Waves carry energy. The energy of a tsunami can be devastating.

Surfers use the energy of water waves.

Is the slinky your Physics teachers favourite toy ?

Waves

Introduction

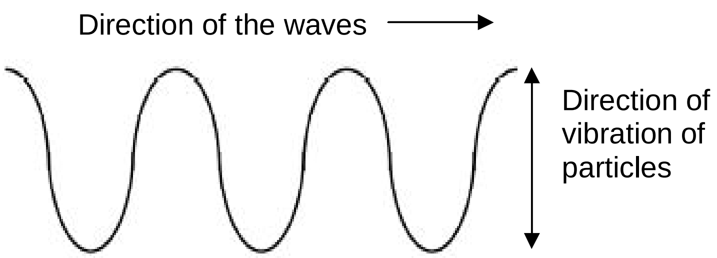
Waves can transfer **energy**, e.g. water waves can transfer energy across the water, sound waves travel through the air carrying energy from an instrument to your ear, radio and television signals travel through the air.

There are two types of waves :-

transverse and longitudinal waves

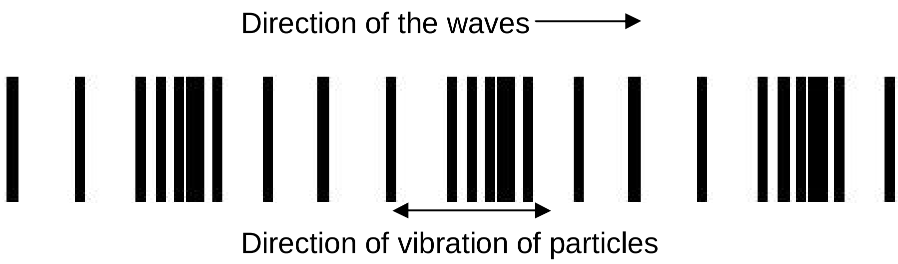
Transverse Waves

A transverse wave is one in which the particles making up the wave vibrate at 90° to the direction of the wave.
Examples of transverse waves are water waves, light, gamma rays, X-rays (in fact, all members of the electromagnetic spectrum).

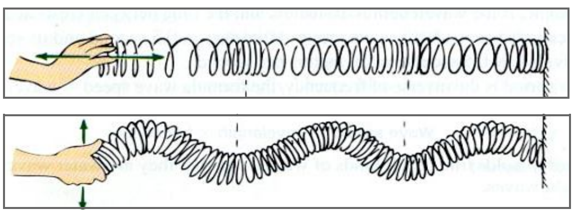


Longitudinal Waves

A longitudinal wave is one in which the particles vibrate along the same line as the direction of the wave.
Sound travels as a longitudinal wave.



A slinky can be used to display both transverse and longitudinal waves.



Wave Characteristics

Speed or velocity: the distance a wave travels in one second.

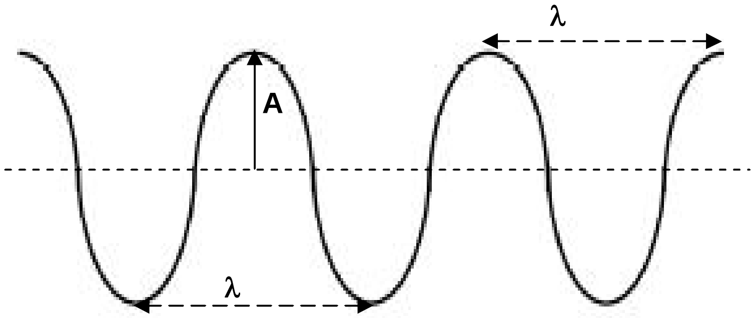
The symbol for speed or velocity is **v**.

Speed or velocity is measured in metres per second (m/s).

Frequency: the number of waves which pass a point in one second.

The symbol for frequency is **f**.

Frequency is measured in hertz (Hz).



Wavelength: the distance between any point on one wave and the corresponding point on the next wave.

The symbol for wavelength is λ (the Greek letter lambda).

Wavelength is measured in metres (m).

Amplitude: the height of the wave measured from the centre line to the top of the crest, or bottom of the trough. The amplitude is a measure of the energy the wave possesses. The bigger the amplitude, the more energy the wave carries.

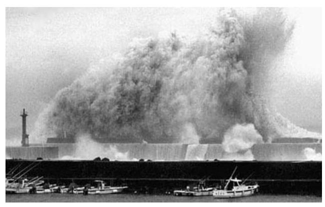
The symbol for amplitude is **A**.

Amplitude is measured in metres (m).

It is very important to learn the wave characteristics as they are used in wave calculations.

Tsunamis can travel at a speed of 100 miles per hour.

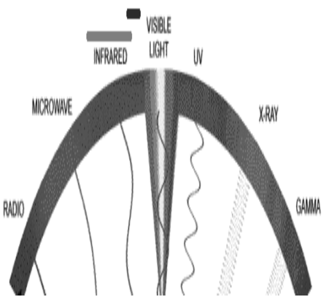
Microwaves, radio waves and TV waves all have different frequencies.



A Tsunami has gigantic swells, often many kilometres deep and can move the entire depth of the ocean.

The crest of a wave.

Waves crashing against a pier during Hurricane Ivan.

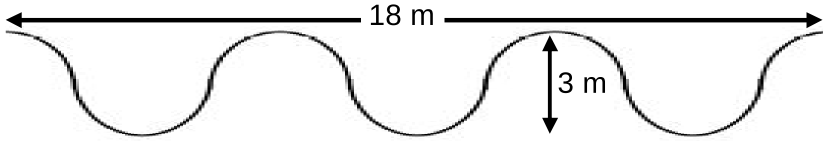


At what speed do the waves of the electromagnetic spectrum travel ?

Wave Calculations

Example 1

The diagram below represents water waves.



i) What is the wavelength of the water waves?

$$\lambda = \frac{distance}{number\ of\ waves} = \frac{18}{3} = 6\ m$$

ii) What is the amplitude of the waves?

$$A = \frac{3}{2} = 1.5\ m$$

Example 2

Twenty water waves pass by a point in 4 seconds.
What is the frequency of the water waves?

$$f = \frac{number\ of\ waves}{time} = \frac{20}{4} = 5\ Hz$$

If the distance travelled in a given time is known, wavespeed can be calculated from :

$$\mathbf{v = \frac{d}{t}}$$

Example 3

Water waves travel a distance of 50 m in 10 s. At what speed are the waves travelling ?

$$v = \frac{d}{t}$$

$$= \frac{50}{10}$$

$$= 5\ m/s$$

Example 4

A diver 4.5 km away from a diving bell hears the sound which signals his return 3 s after it is sounded. What value does this give for the speed of sound in water ?

$$v = \frac{d}{t}$$

$$= \frac{4500}{3}$$

$$= 1500 \text{ m/s}$$

However wavespeed can also be calculated from the **wave equation**. If the wavelength and frequency of a wave are known then wavespeed can be calculated from the wave equation :

wavespeed = frequency x wavelength

$$v = f \times \lambda$$

Example 5

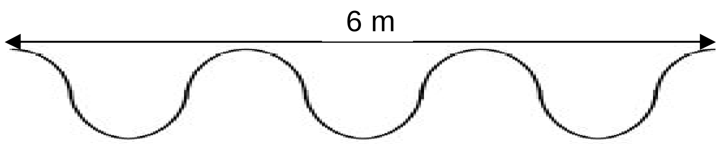
A wave has a wavelength of 0.5 m and a frequency of 680 Hz. Calculate its speed.

$$v = f \times \lambda$$

$$= 680 \times 0.5$$

$$= 340 \text{ m/s}$$

Example 6



The waves shown in the diagram above have a frequency of 20 Hz.

