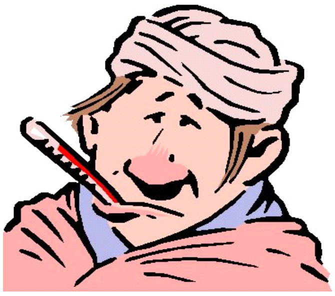
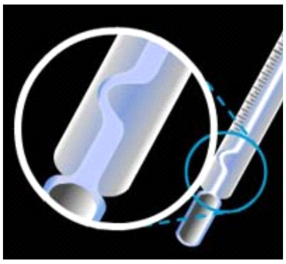


A temperature of 39ºC or above is usually considered to be a significant fever

A temperature of 35ºC can result in hypothermia.



A clinical thermometer has a constriction in the tube. This breaks as the mercury contracts.

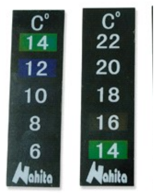
Thermometry

Temperature Measurement

Normal body temperature is **37 °C.** This is an average temperature and can vary by 0.5°C either way. A change of 3°C above, or 2°C below, that temperature can be dangerous and requires medical attention.
Hence taking body temperature is important.

Thermometers

All thermometers, as you know, measure temperature and have a property that changes with temperature.



Liquid-in-glass thermometers

These use the expansion of a liquid to measure temperature. The greater the temperature the greater the expansion of the liquid. As the liquid gets warmer, it expands along the fine glass tube (capillary tube), where there is a scale of numbers marked in °C.

Clinical Thermometers

An ordinary thermometer cannot accurately measure body temperature since;

- the range is too large to measure small temperature changes of the human body.
- the liquid in the tube starts to fall, changing the reading once the thermometer is removed.

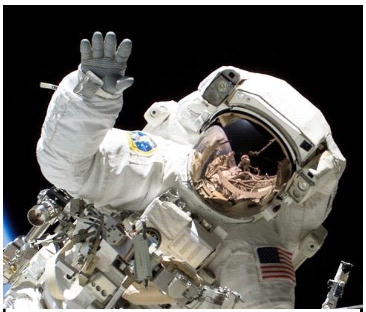
In a clinical thermometer;

- the scale ranges from 35 to 42°C.
- keeps the highest reading for ease of use (the little bend in the tube breaks the thread when the liquid cools and contracts). To reset a clinical thermometer it has to be shaken fairly vigorously.
- the glass tube is shaped like a lens to magnify the thin thread of liquid.

Using Sound

Sound

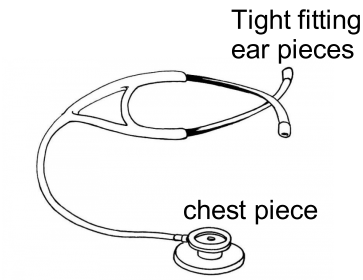
Before sound can be produced an object must be made to vibrate. Solids, liquids and gases are made up of particles. A sound wave makes the particles vibrate and the wave is transmitted from one particle to the next.



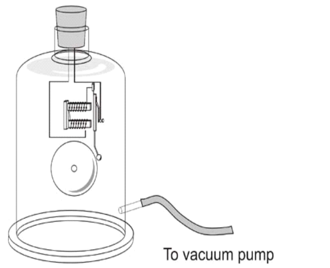
In space there is no air—no particles. This means there is no sound. Astronauts use radios in their helmets to speak.

The Stethoscope

The stethoscope is a hearing aid which allows a doctor or nurse to listen to sounds made within the body. It is most often used to listen to the heart and the lungs.



The main parts of a modern stethoscope are shown. The chest piece has two 'bells', one open and the other closed by a thin diaphragm (a semi-rigid disc). A valve can be turned to change from the open to the closed bell. The open bell is used to listen to heart sounds. The closed bell is used to listen to sounds which have a higher frequency than heart sounds such as from the lungs.



Sound can't travel through a vacuum. An experiment to show this is the 'Bell Jar Experiment.'

