Science Eight

Module Three

Light & Optical Systems

Name:

Date Received:

Date In:

Grade:

Science Light

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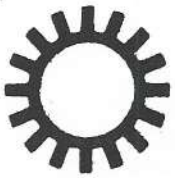
Part A: What is light?

Light is a form of **energy** that allows us to see. Sources of light (where it comes from) can be natural or artificial. The sun is a **natural light source** and a light bulb is an **artificial light source.**



The basic properties (characteristics) of light are:

- it is a form of energy
- it travels in straight lines
- it can be reflected
- it can be bent

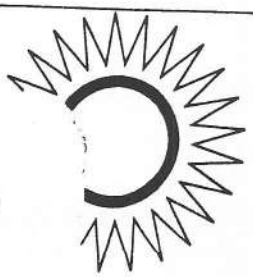
Brainstorm!

1. Before you start working through this unit, quickly write down all of the things you know about how light behaves. Think about interesting things you have seen light do or ways that you have played with light.

2. Write two questions about light that you think will be answered in this unit or you would like to know the answers to.

Did you know?

We often think of hurtful things when we hear the word ***radiation,*** *but it is actually a scientific word that describes how light moves away from the sun. The sun creates light and the light* ***radiates*** *from the sun and the light rays spread out in all directions like the spokes in a bike wheel.*



Part B: What did people in the past think about light?

Pythagorus

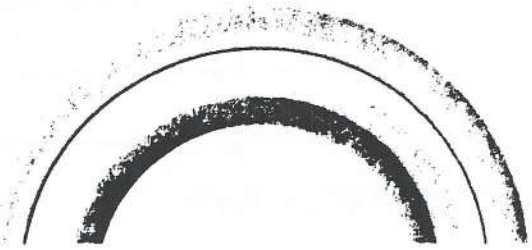
In ancient Greece, a mathematician named Pythagorus developed a theory about light beams. He believed that light was made up of straight beams that came from a person's eyes and "lit up" the things they looked at. The obvious problem with his theory was that, if it were true, people would be able to see in the dark. Even though the theory was obviously not correct, people accepted it (believed it was true) for many years.

Euclid

Euclid, another scientist from ancient Greece, also believed that light travelled in straight lines. He used that knowledge to prove that the angle that a beam of light hit a mirror at was exactly the same as the angle of the reflected beam of light.

al-Haytham

In the year 1000, al-Haytham, an Arab scientist came up with a theory of how vision (eyesight) worked. Opposite to Pythagorus and Euclid, he believed that light bounced off objects and travelled towards our eyes and that is what made us able to see. Although he tried very hard to discover how light was responsible for making rainbows, he never came up with the answer.



Rene Descartes

Rene Descartes was a French "thinker" who believed that rainbows were made up of sunlight that had been changed somehow so that it shined with different colours.

Newton

Sir Isaac Newton, an English scientist, conducted an experiment where he shined a beam of light through a prism (a piece of glass with triangular-cut sides). When the white light beam passed through the prism, it split into different colours. When another prism was put in front of the coloured light, it combined to form the white light beam again. This discovery lead to theories of light that are still believed by scientists today.

Use the information on the previous pages to help you answer the following questions:

1. What part of Pythagorus's theory was obviously wrong? Why?

2. What part of the theories of Pythagorus and Euclid do present-day scientists agree with?

3. Why do you think people were willing to stop believing the theory that Pythagorus had come up with and start believing al-Haytham's theory?

4. Was Rene Descartes close to the truth about light?

5. What did Newton do that helped future scientists begin to understand that white light is actually made up of rays of different coloured light?

_____

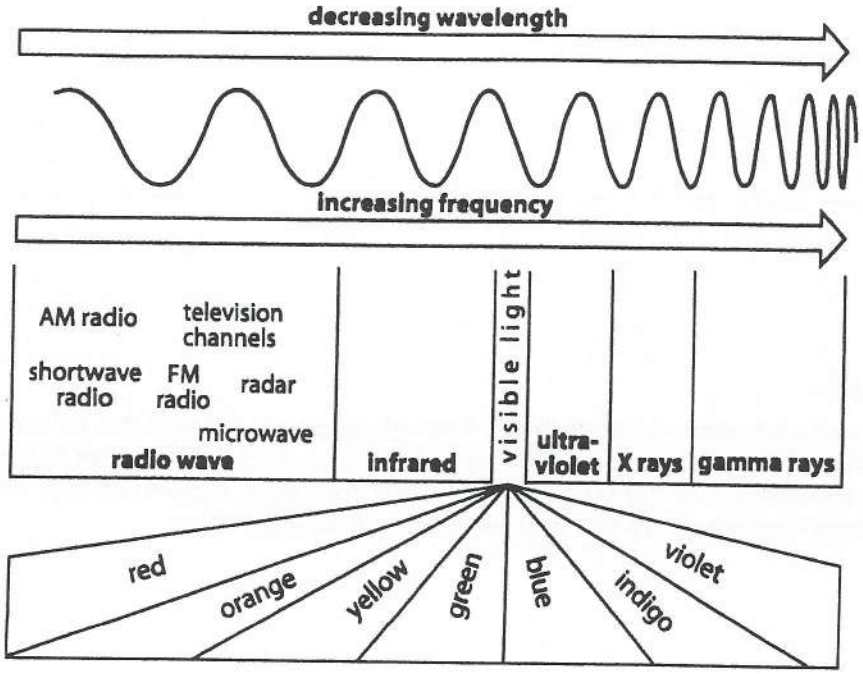
_____

_____

Did you know?

A rainbow is created when sunlight shines through drops of water in the air and the light is bent so much that it splits into its different-coloured rays. Red is always on the outside of the arc because those rays are the longest and lowest in energy. Violet is always on the inside of the arc because those rays are the shortest and most energetic.