Find (a) the wavelength
(b) the speed.

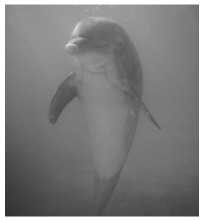
(a) wavelength = $\frac{6}{3}$

$= 2 \text{ m}$

(b) $v = f \times \lambda$

$= 20 \times 2$

$= 40 \text{ m/s}$

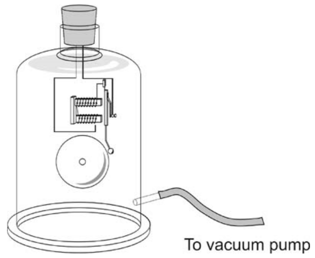


Dolphins use sound to communicate. The speed of sound in water is approx. 1500 m/s.

λ

The eleventh letter of the Greek alphabet, **lambda**, is the symbol for wavelength.

Heinrich Hertz was the first physicist to conclusively prove the existence of electromagnetic waves.



The ringing bell can no longer be heard when the air is removed from the jar.

Sound

Sound can travel though solids, liquids and gases. The only place that sound waves cannot travel through is a vacuum. A vacuum is an empty space, so there are no particles to pass on the vibrations.

The speed of sound varies. The speed of sound changes from one material to another. The speed of sound in air is of particular interest to ourselves as we communicate because of sound travelling through the air.

The Speed of Sound in Air

Light travels very much faster than sound. So lightning is seen before thunder is heard, and an athlete sees a puff of smoke from the starter's gun before hearing the bang.

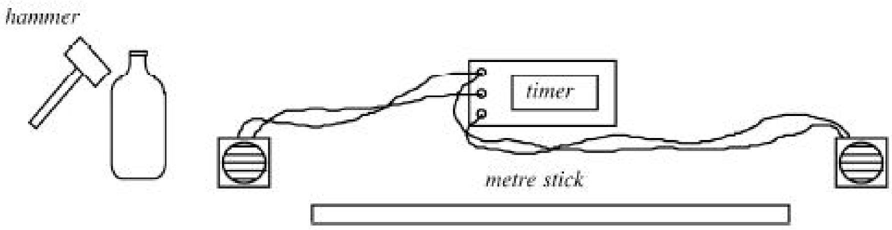
The light from fireworks are seen before the sound is heard.

The speed of *sound* in air is about 340 metres per second.

The speed of *ligh*t in air is 300 000 000 metres per second.

Measuring the Speed of Sound in Air

In the laboratory, the apparatus below is used to measure the speed of sound in air.



Felix Baumgartner broke the speed of sound during his world record skydive from an estimated 39 kilometres.

The bottle is struck to make a sound. This sound passes the first sound sensor to start the timer, covers the distance between the sensors and stops the timer when passing the second sound sensor. The time taken by the sound to pass between the sensors is recorded and the distance between the sensors is measured with the metre stick. The speed of sound is calculated by using the formula :

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Frequency

Each note or sound has a frequency which is measured in hertz (Hz).

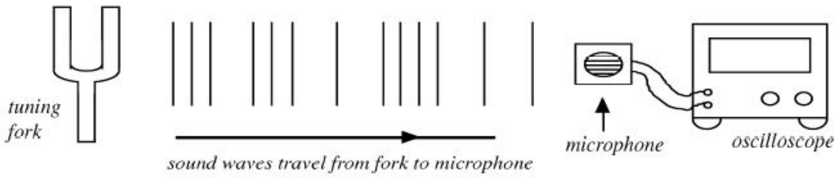
A tuning fork has a frequency engraved on it. The one in the picture opposite has a frequency of 440 Hz. This means the fork will produce 440 vibrations per second, 440 sound waves in one second.

Frequency is the number of waves produced in one second.

Musical instruments produce a range of frequencies. A whistle produces a higher frequency sound than a drum. The whistle has a higher pitch. The higher the pitch means the higher the frequency.

Detecting Sound

Sound can be taken in by a microphone and a trace displayed on an oscilloscope.



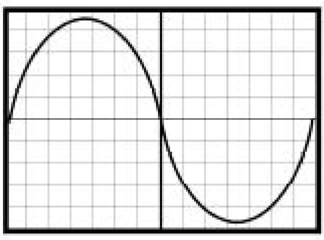
Loudness and Frequency

An oscilloscope shows whether a sound wave is loud or quiet, or has a high or low frequency (pitch).

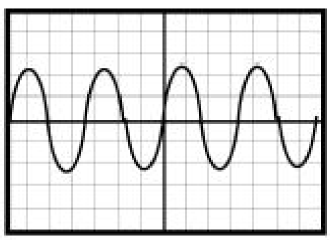
The greater the height of the wave pattern, the louder the sound.

The greater the number of waves, the greater the frequency or pitch.

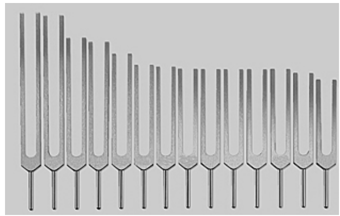
The oscilloscope patterns below display examples of sound -



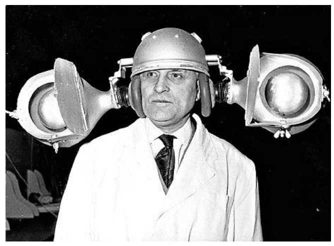
loud, low pitch sound



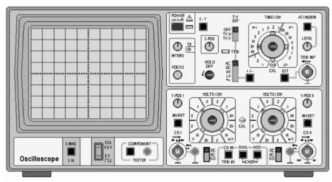
quiet, high pitch sound



Tuning forks give out a pure musical tone and were traditionally used in the tuning of instruments.



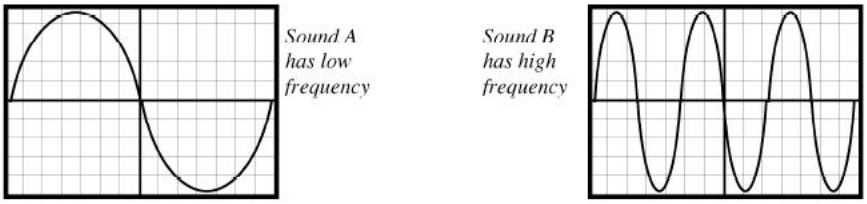
Detecting sound is a serious business.