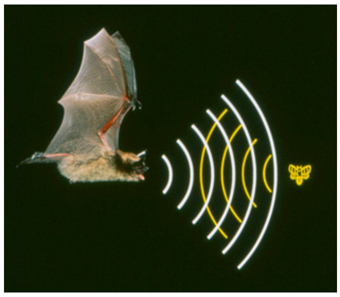
Range of Human Hearing

Young people can hear sounds with frequencies which range from **20 to 20 000 Hz**. Frequencies above 20 000Hz are called **ultrasound** or ultrasonic vibrations.

<u>Uses of Ultrasound in Medicine</u>

Scanning the body

Ultrasound can be used to image the body. When these higher frequency ultrasonic waves are sent out by a transmitter and hit an object, some of the waves will pass through the object while some will be reflected.
These waves will take different time receiver and a computer can use th image.

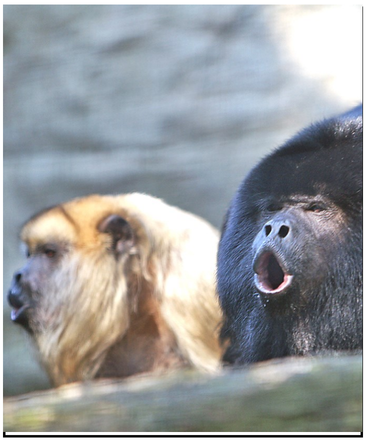


Bats use ultrasound to map the environment and catch prey.

A typical scan can check on the progress of a baby in the womb or check the functioning of the valves in the heart.

Treating kidney stones
Kidney stones can be shattered by these high frequency sound waves.

The Blue whale has been recorded "singing" at 188 dB. Scientists think it can sing loud enough to be heard over an entire ocean.



The loudest land animal is believed to be the "Howler Monkey." It can be heard clearly for 3 miles.

However the loudest animal of all is the two inch "Pistol shrimp." It shoots a hot bubble at fish with an enlarged claw. The snapping noise can reach 218dB!

Loudness

The human ear is sensitive and can be damaged by loud sounds. The loudness of sound is measured in decibels (dB) using a sound level meter.

0dB is the quietest noise a good human ear can hear. The table below contains some common sound level readings.

Sound Source	Sound Level
Library	30dB
Quiet Room	40dB
Normal conversation at 1m	60-65dB
City Traffic (inside car)	85dB
sustained exposure may result in damage (hearing loss)	*90 dB*
Motorcycle	100dB
Loud Rock Concert	115dB
Pain begins	*125 - 130 dB*
Jet engine at 30m	140dB

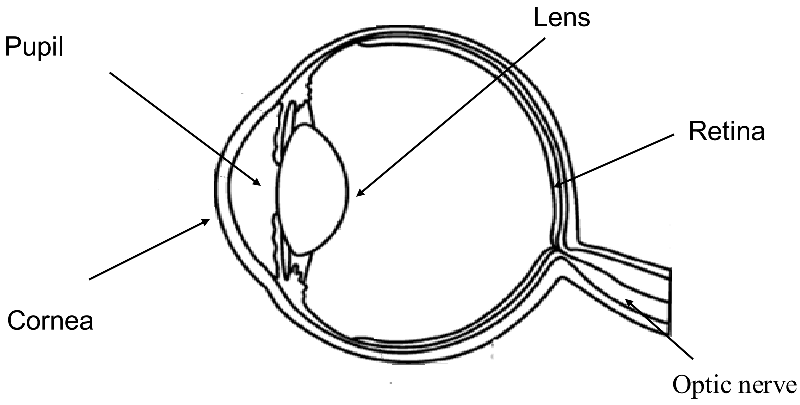
Monitoring sound levels is important as loud sounds can cause damage to the hearing. People exposed to long periods of loud sounds at work should wear ear protection, such as ear muffs or ear plugs, to protect their hearing.

Noise

Noise is unwanted sound. It may be sound from aircraft, from machinery or a neighbour's radio. **Noise pollution** is a term used to describe unwanted environmental sounds.

