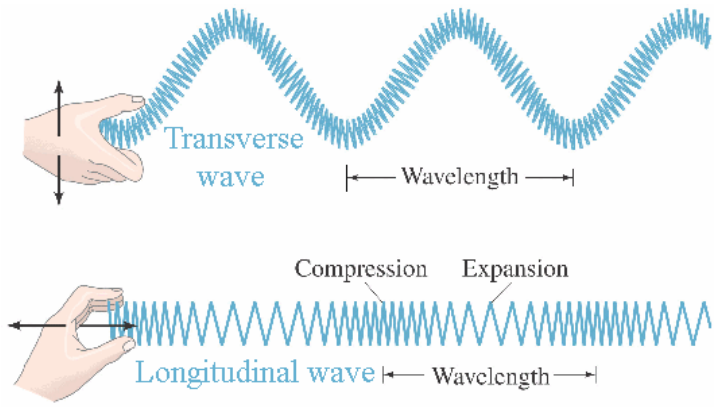
# Physics in Action - Light  Junior Science

What is light?

Light is a form of energy that we can see and is given out by hot objects. It is made up of waves that travel outwards from a light source. Some of the waves reach our eyes, but most continue elsewhere.

Waves can be transverse or longitudinal

The two main types of waveform are transverse waves and longitudinal waves. All types of electromagnetic waves, including light, as well as water waves travel as transverse waves. Sound waves travel as longitudinal waves.

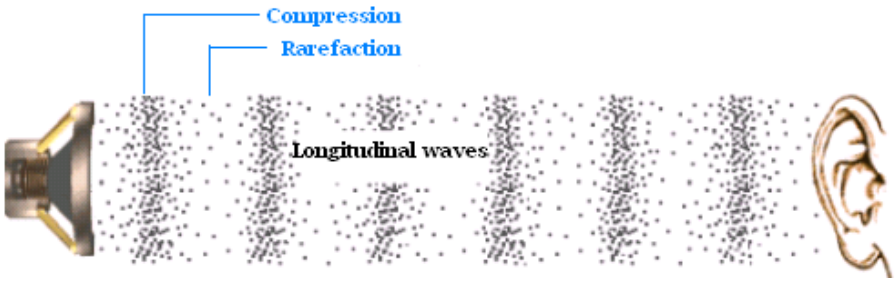



Transverse waves (light) are a moving wave where each part of the wave travels up and down in repeating motion as the wave moves forward. These do not need a medium to travel through and can travel through empty space.

Longitudinal waves (sound) are a compressing and expanding wave that needs a medium to travel in. A medium could be gas, solid or liquid.

Sound travels as a longitudinal wave

Sound waves are mechanical waves requiring particles. (a medium to travel through) Air particles vibrate back and forward creating repeating patterns of high (compressed particles) and low (spaced apart particles) pressure. Sound travels in the form of longitudinal waves. One wave stretches from one compressed area of particles to the next. Waves of sound energy travel through air, water or solid.



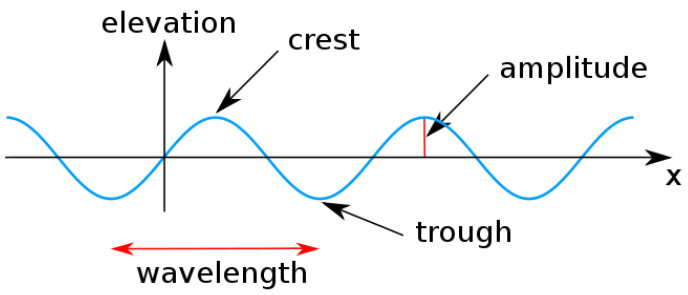

Waves transfer energy

Waves are a means of transferring energy from one place to another  without also transferring matter. Some waves need a medium (matter) to travel through in order to transport their energy from one location to another and are known as mechanical waves, such as ocean waves, sound waves and earthquake waves.

extra info

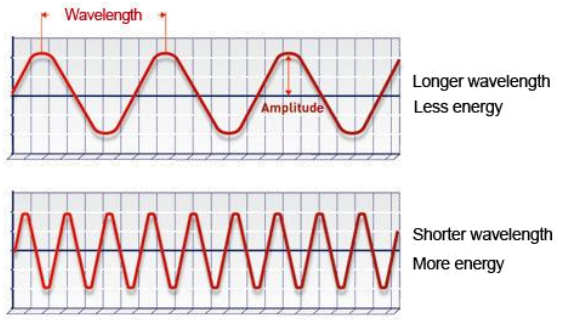
Other waves can travel through the vacuum of space where there is little or no atoms. These are know as electromagnetic waves. Examples of those waves include light waves, microwaves and radio waves.

