SAND2007-0626P

Lesson 2

Biological Effects of Radiation Exposure

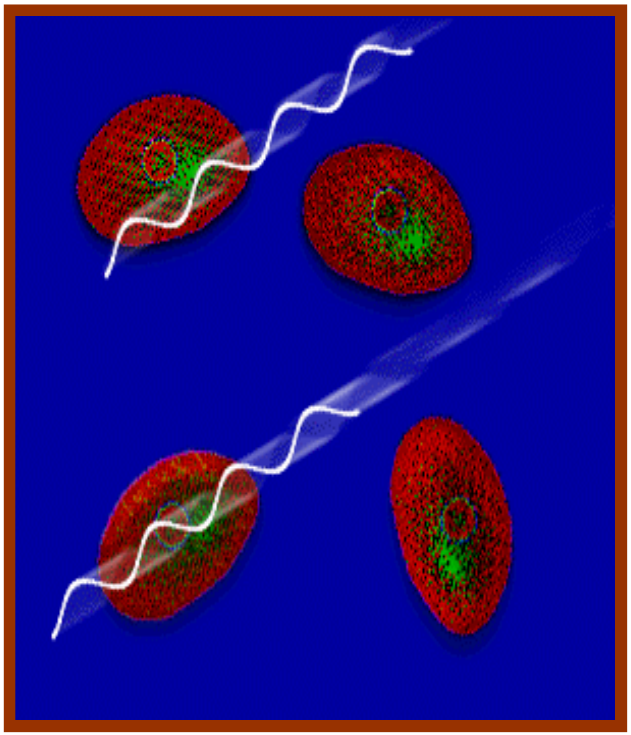
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Lesson 2 – Biological Effects

- Biological Damage from Exposure to Radiation
- Radiation Damage Factors
- Potential Effects from Acute Exposure to Radiation
- Potential Effects from Chronic Exposure to Low-Level Radiation
- Hereditary Effects from Exposure to Radiation
- Prenatal Exposure
- Risks in Perspective

Radiation Risk

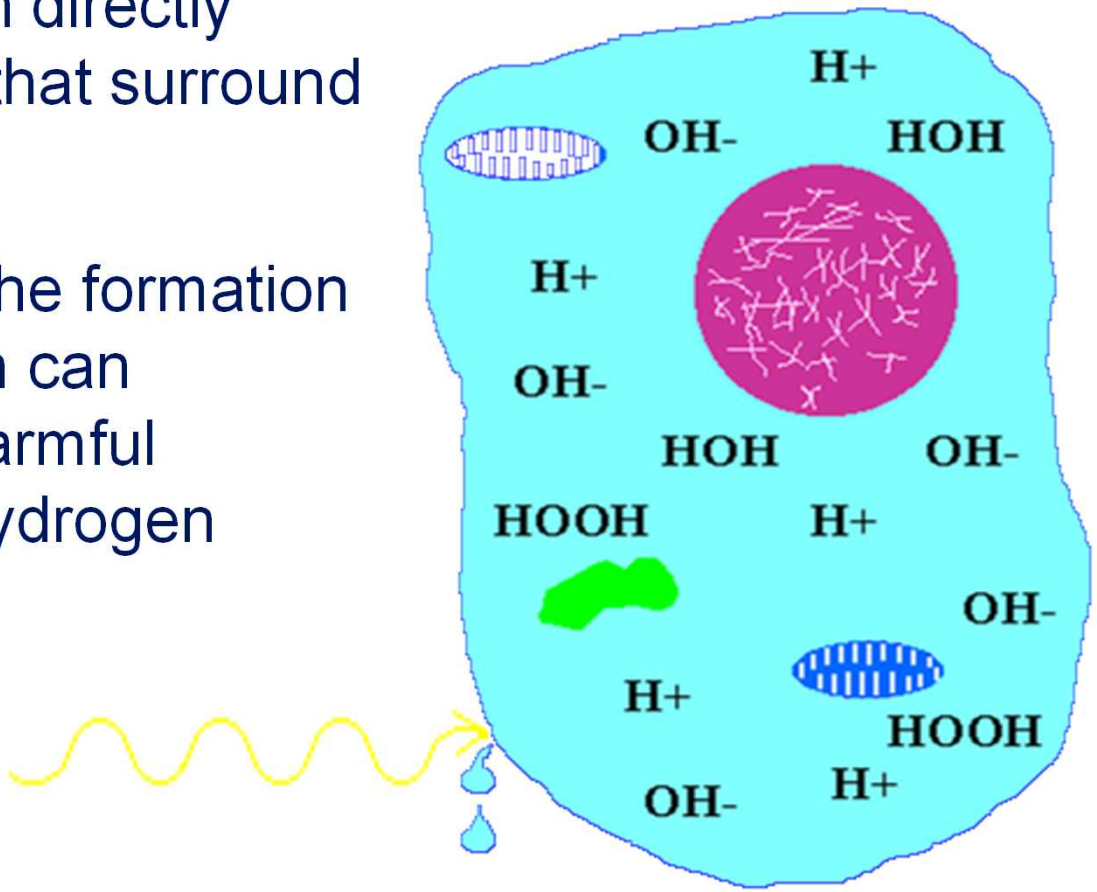
- Radiation exposure comes from a variety of natural and man-made sources
- The method by which radiation causes damage to human cells is by *ionization of atoms in the cells*.
- Any potential radiation damage begins with damage to atoms.



