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## **Biological Effects of Radiation**

Whether the source of radiation is natural or man-made, whether it is a small dose of radiation or a large dose, there will be some biological effects.



**Radiation Causes Ionizations of:**

**ATOMS**

which may affect

**MOLECULES**

which may affect

**CELLS**

which may affect

**TISSUES**

which may affect

**ORGANS**

which may affect

## **THE WHOLE BODY**

Even though all subsequent biological effects can be traced back to the interaction of radiation with atoms, there are two mechanisms by which radiation ultimately affects cells. These **two mechanisms** are commonly called **direct** and **indirect** effects.

### **Direct Effect**

If radiation interacts with the atoms of the DNA molecule, or some other cellular component critical to the survival of the cell, it is referred to as a direct effect. Such an interaction may affect the ability of the cell to reproduce and, thus, survive. If enough atoms are affected such that the chromosomes do not replicate properly, or if there is significant alteration in the information carried by the DNA molecule, then the cell may be destroyed by “direct” interference with its life-sustaining system.

### **Indirect Effect**

When radiation interacts with water, it may break the bonds that hold the water molecule together, producing fragments such as hydrogen (H) and hydroxyls (OH). These fragments may recombine or may interact with other fragments or ions to form compounds, such as water, which would not harm the cell. However, they could combine to form toxic substances, such as hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), which can contribute to the destruction of the cell.

### **Cellular Sensitivity to Radiation**

(From most sensitive to least sensitive)

**Lymphocytes and Blood Forming Cells**

**Reproductive and Gastrointestinal (GI) Cells**

**Nerve and Muscle Cells**

living cells can be classified according to their rate of reproduction, which also indicates their relative sensitivity to radiation. This means that different cell systems have different sensitivities. Lymphocytes (white blood cells) and cells which produce blood are constantly regenerating, and are, therefore, the most sensitive. Reproductive and gastrointestinal cells are not regenerating as quickly and are less sensitive. The nerve and muscle cells are the slowest to regenerate and are the least sensitive cells.

### **Organ Sensitivity**

(From most sensitive to least sensitive)

#### **Blood Forming Organs**

#### **Reproductive and Gastrointestinal Tract Organs**

#### **Skin**

#### **Muscle and Brain**

blood forming cells were one of the most sensitive cells due to their rapid regeneration rate, the blood forming organs are one of the most sensitive organs to radiation. Muscle and nerve cells were relatively insensitive to radiation, and therefore, so are the muscles and the brain



In cases of mild to moderate radiation dermatitis, the person develops redness and/or peeling of the skin.

### **Whole Body Sensitivity Factors**

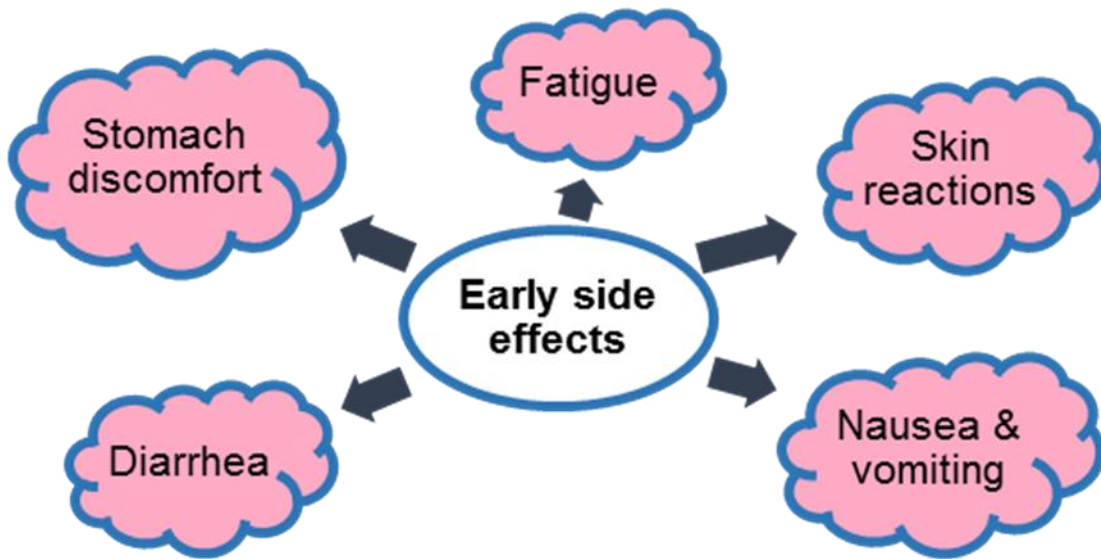
- 1) Total Dose
- 2) Type of Cell
- 3) Type of Radiation
- 4) Age of Individual
- 5) Stage of Cell Division
- 6) Part of Body Exposed
- 7) General State of Health
- 8) Tissue Volume Exposed
- 9) Time Interval over which Dose is Received

