

<u>Radiation Dosage Received (Sv)</u>	<u>Physiological Symptoms</u>
10 Sv or more	Immediate death
1 Sv	Vomiting, nausea, malaise, fatigue, headaches, loss of appetite, diarrhea, epilation (hair loss), anemia, bloody discharge, fever, lens opacity
0.5 Sv	Increased blood lymphocyte counts

Table 2: Cancer deaths between 1950 and 1990 among Life Span Study survivors with significant exposures.

<b>Dose range</b>	<b>Number of cancer deaths</b>	<b>Estimated excess death</b>	<b>Attributable fraction</b>
0.005-0.2 Sv	3391	63	2% (=100 x 63/3391)
0.2-0.5 Sv	646	76	12%
0.5-1 Sv	342	79	23%
>1 Sv	308	121	39%
<b>All</b>	<b>4687</b>	<b>339</b>	<b>7%</b>

Table Credit: [Radiation Effects Research Foundation](http://www.rerf.or.jp/)

### References

A-Bomb WWW Museum (2006). *Introduction: About the A-Bomb*. Retrieved October 18, 2006 from: <http://www.csi.ad.jp/ABOMB/index.html>

Radiation Effects Research Foundation (2006). Retrieved October 19, 2006 from: <http://www.rerf.or.jp/>

## Hiroshima and Nagasaki: Part 5 The Effects of Radiation on Cellular Processes

Of the four types of radiation emitted by the nuclear bombs deployed at Hiroshima and Nagasaki, gamma and neutron rays were the only types strong enough to reach ground and hurt people (see [Part 2](#)). The penetration of **ionizing radiation** into living human cells can result in cell alteration or death (Bertell, 1985). Figure 1 is a diagram depicting the process of ionization.

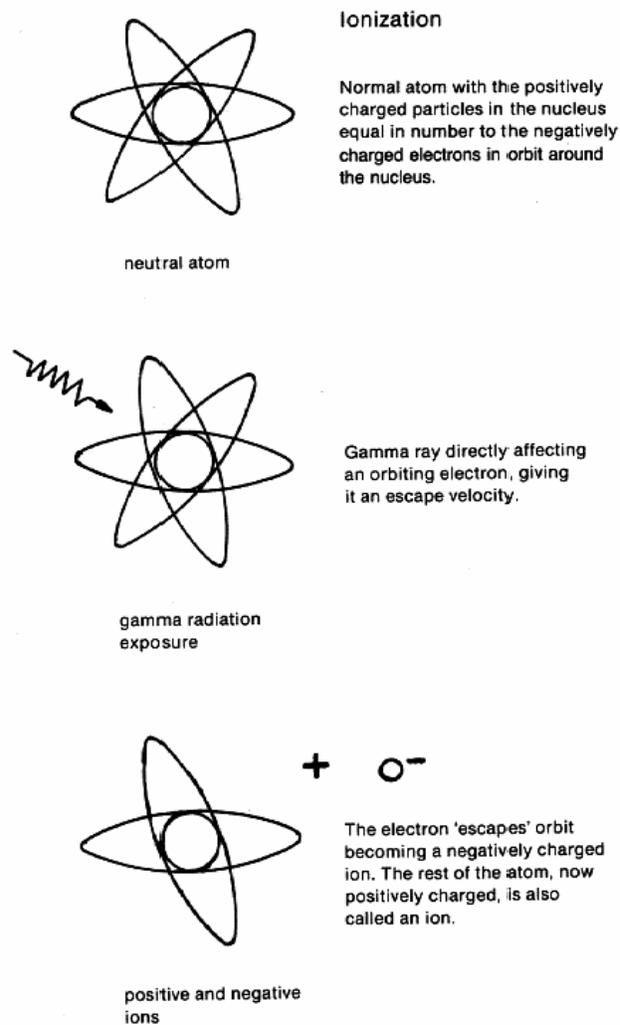


Figure 1 - Graphic credit: Bertell, R. (1985).

According to the U.S. Nuclear Regulatory Commission (2006), high doses of radiation tend to kill cells. If enough cells are killed, tissues and organs will suffer immediate damage. In Nagasaki and Hiroshima this phenomenon became known as **Acute Radiation Syndrome** (U.S. Nuclear Regulatory Commission) and resulted in thousands of fatalities.

