PART 4

Part 4: How do we see the world?

Activity 4.1 Mirror, mirror

Ricochet marble

What to use:

Each PAIR will require:

- A4 white paper
- heavy block of wood
- marble
- ruler
- pencil.

What to do:

Step 1
Place the block of wood slightly off-centre on the paper (see picture).

Step 2
Roll a marble towards the block, noting the path it takes, where it hits the block and where it travels afterwards.

Step 3
Perform Step 2 for at least three different angles. Is there a pattern?

How can we explain reflection?

Reflecting light ray

What to use:

Each PAIR will require:

- A4 white paper
- pencil and ruler
- plane (flat) mirror
- light box and power supply
- protractor.

What to do:

Step 1

Place the mirror off-centre on the paper (see picture).

Step 2
Use a pencil to draw the edge of the mirror on the paper and a perpendicular dotted line from the centre of the mirror. Label this line the 'normal'.

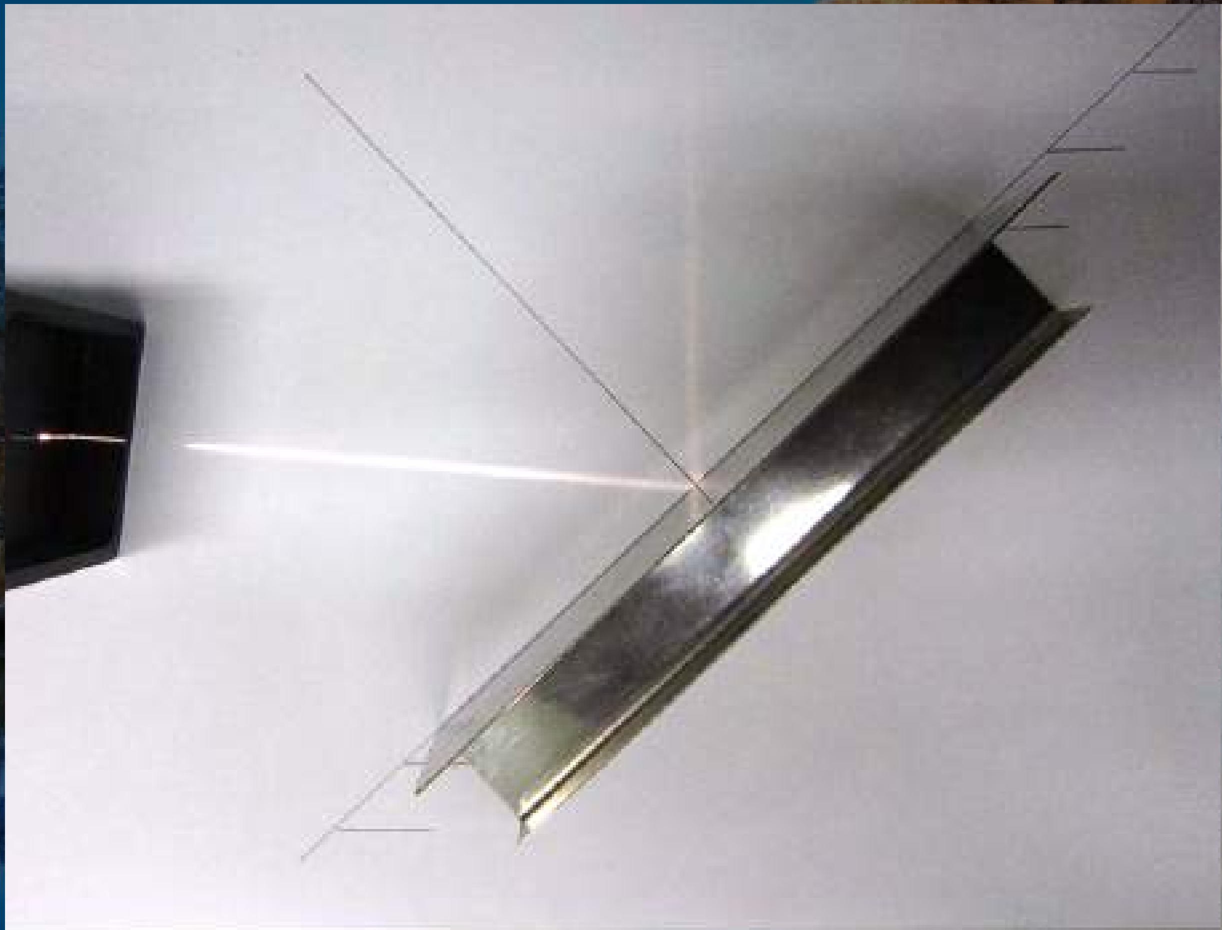
Step 3
Make the light box produce a single light ray and place it at an angle to the centre of the mirror. Use a protractor to find the angle the ray makes with the normal. This is called the angle of incidence.

