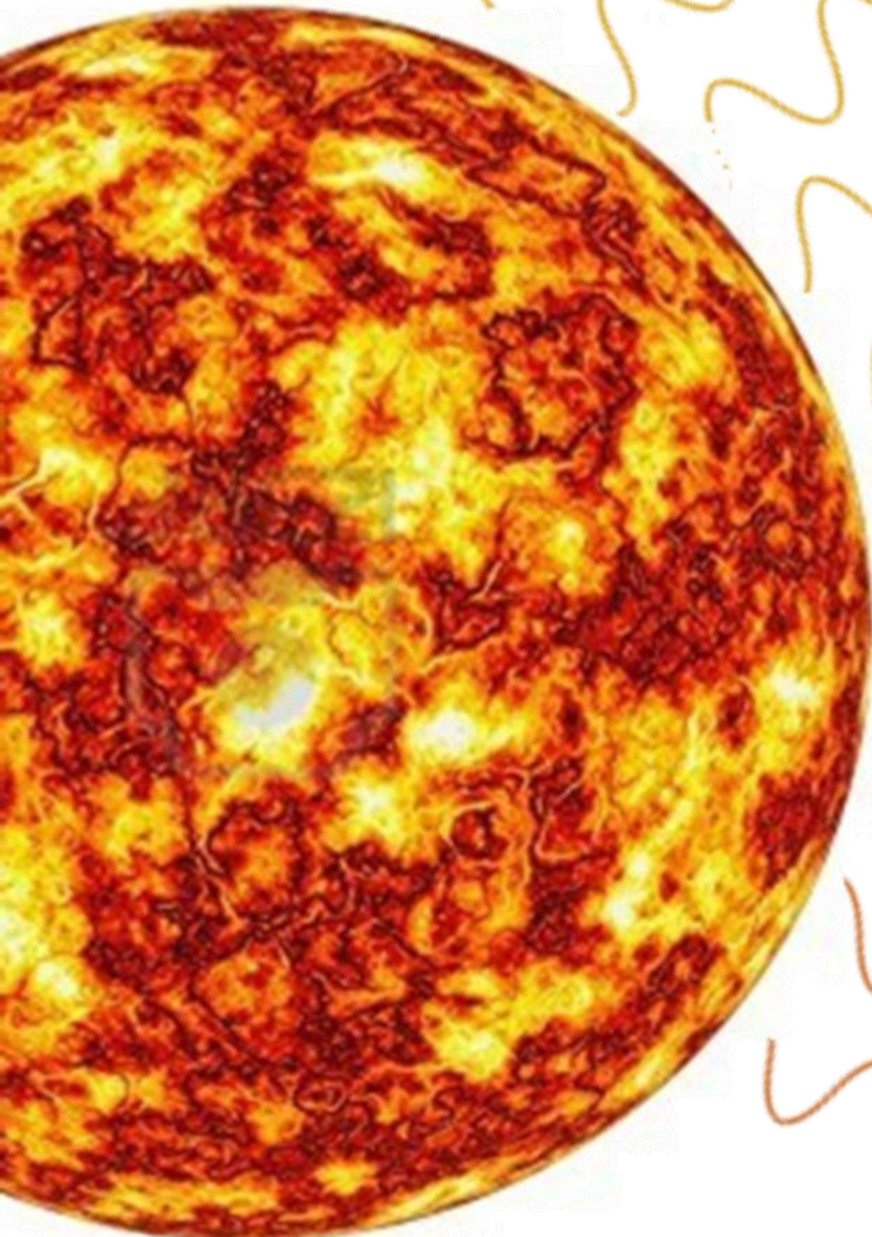
**2019**
Version

# Light and Sound

## Junior Science

GZ Science Resources

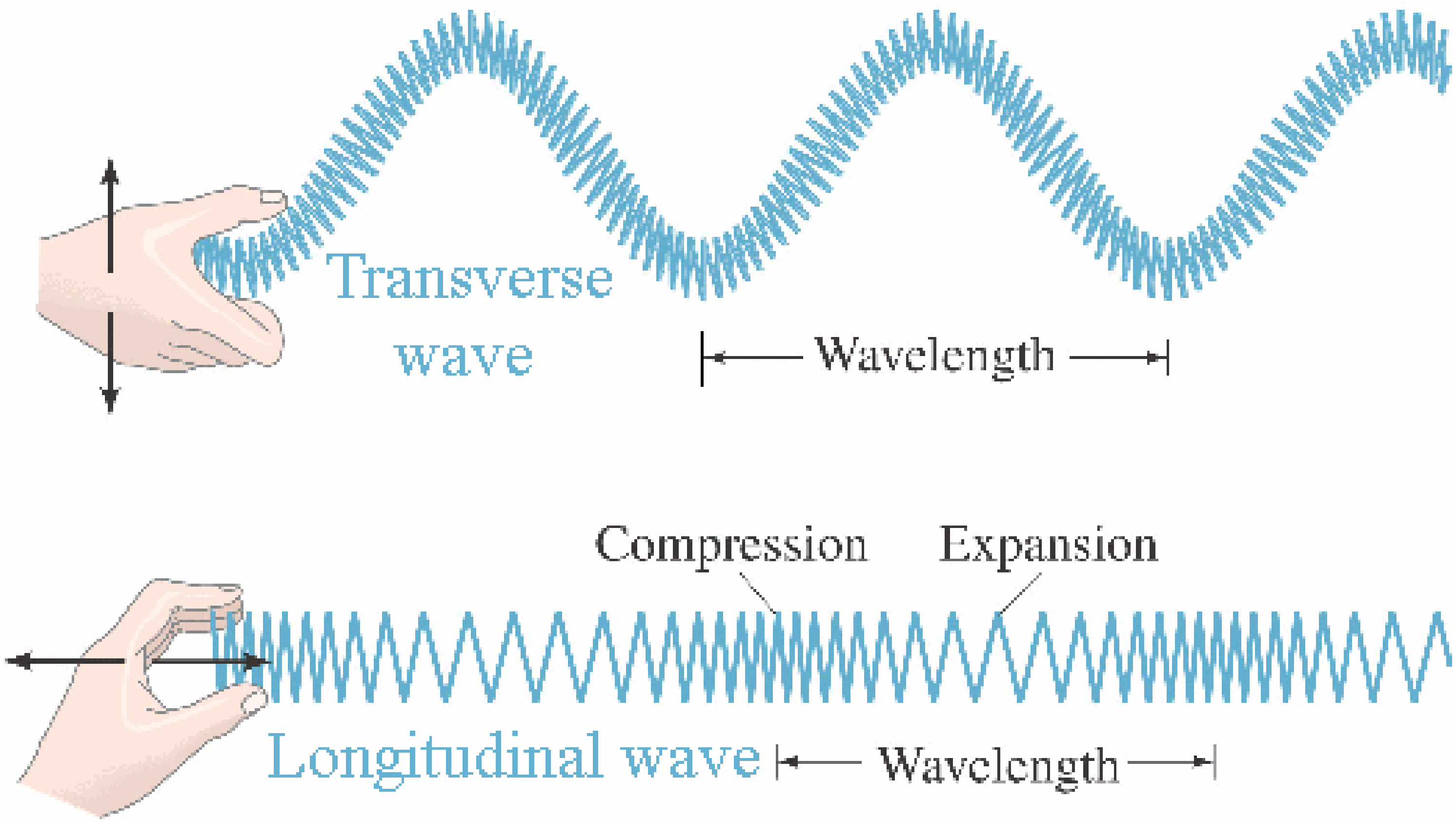
# What is light?



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.

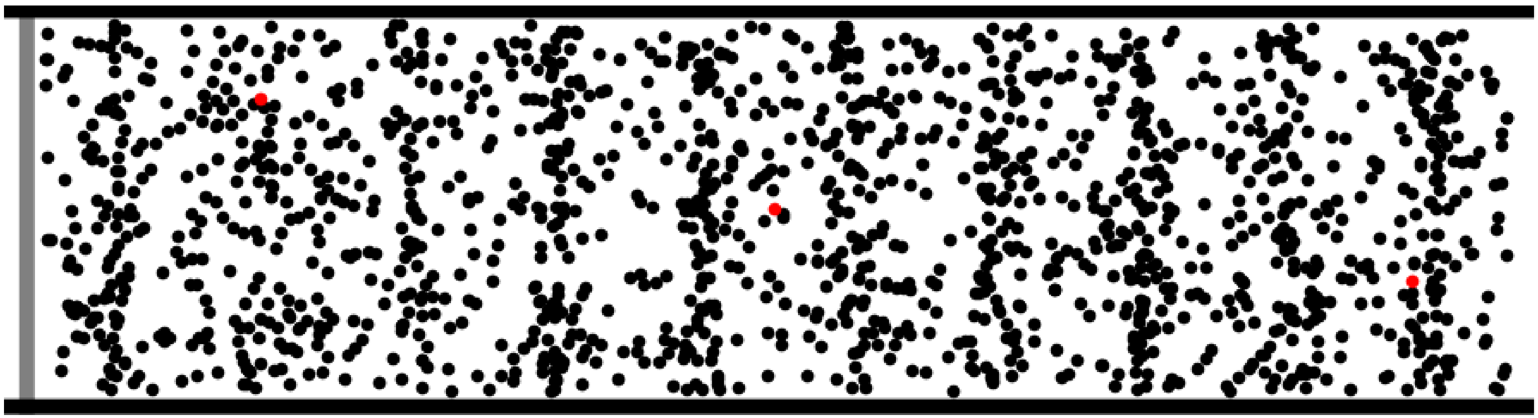
# Waves can be transverse or longitudinal

The two main types of wave form 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.

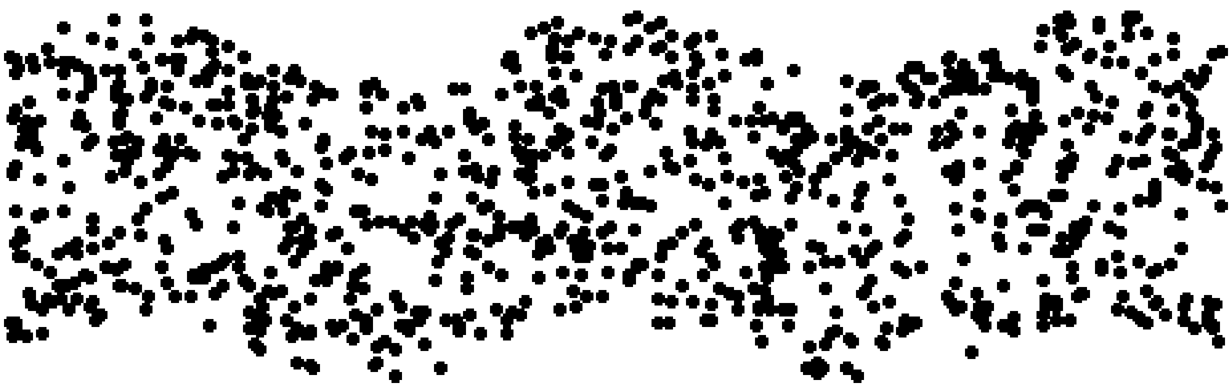


# Particle movement in transverse and longitudinal waves

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

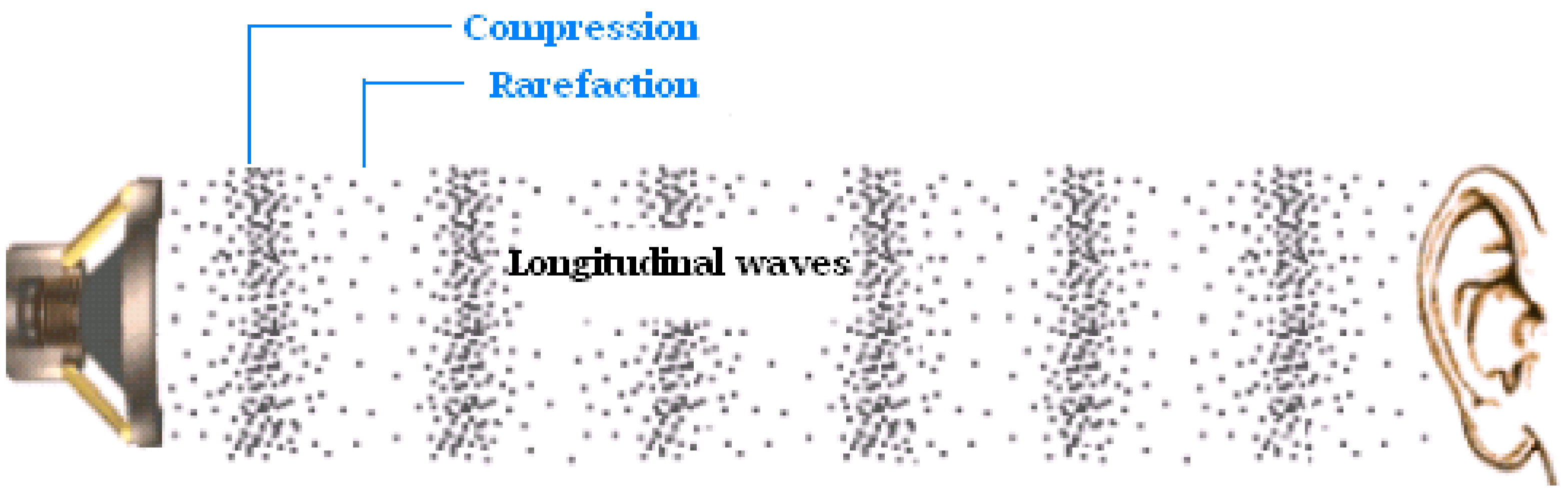



Transverse waves (**light**) are a moving wave where each part of the wave travels up and down in repeating motion as the wave moves forward. These do not need a medium to travel through and can travel through empty space.



# 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 generated from Earthquakes can be transverse or longitudinal

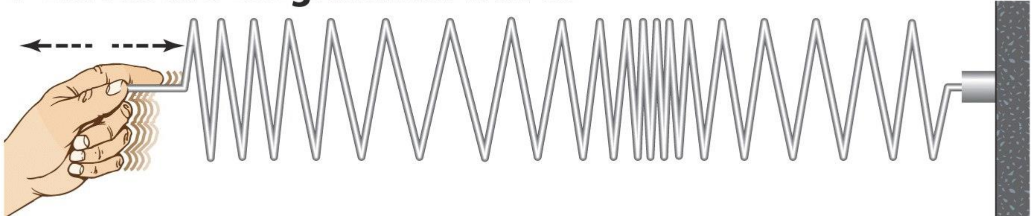
extra info

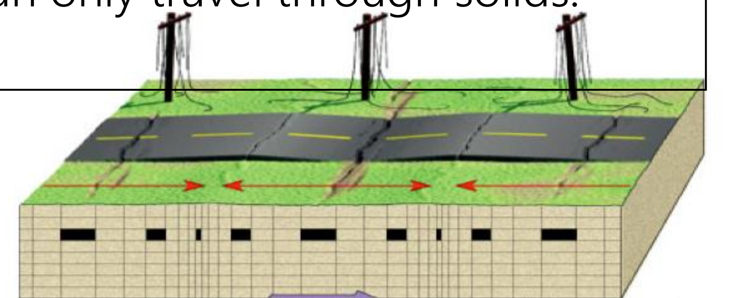
The waves generated from an earthquake travel through the ground as both longitudinal and transverse waves.

**Primary (or P) waves** are longitudinal waves and move the fastest. They are similar to sound waves and can travel at 5000 metres per second through solid rock. Longitudinal waves can also travel through liquid and gas, travelling at the speed of sound through air.

**Secondary (or S) waves** are transverse waves and can only travel through solids. They travel at nearly half the speed of P waves.

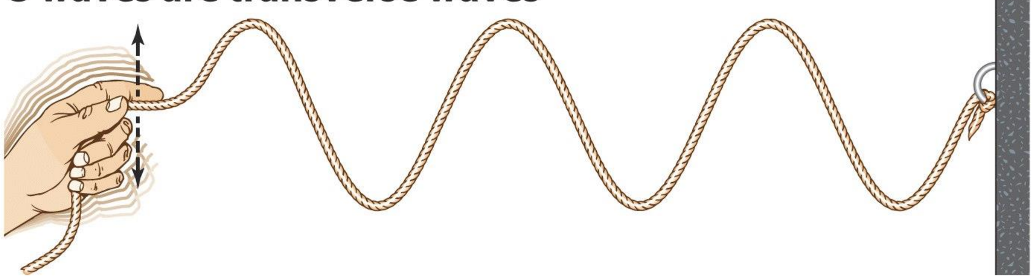
**P waves are longitudinal waves**

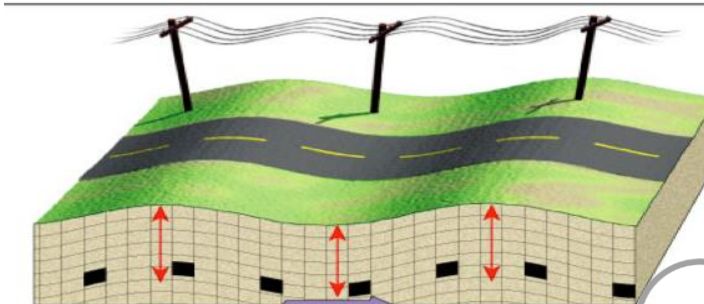




The back-and-forth motion produced as P waves travel along the surface can cause the ground to buckle and fracture.

**S waves are transverse waves**





S waves cause the ground to shake up-and-down and sideways.

# Waves transfer energy



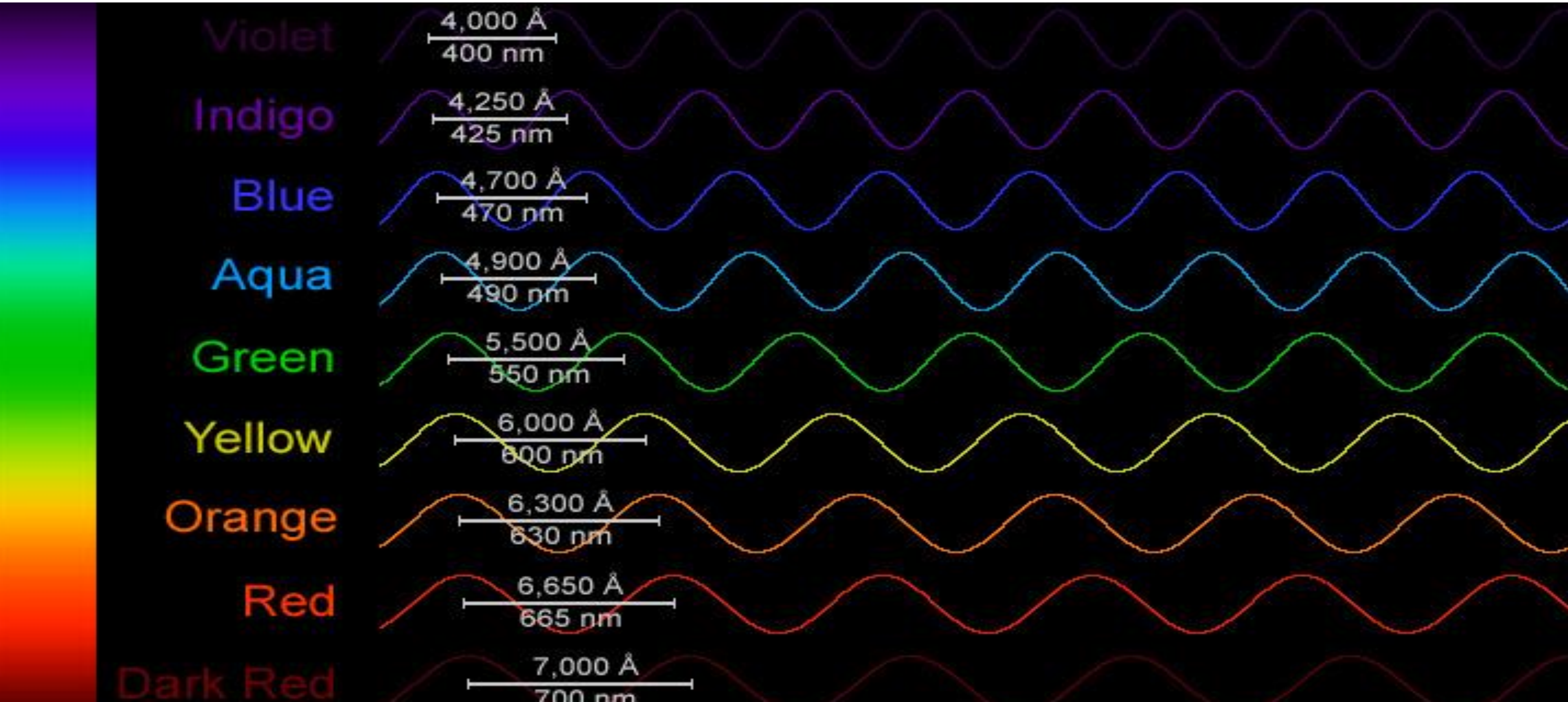
Waves are a means of transferring energy from one place to another without also transferring matter. Some waves need a medium (matter) to travel through in order to transport their energy from one location to another and are known as **mechanical waves** such as ocean waves, sound waves and earthquake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

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.

# Electromagnetic radiation travels as waves

Light and other types of electromagnetic radiation from the sun and even further away stars travel through space in a vacuum – Light does not need matter or a medium through which to travel.