Part C: Electromagnetic Spectrum



The Ray Model of Light

Scientists today believe that light travels in straight lines (rays) out in all directions from the light source. Radiation is when light moves out in all directions like the spokes of a wheel.

The Composition of Light

White light is the light we see around us but it is actually made up of rays of different lengths and colours. The colours of the rainbow—red, orange, yellow, green, blue, indigo and violet, are all combined to make white light.

Refraction

When a ray of light shines through two materials of different density, it is refracted (the ray of light is bent). This usually happens because the speed of light slows when it passes from a less dense material to one that is more dense. This only works when light can shine through both materials.

Reflection

Reflection is when light is cast (bounced) back from a surface. Reflection is what allows us to see the things in our world—from our image in a mirror to words on a piece of paper.

Absorption

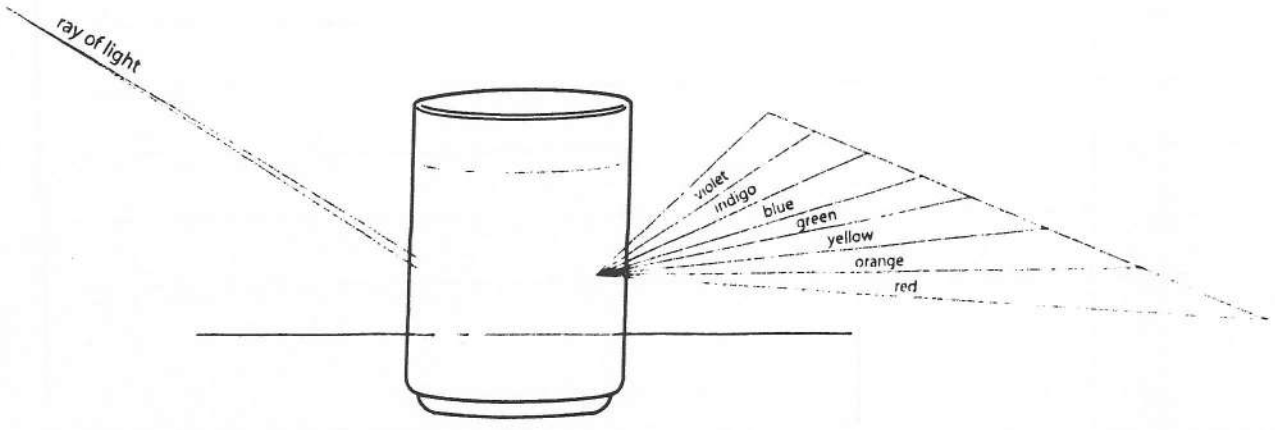
Absorption is when surfaces "soak up" light and usually change it to a different kind of energy like heat. Think of something that doesn't reflect light but gets very warm when light is shined on it.

Use words from the definition boxes on the previous page to fill in the blanks in the following sentences in a way that makes sense.

1. When you look in a mirror, you see your _____ (1) because the light is _____ (2) back from the _____ (3) of the mirror.
2. The light you see around you is called _____ (4) light, but it is actually made up of _____ (5) of different _____ (6) and _____ (7).
3. When a ray of light shines through one material and then another, it is _____ (8) if one material is more _____ (9) than the other.
4. When light shines from the sun, it travels in _____ (10) lines called _____ (11) and moves out in all _____ (12) like the _____ (13) of a wheel.
5. Shadows are formed when solid objects are held in front of a light source because light travels in _____ (14) lines and can't bend around solid objects.
6. Dark, rough surfaces usually "soak up" the light through a process called _____ (15).
7. What do we currently believe about the nature of light?

_____

_____



Investigate

Playing with Light

Consider: How does water affect rays of light?

Hypothesis: (check the one you agree with)

- ☐ when light shines through water it bends
- ☐ light can shine straight through water

Materials:

- one clear cup or glass
- water
- a pencil

Procedure: (record information in the box)

1. Place the pencil in the cup (let it lean against the side).
2. Move down so you can look directly in the side of the cup. Record what you see (use pictures and words).
3. Fill the cup half full of water.
4. Move down so you can look directly in the side of the cup again. Record what you see (use pictures and words).

Analysis/Conclusion:

1. Did the light travel in a straight line through the air and the water? How do you know?

2. Now, answer the original question using evidence/examples from your investigation OR prove why your hypothesis was correct.

Part D: Interactions of Light

Transparent

Transparent materials, often called "see through," transmit light. This means that rays of light can travel right through them.

Translucent

Translucent materials let some, but not all, light travel through them. Shapes can be seen on the other side of translucent materials, but the actual images are blurry.

Opaque

Opaque materials don't let any light travel through them. They absorb or reflect light so it bounces back and a shadow is cast on the other side of the material.

Write the word **transparent**, **translucent** or **opaque** to describe how clearly we can see through each of these materials.

1. _____ A solid wood door
2. _____ A regular window pane
3. _____ A frosted window pane
4. _____ A piece of Saran Wrap
5. _____ A pencil
6. _____ A white piece of paper
7. _____ A piece of cardboard
8. _____ Water

Hint: If you aren't sure, try looking through each of these things when there is bright light on the other side. How clearly can you see through each one?

Sight

Light allows us to see objects because light reflects off objects in our surroundings and bounces back into our eyes.

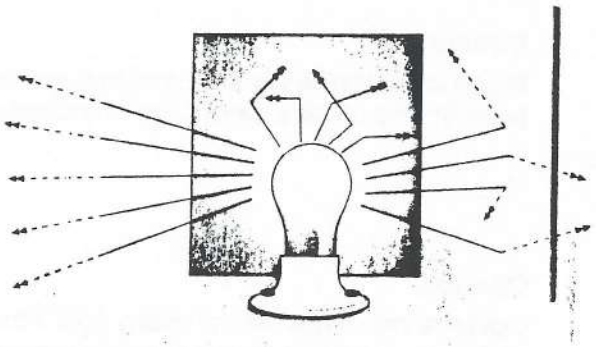
Luminous

Objects that produce light, either naturally or artificially.

