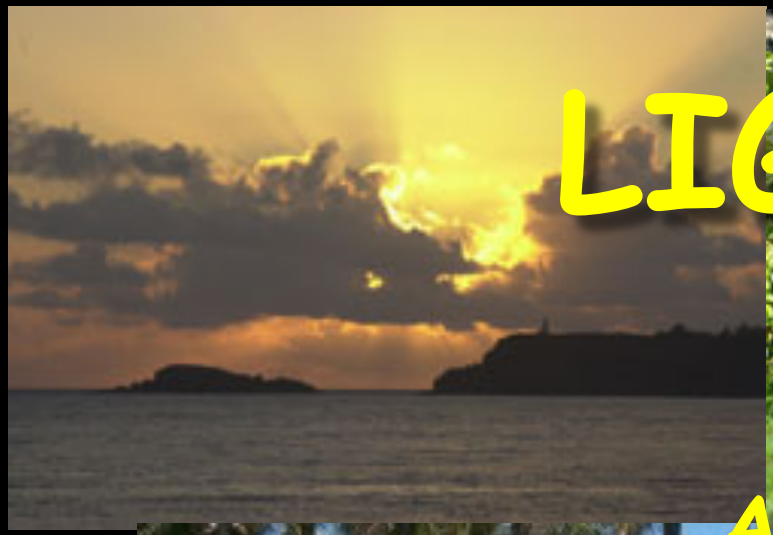
Yikes! It's dark in here…



LIGHT

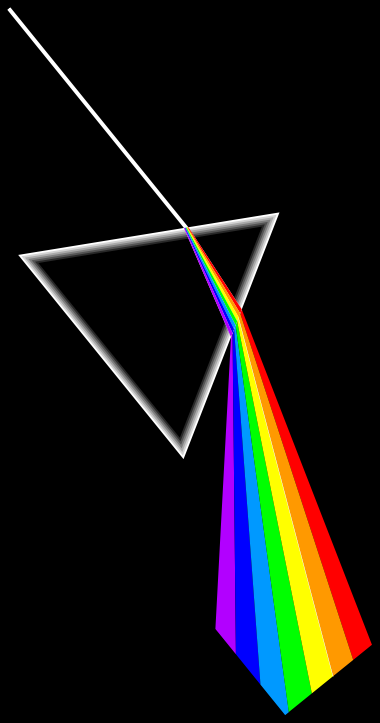
AND

OPTICAL SYSTEMS

Light and Optical Systems

In this unit…

1) *Early Ideas about Light and Vision*
2) *Properties of Light*
3) *Optical Devices*
4) *Reflection*
5) *Refraction*
6) *Eyes and Cameras*
7) *Image Storage and Transmission*



What did each of these historians contribute to the understanding of light?

- Archimedes

- Pythagoras

- Euclid

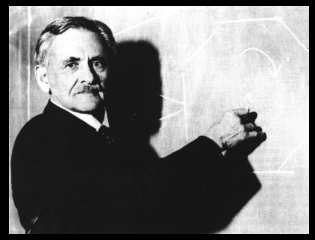
- Ptolemy

- al-Haytham

- Newton

- Romer

- Michelson

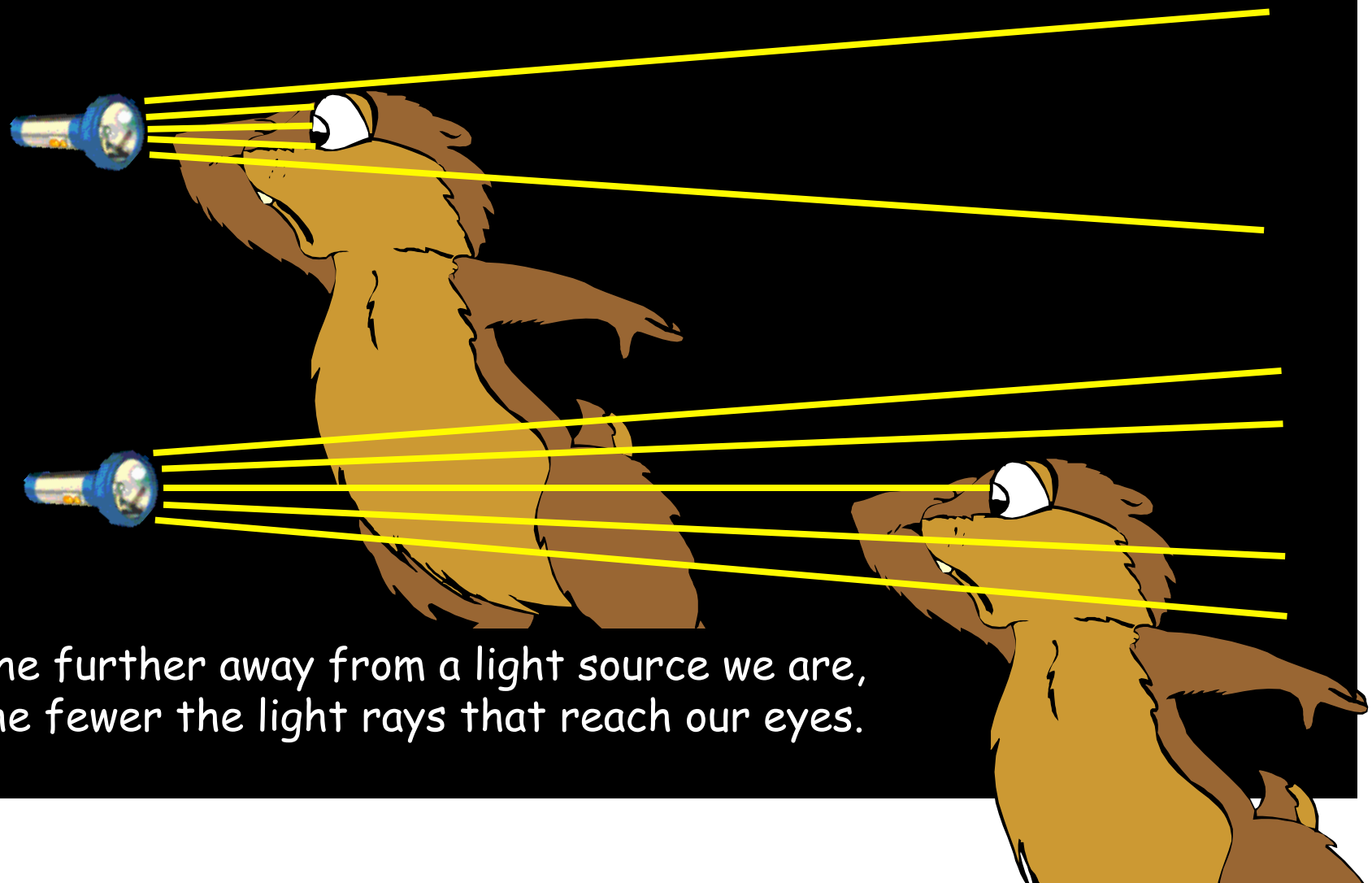


What some Properties of Light?

1 - Light is a form of *ENERGY* and it travels in straight lines:

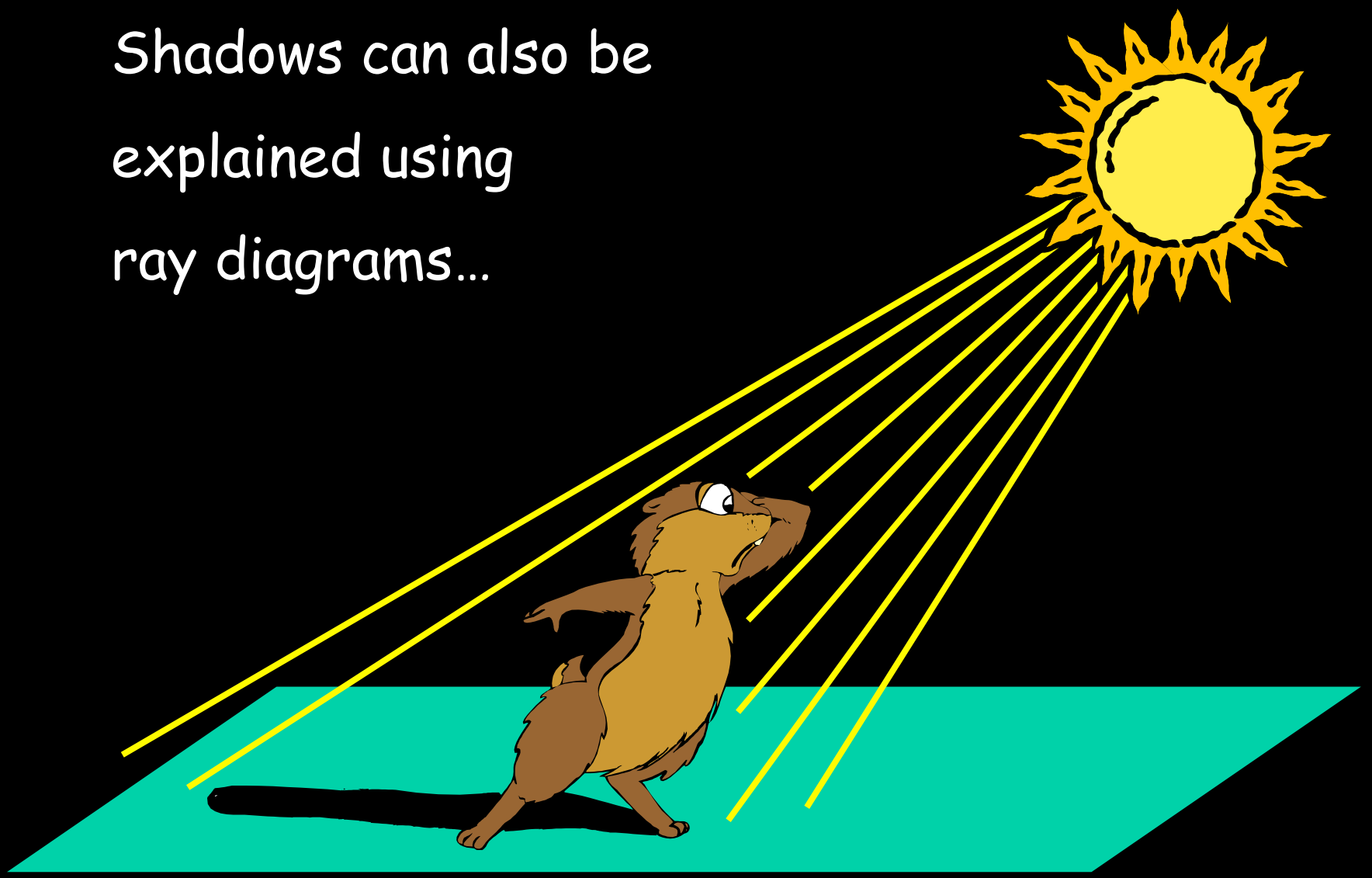
These paths of light are called **'RAYS'**

Ray diagrams help us explain the behaviour of light and our perception of light.