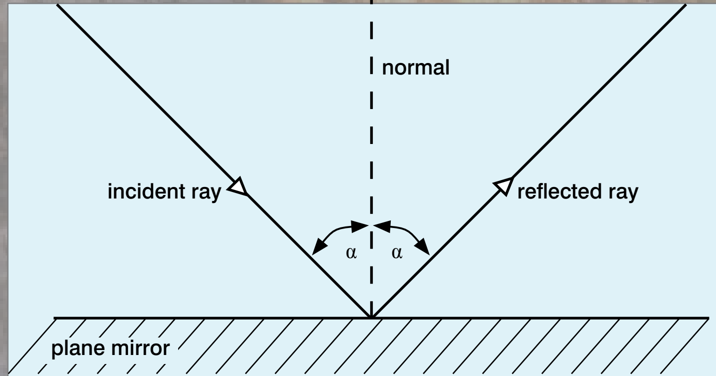
Step 4
Measure the angle between the reflected ray and the normal. This is called the angle of reflection.

Step 5
Repeat this process for at least three different angles. Can you determine a pattern?

Discussion:

1. Were the results for the ricochet marble similar to the reflecting light ray?
2. What can you conclude?





The angle the marble or light ray strikes the surface is called the **ANGLE OF INCIDENCE**. This is the angle between the path of the ray or marble and the dotted line perpendicular to the surface, called the normal.

The angle between the normal and the exit path is called the **ANGLE OF REFLECTION**.

The **LAW OF REFLECTION** states that the angle of incidence equals the angle of reflection.

KEEP GOING

MIRRORS are pieces of glass with a reflective coating (aluminium or silver) on one side. The image we see is not 'in' the mirror but appears to be behind the mirror. We call this a virtual image. How does this image differ from the real object?

Curved mirrors can magnify, diminish or invert the image. To allow drivers to see a wider area, the rearview mirrors of cars are bulging outwards and curved (termed 'convex'). Consequently, objects appear smaller and your brain interprets them as being further away than they are.

Shaving or cosmetic mirrors have inward-curving surfaces (termed 'concave' – remember 'cave') to magnify the face. If you stand further away, your image will be inverted (upside down).

KEEP GOING

Curved mirrors

Do all mirrors behave the same way?

What to use:

Each PAIR will require:

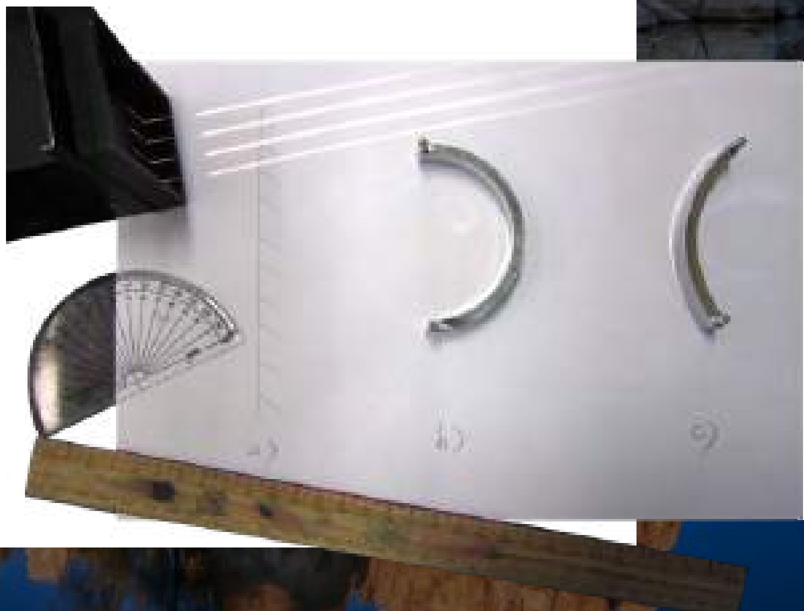
- A4 white paper
- plane (flat) mirror
- concave mirror
- convex mirror
- light box and power supply.