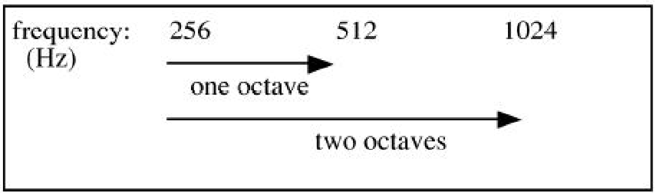
Oscilloscopes are used to display electrical signals, if it is attached to a microphone it will show the sound waves entering the microphone.

High and Low Frequency

The effect of changing the frequency of a sound can be seen on an oscilloscope screen.
Sound B has a higher frequency than sound A.



If the frequency is doubled, we say the sound is an octave higher.
If the frequency is halved, we say that the sound is an octave lower.



Changing the Note

A musician tunes a guitar by making the string tighter or looser.

While playing the guitar, the note is changed by altering the length of string which vibrates.

- Short strings produce a higher frequency than long strings
- Tight strings produce a higher frequency than slack strings.

The variety of notes produced by a saxophone depends on the length of the air column which vibrates.

When the upper tone holes are open, much of the sound goes through them. This creates a shorter column of air which produces a note of higher pitch (higher frequency).

When a longer column of air vibrates a note of lower pitch (lower frequency) is produced.

Signal generators can be used to make sounds of varying loudness and frequency.

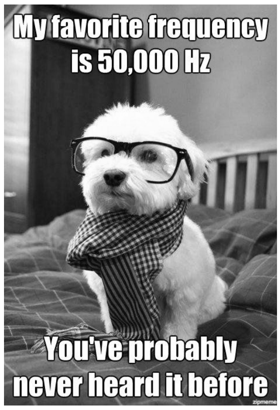
Sound of a particular frequency and volume can shatter a glass.

Can you change the pitch of a note on a kazoo?

Range of Human Hearing

Humans can hear sounds with a range of frequencies. We can detect sounds that range from **20 to 20 000 Hz**. As we get older the upper limit gradually falls to about 15 000 Hz.

Other animals detect sounds with different Frequencies.

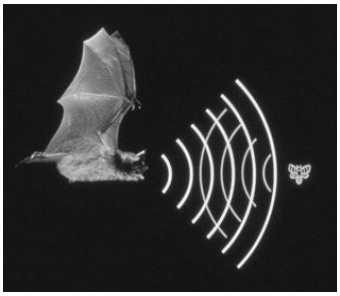


Ultrasound

Frequencies beyond the upper level of human hearing (20 000 Hz) are called **ultrasound** or ultrasonic vibrations.

Ultrasound in Medicine

Scanning the body
Ultrasound can be used to image the body. When these high frequency 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. The reflected waves are picked up by a receiver and processed to provide an image.



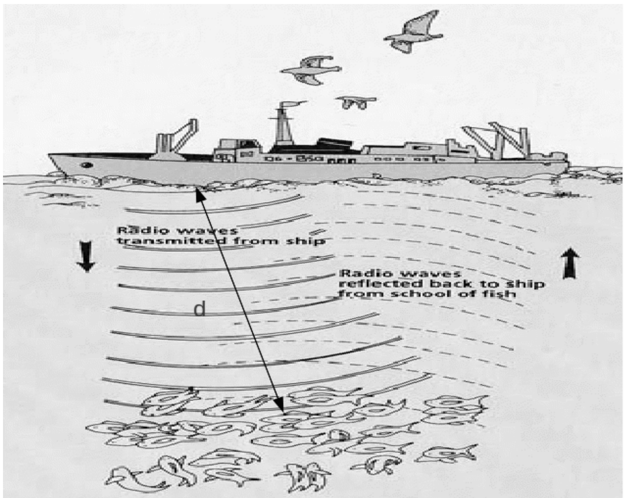
Bats use ultrasound to map the environment and catch prey.

A typical scan can check on the progress of a baby in the womb (see the image opposite) or check the functioning of the valves in the heart.

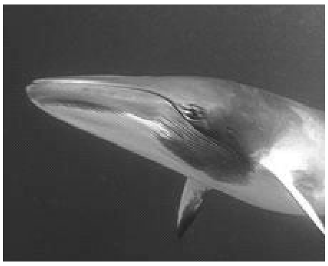
Treating kidney stones
Kidney stones can be shattered by these high frequency sound waves.

Other Uses of Ultrasound

Fishermen use a system called sonar. This involves sending out ultrasound waves towards the sea bed and detecting the echo, the reflected signals. This helps the fishermen to locate shoals of fish.



Elephants can produce infrasounds that travel over 10 kilometres.



The Blue Whale has been recorded "singing" at 188 dB.

The "Howler Monkey" - Is it the loudest land animal ?

Do headphones protect the ears or damage them ?

Sound Levels

The human ear is sensitive and can be damaged by loud sounds. Hence it is important that sound levels are monitored. The sound level varies depending on the source of the sound.

Sound levels are 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.

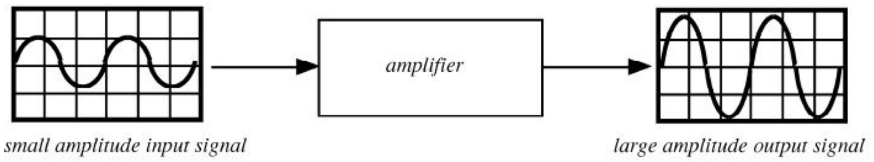
Sound Source	Sound Level
Library	30 dB
Quiet Room	40 dB
Normal conversation at 1m	60-65 dB
City Traffic (inside car)	85 dB
sustained exposure may result in damage (hearing loss)	*90 dB*
Motorcycle	100 dB
Loud Rock Concert	115 dB
Pain begins	*125 - 130 dB*
Jet engine at 30m	140 dB

When sound levels rise to unacceptable levels, the problem is described as **noise pollution**. There are many sources of noise pollution, such as aircraft noise or pneumatic drills. Noise pollution is a term used to describe unwanted environmental sounds.

Exposure to high sound levels over a long period of time can damage our 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.

Amplified Sound

Many electronic devices, such as iPods or phones, contain an amplifier. Amplifiers take an electrical signal of small amplitude and change it into a higher amplitude one.



Only the amplitude of the signal is changed. The frequency does not change.

Amplifiers are used in public announcement systems in airports and stations. This requires sound to be changed into electrical signals, amplified and changed back to sound. A public announcement (PA) system is an electronic system made up of three parts (input, process and output).