The further away from a light source we are, the fewer the light rays that reach our eyes.

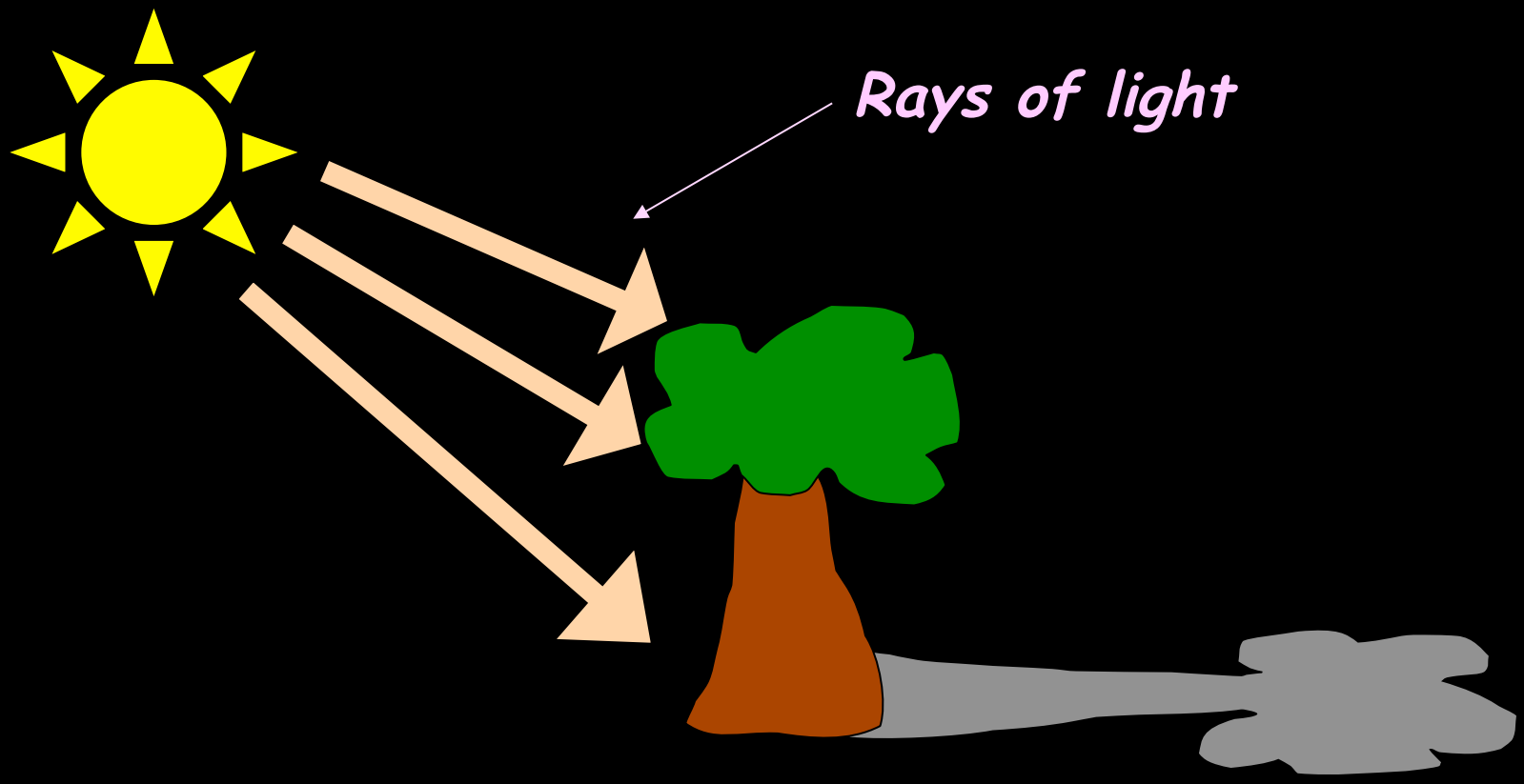
Shadows can also be explained using ray diagrams…



Wherever light rays are blocked… there's a shadow!

Shadows

Another Example…



Light travels VERY FAST, around 300,000 kilometres per second or 3.0 x 10^8 m/s

Or 300000000 m/s

At this speed it can go around the world 8 times in one second.

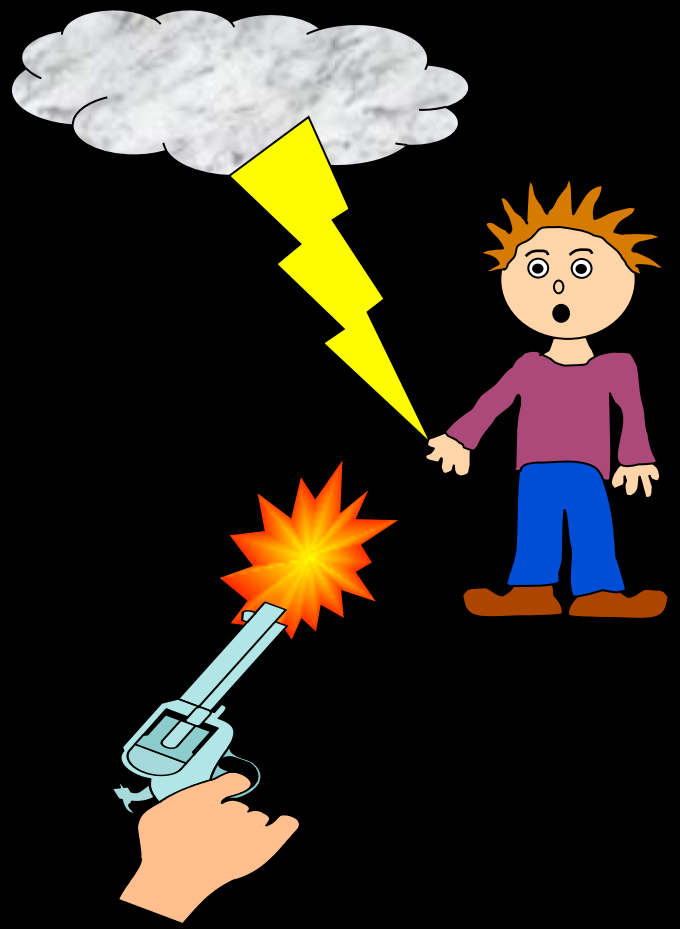
Light travels <u>much faster</u> than sound:

- Speed of sound is **340.29 m/s**
- **Speed of light is 300000000 m/s**

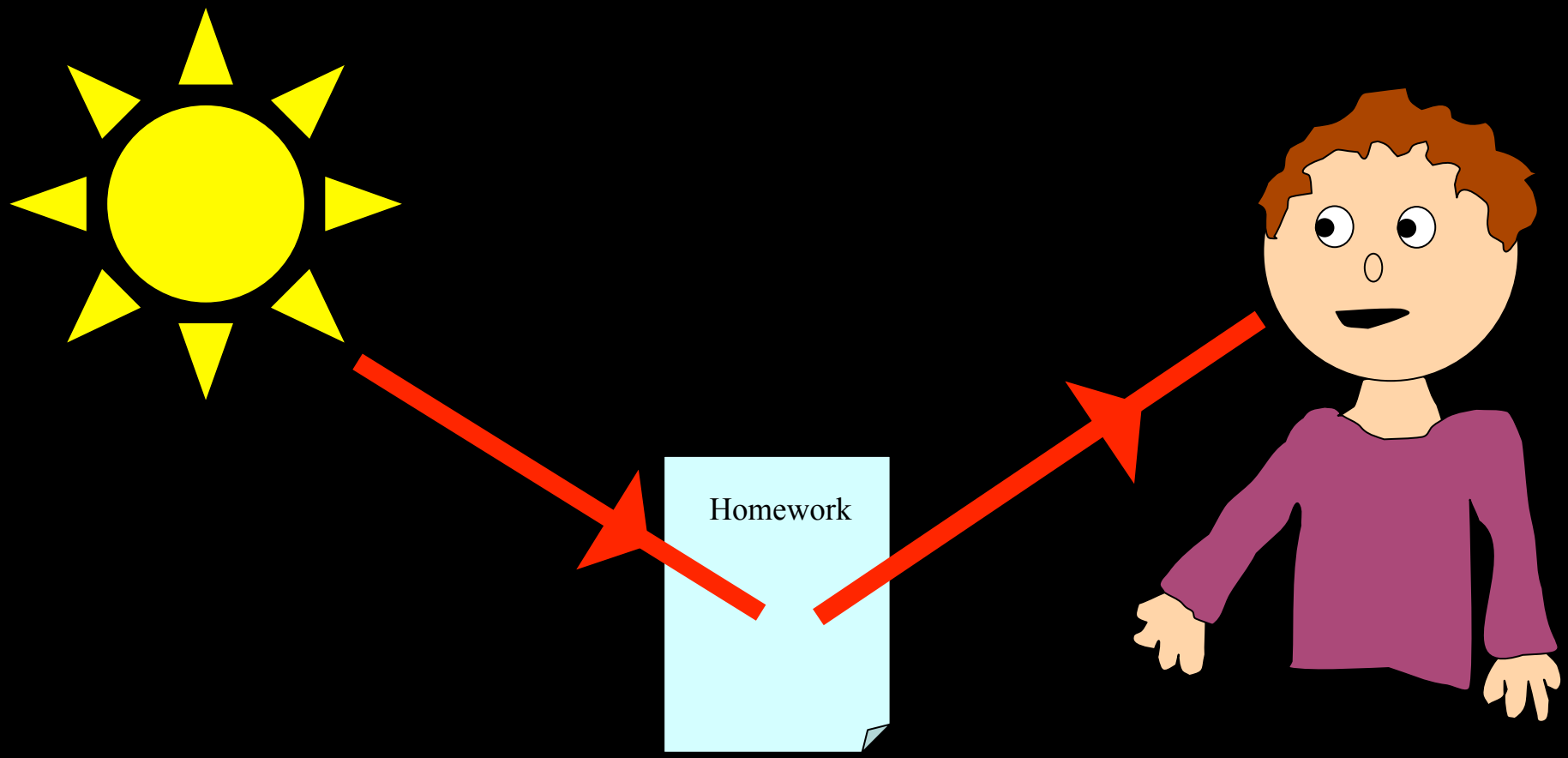
For example:

1) Thunder and lightning start at the same time, but we will see the lightning first.

2) When a starting pistol is fired we see the smoke first and then hear the bang.



We see things because they reflect light into our eyes:



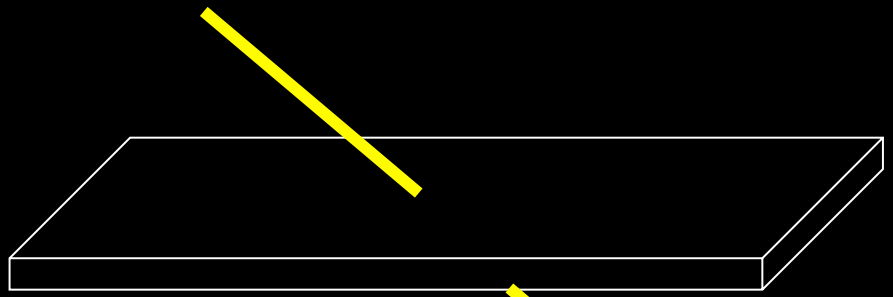
Luminous and non-luminous objects

A luminous object is one that produces light.

