Biological effects of radiation

Radiation describes a process in which energetic particles or waves travel through a medium or space. There are two distinct types of radiation; ionizing and non-ionizing. The word radiation is commonly used in reference to ionizing radiation only having sufficient energy to ionize an atom but it may also refer to non-ionizing radiation example like radio waves or visible light. The energy radiates travels outward in straight lines in all directions from its source. This geometry naturally leads to a system of measurement and physical that is equally applicable to all types of radiation. Both ionizing and non-ionizing radiation can be harmful to organisms and can result in changes to the natural environment.

Radiation with sufficiently high energy can ionize atoms. Most often, this occurs when an electron is stripped from an electron shell, which leaves the atom with a net positive charge. Because cells are made of atoms, this ionization can result in cancer. An individual cell is made of trillions of atoms. The probability of ionizing radiation causing cancer is dependent upon the dose rate of the radiation and the sensitivity of the organism being irradiated.

Alpha particles, Beta particles, Gamma and X-Ray radiation, and Neutrons may all be accelerated to a high enough energy to ionize atoms.

Radiation includes alpha particle, beta particle, and gamma particle.

Alpha particle: In alpha particle, the spontaneous process of emission of an alpha particle from a radioactive nucleus. Alpha particle is generally termed as alpha decay. An alpha particle is emitted by a heavy nucleus. The nucleus, called parent nucleus has a very large internal energy and is unstable. An alpha particle is a helium nucleus having two protons and two neutrons. When two electrons orbiting around the nucleus of helium atom are knocked out completely, we have doubly ionized helium atom known as alpha particle.

Beta particle: a beta-particle is a fast moving electron. The spontaneous process of emission of beta-particle from a radioactive nucleus is called beta decay. Beta decay is of three types: beta-minus, beta-plus, and electron capture.

Beta-minus: beta-minus is like an electron. It is surprising that nucleus contains no electron, then a nucleus can emit electron. In the neutron inside the nucleus is converted in to a proton and an electron like particle. This electron like particle is emitted by the nucleus during beta-decay.

In beta-minus decay, neutron in the nucleus is converted in to a proton and a beta-minus particle is emitted so that the ratio of neutron to proton decreases and hence the nucleus becomes stable.

Beta-plus: In a beta-plus decay, a proton is converted in to a neutron and a positron is emitted if a nucleus has more protons than neutrons.

Electron capture: In electron capture, nucleus absorbs one of the inner electrons revolving around it and hence a nuclear proton becomes a neutron and a neutrino is emitted. Electron capture is comparable with a positron emission as the processes lead to the same nuclear transformation. However, in electron capture occurs more frequently than positron emission in heavy elements. This is because the orbits of electrons in heavy elements have same radii and hence orbital electrons are very close to the nucleus.

Gamma ray: Gamma rays are the high energy packets of electromagnetic radiation. Gamma radiations have high energy photons. They do not have any charge and their relative rest mass is zero. Gamma-decay it is the spontaneous process of emission of high energy photon from a radioactive nucleus.

When a radioactive nucleus emits a beta particle, the daughter nucleus is excited to the higher energy state. This excited nucleus rays are emitted by the daughter nucleus so it is clear that the emission of gamma rays follows the emission of alpha or beta particle.

Non ionizing radiation:

Non-ionizing forms of radiation on living tissue have only recently been studied. Instead of producing charged ions when passing through matter, the electromagnetic radiation has sufficient energy to change only the rotational, vibration or electronic valence configurations of molecules and atoms. Nevertheless, different biological effects are observed for different types of non-ionizing radiation

Radio waves: Radio waves whose wavelengths range from than 10^4m to 0. 1m, are the result of charges accelerating through conducting wires. They are generated by such electronic devices as LC oscillators are used in radio and television communication system.

Infrared rays: Infrared radiations have wavelength ranging from approximately 0. 3m to 10^ -4m and also generated by the electronic devices. The infrared radiation energy absorbed by a substance as internal energy because the energy agitates the object's atoms, increasing their vibration or translational motion, which results temperature increases. Infrared radiation has practical and scientific application in many areas, including physical therapy, infrared radiation photography, and vibration spectroscopy.

Ultraviolet radiation: Ultraviolet radiation cover wavelength ranging from approximately 4X10^4m to 6X10^-10m. The sun is an important source of ultraviolet radiation light, which is the main cause of sunburn. Sunscreen locations are transparent to visible light but greater percentage of UV light absorbed. Ultraviolet rays have also been implicated I the formation of cataracts.

Most of the UV light from the sun is absorbed by ozone molecules in the earth upper atmosphere, in a layer called stratosphere. This ozone shield converts lethal high energy ultraviolet radiation to infrared radiation, which in turns warm the stratosphere.

X-rays: X-rays have the range from approximately10^-8 to 10^-12m. The most common source of x-rays is stopping of high energy electrons upon the bombarding a metal target. X-rays are used as diagnostics tool in medicine and as the treatment for certain forms of cancer. Because x-rays can damage or destroy living tissue and organism, care must be taken avoid necessary exposure or over-exposure. X-rays are also used in the study of crystal structure because x-rays wavelengths are comparable to the atomic separation distance in solids.

