

Basic scientific information and facts about radiation

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1. Types of radiation

➤ **What is radiation?**

Radiation are waves or particles travelling through space which can transmit all or part of their energy on contact to matter.

➤ **What types of radiation do exist?**

The most important type of radiation are *electromagnetic waves*. Equivalently they can also be described as particles which are called *photons*. All electromagnetic waves or photons can be characterised in groups according to their wave lengths or equivalently energy and can be depicted what we call the *electromagnetic spectrum* (see Fig. 1). According to their energy electromagnetic waves can be classified from short to long wave lengths high low energies: gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves and radio waves.

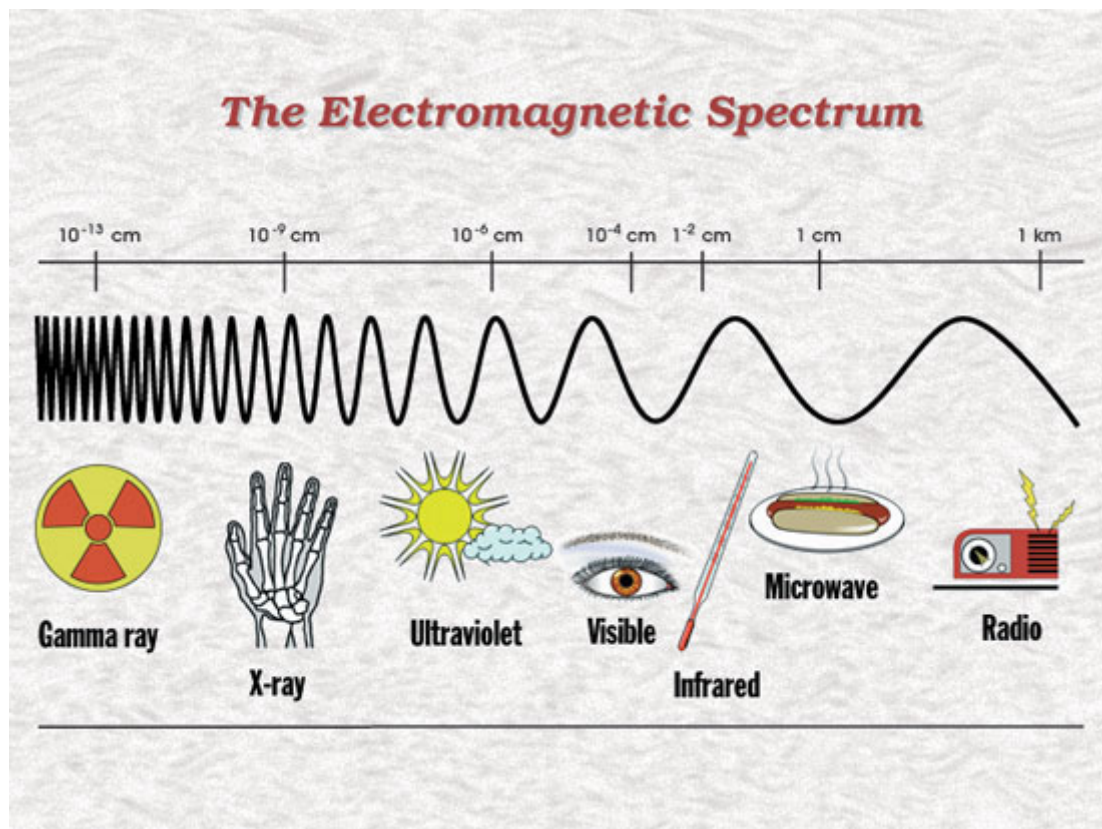


Fig.1: The electromagnetic spectrum [Source: NASA]

2. Radioactivity

- **Ionising and non-ionising radiation:** Ionising radiation like **gamma rays or X-rays** has such a high energy that it alters an atom or a molecule permanently. For instance, electrons can be kicked out from the atom molecule through ionising radiation. Ionising radiation is much more effective and dangerous for living beings than non-ionising radiation like **ultraviolet, visible light, infrared, microwaves and radio waves**, because non-ionising radiation can alter atoms or molecules only for a very short time. An analogue that radiation with high energy is much more dangerous than radiation with low energy is that either a stone or sand having both 1 kg fall on your head from a building. Of course, the stone is much more dangerous than the sand.
- **Radioactive rays** is radiation of **very high energy** and is therefore an ionising radiation. There exist three kinds of radioactive rays:

- **Alpha rays** are emitted from naturally occurring heavy elements such as uranium and radium, as well as from some man-made elements. They have little penetrating power and can be stopped by the first layer of skin or a sheet of paper (see Fig. 2). 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. Inside the body, because they give up their energy over a relatively short distance, alpha particles can inflict more severe biological damage than other radiations.

