Answers to Frequently Asked Questions (FAQs)

UNSCEAR, the United Nations Scientific Committee on the Effects of Atomic Radiation, is the international body with the responsibility to report on the exposure of people to radiation worldwide and to assess the scientific information on the effects of exposure to ionizing radiation. The following is intended to provide a very brief insight into radiation exposure and its effects, and to indicate more detailed sources of relevant information.

- What is radiation?
- How is radiation measured?
- How are people exposed to radiation?
- What levels of radiation exposure do people receive?
- What are the effects of exposure to radiation?

What is radiation?

Radiation is a form of energy transmitted through the air. There are many types of radiation that we come across frequently in everyday life, such as heat, light, radio-waves, microwaves and X-rays. Some radiation types, associated with nuclear and atomic processes, have the ability to penetrate material and in doing so cause a process called ionization to happen. These radiation types are known as ionizing radiation; they are the ones commonly referred to as just as "radiation" and are associated generally with nuclear and atomic facilities and activities. The source of such radiation is either from radiation generators (such as x-ray machines) or from radioactive material. Radioactive material occurs in nature, but can also be produced artificially - large amounts are produced by the operation of nuclear reactors. There are a number of different types of ionizing radiation having different powers of penetration and causing different rates of ionization in material. The most widely known types of radiation are X-rays, gamma rays, beta radiation, alpha radiation and neutron radiation. Different types of radioactive material emit these radiation types with differing intensities and differing energies. The radioactive material can be in many physical forms (it can be solid, liquid or gaseous) - and it can be in many different chemical forms.

The rate at which a radionuclide disintegrates (becoming less radioactive) is characterized by the concept of radioactive half-life-the time it takes for an amount of radioactive material to decay from its original radioactivity to one half of that amount ($T_{1/2}$). Depending on the radionuclide this can vary from fractions of a second to millions of years.

How is radiation measured?

Because radiation can penetrate materials and cause ionization within material, it is very easy to measure, even at very low levels. Radioactive material in some sort of medium (such as air, water, soil, grass, foodstuffs, tissues and so on) can also be collected and the quantity of radioactivity measured and expressed as a concentration (e.g. radioactive dust can be collected on an air filter for which the total air flow that passed through is known; the amount of radioactive material on the filter is measured; and hence the concentration of radioactive material in the air where the sample was taken can be calculated.

How are people exposed to radiation?

There are basically two ways that people can be exposed to radiation: they can be exposed externally to a close source of radiation or they can be exposed internally by radioactive material that has entered the body.

For external exposure, the intensity of radiation falls with distance from the radiation source, just as the brightness of light falls with distance from a light bulb. The total amount of external exposure will also depend on the length of time the person remains close to the source.

Radioactive material can be taken into the body by consuming foodstuffs and liquids with radioactivity in them, by inhaling radioactive gases or aerosol particles, or by absorption through wounds in the skin. The material taken in will internally expose the organs and tissues for as long as it remains inside the body. The time the radioactive material remains in the body will depend on the way it was taken in and the physical and chemical form of the material. Radioactive gas will have a short residence time, while inhaled aerosols will take longer to clear the lungs. Ingested material will reside for some time within the gastrointestinal tract but then radioactive elements will be taken into the body and metabolized in the same way as non-radioactive forms of the same chemical element.

What levels of radiation exposure do people receive?

Radiation is a natural phenomenon. The earth itself is composed of minerals that contain the naturally occurring radioactive elements uranium and thorium. This presence creates a field of radiation, which varies from place to place depending on the local geology. Cosmic radiation from the sun and from outer space also continually penetrates the earth's atmosphere adding to this field that represents a source of external exposure. The inert radioactive gas, radon, is created by the uranium and thorium in the soil; it percolates through the soil, and concentrates in the indoor air of buildings. Inhalation of radon gas leads to internal exposure to radiation, which varies significantly from place to place depending on the nature of the buildings and local geology. In addition, small amounts of other naturally occurring radioactive materials are present in foodstuffs and water and contribute to internal exposure. The external and internal exposure together deliver a small dose of radiation to everyone on the planet, known as background radiation. In addition to radiation dose received from natural sources of background radiation, a number of human activities enhance exposure, e.g. flying at altitude (greater levels of cosmic radiation), medical uses of radiation, the generation of nuclear energy, and other industrial uses of radiation or radioactive material.

A measure of the total radiation dose received is expressed in the unit sievert (Sv) or fractions according to the metric system: a millisievert (mSv) is one-thousandth of a sievert; a microsievert (µSv) is one-millionth of a sievert. The rate of accumulation is expressed as dose rate or dose accumulated per unit time e.g. in units of microsieverts per hour (µSv/h). A direct measurement can be made of radiation dose rates from sources external to the body in microsieverts per hour. The dose received by a person is the given by the dose rate multiplied by the time of exposure.

The intake of radioactive material into the body is expressed in terms of becquerels. One becquerel (Bq) represents one disintegration of a radioactive atom per second. The radiation dose arising from the intake is also expressed in sieverts, and is assessed using the concentration of radioactivity in food, water or air (Bq/kg or Bq/L or Bq/m ^{3}), the intake rate, the metabolism of the particular radionuclide and its half-life.