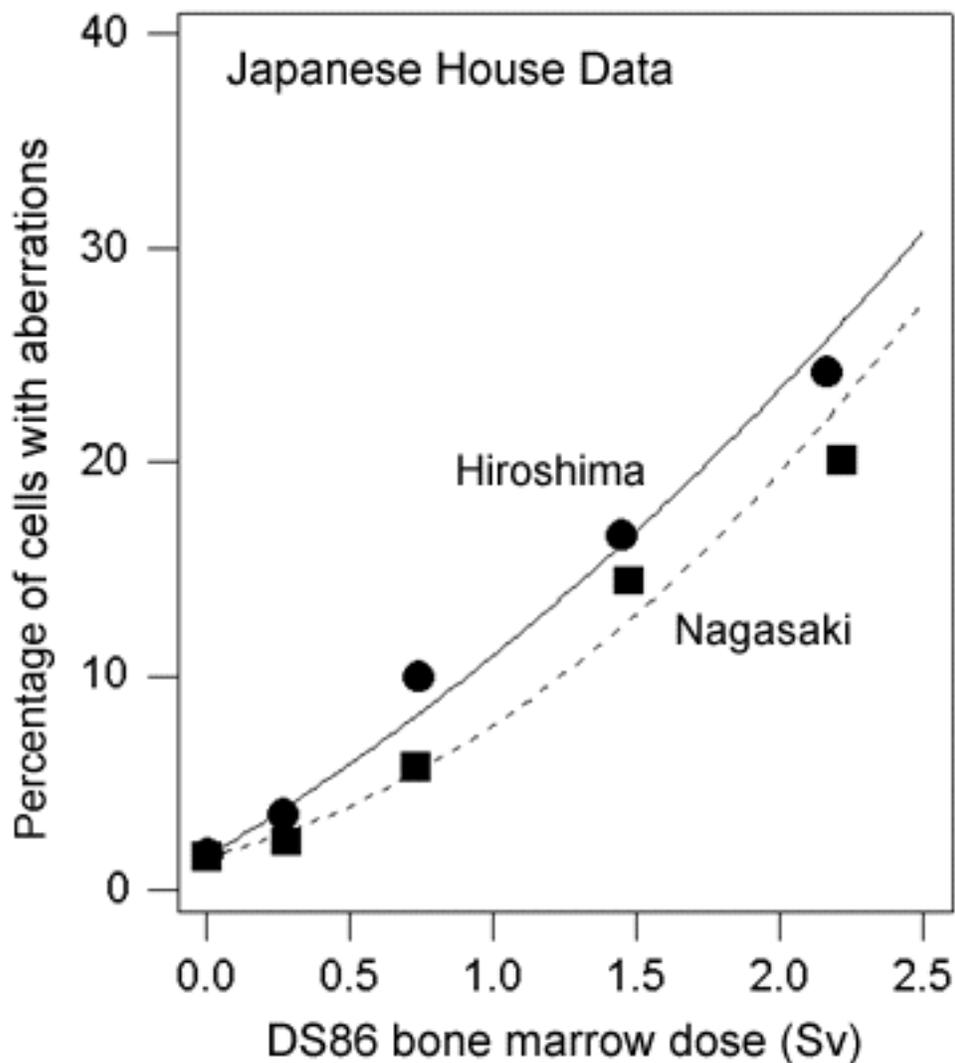


Figure 2 - Graphic credit: [Atomicarchive.com](http://Atomicarchive.com)

The rapid invasion of energy into a human cell may also result in the loss of the cell's ability to reproduce itself or may cause the cell to produce an altered hormone or enzyme from what it would normally produce. These altered or mutated cells will replicate themselves, eventually resulting in the production of millions of such altered cells. This is known as **biological magnification** and causes many chronic diseases normally only associated with the elderly and aging (Bertell, 1985). An example of one such mutation is the destruction of the cell's ability to rest following cell division. A cell unable to rest will chaotically and rapidly produce an astronomical number of cells in one location, resulting in a tumor (either **benign** or **malignant**) (Bertell, 1985). Another cellular process affected by ionizing radiation is blood cell production. The rapid production of too many white blood cells (leukocytes) can cause **leukemia**, while a rapid proliferation of red blood cells (erythrocytes) often causes **polycythemia vera**. For more

information on leukemia, access the National Cancer Institute's Leukemia Home Page at <http://www.cancer.gov/cancertopics/types/leukemia>. To learn about polycythemia vera, contact the Leukemia and Lymphoma Society at this link: [http://www.leukemia-lymphoma.org/all\\_mat\\_toc.adp?item\\_id=9955](http://www.leukemia-lymphoma.org/all_mat_toc.adp?item_id=9955).