The three parts used to amplify the sound are

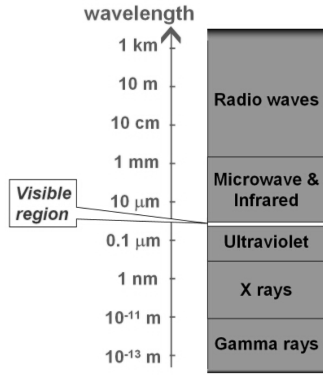
Input **Microphone** → Process **Amplifier** → Output **Loudspeaker**

Part of the System	Function
Microphone	Change sound energy into electrical energy.
Amplifier	Make the electrical signal bigger (stronger).
Loudspeaker	Change electrical energy back into sound energy.

Any device with a loudspeaker has an amplifier.

The classic rock guitar amp ?

Mr. McFarlane's karaoke machine is a PA system of sorts.



Wavelengths in the spectrum.

The Electromagnetic Spectrum

The electromagnetic spectrum is made up of waves as shown below. All the waves of the electromagnetic spectrum travel at the speed of light (300 000 000 m/s).

Low λ —— increasing λ ——→ Long λ

Gamma Rays	X-Rays	Ultra-violet	Visible Light	Infrared	Micro-waves	Radio & TV Waves

High f ←—— increasing f —— Low f

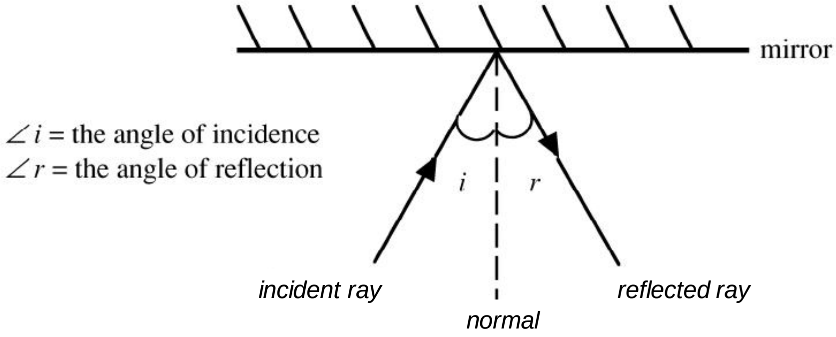

Car headlamps are a source of light which use reflectors.

Visible Light

Visible light is essential for sight. Objects can be seen if they send out light or reflect light in the direction of your eye. An object which gives out light is called a source.

Reflection of Light

The diagram below shows the path of a ray of light when reflected off a plain mirror.

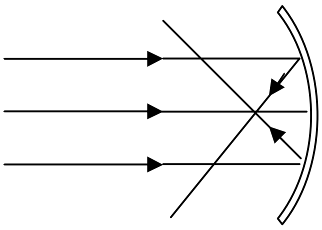


The normal is an imaginary line at right angles (90^o) to the surface.
The normal is used as a reference for measuring angles.

The angle of incidence is always equal to the angle of reflection.


Curved reflectors of solar collectors face the sun capturing sunlight.

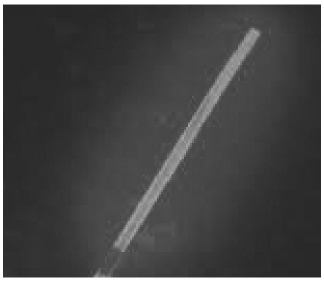
Curved reflectors rely upon reflection to bring rays of light to a focus as shown opposite.
Sometimes curved reflectors are used to send out light in a straight line, for example in car headlamps.



Optical Fibres

Optical fibres, thin glass fibres through which light travels, make use of an effect called **total internal reflection**.

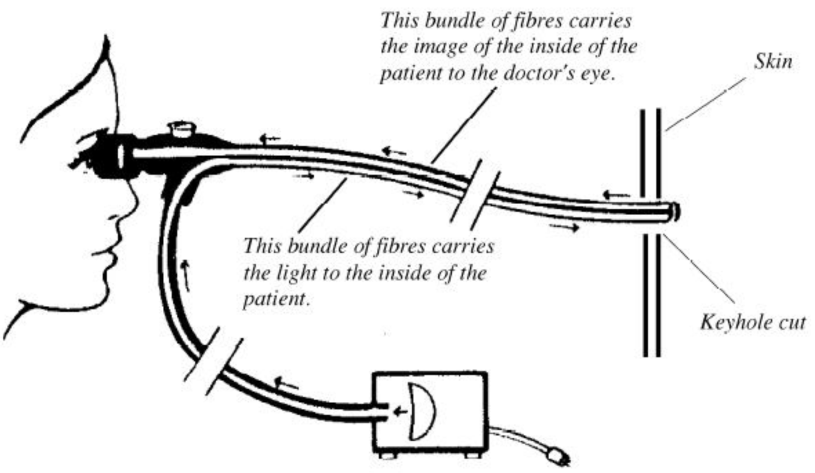
If light enters a very narrow glass fibre at a large angle it will reflect and none of the light will escape. If you bend the fibre this will still happen. This is why optical fibres are used in both medicine and telecommunications.



Lasers and optical fibres are often used together. Why ?

The Fibrescope

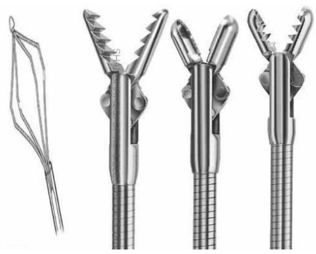
Optical fibres are put to use in fibrescopes, sometimes called endoscopes which are used to view inside the body. An endoscope consists of two bundles of very thin glass fibres. One bundle carries light down inside the patient using total internal reflection. The second bundle carries light back up to an eyepiece or camera, using total internal reflection, which provides the doctor with a clear view.



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

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.

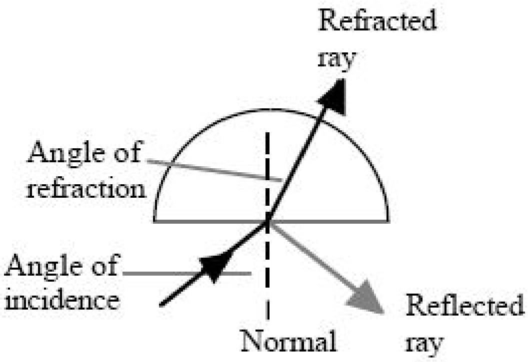
Fibrescopes can be used to investigate the intestines, gut, stomach and upper respiratory tract by passing the endoscope down the patient's throat. It also can be used in "keyhole" surgery, operating through small incisions. Without the fibrescope, the patient would have to undergo surgery. Since surgery is not required there is less damage to healthy tissue and the patient recovery time is shorter.



Small operating tools can be passed down the endoscope to carry out simple procedures remotely.