Cell Damage

Ionizing radiation can directly rupture membranes that surround the cells

Ionizations result in the formation of free radicals which can recombine to form harmful chemicals such as hydrogen peroxide

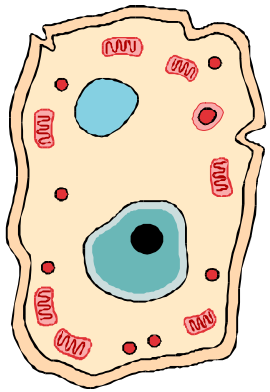


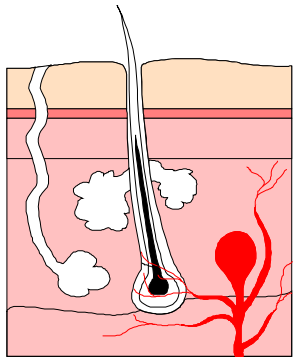
CELL Sensitivity

Some cells are more sensitive than others to environmental factors (viruses, toxins, ionizing radiation).

HIGHEST SENSITIVITY

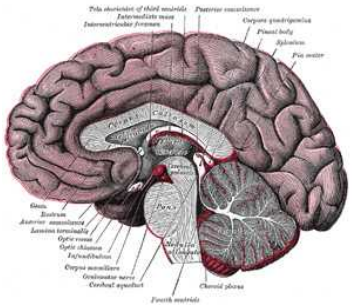
- Actively dividing cells
- Non-specialized cells
- Such as blood forming cells, hair follicles, cells that form sperm

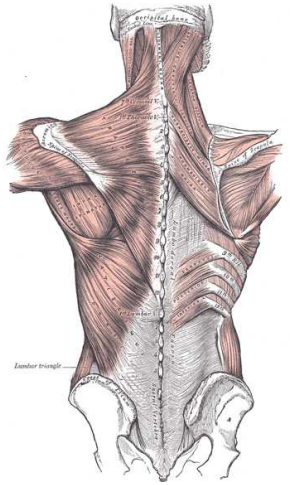




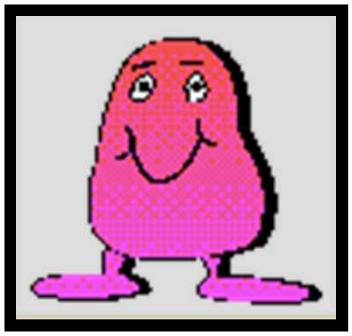
LOWEST SENSITIVITY

- Less actively dividing cells
- More specialized cells
- Such as brain and muscle cells