A non-luminous object is one that reflects light.

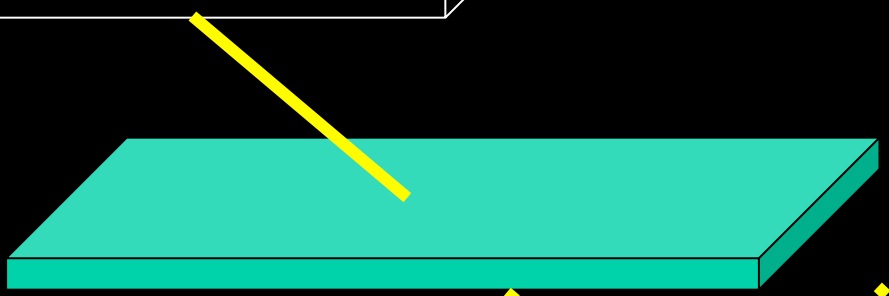
Luminous objects	*Non-luminous objects or Reflectors*

When light strikes an object, the light behaves in different ways depending on the type of material the object is made of.

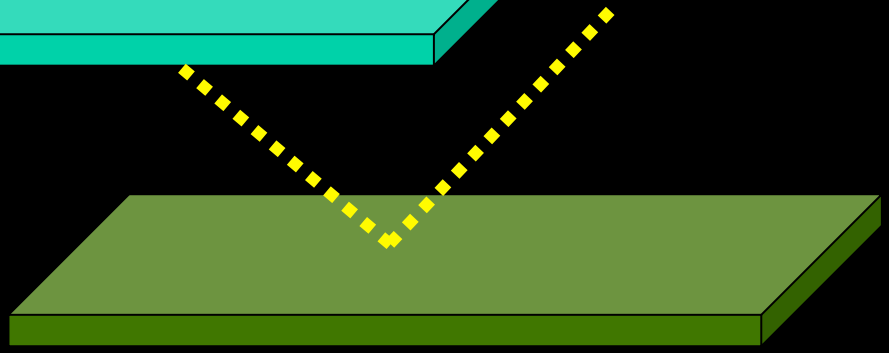


Transparent materials transmit light – it travels right through them.

Translucent materials allow some, but not all light to pass through them.



Opaque materials do not allow any light to pass through them and either absorb or reflect the light that hits them.

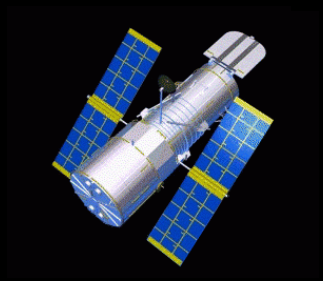


Properties of Light summary

1) *Light travels in straight lines*
2) *Light can be reflected*
3) *Light can be bent*
4) *Light is a form of energy*
5) *Light travels at a constant speed (in a vacuum)*

How and why were these inventions created?

Microscopes

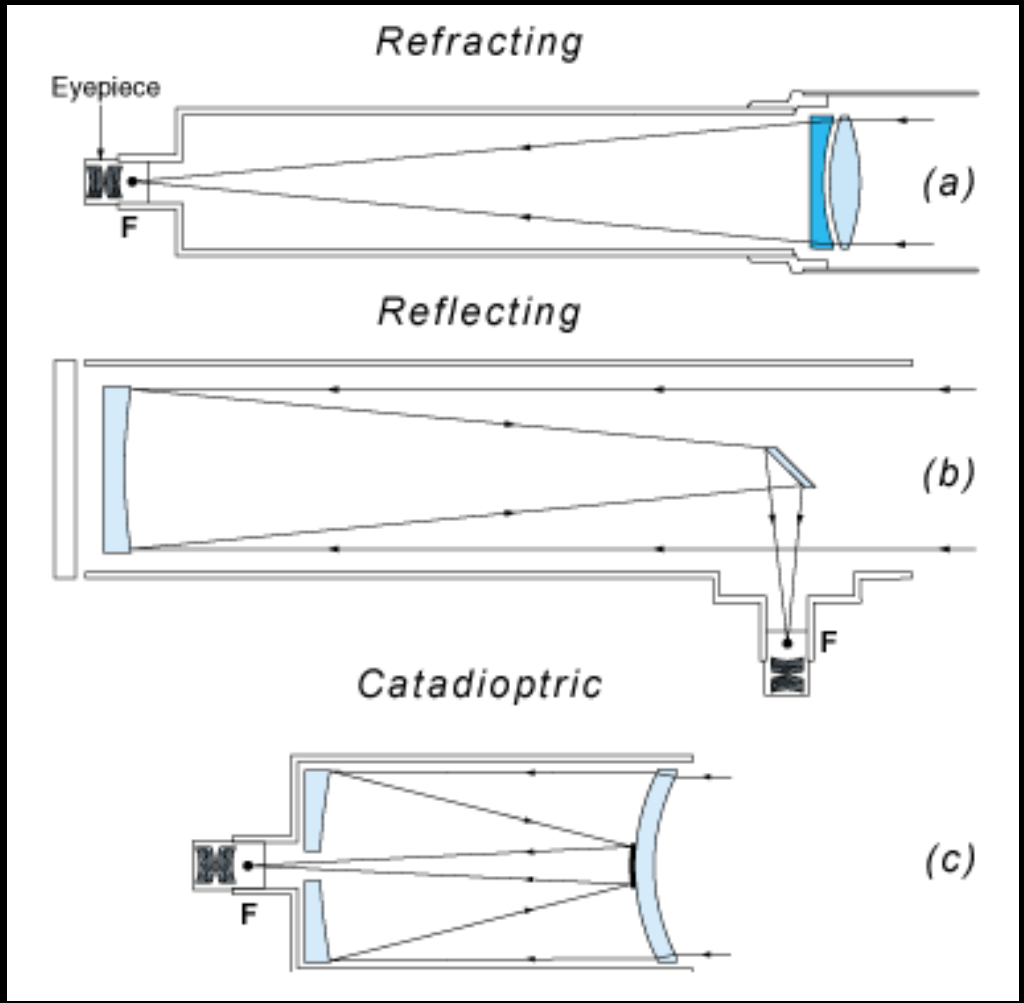


Telescopes

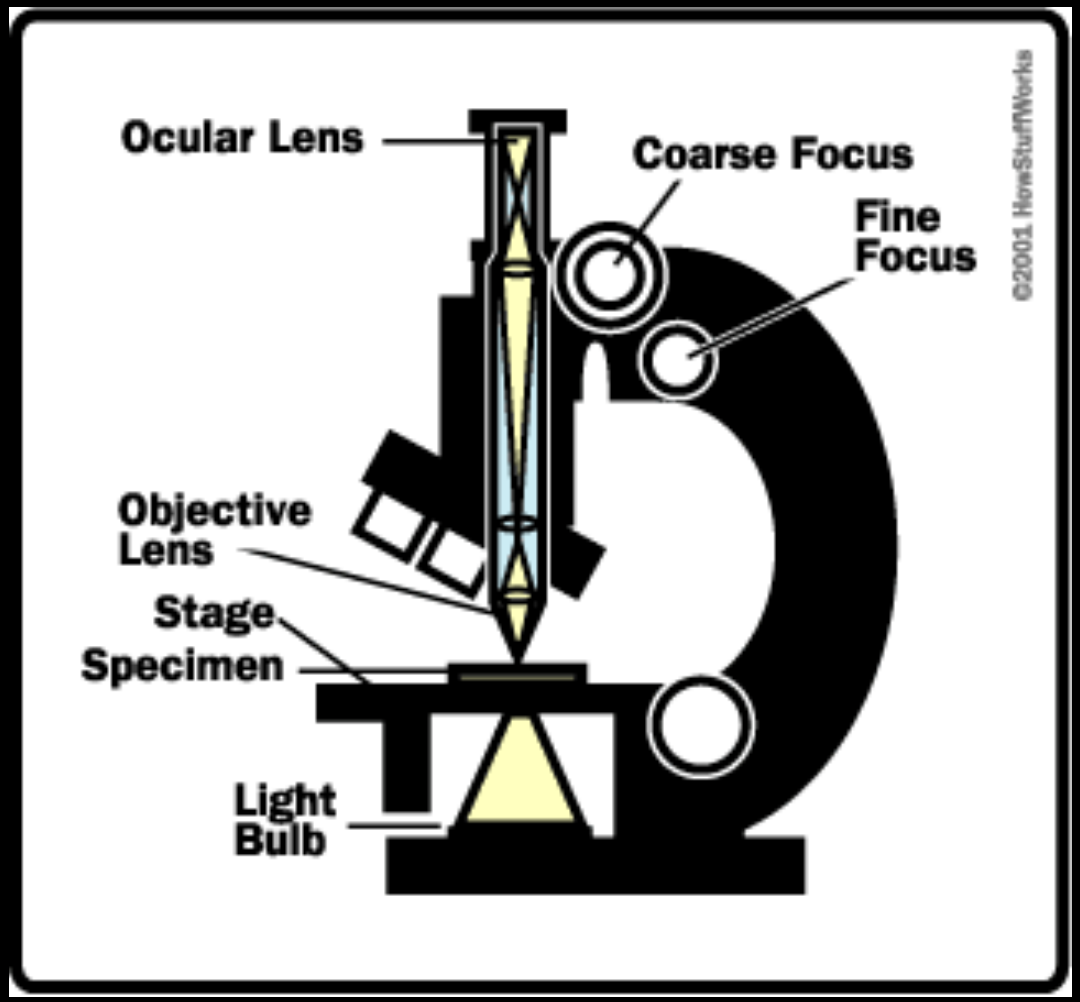
Cameras

Binoculars

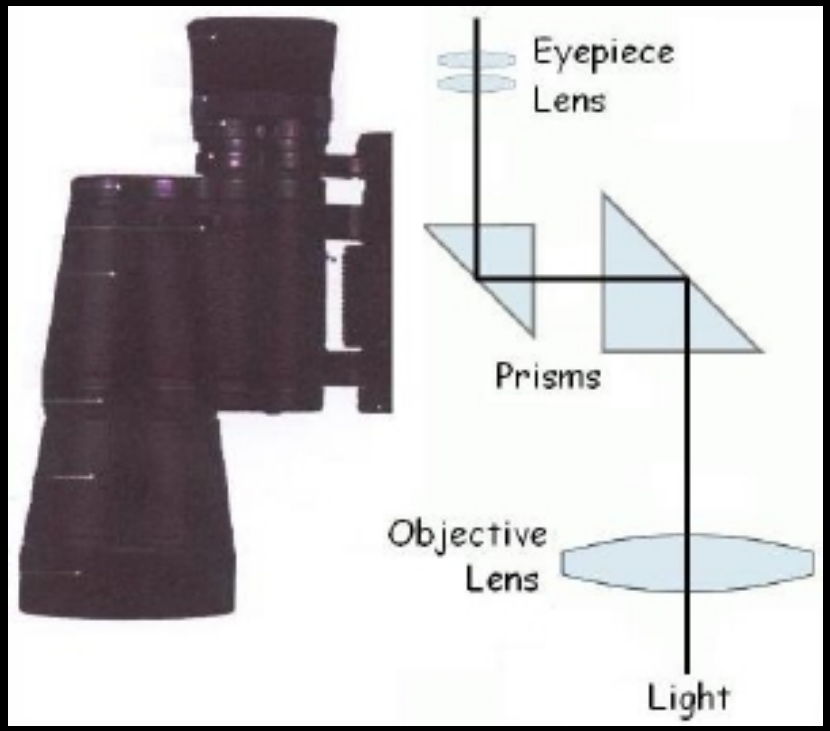
How does a telescope work?



