

## 7. What Are the Health Effects of Ionizing Radiation?

Radiation may affect living things by damaging the cells that make up the living organism. Radiation effects on a cell are random. That is, the same type and amount of radiation could strike the same cell many times and have a different effect, including no effect, each time. However, in general, the more radiation that strikes a cell, the greater the chances of causing an effect. If a significant number of cells are affected, the organism may be damaged or even die.

All living things are constantly exposed to background radiation (see Fact Sheet #3: “What are the Sources of Ionizing Radiation?”) Most cells have the ability to repair some damage done by this level of radiation. As a result, the effects of doses similar to background levels are impossible to measure. Effects of such low levels of radiation are often estimated for very large groups of people rather than for individuals.

This Fact Sheet describes how low levels of radiation affect cells, how cell damage affects the health of individuals, and how the health effects on populations are estimated.

Dose (in mrem)	Effect
25,000 to 100,000	Temporary blood changes
More than 50,000	Temporary sterility in males
100,000	Double the normal incidence of genetic defects
100,000 to 200,000	Vomiting, diarrhea, reduction in infection resistance, possible bone growth retardation in children
200,000 to 300,000	Serious radiation sickness, nausea
More than 300,000	Permanent sterility in females
300,000 to 400,000	Bone marrow and intestine destruction
400,000 to 1 million	Acute illness and early death (usually within days)

**Table 1. Threshold Effects**

### ► Radiation Effects on a Cell

When a cell absorbs radiation, there are four possible effects on the cell.

- The cell may suffer enough damage to cause loss of proper function, and the cell will die.
- The cell may lose its ability to reproduce itself.
- The cell’s genetic code (i.e., the DNA) may be damaged such that future copies of the cell are altered, which may result in cancerous growth.
- The absorption of radiation by a cell may have no adverse effects.

Cells are made up of molecules. Cell damage may be caused by interaction of radiation with these molecules. If radiation strikes a molecule crucial to the cell’s function, such as DNA, damage to the cell is likely to be greater than if the radiation strikes a less crucial molecule such as water.

Cells that multiply rapidly are more likely to be affected by radiation than others. An example of rapidly dividing cells is fetal tissue. For this reason, a fetus is especially sensitive to radiation. Another example is a cancerous tumor, which can often be destroyed by radiation treatment. Cells can often repair radiation damage, but if the cell multiplies (splits into two identical cells) before it has had time to repair the most recent radiation damage, the new cells might not be accurate copies of the original one.

### ► Health Effects of Radiation

These are divided into two categories: threshold effects and non-threshold effects. Threshold effects appear after a certain level of radiation exposure is reached and enough cells have been damaged to make the effect apparent. Non-threshold effects can occur at lower levels of radiation exposure.

**Threshold effects** occur when levels of radiation exposure are tens, hundreds, or thousands of times higher than background, and usually when the exposure is over a very short time, such as a few minutes. They do not occur when doses of radiation are smaller than the threshold value. Some examples of observed threshold effects and the doses which cause them are presented in Table 1. Dose is measured in rem or millirem (1,000 millirem = 1 rem).

**Non-threshold effects** can occur at any level of radiation exposure. However, the risk of harmful health effects generally increases with the amount of radiation absorbed. The most studied non-threshold effect is cancer. Studies are somewhat complicated by the facts that most cancers are not caused by radiation, exposure to a particular dose may cause cancer in one person but not in another, and the cancer often doesn't appear until many years after the exposure. It is currently impossible to determine which cancers are caused by radiation and which are caused by other carcinogens in our environment.

Susceptibility to radiation-induced cancer depends on a number of factors such as the site of exposure in the body, and the sex and age of the exposed individual. Sites in the body where cells rapidly grow and multiply, and those where radioactive materials tend to concentrate, are more prone to cancer than others. For example, the breast and thyroid gland have relatively high susceptibilities to radiation-induced cancer, while the kidney and nerve cells have lower susceptibilities.

Many studies have been done on other possible effects of radiation on human health. The detail necessary to present accurate information on these studies is beyond the scope of this Fact Sheet. Health effects are

thoroughly discussed in several books; see references below.

### ► **Radiation Effects on Populations**

Because it is impossible to predict the effect of low levels of radiation on any one person, studies of the human health effects of radiation are usually done by trying to predict how many people in a large population might be affected. The result of such studies is an estimation of how many people in a population of, say, a million may get cancer because of a specific radiation exposure. The estimated cancers due to this specific radiation exposure are *in addition to* cancers that would normally be expected in a population of this size.

### ► **For More Information**

If you want to read more about the health effects of radiation, some of the references and other fact sheets listed below may be helpful.

- Fred A. Mettler, Jr., M.D. and Arthur C. Upton, M.D. *Medical Effects of Ionizing Radiation*, Grune & Stratton, Inc., Orlando, Florida, 1995.
- National Research Council, Committee on the Biological Effects of Ionizing Radiation, *Health Effects of Exposure to Low Levels of Ionizing Radiation, BEIR V*, National Academy Press, Washington, D.C., 1990.
- Other Fact Sheets:
  - #3. *What Are the Sources of Ionizing Radiation?*
  - #5. *How do Radioactive Materials Move Through the Environment to People?*
  - #6. *How are People and the Environment Protected from Ionizing Radiation?*
  - #8. *How Do We Assess Risk?*

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