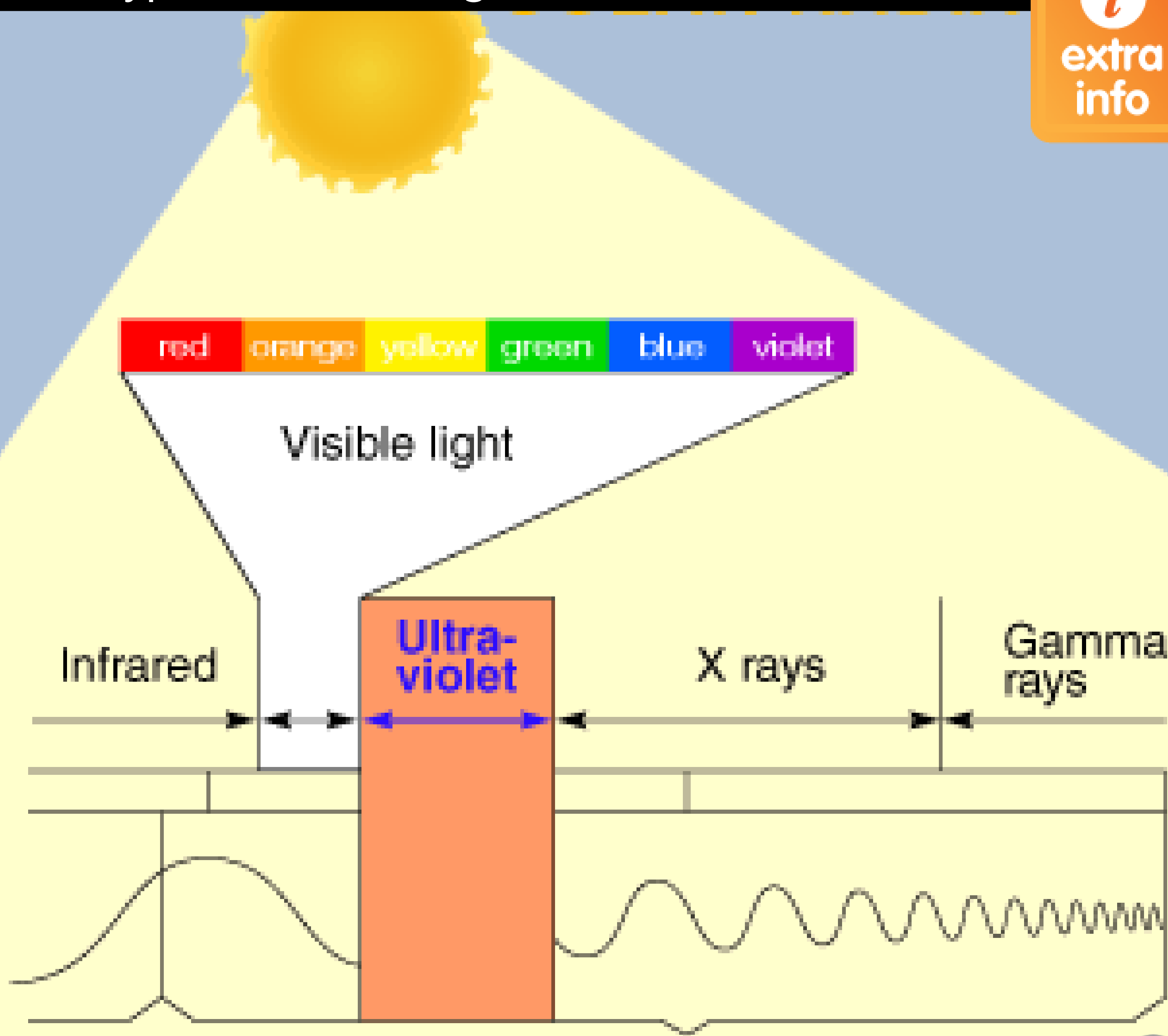
Each particular type of electromagnetic radiation, including each different colour of light, has a unique fixed length of wave, called the **wavelength** (λ), that it travels in.



# Types of Electromagnetic radiation

extra info

Some objects, such as the sun, release large amounts of energy. The energy can be **emitted** from the energy source in the form of **electromagnetic radiation** and travels in **electromagnetic waves.** Light, radio waves and x-rays are all forms of electromagnetic radiation.

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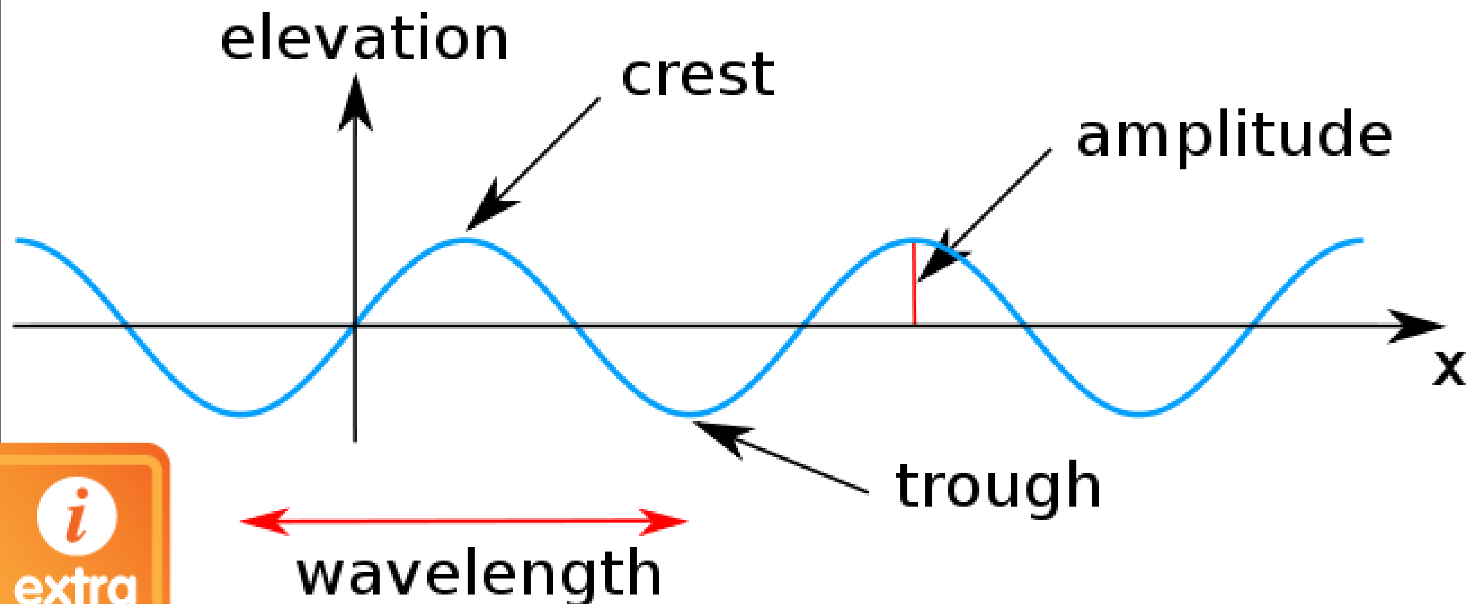
# Features of a wave

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.

A higher amplitude wave indicates a wave has more strength and that a light wave contains more **photons**, little packets of light energy.

extra info



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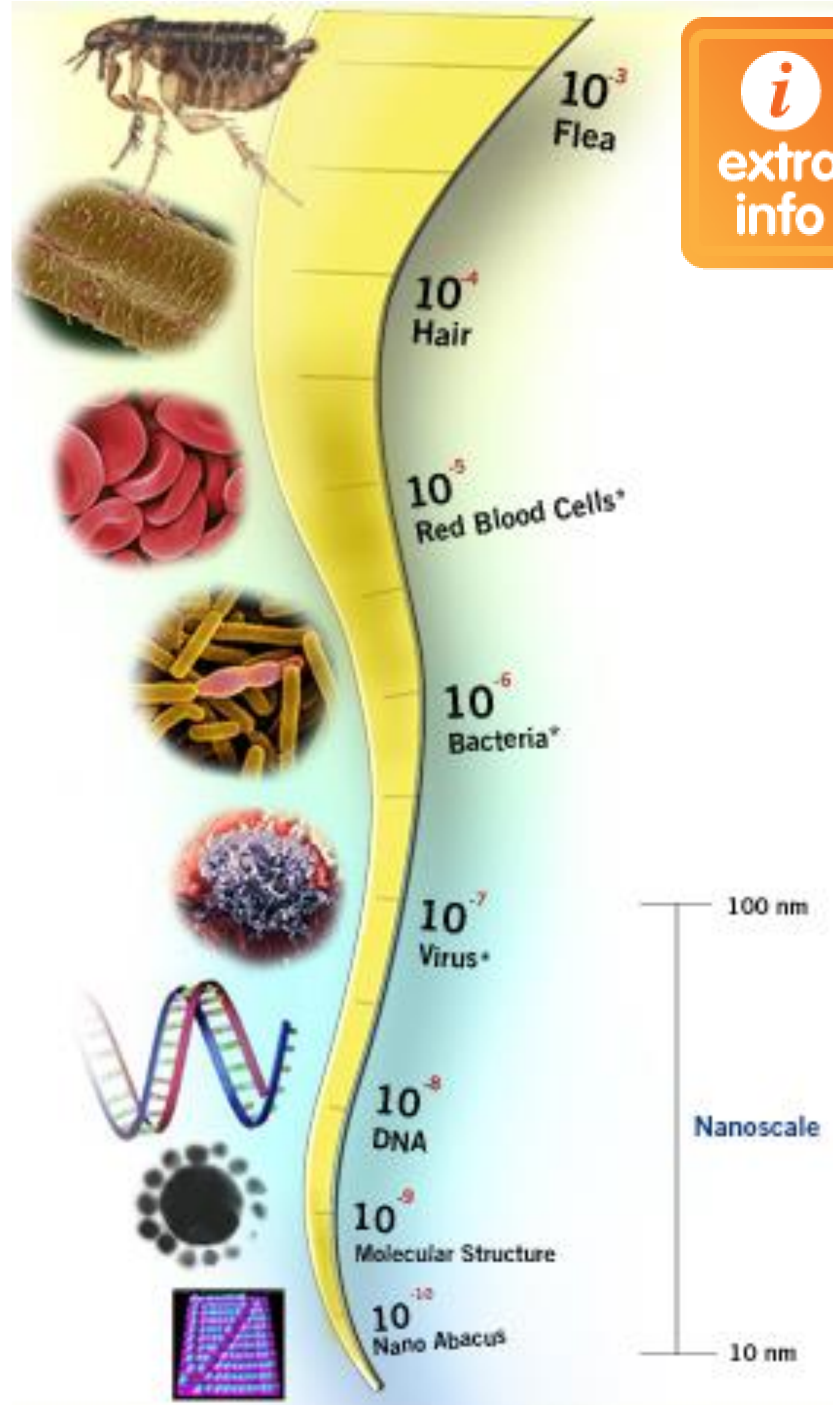
# A nanometre is very small

extra info

Small objects such as atoms, viruses and light waves need to be measured using very small units called a nanometre.

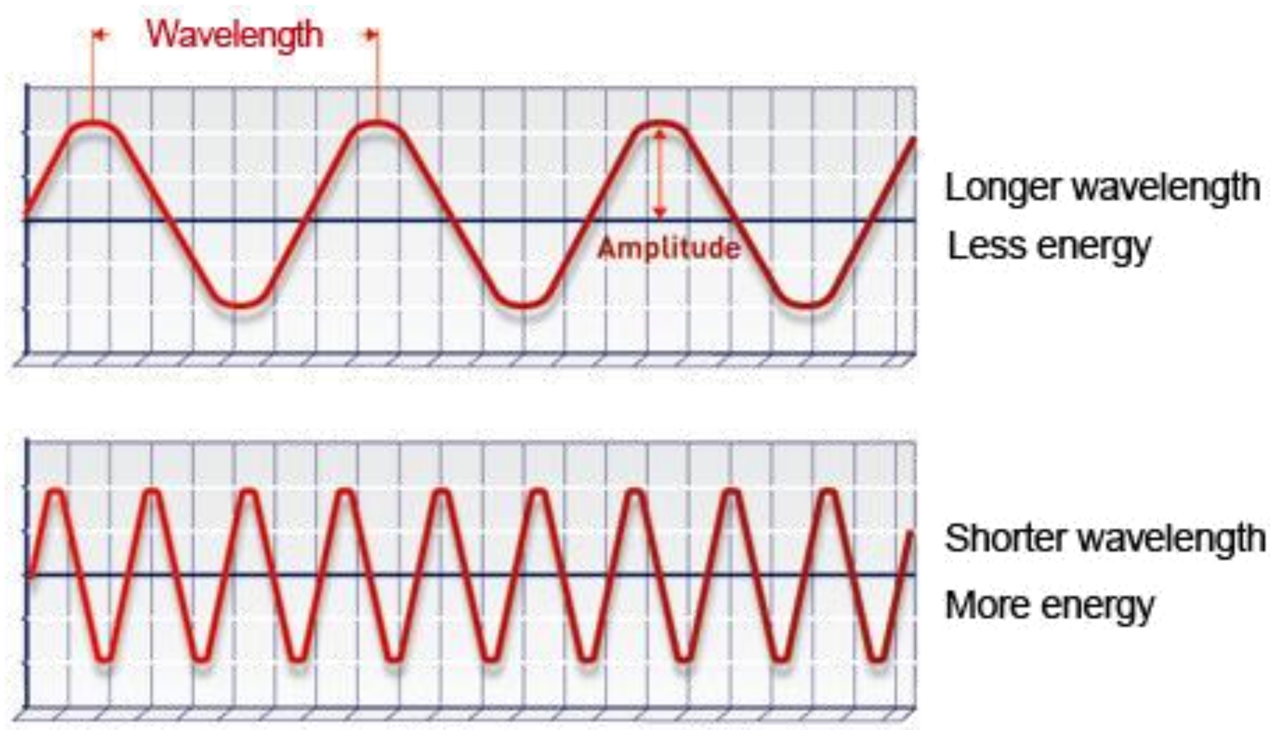
A **metre** (m) can be divided into one thousand equal parts called **millimetres** (mm). If one millimetre is divided into a thousand equal parts then we have a **micrometre (**μm). If one micrometre is divided into a thousand parts then we have a **nanometre** (nm). A nanometre is one-billionth of a metre.

Wavelengths can be measured in metres (m) or nanometres (nm). The type of electromagnetic radiation can be determined by its wavelength.



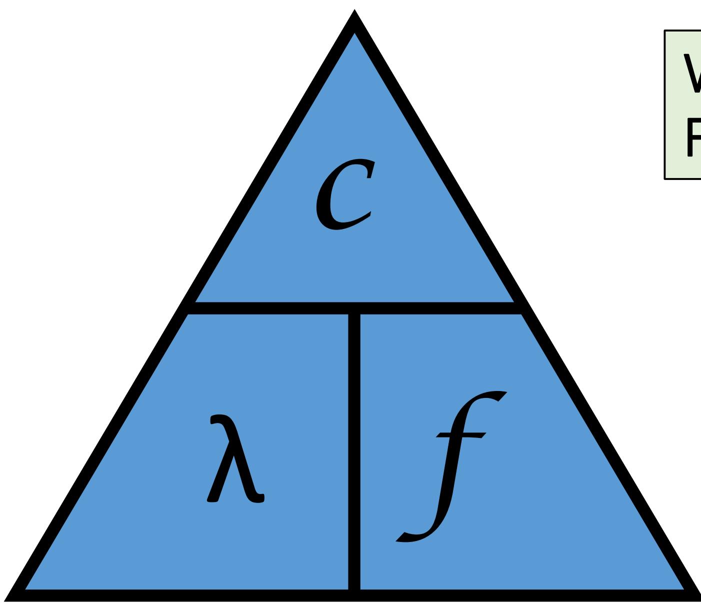
# Frequency of a wave

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.

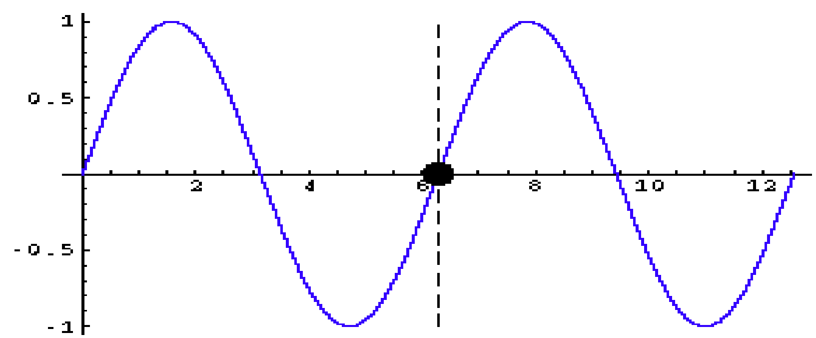


# wave speed = wavelength x frequency

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

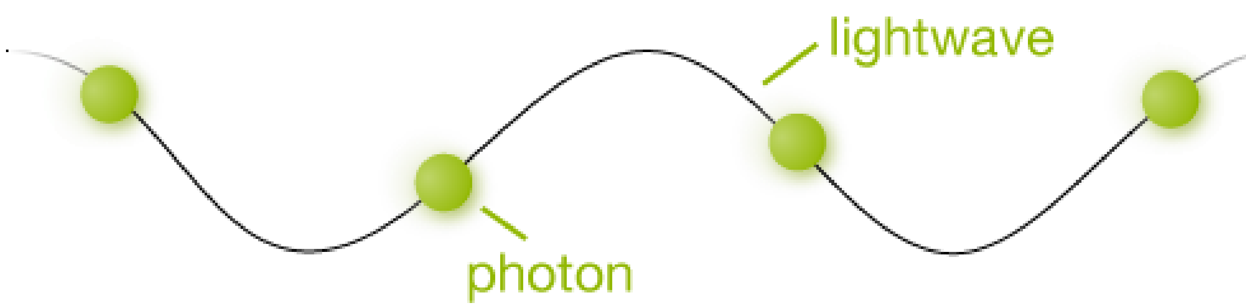


# Light energy is carried by photons

extra info

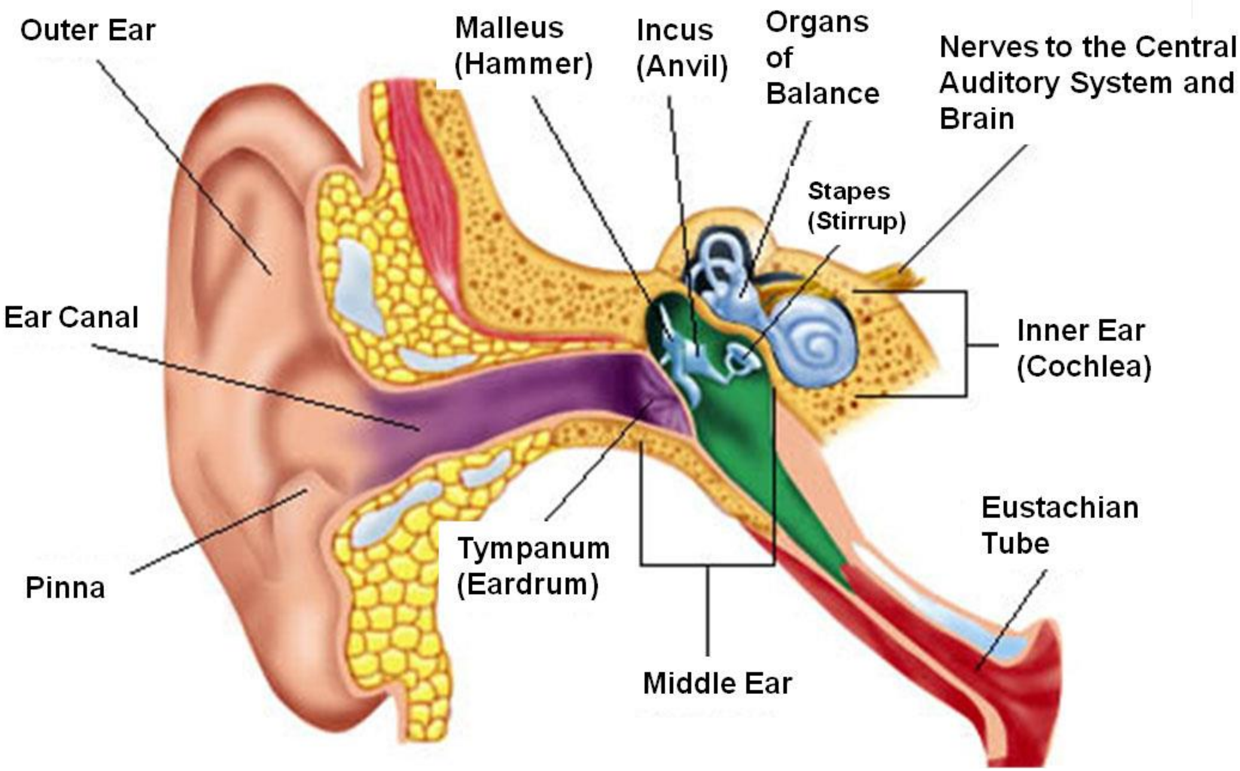
The amount of energy in a wave depends upon the frequency of the wave. The energy of a photon can be calculated by multiplying the frequency by another constant called **Planck's constant** (h). This constant is named after a famous German scientist called **Max Planck** who made many discoveries about light and how it also travels as particles called photons. A photon does not have mass like matter does, it only contains energy.

## Light consists of particles travelling in a wave:




Planck's constant is $6.626 \times 10^{-34}$ joules per second. This value is so small because a photon is so tiny but there are so many of them within a light wave.

# 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.

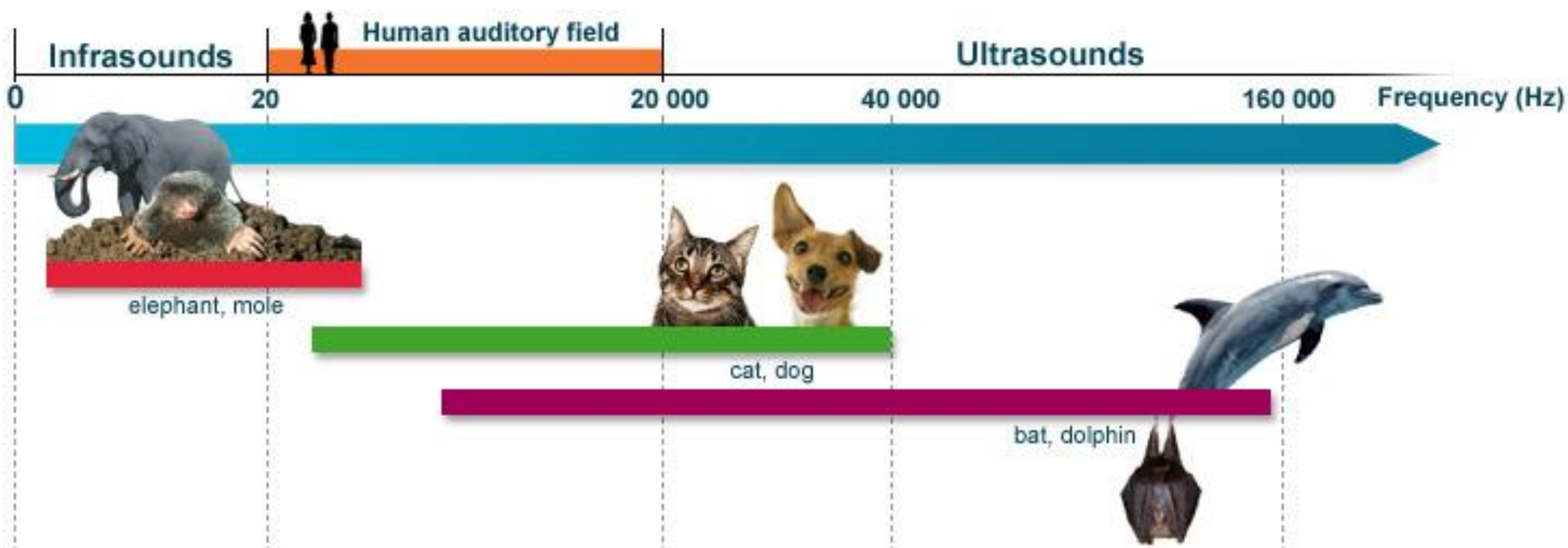
# Audible range of humans and other animals

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.