Electromagnetic radiation: The wave nature of electromagnetic radiation explains various phenomena like interference, diffraction and polarization. However, wave nature of electromagnetic radiation, could explain phenomena like photoelectric effect, Compton Effect. The cathode rays consist of negative charged particles called electrons which are the constituent of an atom and hence the constituent of matter.

According to the concept of radiation example light wave’s radio waves, X-rays, microwaves etc. are assumed to carry energy in packets or bundles known as photons or quanta.

Biological effect of radiation:

In biological effect of radiation, there are many dangerous effects of our health and body. Biological effects of radiation are typically can be divided into two categories. The first category consist of exposure to high doses of radiation over shots period 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 dose (acute): 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 is turn may cause a rapid whole body response often called the acute radiation syndrome (ARS).

Low doses (chronic): 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.

Although we tend to associate high doses of radiation with catastrophic events such as nuclear weapons explosions, there have been documented cases of individuals dying from exposures to high doses of radiation resulting from tragic events.

High effects of radiation: high effects of radiation are skin burns, hair loss, sterility, cataracts.

Effects of skin include (reddening like sunburn), dry (peeling), and moist (blistering). Skin effects are more likely to occur with exposure to low energy gamma, x-ray, or beta radiation. Most of the energy of the radiation deposit in the skin surface. The dose required for erythematic to occur is relatively high, in excess of 300 radiations. Blistering requires a dose in excess of 1, 200 radiations.

Hair loss, also called epilation, is similar to skin effects and can occur after acute doses of about 500 radiations.

Sterility can be temporary or permanent in males, depending upon the doses. To produce permanent sterility, a dose in excess of 400 radiations is required to the reproductive organs.

Cataracts (a clouding of the lens of the eye) appear to have a threshold about 200 radiations. Neutrons are especially effective in producing cataracts, because the eye has high water content, which is particularly effective in stopping neutrons.

High dose effects:

Dose (radiation)	effect observed
15-25	blood count changes.
50	blood count change in individual.
100	Vomiting (threshold).
150	Death (threshold).

Categories of effects of exposure to low doses of radiation:

There are three general categories of effects resulting from exposure to low doses of radiation. These are:

Genetic: the effect is suffered by the offspring of the individual exposed.

Somatic: the effect is primarily suffered by the individual exposed. Since cancer is the primary result, it is sometimes called the carcinogenic effect.

In-utero: some mistakenly consider this to be a genetic consequence of radiation exposure, because the effect, suffered by a developing is after birth. However, this is actually a special case of the somatic effect, since the embryo is the one to the radiation.

Radiation risk: the approximate risks for the three principal effects to level of radiation are:

In genetic effect, risk from 1 rem of radiation exposure to the reproductive organs approximately 50 to 1, 000 time’s less than spontaneous risk for various anomalies.

In somatic effect, for radiation induced cancer, the risk estimate is developing any type of cancer. However not all cancers are associated with exposure to radiation. The risk from dying from radiation induced cancer is about one half the risk of getting the cancer.

In utero: Spontaneous risks of fetal abnormalities are about 5 to 30 times greater than risk of exposure to 1 rem radiation. However, the risk of child hood cancer from exposure in utero is about the same as the risk to adults exposed to radiation exposures.

Linear no-threshold risk model: general consensus among experts is that some radiation dose by a linear, no threshold model. This model is accepted by the NRC since it appears to be most conservative.

Linear: an increase in dose adults in a proportional increase in risk.

No-threshold: any dose, no matter how small, produces some risk.

The risk does not start at 0 because there is some risk of cancer, even with no occupational exposure. Exposure to radiation is guarantee of harm. However, because of the linear, no-threshold model, more exposure means more risk, and there is no dose of radiation so small that it will not have some effect.

EFFECTS OF RADIATION ON CELLS

Ionizing radiation absorbed by human tissue has enough energy to remove electrons from the atoms that make up molecules of the tissue. When the electron that was shared by the two atoms to form a molecular bond is dislodged by ionizing radiation, the bond is broken and thus, the molecule falls apart. This is a basic model for understanding radiation damage. When ionizing radiation interacts with cells, it may or may not strike a critical part of the cell. We consider the chromosomes to be the most critical part of the cell since they contain the genetic information and instructions required for the cell to perform its function and to make copies of it for reproduction purposes. Also, there are very effective repair mechanisms at work constantly which repair cellular damage – including chromosome damage.

Uses of radiation: Nuclear physics application are extremely widespread in manufacturing, medicine in biology, we present a few of these application and underlying theories supporting them.

Tracing: Radioactive tracers are used to track chemicals participating in various reactions. One of the most valuable uses of radioactive tracers in medicine. For example, iodine, a nutrient needed by the human body, is obtained largely through intake of iodized salt and sea food.

Radiation therapy: Radiation causes much damage to rapidly dividing cells. Therefore, it is useful in cancer treatment because tumor cells divide extremely rapidly. Several mechanisms can be used to deliver radiation to a tumor. In some cases, a narrow beam of x-ray or radiation from a source such as 60co is used. In other situation, thin radioactive needles called seeds are implanted in the cancerous tissue. The radioactive isotope 131I is used to treat cancer of the thyroid.

