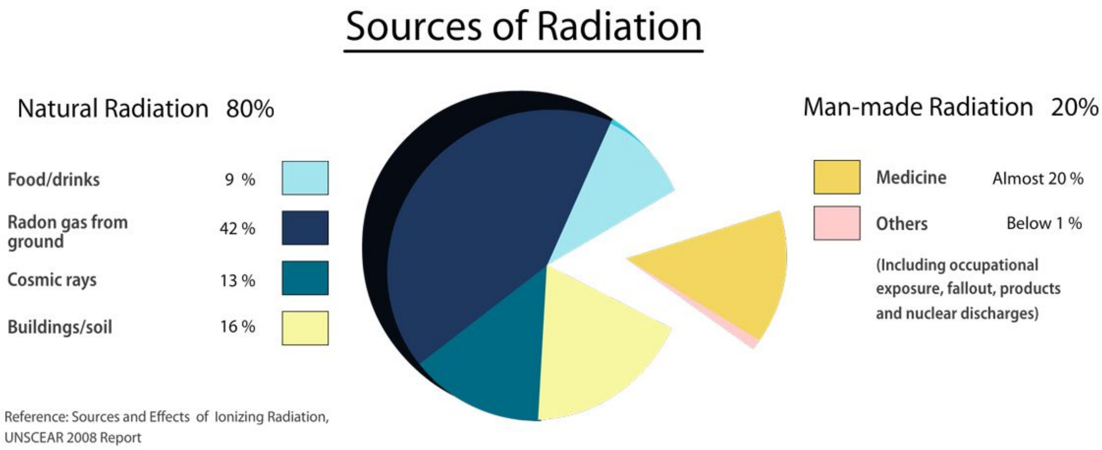
How Dangerous is Nuclear Radiation?

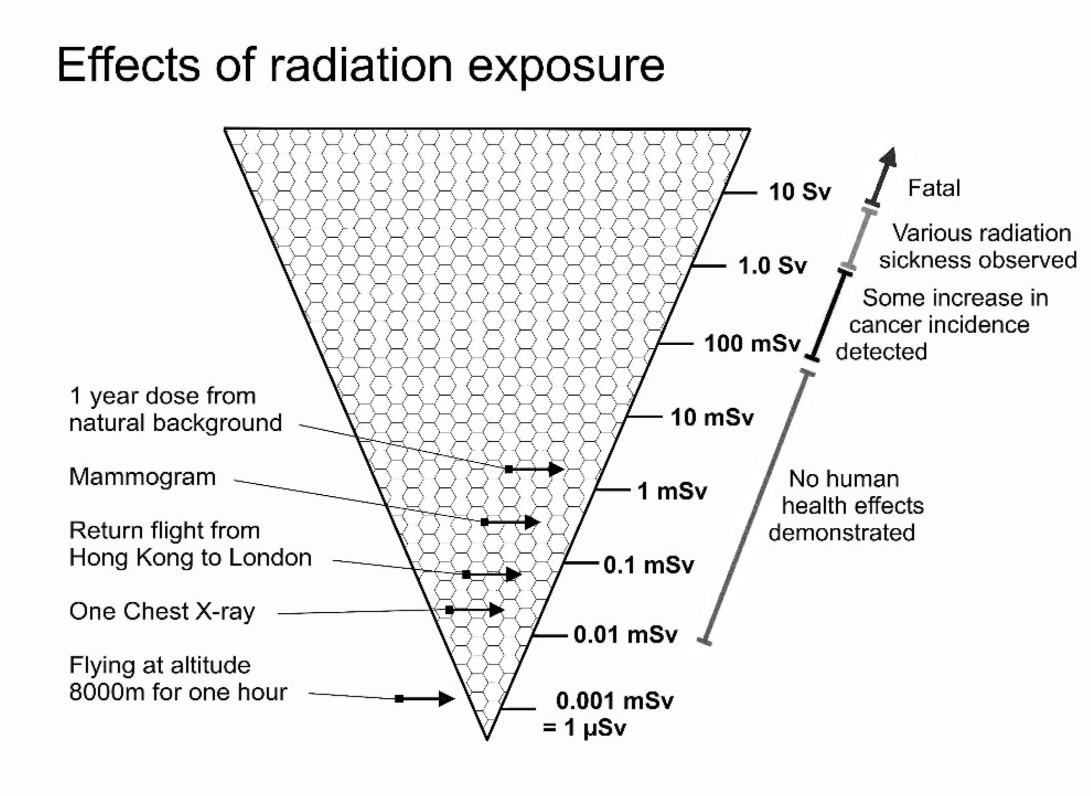
The explosion of an atomic bomb or a nuclear reactor releases high-energy radiation. This comes from nuclides, i.e. atoms, which emit energy in the form of high-energy radiation when they decay. Nuclides and high-energy radiation are also used in medicine for diagnosis and therapy. Moreover, it is often forgotten that the human body is permanently exposed to natural sources such as radon and cosmic radiation.