Radiation doses to people from human activities can arise during normal planned operations or can arise from accidents. People working with radioactive materials or in facilities where radiation is present can receive doses from handling and processing radioactive materials or from the presence of radioactive materials within the workplace. Members of the public can receive doses from effluent discharges with some levels of radioactivity, from materials released from nuclear facilities, from the transport of radioactive material to and from the facilities, and from the management of radioactive waste. Such doses can be as a result of direct external exposure to the radiation associated with the radioactive material, or from internal exposure due to intakes of radionuclides in air, foodstuff and water. Radiation doses to people can also arise from accidents in which control is lost over a radiation source within a facility or in which radioactive material is released to the environment. Such releases can be airborne or through water pathways. Airborne releases can be gaseous, particulate or volatile material. Accidental releases generally take place over short periods lasting hours to days, they take place often without warning or after some time into the evolution of an accident.

The annual doses in millisieverts (mSv) due to natural sources of radiation are summarized below:

Source or mode	**Annual average dose (mSv)**	**Typical range of annual dose (mSv)**	**Comments**
Inhalation (radon gas)	1.26	0.2-10	Dose is much higher in some homes.
External terrestrial	0.48	0.3-1	Dose is higher in some places.
Ingestion	0.29	0.2-1	

Cosmic radiation	0.39	0.3-1	Dose increases with altitude.
Total natural	**2.4**	**1-13**	**Sizeable population groups receive 10-20 mSv annually.**

The doses received by persons from artificial sources of radiation are summarized below:

Source or mode	
10 hour aeroplane flight	
Chest x-ray	
CT scan	
Annual dose from natural background	
Annual dose to nuclear worker	
Annual cosmic radiation at sea level	
Annual cosmic radiation Mexico City (2 300m)	
Chernobyl recovery workers in 1986	

Typical dose rates experienced:

Source or mode	
External dose rate from natural background	

Source or mode	
Dose rate from natural background (total)	
During an aeroplane flight	
During a 10 second chest X-ray	
During a 20 second CT scan	

What are the effects of exposure to radiation?

When radiation passes through material, it causes ionization which can damage chemical structures. If the material in question is biological material (such as the cells that make up human organs and tissues) and if the damage occurs to critical chemicals within the cells (such as the DNA molecules making up the chromosomes within the cell nucleus), the cell itself can be damaged. It should be noted that the cell and the DNA are undergoing physical and chemical damage all the time (e.g. from temperature fluctuations and oxidation processes). However the cell and DNA have mechanisms to repair damage. The radiation damage will usually be repaired by these normal cell repair processes; or the cell may be sacrificed. This is of not significance if the repair is successful or if the number of cells killed is not large. However it is possible also that the DNA may be misrepaired; in the majority of cases, such mutated cells will also die. However there is a small possibility that the cell survives and the mutation in the DNA is replicated as the cell divides. This can be the start of a multi-step process that could eventually lead to formation of a cancer.

These various possible effects at the molecular, cellular and tissue level influence the overall outcome of a person exposed to radiation. The severity of any immediate effect will depend on the total amount of exposure to radiation within a given period of time-termed the radiation dose. If a person is exposed to very high levels of radiation for a significant period of time and the accumulated dose is high, a large number of cells can be killed. This represents serious injury to the exposed person (e.g. skin burns, hair loss, sterility, damage to the blood-producing systems and the immune system). Depending on the dose, the exposed person can recover from the injuries, particularly if good medical treatment is made available quickly. But at very high doses, recovery is not possible, leading to death over days or weeks.

At lower doses of radiation, below the levels associated with early onset of injury and death due to cell-killing, an exposed population may show an increased incidence of certain types of cancer, years to decades later, compared with populations that were not exposed. In this respect ionizing radiation is a carcinogen similar to cigarette smoke and the incidence of cancer in a population increases with the radiation dose received. In scientific studies on animals, hereditary effects have been observed, but this has never been observed in human populations, though we can assume that it probably does occur in humans to a small degree.

Indicative dose range (mSv)	Effects on human health (including unborn child)
Up to 10	No direct evidence of human health effects
10 - 1 000	No early effects; increased incidence of certain cancers in exposed populations at higher doses
1 000 - 10 000	Radiation sickness (risk of death); increased incidence of certain cancers in exposed populations
Above 10 000	Fatal always

Animals and plants are also affected by exposure to radiation, the damage mechanisms being essentially the same as for humans. At higher doses morbidity and death can occur, and at lower doses the same carcinogenic effects occur.

Approximate lethal doses of radiation for plants and animals are summarized below:

Indicative dose range (Sv)	Mortality
1 - 10	Mammals and birds
10 - 100	Crustaceans, reptiles amphibians, fish, higher plants
100 - 1 000	Molluscs
1 000 - 10 000	Protozoa, bacteria, moss, lichen, algae, Insects

Information on the uses and applications of radiation and radioactive material, nuclear energy, international safety standards and international conventions related to nuclear and radiation safety can be found on the website of the International Atomic Energy Agency (IAEA).

Information on the public health aspects associated with radiation and radioactive materials can be found on the website of the World Health Organization (WHO).

The material on this page has been prepared by the UNSCEAR secretariat based on the published UNSCEAR reports.

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