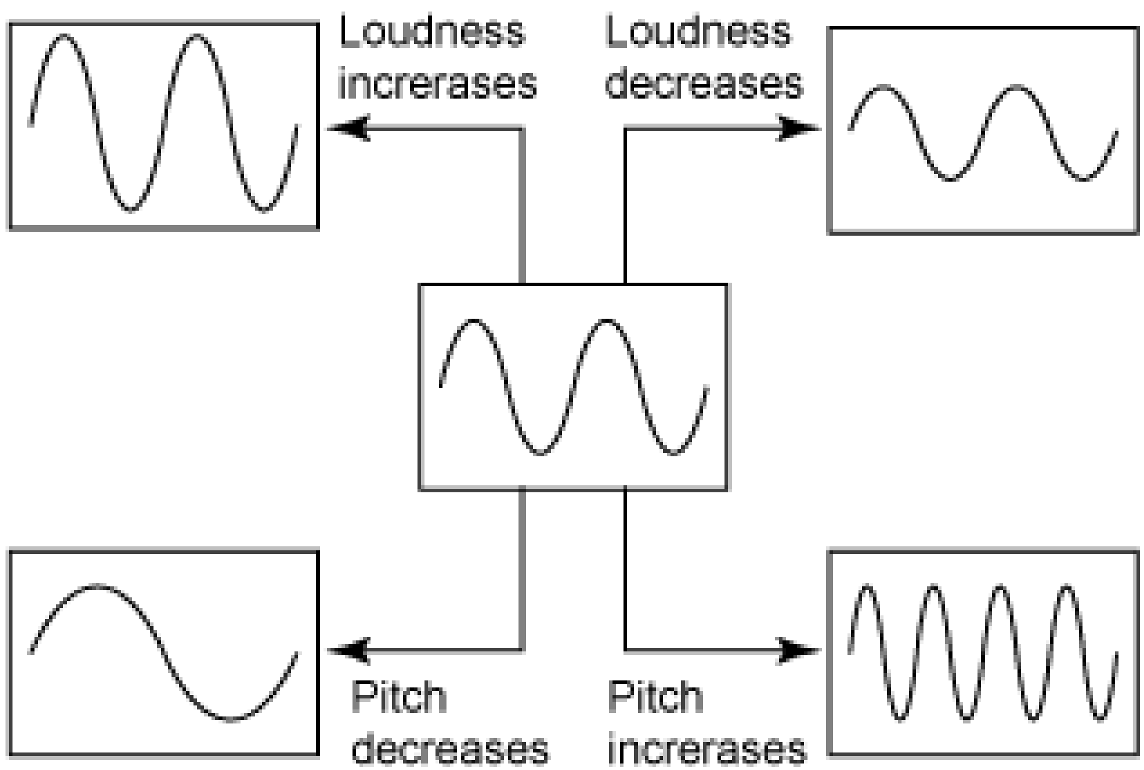
Low rumbling noises of elephants and moles are below our auditory range but can travel long distances.



# Pitch and Loudness of sound

extra info

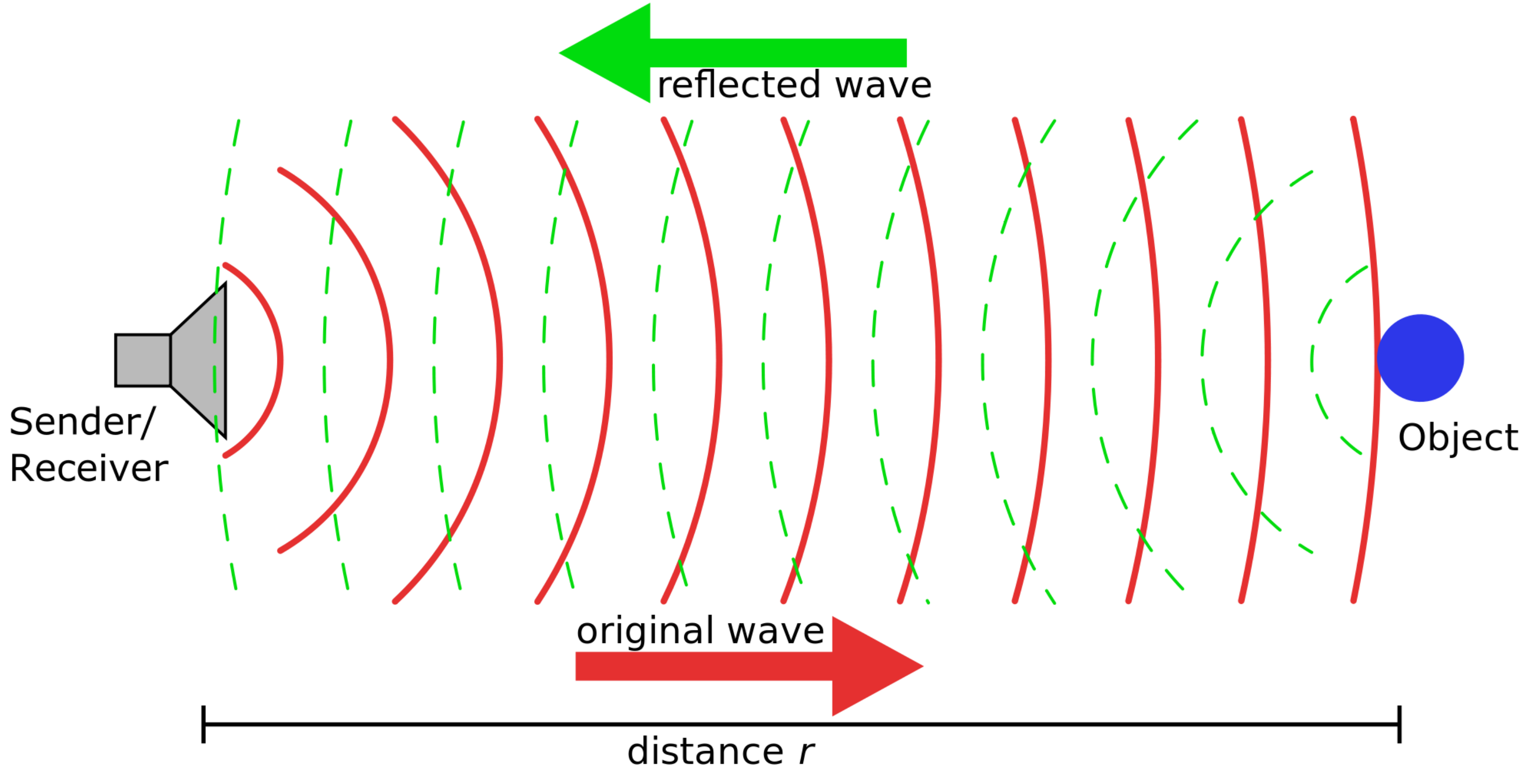
Sound can be described by "characteristics" called pitch and loudness. **Pitch** is related to **frequency** – the higher the frequency then the higher the pitch of the note (a single sound at a particular level). **Loudness** is related to **amplitude** – the higher the amplitude the louder the sound.



# Reflecting sound waves

extra info

Sonar (originally an acronym for **SO**und **N**avigation **A**nd **R**anging) 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.



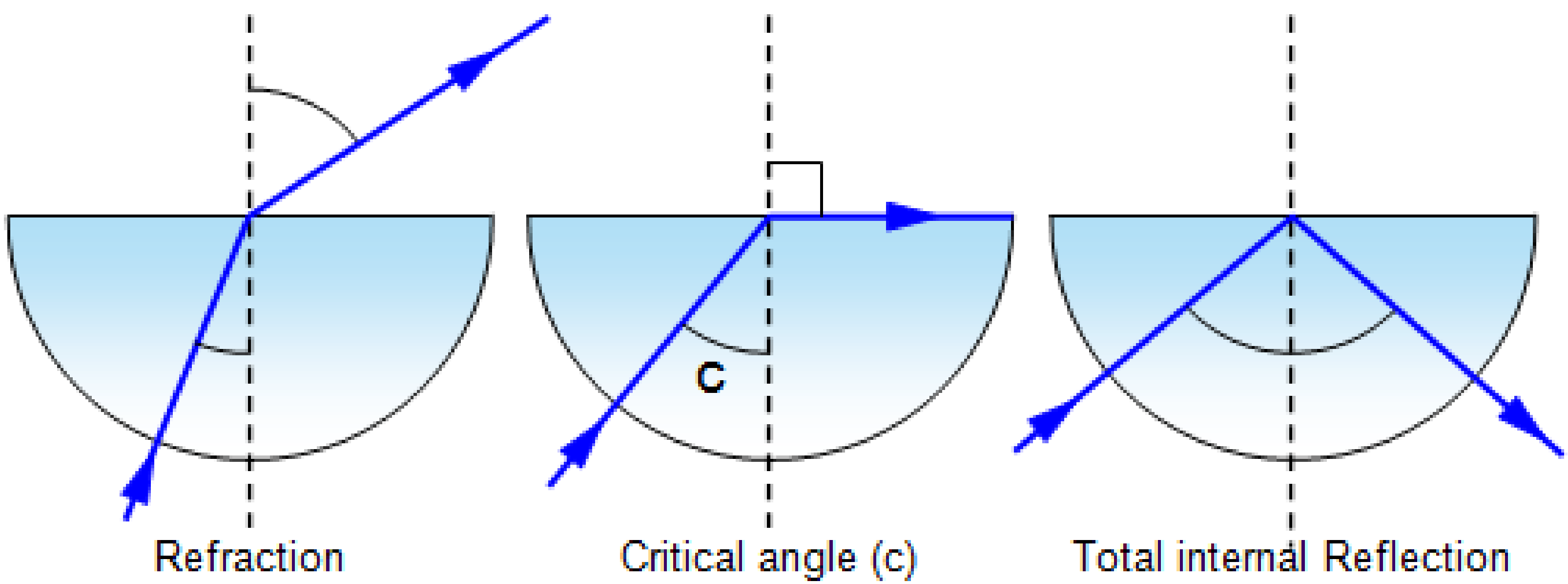
# Total internal reflection

extra info

When waves are going from a dense medium to a less dense medium they speed up at the boundary. This causes light rays to bend when they pass from glass to air at an angle other than 90°. This is **refraction**.

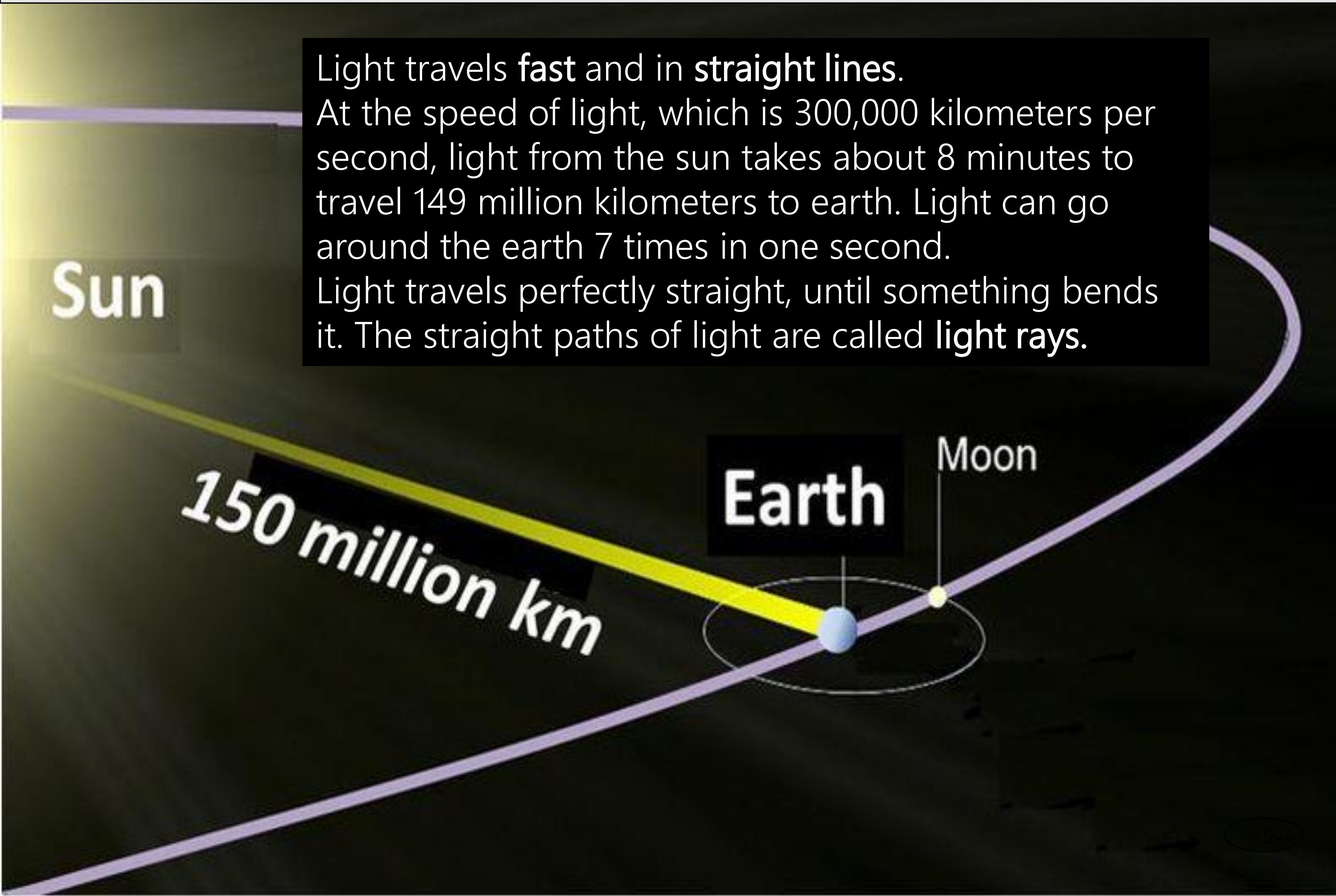
Beyond a certain angle, called the **critical angle**, all the **waves reflect back** into the glass. We say that they are totally internally reflected. All light waves, which hit the surface beyond this critical angle, are effectively trapped.

The critical angle for most glass is about 42 °. Fibre optics makes use of this so light rays can travel down a glass fibre that has curves in it.



# 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 perfectly straight, until something bends it. The straight paths of light are called **light rays.**



# Light energy can be reflected, refracted or dispersed

extra info

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.

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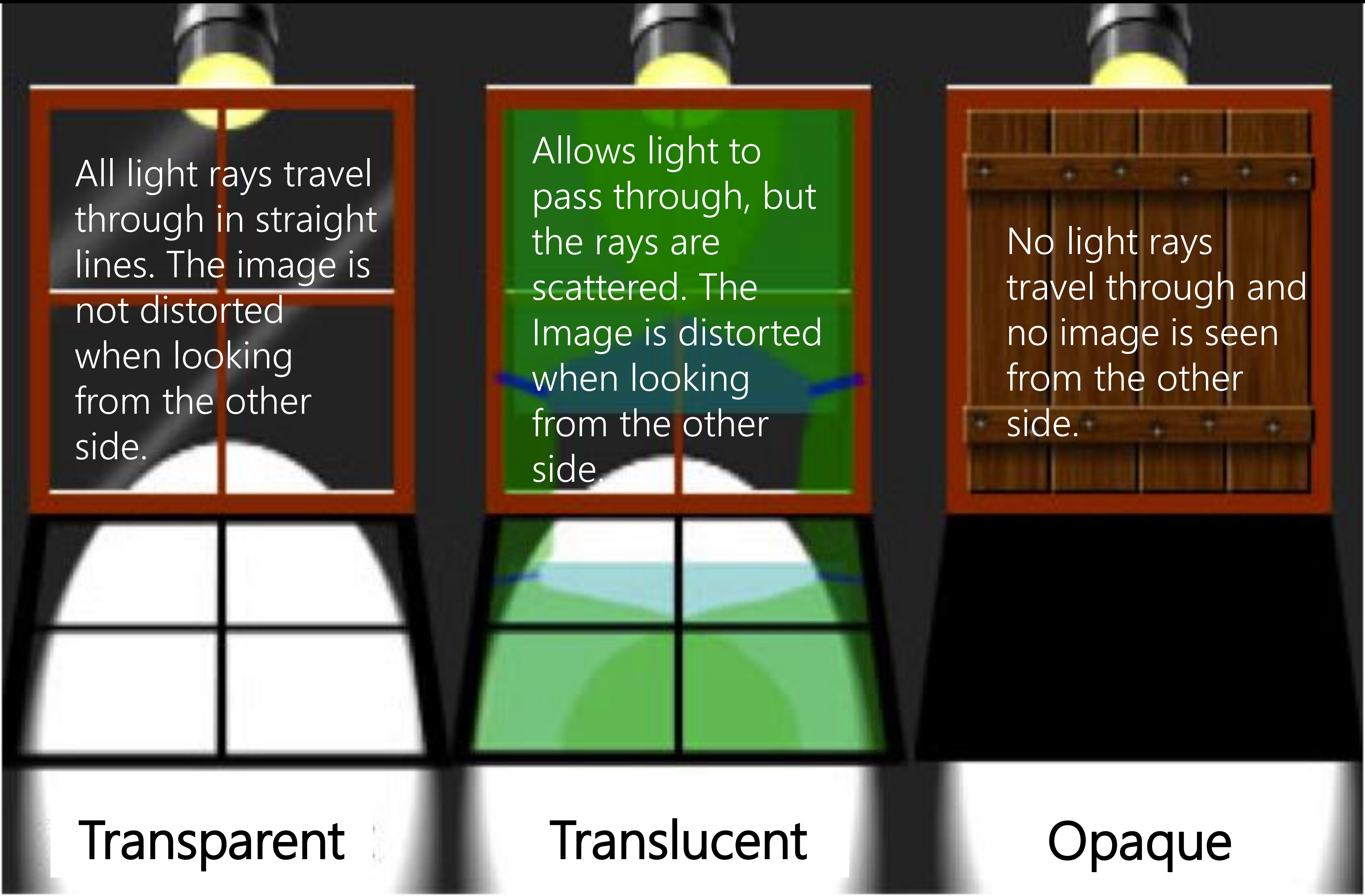
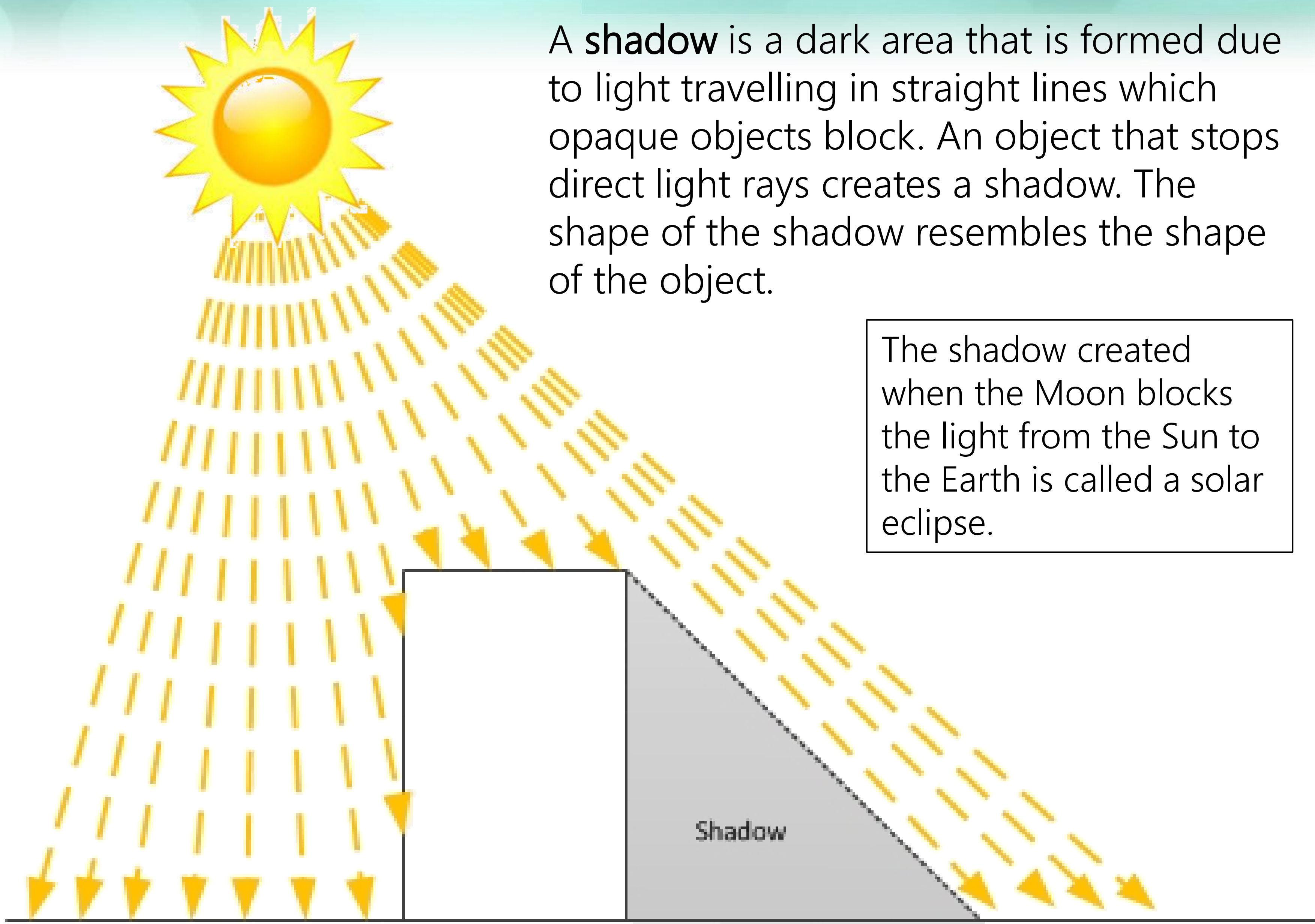
# Transparent, Translucent and Opaque