Non-luminous

Objects that do not produce light.

Use the information you have learned so far to help you analyze this picture and then fill in the blanks in the passage below.



Our sense of _____ (1) allows us to see the picture. The light bulb is a _____ (2) object that gives off light. The panels around the light bulb are _____ (3) because they don't make their own light. The left panel is obviously _____ (4) because light rays travel through it and stay _____ (5). The right panel is obviously _____ (6) because not all of the light rays are shining through and the ones that do go through have been _____ (7) and are now shining out at a different angle. This is called _____ (8). The back panel is obviously _____ (9) because no light rays are shining through, they are being _____ (10) back away from the panel.

Check your answers! These are the words that are missing from the passage above.

non-luminous	opaque	refraction	transparent	straight
sight	translucent	luminous	bent	reflected

Part E: How does reflection work?

Reflection

Reflection is a process where light hits a surface and then bounces back off that surface. How the reflection process works depends on how smooth the surface is. Seeing our image in a mirror and reading the words on this page both involve the process of reflection. We see different things because the two surfaces—glass and paper—are very different. Glass is very smooth and reflects light rays straight back. Paper (when you look at it with a microscope) is very rough, so the light rays bounce off in all directions. When light bounces straight back, you see a "copy" of the image in front of it. When light bounces off in different directions, you see what is on the surface (e.g., writing on a page).

In the reflection process, rays of light are given different names depending on the "job" they do, for example:

Incident (in-si-dent) Ray

The ray of light that first hits the surface.

Reflected Ray

The ray of light that bounces off the surface. The straight path (line) that each ray of light travels along is compared to the "normal" line and then described as an angle.

Normal Line

A straight, perpendicular line (90 degrees from the surface) that extends (goes out) from where the incident ray hit the surface.

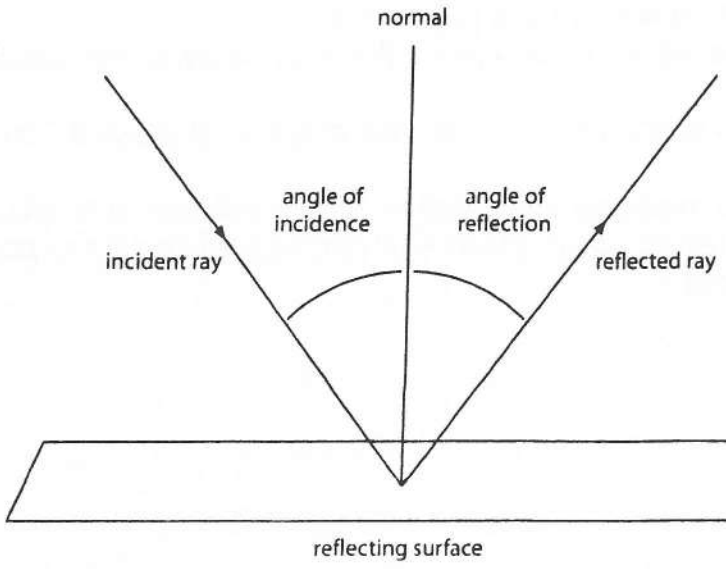
Angle of Incidence

The difference between the line that the incident ray followed and the normal line (called an angle because it's measured in degrees).

Angle of Reflection

The difference between the line that the reflected ray followed and the normal line.

Study the diagram below and then answer the questions on the next page.



Activity - Using the laser pointer and mirrors see how many times you can reflect the light. (ask for materials)

Use the information on the previous page to help you answer the following questions. Label questions that are **True** with a **T** and questions that are **False** with an **F**.

1. ____ The ray of light that bounces off a surface is called the reflected ray.
2. ____ The ray of light that bounces off a surface is called the incident ray.
3. ____ The ray of light that first hits a surface is called the reflected ray.
4. ____ The ray of light that first hits a surface is called the incident ray.
5. ____ The normal line is a straight, perpendicular line that extends from where the incident line hits the surface.
6. ____ The angle of incidence is the difference between the path of the reflected ray and the path of the incident ray.
7. ____ The angle of incidence is the difference between the path of the incident ray and the normal line.
8. ____ The angle of reflection is the difference between the path of the reflected ray and the normal line.
9. ____ The angle of reflection is the difference between the path of the reflected ray and the incident line.

Consider the following question:

Is the angle of incidence always the same as the angle of reflection?

Using the planner on the following page, design an experiment to find the answer to the question above. Consider the following things:

- What is your hypothesis (guess)?
- What reflective surface will you use (e.g., mirror)?
- What other materials will you need (e.g., flashlight, dark room, measuring devices)?
- Do you know how to calculate a 90 degree angle and draw a "normal" line?
- Do you know how to measure your angles using a protractor or will you need help? Will you reflect onto a piece of paper and trace the path of the light with a pencil?

Title: _____

Question to Consider: _____

Hypothesis: (my guess) _____

Materials:

-
-
-
-
-

Procedure: (record information on the lines)

1. _____
2. _____
3. _____
4. _____

My Observations: (what happened)

Analysis/Conclusion:

1. My answer to the original question using evidence/examples from my investigation OR my proof that my hypothesis was correct.

