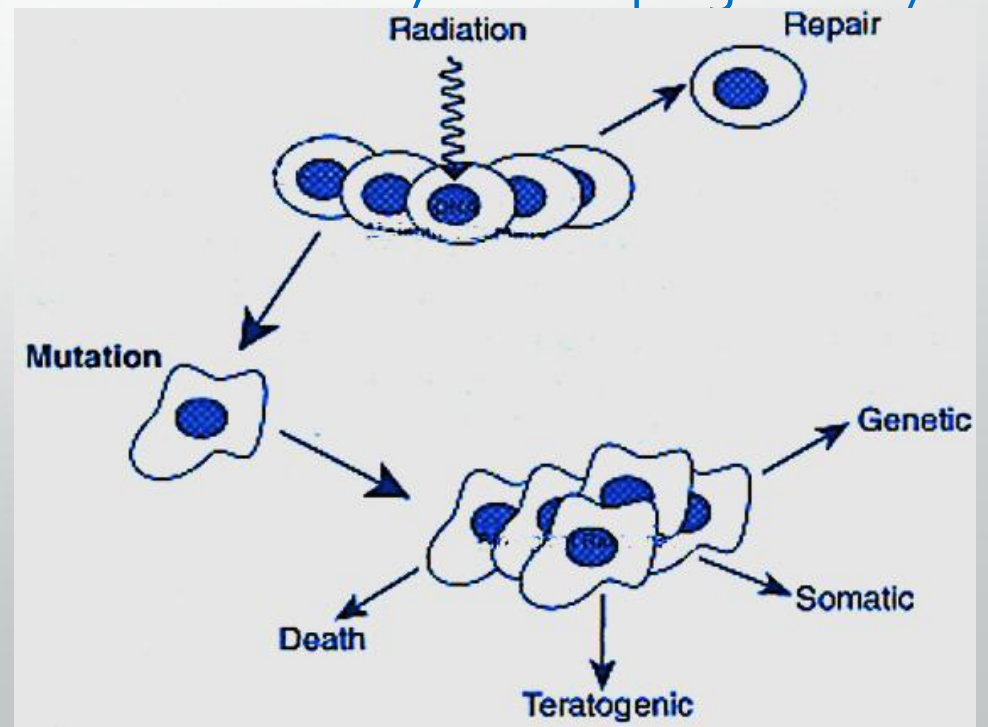


# Long-Term Effects of Radiation

*Dr. Khalid M. Salih*

- Appear years after original exposure:
  - ✓ either from previous acute (high-dose) exposures
  - ✓ or chronic low level exposure over a period of years.
- There are 3 categories of effects resulting from exposure to low doses:
  - A. Genetic effect** suffered by offspring of the individual exposed.
  - B. Somatic effect** suffered by individual exposed.
  - C. Embryological (teratogenic) effect** suffered by developing embryo exposed during pregnancy period.



# A. Genetic Effects

- Damage DNA in germ cells lead to gene mutations passed to offspring of individual exposed.
- Genetic effects are difficult to be measured because:
- Fertilized egg may result nonviable organism which is aborted.
- Majority of mutations are recessive.
- Genetic effects can be grouped as:
  - 1. Dominant gene disorders**
  - 2. X-Linked Single-Gene Disorders**
  - 3. Chromosome disorders**
  - 4. Multifactorial disorders**

# 1. Dominant gene disorders

*Achondroplastic dwarfism* is an example of a dominant gene disorder that could be caused by ionizing radiation.



## 2. X-Linked Single-Gene Disorders

- Bad gene present on X-chromosome will produce effect in males because males only have one X-chromosome.
- *Muscular dystrophy* is an example of an X-linked effect



### 3. Chromosome disorders

- Abnormal number of chromosomes (*aneuploidy*) could severely affect the unborn or newborn child.
- *Down's syndrome* is caused by extra copy of chromosome 21 (*trisomy 21*) result in:
  - ✓ reduction in their life expectancy
  - ✓ abnormal body features
  - ✓ infertile.