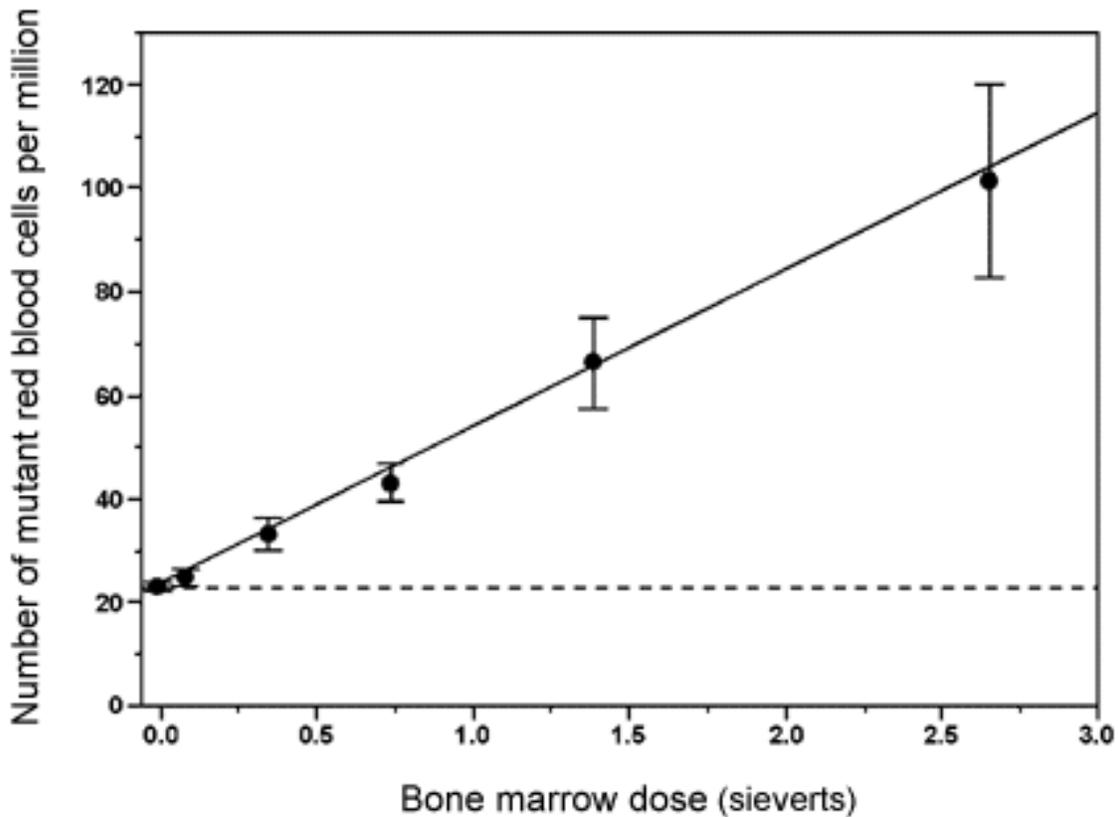


Figure 3 - Graphic credit: [Radiation Effects Research Foundation](http://www.cancer.gov/cancertopics/types/leukemia) Institute's Leukemia Home Page at <http://www.cancer.gov/cancertopics/types/leukemia>. To learn about polycythemia vera, contact the Leukemia and Lymphoma Society at this link: [http://www.leukemia-lymphoma.org/all\\_mat\\_toc.adp?item\\_id=9955](http://www.leukemia-lymphoma.org/all_mat_toc.adp?item_id=9955).

### **Documented Effects of Nagasaki/Hiroshima Bombings on Cellular Processes**

Survivors under shelter at the time of the blasts received less radiation exposure than those out in the open. A medical study conducted on Nagasaki/Hiroshima survivors who reported being in their homes at the time of the bombings indicated a direct correlation between dosage received

and chromosomal abnormalities. Figure 2 shows this correlation (Radiation Effects Research Foundation, 2006).