# 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.

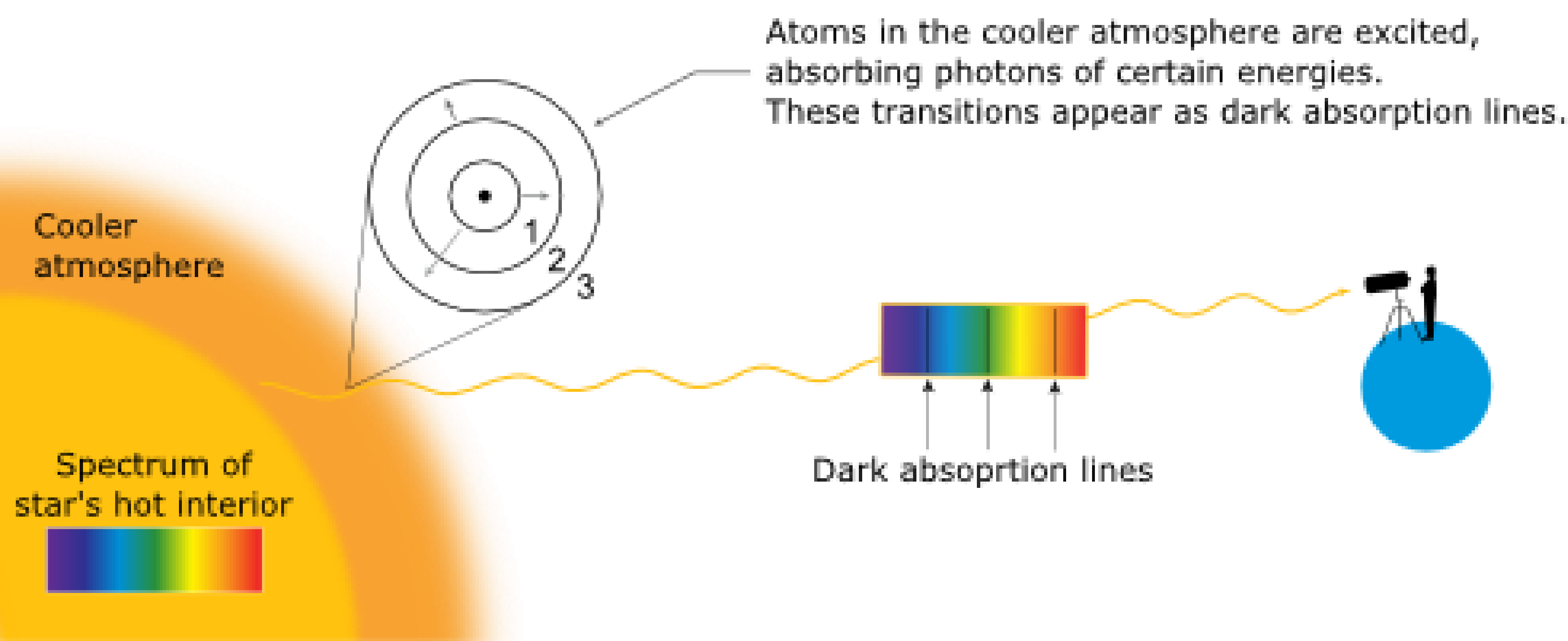
**Objects that appear to produce light** such as the Moon or shiny objects **but do not use energy are reflectors of light**. Light rays must originally come from a light source, such as the Sun's light reflecting off the moon.

# The sun is an incandescent light source

extra info

Virtually all of the electromagnetic radiation that arrives on Earth is from the Sun. The Sun is an **incandescent** light source because the light energy is generated from heat. The nuclear reactions that occur within the high pressure centre of the Sun release large amounts of heat. The heat causes the atoms that make up the Sun to move around fast. As the atoms collide together the electrons move up and down orbits around the nucleus and release photons of light each time.

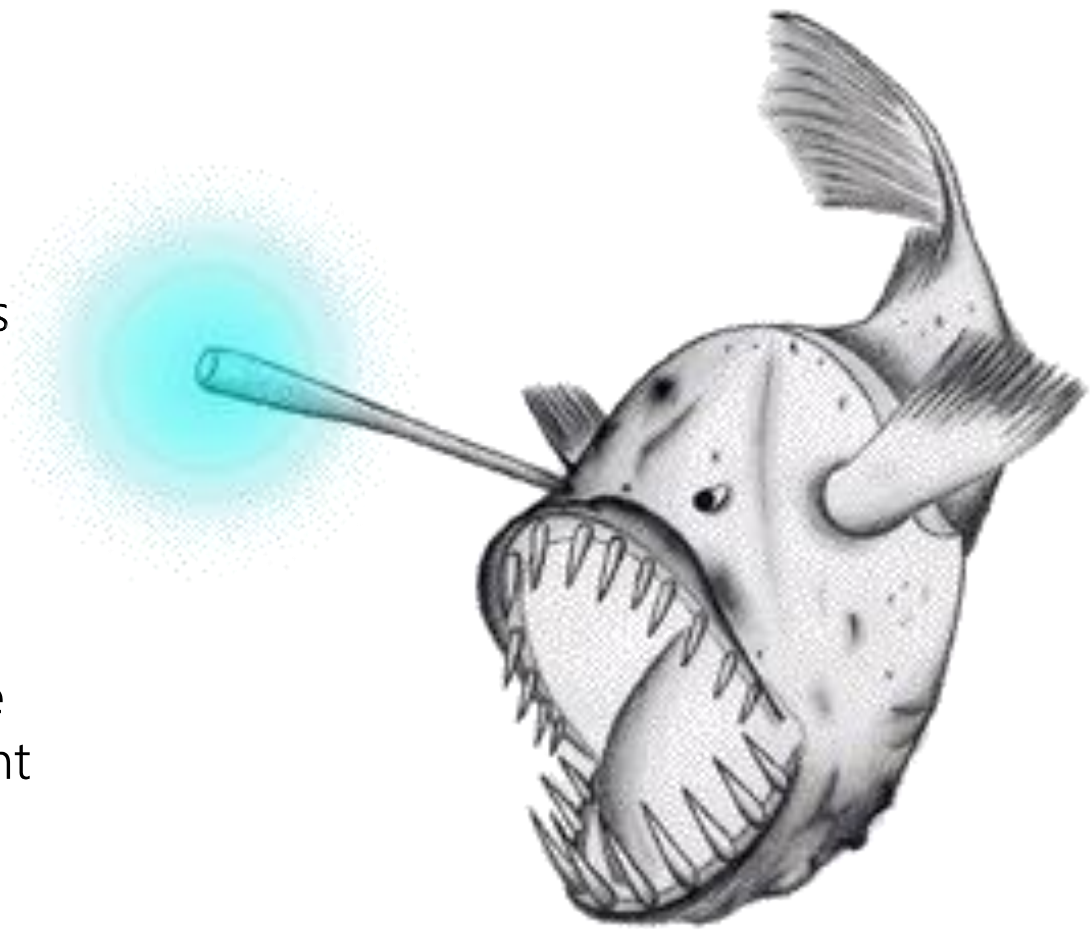
Each different type of element releases combinations of light in different wave lengths or colours called its **spectra**. We can “read” what type of elements make up the Sun, and other stars as well, by looking at what spectrum of light is emitted.



# Luminescent light is produced from chemical or electrical energy

extra info

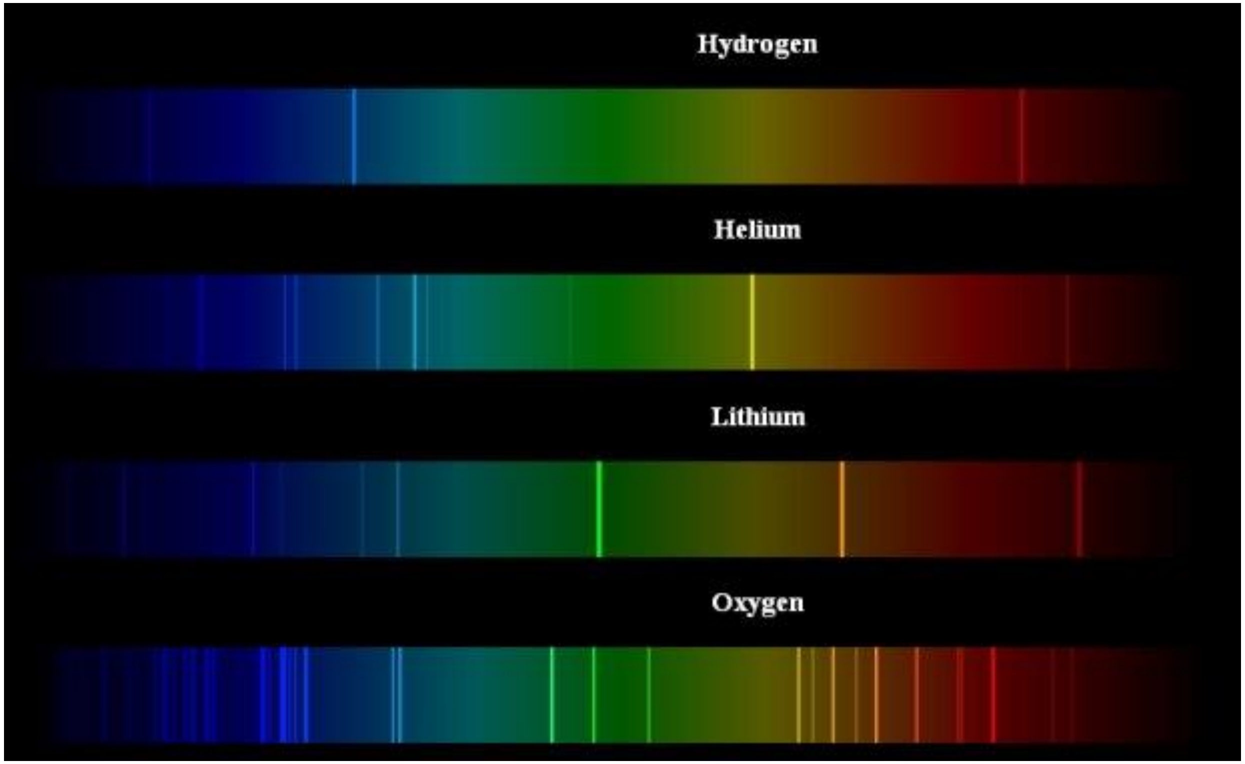
Some animals can produce their own light through chemical reactions in their bodies. This light is known as luminescence. It is much cooler than incandescent as it does not require heat energy to produce it. Glow sticks and florescent lamps also emit this type of light without producing heat so are far more efficient to use than a incandescent filament light bulb.



# Spectroscopy is the study of spectra

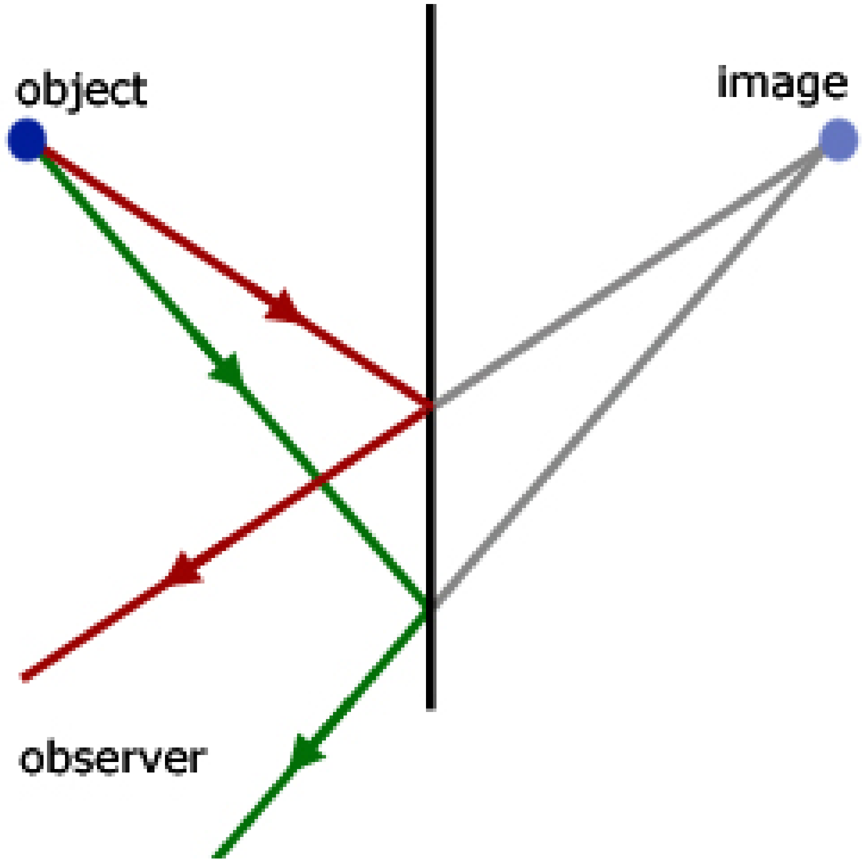
extra info

Our Sun is mainly made up of Hydrogen and Helium. Helium is very rare and unreactive on Earth. It was not discovered until scientists, using spectroscopy on the Sun, found an unknown element emitting a spectra of light that did not match to any known elements. They named this element Helium after Helios, the Latin name for Sun. We now know many stars contain Helium along with assorted other elements rare and common on earth.



# Ray diagrams in a plane mirror

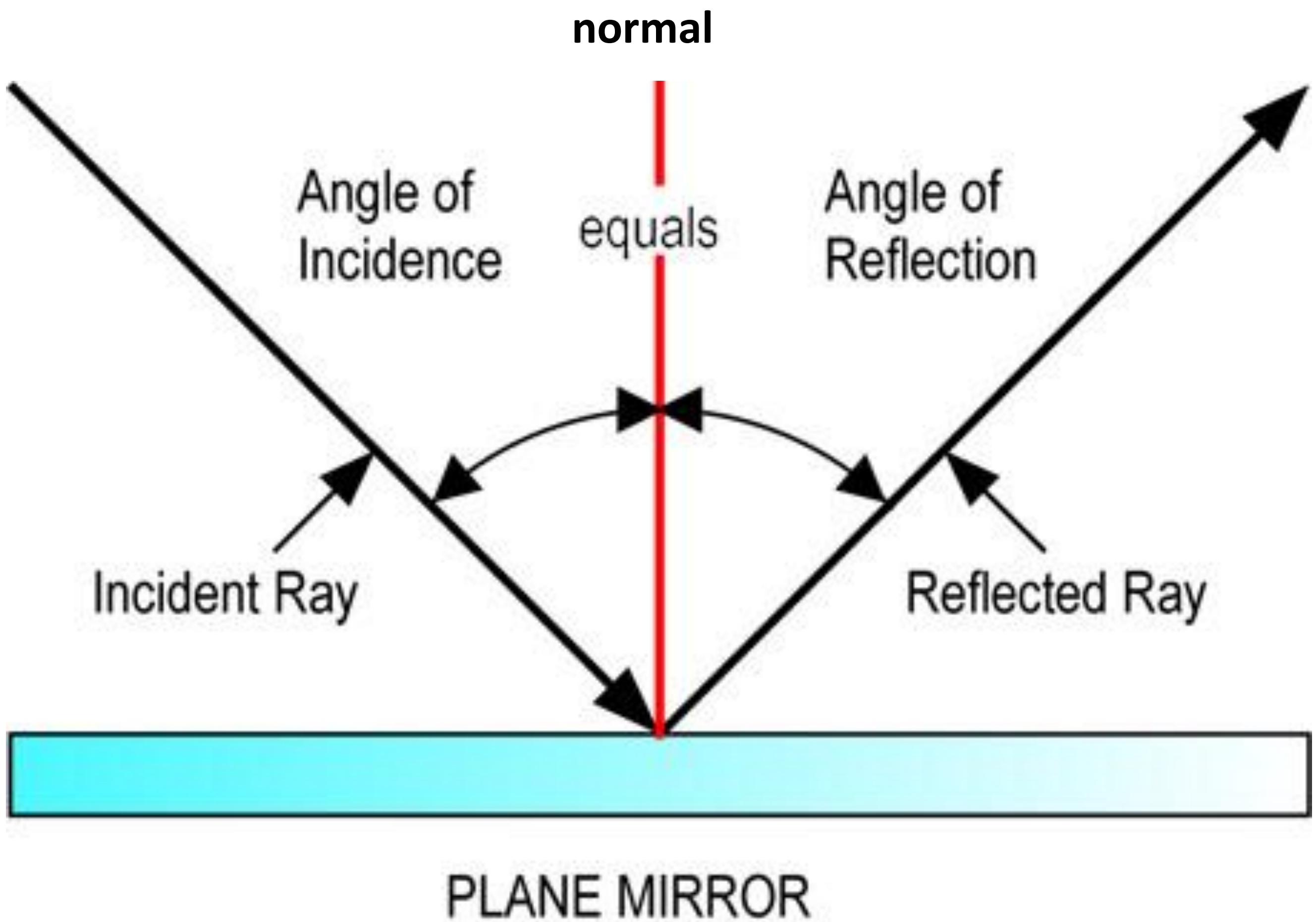
**Ray diagrams** are used to show an image of an object reflected in a mirror. Straight lines from the object are drawn towards the mirror. Using the rule from the **angle of incidence** and **reflection** the lines are then reflected back. <u>Arrows</u> are used on the lines to show the light rays direction.



# The angle of incidence and angle of reflection

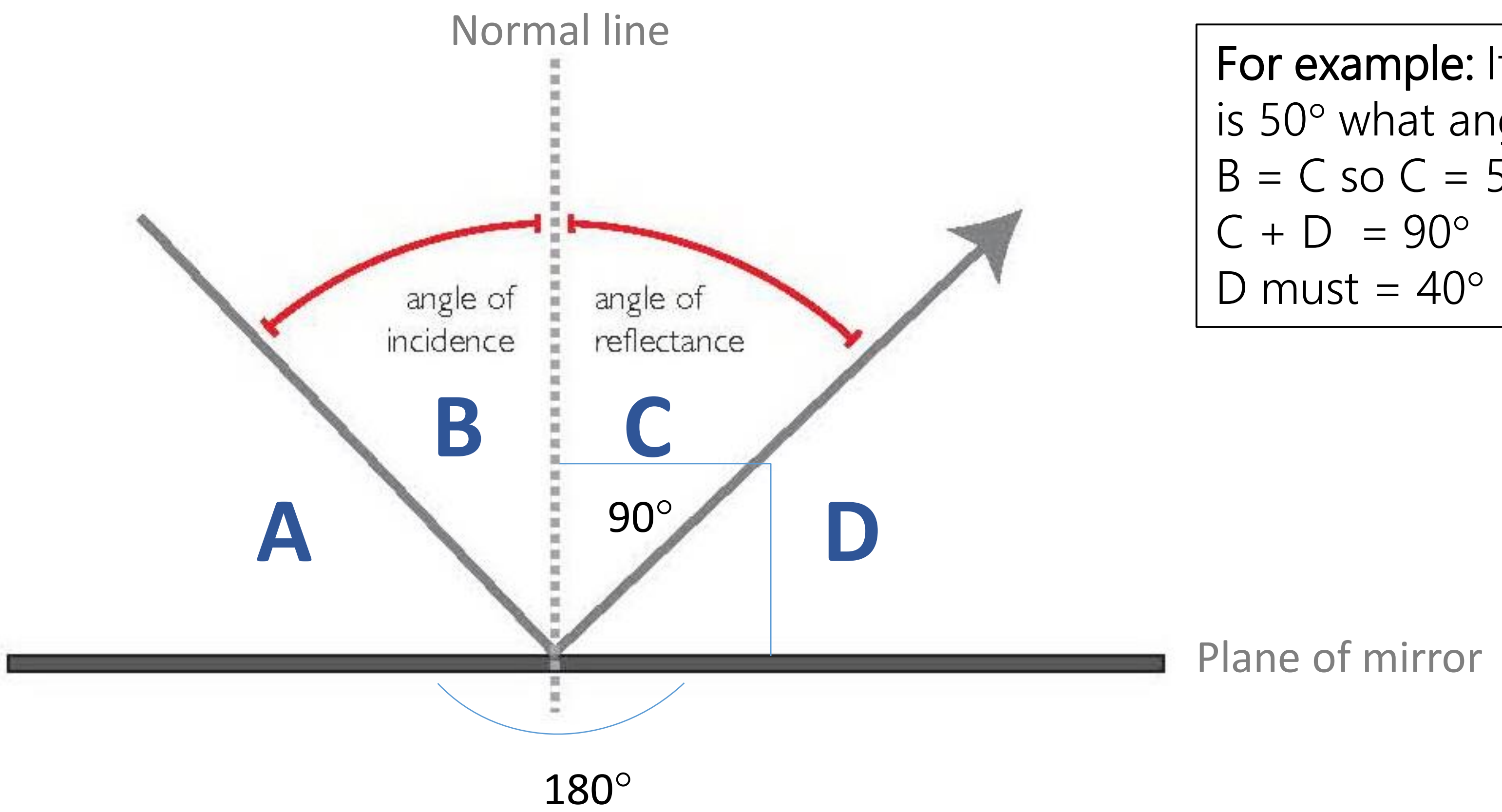
The main rule for mirrors is that **the angle of incidence equals the angle of reflection**.