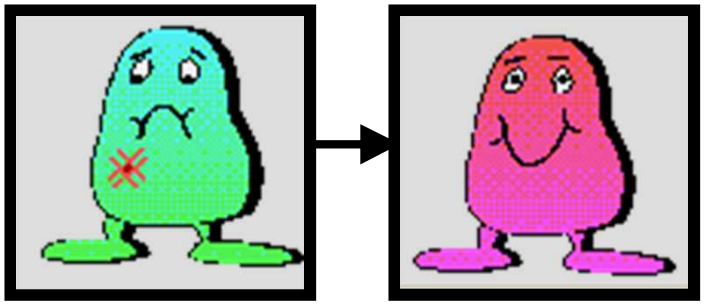




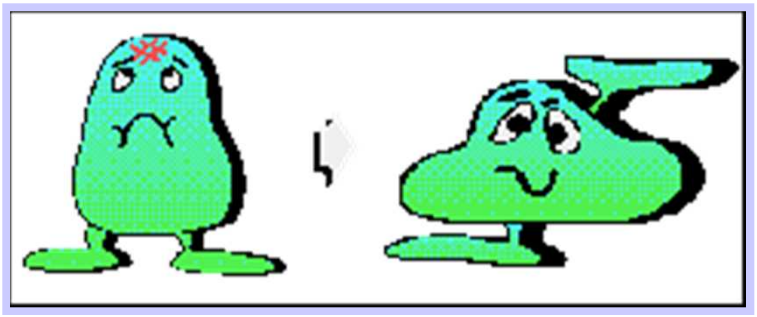
Possible Radiation Effects On Cells



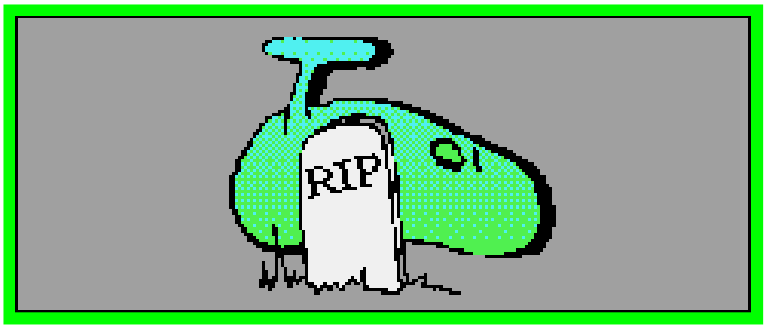
There is no damage



Cells repair the damage and operate normally



Cells are damaged and operate abnormally



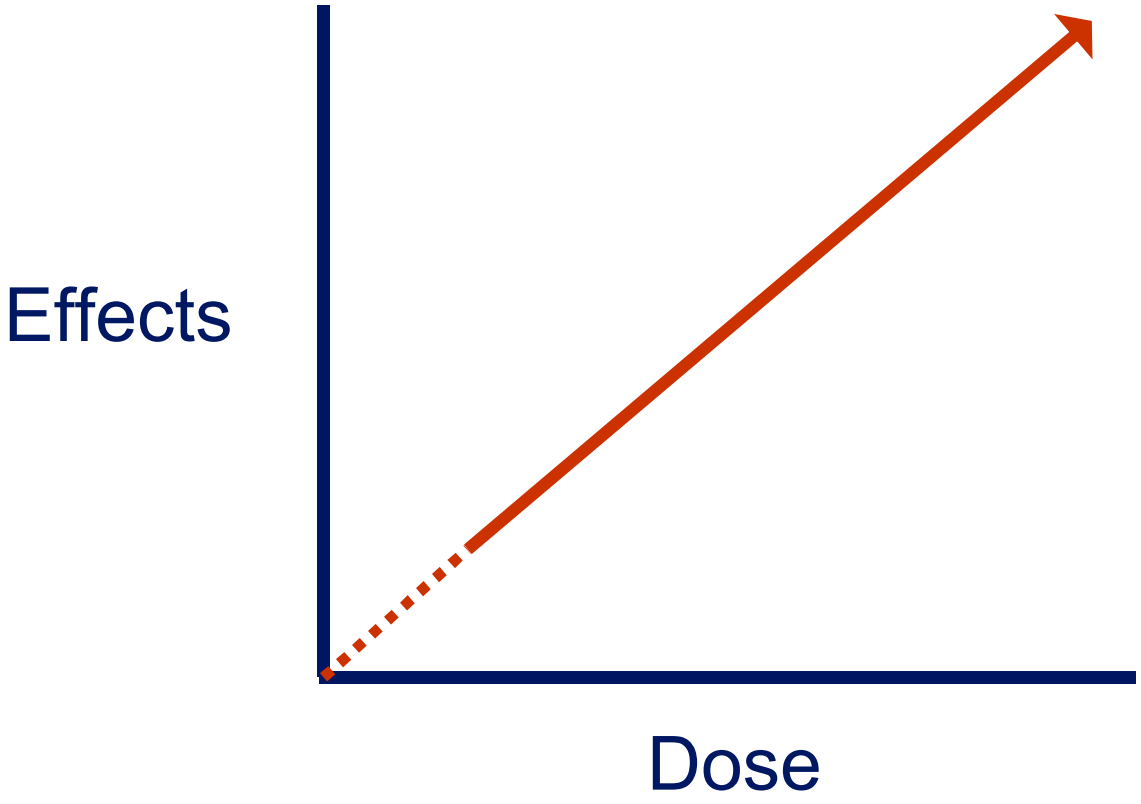
Cells die

Radiation Damage Factors

- Total Dose
- Dose Rate
- Type of Radiation