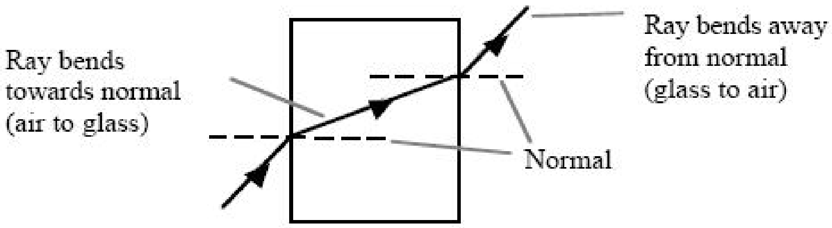
Refraction of Light

When a ray of light passes from one material to another, e.g. air to glass, part is reflected back into air but most of it passes through the material with a change in direction as shown below.

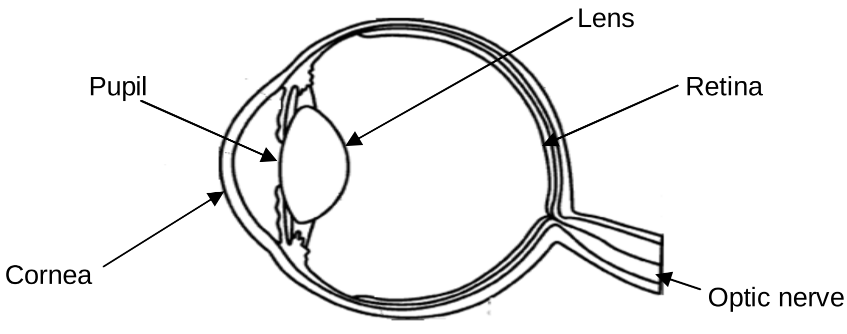


The light is said to be bent or **refracted** as it passes through the glass. This is due to the speed of light being less in glass than in air. The ray bends **towards** the normal.

When a ray of light passes from one material to another and the speed increases then it will bend **away** from the normal.

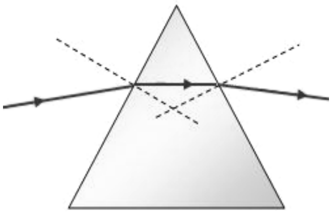


Refraction occurs in our eye. It allows us to see things clearly.

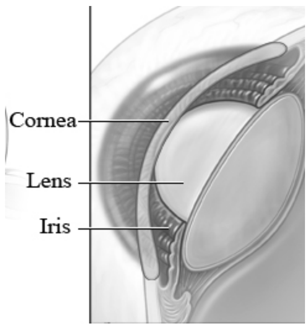


Light refracts when passing through the cornea, which is the clear film at the front of the eye. The light then goes through the pupil and refracts when passing through the lens. This results in the light focussing on the retina where an upside down image is formed.

Refraction though a beaker of water.

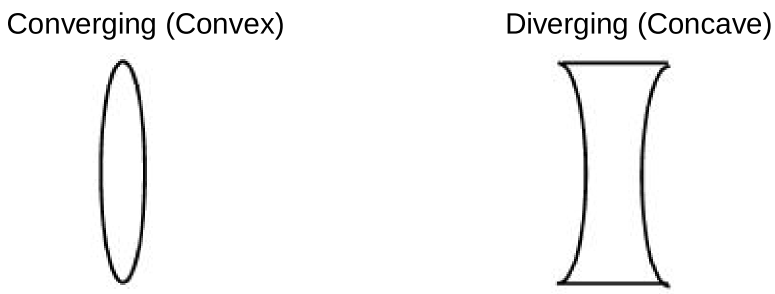


Refraction of laser light through a prism.

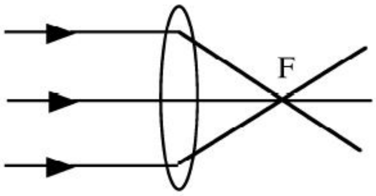


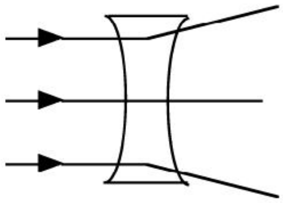
Cross section of the front of the eye.

Lenses



Converging and diverging, as shown above, are the most common lenses.





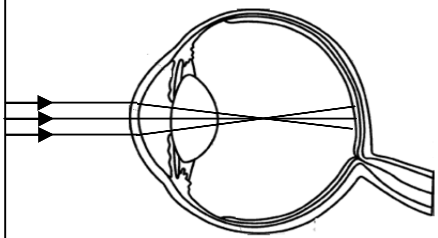
The converging lens brings rays of light to a focus (F).

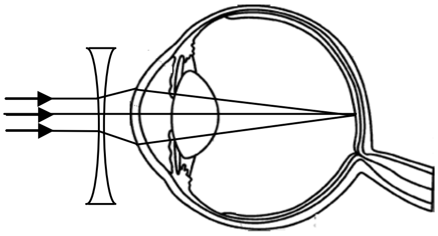
The diverging lens spreads rays of light out.

These lenses can be used to correct eye defects - short sightedness and long sightedness - which prevent light from focussing upon the retina of the eye.

Eye Defects

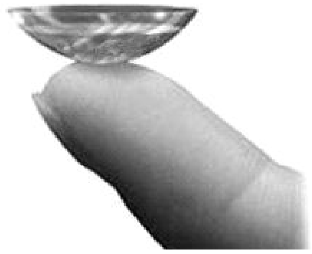
Short Sightedness



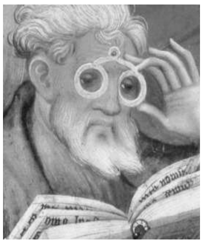


A short sighted eye can focus on nearby objects but cannot see distant objects clearly. The light comes to a focus before the retina.

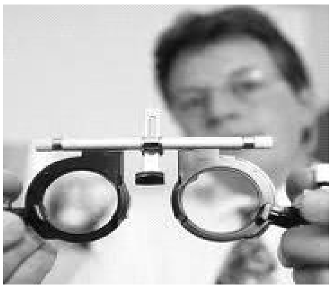
A diverging (concave) lens makes the rays diverge before entering the eye. The light from a distant object now comes to a sharp focus on the retina.



The first contact lenses were used in 1887. They were large, thick and uncomfortable.

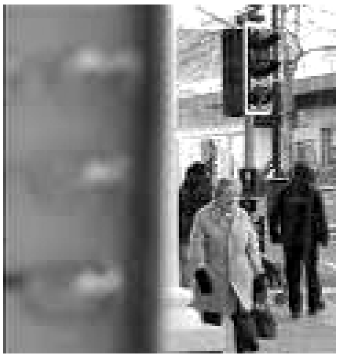


The first glasses were made around 1286 in Italy. They had frames of tortoise shell, ivory, metal or wood.



Opticians use test-glasses when trying to correct eye defects.

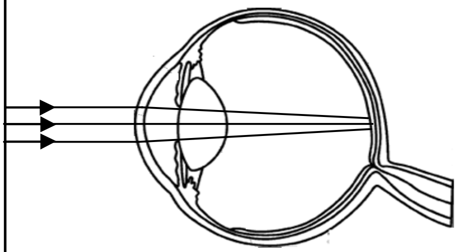
Short Sightedness



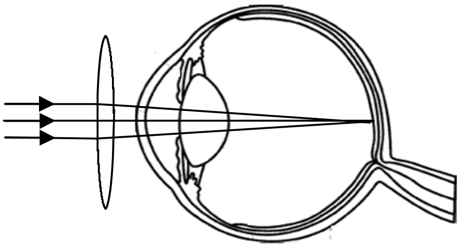
Long Sightedness

Laser "correction" of the cornea.