Features of a wave




Waves have troughs, the lowest point, and crests, the highest point. A wavelength is the distance between two closest crests. The amplitude of a wave is a measure of its height. The height is taken from a midpoint between a trough and a peak up to the top of a peak of a wave.

Frequency of a wave



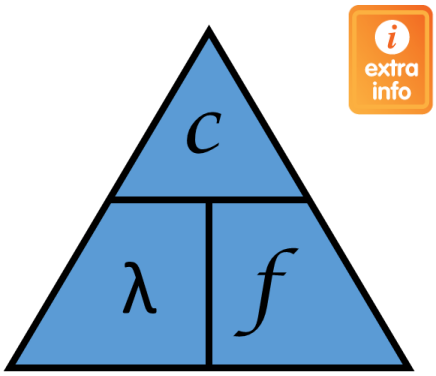

The frequency of a wave is calculated by the number of waves that pass by a fixed point in a given amount of time. The frequency is measured in hertz (Hz). Because all electromagnetic radiation travels at the same speed then more waves of shorter wavelength will pass by a point over the same time as waves of longer wavelength.

wave speed = wavelength x frequency

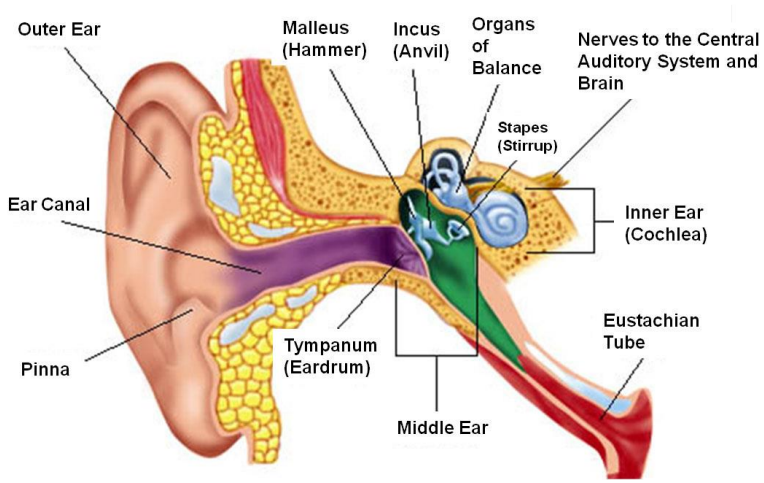
Waves always travel at the same speed. A scientific value that always remains the same is called a constant. The constant for the speed of light is c = $3 \times 10^8$ m/sec or 300,000 kilometres per second.

Because we know the speed of light, if we know either the wavelength (λ) in metres or the frequency (f ) in hertz then we can calculate the other.

Wavelength = speed of light / frequency
Frequency = speed of light / wavelength




Structure and Function of the human ear



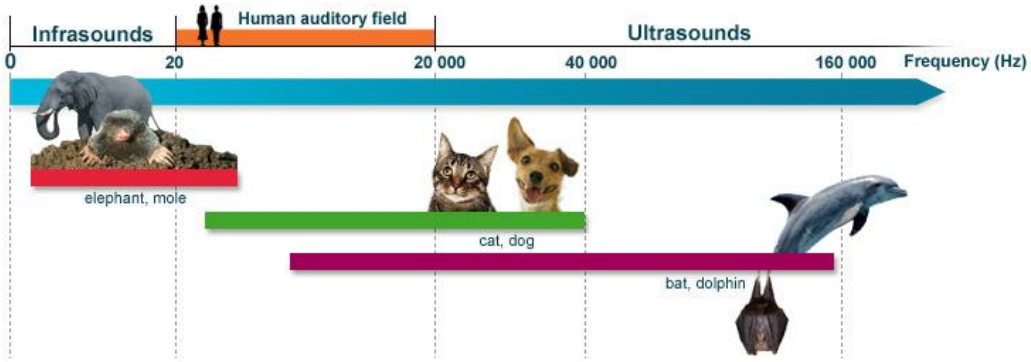

Sound waves travel through the ear canal and cause the eardrum to vibrate. The small bones of the inner ear transfer this vibration to the inner ear cochlea.

