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.

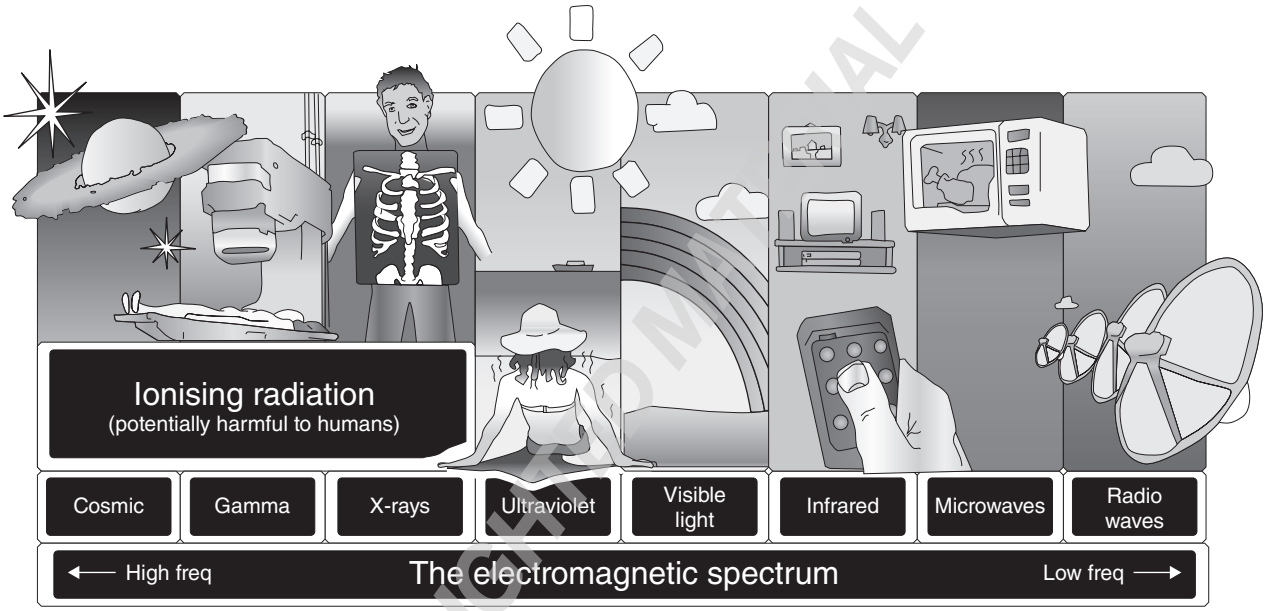

Figure 1 The electromagnetic spectrum.

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.

Chest X-rays for Medical Students, First Edition. Christopher Clarke, Anthony Dux.

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).

1. Air / Gas: **Black** (Aerated lungs, Air in the Stomach or Bowel)
2. Fat: **Dark Grey** (Subcutaneous tissue layer, Retroperitoneal fat)
3. Soft tissues / Water: **Light Grey** (Solid organs, Heart, Blood vessels, Muscle and fluid filled organs such as Bladder)
4. Bone: **Off-White**
5. Contrast Material / Metals: **Bright White** (Pacemakers, Joint prosthesis, Bullets etc)

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** (**P**icture **A**rchiving and **C**ommunication **S**ystem). 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.