According to Bertell, if radiation penetration affects germ cells (**sperm** or **ovum**), defective offspring may result. Chromosomal diseases resulting from germ cell radiation include Down's Syndrome, which is caused by failure of chromosomal separation (**nondisjunction**). In nondisjunction, one of the daughter cells resulting from cell division lacks a chromosome and the other daughter cell has an extra chromosome. In the case of Down's Syndrome, the extra chromosome is at location number 21 (trisomy 21). An individual with Down's Syndrome is generally moderately to severely retarded (Schull, 1995). For more information on Down's Syndrome, click on the following link: <http://www.ndss.org/>. For an animation of nondisjunction during meiosis resulting in Down's Syndrome, click here: <http://www.tokyo-med.ac.jp/genet/mfi-e.htm>.

According to Schull (1995), in children of survivors of Nagasaki and Hiroshima, the most commonly encountered sex chromosomal abnormalities were Klinefelter's Syndrome (a male abnormality resulting from an extra X chromosome) and Turner's Syndrome (a female abnormality resulting from an extra X chromosome). For more information on Klinefelter's Syndrome click on the following link: [http://www.nichd.nih.gov/health/topics/klinefelter\\_syndrome.cfm](http://www.nichd.nih.gov/health/topics/klinefelter_syndrome.cfm). For more information about Turner's Syndrome click on this link: <http://www.turner-syndrome-us.org/>.

#### **Note To Teacher**

1. Ionizing Radiation: High-energy radiation capable of producing ionization in substances through which it passes. It includes nonparticulate radiation, such as x-rays, and radiation produced by energetic charged particles, such as alpha and beta rays, and by neutrons, as from a nuclear reaction.
2. Acute Radiation Syndrome: The immediate effects of a short term, whole body overexposure of a person to ionizing radiation.
3. Biological Magnification: The rapid and abnormal replication of cells.
4. Benign: Of no danger to health; not recurrent or progressive; not malignant: a benign tumor.
5. Malignant: Tending to metastasize; cancerous.
6. Leukemia: Any of various acute or chronic neoplastic diseases of the bone marrow in which unrestrained proliferation of white blood cells occurs.
7. Polythycemia Vera: Abnormal and rapid red blood cell production.
8. Sperm: A male gamete or reproductive cell.
9. Ovum: A female gamete or reproductive cell.
10. Nondisjunction: The failure of paired chromosomes or sister chromatids to separate and go to different cells during meiosis.

Definitions Credit: Answers.com (<http://www.answers.com>).

#### **References**

Answers.com (2006). Retrieved October 24, 2006 from <http://www.answers.com>

Bertell, R. (1985). *No Immediate Danger, Prognosis for a Radioactive Earth*. Summertown, TN: The Book Publishing Company.

National Down's Syndrome Society (2006). Retrieved October 25, 2006 from <http://www.ndss.org/>

National Institute of Child Health and Development (2006). Retrieved October 24, 2006 from [http://www.nichd.nih.gov/health/topics/klinefelter\\_syndrome.cfm](http://www.nichd.nih.gov/health/topics/klinefelter_syndrome.cfm)

Numabe, H. (2006). Genetics Study Group. Tokyo Medical University. Retrieved October 26, 2006 from <http://www.tokyo-med.ac.jp/genet/mfi-e.htm>

## Component 4, Part 6

### Atomic Bomb Injuries/Casualties and Long-term Effects

The populations of both Hiroshima and Nagasaki were drastically decreased due to the atomic bombing of these cities. Table 1 (Radiation Effects Research Foundation, 2003) shows the estimated population sizes of Nagasaki and Hiroshima pre and post bombings (post is within four months of the bombings).

Table 1

<u>City</u>	<u>Estimated city population at time of the bombings</u>	<u>Estimated number of acute deaths</u>
Hiroshima	310,000 persons	90,000-140,000
Nagasaki	250,000 persons	60,000-80,000

**Table Credit:** [Radiation Effects Research Foundation](#)

Almost everything and all people located at the hypocenters of the bombs was immediately **vaporized** due to the extremely high temperatures (up to 20 million degrees Fahrenheit) generated by the explosions. Moving in a radius outward from the hypocenters into the blast areas, injuries suffered by individuals were heat-related (burns), caused by collapsing buildings and flying objects (from shockwave) and related to acute, high level radiation exposure (Radiation Effects Research Foundation, 2006). Outside the blast areas, individuals suffered heat, radiation, and fire related deaths and injuries. On the outer fringes of the affected areas, casualties resulted from longer-term health problems. Figure 1 (Radiation Effects Research Foundation, 2003) depicts the types of injuries received based on distance of individuals from the hypocenters.

Figure 1 Graphic  
credit: [Radiation Effects Research Foundation](#)