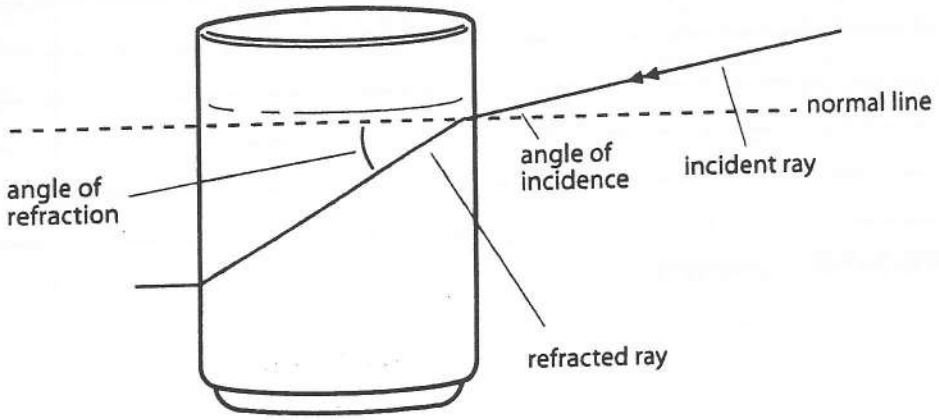
Part F: How does refraction work?

Refraction

Refraction is when light bends because it is moving from one type of material to another (usually transparent). "Bent" light still travels in straight lines. It's just the direction of the line that changes (think back to what you learned before about angles). Light bends because the speed at which it is moving changes when it passes through materials that have different densities (a different number of particles packed into them). The more dense a material is, the slower light passes through it. When the light bends, it makes objects look as if they are in a different position.

Think back to the experiment you conducted earlier in this unit, did the water bend the light? Did the pencil look as if it were in a different position in the water?

Study the diagram below and then answer the questions.



1. Is water more dense than air? How do you know?

2. Are the angle of incidence and the angle of refraction always the same? Explain.

Refraction

Consider: How does the density of a liquid affect the way light refracts?

Important Information: The more particles packed into a substance, the denser it is.

Hypothesis: (check the one you agree with)

- ☐ the greater the density, the more obvious the refraction
- ☐ the lower the density, the more obvious the refraction

Materials:

- four clear cups or glasses
- water, water mixed with salt, cooking oil, translucent shampoo
- four pencils

Procedure: (record information in the boxes)

1. Fill each cup with one of the liquids.
2. Place a pencil in each of the filled cups.
3. Record your observations (use pictures and words).

Water	Salt Water	Cooking Oil	Shampoo

Analysis/Conclusion:

1. Answer the original question using evidence/examples from your investigation OR prove why your hypothesis was correct.

2. Go back to question 2 on page13. Check your answer.

Use what you have learned to correctly organize this information in the chart below.

Type of Behaviour:

- Absorption
- Reflection
- Refraction

What happens to the light that hits the surface?

- Bounces off the surface and travels back
- Disappears/changes into another kind of energy like heat
- Travels through the surface and out in a new direction

What is the surface usually like to make that happen?

- Different, transparent material
- Smooth, shiny surface
- Rough, dark, opaque surface

Type of Behaviour	What happens to the light when it hits the surface?	What is the surface usually like to make that happen?

Did you know?

Sunsets are red, orange and yellow because those are the longest rays of light. As the sun disappears below the horizon, it gets further away from us so more of the particles (dust, etc.) in our atmosphere get in the way of the light. The shortest rays of light get bounced away, so those colours "disappear" before the light gets to us and all we see are the longer rays (red, orange, yellow).

Part G: How do lenses help us control light?

Lens

A lens is a piece of glass or other transparent material that either brings rays of light together or spreads them apart.

Concave Lens

A concave lens is a piece of transparent material that is thinner in the middle than it is at the edges. Looking into a concave lenses is like looking into a dish.

When light rays shine through concave lenses, the rays spread out.

When you look at an image through a concave lens, the image looks smaller and closer.

Convex Lens

A convex lens is a piece of transparent material that is thicker in the middle than at the edges. Looking into a convex lens is like looking through an upside-down dish.

When light rays shine through convex lenses, the rays are brought closer together.

When you look at an image through a convex lens, the image looks larger and further away.

Single Lens

A single lens has only one side that is curved (convex or concave) and the other side is flat.

Double Lens

A double lens has two sides that are curved (convex or concave) so it doubles the effect of the lens.

Use the information above to help you complete the sentences below.

1. When you look through a magnifying glass, the objects you are looking at seem larger and you can see them in more detail. The lenses in a magnifying glass are _____.

2. A telescope takes a view that is far away and brings the light rays together so the image seems closer and is easier to see. The lens in a telescope is _____.

3. A microscope has lenses of different powers that take an image and spread the light rays apart so the image looks larger and you can see it in more detail. The lenses in a microscope are _____.

Use what you have learned so far to help you answer the following questions:

1. Are telescopes and microscopes "opposite" technology? Explain your answer.

2. What kinds of things can magnifying glasses be used for?

People who wear glasses are either near-sighted or far-sighted. People who are near-sighted can see things that are close to them but have trouble seeing things that are far away. People who are far-sighted can see things that are far away but have trouble seeing things that are close to them.

3. What kind of lenses should people who are near-sighted have in their glasses? Why?

4. What kind of lenses should people who are far-sighted have in their glasses? Why?

Playing with Lenses

Consider: What happens to a beam of light when it passes through a concave and convex lens?

Hypothesis: (check the one you agree with)

- ☐ the concave lens will spread the light rays apart and the convex lens will blend them back together
- ☐ the convex lens will spread the light rays apart and the concave lens will blend them back together

Materials:

- concave lens
- convex lens
- flashlight or other source that sends out a beam of light
- darkened room

Procedure: (record observations in the box)

1. Shine the light through one of the lenses.
2. Shine the light through the other lens.
3. Position the lenses in a way that lets you shine the light through one and then the other.

Analysis/Conclusion:

1. Now, answer the original question using evidence/examples from your investigation OR prove why your hypothesis was correct.

_____

_____

_____

_____

Optional Extension!

Investigate to find out what happens when you shine light through double lenses. Record your findings.

Part H: How do mirrors help us control light?

Mirrors

A polished surface of glass or metal that clearly reflects an image. Light rays bounce straight back from flat mirrors.

Concave Mirror

A concave mirror is thinner in the middle than it is at the edges. Looking into a concave mirror is like looking into a dish.