How does a microscope work?

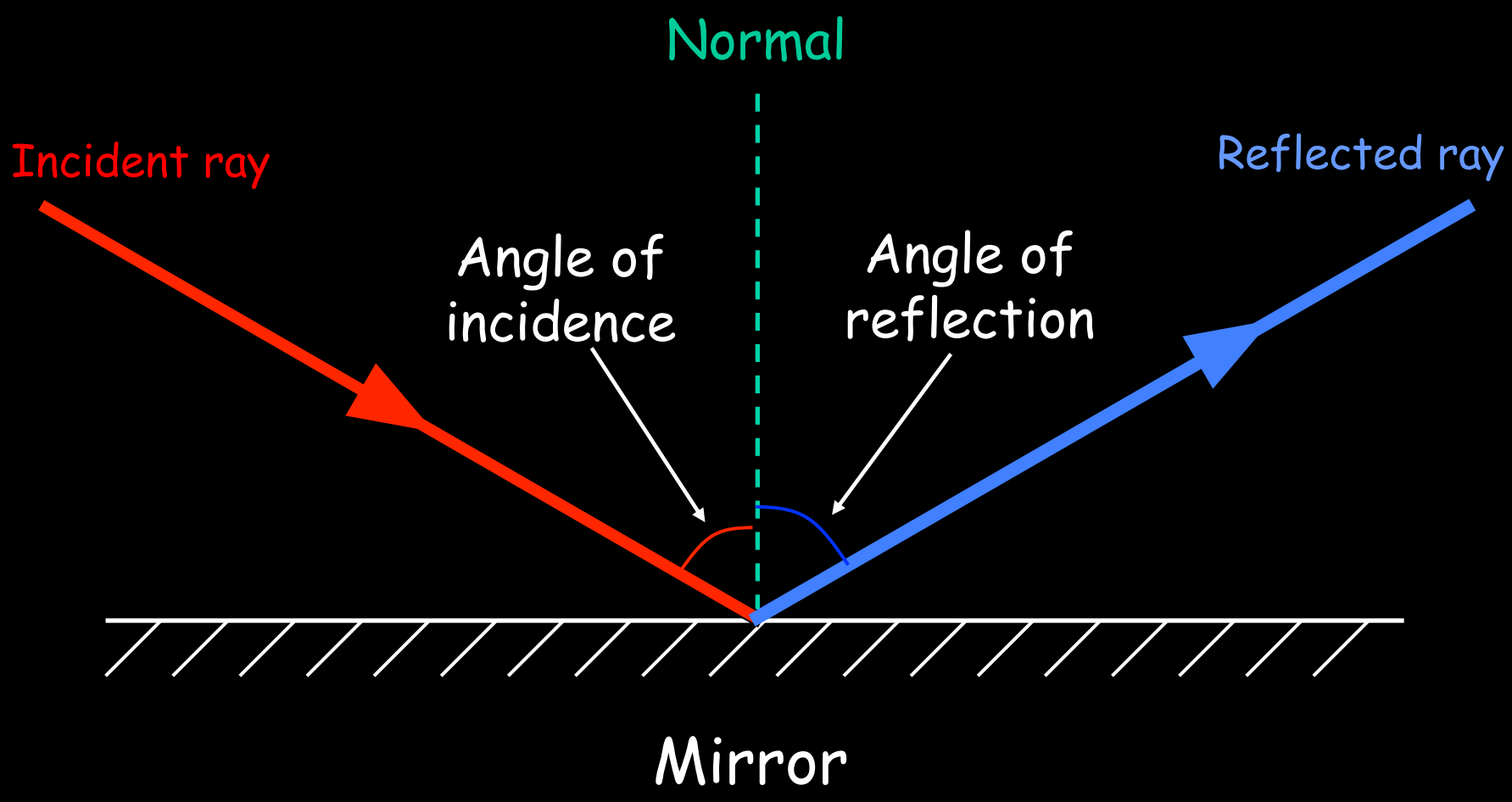


How do binoculars work?



4) Reflection

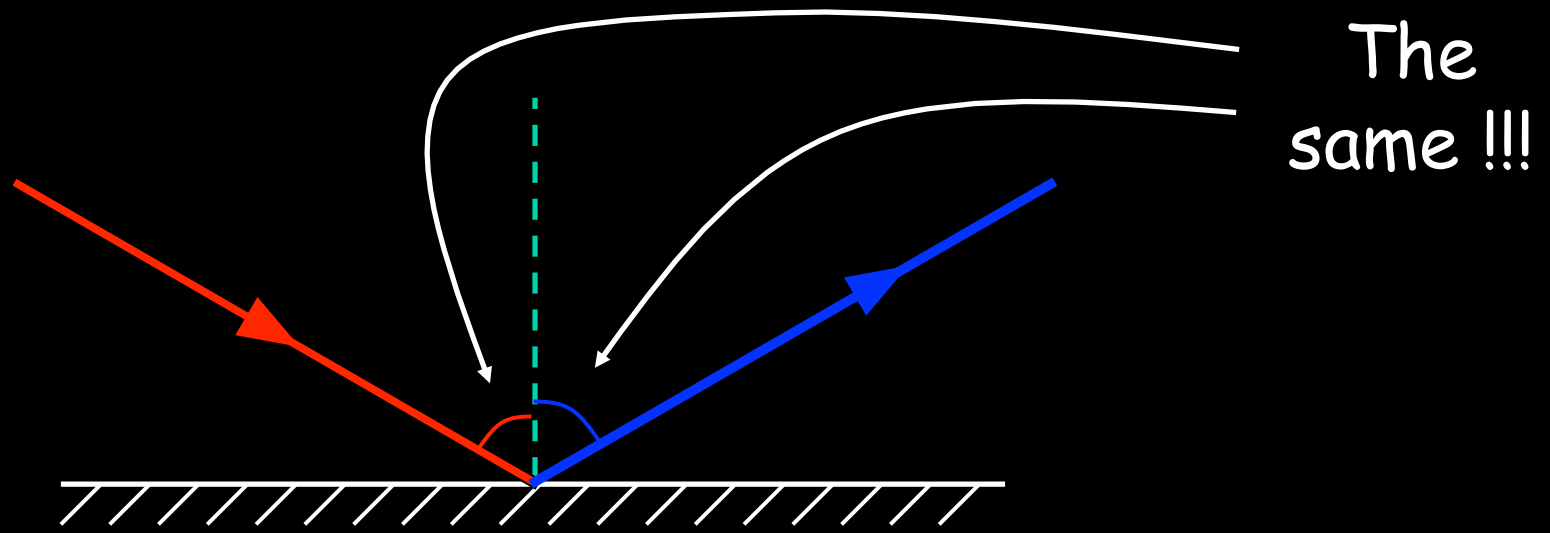
Reflection from a mirror:



The Law of Reflection

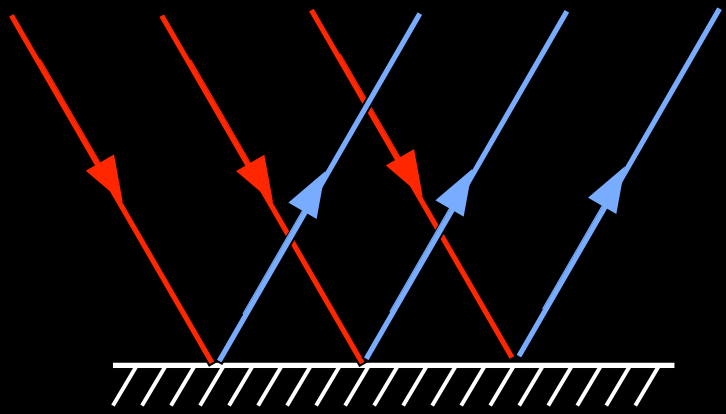
Angle of incidence = Angle of reflection

In other words, light gets reflected from a surface at ____ _____ angle it hits it.



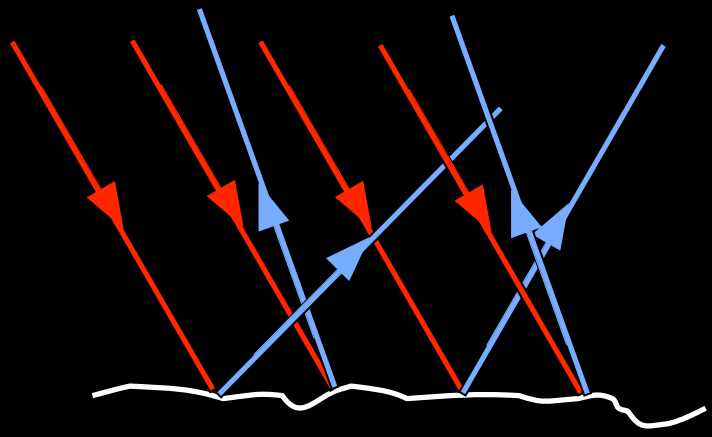
Regular vs. Diffuse Reflection

Smooth, shiny surfaces have a *regular* reflection:

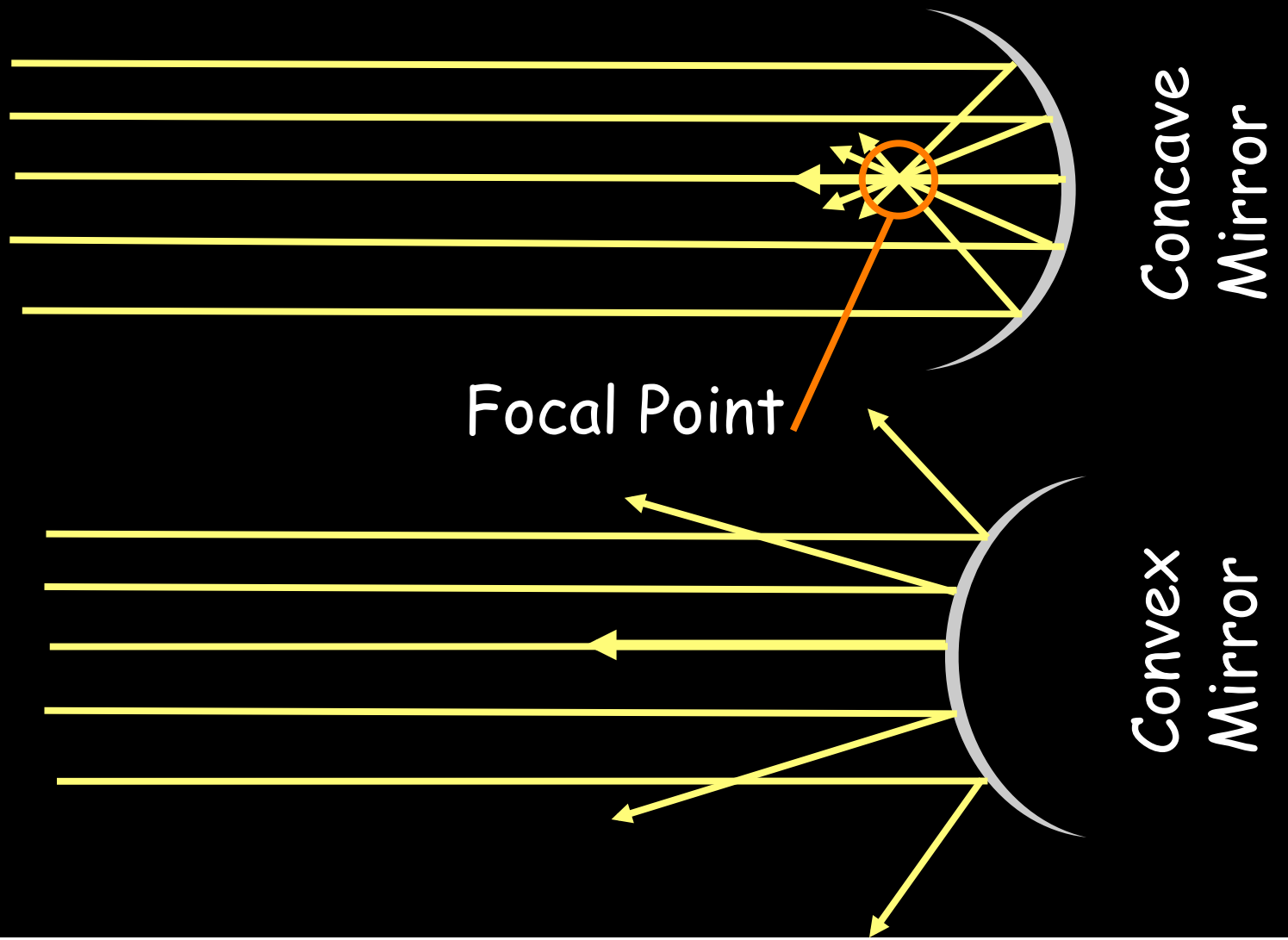


Rough, dull surfaces have a *diffuse* reflection.

Diffuse reflection is when light is scattered in different directions



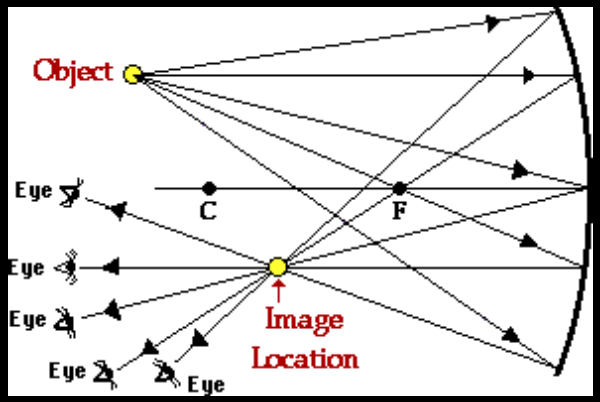
Reflecting Light with Curved Mirrors



a) Concave Mirrors

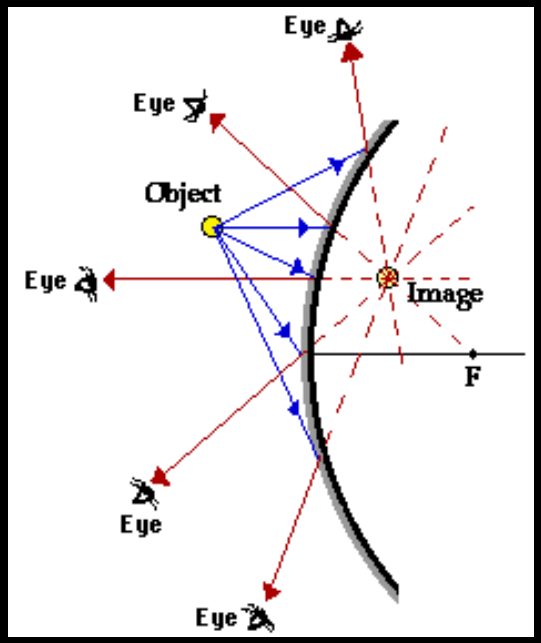
C = centre of the imaginary circle

F = focus



Concave mirrors will produce an image that is real (in front of the mirror) or virtual (behind the mirror). The real images will be inverted and their distance from the mirror is determined from the location of the object from the mirror, focus, and centre. Virtual images appear to be located behind the mirror and will always be right-side up and enlarged. Virtual images will be produced when an object is located between the focus and the mirror. *Refer to the handout on concave and convex mirrors for a more detailed explanation.*

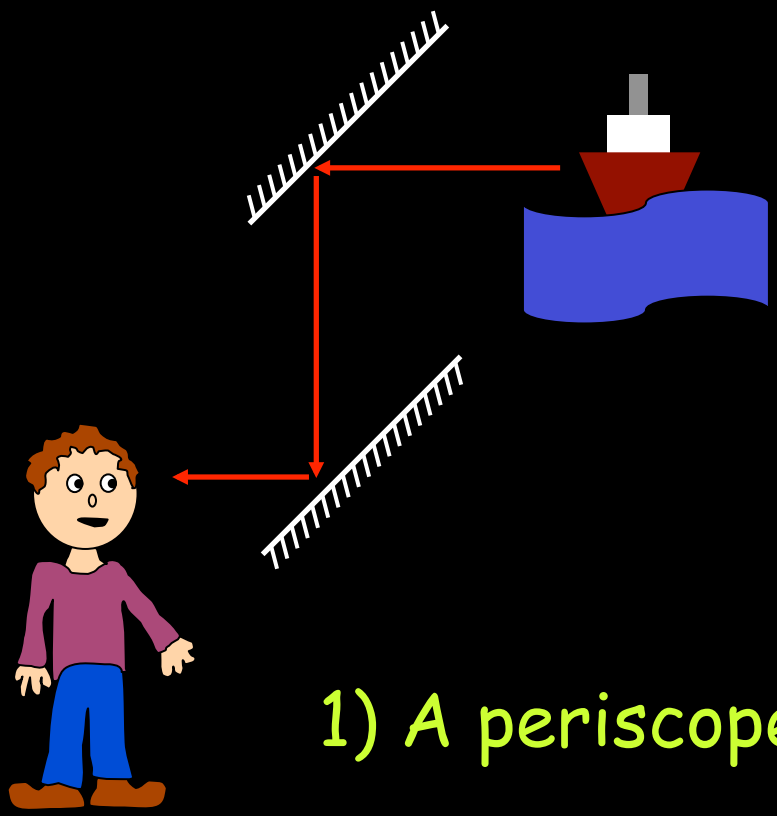
b) Convex Mirrors



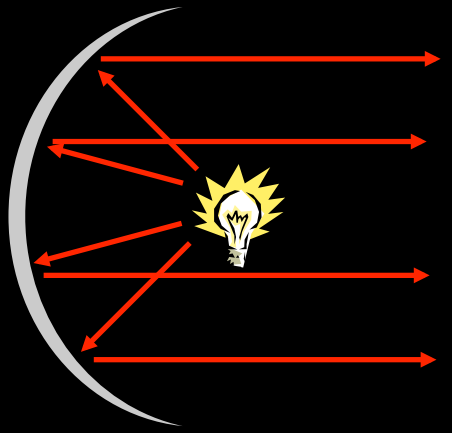
Convex mirrors will produce a virtual image (located behind the mirror) that is right-side up and smaller than the object. The reflected rays diverge from the mirror resulting in a virtual images located behind the mirror. *Refer to the handout on concave and convex mirrors for a more detailed explanation.*

Using mirrors

Two examples:



1) A periscope



2) A car headlight

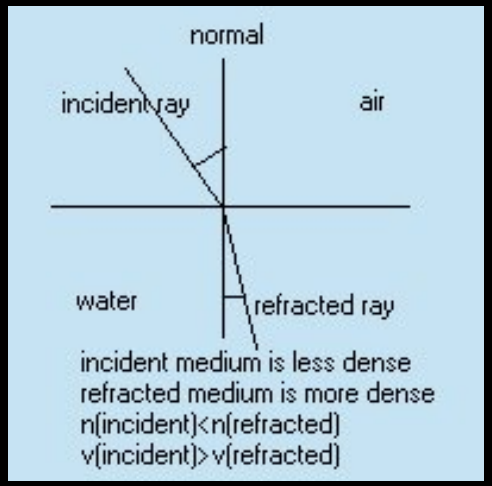
5) Refraction

Refraction is when waves _____ __ or slow down due to travelling in a different medium. A medium is something that waves will travel through. When a pen is placed in water it looks like the diagram in the text, page 201.

In this case the light rays are slowed down by the water and are _____, causing the pen to look odd. The two mediums in this example are _____ and _____.