What to do:

Step 1
Place the plane mirror on the paper so that you can fit three separate diagrams (see picture).

Step 2
Use a pencil to draw the edge of the mirror on the paper and place the multiple ray filter in front of the light box.

Step 3
Aim the multiple rays at an angle to the mirror and draw in the light beams on the page.



Step 4
Repeat Step 3 for each mirror shape.

Discussion:

1. How does your image differ in the three mirrors?
2. What did you notice about the reflected rays from the three mirrors?

A curved mirror can curve inwards looking like the entrance to a cave (**CONCAVE**),

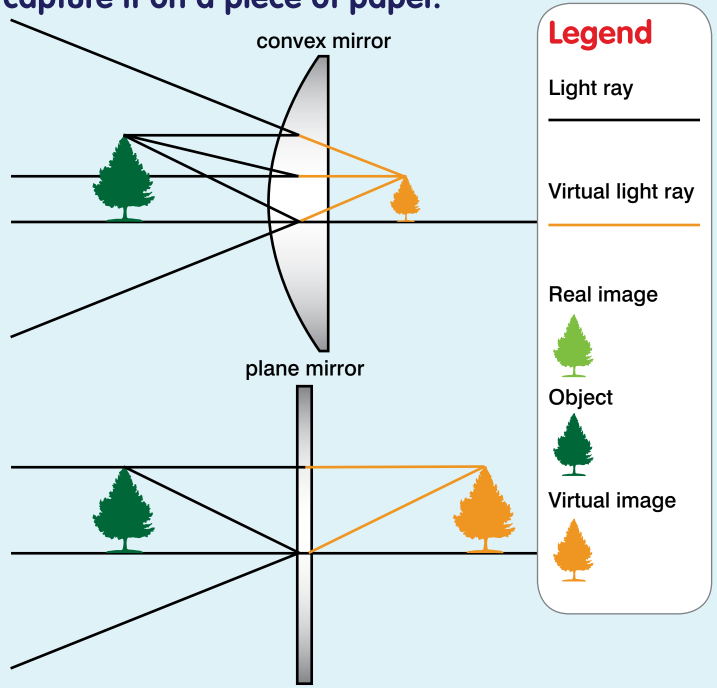
or outwards (**CONVEX**).

Challenges:

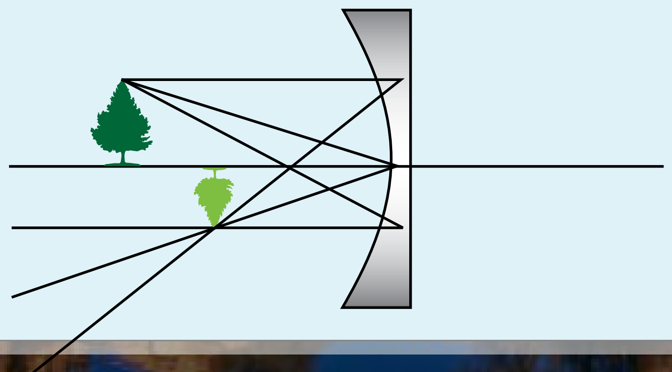
1. Can you use any mirror (plane, convex, concave) to make a ray of light reverse its direction?
2. Can you use a fixed number of plane mirrors, or as few as possible to navigate a beam around a book and pencil case obstacle course?

KEEP GOING

An image behind the mirror is called a **VIRTUAL IMAGE**. This means you cannot capture it on a piece of paper.



An image in front of the mirror is called a **REAL IMAGE** and you can capture it on a correctly placed piece of paper.



Capturing a real image

What to use:

Each PAIR will require:

- concave mirror
- convex mirror
- plane mirror
- sheet of A4 paper.

What to do:

Step 1
Point a concave mirror towards the classroom window. Place a sheet of A4 paper at an angle between the mirror and the window. Can you capture an image of the view? Describe it.

Step 2
Now use the convex and plane mirrors. Is it possible to capture an image?

Click here to explore more about plane and curved mirrors.

Activity 4.2 Does light travel in straight lines?

