

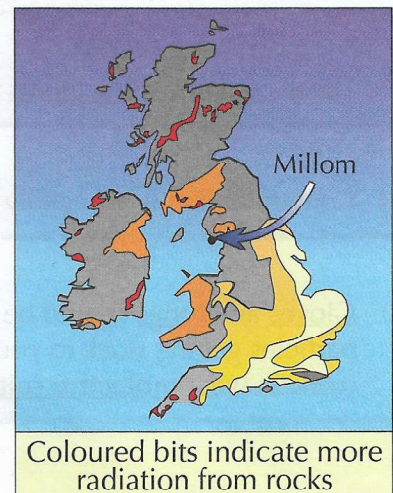
Background Radiation

Forget love — radiation is all around. Don't panic too much though, it's usually a pretty small amount.

Background Radiation Comes From Many Sources

Background radiation is the low-level radiation that's around us all the time. You should always measure and subtract the background radiation from your results (to avoid systematic errors, p.7). It comes from:

- 1) Radioactivity of naturally occurring unstable isotopes which are all around us — in the air, in food, in building materials and in the rocks under our feet.
- 2) Radiation from space, which is known as cosmic rays. These come mostly from the Sun. Luckily, the Earth's atmosphere protects us from much of this radiation.
- 3) Radiation due to human activity, e.g. fallout from nuclear explosions or nuclear waste. But this represents a tiny proportion of the total background radiation.



The radiation dose tells you the risk of harm to body tissues due to exposure to radiation. It's measured in sieverts (Sv) (p.140). The dose from background radiation is small, so millisieverts are often used to measure it ($1 \text{ Sv} = 1000 \text{ mSv}$). Your radiation dose is affected by where you live and whether you have a job that involves radiation. Other factors, such as having x-rays taken, also affect your radiation dose (see p.139).

Exposure to Radiation is called Irradiation

- 1) Objects near a radioactive source are irradiated by it. This simply means they're exposed to it (we're always being irradiated by background radiation sources).
- 2) Irradiating something does not make it radioactive.
- 3) Keeping sources in lead-lined boxes, standing behind barriers or being in a different room and using remote-controlled arms when working with radioactive sources are all ways of reducing irradiation.

See page 83 for the dangers of being exposed to radiation.

Your exposure to background radiation depends on where you live...

Background radiation comes from many sources, from food and drink to cosmic rays, but mostly it comes from the ground and is given out by certain rocks, like granite. That's why some parts of the UK have higher levels of background radiation than others. Areas like Cornwall and Devon, where there's lots of granite, have higher background radiation levels than is average for the UK. But they do have lovely beaches.

Contamination

Radioactive contamination is pretty dangerous — it comes about from touching and handling radioactive substances. Fortunately, there are some simple steps you can take to keep yourself safe from contamination.

Contamination is Radioactive Particles Getting onto Objects

- 1) If unwanted radioactive atoms get onto or into an object, the object is said to be contaminated. E.g. if you touch a radioactive source without wearing gloves, your hands would be contaminated.
- 2) These contaminating atoms might then decay, releasing radiation which could cause you harm.
- 3) Contamination is especially dangerous because radioactive particles could get inside your body.
- 4) Gloves and tongs should be used when handling sources, to avoid particles getting stuck to your skin or under your nails. Some industrial workers wear protective suits to stop them breathing in particles.

Exposure to Some Sources can be More Harmful than to Others

Contamination or irradiation can cause different amounts of harm, based on the radiation type.

- 1) Outside the body, beta and gamma sources are the most dangerous. This is because beta and gamma can penetrate the body and get to delicate organs. Alpha is less dangerous because it can't penetrate the skin and is easily blocked by a small air gap (p.75). High levels of irradiation from all sources are dangerous, but especially from ones that emit beta and gamma.
- 2) Inside the body, alpha sources are the most dangerous, because they do all their damage in a very localised area. So contamination, rather than irradiation, is the major concern when working with alpha sources. Beta sources are less damaging inside the body, as radiation is absorbed over a wider area, and some passes out of the body altogether. Gamma sources are the least dangerous inside the body, as they mostly pass straight out — they have the lowest ionising power, p.75.

