About X-rays

What are X-rays?

X-rays are a form of ionising radiation. They are part of the electromagnetic spectrum and have sufficient energy to cause ionisation. They contain more energy than ultraviolet (UV) waves but less energy than gamma rays.

![The electromagnetic spectrum](image)

**Radiation**: is the transfer of energy in the form of particles or waves.

**Ionising radiation**: is radiation with sufficient energy to cause ionisation, which is a process whereby radiation removes an outer-shell electron from an atom. Thus ionising radiation is able to cause changes on a molecular level in biologically important molecules (e.g. DNA).

**Uses of ionising radiation**: include conventional X-rays (plain film), contrast studies, computed tomography (CT), nuclear medicine and positron emission tomography (PET).

How are X-rays produced?

X-rays are produced by focusing a high-energy beam of electrons onto a tungsten target. If the electron has enough energy it can knock out another electron from the inner shell of a tungsten atom. As a result, electrons from higher energy levels then fill up this vacancy and X-rays are emitted. This process of producing X-rays is extremely inefficient (~0.1%), so most of the energy in the beam of electrons is wasted as heat. This is why X-ray tubes need to have advanced cooling mechanisms. The X-rays produced then pass through the patient and onto a detector mechanism, which produces an image.
The resulting image on the X-ray film

Main points:

1. The resulting image on the X-ray film is a **two-dimensional (2D) representation of a three-dimensional (3D) structure**.

2. While passing through a patient the X-ray beam is absorbed in proportion to the cube of the atomic number of the various tissues through which it passes. By convention, the greater the amount of radiation hitting a detector, the darker the image will be. Therefore the less ‘dense’ a material is, the more X-rays get through and the darker the film will be. Conversely the more ‘dense’ a material is, the more X-rays are absorbed and the film appears whiter. **Materials of low ‘density’ appear darker than materials of high ‘density’**.

3. **Structures can only be seen if there is sufficient contrast with surrounding tissues** (contrast is the difference in absorption between one tissue and another).

   ![Density Spectrum](image)

   Figure 2 The spectrum of tissues of different densities as seen on a conventional radiograph.

How are X-ray images (radiographs) stored?

In some hospitals radiographs are printed onto X-ray film, but most now use a computer-based digital film storage system for storing X-ray images, thereby eliminating the need for film.

This system is known as **PACS (Picture Archiving and Communication System)**. Doctors and other healthcare professionals are able to view the images (radiographs) on a computer screen, making it easy to manipulate the image (e.g. changing the contrast, zooming in/out, etc).

The advantages are ease of access, cost saving and no more lost films. The disadvantages are the initial cost and the risk of a system failure, which could be potentially catastrophic.