When light rays bounce off a concave mirror, the rays are brought closer together. When you look at an image reflected by a concave mirror, the image looks bigger (magnified).

Convex Mirror

A convex mirror is thicker in the middle than at the edges. Looking into a convex mirror is like looking at an upside-down dish.

When light rays bounce off a convex mirrors, the rays spread out. When you look at an image reflected by a convex mirror, the image looks smaller but the field of view is greater.

Use the information above to answer the questions below.

1. Are mirrors and lenses "opposite" technology? Explain your answer.

_____

_____

_____

The side mirrors on cars usually have a warning that "objects may be closer than they appear." In other words, the reflection is what makes the object look smaller so it seems farther away and more of the area around the car can be seen.

2. What kind of mirrors are used in car side mirrors? How do you know?

_____

_____

_____

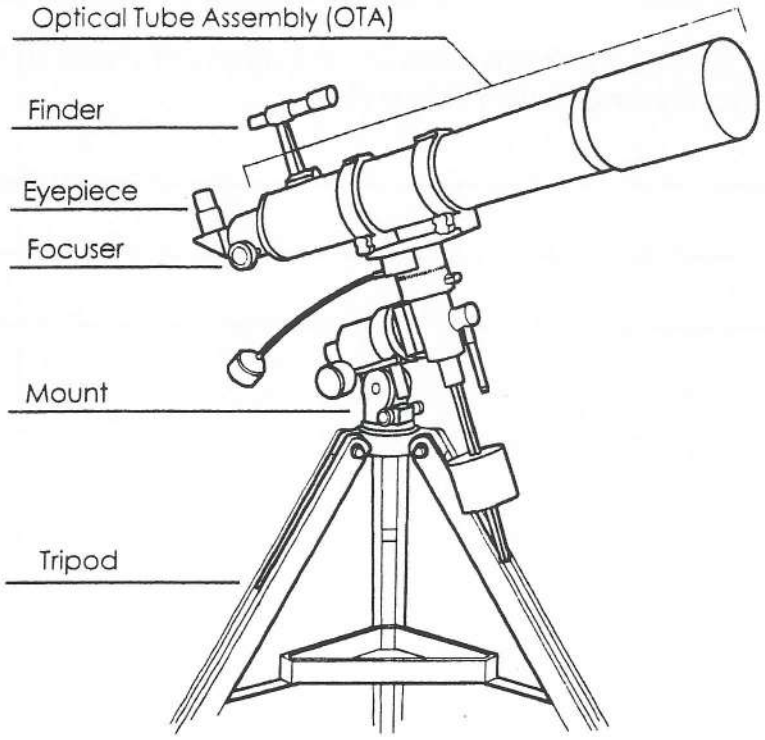
3. How does using these types of mirrors in car side mirrors make it safer for drivers?

4. What kinds of mirrors do you think are used in far corners of stores so that staff can watch people closely and catch thieves?

Part I: What do we know about light today?

What is a telescope and how does one work?

Telescopes consist of many basic parts. Look at the diagram below and read the labels, then use what you have learned to complete the passage below.



The Parts of a Telescope

Use each of the diagram labels to fill the blanks in the passage below.

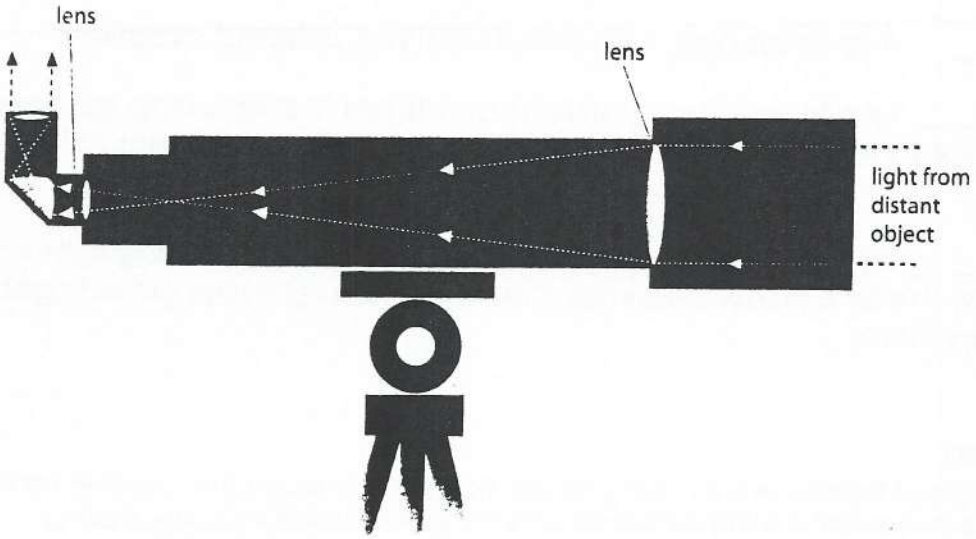
The _____ (1) is the main "long part" of a telescope that contains mirrors and/or objective lenses for magnification. The _____ (2) is the small end of the telescope that you look through. The _____ (3) lets a person see more clearly by moving the mirrors and/or lenses up and down in the tube. A _____ (4) is a mini-telescope that is mounted on the outside of the tube to help in locating objects in a larger area before looking at them closely. The _____ (5) holds a telescope in position on the _____ (6).

What are the two main types of telescopes?