When high-energy radiation hits our bodies, it breaks down molecules and the genetic material DNA. The more energy arrives, the more breaks are created in the DNA-strand. In the case of acute radiation damage, the defects are so severe that they cannot be repaired. Thus, the affected cells can no longer produce vital protein molecules or divide. Many cells die within a short time. Affected organs are no longer functional.

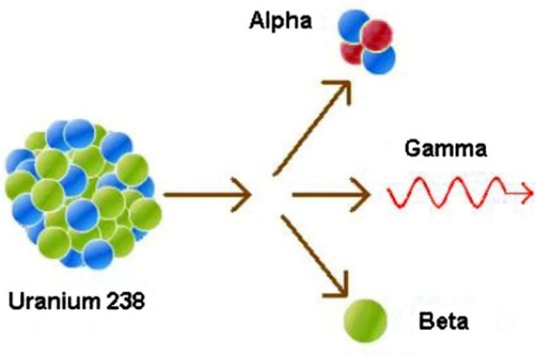
The **radiation dose** that a person has received is decisive for the extent of the damage. In radiation medicine, the unit of total absorbed dose is the Gray. One Gray (Gy) is equal to one Sievert (Sv). If the human body was exposed to less than one Gray, disorders of the hematopoietic system may occur. If a person was exposed to three Gray, he or she will have burn-like injuries to the skin and mucous membranes. Above a dose of five Gray, damage to the gastrointestinal tract also occurs. Higher doses cause damage to the brain and spinal cord. If a person has received more than twenty Gray, the chance of survival is minimal.

Even small doses of energy can lead to a few DNA damages. These do not immediately render a cell non-functional. But if the damage is not repaired completely or not completely correctly, then the affected cells can degenerate into tumor cells years later. However, many factors play a role in the development of a cancerous tumor, such as diet, lifestyle or even the genetically determined efficiency of the body's own repair systems.



What is Radioactivity?

Nuclides, i.e. atoms, emit energy in the form of high-energy radiation when they decay. There are three types of emissions: alpha, beta, and gamma rays. Alpha particles are positively charged, beta ones are negative, and gamma rays are neutral.



These types can be condensed in two general types:

- Electromagnetic radiations (gamma radiation and X-rays)
- Particulate (beta and alpha radiation).

Measuring Radioactivity

The amount of radioactivity is measured by finding out how many radioactive atoms decay every second. These atoms may be giving off alpha particles, beta particles, and/or gamma rays.

Geiger counters are commonly used to measure the amount of radioactivity. But there are other types of detectors that may be used such as the solid-state sensor BG51 from Teviso. This type of sensor is robust and compact.

Teviso Sensor BG51 detecting alpha and beta

When a decay product of a radioactive atom (alpha or beta particle or gamma ray) hits the detector, it generates a pulse. In the measurement device, these pulses are made audible as a "click", indicating the **dose rate** level. A counter registers the sum of all pulses within a time period, indicating the **effective dose**.

Dose rate levels measure how much radiation is in the environment. Dose rate levels are reported in Gray per hour (Gy/h) or Sievert per hour (Sv/h), which are the international units.

Effective dose is the amount of radiation absorbed by the body. Radiation doses are reported in Gray (Gy) or Sievert (Sv), which are international units.
1 Gray (Gy) = 1 Sievert (Sv).

Alarming dosimeters can be used by first responders and safety officers to monitor dose rate in real time. There are also specialized instruments used by hospitals and laboratories that can measure effective dose.

BG51 Sensor Number of Pulse Counts	**Dose Rate**	Duration of Exposure	**Effective Dose**	Equivalent Effect
1 per minute >	0,2 µSv/h >	1 year >	1.8 mSv	Natural background radiation
1 per second >	12 µSv/h >	1 hour >	12 µSv	One chest X-ray
10 per second >	120 µSv/h >	1 hour >	120 µSv	10 hours flight at 8000m
100 per second >	1,2 mSv/h >	4 days >	115 mSv	Increased risk of cancer
100 per second >	1,2 mSv/h >	1 year >	10.5 Sv	Fatal

Teviso Sensor BG51 dose rate vs effective dose

How to Protect Yourself from Nuclear Radiation

First >> Increase distance

2 m distance, compared to 1 m >> Reduction of dose rate by a factor of 4.
4 m distance, compared to 1 m >> Reduction of dose rate by a factor of 16 (inverse-square law!).

Second >> Reduce time of exposure

Half time of exposure >> half effective dose

Third >> Provide adequate shielding

Example: Concrete, 20 cm thick >> 85% reduction of gamma dose rate

Efficiency of Shielding

Each type of emission has different penetrating power in the matter and different ionization energy. They can cause damage to life in different ways.

Though the most massive and most energetic of radioactive emissions, the alpha particle is the shortest in range because of its strong interaction with matter. The electromagnetic gamma ray is extremely penetrating, even penetrating considerable thicknesses of concrete. The electron of beta radioactivity strongly interacts with matter and has a short range.