



## **Cellular Sensitivity to Radiation**

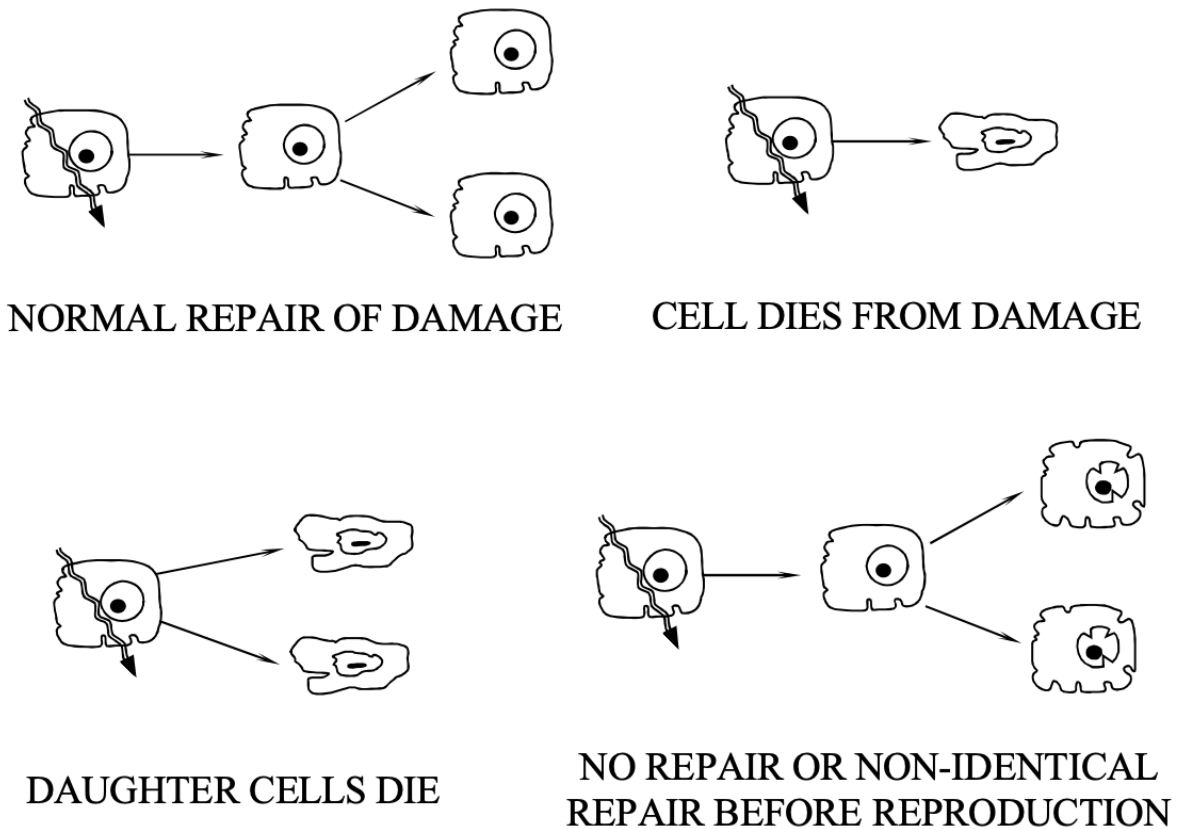
Not all living cells are equally sensitive to radiation. Those cells which are actively reproducing are more sensitive than those which are not. This is because dividing cells require correct DNA information in order for the cell's offspring to survive. A direct interaction of radiation with an active cell could result in the death or mutation of the cell, whereas a direct interaction with the DNA of a dormant cell would have less of an effect.

As a result, 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.

Cells, like the human body, have a tremendous ability to repair damage. As a result, not all radiation effects are irreversible. In many instances, the cells are able to completely repair any damage and function normally.

If the damage is severe enough, the affected cell dies. In some instances, the cell is damaged but is still able to reproduce. The daughter cells, however, may be lacking in some critical life-sustaining component, and they die.