The cochlea is fluid filled and lined with many hair-like nerve cells. Different length nerve cells detect different wave frequencies and transmit this information to the brain using electrical impulses that move along the nerves.

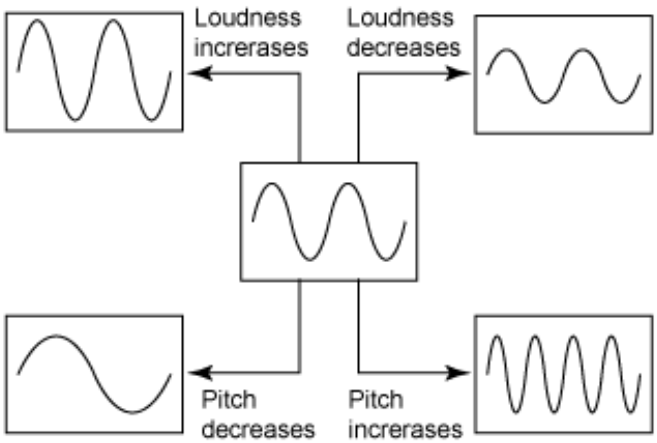
Audible range of humans and other animals

Humans can hear between 20 – 20,000 Hertz, a measure of frequency.  The frequency of a wave is calculated by the number of waves that pass by a fixed point in a given amount of time.

In comparison to many other animals, humans have a very limited audible range. Bats and dolphins can hear and produce sound at an exceedingly high frequency – and use it to bounce back off objects as sonar to "see" without light. Low rumbling noises of elephants and moles are below our auditory range but can travel long distances.



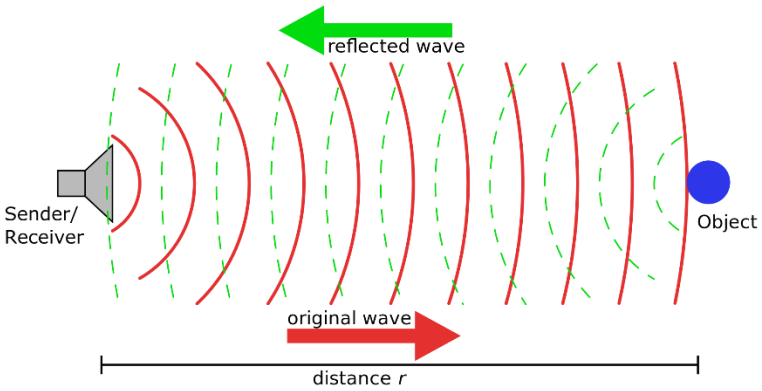

Pitch and Loudness of sound



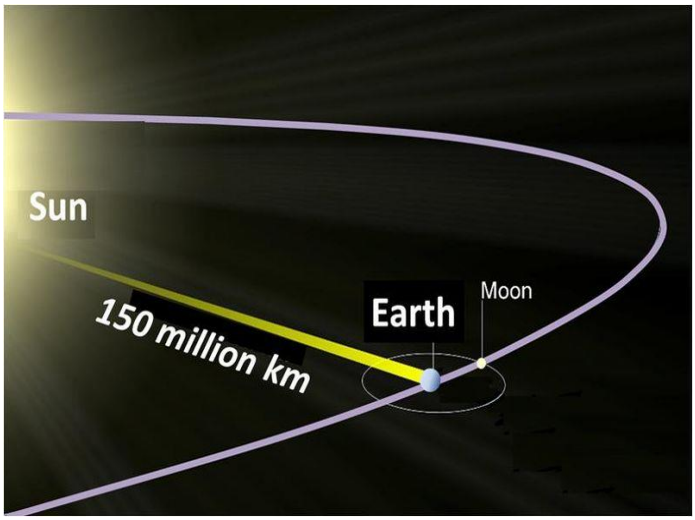

Sound can be described by "characteristics" called pitch and loudness. Pitch is related to frequency – the higher the frequency then the higher the pitch of the note (a single sound at a particular level). Loudness is related to amplitude – the higher the amplitude the louder the sound.