- Area of Body Exposed
- Individual Sensitivity

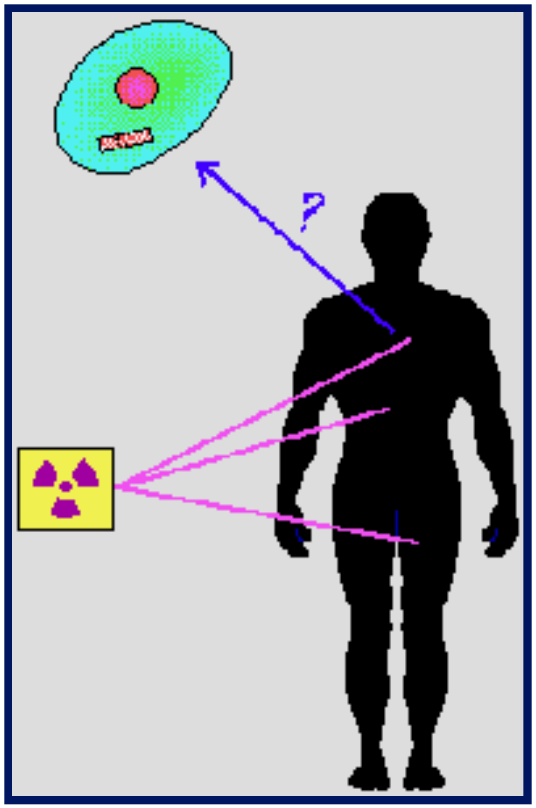
Total Dose

In general, the greater the dose, the greater the potential for biological effects.



Dose Rate

The faster the dose is delivered, the less time the body has to repair itself.



Type of Radiation

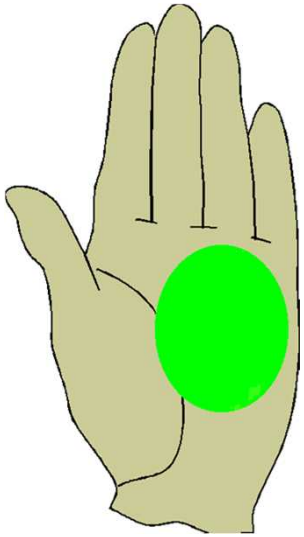
Cell damage varies with the type of radiation.