Words – speed up, water, air, bent

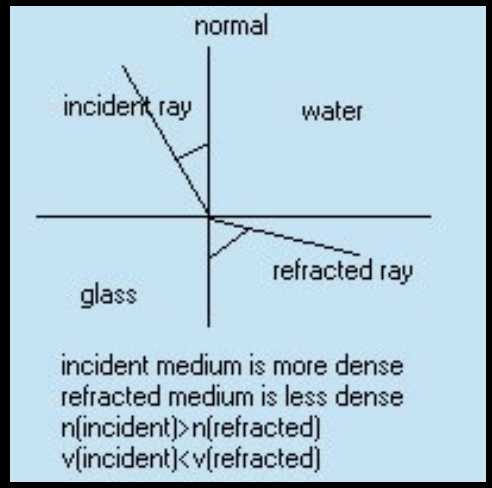
Refraction con't



The normal is located perpendicular to the division between the two mediums.

n = index of refraction
(speed of light in a vacuum/speed of light in a medium)

v = speed of light in the medium



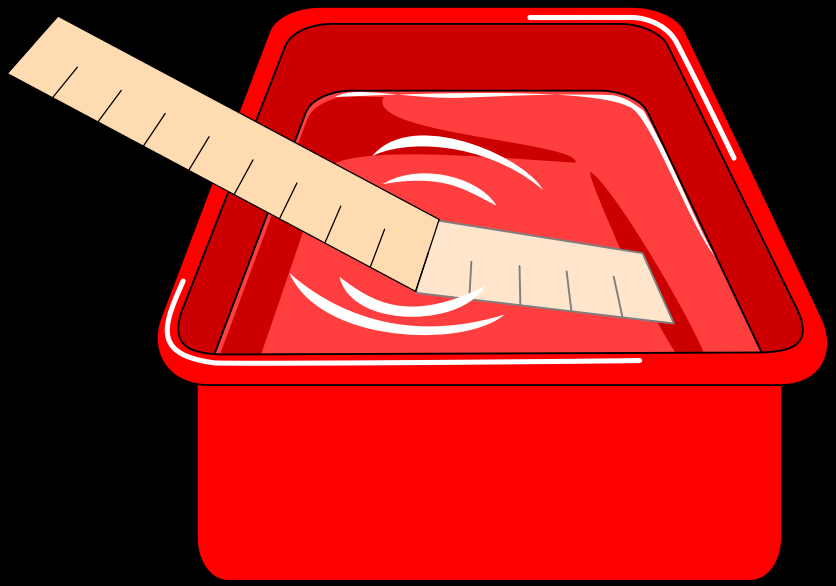
As an incident ray enters a new medium that is more dense, the ray will bend towards the normal. Therefore, the angle of incidence is larger than the angle of refraction.

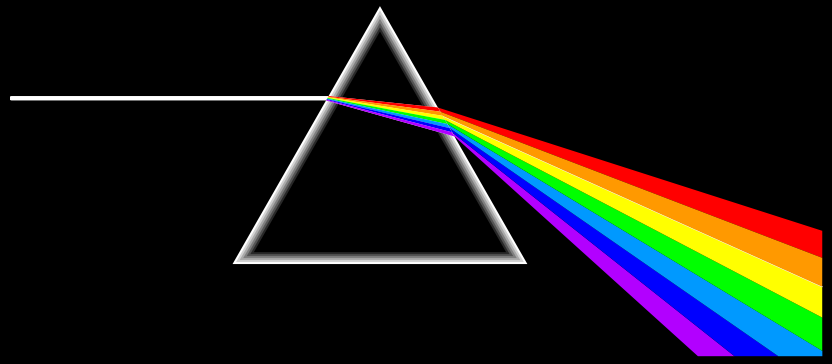
As an incident ray enters a new medium that is less dense, the ray will bend away from the normal. Therefore, the angle of incidence is smaller than the angle of refraction.

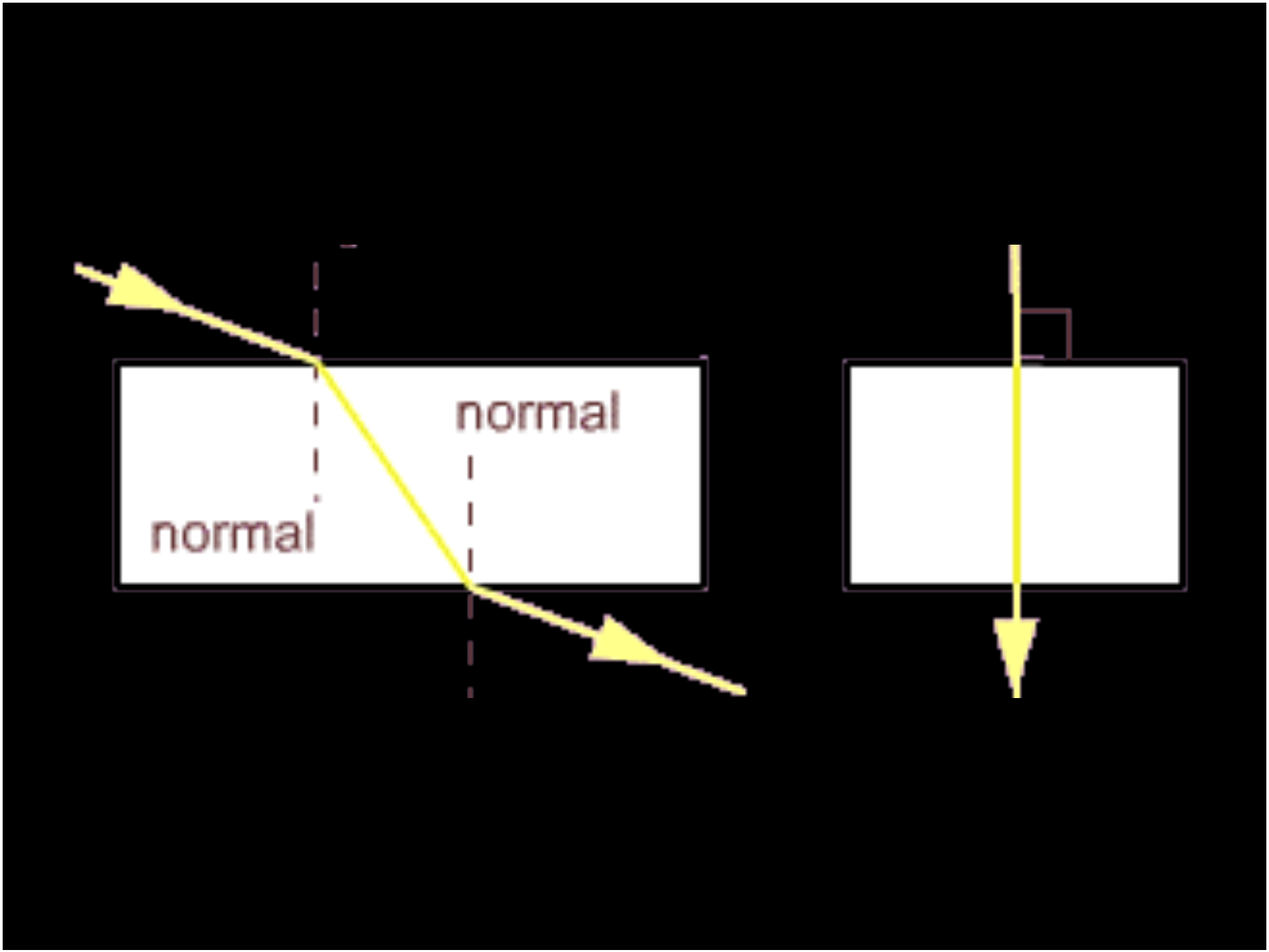
Refraction con't

Medium	Index of Refraction>
vacuum	1.00
water	1.33
ethanol	1.36
fluorite	1.43
polystyrene	1.49
crown glass	1.52
quartz	1.54
Zircon	1.92
diamond	2.42

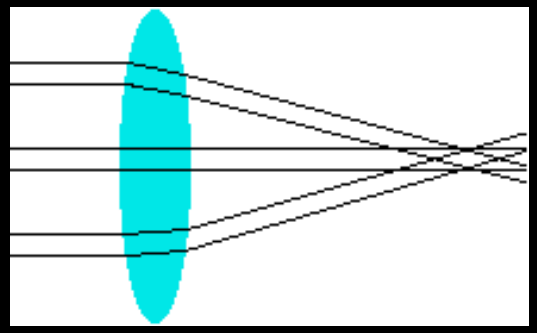
Ex: if you pass a beam of light from a diamond medium to an ethanol medium, will the light bend towards the normal or away? AWAY!





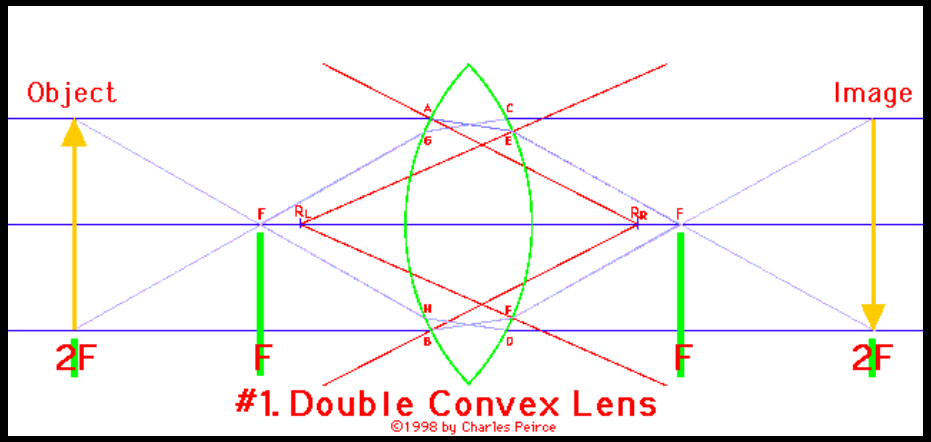

normal
normal

a) Convex Lenses (converging lens)



- A convex lens is **always** thicker in the centre than at the edges.
- Light travelling through the lens goes slower through the thick centre and faster through the thin ends causing the rays to focus or converge.
- The focal length of a convex lens is always positive (on the opposite side of the incidence ray).
- No image is produced when the object is at the focus.
- Virtual images (found on the same side of the incidence ray) are produced when the object is within the focus.
- *Refer to the diagrams in the text from page 208.*

• Real images (found on the opposite side of the incidence ray) are produced when the object is outside of the focus.



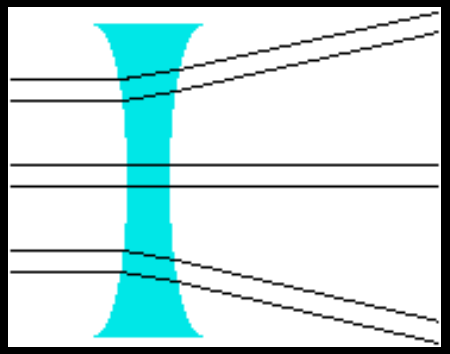
Follow the incident rays like you would with a mirror.

•First ray from the top of the object, parallel to the principal axis refracts through the lens to pass the focus on the other side of the lens. This continues until it meets with the other ray from the top of the object.

•Second ray from the top of the object, travels through the "imaginary focus" found before the lens to refract and create a refracting ray parallel to the principal incidence.