- **Beta rays** are much smaller than alpha particles and can penetrate up to several millimetres of aluminium or one to two centimetres of water or human flesh (see Fig. 2). Beta particles are emitted from many radioactive elements. They can be stopped by a sheet of aluminium a few millimetres thick.

- **Gamma rays** is electromagnetic radiation like light. Unlike light, gamma rays have great penetrating power and can pass through the human body. Thick barriers of concrete, lead or water are used as protection from them (see Fig. 2).

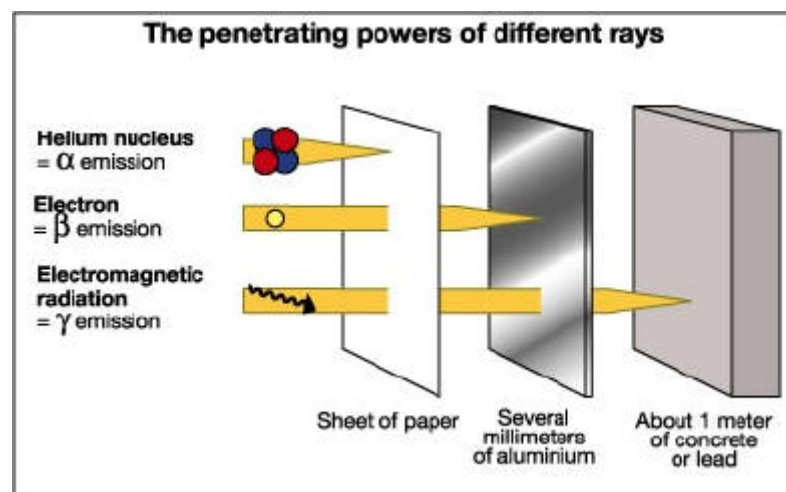


Fig. 2: Penetrating powers of radioactive rays [Source: Comega]

3. Radiation sources

- **Natural radiation:** Radiation has always existed in nature and comes from the sky (sun, cosmic radiation), from the ground (terrestrial radiation), from the air (mainly radon), and also from our own bodies (internal radiation).
- **Man-made radiation:** Following main types of man-made radiation sources exist: Light sources, radio, TV, power supply lines, cellular phone network, nuclear medicine, nuclear power plants, commercial products like tobacco, fertilizer, luminous watch dials, and industrial activities.
- **Radioactive sources:** Radioactive sources emit high-energy ionising radiation. Human beings are exposed to natural sources as well as man-made sources (see Fig. 3). The soil we walk on, the food we eat, the water we drink, and the air we breathe are naturally radioactive and about 80% of the radiation comes from such natural sources. The main component is radon, a gas contained in the air, which comes from substances like rocks containing uranium. Man-made radioactive sources contribute only 18% to the total amount of radiation, most of the man-made sources belonging to the medical sector.