1 MeV Beta particle creates 60 ion pairs per 1 cm of travel

1 MeV Alpha particle creates 7000 ion pairs per 0.1 cm of travel

Area of Body Exposed

- In general, the larger the area of the body that receives a dose, the greater the biological effect.
- Extremities are less sensitive than blood forming and other critical organs.



vs.

Individual Sensitivity

- **Age**

  The human body becomes less sensitive to ionizing radiation with increasing age; however, elderly people are more sensitive than middle-aged adults.

- **Genetic make-up**

  Some individuals are more sensitive to environmental factors.

Acute vs. Chronic Dose

Potential biological effects depend on how much and how fast a radiation dose is received.

Radiation doses are grouped into:

- Acute - high dose of radiation received in a short period of time (seconds to days)
- Chronic - a small dose of radiation received over a long period of time (months to years)

Acute Dose

The body's cell repair mechanisms are not as effective for repairing damage caused by an acute dose.

- Damaged cells will be replaced by new cells and the body will repair itself, although this may take a number of months.
- In extreme cases the dose may be high enough that recovery would be unlikely.

Acute Exposure Effects

AVG DOSE	DAMAGE
> 5000 rem	Death Within 2 -3 Days
> 500 rem	Gastrointestinal Damage
450 - 600 rem	LD 50-60
200 - 500 rem	Blood System Damaged
100 - 200 rem	Radiation Sickness
25 - 50 rem	Slight Blood Changes
5 rem	Annual Limit

Effects of High-Level Acute Doses (Skin/Extremities)

- Burns
- Necrosis
- Loss of fingers

Chronic Dose

A small dose of radiation received over a long period of time.

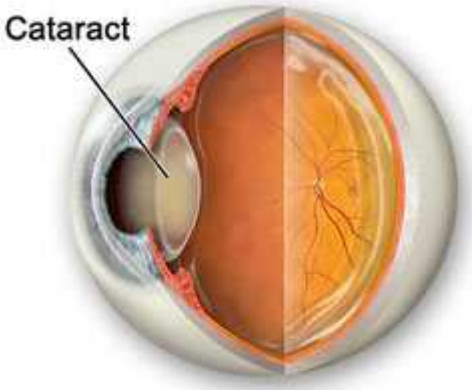
Typical examples are:

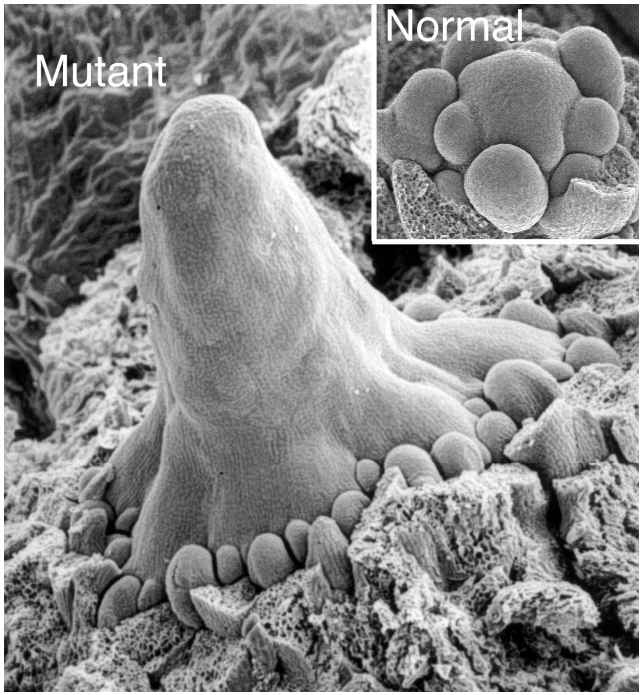
- The dose we receive from natural background
- The dose we receive from occupational exposure