## 4. Multifactorial disorders

- Associated with effects of **multiple genes** + **lifestyles** + **environmental** factors.
- Result in congenital malformations such as:
  - a) Spina bifida** (split spine) caused by incomplete closing of embryonic neural tube, so some vertebrae are not fully formed and remain unfused and open that allows a portion of spinal cord to protrude.
  - b) Cleft palate** is a fissure in mouth roof resulting from incomplete fusion of the palate during embryonic development.



## B. Somatic Effects

- Late somatic effects occur in somatic cells years after brief or chronic exposure to radiation such as carcinogenic and cataractogenic effects:

### 1. Carcinogenic Effect:

- Radiation can cause up to 10% of invasive cancers in most parts of the body, in all animals, and at any age.
- It is stochastic effect (10–15 years for solid tumors) (2–10 years for leukemia)
- Evidences that confirmed the carcinogenic effect of radiation in human:
  - a) **Painters** (bone cancer) (ingestion radium paint).
  - b) **Radiologists & Dentists** (skin cancer) (x-ray)
  - c) **Miners** (lung cancer) (inhalation radon)
  - d) **Survivors of atomic bombing** (leukemia, thyroid & breast cancers)
  - e) **Irradiation during pregnancy** (leukemia in children)
  - f) **Radiotherapy** (thyroid, brain, skin, breast & leukemia)

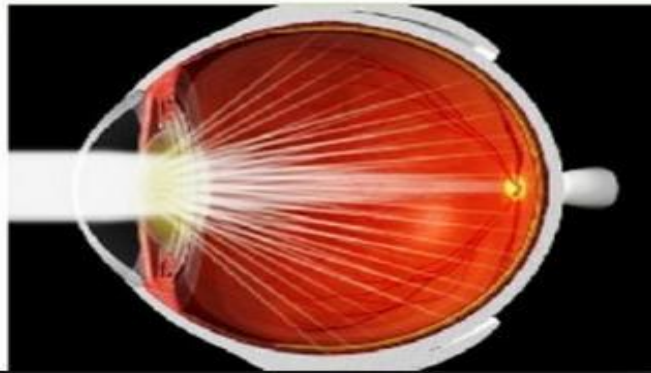
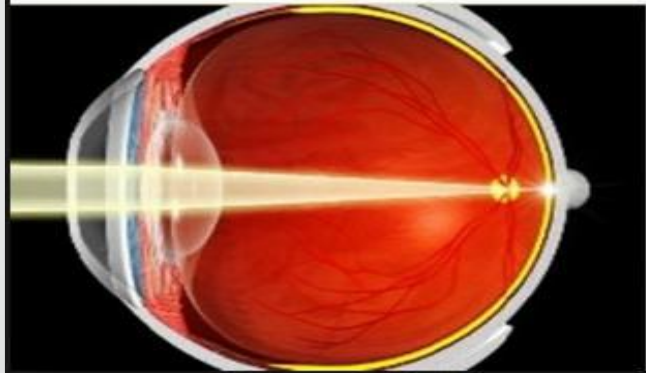




# B. Somatic Effects

## 2. Cataractogenic Effect:

- A cataract is a cloudy (opaque) area that forms in the lens which allows less light to pass into the eye leading to blurred vision (images are not clear) leading to blindness.
- It is deterministic effect with threshold dose 200 rad (2 Gy) up to 700 rad (7Gy)
- The average latent period for cataract formation is approximately 15 years and appears to be inversely related to the dose received.



**Normal eye**

**Cataract eye**



## C. Embryological (Teratogenic) effects

- **Teratogen** (monster) is any agent that alters fetal morphology or functions if fetus is exposed during critical stage of development, such as:
  - Physical (radiation),
  - Chemical (drugs)
  - Biological (rubella viruses which cause German measles).
- It is a special case of somatic effect because the somatic cells of the embryo/fetus are exposed to radiation, not the reproductive cells of the parents.
- Developing embryo is very radiosensitive and its response depends on:
  - 1) total dose*
  - 2) rate of dose*
  - 3) type of radiation*
  - 4) stage of development*