Long Sightedness



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



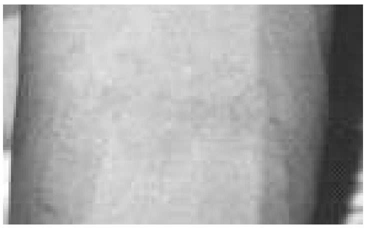
A converging (convex) lens makes the rays converge before entering the eye. The light from a nearby object now comes to a sharp focus on the retina.

Lasers

Sunlight looks white but is made up of many colours combined together. A laser is a source of light that is made up of one single colour (wavelength). A laser is a very narrow beam of light which does not spread out - this means its energy is concentrated into a very small area.

Practical Uses of Lasers

- Lasers are used with optical fibres in telecommunications to send information over long distances.
- Lasers are used to repair damage to the back of the eye. A short pulse from the laser welds the retina back in place. There is no pain as the pulse lasts for a short time.
- Lasers are used to vaporize cancerous tissue and tumours without scarring surrounding healthy tissue.



- "Before" and "After" laser tattoo removal.
- Lasers are used in firearms as a tool to enhance the targeting of other weapon systems.
- Lasers are used in industry to cut metals accurately and to weld together dissimilar metals.

Infrared

Infrared (IR) rays are invisible to the naked eye.
It is not the glow you see from a red hot object like a fire, that is light. You can feel infrared radiation with your skin. Infrared radiation is sometimes called heat radiation.

Infrared digital ear thermometer

Uses of Infrared

- Special cameras called thermal imagers, which can detect infrared, are used to help find people in the dark or in smoke filled rooms.
- In medicine heat photographs called thermograms are used to show up small temperature differences in the body. The different temperatures appear as different colours in the thermogram. Colder areas often mean poor blood supply while warmer areas are often the sign of an infection.
- Physiotherapists use heat lamps, which emit infrared radiation, to heal sports injuries.
- Infrared is used in to dry paint on newly sprayed cars and to bake biscuits.
- Used in remote controls for TVs.

Infrared cameras are used for surveillance by the military, particularly at night.

Ultraviolet

Ultraviolet (UV) radiation is found naturally in sunlight. It is also invisible to the naked eye, but our skin responds to it by turning darker.

Uses of Ultraviolet

- Used to help treat skin conditions. Psoriasis is a severe form of rash which can be treated by chemicals which can harm healthy skin. Ultraviolet radiation shone over the affected areas switches on the chemical only where it is needed.
- Some chemicals fluoresce (glow and emit visible light) when they absorb ultraviolet. Credit cards and banknotes have security markings which cannot be seen in normal light but glow under an ultraviolet lamp.
- Soap powders also fluoresce. This makes your clothes appear very bright and clean in sunlight.
- Dentists use ultraviolet light to set modern white fillings, known as composite fillings.

UV lamps are useful for examining security markings.

A skin scan showing the damage caused by too much UV.

Exposure to Ultraviolet

When the skin is exposed to UV, it becomes tanned. If you spend too long in the sun or exposed to UV, your skin burns. If you keep on exposing your skin to UV over several months or years, you may develop skin cancer. People use sun cream to reduce the amount of UV reaching the skin. These creams are given a “factor “ number, the higher the factor the less UV exposure.

However in recent years, a disease called rickets has re-emerged. Rickets affects bone development in children causing their bones to become soft and weak. It is usually caused by a lack of vitamin D and/or calcium. Vitamin D is produced naturally by your body when your skin is exposed to sunlight. So, children who don't go outside in the sunlight very often or are frequently covered up can develop rickets.

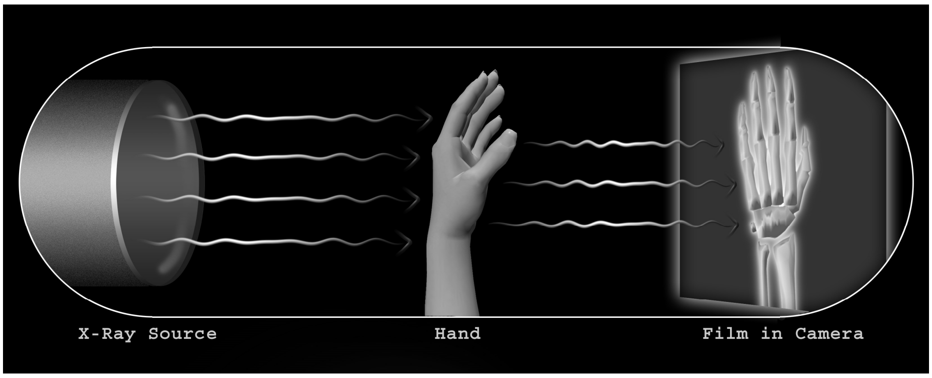
X-rays

In 1895 Wilhelm Röntgen, the German physicist, first detected X-rays.

X-rays are also invisible to the naked eye. X-rays can pass through many materials and this characteristic is put to use in medicine and industry. However X-rays are dangerous, they damage living cells and as such safety precautions must be taken when working with them.

X-rays in Medicine

X-rays are used to either see inside the body or to treat some diseases.



Is this X-ray necessary ?

The most common use of X rays is detecting broken bones. This depends on the fact that X rays pass through body tissues like skin, fat and muscle fairly easily, but are absorbed by bones. When X-rays hit the photographic film on the other side of the patient, the photographic film blackens. And so the image 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 rays reaching it. Any break in a bone lets X-rays through and will show up as a dark line on the film.

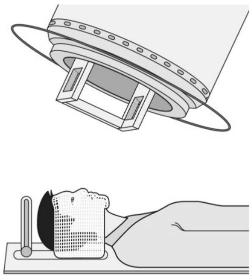
X-rays can also be used to treat people with cancer. In radiotherapy high energy x-rays, produced by a linear accelerator, are directed from outside the body towards the cancer cells within the patient.

This works by destroying cancer cells in the area that's treated. Although normal cells can also be damaged by radiotherapy, they can usually repair themselves.

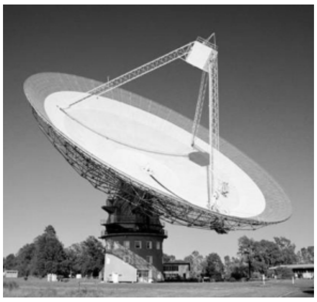
Radiographers and doctors who work with x-rays all day must be protected when they are operating the x-ray machine. They use lead screens to block the x-rays, they stand as far as possible from the machine and they wear special photographic film badges which monitor their exposure.