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.



# Measuring the angle of incidence and angle of reflection

Unknown angles can be calculated using rule for mirrors that the angle of incidence equals the angle of reflection. You also need to know the normal line is 90° to the plane of the mirror and all angles (A,B,C & D) must add up to 180°



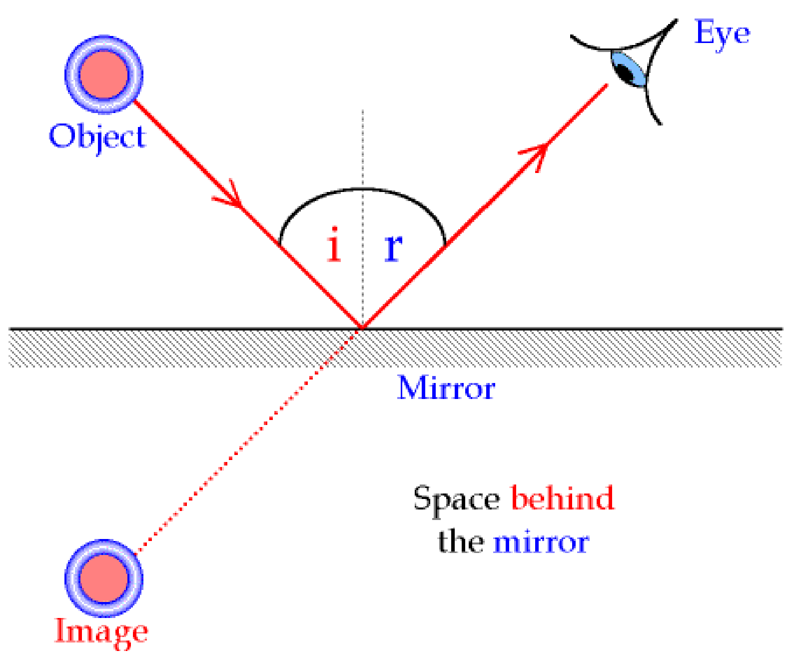

**For example:** If angle B is 50° what angle is D?
B = C so C = 50°
C + D = 90°
D must = 40°

# Light energy can be reflected by a mirror

extra info

When you look directly at an object you can see where it is. But if you look at it in a mirror, then you are looking at a **reflection** of the object – the image is behind the mirror. An image is a view of an object at a place other than where the object is. Images can either be **real** or **virtual**. A real image occurs when the light rays pass through the place where the image is, for example, the image on a cinema screen or the image that falls on film in a camera.

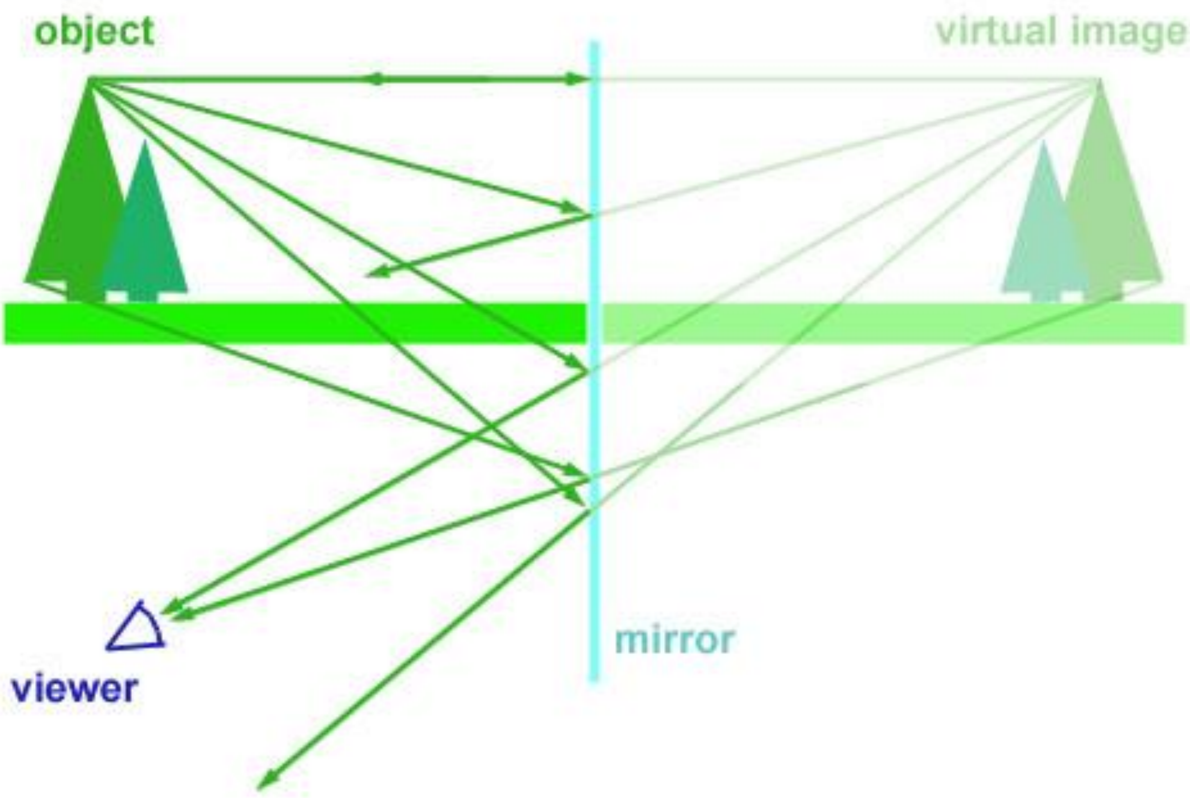
A virtual image occurs when the image appears to be at a place where the light rays do not pass
When you hold an object in front of a mirror, the reflected image you see is behind the mirror. Obviously no light can come through the mirror, so the image must be a **virtual** one.
**All reflected images off flat surfaces are virtual images**.



# Light energy can be reflected by a mirror

**Images in plane mirrors are:**

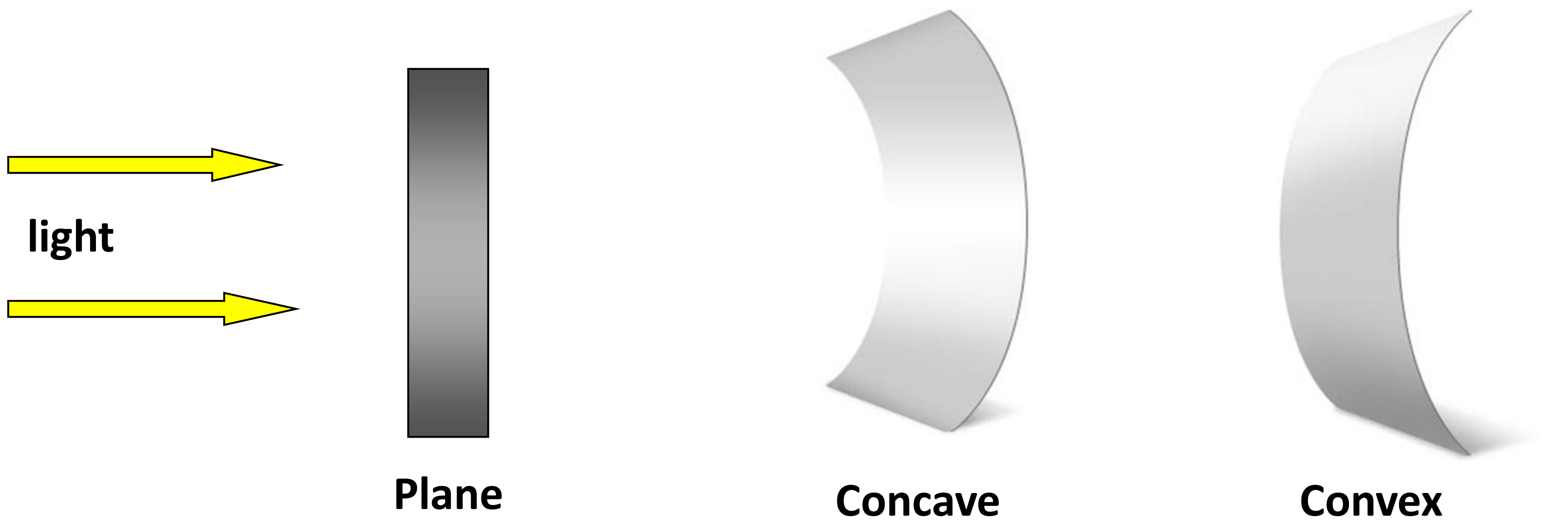
the same size as the object;
the same distance behind the mirror as the object is in front;
virtual (light does not really go to them);
laterally inverted (the left side is swapped to the right side and the right side swapped to the left).



# Convex and concave mirrors

extra info

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

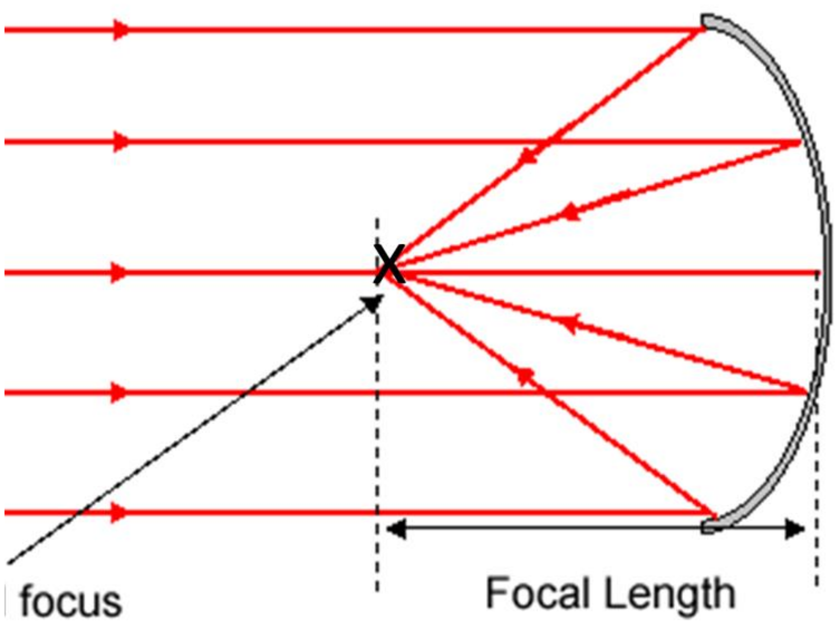
a) magnified and the right way up when you are near to the mirror

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

# Ray diagrams in a concave mirror

With **concave mirrors**, light being reflected converges (goes in an inward direction) towards the focal point (x). From a distance, images appear upside down but when brought nearer, image become larger in size and appears right side up. A focal point is where parallel rays meet.




Concave

# Ray diagrams in a convex mirror

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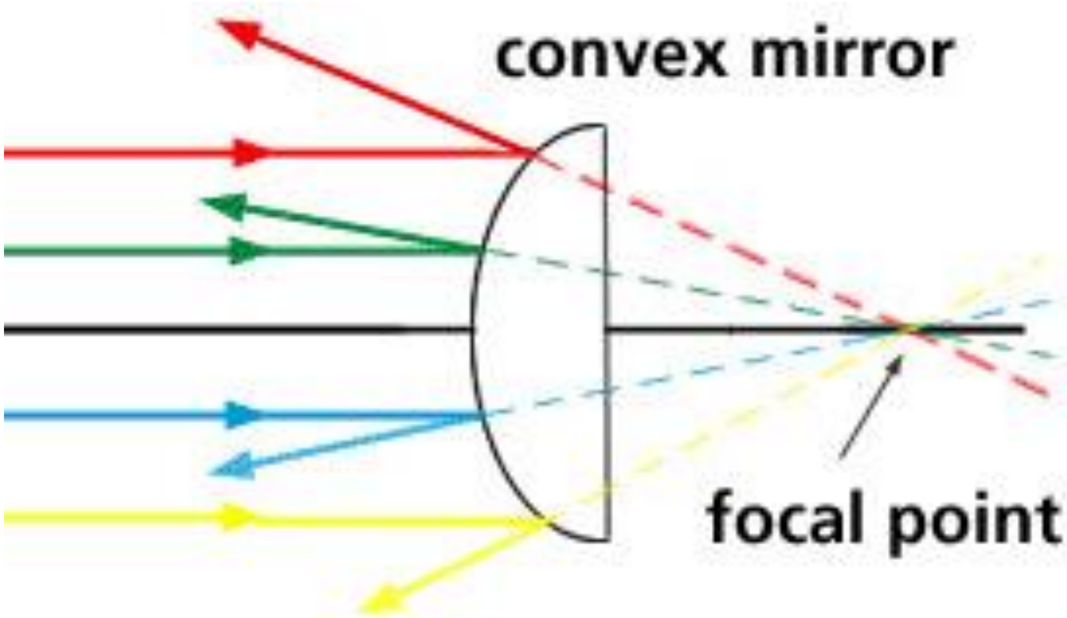
extra info

The image formed in a **convex mirror** is always upright and smaller in size. The light rays diverge (spread apart). The focal point is behind the mirror where light rays do not actually pass through.

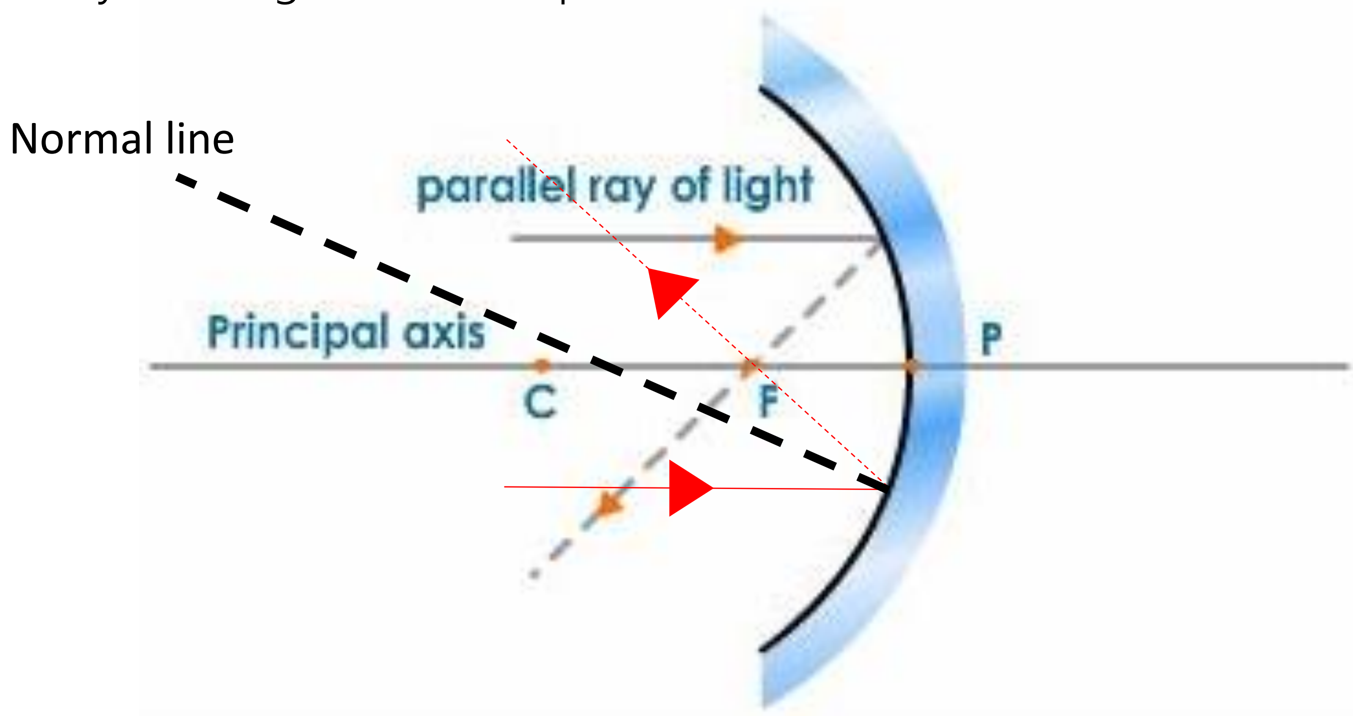



**Convex**

# Drawing Ray diagrams in concave mirrors

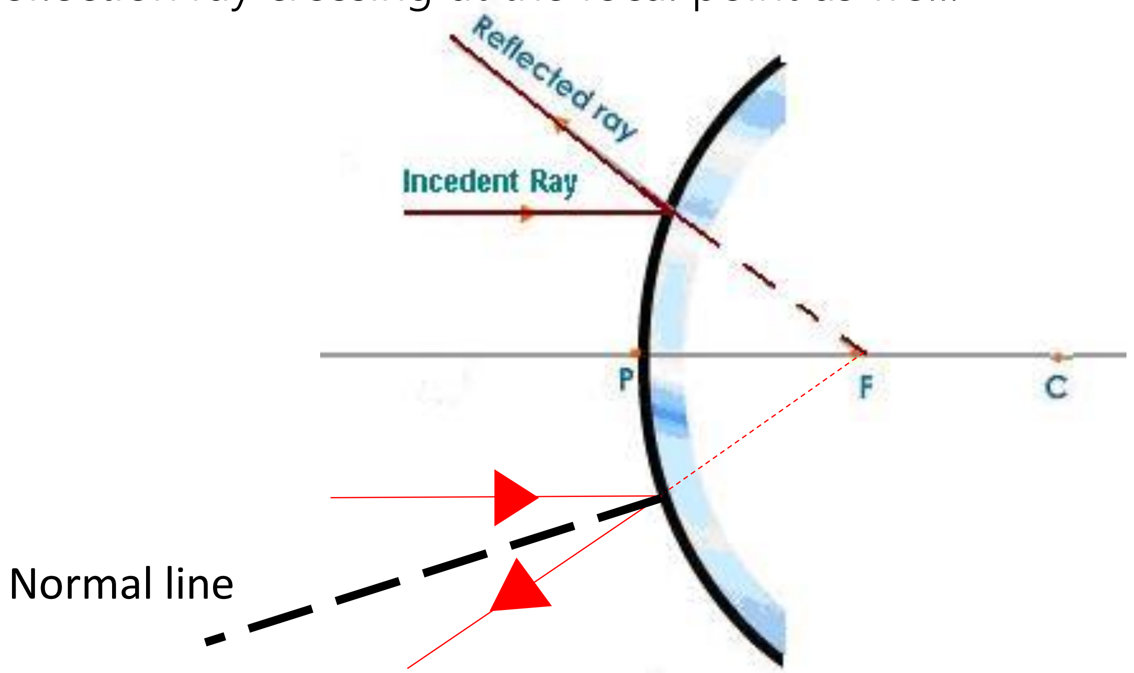
extra info

Typically three rays of light are drawn reflecting off a concave mirror.
The centre incident ray follows the principal axis which travels straight into the centre of the mirror. The reflection ray travels directly back on the same line.
Another incident ray of light parallel to the principal axis is drawn and the reflection ray reflects inwards. (a normal line can be drawn where the ray hits the mirror and the incidence ray=reflection ray). Where the rays cross is the focal point (F).
A third incidence ray can be drawn on the opposite side of the principal axis with the reflection ray crossing at the focal point as well.



# Drawing Ray diagrams in convex mirrors

Typically three rays of light are drawn reflecting off a convex mirror.
The centre incident ray follows the principal axis which travels straight into the centre of the mirror. The reflection ray travels directly back on the same line.
Another incident ray of light parallel to the principal axis is drawn and the reflection ray reflects outwards. (a normal line can be drawn where the ray hits the mirror and the incidence ray=reflection ray). Extending the reflected ray back past the mirror to cross the principal axis is the focal point (F).
A third incidence ray can be drawn on the opposite side of the principal axis with the extended reflection ray crossing at the focal point as well.



# Everyday use for concave and convex mirrors

**Convex** traffic safety mirrors are designed for road safety to see better at blind corners, concealed entrances and exits.

Convex ceiling dome mirrors are used in surveillance for shops because they allow someone to watch what is going on in a wide area.

They are also used in car side mirrors to see a wide view from behind.

extra info

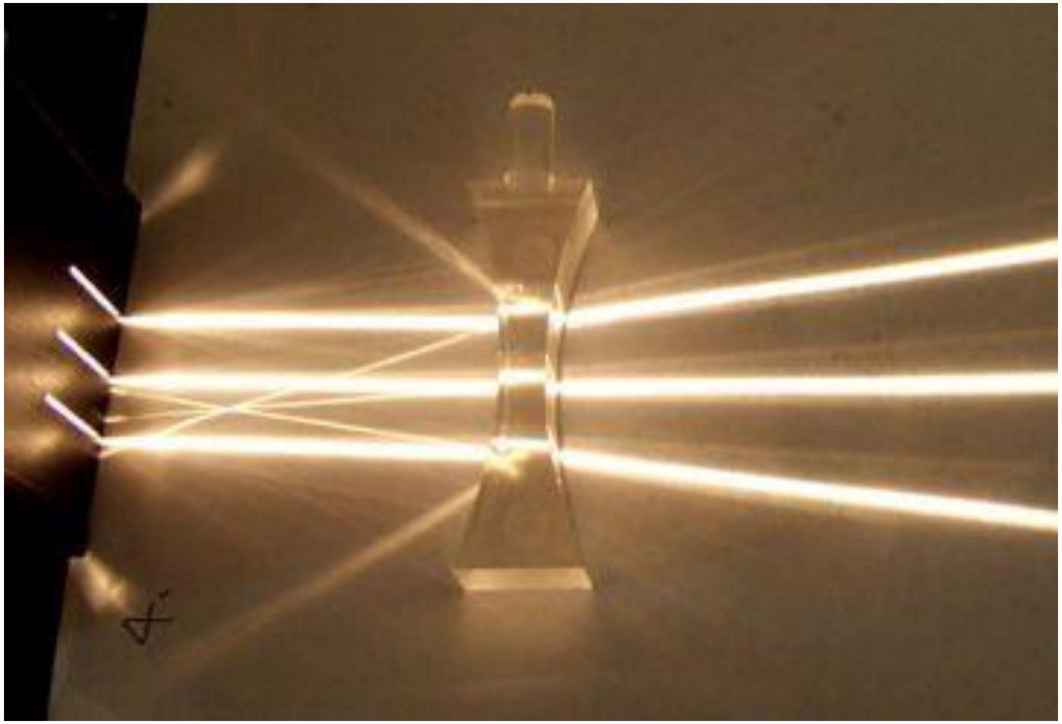
**Concave** mirrors are commonly found in the head lights of vehicles making the light more reflective and wider, making it possible for the drivers to have a better view at night. Concave mirrors are also used in microscopes and face mirrors to enlarge the view as magnified and the right way up when you are near to the mirror

# Light can be Refracted by a lens

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.