# *Fetal Stages*

## **1. Pre-implantation Stage (The 1<sup>st</sup> 9 days after fertilization):**

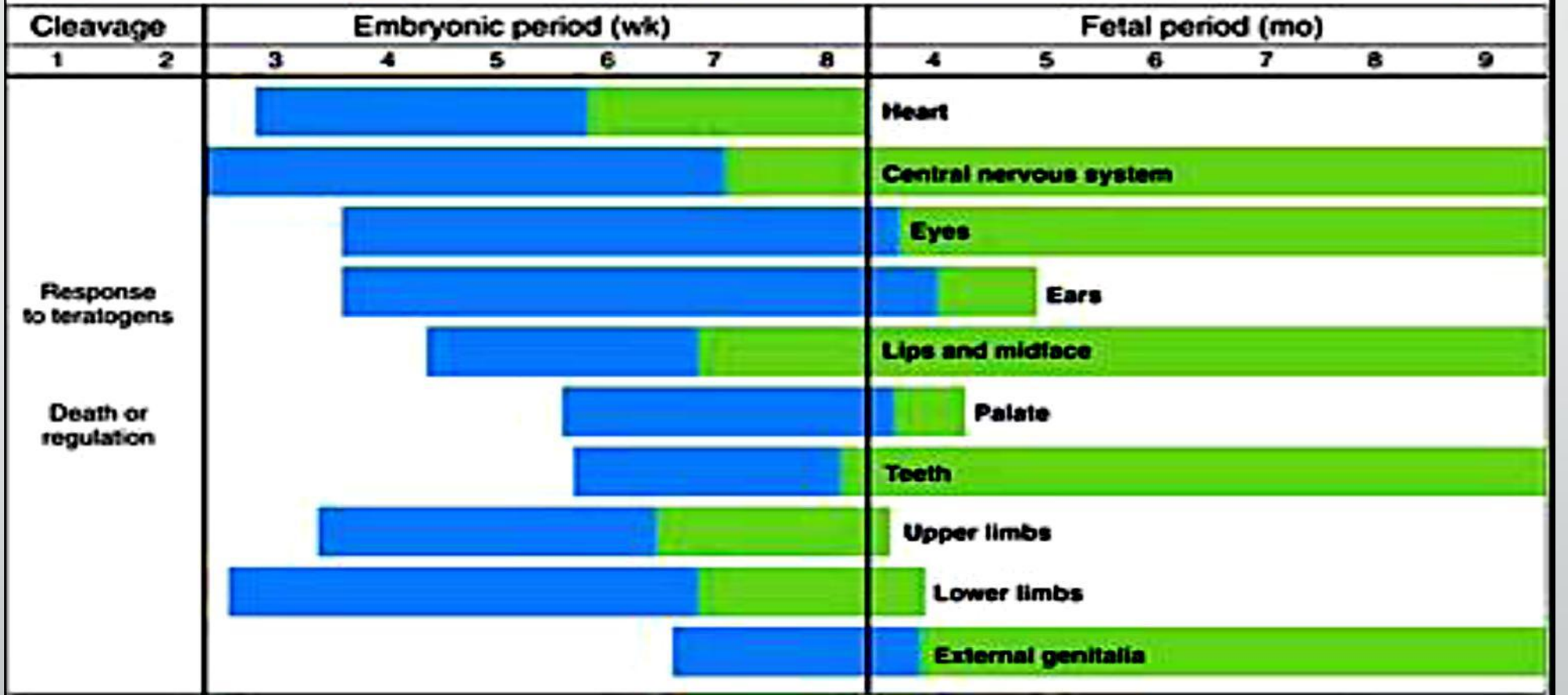
Radiation damage cause **death** either before birth (*intrauterine death*), or few days after birth (*neonatal death*).

## **2. Embryonic Stage (2-8 weeks of conception):**

Radiation damage cause **morphological abnormalities** which appear directly after birth such as *growth retardation & developmental abnormalities*.

## **3. Fetal Stage (continue until term):**

Radiation damage cause **physiological abnormalities** which involve nervous system and sense organs and are not manifest until later in life such as *reduced intelligence (IQ), behavioral changes, and cancer*.