In **Activity 4.1 Mirror, Mirror** we looked at reflection. We saw that light bounces off shiny surfaces.

If an object is **TRANSPARENT**, light will go through it. Here we will investigate what happens.

Does light go in a straight line when it passes through plastic?

Is the chopstick bent?

Does light go in a straight line when it passes through water?

Can light bend?

What to use:

Each PAIR will require:

- A4 white paper
- pencil
- rectangular block (glass or plastic)
- light box and power supply
- single-ray filter.

What to do:

Step 1
Place the rectangular block on the paper, leaving room for a second diagram, and draw around it with a pencil.

Step 2
Place the single-ray filter in front of the light box. Now point the ray at one of the faces of the block, so that it hits the face at 90 degrees.

Step 3
Draw in the light rays on the page.

Step 4
Move the block to make the second diagram. Repeat Steps 1-3 but at an angle of about 30 degrees from the perpendicular.

Discussion:

1. What did you notice about the path the light took?
2. Can you link the investigation to the image of the chopstick in water?

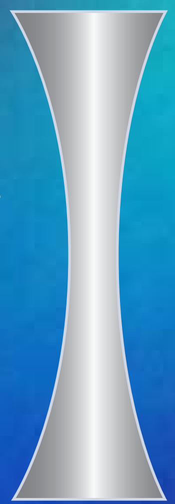
Activity 4.2 Does light travel in straight lines? Continued

Does light go in a straight line when it passes through a lens?

Does the shape of the lens matter?

CONVEX LENS

CONCAVE LENS



Sketch in your *Notebook* a prediction for the path the beams of light will take with each lens.

Click here to explore light further.

How does light travel through lenses?

What to use:

Each PAIR will require:

- A4 white paper
- concave lens
- convex lens
- multiple-ray filter
- light box and power supply.

What to do:

Step 1
Place the convex lens on the paper, leaving room for a second diagram, and draw around it with a pencil.

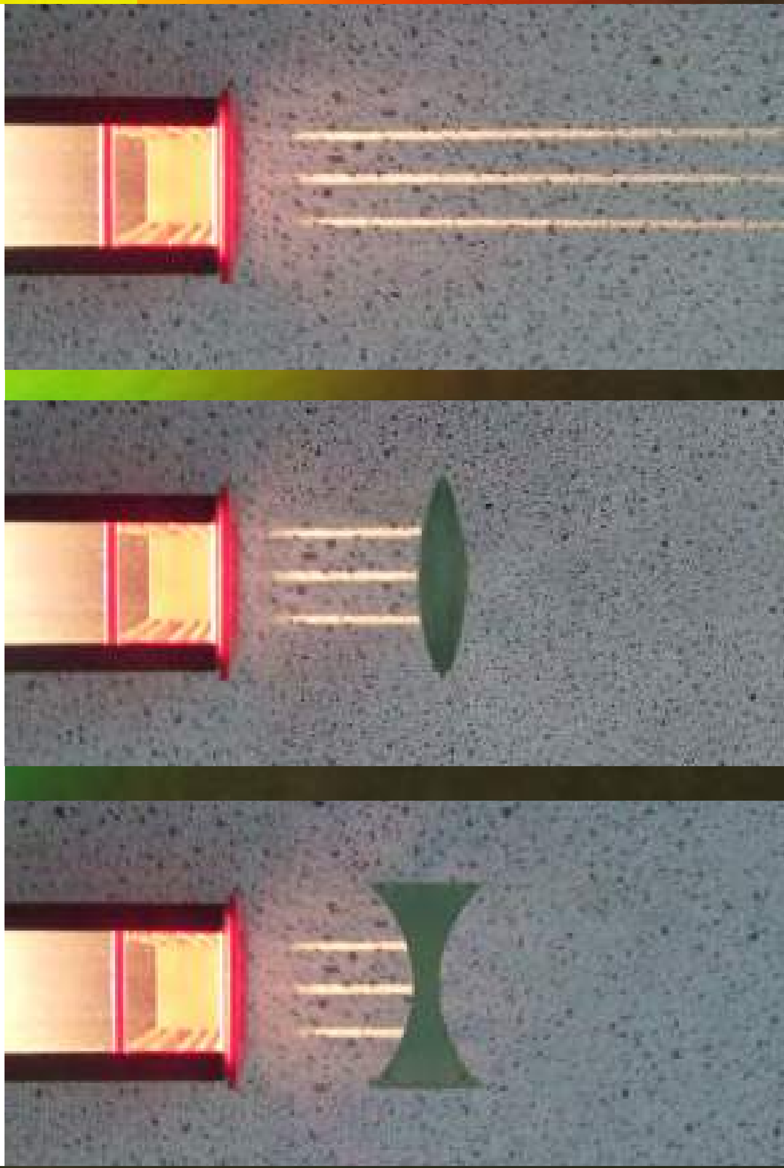
Step 2
Place the multiple-ray filter in front of the light box. Now point the multiple rays at the convex lens.