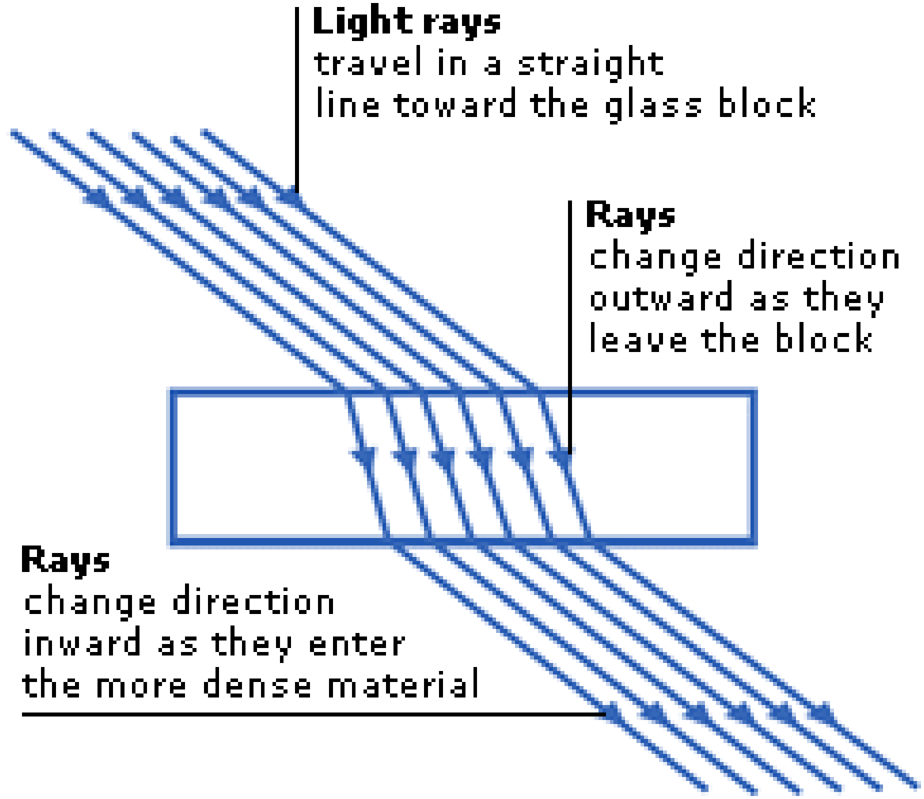
**Refraction** is when light travels between two optically different (densities) mediums that bend light towards or away from the normal.



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

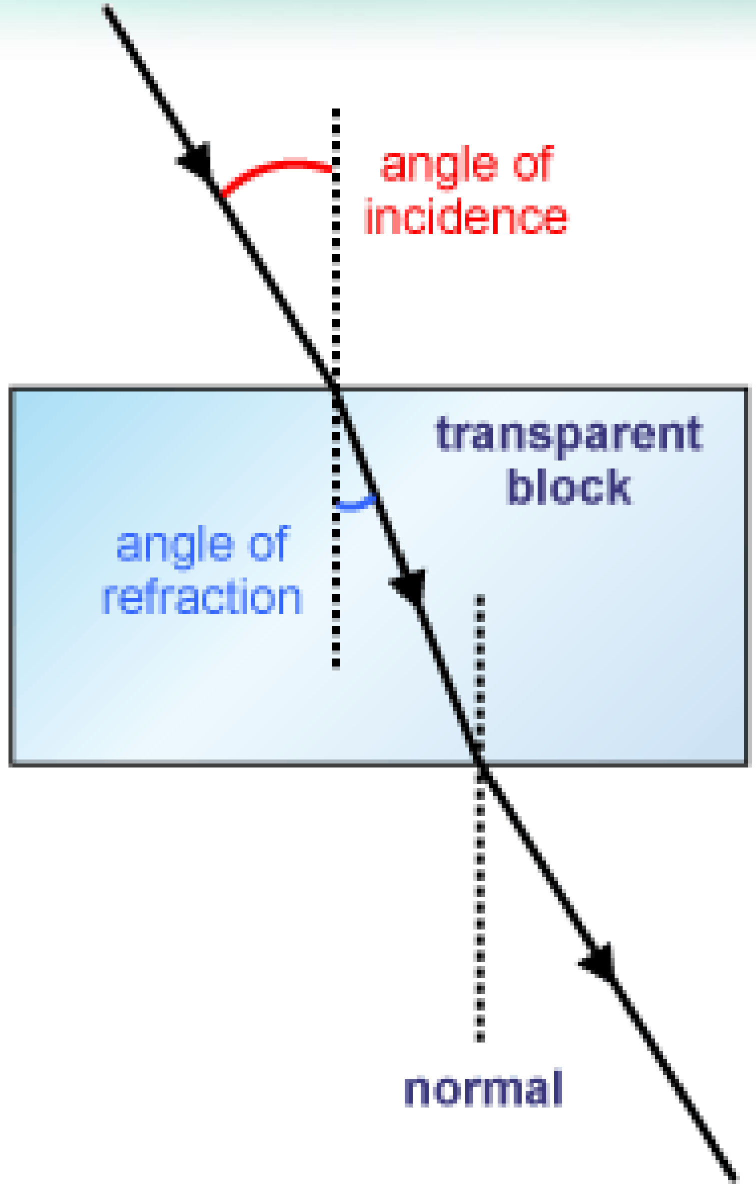
# Refraction

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.

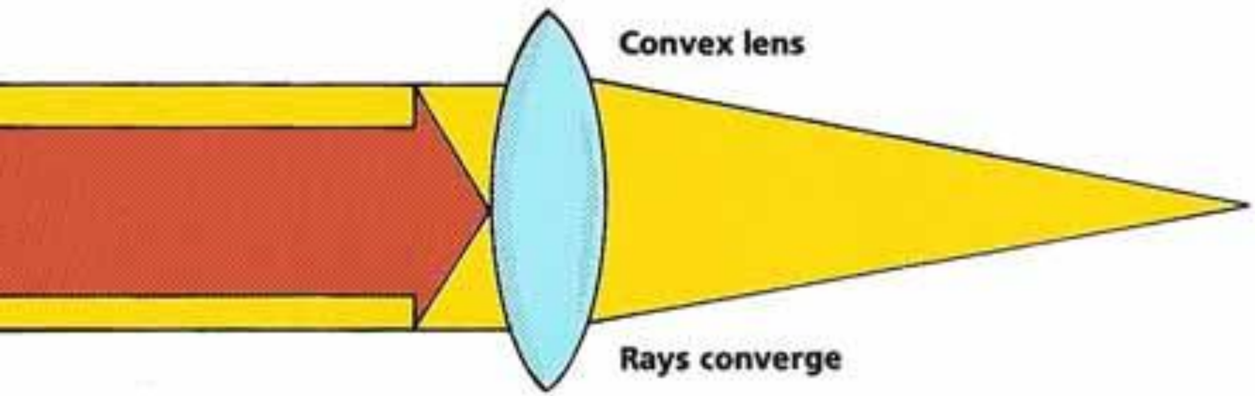


# Refraction in a glass block

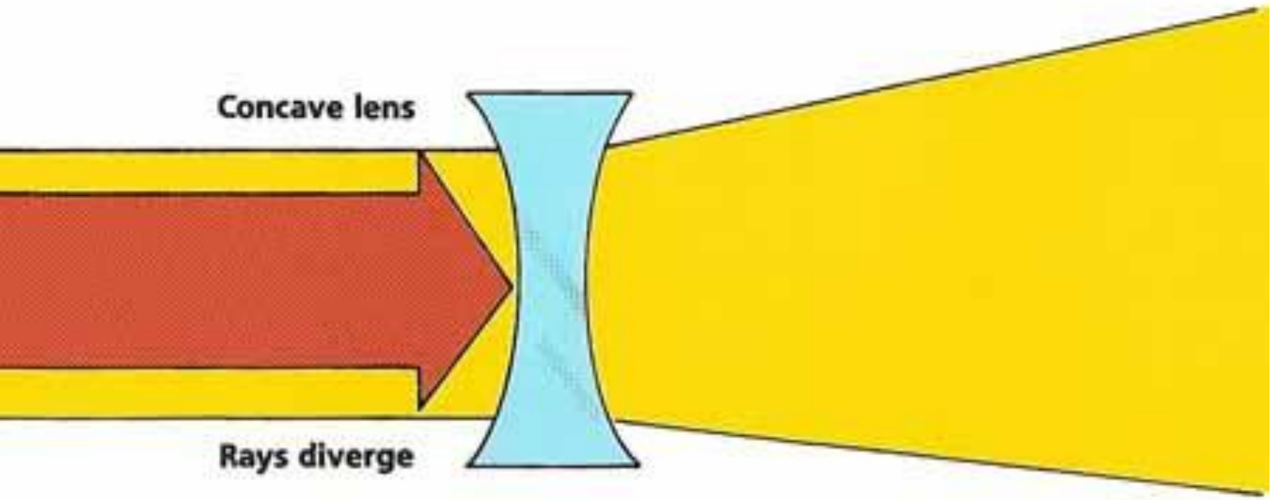
The ray of light bends or **refracts inwards** when it moves into the glass. This makes the **angle of refraction smaller than the angle of incidence**. When the ray emerges from the glass back into the air then it continues on a **parallel** path to the original ray.



# Concave and convex lens



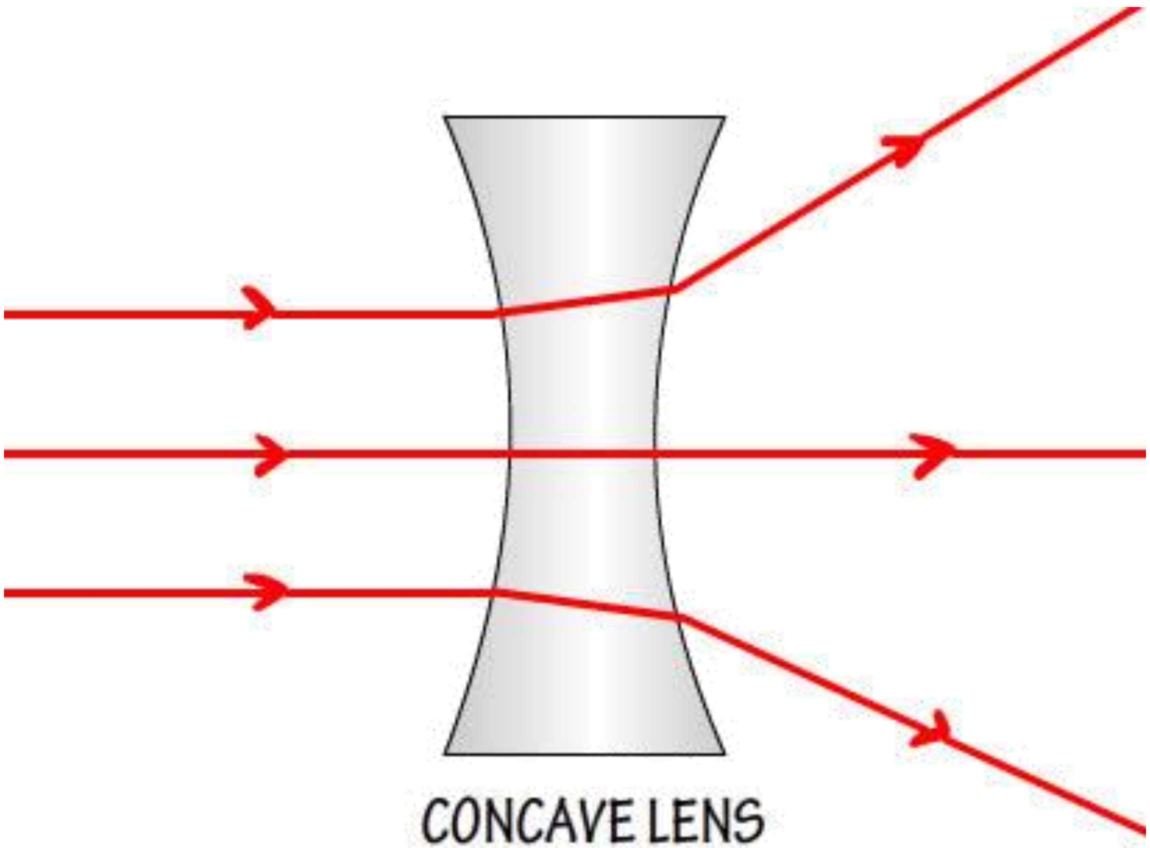

Lenses that **curve outwards** are known as convex lenses.
When light enters them it refracts inwards once it leaves the lens.




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

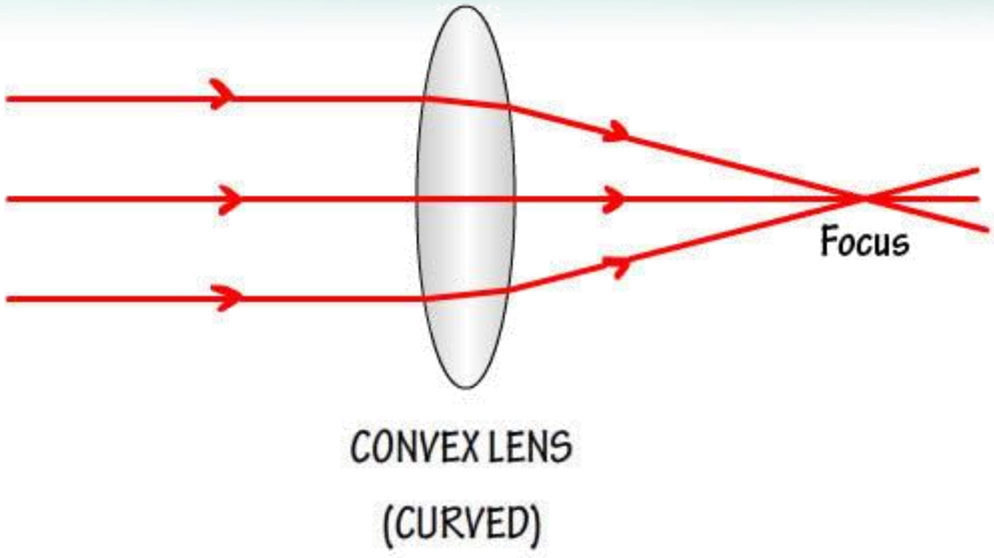
# Concave lens

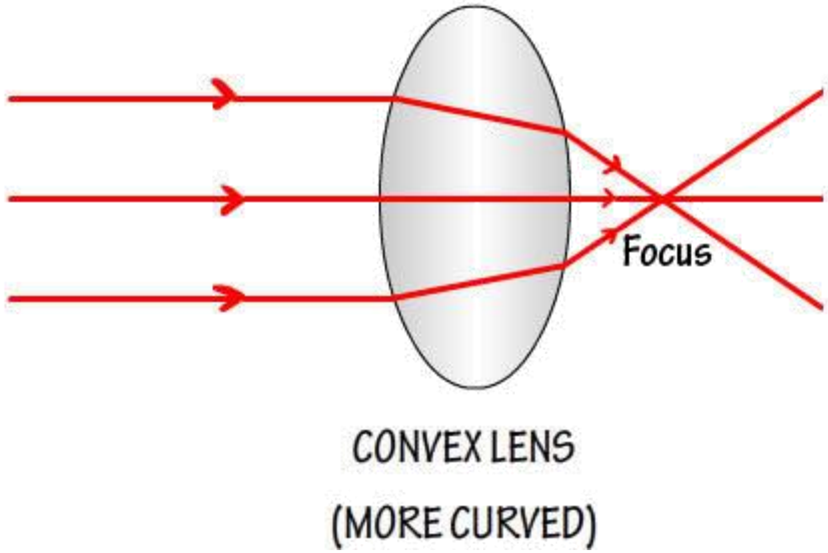
A concave lens will cause parallel light rays entering the lens to diverge (be spread) when leaving it. Rays refract outwards when entering the lens, then refract outwards even more when leaving the lens.



# Convex lens

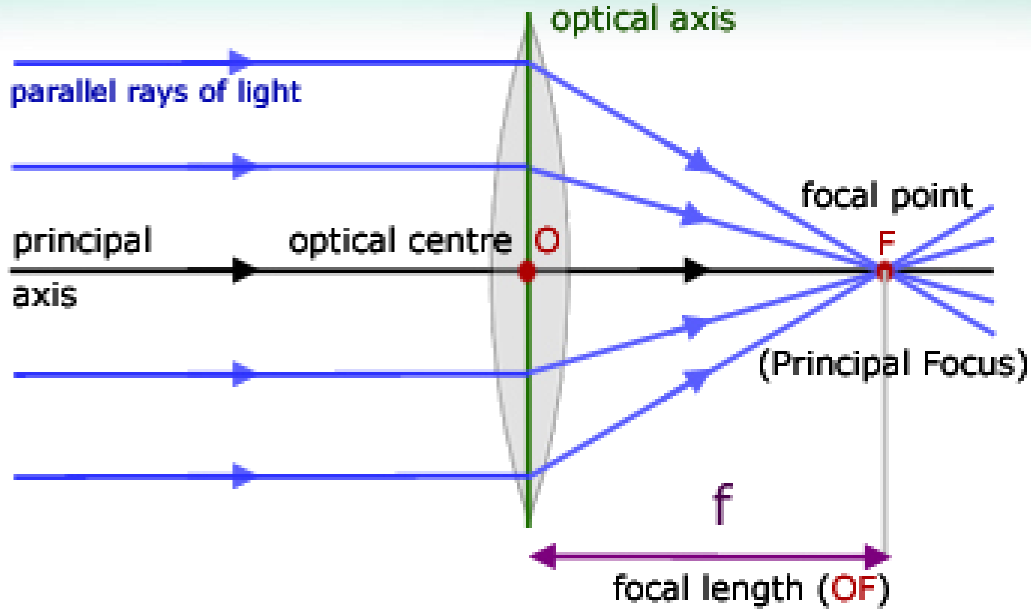
A convex lens will cause parallel light rays entering the lens to converge (bend inwards) when entering the lens and leaving. The "flatter" the lens the lesser the angle of the light rays refracting. The rounder the lens the greater the angle of the light rays refracting.



# Drawing ray diagrams for Convex lens

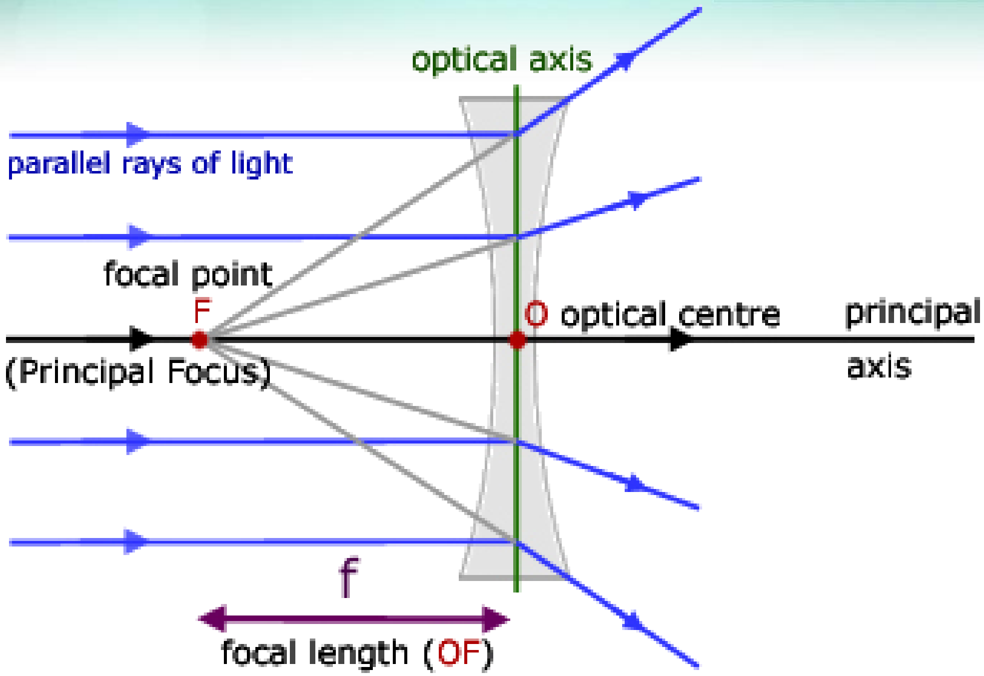
extra info




Typically three rays of light are drawn refracting through a convex lens. (although you may draw more as above)
The centre light ray follows the principal axis which travels straight into the centre of the lens and continues on a straight line through the other side.
Another ray of light parallel to the principal axis is drawn and once reaching the optical axis (middle of the lens) it bends inwards to cross the principal axis at the focal point (F).
A third light ray can be drawn on the opposite side of the principal axis with the bent ray crossing at the focal point as well.

# Drawing ray diagrams for Concave lens

extra info




Once the diagram is drawn only the **BLUE** and principal axis lines are needed.
The grey lines are used to help construct.