The other possible result of radiation exposure is that the cell is affected in such a way that it does not die but is simply mutated. The mutated cell reproduces and thus perpetuates the mutation. This could be the beginning of a malignant tumor.



**Figure 1:** Type of cellular sensitivity to radiation

## Organ Sensitivity

The sensitivity of the various organs of the human body correlate with the relative sensitivity of the cells from which they are composed. For example, since the 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. The rate of reproduction of the cells forming an organ system is not the only criterion determining overall sensitivity. The relative importance of the organ system to the well being of the body is also important.



One example of a very sensitive cell system is a malignant tumor. The outer layer of cells reproduces rapidly, and also has a good supply of blood and oxygen. Cells are most sensitive when they are reproducing, and the presence of oxygen increases sensitivity to radiation. Anoxic cells (cells with insufficient oxygen) tend to be inactive, such as the cells located in the interior of a tumor.

As the tumor is exposed to radiation, the outer layer of rapidly dividing cells is destroyed, causing it to “shrink” in size. If the tumor is given a massive dose to destroy it completely, the patient might die as well. Instead, the tumor is given a small dose each day, which gives the healthy tissue a chance to recover from any damage while gradually shrinking the highly sensitive tumor.

Another cell system that is composed of rapidly dividing cells with a good blood supply and lots of oxygen is the developing embryo. Therefore, the sensitivity of the developing embryo to radiation exposure is similar to that of the tumor, however, the consequences are dramatically different.

## **Whole Body Sensitivity Factors**

Whole body sensitivity depends upon the most sensitive organs which, in turn, depend upon the most sensitive cells. As noted previously, the most sensitive organs are the blood forming organs and the gastrointestinal system.

The biological effects on the whole body from exposure to radiation will depend upon several factors. Some of these are listed below:

- Total Dose
- Type of Cell
- Type of Radiation



- Age of Individual
- Stage of Cell Division
- Part of Body Exposed
- General State of Health
- Tissue Volume Exposed
- Time Interval over which Dose is Received

## Radiation Effects

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.

## Acute Radiation Syndrome (ARS)

If enough important tissues and organs are damaged, one of the Acute Radiation Syndromes could result.



The initial signs and symptoms of the acute radiation syndrome are nausea, vomiting, fatigue, and loss of appetite. Below about 150 rad, these symptoms, which are no different from those produced by a common viral infection, may be the only outward indication of radiation exposure.

As the dose increases above 150 rad, one of the three radiation syndromes begins to manifest itself, depending upon the level of the dose. These syndromes are:

Syndrome	Organs Affected	Sensitivity
Hematopoietic	Blood forming organs	Most sensitive
Gastrointestinal	Gastrointestinal system	Very sensitive
Central Nervous System	Brain and muscles	Least sensitive

#### Summary of Biological Response to High Doses of Radiation

< 5 rad - No immediate observable effects

~ 5 rad to 50 rad - Slight blood changes may be detected by medical evaluations

~ 50 rad to 150 - Slight blood change will be noted and symptoms of nausea, rad fatigue, vomiting, etc. likely.

~ 150 rad to - 1,100 rad Severe blood changes will be noted and symptoms appear immediately. Approximately 2 weeks later, some of those exposed may die. At about 300 - 500 rad, up to one half of the people exposed will die within 60 days without intensive medical attention. Death is due to the destruction of the blood forming organs. Without white blood cells, infection is likely.



At the lower end of the dose range, isolation, antibiotics, and transfusions may provide the bone marrow time to generate new blood cells and full recovery is possible. At the upper end of the dose range, a bone marrow transplant may be required to produce new blood cells.

- ~ 1,100 rad to – The probability of death increases to 100% within one to two  
2,000 rad weeks. The initial symptoms appear immediately. A few days later, things get very bad, very quickly since the gastrointestinal system is destroyed. Once the GI system ceases to function, nothing can be done, and medical care is for comfort only.
- > 2,000 rad Death is a certainty. At doses above 5,000 rad, the central nervous system (brain and muscles) can no longer control the body functions, including breathing blood circulation. Everything happens very quickly. Nothing can be done, and medical care is for comfort only.