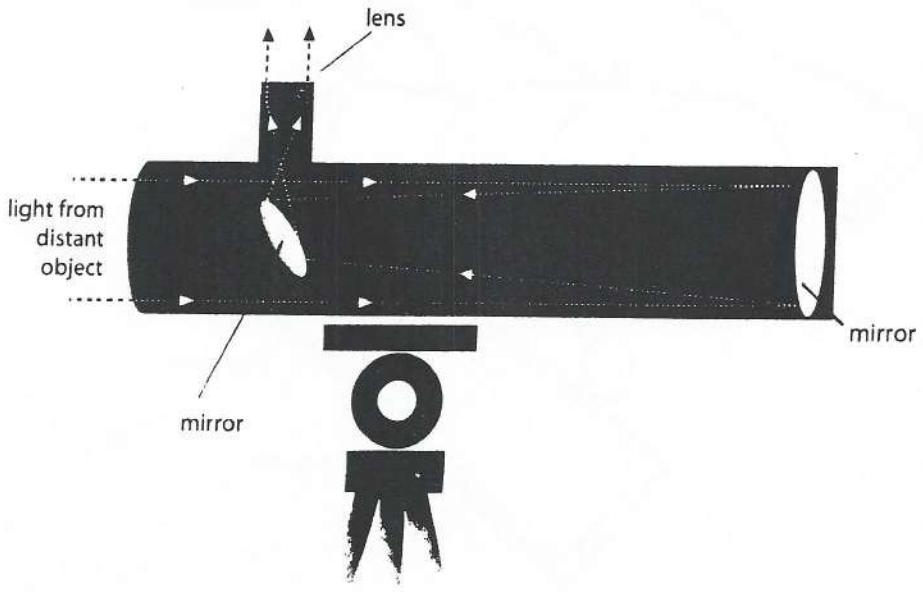
The two main types of telescopes are the refracting telescope and the reflecting telescope. A refracting telescope uses only lenses, but a reflecting telescope uses a combination of lenses and mirrors.

Study the diagrams below. Look closely at the arrows that show the path of light through each telescope and then answer the questions on the next page.

Refracting Telescope



Reflecting Telescope

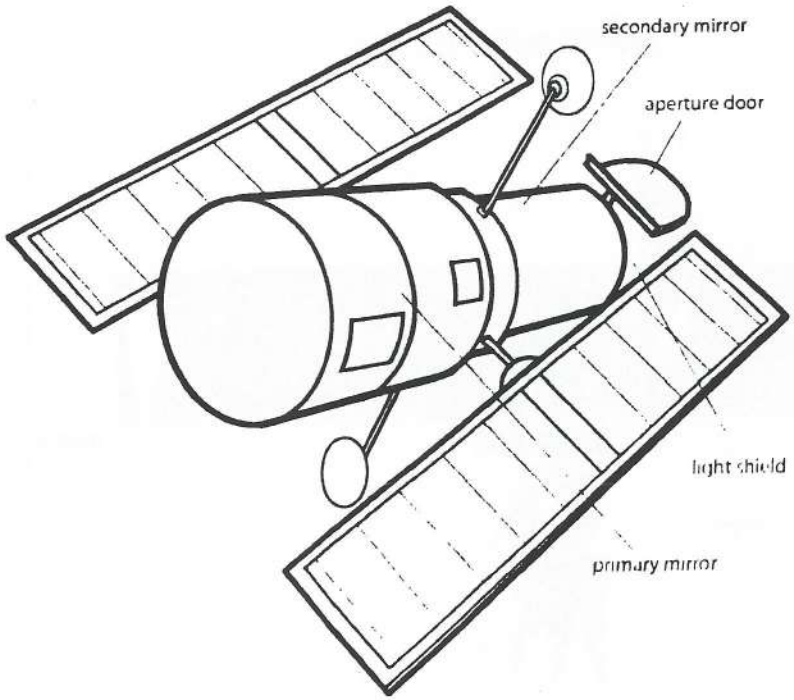


Write the word **refracting** or **reflecting** in the blanks in each of the following sentences to make them correct.

1. A ref ___ ting telescope uses a curved, circular mirror that collects rays of light.
2. A ref ___ ting telescope has two lenses—one on each end of a long tube.
3. In a ref ___ ting telescope, light only moves in one direction.
4. In a ref ___ ting telescope, light moves in three different directions.
5. In a ref ___ ting telescope, a large lens catches the incoming light and brings the light's rays close together and focuses them on the lens in the eyepiece.
6. In a ref ___ ting telescope, a large mirror reflects the incoming light to a mirror under the lens in the eyepiece that brings the light rays close together and focuses them.

Did you know?

The Hubble Space Telescope is a moving observatory in outer space that was built for the benefit of the international astronomical community by the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA).



What is a microscope and how does one work?

A microscope is a **tool that extends your sense of sight.** This means that it lets you see more than you could see without it. Unlike a telescope that lets you see things far in the distance, a microscope is used to look more closely at things—so close that you can often see inside them.

Most schools use **compound light microscopes.** Any microscope that has two or more lenses is called a **compound** microscope. The word **light** is added to the name because a bright light is used to help you see better.