Black body radiation: An object at any temperature emits electromagnetic waves in the form of thermal radiation from its surface. The characteristics of this radiation depend on the temperature and properties of the object's surface. Thermal radiation originates from accelerated charged particles in the atoms near the surface of the object; those charged particles emit radiation much as small antennas do. The thermally radiation agitated particles can have a distribution of energies, which accounts for the continuous spectrum of radiation emitted by the object. The basic problem was in understanding the observed distribution of wavelengths in the radiation emitted by a black body. A black body is an ideal system that absorbs all radiation incidents on it. The electromagnetic radiation emitted by the black body is called blackbody radiation.

Radiation damage: Radiation damage means that electromagnetic is all around in the form of radio waves, microwaves, light waves so on. The degree and type of damage depend on several factors, including the type and energy of the radiation and properties of the matter.

Radiation damage in biological organism is primarily due to ionization effects in cells. A cell's normal operation may be disrupted when highly reactive ions are formed as the result of ionizing radiation. Large those of radiation are especially dangerous because damage to a great number of molecules in a cell may cause to die.

In biological systems, it is common to separate radiation damage in two categories: somatic damage and genetic damage. Somatic damage is that associated with any body cell except the reproductive cells. Somatic damage can lead to cancer or can seriously alter the characteristics of specific organism. Genetic damage affects only reproductive cells. Damage to the genes in reproductive cells can lead to defective cells. It is important to be the aware of the effect of diagnostics treatments, such as X-rays and other forms of radiation exposure, and to balance the significant benefits of treatment with the damaging effects.

Damage caused by the radiation also depends on the radiation's penetrating power. Alpha particles cause extensive damage, but penetrate only to shallow depth in a material due to strength interaction with other charged particles. Neutrons do not interact via the electric force and hence penetrate deeper, causing significant damage. Gamma rays are high energy photons that can cause serve damage, but often pass through matter without interactions. For example- a given dose of alpha particle causes about ten times more biological damage produced by radiation than equal dose of x-rays. The RBE (relative biological effectiveness) factor for a given type of radiation is the number of rads of x-radiation or gamma radiation that produces the same biological damage as 1-rad of the radiation is being used.

Radiation detectors: Particles passing through matter interact with the matter in several ways. The particles can, for example- ionize atoms, scatter from atoms, or be absorbed by atoms. Radiation detectors exploit these interactions to allow a measurement of the particle's energy, momentum, or change and sometimes the very existence of the particle if it is otherwise difficult to detect. Various devices have been developed for detecting radiation. These devices are used for a variety of purposes, including medical diagnoses, radioactive dating measurement, measuring back ground radiation, and measuring the mass, energy, and momentum of particles is created in high-energy nuclear reaction.

EFFECT OF RADIATION ON HUMANS

A very small amount of ionizing radiation could trigger cancer in the long term even though it may take decades for the cancer to appear. Ionizing radiation (x-rays, radon gas, radioactive material) can cause leukemia and thyroid cancer. There is no doubt that radiation can cause cancer, but there still is a question of what level of radiation it takes to cause cancer. Rapidly dividing cells are more susceptible to radiation damage. Examples of radiosensitive cells are blood forming cells (bone marrow), intestinal lining, hair follicles and fetuses. Hence, these develop cancer first.

If a person is exposed to radiation, especially high dose, there are predictable changes in our body that can be measured. The number of blood cells, the frequency of chromosome aberrations in the blood cells and the amount of radioactive material in urine, are examples of biomarkers that can indicate if one is exposured high dose. If you do not have early biological changes indicated by these measurements the radiation exposure will not pose an immediate threat to you.

Radiation poisoning

Radiation poisoning, radiation sickness or a creeping dose, is a form of damage to organ tissue caused by excessive exposure to ionizing radiation.

The term is generally used to refer to acute problems caused by a large dosage of radiation in a short period, though this also has occurred with long term exposure. The clinical name for radiation sickness is acute radiation syndrome as described by the CDC A chronic radiation syndrome does exist but is very uncommon; this has been observed among workers in early radium source production sites and in the early days of the Soviet nuclear program. A short exposure can result in acute radiation syndrome; chronic radiation syndrome requires a prolonged high level of exposure.

Radiation exposure can also increase the probability of developing some other diseases, mainly cancer tumors, and genetic damage. These are referred to as the stochastic effects of radiation, and are not included in the term radiation.

Radiation Exposure

Radiation is energy that travels in the form of waves or high-speed particles. It occurs naturally in sunlight and sound waves. Man-made radiation is used in X-rays nuclear weapons, nuclear power plants and cancer treatment.

If you are exposed to small amounts of radiation over a long time, it raises your risk of cancer. It can also cause mutations in your genes, which you could pass on to any children you have after the exposure. A lot of radiation over a short period, such as from a radiation emergency can cause burns or radiation sickness. Symptoms of radiation sickness include nausea, weakness, hair loss, skin burns and reduced organ function. If the exposure is large enough, it can cause premature aging or even death.