Reflecting sound waves

Sonar (originally an acronym for SOund Navigation And Ranging) is simply making use of an echo. When an animal or machine makes a noise, it sends sound waves into the environment around it. Those waves bounce off nearby objects, and some of them reflect back to the object that made the noise. Whales and specialized machines can use reflected waves to locate distant objects and sense their shape and movement.



Light energy can travel as rays




Light travels fast and in straight lines.

At the speed of light, which is 300,000 kilometers per second, light from the sun takes about 8 minutes to travel 149 million kilometers to earth. Light can go around the earth 7 times in one second. Light travels straight, until something bends it. The straight paths of light are called light rays.

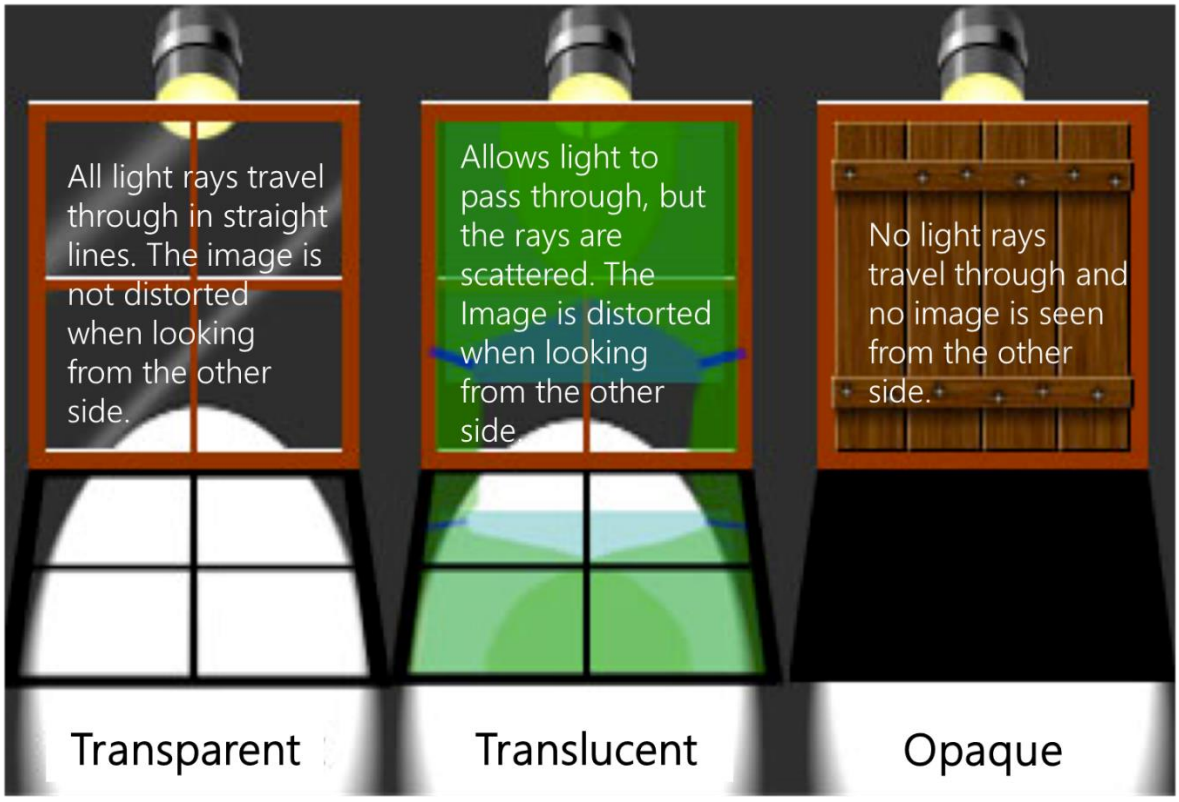
Light energy can be reflected, refracted or dispersed

Light travels in a straight line until it strikes an object or a force. Light can be:

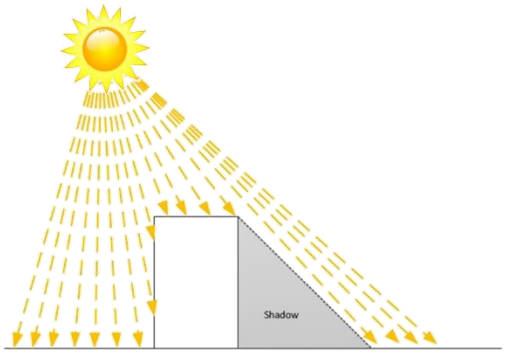
1. Reflected by a mirror
2. Refracted by a lens
3. Absorbed by the object

Light interacts with matter by transmission (including refraction) which is travelling through it, absorption where it enters but doesn't leave again, or scattering (including reflection) where it bounces off. To see an object, light from that object— emitted by or scattered from it—must enter the eye.

Transparent, Translucent and Opaque



Shadows are created when light rays are stopped



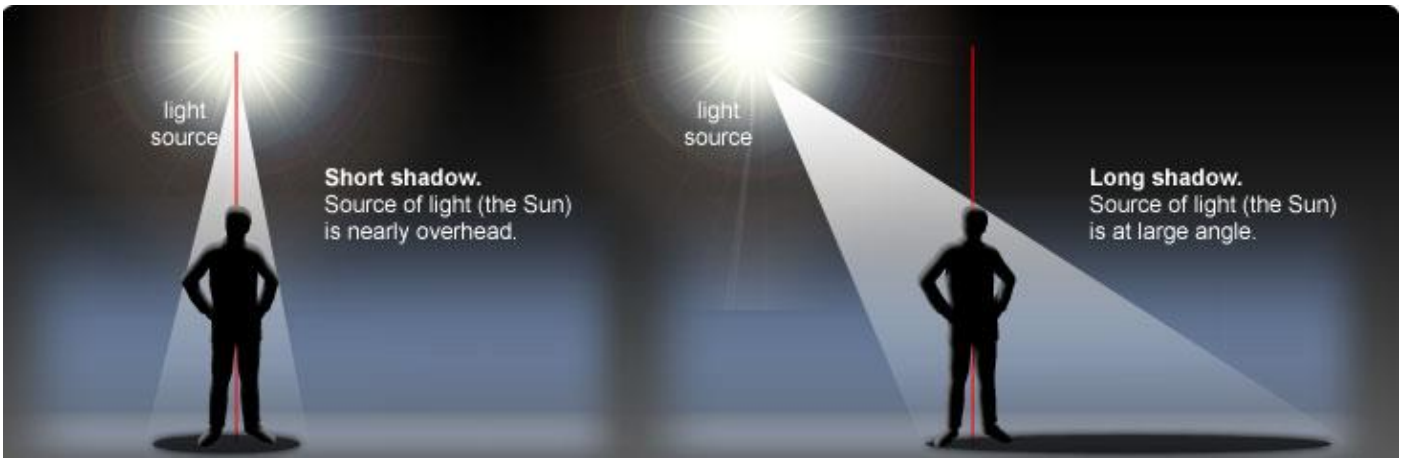

A shadow is a dark area that is formed due to light travelling in straight lines which opaque objects block. An object that stops direct light rays creates a shadow. The shape of the shadow resembles the shape of the object.

The shadow created when the Moon blocks the light from the Sun to the Earth is called a solar eclipse.

The length of the shadow depends on the angle of the light source

The length of the shadow formed on the ground depends on the angle that the light rays hit the object blocking the light. If the light rays hit the object straight on then this will create the smallest possible shadow. The greater the angle the light rays hit the longer the resulting shadow.

The changing of length of shadow can be seen as the Sun moves across the sky. In the morning and afternoon the shadows created are the longest as the Sun is at the greatest angle. The shortest shadows are formed at midday when the sun is directly over head (in Summer).