The Parts of a Compound Light Microscope

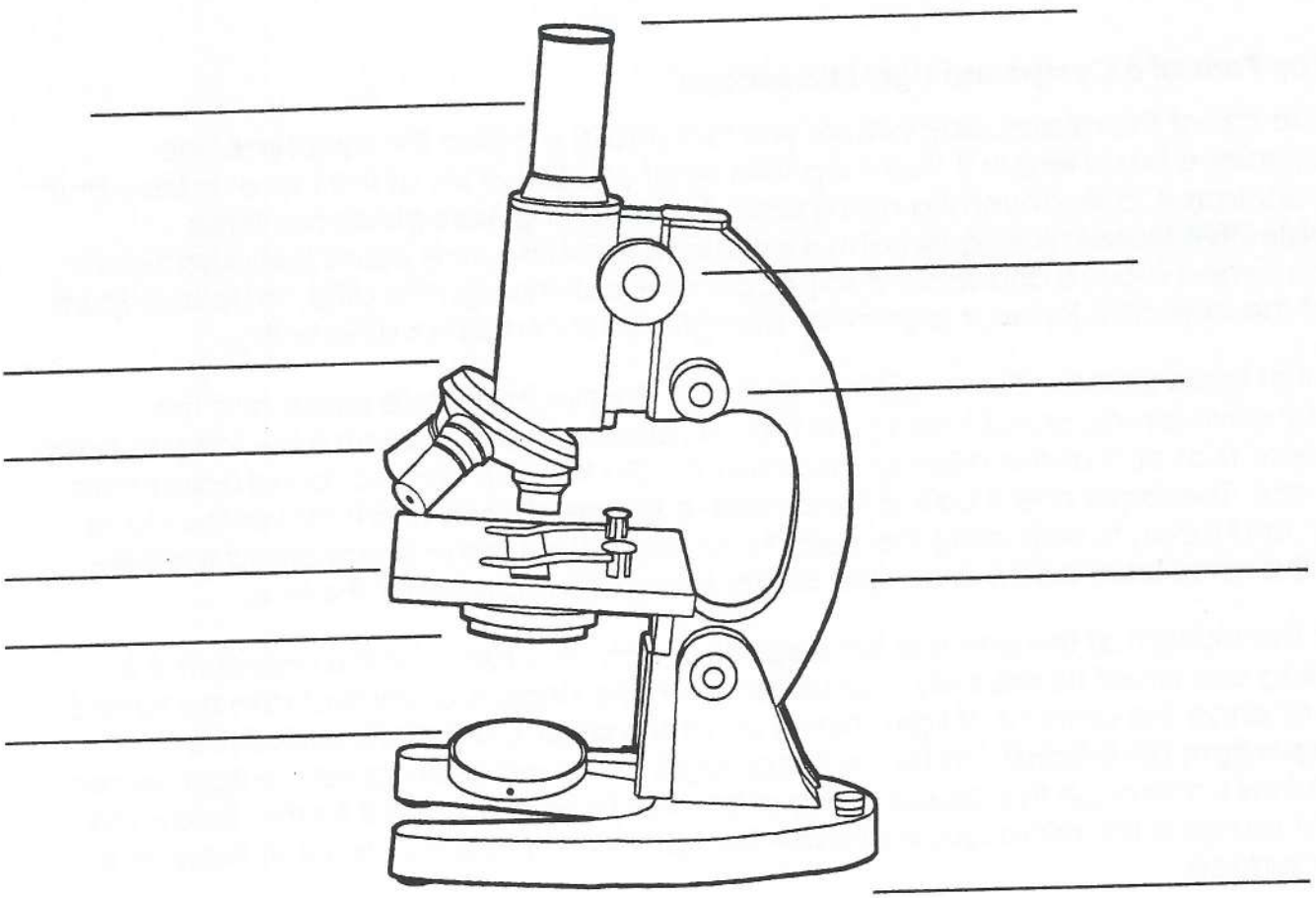
The top of the microscope (where you look into it) is called the **eyepiece**. The eyepiece has a lens in it that magnifies what you see. It sits at the top of a **tube** that connects it to the revolving nose piece. The **revolving nose piece** has three **objective lenses** sticking out of it. It is called a revolving nose piece because it can be turned around and around so people can look through the different lenses. Each of the objective lenses is a different strength (each magnifies differently).

All of these pieces—the eyepiece, the tube, the revolving nose piece and the objective lenses, are all held up by the microscope's **arm**. The arm is the long, curved piece that acts as the microscope's handle. On the arm are two round adjustment knobs. The larger one is called the **coarse-adjustment knob** and it moves the stage up and down to help bring the object into focus. The smaller one is called the **fine-adjustment knob** and it brings the object into sharp focus under the lens.

At the bottom of the arm is a flat **stage** that acts as a table for the object that is being examined (looked at). Just underneath the stage is a dial that can be turned to change the amount of light shining up at the object. This dial is called the **diaphragm (di-a-fram)**. Under the diaphragm is a round bulb called the **light source**. It shines up through the object being examined to help you see it better. Below the light source is the microscope's **base**—the flat, heavy plate that lets it sit firmly on a flat surface.

Parts of a Compound Light Microscope

Use the **bolded words** from the passage called *The Parts of a Compound Light Microscope* to label the diagram below. All of the bolded words must be used and each should be used only once



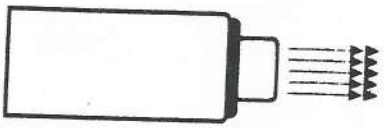
- ask to see our microscope and slides to check out ... dead flies... hair... plant roots...

Part J: What is optical technology?

Optical Technology

Optical technology is when we use light and control the way it behaves to help us do work. Many modern machines, such as microscopes, use optical technology.

Lasers



The word laser is an acronym and it stands for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. In other words, lasers work by amplifying (making stronger or purer) rays of light.

You learned earlier in this unit that light is made up of coloured rays that are all different lengths. This "regular" light is called **incoherent light** because its waves are all different sizes and travel out in all directions sometimes bumping into one another. A laser is a kind of **coherent** light because it controls light rays so they all shine together in one direction and are all the same long length, this is why most laser beams are red (the longest ray).

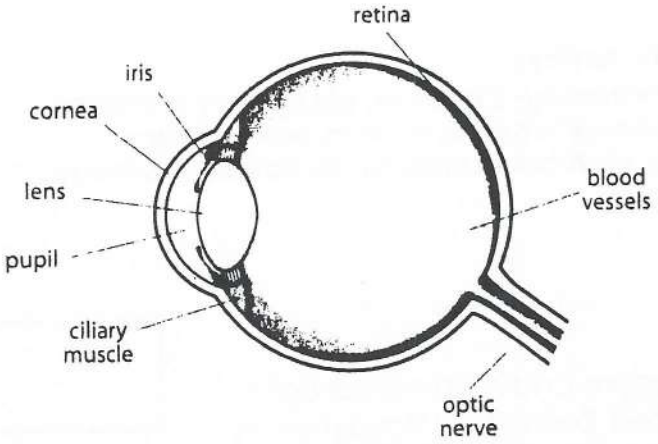
Fibre Optics

Fibre optics is another optical technology that involves creating special tubes for light to travel along. The tubes are usually very small and they often look like fishing line. The tubes are made of a thin circle of glass covered in plastic. When light shines on the tube, it reflects all the way along but doesn't escape out the sides. The only place you can see the light is at the end of the tiny tube. Fibre optic cables can carry light a long distance and are often used to carry information that is communicated through light signals.