The more we understand how different types of radiation affects our bodies, the better we can protect ourselves when using them. This is why it's so important that research about this is published. The data is peer-reviewed (see page 1) and can quickly become accepted, leading to many improvements in our use of radioactive sources.

Alpha sources are the most dangerous inside the body...

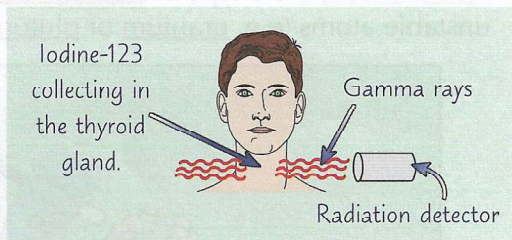
Alpha sources are the most ionising (see page 75), so if they get into the body, they can wreak havoc. Beta and gamma sources however are the most dangerous outside the body. This is because they are more penetrating than alpha sources (see page 75), so can get through the skin and cause damage to cells.

Uses and Risks of Radiation

Radiation can be pretty useful. We use it in our homes, in industry and in medicine. But it's not without its dangers. Using radiation is all about reducing the risks whilst still keeping the benefits.

Gamma Sources are Usually Used in Medical Tracers

- 1) Certain radioactive isotopes can be injected into people (or they can just swallow them) and their progress around the body can be followed using an external detector. A computer converts the reading to a display showing where the strongest reading is coming from.
- 2) One example is the use of iodine-123, which is absorbed by the thyroid gland (just like normal iodine-127), but it gives out radiation which can be detected to indicate whether the thyroid gland is taking in iodine as it should.
- 3) Isotopes which are taken into the body like this are usually gamma emitters (never alpha emitters), so that the radiation passes out of the body without causing much ionisation. They should have a short half-life so that the radioactivity inside the patient quickly disappears.

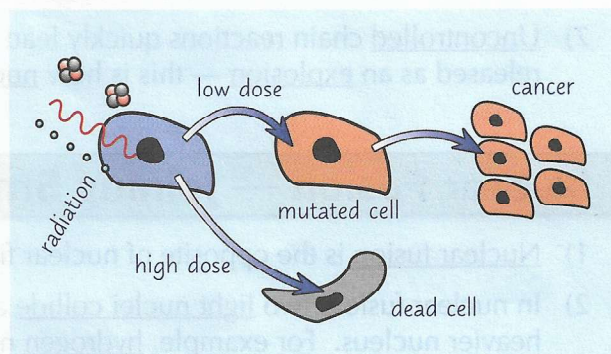


Radiotherapy — Treating Cancer with Radiation

- 1) Since high doses of ionising radiation will kill all living cells (see below) it can be used to treat cancers.
- 2) Gamma rays are directed carefully and at just the right dosage to kill the cancer cells without damaging too many normal cells. Radiation-emitting implants (usually beta-emitters) can also be put next to or inside tumours.
- 3) However, a fair bit of damage is inevitably done to normal cells, which makes the patient feel very ill. But if the cancer is successfully killed off in the end, then it's worth it.

There are Risks to Using Radiation

- 1) Radiation can enter living cells and ionise atoms and molecules within them. This can lead to tissue damage.
- 2) Lower doses tend to cause minor damage without killing the cells. This can give rise to mutant cells which divide uncontrollably. This is cancer.
- 3) Higher doses tend to kill cells completely, causing radiation sickness (leading to vomiting, tiredness and hair loss) if a lot of cells all get blasted at once.