Light and Sight

The Eye

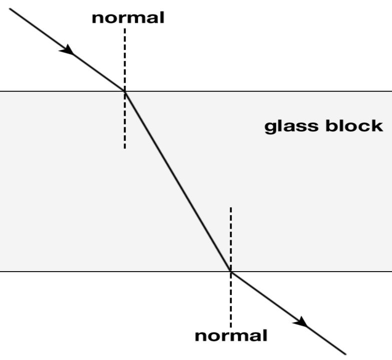


Light enters the eye at the cornea which is a clear film at the front of the eye. The light bends when passing through the cornea, goes through the pupil and bends when passing through the lens. This bending of light which occurs at the cornea and lens is due to the light changing speed. This change in speed is known as **refraction**.

This results in the light focussing on the retina, where an image is formed. The image formed at the back of the eye is upside down. The retina is full of light sensitive cells and these cells send signals to the brain. The brain interprets the signals as vision.

Refraction

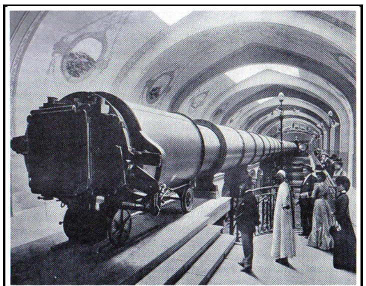
Refraction is the change in speed of light as it passes from one material to another. This results in the light changing direction as it passes from one material to another.



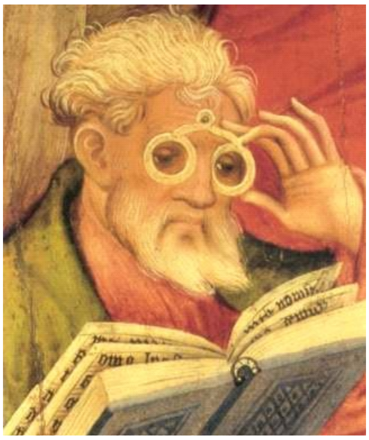
Refraction happens when light passes through lenses.

Antoni van Leeuwenhoek built hundreds of early microscopes.They were made using little “bead” lenses and the microscopes were about 2 inches long.

The first lens was discovered by the ancient Roman writer Seneca (4B.C.-65 A.D.). He found that images became magnified when seen through a glass ball filled with water.



The Great Paris Telescope of 1900 had a lens of diameter 125cm.



The first glasses were made around 1286 in Italy. The inventor is unknown. They had frames of tortoiseshell, ivory, metal (heavy metal), or wood.

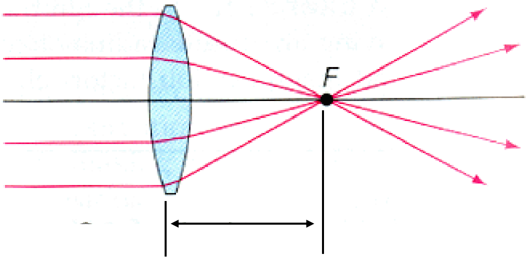
The first contact lenses were used in 1887, but they were large and thick and not comfortable.

Even the Hubble Telescope needed correcting lenses! Once in orbit, it was discovered that it had a relatively huge optical error. A large correcting lens was constructed and fitted to the telescope in space.

Lenses

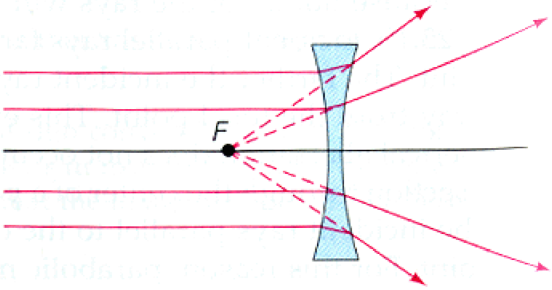
These are different shapes of glass. There are two types of lenses:

Converging Lenses



Converging (convex) lenses bring parallel rays to a focus. The distance from the lens to focal point is the focal length.