Step 3
Draw in the light rays on the page.

Step 4
Repeat Steps 1-3 with the concave lens.

Discussion:

- How close was your prediction?



Activity 4.3 The world of colour

Activity type

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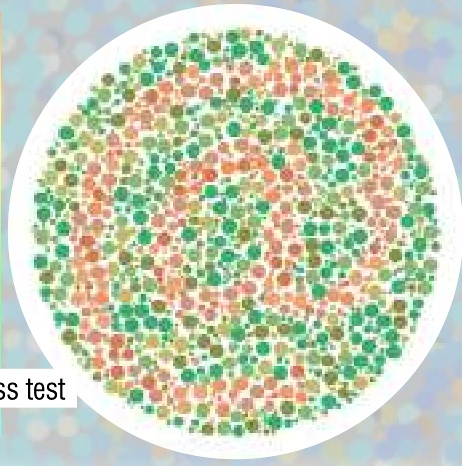


Colour blindness test

Colour blindness affects the way you see certain colours. There are several forms, but red-green is most common.

Triangular prism

What to use:

Each PAIR will require:

- light box and power supply
- triangular prism
- single-ray filter
- set of coloured filters
- A4 white paper.

What to do:

Step 1
Place the triangular prism on the paper.

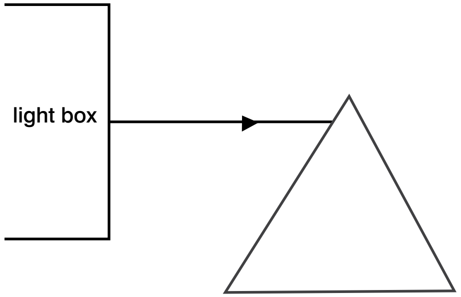
Step 2
Place the single-ray filter in front of the light box. Point the ray at the apex of the prism.

Step 3
Sketch what you see. Change where the beam hits. Is the result always the same?

Step 4
Predict what will happen if you place a red filter in front of the single beam before the prism. Try it and record your observations in your ***Notebook***.

Discussion:

- What would happen if you only shone green light at the prism?



Coloured light and coloured cards

What to use:

Each PAIR will require:

- light box and power supply
- set of coloured filters
- a range of coloured cards or objects.

What to do:

Step 1
Construct a suitable table to make predictions and record your results as you look at each of the coloured cards in different coloured lights.

Step 2
Place a red filter in front of the light box.

Step 3
Now point the red beam of light at each of the coloured cards and record your observations.

Step 4
Repeat for yellow light, blue light and another of your choosing.

Discussion:

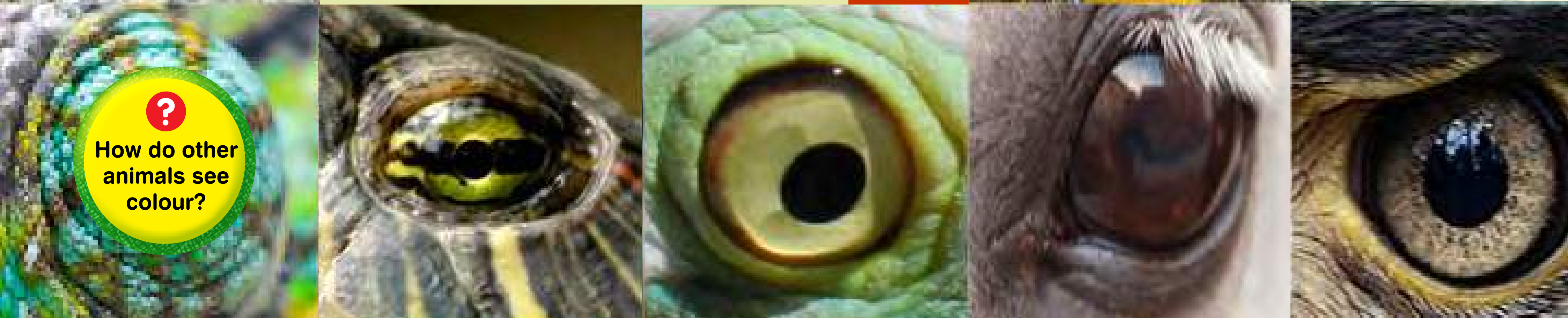
1. Do blue objects look blue in red light?
2. Do red objects look red in green light?
3. How do you get an object to appear orange?