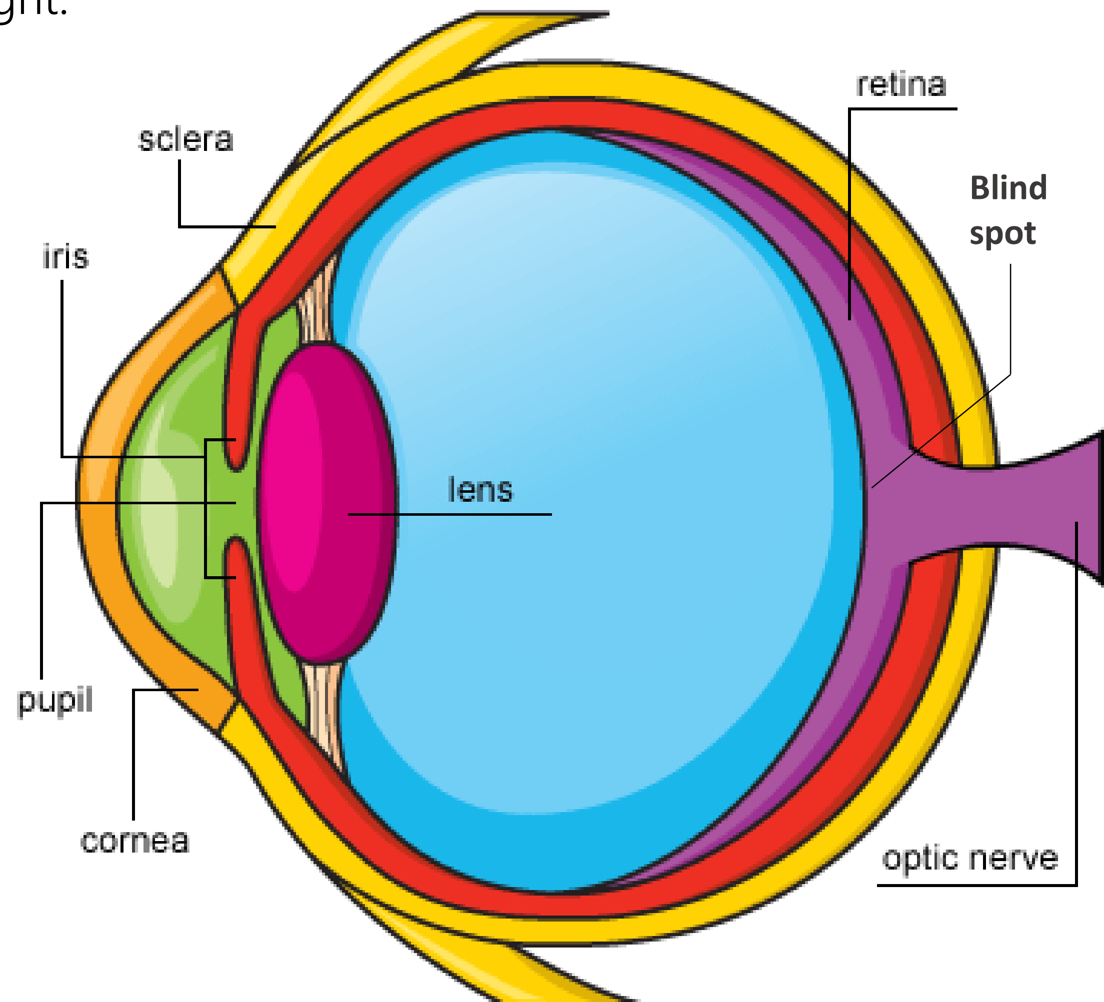
Typically three rays of light are drawn refracting through a concave lens. (although you may draw more as above)
The centre light ray follows the principal axis which travels straight into the centre of the lens and continues on a straight line through the other side.
Another ray of light parallel to the principal axis is drawn and once reaching the optical axis (middle of the lens) it bends outwards (if this line is extended backwards it will cross the principal axis at the focal point) A third light ray can be drawn on the opposite side of the principal axis with the bent ray extended back and crossing at the focal point as well.

# 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

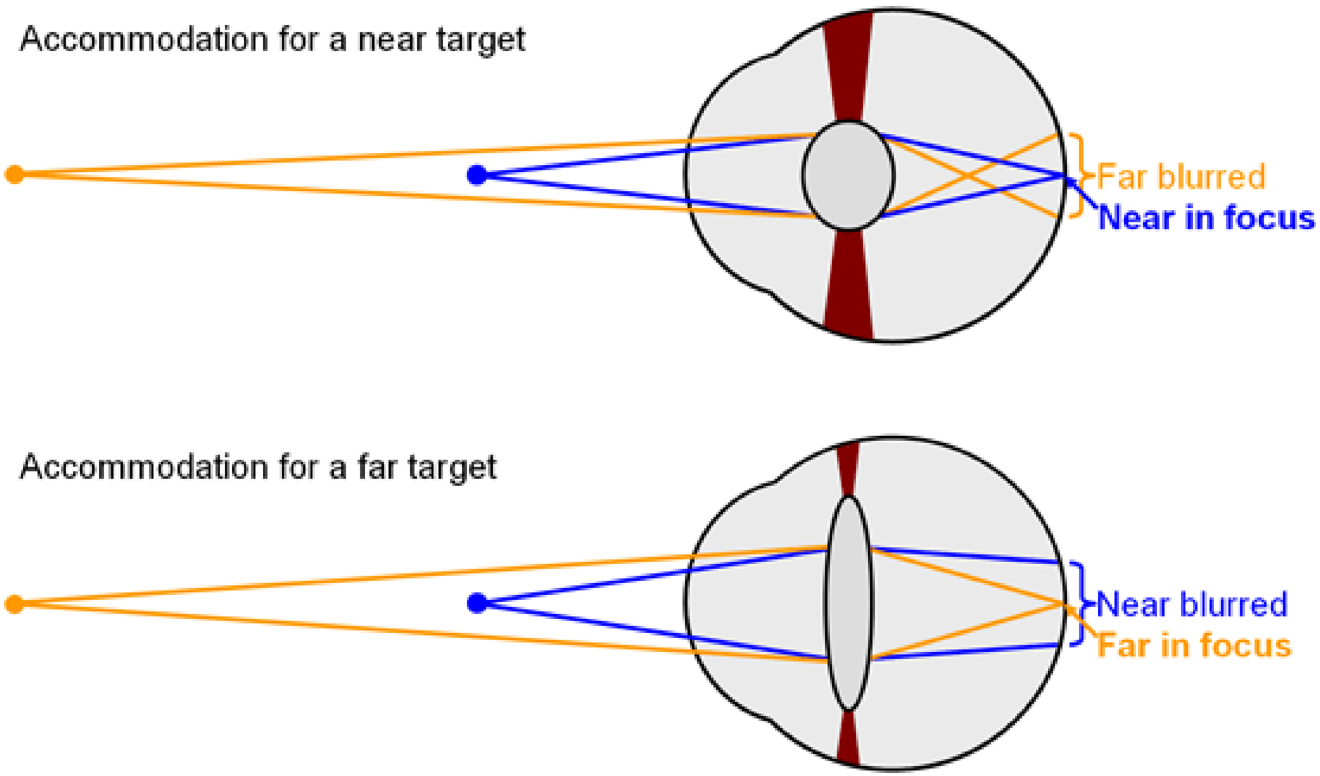
Messages from the retina travel through the optic nerve to the brain. The brain further processes the images in various parts of the brain responsible for language, speech and thinking.



# The lens of the Human Eye

The lens of the eye is able to change shape to focus light clearly from different distances.
Muscles surrounding the lens relax to produce a more rounded lens, that is able to focus on nearer objects.
Muscles surrounding the lens contract to produce a more flattened lens, that is able to focus on far away objects.

While the eye is focused to see close up images the distance is blurry and vice versa.

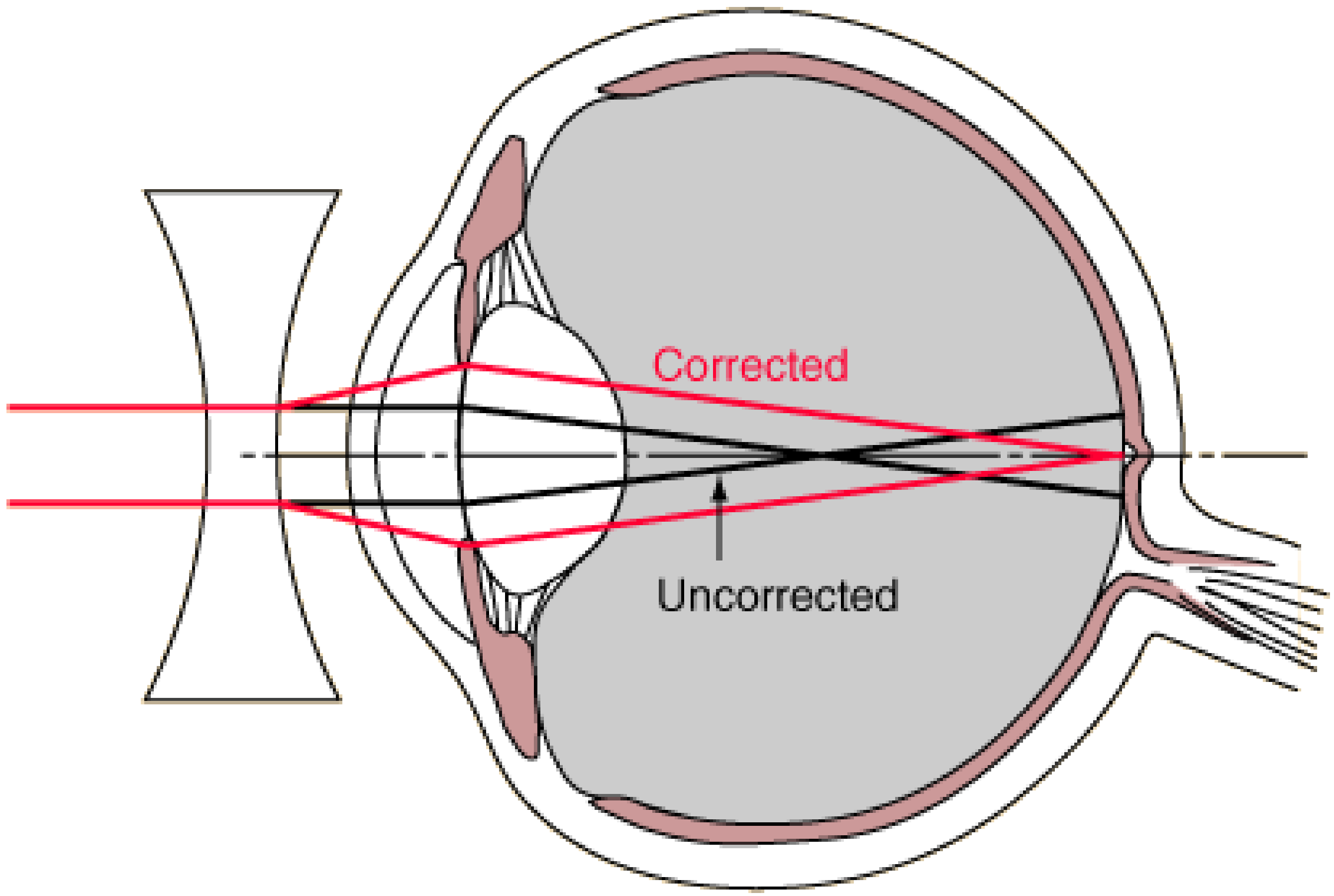


# Other types of eyes in the animal kingdom

# Short sighted



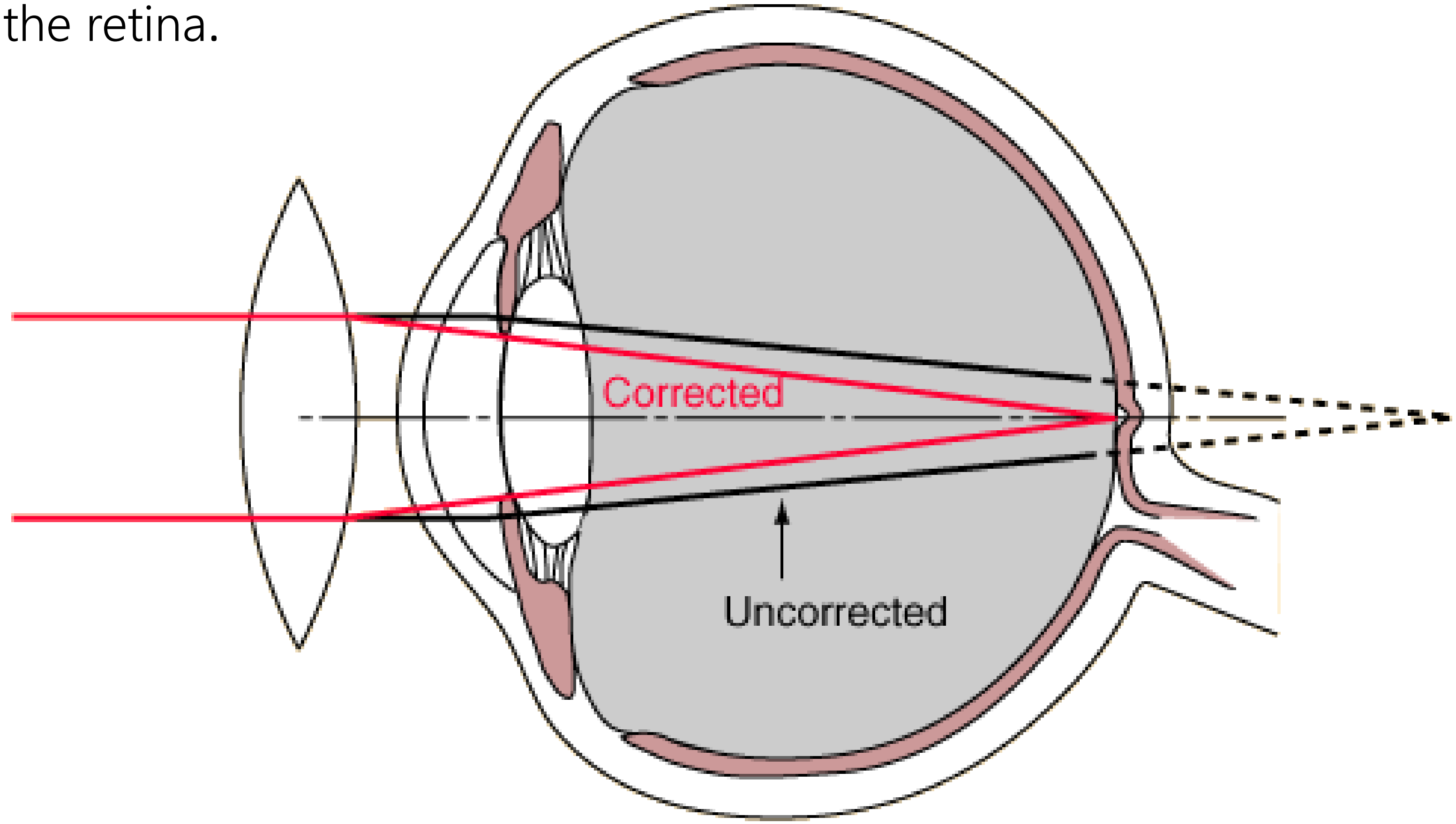
A **short sighted (near sighted)** person is not able to focus on distant objects clearly. Their very convex eye lens bends light rays into a focus point before it reaches the retina. A concave lens cause the light rays to disperse (bend outwards) before reaching the eye lens. The light rays then are able to have their focus point at the retina.



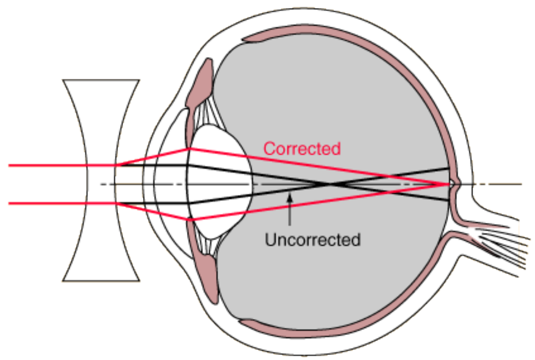
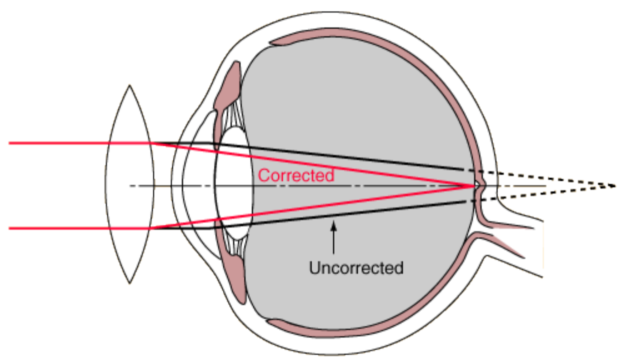
# long sighted

A long sighted (far sighted) person is not able to focus on close up objects clearly. Their less curved convex eye lens converges bends light rays into a focus point after it reaches the retina.

A convex lens cause the light rays to converge (bend inwards) before reaching the eye lens. The light rays then are able to have their focus point at the retina.



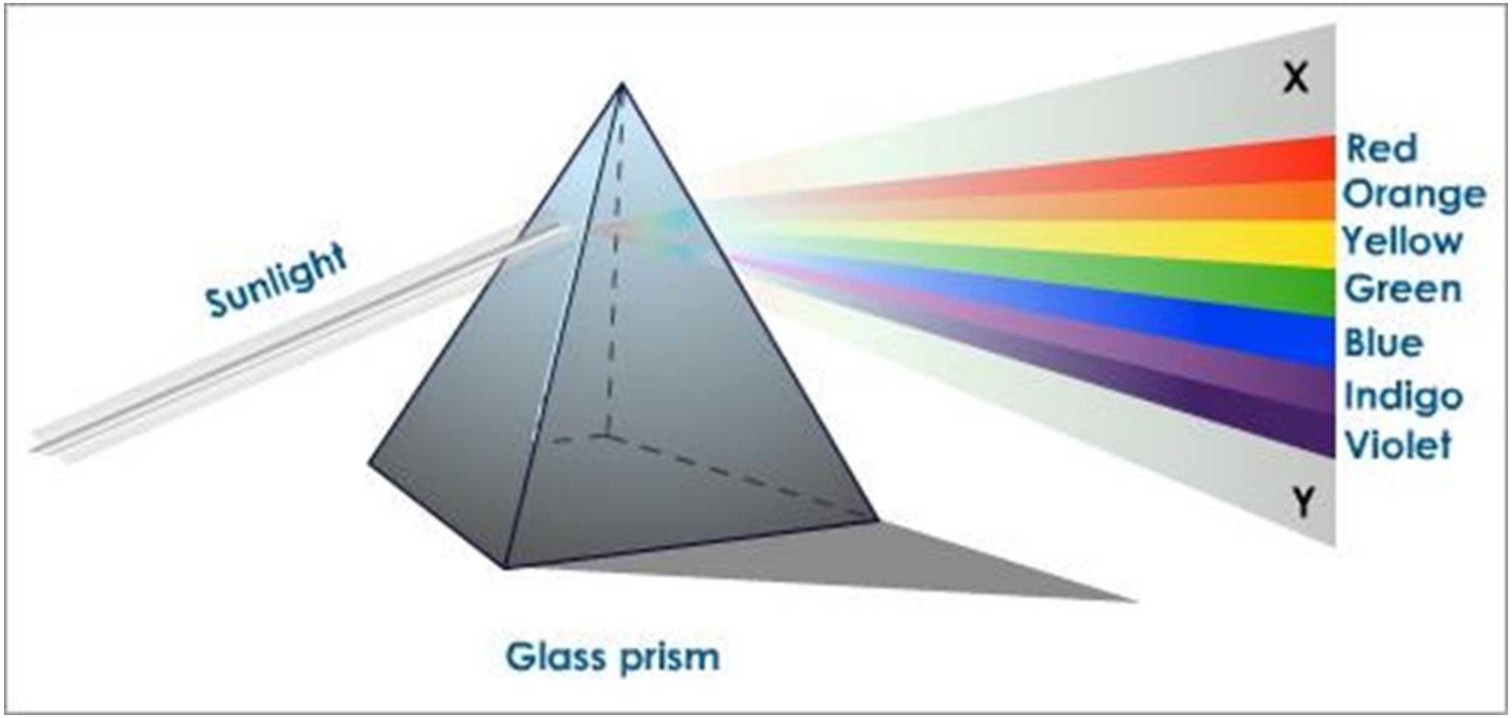
# Eye focusing corrections

| Eye problem | Lens diagram | Summary |
|---|---|---|
| **short sighted** people who are not able to focus clearly on distant objects. |  | A concave lens helps bend the light outwards for a person who focusses before the cornea |
| **Long sighted** people who have trouble focussing on close objects. |  | A convex lens helps bend the light inwards for a person who focusses after the cornea |

# Prisms work by diffracting colours of different wavelengths

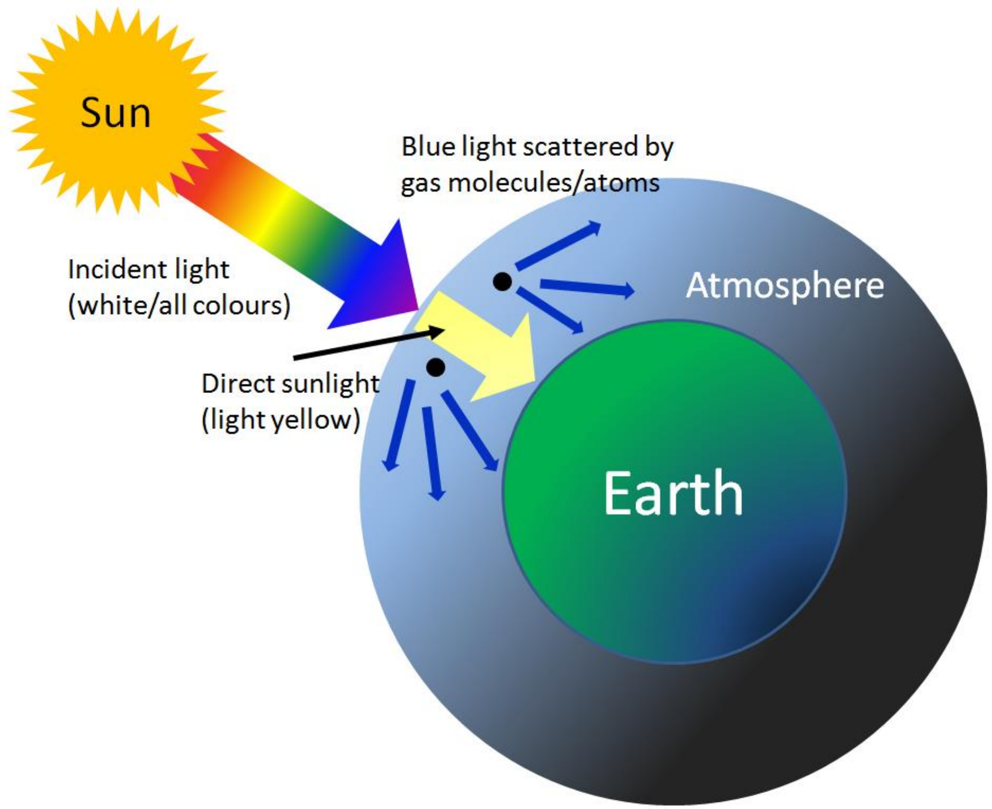
extra info

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.