Diverging Lenses

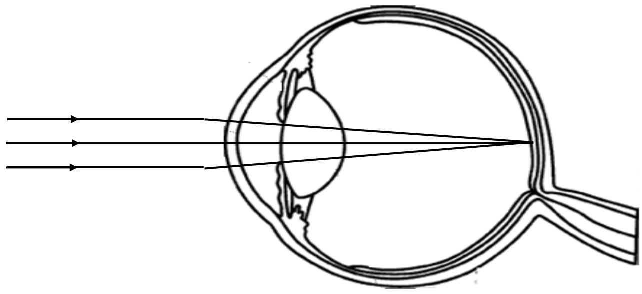


Diverging (concave) lenses make parallel rays spread out.

Measuring the focal length of a spherical converging lens.

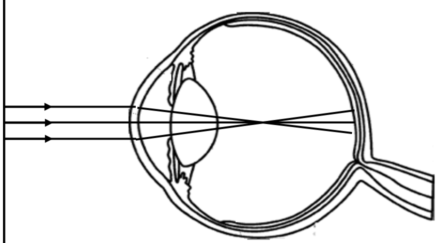
- A screen (card) is placed opposite a distant light source (e.g. a window). The lens is placed in front of the screen.
- The lens is moved slowly away from the screen toward the light source (window) until a sharp image of the source is focused on the screen.
- A ruler is used to measure the distance between the lens and the screen. This is the focal length.

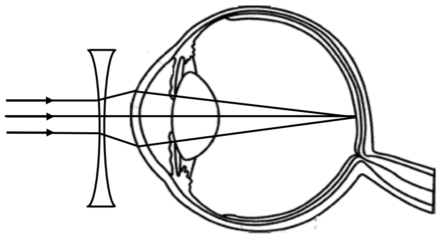
The lens in the eye is essential to ensure good vision. It helps to focus light upon the retina, the layer of light sensitive cells at the back of the eye. The retina has a very small area for really sharp vision. The lens in the eye changes in thickness to accommodate light travelling from varying distances. This is a reflex which happens perfectly when someone has perfect sight. See the diagram blow.



However there are eye defects, short sightedness and long sightedness, which prevent light from focusing on the retina perfectly. Lenses can be used to correct these defects.

Short sight

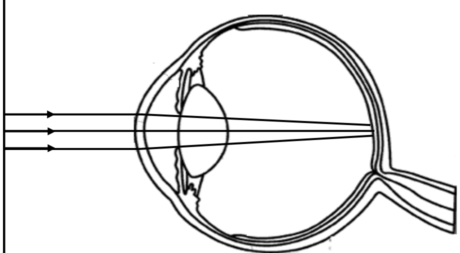


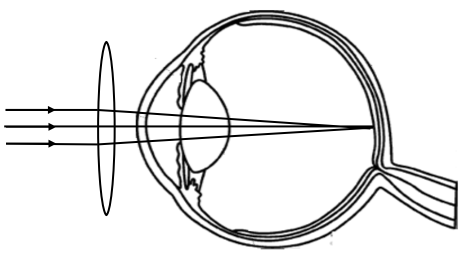


A short sighted eye can focus on nearby objects but cannot see distant objects clearly. The light comes to a focus before the retina.

A diverging (concave) lens makes the rays diverge before entering the eye. The light from a distant object now comes to a sharp focus on the retina.

Long sight





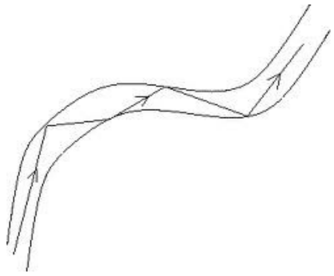
A long sighted eye can focus on distant objects but cannot see nearby objects clearly. The light comes to a focus after the retina.

A converging (convex) lens makes the rays converge before entering the eye. The light from a nearby object now comes to a sharp focus on the retina.

Opticians test-glasses allow the use of changeable lenses.