KEEP GOING

The colour of an object is partly due to the frequency of light entering the eye. Objects appear to have colour because they reflect some frequencies of light and absorb others. A wide range of colours is possible because many objects reflect a mix of different frequencies.

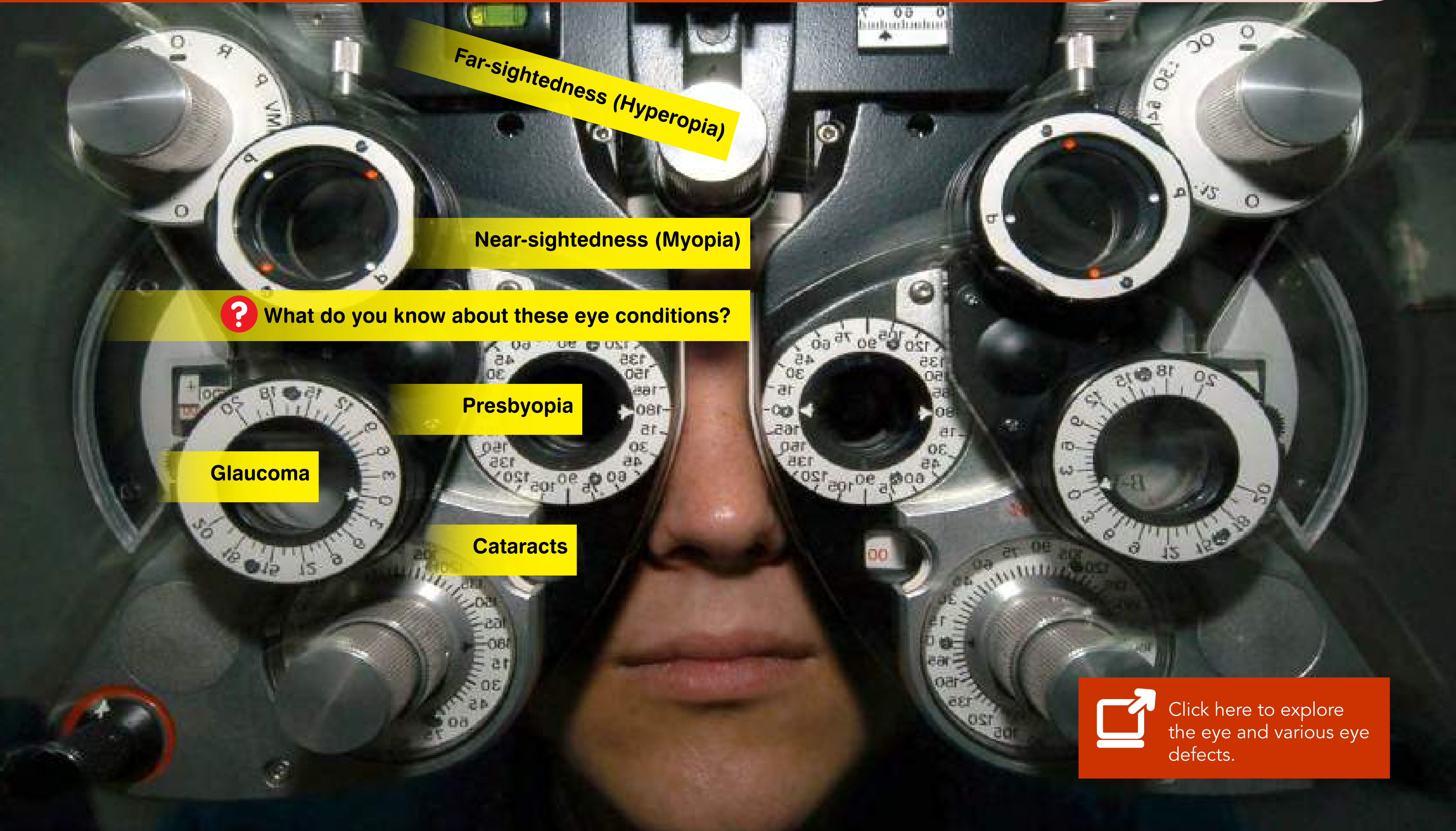
Colour vision depends on cells in the retina, called cones, which respond to light of different frequencies. But it also depends on the brain, which must interpret these signals to give us a sensation of seeing colour.