Sources of light and reflectors of light

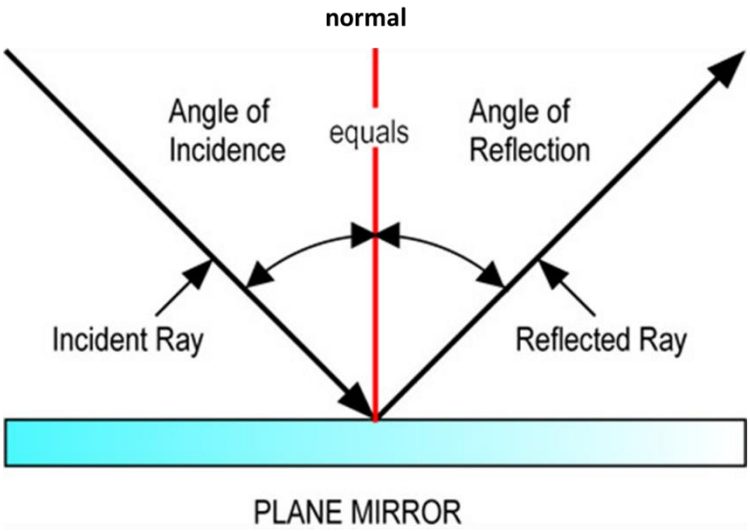
Light is a form of energy. The Sun is our most important source of light, which is produced along with heat energy, that is transformed from matter during a nuclear reaction. Other sources of light energy such as electrical lighting, fire and the glow from bioluminescent animals are produced during energy transformations as well. Light sources need energy to be transformed to produce light. These are also called illuminators.

Objects that appear to produce light such as the Moon or shiny objects but do not use energy are reflectors of light. Light rays must originally come from a light source, such as the Sun's light reflecting off the moon.

Ray diagrams in a plane mirror

Ray diagrams are used to show an image of an object reflected in a mirror. Straight lines from the object are drawn towards the mirror. Using the rule from the angle of incidence and reflection the lines are then reflected back. Arrows are used on the lines to show the light rays direction.

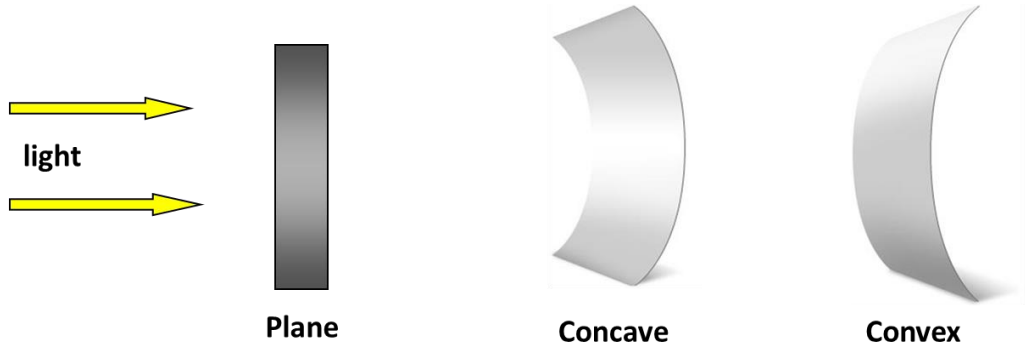
The main rule for mirrors is that the angle of incidence equals the angle of reflection.




This means that the angle of the light ray between where it arrives and the perpendicular line called the normal, to where it hits on the surface of the mirror is the same angle it leaves and the same perpendicular (normal) line.

Convex and concave mirrors

Mirrors work because light is reflected from them. The three types of mirrors are:




The images in the plane mirrors are the same size, the right way up but laterally inverted (changed right to left) and is a flat reflecting surface.