Short sight

Long sight

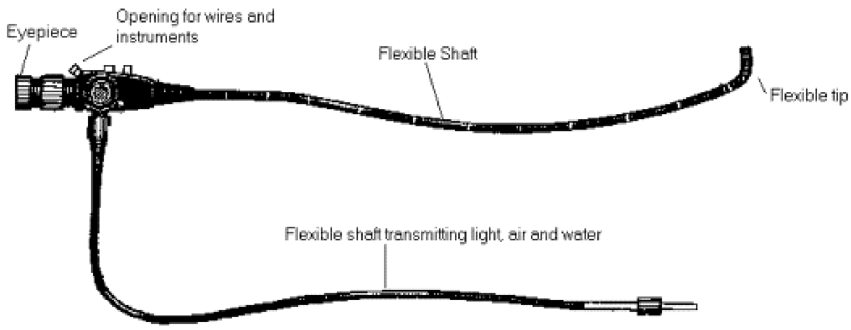


Total internal reflection is an essential process in optical fibres

Lasers and optical fibres are often used together.

Optical Fibres in Medicine

Optical fibres are put to use in endoscopes which are used to view inside the body. An endoscope consists of a flexible shaft containing two optical fibre bundles. One bundle carries light down inside the body and the second bundle carries light back up to an eyepiece or camera which provides the doctor with a clear view.



The light which is directed down one bundle is passed through a heat filter thus it acts as a "cold" light source which will not heat or burn the patients insides.

Endoscopes can be used to investigate the intestines, gut, stomach and upper respiratory tract without using a knife. It also can be used in "keyhole" surgery, operating through small incisions.

Laser light and small operating tools can be passed down the endoscope allowing simple procedures to be undertaken remotely.

A surgeon using an endoscope to view the inside of a patient.

Lasers in Medicine

A laser is a very concentrated narrow beam of light. The light is of one particular colour (wavelength). In medicine the laser has proved itself invaluable for some types of surgery, yet it has not replaced the scalpel to the extent which was predicted.

The laser is used to produce extreme heating in a very small piece of tissue. In one application, the laser beam is used to seal blood vessels by clotting the blood - **photocoagulation**.

Doctors use the neodymium-YAG laser to vaporise tumours that obstruct the flow of air to the lungs. After laser treatment for a tumour that blocks the oesophagus, the patient can swallow again.

Laser as a scalpel
As the carbon dioxide laser beam is almost totally absorbed in the first tenth of a millimetre of tissue, it is particularly suited for use as a 'laser scalpel'. The shallow penetration makes it ideal for treating areas where it is important not to damage underlying structures. Certain malignant tumours can be vaporised using a carbon dioxide laser.

Eye problems
Eye surgery is the best known application of Argon Lasers. The retina of a diabetic person sometimes does not get enough oxygen from the blood vessels. To compensate for this lack of oxygen, abnormal vessels grow forwards and bleed into the eye. Vision at the edge is altered and the patient can eventually go blind. The eye surgeon uses an argon laser to seal the less important areas of the retina. Although this reduces the patient's field of vision, the patient is much less likely to go blind. This technique can be used for repairing retinal tears and holes which develop prior to the retina coming away from the back of the eye.

Other uses
Port wine birth marks are caused by blood vessels which have not sealed properly. The light from the argon laser is absorbed by the blood vessels causing them to seal. A similar treatment can be used on some tattoos. In this case the argon laser breaks up the dye.

"Before" and "After" laser tattoo removal.

Laser "correction" of the cornea.

In H.G.Wells' "War of the Worlds."(1898) the Martians fought with a "heat ray." Can you think why we don't use a heat laser as a weapon today?

Answer (Use mirror)

We do have lasers that cut through concrete and steel! However, laser light would easily be scattered by rain or cloud and enemy vehicles would just be designed with a very shiny finish and so reflect most of the heat. Also the cooling system would be heavy and cumbersome.

Infra red thermogram shows cold fingers indicating poor peripheral circulation.

A premature baby receives UV in an incubator. This helps with the production of

Insects and bees see UV. Flowers look very different to them.