Body is better equipped to tolerate chronic doses

Effects of Chronic Doses

- Increased risk of cataract formation





- Increased risk of developing cancer

Somatic vs. Heritable

- Somatic effects appear in the exposed individual. Some examples:
  - Cells may become cancerous
  - Increased risk of cataract formation
  - Possible life shortening

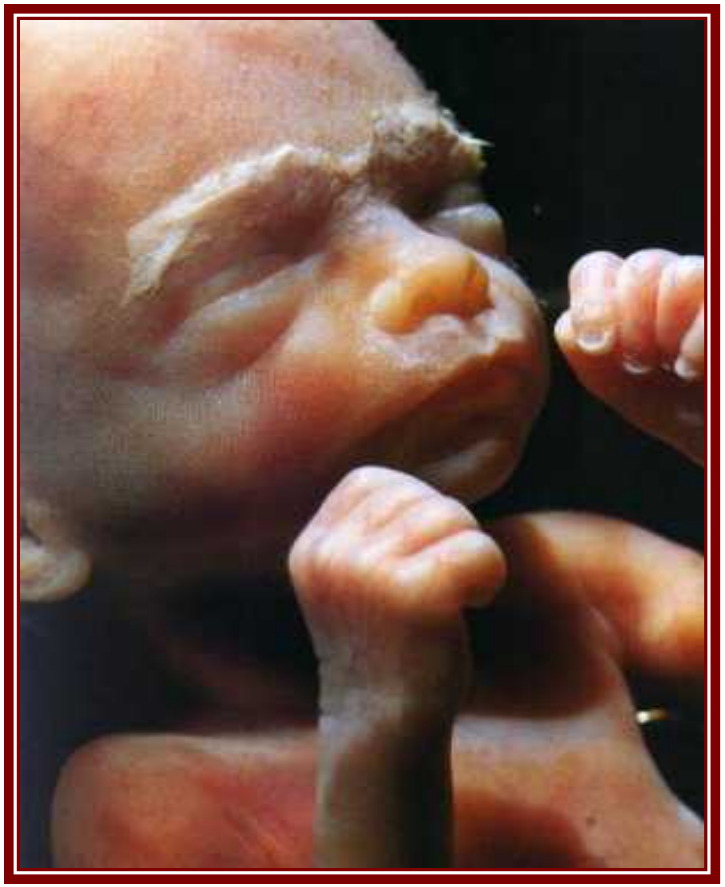
- Heritable (genetic) effects appear in future generations
  - Not yet observed in human populations

Prenatal Exposure

- Prenatal Sensitivity
- Potential Prenatal Effects

Prenatal Sensitivity

Embryo/fetus cells are rapidly dividing, which makes them sensitive to many environmental factors including ionizing radiation.



Potential Prenatal Effects for Entire Pregnancy

Although no effects were seen in Japanese children conceived after the atomic bomb, there were effects seen in some children who were in the womb when exposed to radiation.

Risks in Perspective

- Cancer Risk Info
- Comparison of Health Risks
- Occupational Risk Comparison

Cancer Risk Information

- Health effects have been observed in humans at acute doses in excess of 10 rem.
- No increase in cancer has been observed in individuals who receive a dose of ionizing radiation at occupational levels.
- The possibility of cancer induction cannot be dismissed even though an increase has not been observed.
- Current rate of cancer death is about 20%.
- An individual who receives 25,000 millirem over a working life increases his/her risk of cancer by 1% to about 21%.

Comparison of Health Risks

Health Risk	Days Lost
Unmarried Male	3500
Tobacco User	2250
Unmarried Female	1600
Overweight Individual	777
Alcohol Consumer	365
Motor Vehicle Driver	207
100 mrem/yr for 70 yrs	**10**

Comparison of Occupational Risk

Industry	Days Lost
Coal Miner	328
Farmer	277
Transportation Worker	164
U.S. Average	74
Manufacturer	43
Radiological Worker	**40**
Trades Employee	30