- Biological Effects of Radiation -

The radiation dose levels that are stated in Part V pertains to all persons. We shall now concentration on persons who work with radioactive materials or X-rays or, because of certain circumstances, receive above average doses.

There are three broad categories used to describe the effects of whole body radiation dose, which are: genetic effect, effects that occur in an individual’s progeny, acute effects, effects due to a large dose of radiation in a short time period, and chronic effects, effects due to small doses received over long time periods.

**Genetic effects.** As stated above, radiation can damage the DNA molecule in the gene-carrying chromosomes but only chromosomal damage to germ cells can affect inheritance. It is also accepted that radiation will cause mutations. However there does not appear to be any conclusive evidence of any heredity effects in humans due to radiation. Even experiments done on animal populations fail to indicate any genetic effects resulting from increased radiation levels. For example, no change was observed in the population of a colony of Texas field mice in which the gonads of captured males were subjected to high levels of radiation and then released back into the colony. Nor were any effects of possible mutations on the colony viability observed. Another example comes from studies done on the animal population at Bikini and Eniwetok atolls after the nuclear bomb testing. Some of these animals received above-lethal doses of radiation yet appear to produce healthy, normal offspring.

**Acute effects.** As a result of accidents, for example, persons working with fissionable material that became critical for a short period (a few minutes) and the disaster of the Russian reactor at Chernobyl, several people are known to have died due to large doses of radiation, 6 in the U.S. and 31 in Russia. There most likely have been others. Here the term “large dose” means greater than about 100 rem (1 sievert). A dose greater than about 300 rem (3 sievert) is considered to be “LD_{50}(30)” which means: Lethal Dose with a 50% probability of survival within 30 days. The graph below shows the approximate relationship between probable death and whole body dose.
Short term effects of an acute whole body dose:

**25 rem.** This level dose may just be detectable from measurements of a drop in red and white blood cell count.

**100 rem.** About half of those receiving this level will become nauseous. There will be noticeable reductions in red and white blood cell count and feeling fatigue.

**200 rem.** All will become nauseous and feel fatigue. Some may loose their hair and some may die especially if they do not receive rest and medical treatment.

**300 to 400 rem.** About half will die even given medical treatment.

**500 to 600 rem.** Most will die even with medical treatment.

**700 to 800 rem** Most likely all will die even with medical treatment.

Cells are most susceptible to radiation damage during mitosis, during cell division. This also implies that organs and organisms that consist of rapidly dividing cells are more susceptible to radiation damage. This explains why many types of cancer are treated with gamma radiation from cobalt 60. Many cancers consist of rapidly dividing cells. It also explains why pregnant women and infants are more susceptible and have greater restrictions placed upon them regarding radiation exposure. Radiation induced nausea is understood because the cells in the small intestine undergo relatively rapid mitosis.

**Chronic effects.** Most of the information regarding chronic whole body radiation comes from studies of radiologists who may receive between 100 to 1500 mrem with an average of about 500 mrem per year in addition to background. The data indicate that radiologists have a slight increase in longevity compared to both physicians and the general population. However there is a somewhat higher, but decreasing, incidence of leukemia among radiologists frequently attributed to their radiation exposure.
It should be evident that the most hazardous situation results from radioactive material being ingested into the body. In this case the radiation-producing chemical is in intimate contact with tissue and consequently can do the most damage. Depending upon the chemical makeup of the material it may be flushed from the body after time or it may become permanently incorporated. An example of the latter occurred back in the early 1930s in which young women that were employed to paint the numerals on clock and watch dials with paint that contained some radium salts. Phosphors were also included in the paint so that the numerals glowed in the dark. The young women tipped their brushes with their lips for the fine work and so ingested some of the radium in the paint. Radium is chemically similar to calcium, being in the same column in the periodic table, so that it migrated and became incorporated into their bones. Recall that radium is an alpha emitter and that alphas produce considerable ionization along their paths in matter and so are very damaging to tissue. As a result many of these women developed degrees of bone cancer years later. The lesson here is to keep radioactive material out of the body. Wear rubber gloves and do not eat or drink in the laboratory.