# Blue skies and red sunsets

extra info




## Why is the sky blue?

Sunlight, that is made up of all colours, reaches Earth's atmosphere and is scattered in all directions by all the gases and particles in the air. Blue light is scattered in all directions by the tiny molecules of air in Earth's atmosphere. Blue is scattered more than other colours because it travels as shorter, smaller waves. Though the atmospheric particles scatter violet more than blue, the sky appears blue, because our eyes are more sensitive to blue light and because some of the violet light is absorbed in the upper atmosphere.

## Why are sunsets red?

When the Sun gets lower in the sky, its light is passing through more of the atmosphere to reach you. Even more of the blue light is scattered, leaving only the reds and yellows to pass straight through to your eyes.

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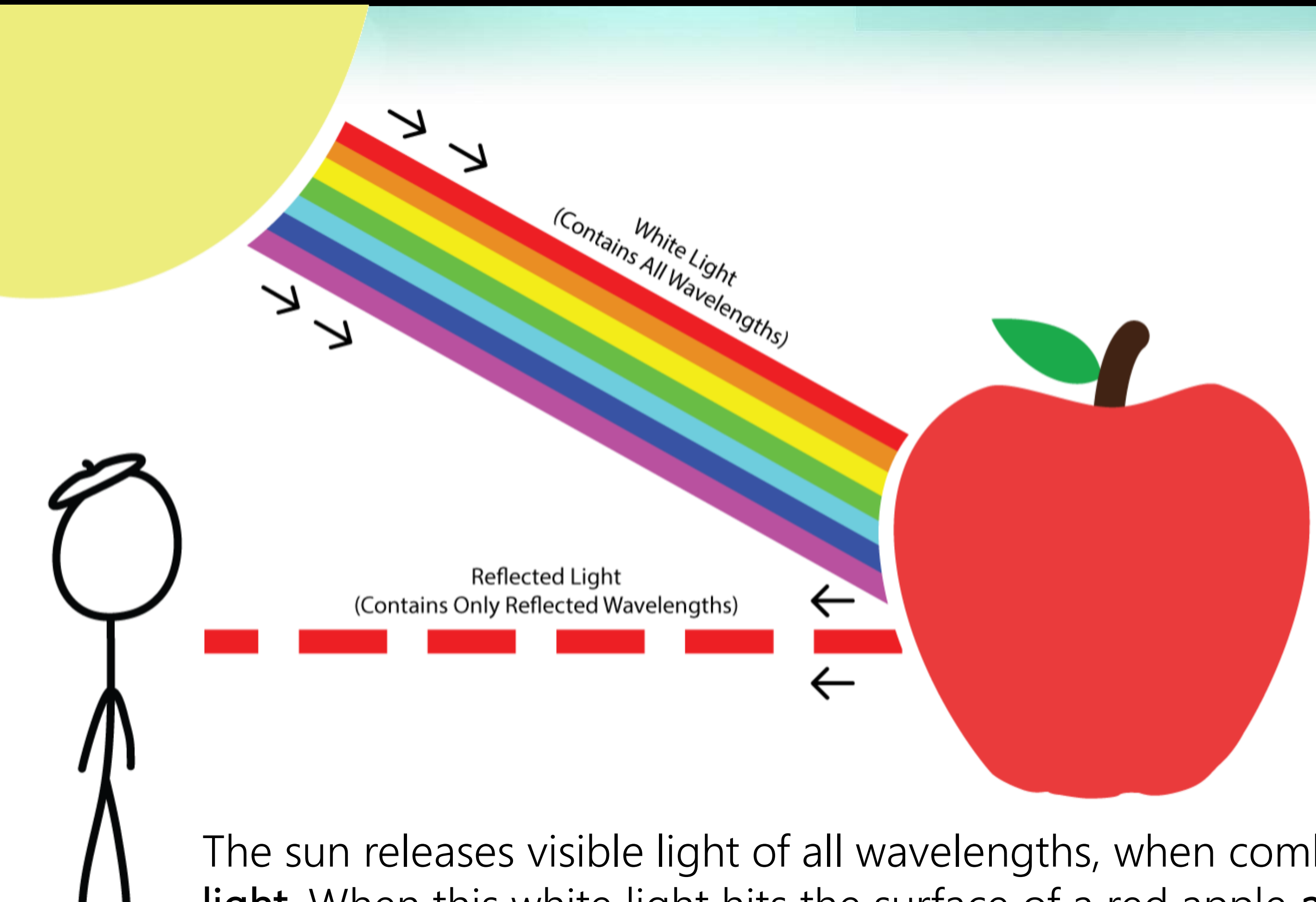
# White light is made from colours mixed together

extra info

White light is a combination of all of the other colours of light mixed together.  The main colours that make up white light can be seen in a rainbow. They are red, orange, red, green, blue, indigo (a dark inky blue) and violet. They can be remembered by the acronym ROY G BIV. A prism can be used to separate out the different colours. This is called dispersal.

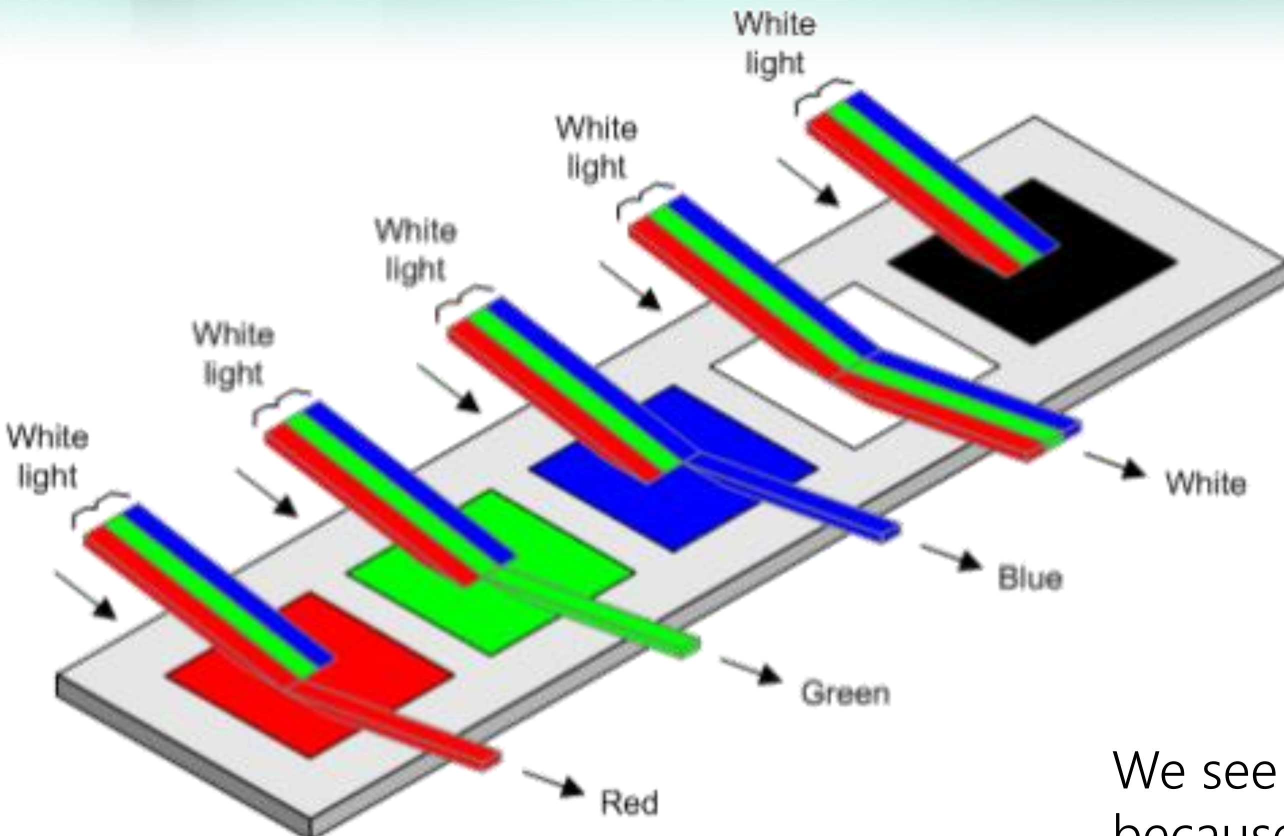
# What colour is that




The sun releases visible light of all wavelengths, when combined becomes **white light**. When this white light hits the surface of a red apple **all of the other colours** of light except red are **absorbed**. The **red light** is instead **reflected**, and when hitting our eyes we see the apple as red because that is the only wavelength detected.

# We see colours because of what wavelengths are reflected

extra info




Shining white light on different colored paints

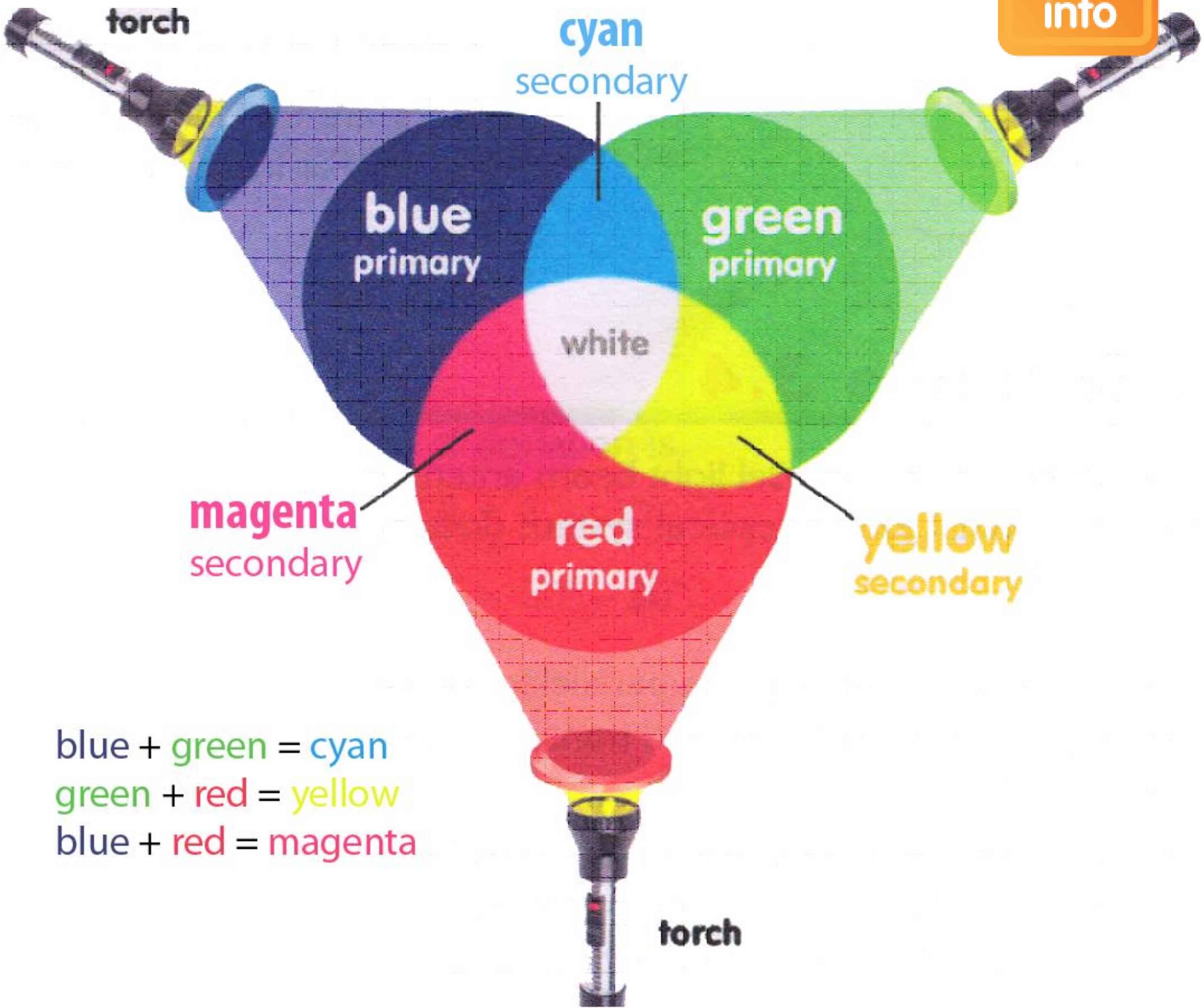
A colour is a property processed by an object as a result of the way it reflects, absorbs or emits light of a specific wave length.

We see a tree as green because the leaves absorb the red and blue light waves, and only the green light is reflected into our eyes.

# The nature of colour vision - primary and secondary colours

extra info

Combining light colours is said to be **additive**. Each wavelength of light adds to another.
The three main colours of light are called **primary**. Two primary colours together make a **secondary** colour and all three primary colours together make up **white light**.




blue + green = cyan
green + red = yellow
blue + red = magenta

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# Paint pigments are subtractive colours.

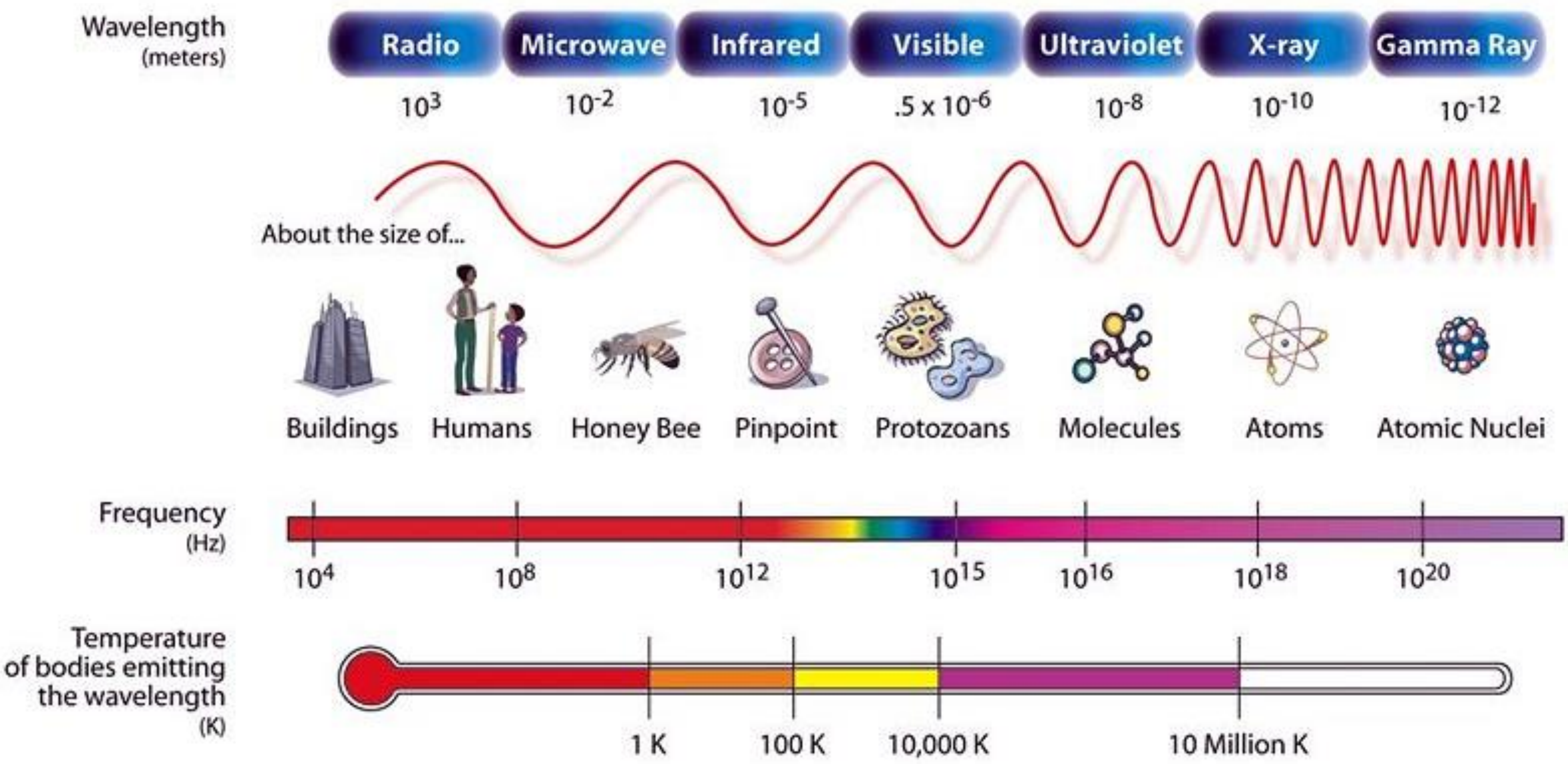
extra info

Paint absorbs light waves. The paint is called **subtractive** because with each addition of colour more of the wave lengths are absorbed. The three primary colours of paint are cyan, yellow and magenta. When these three are added together the resulting colour is **black**: all of the different wavelengths of coloured light are absorbed.

# Visible light belongs to the electromagnetic spectrum

extra info

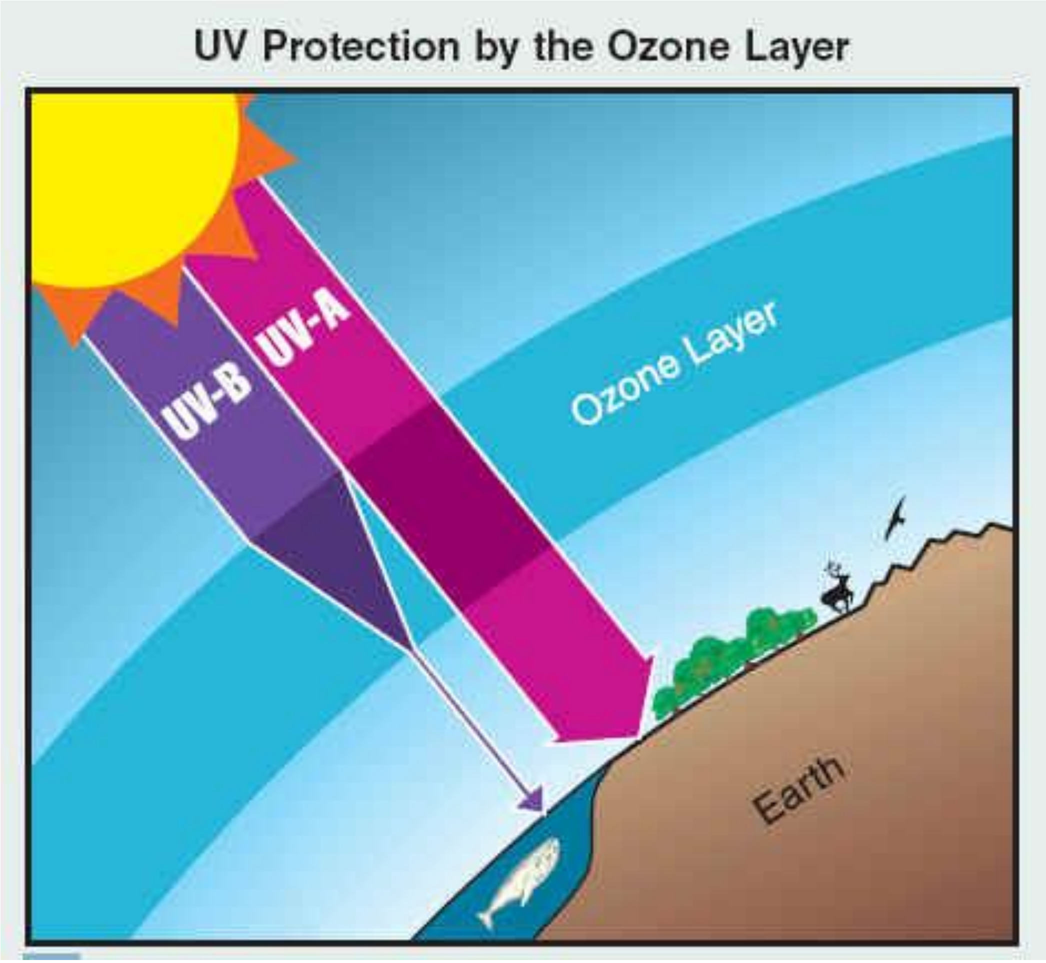
Light is a type of energy called electromagnetic (EM) radiation. There are other kinds of EM radiation such radio waves, microwaves, x-rays, etc., but light is the only part we can see with our eyes. All of the types of EM radiation together are known as the **electromagnetic spectrum.**



## Short wave length EM radiation can be dangerous

Forms of EM radiation that have a shorter wavelength than visible light such as **ultra-violet radiation** (UV) and **X-rays** can be dangerous to us in high quantities.

The sun emits EM radiation of all different wavelengths but a magnetic layer, produced by the magnetised iron inside earth, shield us from the most harmful radiation. The ozone layer (oxygen molecules made of 3 oxygen atoms) shield us from a large amount of UV-B radiation but if we remain out in the Sun for to long we can be sunburnt. Sunblock provides a layer on our skin, often containing chemicals like zinc, that stop UV radiation.



# Long wave length EM radiation can provide us with information

extra info

EM Radiation with wave lengths longer than visible light can be detected with special types of receptors. **Infra-red** radiation is emitted from warm objects. Night vision goggles pick up this type of EM radiation from living bodies when no visible light is present.

Microwaves are longer again and can be used to heat food. The waves cause the water molecules in food to move back and forward rapidly and produce heat. Objects such as plastic without water, do not heat up directly.

Radio waves are the longest type of EM radiation. Radio receivers are used to pick up these waves that can be generated by radio stations or even from objects in space. Cell phones work by receiving radio waves reflected from satellites orbiting above earth.