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THE EFFECTS OF RADIOACTIVE RADIATION ON LIVING TISSUES

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Annotation: Radioactive radiation is a powerful physical factor that exerts both direct and indirect effects on living tissues. Alpha, beta, and gamma radiation interact with matter by ionizing atoms and molecules, which causes significant damage to cellular structures. Ionizing radiation is particularly hazardous as it can break DNA strands, induce genetic mutations, disrupt the cell cycle, and trigger apoptosis. These processes may lead to the development of cancer, immune system suppression, hematologic disorders, and other serious pathologies

This topic provides a comprehensive analysis of the types of radioactive radiation, their physical characteristics, and their molecular mechanisms of interaction with biological tissues. It also examines short- and long-term exposure effects, sensitivity variations based on age and genetics, and the cumulative risks of radiation. The scientific insights from this analysis contribute to improving preventive strategies, enhancing diagnostic and therapeutic approaches, and ensuring radiation safety. Additionally, the topic covers protective equipment, individual dosimetry, cellular resistance mechanisms, and international safety regulations.

Keywords: radioactive radiation, alpha particles, beta particles, gamma rays, ionizing radiation, cell structure, DNA damage, cellular mutation, free radicals, apoptosis, cancer, genetic alterations, tissue regeneration, radiation dose, biological effect, radiation sickness, protective equipment, molecular analysis, radiation safety, international standards

Radioactive radiation is a stream of energetic particles or waves released as a result of changes occurring at the nuclear level of a substance. These radiations are divided into alpha (α), beta (β) and gamma (γ) types. Alpha radiation is a heavy particle consisting of two protons and two neutrons, which has a high ionizing ability, but a very low penetration depth. They can only be blocked by paper or human skin, but if they hit internal organs, they can cause serious biological damage. Beta radiation is a stream of high-energy electrons or positrons, which move more easily and actively than alpha particles. They penetrate the surface tissues of the body and have an ionizing effect at the molecular level. Gamma radiation is in the form of electromagnetic waves and has the highest absorption, that is, it reaches the inner layers of the human body. Gamma radiation is fully ionizing radiation that can damage DNA, alter the cell

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cycle, and cause cancer. All three types of radiation pose varying degrees of risk to living tissue, with their effects depending on dose, time, tissue type, and individual susceptibility.

The effect of radioactive radiation on the cells and tissues of a living organism depends mainly on its ionizing properties. When radiation ionizes molecules of a substance, atoms lose or gain electrons, which seriously disrupts the chemical composition and biological functions. First of all, the DNA molecule located in the cell nucleus is damaged by radiation. Alpha, beta and gamma particles enter the cell and break DNA chains, change molecules or cause genetic mutations. As a result of these mutations, the cell loses its ability to divide normally, the structures of the nucleus and cytoplasm are deformed, protein synthesis is disrupted, and as a result, the cell cannot perform its functions. If this happens in many cells, dysfunction occurs in the entire tissue or organ. Another important effect of radiation is the formation of free radicals in the body. These radicals increase oxidative stress and damage cell membranes, mitochondria and other organelles. Rapidly dividing cells, especially blood cells, intestinal epithelial cells, and germ cells, are very sensitive to radiation. These processes also weaken the immune system, reduce regeneration capabilities, and make the body vulnerable to various diseases. Depending on the dose of radiation exposure, cell death, apoptosis, necrosis, or permanent disruption of cell function occurs. Low-dose exposure can cause dangerous diseases such as cancer even after many years. High doses cause severe pathological conditions in a short period of time. The strength of the biological effect depends on the age, genetic reserve, general health, and the type of radiation being exposed.