Using the Spectrum

The light that we can detect with our eyes is referred to as visible light. The visible light spectrum ranges from 400 to 700 nanometres (nm). This spectrum is only a small part of all the wavelengths that exist. The complete range of wavelengths is called the electromagnetic spectrum.
Other parts of the spectrum are also used in medicine:

Infrared Radiation in Medicine

All hot objects give off invisible 'heat rays' called infrared radiation. Typical wavelengths for infra red radiation are from 700 to 1500 nm. Special infrared cameras can be used to take colour photographs called thermograms using this radiation instead of light. Infra red radiation allows us to measure small temperature changes inside tissue without surgery.

In medicine, thermograms of a patient's body show areas of different temperature. Doctors have found that malignant tumours are warmer than healthy tissue and show up clearly on thermograms. If people suffer from arthritis then the affected joint will show as a different temperature from the normal joint.

Infrared radiation is also used by physiotherapists to treat people who have suffered a muscle injury. They use infrared lamps to heat muscles and tissues. This helps to speed up the healing process.

Ultraviolet

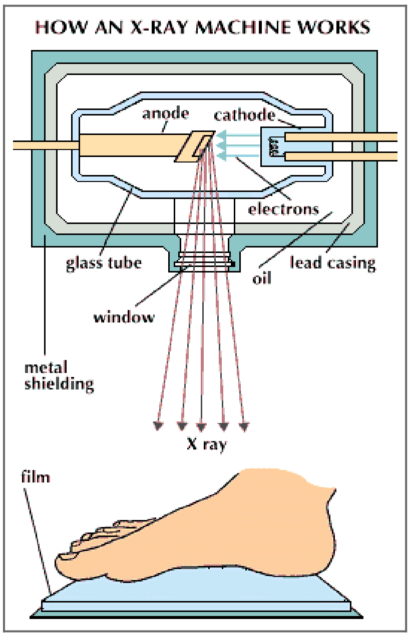
Ultraviolet (UV) is another type of invisible radiation. The wavelength of ultraviolet ranges from 200 to 400 nm. This is shorter than the wavelength of visible light.

UV is partly absorbed by the earth's ozone layer. UV is the part of the spectrum that causes sunburn, but we need some UV for healthy growth and to make vitamin D.

Excessive exposure to ultraviolet can cause skin cancers called melanomas. There is also a risk from long exposure under sun beds and in this case care should be taken to cover the eyes since they are especially sensitive to this damage. Too much ultraviolet light on the skin produces sunburn and can cause the skin to turn red and be very painful. In addition there is evidence that the skin ages more prematurely. Excessive UV radiation can also increase the chance of cataracts. Suntan lotions absorb some of the ultraviolet rays which cause the burning, but they allow the lower frequency rays to reach the skin and to produce a tan. The tan is due to a pigment called melanin being produced.

X-rays

X-rays are used to either see inside the body or to treat some diseases. They are made by putting a high voltage across a tube which has been evacuated (no air is present). One of the wires is heated to emit electrons which are accelerated until they hit another piece of metal which gives off X-rays. The greater the voltage across the two plates the greater the energy of the X-rays. If the voltage is between 80 and 120 kV then the X-rays can be used to produce pictures. Voltages of greater than 200 kV can produce X rays for treating cancers.



The use of X rays in medicine depends on the fact that they pass through body tissues like skin, fat and muscle fairly easily, but are more readily absorbed by bones. When X-rays hit the photographic plate on the other side of the patient, they affect the photographic emulsion and blacken it, and so the image of the arm would be fairly dark, with lighter areas for the bone. The bones are white since they absorb the X- rays. The degree of blackening on the plate will depend on the number of rays reaching it. Any break in a bone lets X-rays through and may show up as a dark on the film. The boundary between organs both made of similar tissue will not be particularly clear.

A contrast agent is used such as iodine or barium which absorbs X -rays. Barium is drunk by the patient to outline the stomach and iodine is used to outline arteries and veins. The organ which has the contrast agent will show up lighter on the photographic plate. (See the X-ray of the skull) Some X - ray machines do not use film to record results but use special detector tubes called image intensifiers to receive the rays and convert them into electrical signals. These can be converted into digital signals and displayed on a monitor screen.