■ Highly sensitive period (major structural anomalies)

■ Less sensitive period (functional and/or minor structural anomalies)



**THANK YOU**



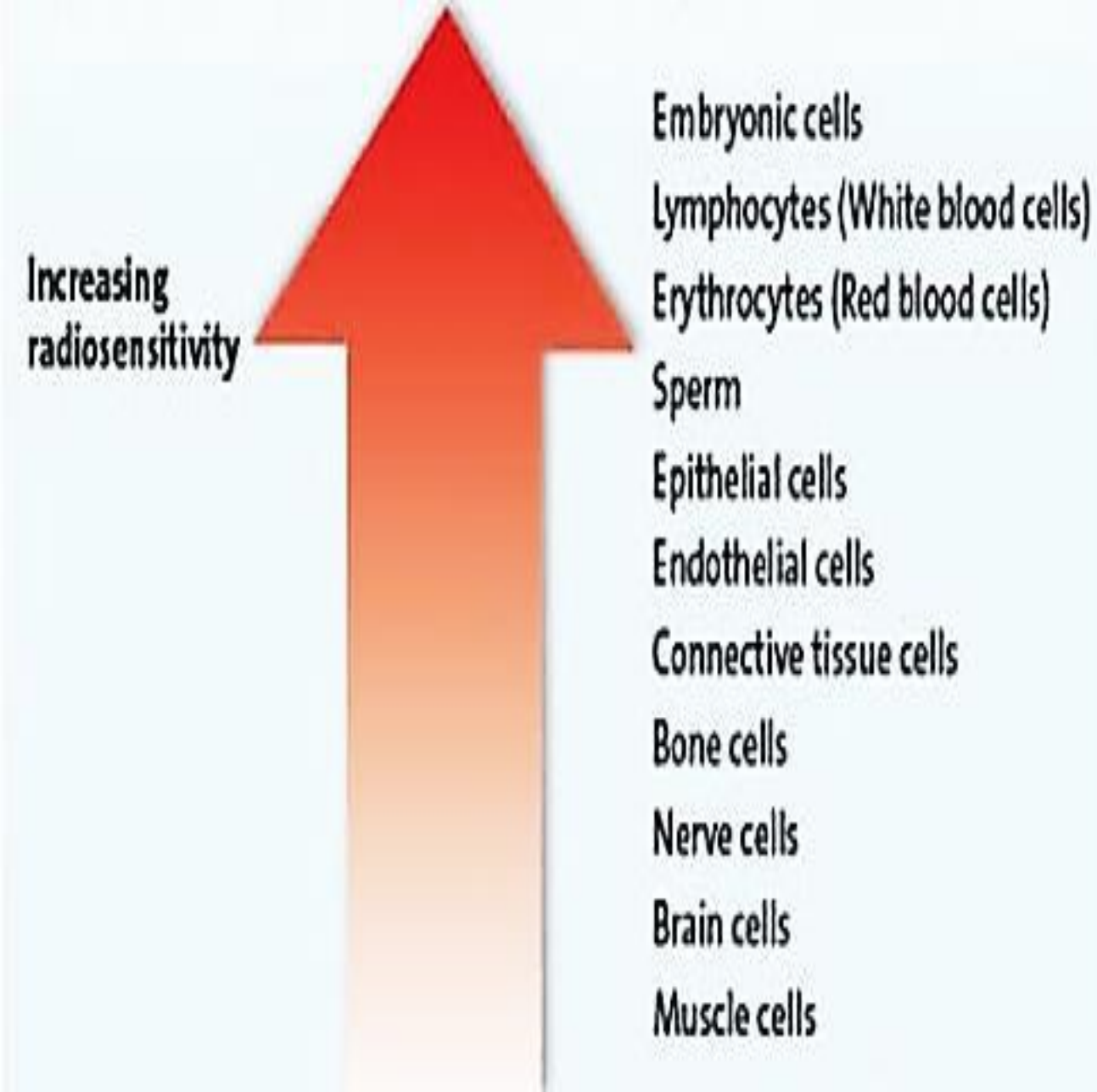


# Determinants of Radiation Effects

1. Type of radiation
2. The radiation dose
3. The dose rate of radiation
4. Species Sensitivity (*LD<sub>50/30</sub>*)

Organism	LD <sub>50</sub> (rad)	Organism	LD <sub>50</sub> (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 tissue is *directly* proportional to the *rate of proliferation* of its cells, and *inversely* proportional to the degree of *cell 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.