Lessons from Chernobyl

Radiation – can it damage your health?

We've known that some types of radiation can affect our health ever since Marie Curie noticed burns on her hands during her experiments on radioactive materials in the 1890s. In the years since, scientists have learnt a lot about how radiation can interfere with the way our bodies work and about radiation sickness and cancer. But there is still a lot of uncertainty about the risks. We're exposed to radiation all the time, so is any level of radiation safe?

When radiation passes through the cells of our body it can cause random chemical changes in the molecules that make up each cell. One of the most important molecules in the cell is DNA, which controls the behaviour and growth of the cell. If this is damaged or changed beyond repair, it could stop the cell from carrying out its normal functions or growing and dividing normally. It could even kill the cell completely.

Some cells are more sensitive to radiation than others. Fast-dividing cells in the bone marrow and sexual organs are particularly susceptible to radiation. Because unborn babies and young children are growing so rapidly they're also more vulnerable.

Radiation affects our health in different ways, depending on how badly our cells are damaged. Very large doses will kill many more cells causing skin burns, radiation sickness and even death. Smaller doses are more likely to damage cells than kill them, affecting how they work in the future. If you receive a very small dose you won't notice any immediate effects, but may develop cancer years later or possibly pass on genetic mutations to your children.

Radiation sickness
High doses of radiation can cause radiation sickness. Radiation sickness includes a range of different symptoms like nausea, dehydration, sterility, hair loss and loss of muscle control. Some or all of these symptoms will appear within days or weeks of being exposed, depending on the size of the dose. With larger doses the symptoms become more severe and longer lasting, and very large doses will kill you.

Cancer
Radiation can cause changes in the DNA of a cell. Many of these changes will be harmless, but occasionally they may kill the cell, or affect the way it grows and divides. If the latter happens it may increase the chances that the cell will develop into a cancer in the future. There is still some uncertainty about whether radiation triggers cells to become cancerous or whether it makes them more susceptible to other causes of cancer.

Many scientists believe that any dose of radiation, no matter how small, increases your chances of developing cancer and that the risks increase with larger doses. However, studies of the link between cancer and very low radiation doses have produced conflicting evidence and disagreement remains about the exact risks associated with low doses.

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Genetic mutations

If radiation damages the reproductive cells in a person's testes or ovaries, any changes or mutations that it causes in the DNA of the cells can be passed onto that person's children. Many changes will be completely harmless or may cause only small differences, like giving the child a different eye colour from its parents. But it's thought that some changes could be more serious and could lead to conditions like anaemia and Down's syndrome.

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What is radiation?
Radiation can consist of either flying particles or fast-moving rays. When an atom splits up, parts of it may fly off into the air. These flying particles may be one of three types.

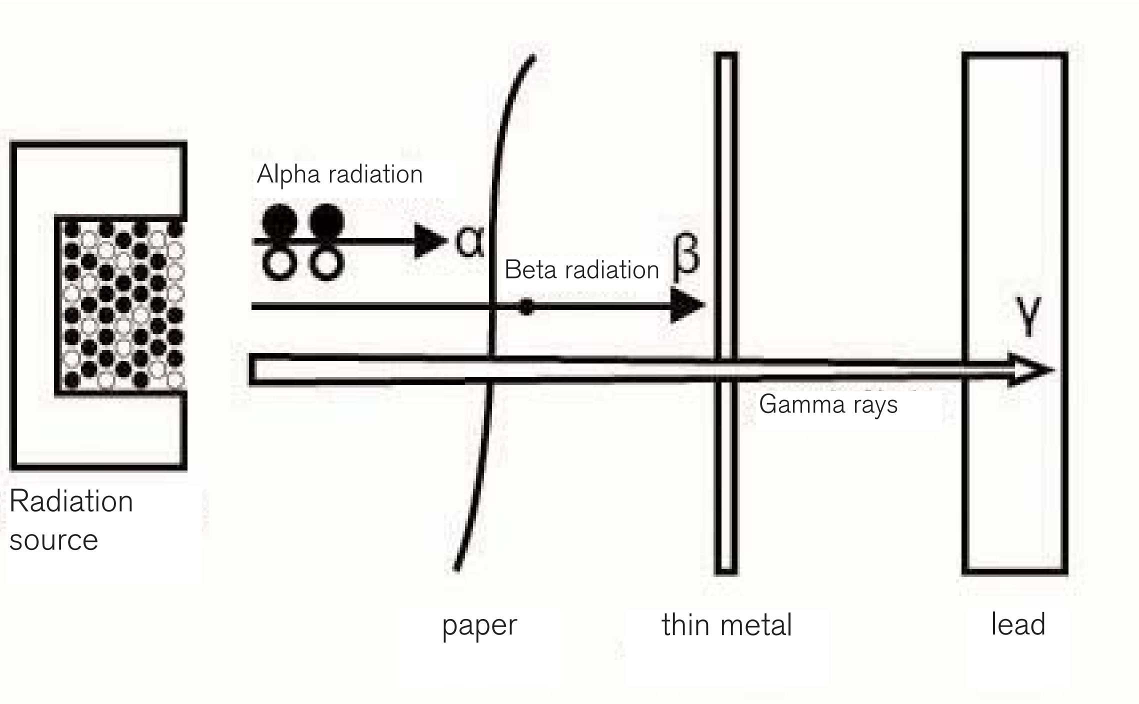

Figure 1 – Types of radiation

Neutrons: These travel very quickly but only usually occur inside nuclear reactors. They collide with nitrogen in the air and change it into carbon-14 (C-14). This is radioactive, though fairly weak.