X-rays in Industry

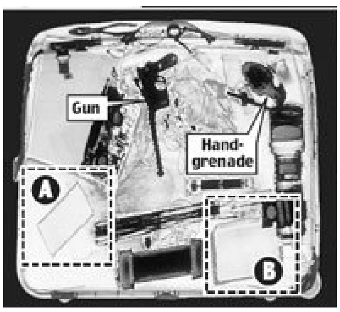
- Thick steel pipes can be made by rolling a steel plate into a cylinder and then welding a seam along the pipe. Although a weld might look perfect it can have Small gaps that weaken it and can be disastrous. X-rays are used to study the weld to make sure there are no cracks. An x-ray source is placed outside the pipe and an x-ray detector is placed inside the pipe. Any cracks in the weld allow x-rays to pass through and show up as darker areas on the detector.
- Many objects in the universe emit X-rays, astronomers detect these x-rays using suitable radio telescopes.
- Airport security checks use x-rays to see inside your luggage.



A radiotherapy mask keeps the head as still as possible during treatment to ensure the right area is treated.



The Parkes Radio Telescope in Australia.



A case passing through airport security.

Gamma Radiation

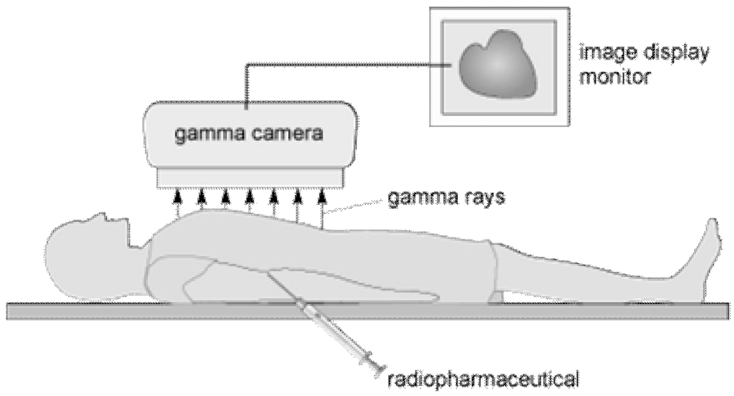
Radioactivity symbol

Like X-rays, gamma rays are invisible to the naked eye. They are also dangerous as they can cause damage to living cells or change how they grow and work. They can also pass through thicker, denser materials. The ability to penetrate materials and to damage living cells can be put to good use.

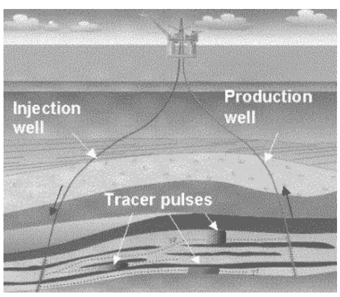
Uses of Gamma Rays

In medicine, doctors often want to follow a particular chemical as it moves through the body to allow them to find anything unusual. They add a radioactive version of the chemical, which contains a gamma source, to the body. As it moves through the body the radioactive chemical can be followed using a detector (gamma camera) outside the body. This chemical is called a radioactive tracer because its path can be traced. The strength of this tracer decreases with time just as the strength of any radioactive (gamma) source decreases with time. In this application doctors have to be very careful the strength does not decrease too quickly or too slowly.

Whole-body bone scan obtained using a gamma camera system.

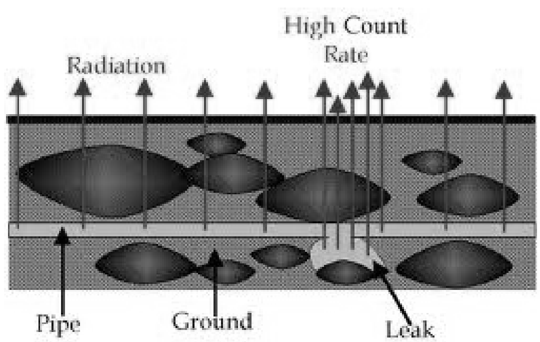


A radioactive tracer injected into the body is used with a gamma camera to image the heart.



Tracer technology is put to use in the oil and gas industry.

In industry the penetrating power of gamma rays is also used to trace materials, often through pipelines. The strength of the source has to be very great so that the gamma rays get through the steel pipes and surrounding ground and its strength usually has to remain high for longer as the pipelines can be very long. It can be used to detect leaks in a pipe (see below).



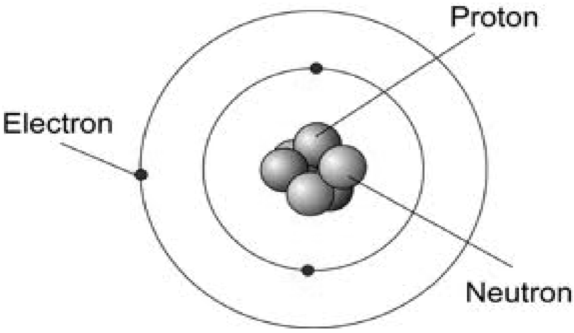
Nuclear Radiation

Atoms

Every substance is made up of atoms. Each element is made up of the one kind of atom, sometimes these atoms are combined together to form molecules. Inside each atom there is a central part called the nucleus. The nucleus contains two particles:

Protons: these have a positive charge
Neutrons: these have no charge.

Surrounding the nucleus are negatively charged **electrons.**



An uncharged atom will have an equal number of protons and electrons. An atom can be drawn as shown above.

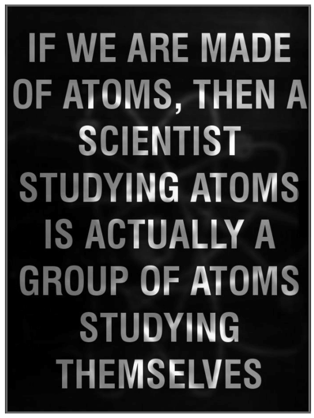
Some atoms have an unstable nucleus. In order to become stable these atoms eject particles and energy from their nucleus. They give out radiation**.**

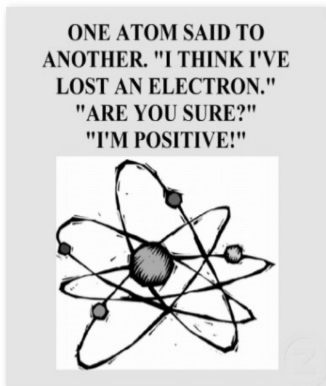
Background Radiation

Background radiation is always present around about us. Everyone is exposed to background radiation from natural and man-made radioactive material. The natural factors affecting background radiation levels are:

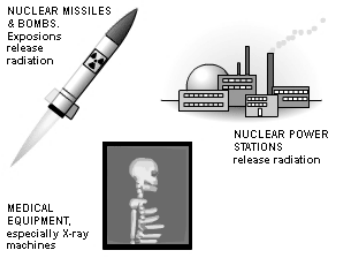
- Rocks and minerals which give off radioactive radon gas.
- Cosmic rays—radiation that reaches the Earth from space.
- Building materials contain radioactive particles.
- Animals all emit natural levels of radiation. The human body contains radioactive potassium and carbon.