The effects of radioactive radiation on human health vary depending on the dose, duration, and individual characteristics of the body. Short-term exposure to high doses of radiation usually causes acute radiation syndrome. The initial symptoms of this syndrome include weakness, nausea, vomiting, headache, and loss of appetite. If the body receives a large dose, these symptoms can quickly lead to nervous disorders, disruption of the functioning of internal organs, and even death. In particular, blood-forming tissues - bone marrow - are extremely sensitive to radiation, leading to leukopenia, anemia, and decreased immunity. Intestinal epithelium, hair follicles, gonads, and skin cells are also highly sensitive and are quickly damaged. Moderate doses cause slowly developing but stable pathologies. Among the long-term effects, the most dangerous are oncological diseases, in particular, leukemia, thyroid, and lung cancer. Such diseases often manifest themselves years later. At the same time, due to genetic mutations, the incidence of hereditary diseases, developmental defects in pregnancy and embryonic death increases. Children and fetuses are especially vulnerable to radiation, and the regeneration processes in their tissues stop or develop in the wrong direction. Low-level, prolonged radiation can lead to chronic radiation sickness, in which organs and systems gradually lose their function, and disorders occur in the cardiovascular, nervous and endocrine systems. These negative consequences can be prevented or reduced by determining the radiation dose, individual risk assessment and medical monitoring. In order to reduce or completely prevent the dangerous effects of radioactive radiation on a living organism, it is necessary to take protective measures based on the achievements of modern science and technology. There are three main principles of radiation protection: distance, time and barrier. First, it is recommended to stay as far away from the radiation source as possible, since the intensity of ionizing radiation decreases inversely proportional to the square of the distance. Second, reducing the time of exposure to radiation reduces the radiation dose. Third, barrier or

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shielding technologies are used: alpha, beta and gamma rays are blocked by lead, concrete, water or special nuclear-resistant materials.

Modern personal protective equipment (PPE) is necessary for persons working directly with a radiation source, and includes the use of special masks, gloves, impervious clothing, shields, and dosimeters. Dosimetry is a system for determining the amount of radiation received by a person or the environment, through which the level of safety is constantly monitored. Also, radiation monitoring is constantly carried out at industrial enterprises, medical institutions, and nuclear power facilities, that is, the level of background radiation in the environment, workplace, and equipment is measured using special devices.

Great attention is also paid to preventive measures. For example, iodine preparations can be administered to the population living in areas with a radiation hazard to reduce the absorption of radioactive substances by the thyroid gland. In emergency situations resulting from radiation accidents or nuclear weapons explosions, measures such as rapid evacuation, decontamination (cleaning of irradiated clothing and skin), drinking plenty of fluids, and taking drugs that stimulate the immune system are taken.

International approaches have also been developed. In particular, radiation safety laws and regulations have been introduced in each country based on the standards developed by the International Atomic Energy Agency (IAEA), the World Health Organization (WHO), and the International Commission on Radiological Protection (ICRP). These laws strictly control the handling of nuclear waste, the use of radiation methods in medicine, and the management of radiation sources in industry.

The formation of a radiation safety culture, raising public awareness, ensuring technological safety, and developing new protective equipment through scientific research are important in further reducing radiation risks in the future. Strict application of precautions is especially required for children, pregnant women, and the elderly.

Conclusion

The effect of radioactive radiation on living tissues remains one of the most pressing problems in modern biomedicine, ecology and technology. This radiation is mainly ionizing and causes serious changes in the structure and function of cells and tissues. In particular, radiation damage to DNA molecules in the cell nucleus, genetic mutations, disruption of cell division and increased oxidative stress processes lead to the development of various diseases in the human body, in particular cancer, blood diseases, immunodeficiency and reproductive problems.

Studies show that the effect of radiation on health has short-term and long-term consequences, which directly depend on the age, physiological state, genetic reserve and radiation dose of the organism. Rapidly dividing cells - for example, bone marrow, intestinal epithelium, germ cells and embryonic tissues - are particularly sensitive to radiation. Therefore, children, pregnant women and patients should be protected from radiation to the maximum extent possible.

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Scientific approaches within the framework of this topic show that technological means (lead barriers, special clothing, dosimetry devices), safety protocols, international standards and constant monitoring play an important role in protecting against radiation sources. Radiation safety is of practical importance not only in the industrial and medical sectors, but also in everyday life. Strict adherence to sanitary standards developed on the basis of international experience, control of radiation sources, and taking prompt measures in emergency situations are the main directions in preserving human health.

In the future, through in-depth scientific research in this area, new biotechnological solutions, and international cooperation aimed at increasing environmental safety, the possibility of reducing or even preventing the negative impact of radioactive radiation on living tissues will increase. At the same time, the possibility of safe and effective use of nuclear technologies, which are important for humanity, will also expand. This will be one of the important steps in the development of scientific and technical progress without harming human health.

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