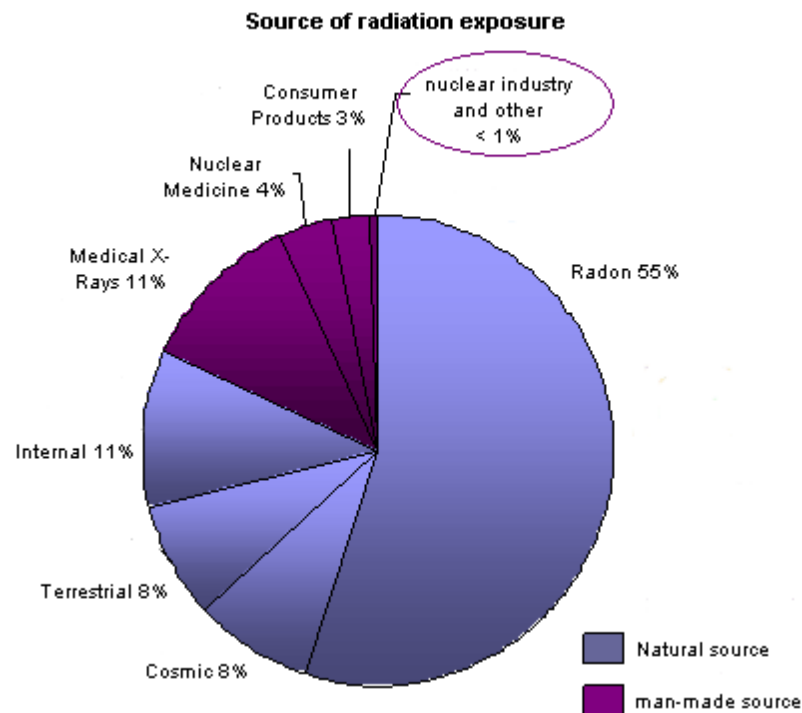


Fig. 3: Sources of radioactive exposure [Source: Comega]

- **Units of radioactivity:** The amount of radioactivity can be measured. There are three international units for such a measure. Each of them measures something a different quantity:
 - Radioactivity itself is measured in **becquerel (Bq)**, a unit that measures the number of decays per second of a radioactive source.
 - The amount of radiation absorbed by an exposed organism or object is measured in **gray (Gy)**, a unit that measures the energy deposited by the radiation in a kilogram of matter.
 - The biological effects of radiation on an exposed living organism are calculated in **sievert (Sv)**.

4. Radiation exposure from radioactive sources

- The **average annual radiation exposure** from natural sources to an individual is on the world average about 2,4 millisieverts (mSv) (1 mSv = 1 milliSievert = 1/1000 Sv). No adverse health effects have been discerned from doses arising from these levels of natural radiation exposure.
- In addition, **man-made sources** of radiation contribute to another 0.6 mSv to our annual radiation exposure, one of the largest sources of exposure being medical X-rays.
- Radioactive radiation exposure, from **natural cosmic sources**, increases with altitude. The amount of natural radiation in 2500 m is about twice as high as at sea level. Also it depends very much on the place you live: it can range from 0,2 mSv up to 10 mSV.

Source	Average amount Per Year
Inside the body (air-radon)	1.2 mSv
Earth's crust	0.9 mSv
Outer space (2500 meters)	0.53 mSv
Inside the body (food and water)	0.3 mSv
Outer space (sea level)	0.26 mSv
Medical X-Ray	0.4 mSv
Living in stone, brick or concrete building	0.07 mSv
Watching television	0.01 - 0.02 mSv
Airline flights (per 1.000 km flown)	0.01 mSv
Computer terminal	0.001 mSv
Luminous Wrist Watch	0.0006 mSv

5. Radiation exposure from the Sun

- The Sun is responsible for the development and continued existence of life on Earth. We are warmed by the Sun's infrared rays and we can see with eyes which respond to the visible part of the Sun's terrestrial spectrum. More importantly, visible light is an essential component of photosynthesis, the process whereby plants, which are necessary for man's nutrition, derive their energy. However, the deleterious effects of sunlight on biological systems are due almost entirely to radiation within the ultraviolet (UV) spectrum of the Sun's emission.
- The observable biological effects in man due to exposure from solar UV-radiation are limited to the skin and to the eyes because of its low penetrating properties in human tissues. The penetration into skin is less than 1 mm and it is absorbed by ocular tissues (mainly the cornea and the lens) before it reaches the retina.

6. Radiation from mobile telephone systems

- The **electromagnetic radiation** used in the mobile telephone system has frequencies in the range of **radio waves** (see Fig. 1). The radiation coming from radio and television transmitters are about a factor 2 - 100 larger than from mobile phone transmitters. The distance to the respective transmitters play a primary role in the biological effectiveness of the radiation.
- The **biological effectiveness** of electromagnetic radiation in the radio and microwave range is are twofold: **thermal and athermal effects**. Thermal effects lead to an increasing temperature in human bodies. Athermal effects would be all other biological effects, like for instance the increase of cancerogenesis (creation of cancer).
- The **maximum permissible value** for electromagnetic radiation in the radio and microwave range is defined that for the general population the temperature rise should be

not more than 0.02°C . This corresponds to an absorption of radiation of 0.08 Watt/kg or 1 SAR (**SAR = Specific absorption rate**).

Conversion: Temperature rise in degrees Celsius = SAR-value/4.

- No harmful athermal effects like the creation of brain cancer have been found yet in many long-term scientific investigations like from the World Health Organisation (WHO).