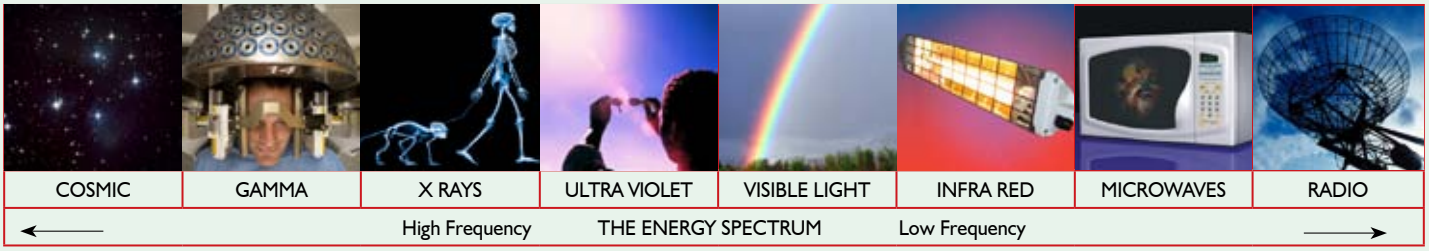
Radiation & Radioactivity

World Nuclear Association

"Life on earth has developed with an ever present background of radiation. It is not something new, invented by the wit of man: radiation has always been there."

Eric J Hall, Professor of Radiology, College of Physicians and Surgeons, Columbia University, New York, in his book Radiation and Life.



Radiation is energy travelling through space. Sunshine is one of the most familiar forms of radiation. It delivers light, heat and suntans. We control our exposure to it with sunglasses, shade, hats, clothes and sunscreen.

There would be no life on Earth without lots of sunlight, but we have increasingly recognised that too much of it on our persons is not a good thing. Sunshine consists of radiation in a range of wavelengths from long-wave infra-red to short-wavelength ultraviolet, which creates the hazard. Beyond ultraviolet are higher energy kinds of radiation which are used in medicine and which we all get in low doses from space, from the air, and from the earth. Collectively we can refer to these kinds of radiation as **ionising radiation**. It can cause damage to matter, particularly living tissue. At high levels it is therefore dangerous, so it is necessary to control our exposure.

Living things have evolved in an environment which has significant levels of ionising radiation. Furthermore, many of us owe our lives and health to such radiation produced artificially. Medical and dental X-rays discern hidden problems. Other kinds of ionising radiation are used to diagnose ailments, and some people are treated with radiation to cure disease. We all benefit from a multitude of products and services made possible by the careful use of such radiation.

Background radiation is ionising radiation which is naturally and inevitably present in our environment. Levels of this can vary greatly. People living in granite areas or on mineralised sands receive more terrestrial radiation than others, while people living or working at high altitudes receive more cosmic radiation. A lot of our natural exposure is due to radon, a gas which seeps from the Earth's crust and is present in the air we breathe.

UNSTABLE ATOMS

Ionising radiation comes from atoms, the basic building blocks of matter. Each element exists in the form of atoms with several different sized nuclei, called isotopes.

Most atoms are stable; a carbon-12 atom for example remains a carbon-12 atom forever, and an oxygen-16 atom remains an oxygen-16 atom forever. But certain atoms change or disintegrate into totally new atoms. These kinds of atoms are said to be 'unstable' or 'radioactive'. An unstable atom has excess internal energy, with the result that the nucleus can undergo a spontaneous change towards a more stable form. This is called 'radioactive decay'.

Unstable isotopes (which are thus radioactive) are called radioisotopes. Some elements, eg uranium, have no stable isotopes.

ATOMIC DECAY

When an atom of a radioisotope decays, it gives off some of its excess energy as radiation in the form of gamma rays or fast-moving sub-atomic particles. If it decays with emission of an alpha or beta particle, it becomes a new element. One can describe the emissions as gamma, beta and alpha radiation. All the time, the atom is progressing in one or more steps towards a stable state where it is no longer radioactive.

Another source of nuclear radioactivity is when one form of a radioisotope changes into another form, or isomer, releasing a gamma ray in the process. The excited form is signified with an "m" (meta) beside its atomic number, eg technetium-99m (Tc-99m) decays to Tc-99. Gamma rays are often emitted with alpha or beta radiation also, as the nucleus decays to a less excited state.

Apart from the normal measures of mass and volume, the amount of radioactive material is given in becquerel (Bq), a measure which enables us to compare the typical radioactivity of some natural and other materials. A becquerel is one atomic decay per second[1].

MEASURING RADIOACTIVITY

The becquerel (symbol Bq) is the unit of radioactivity. One Bq is defined as the activity of a quantity of radioactive material in which one nucleus decays per second. The becquerel is named for Henri Becquerel, who shared a Nobel Prize with Pierre and Marie Curie for their work in discovering radioactivity.

As there are many atoms in any substance the decay of one nucleus per second represents a very low level of radioactivity. For more radioactive substances or for much larger quantities multipliers are used. A thousand becquerels is a kilobecquerel (KBq) , a million becquerels is a megabecquerel (MBq), a million million Becquerels is a Terabecquerel (TBq).

Radioactivity of some natural and other materials

1 adult human (100 Bq/kg)	7000 Bq
1 kg of coffee	1000 Bq
1 kg superphosphate fertiliser	5000 Bq
The air in a 100 square metre Australian home (radon)	3000 Bq
1 household smoke detector (with americium)	30 000 Bq
Radioisotope for medical diagnosis	70 MBq
Radioisotope source for medical therapy	100 000 000 MBq
1 kg 50-year old vitrified high-level nuclear waste	10 000 000 MBq
1 luminous EXIT sign (1970s)	1 000 000 MBq
1 kg uranium	25 MBq
1 kg uranium ore (Canadian, 15%U)	25 MBq
1 kg uranium ore (Australian, 0.3%U)	500 000 Bq
1 kg low-level radioactive waste	1 MBq
1 kg of coal ash	2000 Bq
1 kg of granite	1000 Bq

NB. Though the intrinsic radioactivity of the actual uranium is the same, the radiation dose received by someone handling a kilogram of high-grade uranium ore will be much greater than for the same exposure to a kilogram of separated uranium, since the ore contains a number of short-lived decay products (see section on Radioactive Decay).

[1] A former unit of (radio)activity is the Curie – 1 Bq is 27 x 10^{-12} curies.