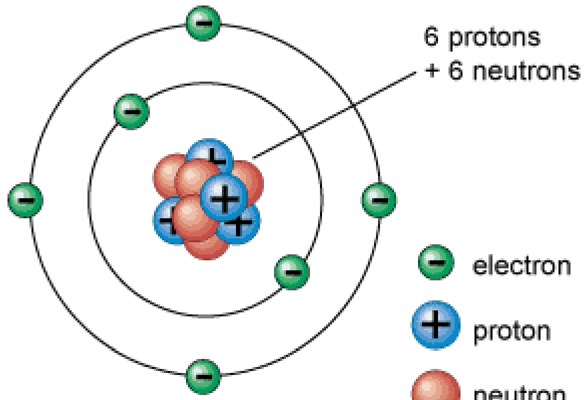
Wilhelm Röntgen made the first x-ray: his wife's hand on a photographic plate.

The image horrified Mrs Roentgen, who remarked, “I have seen my death!”

Nuclear Radiation

The Atom

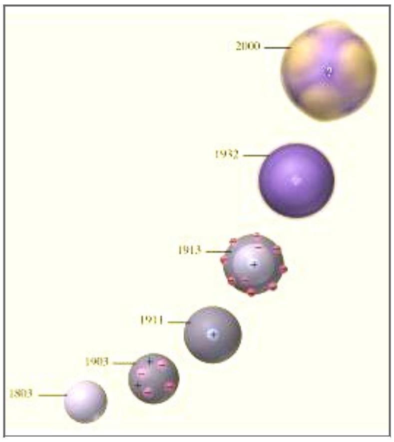
Atoms are the smallest possible particles of the elements which make up everything around us. All atoms of the one element are identical to one another, but they are different from all other elements. This is because they are made up from different combinations of electrons, protons and neutrons.



Carbon atom

The atom is a nucleus, which is made up of protons and neutrons, with electrons in orbit . Protons are positively charged, neutrons have no charge and electrons are negatively charged.

When elements are unstable they are called radioisotope and they release radiation. Radiation, as you know, **can kill living cells or change the nature of living cells.**



Our understanding of the atom has changed over the years. We have changed the "model" (idea) many times, but sometimes the simpler, earlier models are more useful.

Atoms are too small to see with ordinary microscopes. In 2013 IBM used a scanning tunneling microscope to make this film.

There are 3 types of naturally occurring nuclear radiation :

Alpha, α

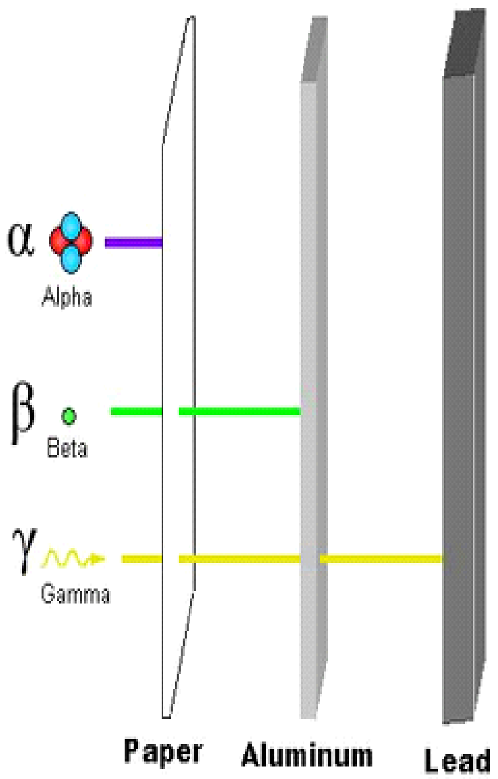
Alpha particles are positively charged, relatively slow and heavy. They have a low penetrating power - you can stop them with just a sheet of paper.