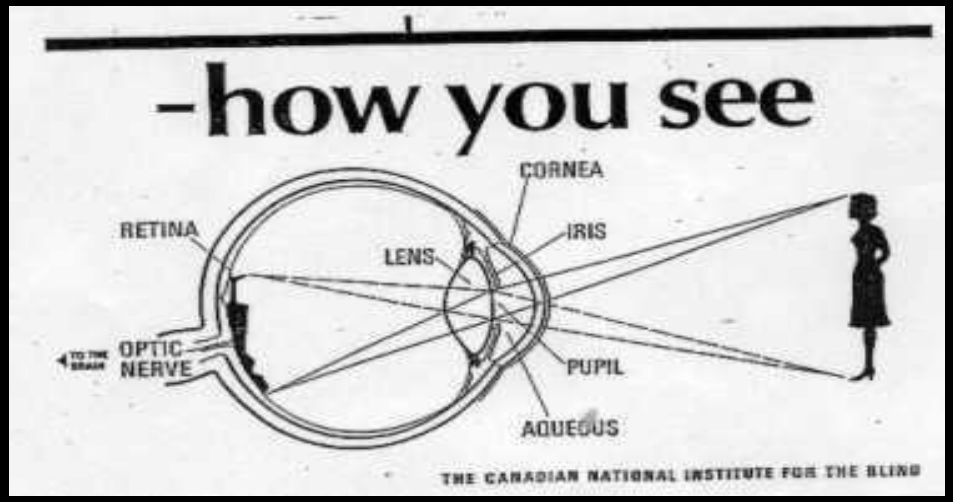
• The point in which the two rays from the top of the object meet will demonstrate where the top of the real image will be on the other side of the lens.

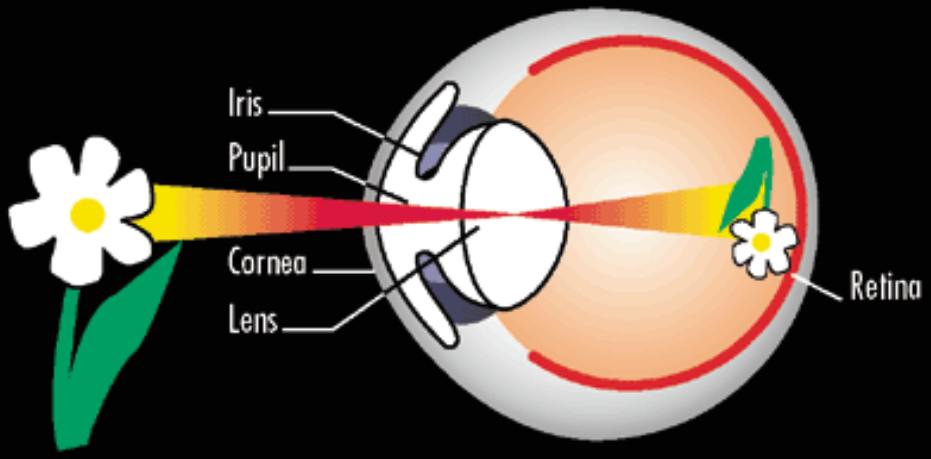
b) Concave Lenses (diverging lens)



- A concave lens is **always** thinner in the middle than at the edges.
- Light travelling through a concave lens goes faster through the centre and slower through the ends. This causes the rays to diverge or not to focus.
- The focal length of a concave lens is always negative.
- Only virtual images are produced by a concave lens.

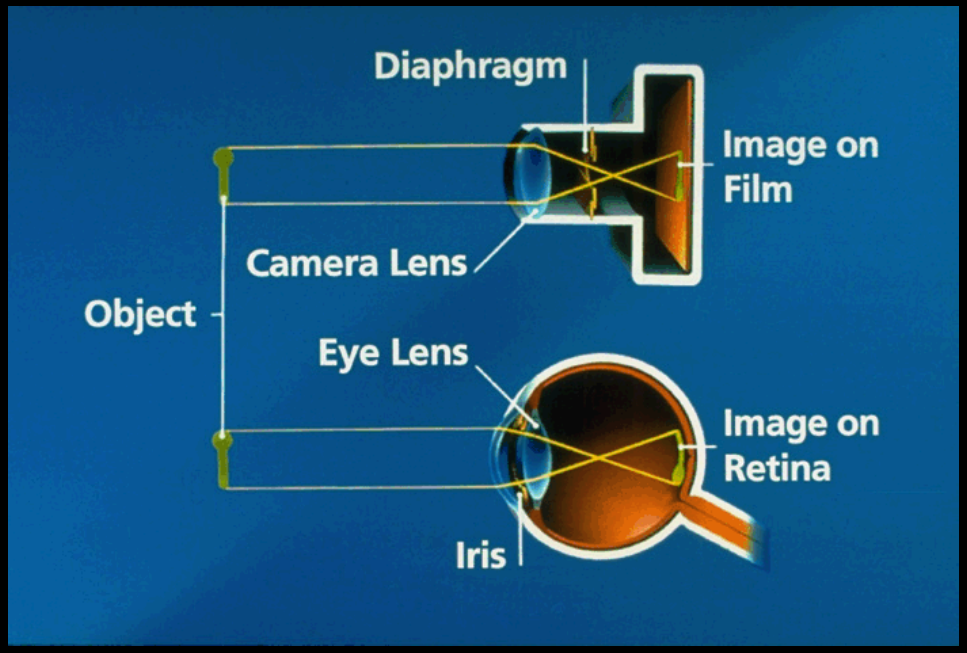
6) Eyes and Camera





Images are formed when the light travels through the lens and towards the retina. The image produced on the retina is upside down due to the lens. The upside down image will then be transferred to the brain for analysis via the optic nerve.

Refer to page 231, 233 in Science in Action 8



1. Light enters the eye through the pupil.
2. The iris, a band of muscle, controls the amount of light that enters through the pupil; opens in dim light situations, constricts in bright light situations.

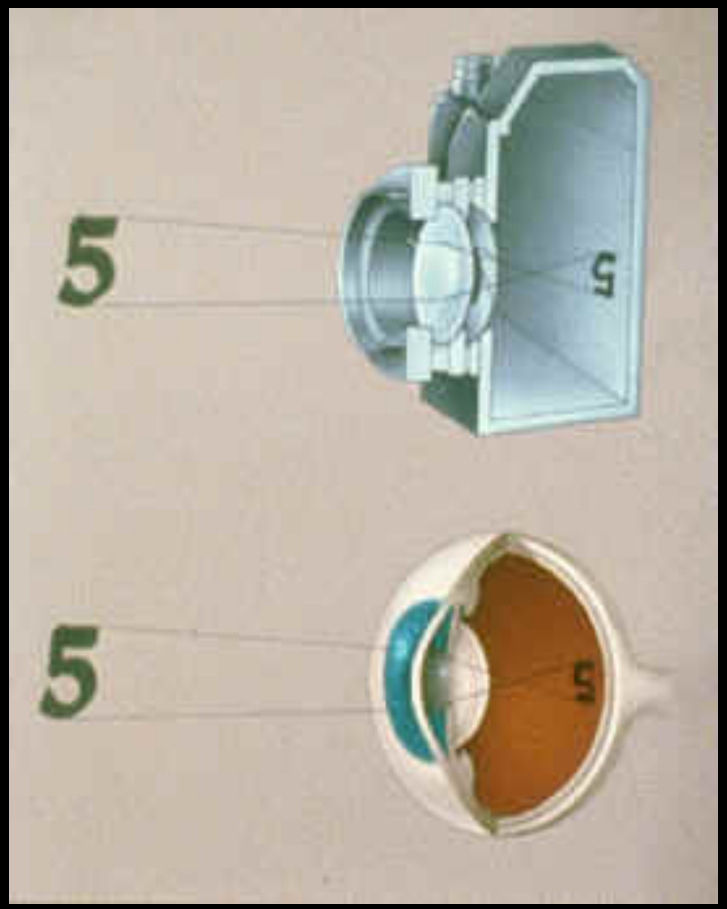
A. Light enters the camera through the aperture.

B. The diaphragm controls the amount of light that enters through the aperture; the shutter which lies behind the aperture acts as a light regulator. It regulates how long the light can strike the film.

Refer to page 231, 233 in Science in Action 8, continued

3. Light rays then hit the retina which is comprised of 2 types of photoreceptors: rods which are sensitive to light and cones which are colour detectors.

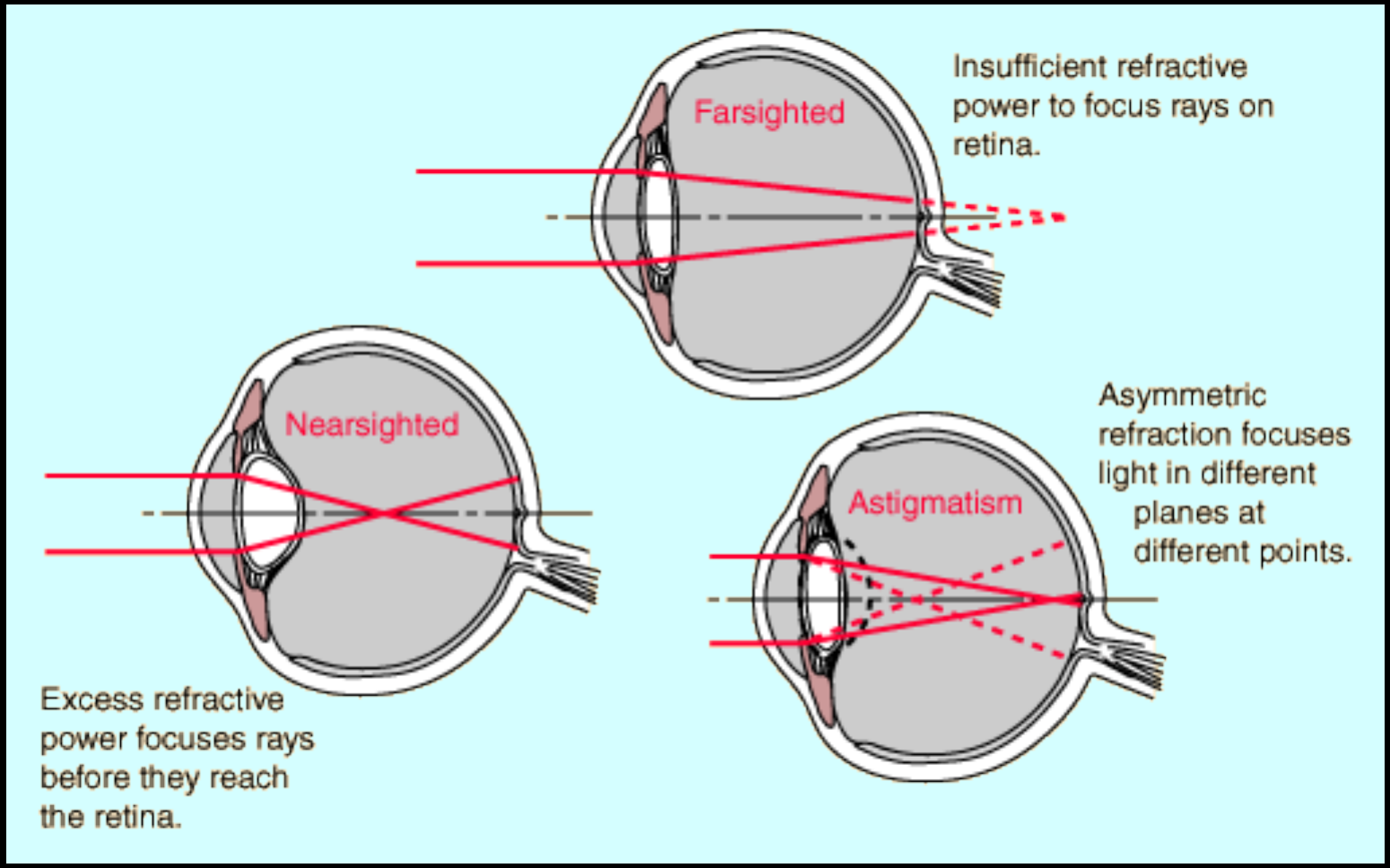
4. Stimulated photoreceptors send information to the optic nerve which in turn relays to the brain.