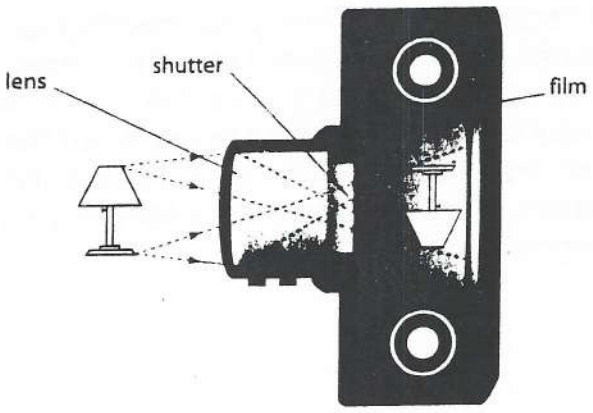
Independent Research

Learn more about laser or fibre optic technology and how each helps people do work. Look for books in the library, search on the Internet or ask your science teacher!

Part K: How are our eyes like film cameras?



The iris is the coloured part of the eye. The black part in the middle is the pupil. The pupil is an opening controlled by a circle of muscles that open and close to adjust the amount of light passing into the eye. When the light goes into the eye, it passes through a convex lens that brings the light rays together and focuses them. The focused light hits the retina at the back of the eye. The retina is like a movie screen that is attached to the brain by the optic nerve. The image that is projected onto the retina is actually an upside-down version of what the eye is looking at. The brain is able to figure out what the right-side up image looks like, so we aren't even aware that the image is upside down.



The lens of a camera is on the front. Light shines through the convex lens that brings the rays together. The light then passes through the hole in the diaphragm (di-a-fram) that opens and closes to let light in. The image is projected onto the camera film. The image is upside-down but, with photographs, all the developer needs to do is flip it the other way to see it properly!

Did you know?

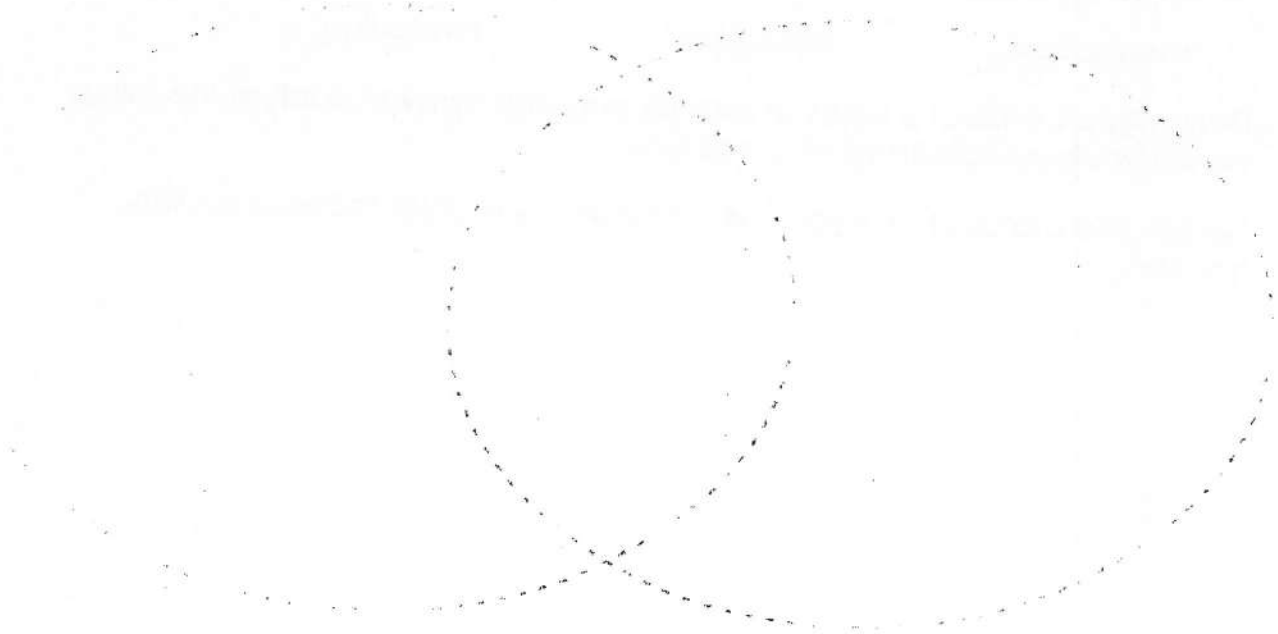
Different kinds of optical technology use lenses in a way that flips images upside down. You can check this by drawing the letter "e" on a piece of paper and looking at it under a microscope.

Use what you have learned to answer these questions.

1. Match the parts of the eye with their "partner" part of a film camera.

a. pupil	____ developer
b. lens	____ film
c. retina	____ diaphragm
d. brain	____ lens

2. Complete this Venn diagram to compare our eyes to a film camera.



3. When a person has to wear glasses, what part of their eyes is probably not working properly? Why do you think so?

Final Project

Choose **one** of the projects below to complete alone or with a partner, and then share your work with your class.

1. Research and create a diagram that shows how one of the following animal's eyes work:

   frog house fly fish

2. Research and create a poster that shows how laser eye surgery works.

3. Research and describe how digital cameras work.

4. Research and create a presentation that describes how and why one of the following optical devices was invented:

   microscope telescope binoculars

5. Design and conduct a series of experiments that "prove" each of the things we know about light listed on page five.

6. Design and conduct an experiment that shows how rainbows or sunsets happen.