Alpha radiation: Alpha (α) particles are quite slow-moving. They cannot penetrate human skin, or even paper, but if particles giving off alpha radiation are swallowed or inhaled they can be extremely dangerous.

Beta radiation: Beta (β) particles are high-speed electrons. Like alpha particles, they do not travel far in air.

Gamma rays: Gamma (γ) rays are very-high-frequency electromagnetic waves. They travel at the speed of light and penetrate metal. They can travel a few miles through the air. Only thick layers of soil, brick, lead or concrete can stop them (see Figure 1). Gamma rays easily enter the human body, and can destroy cells and tissues.

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For how long are radioactive materials dangerous?

Every radioactive substance has its own 'half-life'. No radioisotope ever completely stops being radioactive, so the time taken to lose half its radioactivity is measured. This is the half-life (Figure 2).

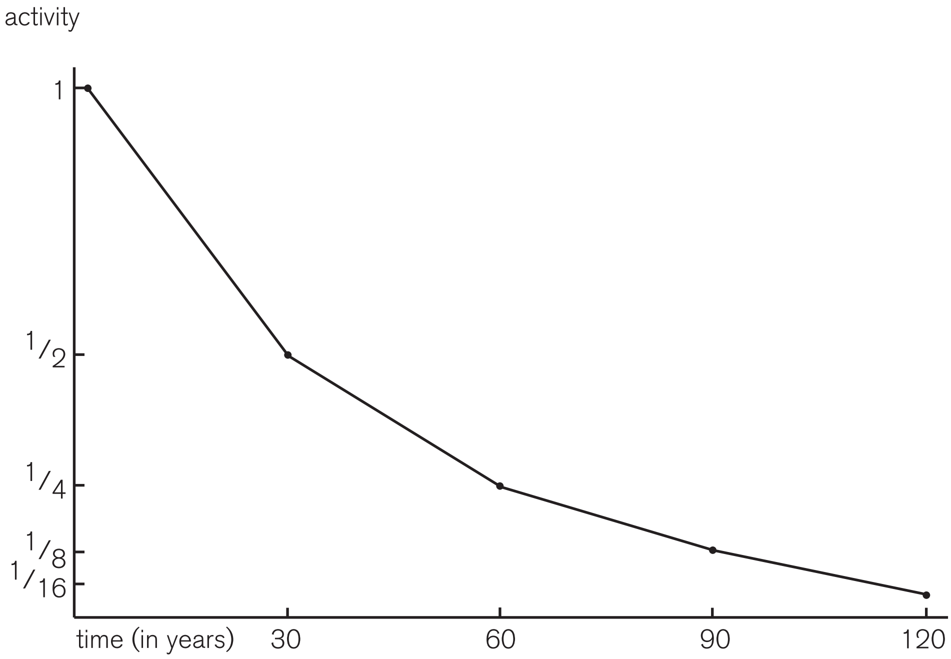

Figure 2 – The decay pattern of a radioactive substance (in this case Caesium-137)

Strontium-90 has a half-life of 28 years. After this time its radioactivity is reduced to half, i.e. it is only half as radioactive as it first was. After 56 years, its radioactivity is reduced to a quarter, and so on.

Caesium-137 has a half-life of 30 years. Its radioactivity drops to half in 30 years, to a quarter in 60 years, to an eighth in 90 years, and so on.

Iodine-131 in contrast, has a half-life of only eight days. This makes it only a short-term hazard. At the other extreme, carbon-14 has a half-life of 5670 years! Its radioactivity lasts for thousands of years. Luckily, it is not highly radioactive.

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How do we know about the effects of radiation?

Our understanding of the effects of radiation comes mainly from observing people who have been exposed to radiation. Over the years, scientists have studied many different groups of people to see how the radiation they have been exposed to may have affected their health – the victims of nuclear accidents and weapons, people who work with nuclear materials, patients who have been treated with radioactive materials, and many others.

Many of the groups of people that have been studied have been exposed to large, one-off doses of radiation; for example, the people exposed after the Chernobyl nuclear accident in 1986 and the victims of the Hiroshima and Nagasaki bombings during the Second World War. The latter are by far the largest group to have been studied – around 100,000 people have been followed in the 50 years since the bombings.

Scientists have tried to study directly the health effects of low levels of radiation, as well as high doses. Many different studies have looked at the health of people who live in areas of high background radiation, or who work daily with radioactive materials, like uranium miners and nuclear power workers. These studies have looked in particular at the incidence of cancers in these groups and at genetic mutations in children within the groups.

Using work like the studies of victims of Hiroshima, scientists have developed mathematical models to show how different doses of radiation are linked to cancer risks. Because of the problems of interpreting data on low radiation doses, these models don't all agree on the risks. But we still have to make decisions about what exposures are acceptable, in order to set regulations for everything from the nuclear industry to x-rays and radon in homes.

Many different things can cause cancer, and nuclear industries aren't the only culprits when it comes to increasing cancer risks. As well as radiation, a range of different chemicals are known to cause cancer, many of which are widely used in industry. People working with these chemicals have a higher risk of developing cancers, and in some cases the chemicals are released into the environment, potentially affecting public health.