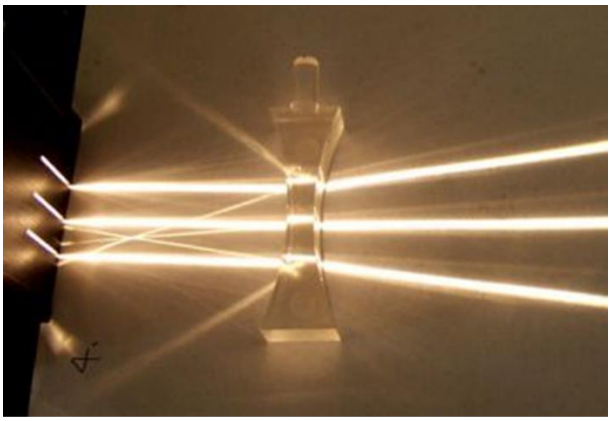
The images in the concave mirror are

a) magnified and the right way up when you are near to the mirror

b) smaller and upside down when you are further away from the mirror

The images in the convex mirror are reduced and the right way up

Light can be Refracted by a lens



A **normal** is a line at right angles to a boundary between mediums

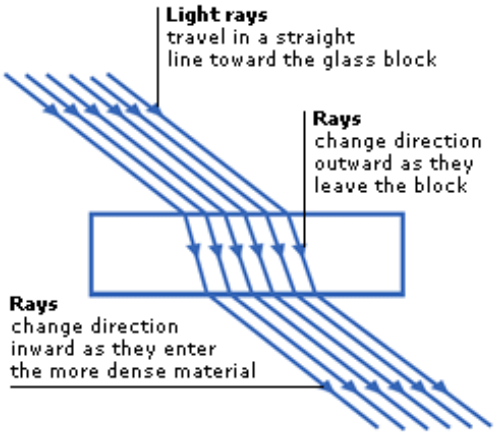
A glass or plastic lens is transparent. This means that light is able to be transmitted through the object without the light being absorbed.

The medium of a plastic or glass lens has a different optical density to air. Light rays entering the lens are refracted to a different angle.

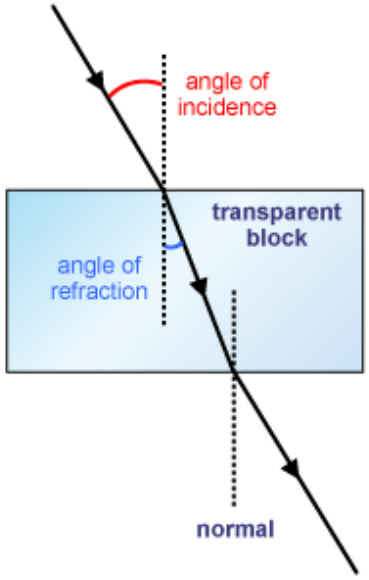
Refraction is when light travels between two optically different (densities) mediums that bend light towards or away from the normal.

## Refraction

A medium is any space or substance which will allow light to travel through it called transmission. Examples of different media include air, water and glass. Each medium has different optical density. The optical density of a medium affects the speed at which light rays travel through. When a light ray passes from one medium into another (e.g. from air into water) it will change direction where two media meet. This 'bending' of light is called refraction and it always occurs when the two media have different optical densities.



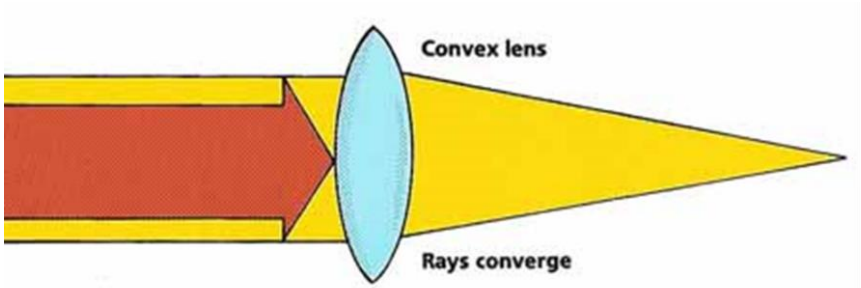

## Refraction in a glass block



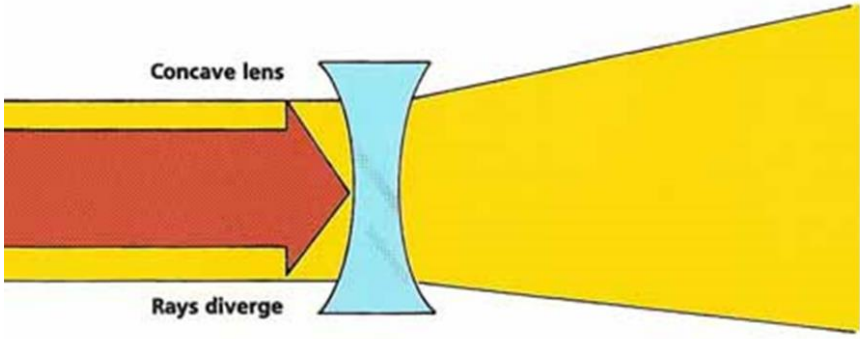

The ray of light bends or refracts inwards when it moves into the glass. This makes the angle of refraction smaller than the angle of incidence.