Artificial radiation created by human activity also contributes to background radiation levels. These include radioactive waste from nuclear power stations, radioactive fall-out from nuclear weapons testing and radiation due to medical uses.



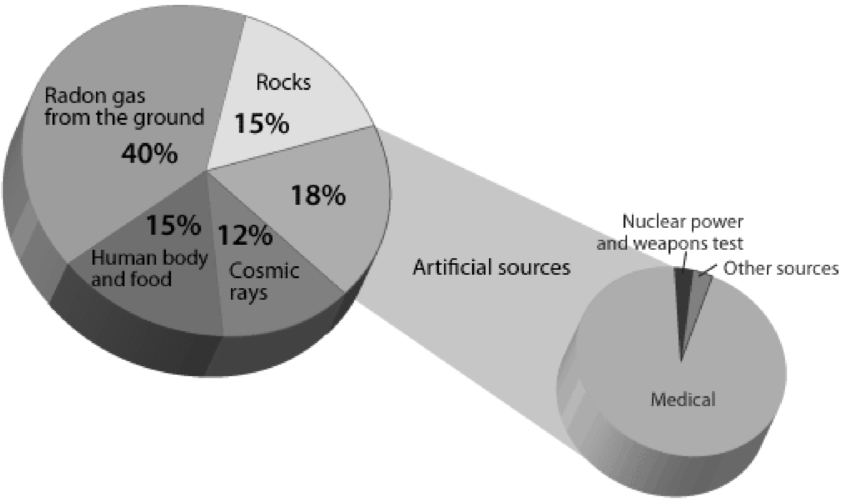


Pitchblende is mined since it contains uranium.



Artificial, manmade, sources of background radiation.

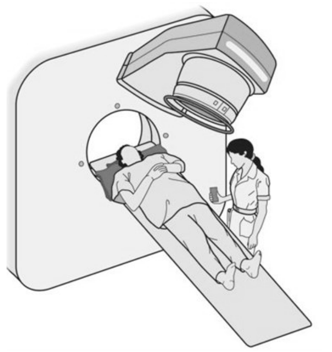
Natural Radiation is by far the greatest influence on our exposure to background radiation, as can be seen in the pie chart below.



Uses of Radiation

Radiation is, of course, dangerous as it can kill or change the nature of living cells. This ability to damage living cells can be put to good use.

Radiotherapy

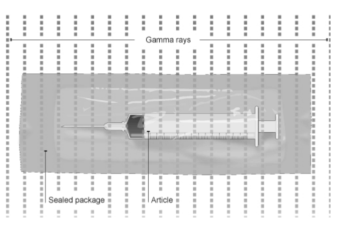


Radiotherapy Machine

Radiation can be used in the treatment of cancer. The radioactive source, cobalt-60 kills malignant cancer cells. The source is rotated around the body centred on the cancerous tissue. This ensures that the cancerous cells receive the radiation at all times but the healthy tissue only receives a limited dose. The healthy tissue therefore is not damaged during the treatment.

Radiation being used to treat a tumour in the brain.

Sterilising Surgical Equipment

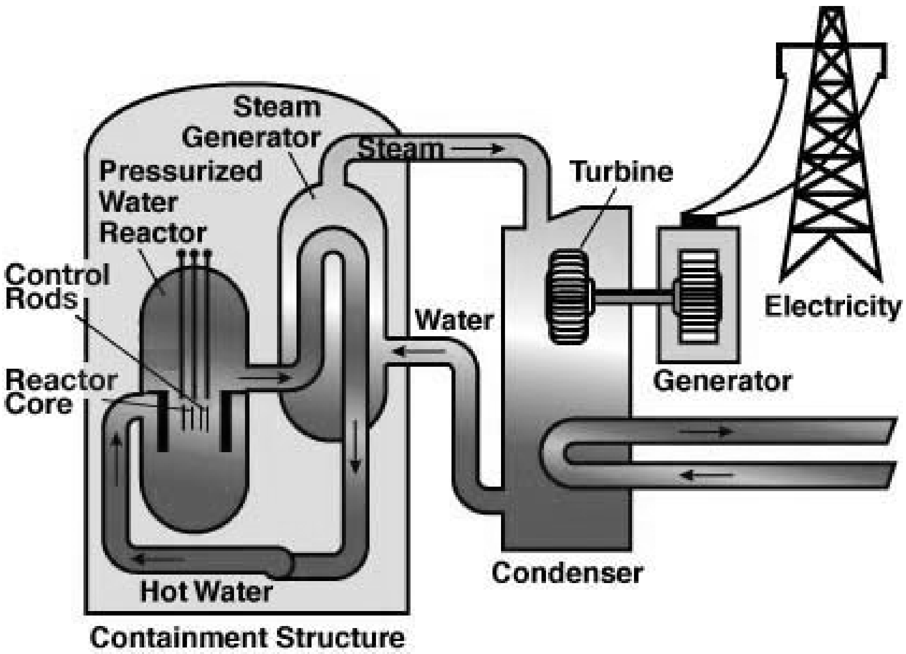


A sealed syringe sterilised with gamma rays.

Gamma radiation is also used to sterilise surgical instruments.

Nuclear Energy

Electricity is generated from nuclear fuel in a nuclear power plant like the one shown below. There are both advantages and disadvantages of generating electricity from nuclear fuel.



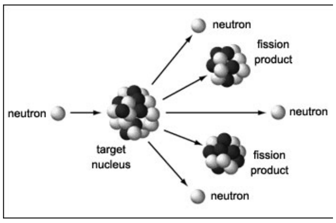
The advantages are:

- Fossil fuels are running out, so nuclear power provides a convenient way of producing electricity.
- A nuclear power station needs very little fuel compared with a coal or oil-fired power station. A tonne of uranium gives as much energy as 25000 tonnes of coal.
- Unlike fossil fuels, nuclear fuel does not release large quantities of carbon dioxide and sulphur dioxide into the atmosphere, which are a cause of acid rain.

The disadvantages are:

- A serious accident in a nuclear power station is a major disaster. British nuclear reactors cannot blow up like a nuclear bomb but even a conventional explosion can possibly release tonnes of radioactive materials into the atmosphere. (The Chernobyl disaster was an example of a serious accident.)
- Nuclear power stations produce radioactive waste, some of which is very difficult to deal with.
- After a few decades nuclear power stations themselves will have to be disposed of.

Nuclear energy - good or bad ?



Nuclear fission reactions, shown above, takes place in the nuclear reactor.

Countries with nuclear power can develop nuclear weapons.

Safety

As radiation can damage living cells it is important to follow safety procedures:

- Always use forceps or a lifting tool to remove a source.
- Always direct radiation away from the body.
- Never leave a source unattended.
- After an experiment, wash hands thoroughly.
- In the U.K students under 16 may not handle radioactive sources.