C. Camera's do not have photoreceptors but they do have film that can detect colour and some that cannot (black and white).

D. Light that hits the film changes it chemically which produces an image.

Eyes and Camera: Focussing Light

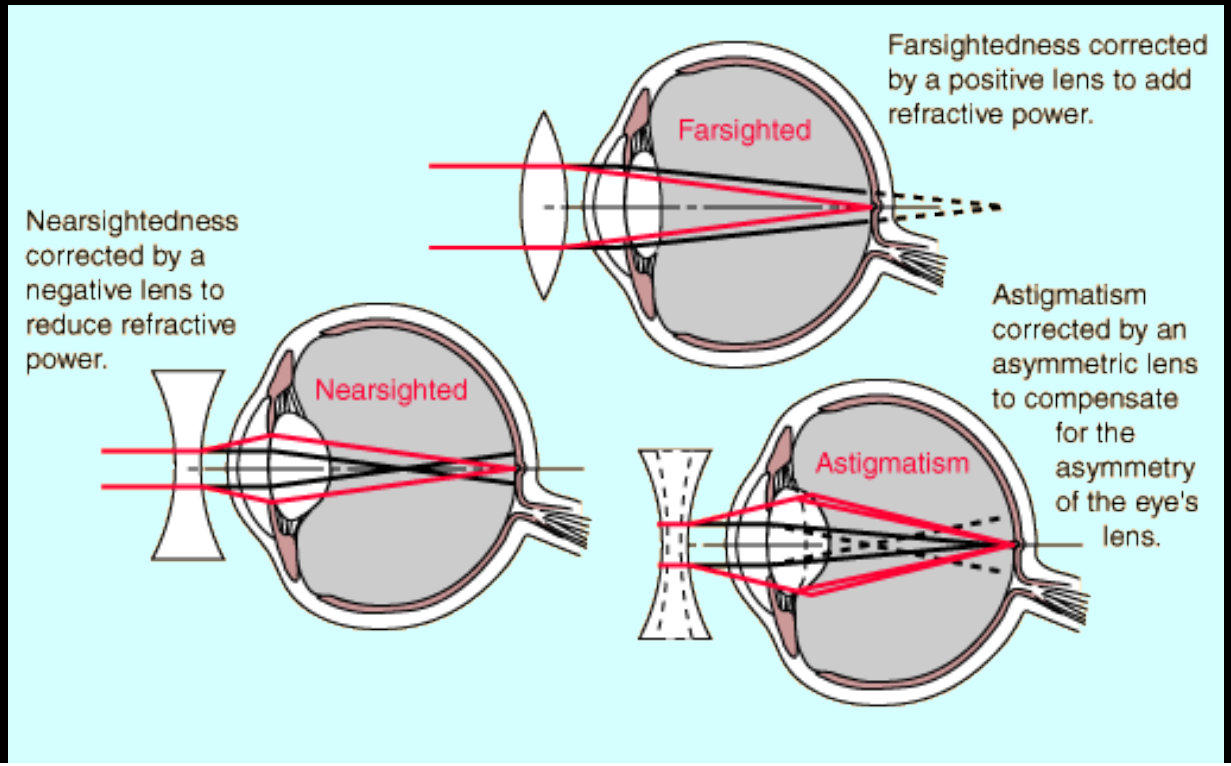


Near-sightedness:

- Individuals who cannot see objects at a distance.
- Light rays do not hit retina, but focus before the retina.
- Need concave lenses to bring the focus to the retina.

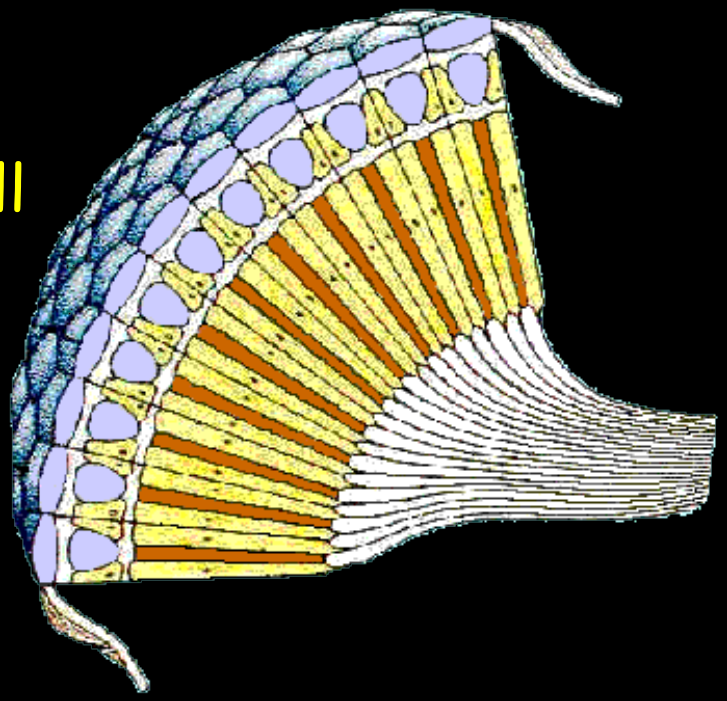
Farsightedness:

- Individuals who cannot see objects that are closely located.
- Light rays focus past the retina.
- Need convex lenses to bring the focus to the retina.



Other Eyes…

Compound Eyes: made up of ommatidium, smaller tube with a lens, focussing cone, and a light-sensitive cell that transmits information to the brain.



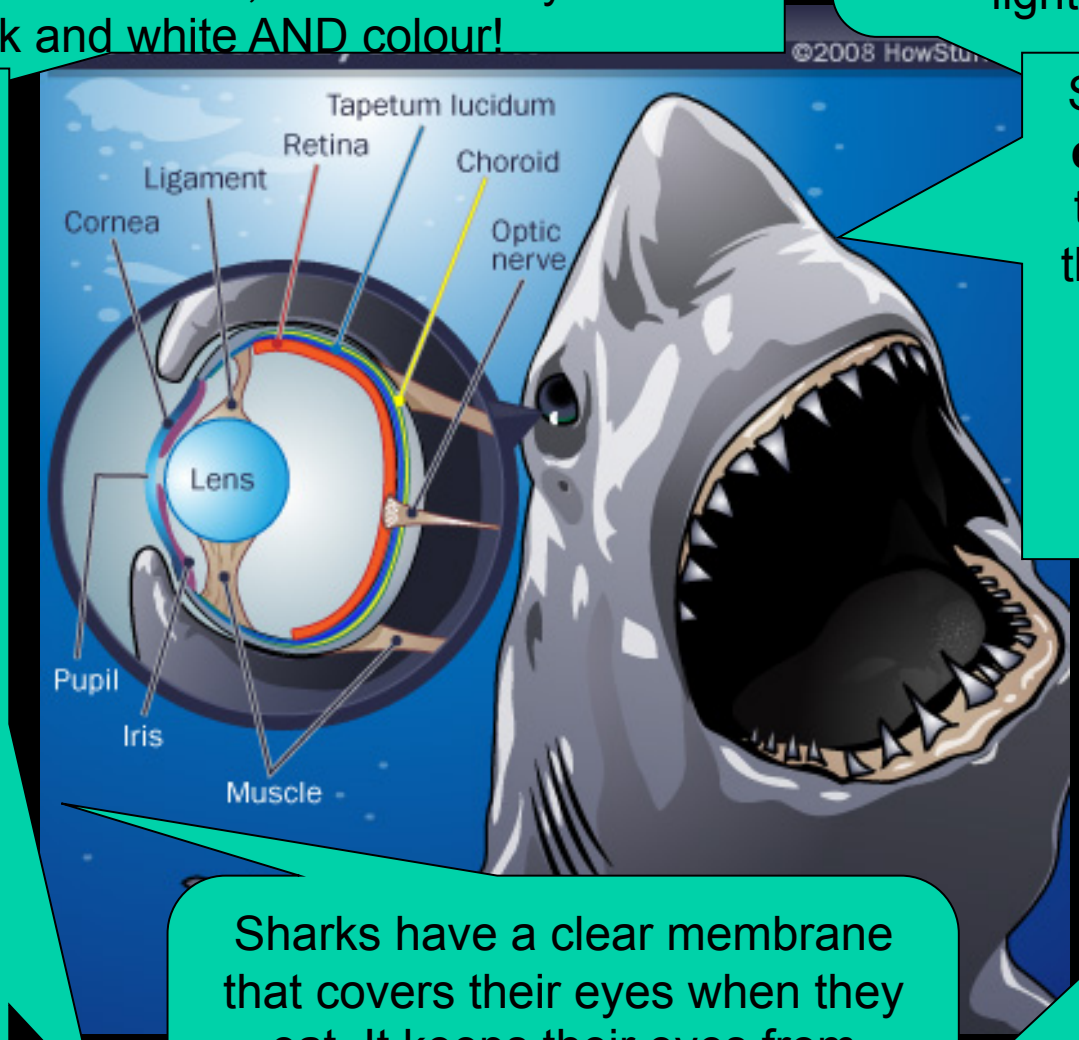
Camera Eyes: roughly round, include a cornea, lens, and retina.

Shark eyes are similar to Human eyes.

•They have the ability to open and close the pupil depending on light (unlike most fish).

•They have rods and cones, therefore they can see black and white AND colour!

Sharks have a mirror-like layer at the back of their eye (like a cat) to increase light sensitivity.



The shark does have two major blind spots, which are right in front of the snout and right behind the head, and because sharks can only see about 50 feet (15 meters) ahead, the sense of sight is really only important to a shark once it has closed in on its prey

Sharks have **lateral eyes**, which means they are located on the side of the head, so the shark has a nearly 360-degree field of vision

Camera Eyes: the aid of the rectus muscles which pull the lens closer to or further away from the retina just as a camera lens focuses.

Sharks have a clear membrane that covers their eyes when they eat. It keeps their eyes from getting damaged by thrashing prey.

7) Image Storage and Transmission

Digital imaging is where a large picture is created out of smaller pieces. Computer images are broken up into pixels (picture elements). Each pixel has a specific location in the picture and a corresponding colour or shade.

The more pixels in a picture the greater the resolution, the greater the quality of the picture.

Digital imaging

Digital cameras work similar to film cameras, except instead of film, the digital camera has a CCD. The light rays enter the aperture and hit a charge-coupled device (CCD) which is like a piece of graph paper with a small amount of electricity. The electrical charge is then translated into digital information.

Digital imaging is very useful for transmitting images great distance. For example, gathering digital images from space.