Ionising Radiation

Here we are concerned mainly with ionising radiation from the atomic nucleus. It occurs in two forms, rays and particles, at the high frequency end of the energy spectrum.

Ionising radiation produces electrically-charged particles called ions in the materials it strikes. This process is called ionisation. In the large chemical molecules of which all living things are made the changes caused may be biologically important. There are several types of ionising radiation:

ALPHA PARTICLES consist of two protons and two neutrons, in the form of atomic nuclei. They thus have a positive electrical charge and are emitted from naturally occurring heavy elements such as uranium and radium, as well as from some man-made elements. Because of their relatively large size, alpha particles collide readily with matter and lose their energy quickly. They therefore have little penetrating power and can be stopped by the first layer of skin or a sheet of paper.

However, if alpha sources are taken into the body, for example by breathing or swallowing radioactive dust, alpha particles can affect the body's cells. Because they give up their energy over a relatively short distance, alpha particles inside the body can inflict more severe biological damage than other types of radiation.

Uranium 238 (U238) Radioactive Decay

type of radiation	nuclide	half-life
	uranium-238	4.47 billion years
α		
	thorium-234	24.1 days
β		
	protactinium -234m	1.17 minutes
β		
	uranium-234	245000 years
α		
	thorium-230	8000 years
α		
	radium-226	1600 years
α		
	radon-222	3.823 days
α		
	polonium-218	3.05 minutes
α		
	lead-214	26.8 minutes
β		
	bismuth-214	19.7 minutes
β		
	polonium-214	0.000164 seconds
α		
	lead-210	22.3 years
β		
	bismuth-210	5.01 days
β		
	polonium-210	138.4 days
α		
	lead-206	stable

MEASURING IONISING RADIATION - GRAYS AND SIEVERTS

The human senses cannot detect radiation or discern whether a material is radioactive. However, a variety of instruments can detect and measure radiation reliably and accurately. The amount of ionising radiation, or 'dose', received by a person is measured in terms of the energy absorbed in the body tissue, and is expressed in **gray**. One gray (Gy) is one joule deposited per kilogram of mass.

Equal exposure to different types of radiation expressed as gray do not however necessarily produce equal biological effects. One gray of alpha radiation, for example, will have a greater effect than one gray of beta radiation. When we talk about radiation effects, we therefore express the radiation as effective dose, in a unit called the **sievert (Sv)**.

Regardless of the type of radiation, one sievert (Sv) of radiation produces the same biological effect.

Smaller quantities are expressed in 'millisievert' (one thousandth) or 'microsievert' (one millionth) of a sievert. We will use the most common unit, millisievert (mSv), here.

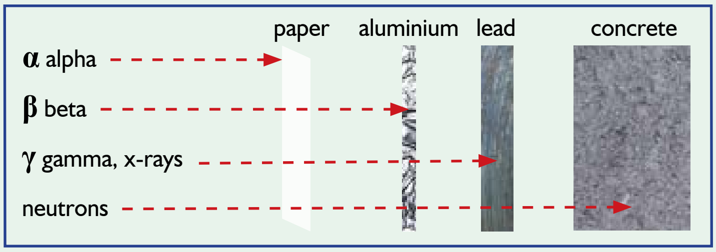
BETA PARTICLES are fast-moving electrons ejected from the nuclei of many kinds of atoms. These particles are much smaller than alpha particles and can penetrate up to 1 to 2 centimetres of water or human flesh. They can be stopped by a sheet of aluminium a few millimetres thick.

GAMMA RAYS, AND X-RAYS like light, represent energy transmitted in a wave without the movement of material, just as heat and light from a fire or the sun travels through space. X-rays and gamma rays are virtually identical except that X-rays are generally produced artificially rather than coming from the atomic nucleus. But unlike light, these rays have great penetrating power and can pass through the human body. Mass in the form of concrete, lead or water are used to shield us from them.

COSMIC RADIATION consists of very energetic particles, mostly protons, which bombard the earth from outer space. It is more intense at higher altitudes than at sea level where the earth's atmosphere is most dense and gives the greatest protection.

NEUTRONS are particles which are also very penetrating. On Earth they mostly come from the splitting, or fissioning, of certain atoms inside a nuclear reactor. Water and concrete are the most commonly used shields against neutron radiation from the core of the nuclear reactor.

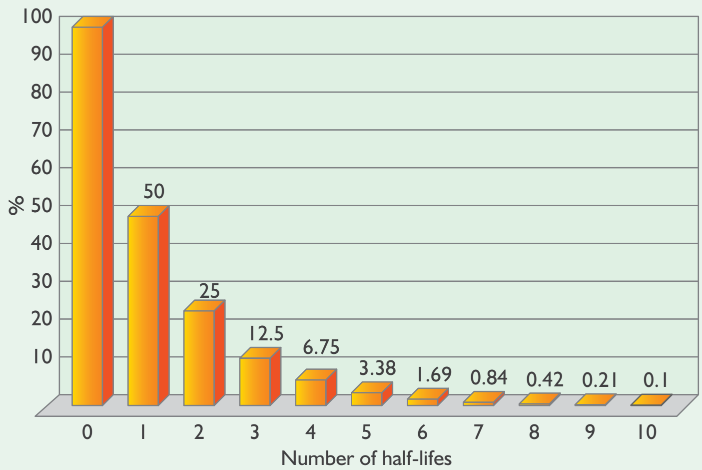
It is important to understand that alpha, beta, gamma and X-radiation does not cause the body or any other material to become radioactive. However, most materials in their natural state (including body tissue) contain measurable amounts of radioactivity.



HALF-LIFE

Atoms in a radioactive substance decay in a random fashion but at a characteristic rate. The length of time this takes, the number of steps required and the kinds of radiation released at each step are well known.

The half-life is the time taken for half of the atoms of a radioactive substance to decay. Half-lives can range from less than a millionth of a second to millions of years depending on the element concerned. After one half-life the level of radioactivity of a substance is halved, after two half-lives it is reduced to one quarter, after three half-lives to one-eighth and so on.



All uranium atoms are mildly radioactive and decay through a number of steps on the way to becoming stable lead. Each step has a half-life, and a characteristic type of radiation. The shorter-lived each kind of radioisotope in the decay series, the more radiation it emits per unit mass. Much of the natural radioactivity in rocks and soil comes from the decay of uranium-238 (U-238) and its daughter products .