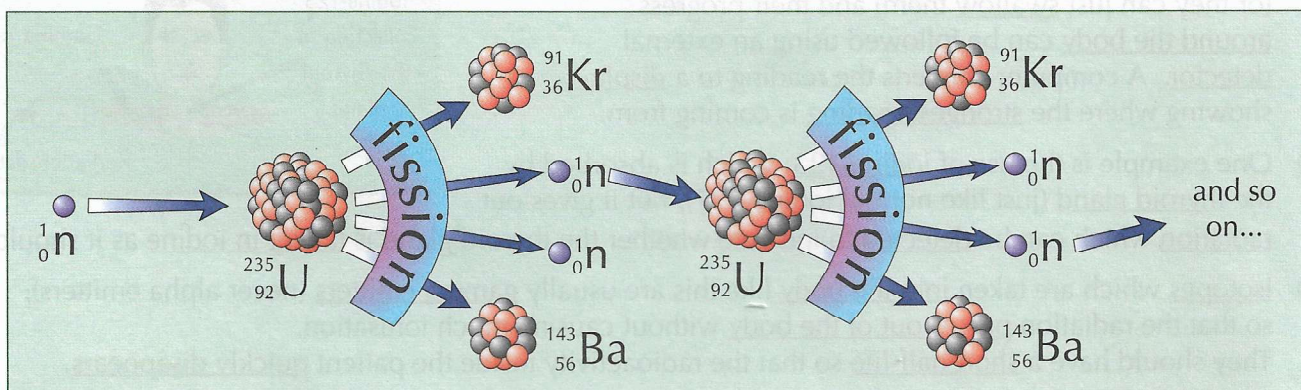
- For every situation, it's worth considering both the benefits and risks of using radioactive materials.
- For example, tracers can be used to diagnose life-threatening conditions, while the risk of cancer from one use of a tracer is very small.
- Whilst prolonged exposure to radiation poses future risks (see p.140 for comparing the risks from different medical procedures) and causes many side effects, many people with cancer choose to have radiotherapy as it may get rid of their cancer entirely. For them, the benefits outweigh the risks.
- Perceived risk is how risky a person thinks something is. It's not the same as the actual risk of a procedure and the perceived risk can vary from person to person. See page 4 for more on this.

Nuclear Fission and Fusion

Splitting up atoms releases lots of useful energy, but it can have explosive consequences.

Nuclear Fission — Splitting a Large, Unstable Nucleus

Nuclear fission is a type of nuclear reaction that is used to release energy from large and unstable atoms (e.g. uranium or plutonium) by splitting them into smaller atoms.



- 1) Spontaneous (unforced) fission rarely happens. Usually, the nucleus has to absorb a neutron before it will split.
- 2) When the atom splits it forms two new lighter elements that are roughly the same size (and that have some energy in their kinetic energy stores).
- 3) Two or three neutrons are also released when an atom splits. If any of these neutrons are moving slow enough to be absorbed by another nucleus, they can cause more fission to occur. This is a chain reaction.
- 4) The energy not transferred to the kinetic energy stores of the products is carried away by gamma rays.
- 5) The energy carried away by the gamma rays, and in the kinetic energy stores of the remaining free neutrons and other decay products, can be used to heat water, making steam to turn turbines and generators.
- 6) The amount of energy produced by fission in a nuclear reactor is controlled by changing how quickly the chain reaction can occur. This is done using control rods which, when lowered and raised inside a nuclear reactor, absorb neutrons. This slows down the chain reaction and controls the amount of energy released.
- 7) Uncontrolled chain reactions quickly lead to lots of energy being released as an explosion — this is how nuclear weapons work.

You may have to draw or complete a diagram to show a chain reaction in the exam, so make sure you're happy with fission reactions.

Nuclear Fusion — Joining Small Nuclei

- 1) Nuclear fusion is the opposite of nuclear fission.
- 2) In nuclear fusion, two light nuclei collide at high speed and join (fuse) to create a larger, heavier nucleus. For example, hydrogen nuclei can fuse to produce a helium nucleus.
- 3) This heavier nucleus does not have as much mass as the two separate, light nuclei did. Some of the mass of the lighter nuclei is converted to energy (don't panic, you don't need to know how). This energy is then released as radiation.
- 4) Fusion releases a lot of energy (more than fission for a given mass of fuel).
- 5) So far, scientists haven't found a way of using fusion to generate energy for us to use. The temperatures and pressures needed for fusion are so high that fusion reactors are really hard and expensive to build.