Click here to explore colour.



Activity 4.4 Eye defects

Activity type



Summary

PART 4

Mirrors are pieces of glass with a reflective coating (aluminium or silver) on one side.

The angle a light ray strikes a mirror is called the angle of incidence. This is the angle between the path of the ray and a line perpendicular to the mirror called the normal.

The angle between the normal and the exit path from the mirror is called the angle of reflection.

The law of reflection states that the angle of incidence equals the angle of reflection.

Flat glass mirrors are called a plane mirrors.

A concave mirror curves inwards looking like the entrance to a cave. Examples include shaving and cosmetic mirrors.

Convex mirrors curve outwards. An example is the rear view mirror in cars.

The image we see in a plane mirror is not 'in' the mirror but appears to be behind the mirror. We call this a virtual image. This means you cannot capture it on a piece of paper.

A concave lens can make an image in front of the mirror and is called a real image because you can capture it on a correctly placed piece of paper.

Light rays travel in straight lines within the same uniform, transparent medium. However, at the boundary of a different medium, they change direction. This change of direction, or refraction, at the boundary is due to a change in speed of the light ray. The refraction of light can be explained using the wave model. When a light wave passes from air into glass it changes direction, has a slower speed, but keeps the same frequency.

Different transparent materials bend light to different extents. Each material has its own refractive index, and the higher the refractive index the more the light bends (or refracts) and the slower the speed of light. Light travels at about 300,000,000 m/s in a vacuum but at about 225,000,000 m/s through water.

When parallel rays pass through a convex lens they converge, or come together. When parallel rays pass through a concave lens they diverge, or move apart.

When we see a mirage of what appears a wet puddle in the foreground, we are actually seeing refracted light from the blue sky above.

When light passes from water into air the light ray bends away from the normal. At the critical angle the incident ray is reflected 100% within the water with no light passing into the air. This is called total internal reflection.

The Earth receives a range of radiation from the Sun and the visible light portion allows us to see colour. When white light passes through a prism it separates into a spectrum of light as red-orange-yellow-green-blue-indigo-violet.

The colour of an object is partly due to the frequency of light entering the eye. Objects appear to have colour because they reflect some frequencies of light and absorb others. A wide range of colours is possible because many objects reflect a mix of different frequencies.

Colour vision depends on cells in the retina called cones. We have three different cones responding to the different light frequencies of red, green or blue. Our brain interprets these signals to give us a sensation of seeing colour. When only red cones signal the brain we interpret the colour as red. When both red and green signal the brain we interpret yellow colour. When red, green and blue signal the brain we interpret white.

Bees and some birds use ultraviolet radiation from the Sun to see, whilst other animals have just two colour cones, rather than the three which humans (and other primates) have. It is believed the ability for primates (including humans) to see red evolved when fruits developed a red pigmentation upon ripening.

The iris (coloured part of the eye) allows the pupil to expand and contract, depending on light levels. Together, the cornea, aqueous humour, lens and vitreous humour focus the image onto the retina at the back of the eye. The retina is made up of light-sensitive cells called rods and cones which initiate nervous messages through the optic nerve to the brain.

Some common eye defects and diseases include:-

Myopia – near sightedness. Light rays are focused in front of the retina.

Hyperopia – far sightedness. Light rays are focused behind the retina.

Presbyopia – age-related disorder where the lens does not change shape to see in long distance.

Glaucoma – an eye disease where increased eye pressure causes damage to the optic nerve.

Cataracts – cloudy patches called cataracts can form in the lens, affecting sight and leading to blindness.

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