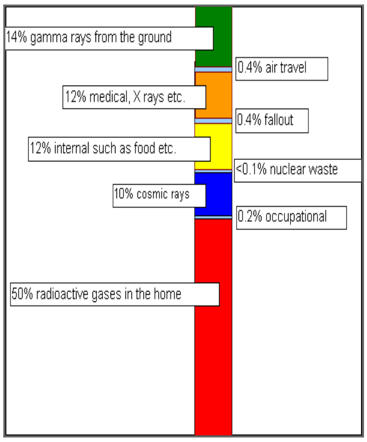
Beta, β

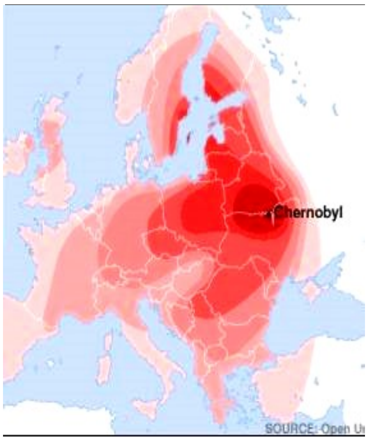
Beta particles are negatively charged, fast and light.
Beta particles have a medium penetrating power - they are stopped by a few millimetres of aluminium or plastics such as perspex.

Gamma, ɣ

Gamma rays are waves, not particles.
This means that they have no mass and no charge. Gamma rays have a high penetrating power - it takes a thick sheet of metal such as lead or concrete to reduce them significantly.







On the 3rd of May, 1986 parts of the UK experienced up to 5 times normal background radiation. This was a result of the accident of Chernobyl.

Radioactivity Symbol

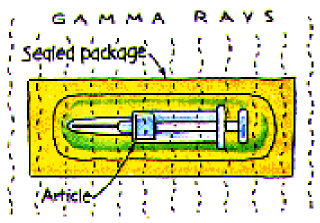
Radiation Therapy

Radiation in Medicine

Treating Cancer - Radiation Therapy

Radiotherapy is the treatment of cancers by radiation. Cancers are growths of cells which are out of control. Cancerous tumours can be treated by drugs, surgery or radiation. The choice of treatment depends on the size and position of the tumour. The object of the radiation treatment is to cause damage to the cancer cells which stops them reproducing. The tumour then shrinks.

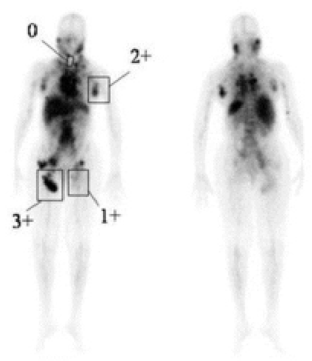
Unfortunately, healthy cells can also be damaged by radiation, and so the amount of radiation has to be very accurately calculated so that sufficient damage is done to cancer cells without overdoing the damage to other cells. The radiation must be aimed very accurately at the tumour.
Some localised tumours (e.g. a bone tumour) can be treated by irradiation with high energy X-rays (sometimes called 'hard x-rays') or gamma rays.
The gamma rays are emitted from a Cobalt-60 source - a radioactive form of cobalt. The cobalt source is kept within a thick, heavy metal container. This has a slit in it to allow a narrow beam of gamma rays to emerge.



Gamma rays kill the germs and viruses on the syringe.

Sterilising Instruments

Gamma radiation can kill cells. This can be used to kill bacteria on instruments leaving them sterile. The instruments are wrapped up inside a package. The package is then exposed to a heavy dose of radiation, which kills all germs inside the pack. The package does not need to be opened until it is required for use. So it stays sterile.



Gamma tracer image.

The Gamma Camera

It is important for scientists to be able to study internal organs without surgery. To see how the kidneys are working, for example, a radiopharmaceutical is used which acts as a tracer. The advantage of the radiopharmaceutical is that the radiation can be detected outside the body. It is injected into the blood and provides a trace of the inside of the body, the kidney, which is viewed with a special camera called a gamma camera which detects the radiation passing from the body. Gamma is chosen since alpha or beta would be absorbed by tissue and would not be detected outside the body.