### **Radiation Effects**

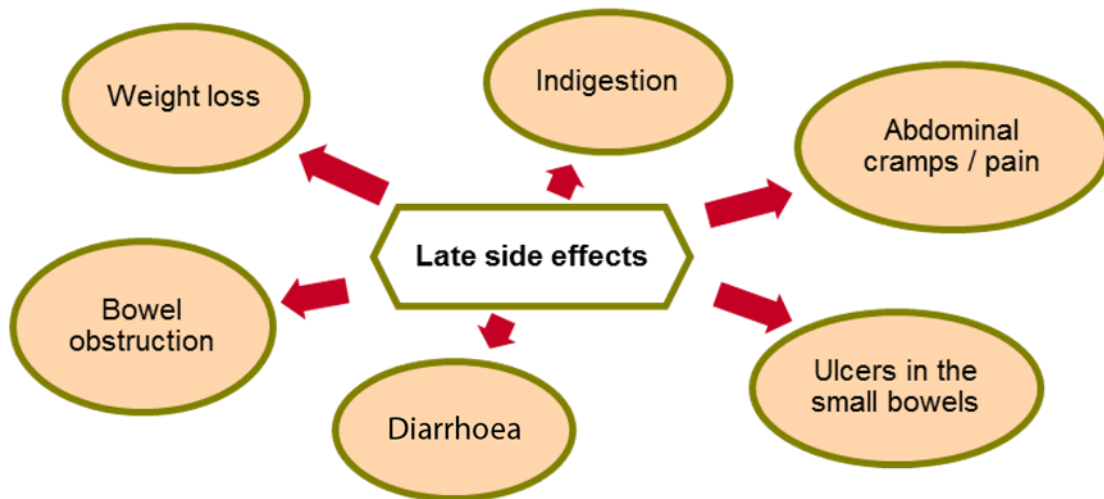
- High Doses (Acute)
- Low Doses (Chronic)

**Biological effects of radiation are typically divided into two categories. The first category consists** of exposure to high doses of radiation over short periods of time producing **acute** or **short term effects**. The **second category** represents exposure to low doses of radiation over an extended period of time producing **chronic** or **long term effects**.

**High doses** tend to kill cells, while low doses tend to damage or change them. High doses can kill so many cells that tissues and organs are damaged. This in turn may cause a rapid whole body response often called the Acute Radiation Syndrome (ARS).



**Low doses** spread out over long periods of time don't cause an immediate problem to any body organ. The effects of low doses of radiation occur at the level of the cell, and the results may not be observed for many years.



### **Other High Dose Effects**

Skin Burns

Hair Loss

Sterility

Cataracts

## **Acute Radiation Syndrome (ARS)**

Hematopoietic

Gastrointestinal

Central Nervous System

### **Categories of Effects of Exposure to**

Low Doses of Radiation

Genetic

Somatic

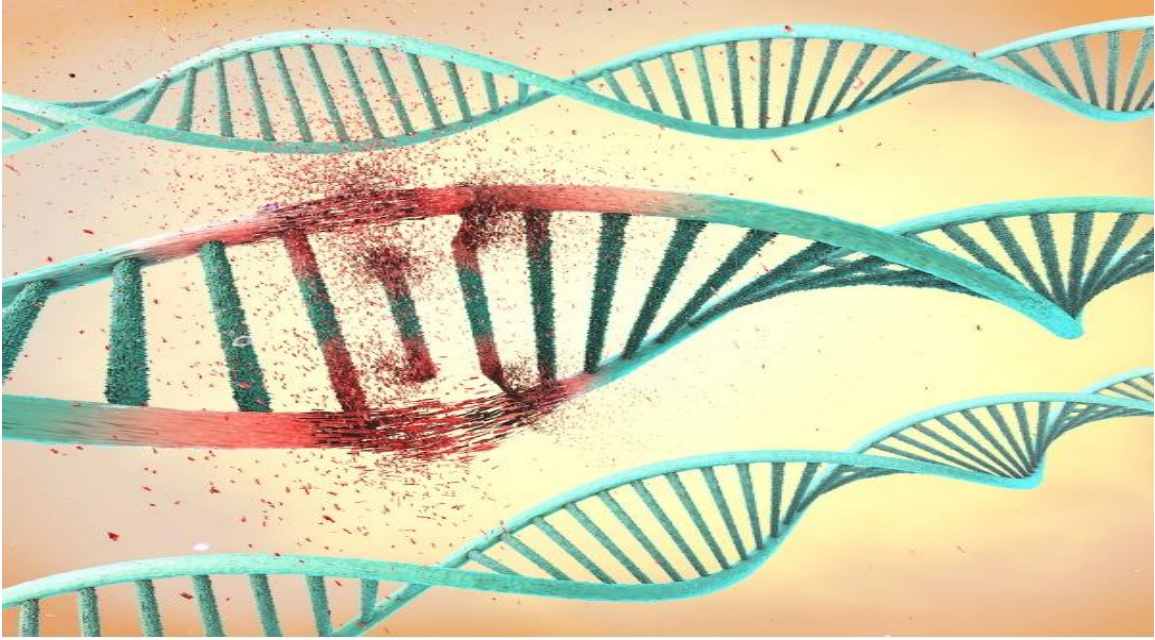
In-Utero

**There are three general categories of effects resulting from exposure to low doses of radiation. These are:**

**Genetic** - The effect is suffered by the offspring of the individual exposed.

**Somatic** - The effect is primarily suffered by the individual exposed. Since cancer is the primary result, it is sometimes called the Carcinogenic Effect.

**In-Utero** - Some mistakenly consider this to be a genetic consequence of radiation exposure, because the effect, suffered by a developing embryo/fetus, is seen after birth. However, this is actually a special case of the somatic effect, since the embryo/fetus is the one exposed to the radiation.



**Damage to DNA (Christoph Burgstedt, iStockphoto)**