When the ray emerges from the glass back into the air then it continues on a parallel path to the original ray.

## Concave and convex lens




Lenses that **curve outwards** are known as convex lenses.
When light enters them it refracts inwards once it leaves the lens.



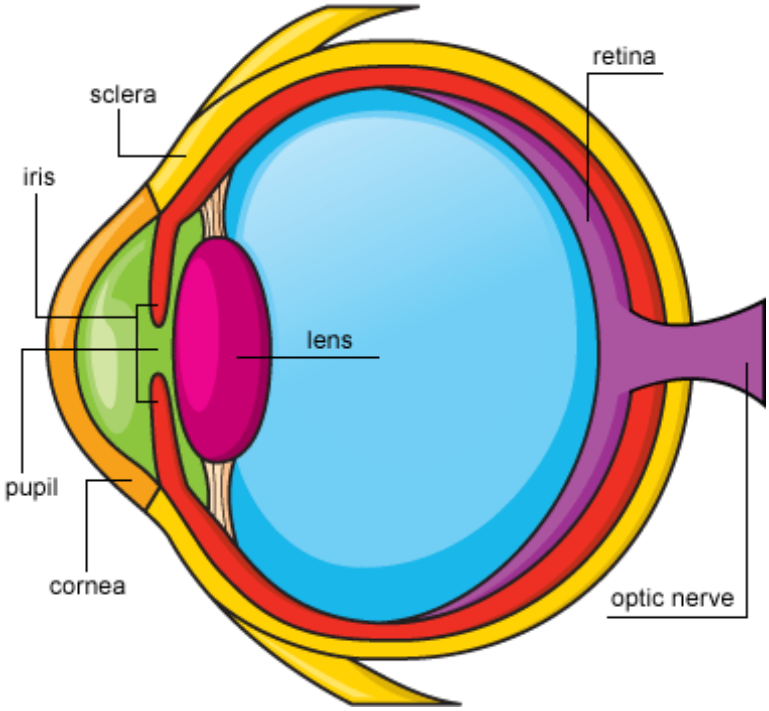

Lenses that **curve inwards** are known as concave lenses.
When light enters them it refracts outwards once it leaves the lens.

Structure of the Human eye

The human eye is a “collecting” organ that allows light to reach sensory nerves which then transmit electrical signals to the brain. The convex lens focuses the images seen onto the retina of the eye. Various sensory cells in the retina called rods and cones detect both amount of light and colour of light.

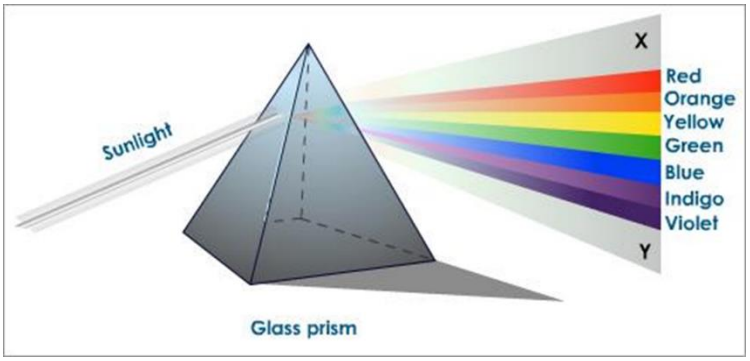
The iris opens to let more light into the eye when it is dimmer. The muscles around the lens change the shape of the lens. The blind spot is the point of entry of the optic nerve on the retina and has no light receptors. The cornea is the tough transparent layer at the front of the eye

Messages from the retina travel through the optic nerve to the brain. The brain further processes the images in various parts of the brain responsible for language, speech and thinking.




Prisms work by diffracting colours of different wavelengths

Light speed changes as it moves from one medium to another (for example, from air into the glass of the prism). This speed change causes the light to be refracted and to enter the new medium at a different angle The degree of bending of the light's path varies with the wavelength or colour of the light used, called dispersion. A prism is a triangular block used to disperse white light. This causes light of different colours to be refracted differently and to leave the prism at different angles, creating an effect similar to a rainbow. This can be used to separate a beam of white light into its spectrum of colours.

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