Unit 3: Chapter 6

Refraction

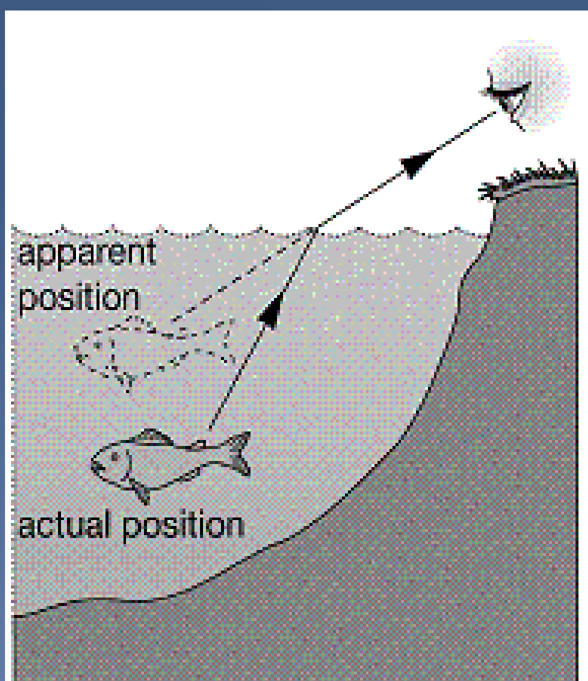
Refraction of Visible Light

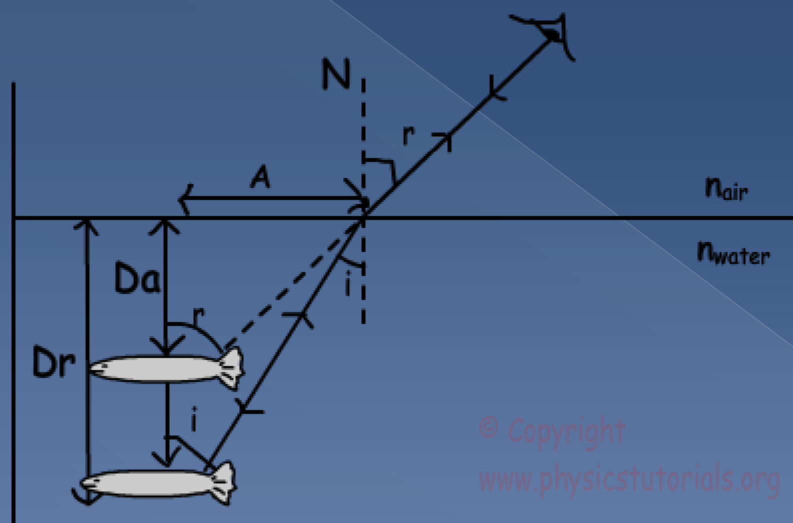
2 Examples:

1. **Bent-stick effect:** When light passes from one **medium** to another (ex: from air into water), the change of speed causes it to change direction.

   This is why a stick half under water looks bent.

2. **Position of a fish under water:** light **refracts** as it travels from the fish in the water to the eyes on land. Due to the light **bending**, a fish appears to be at a location where it isn't. A visual distortion occurs. Some fish can overcome this to hunt for their prey!

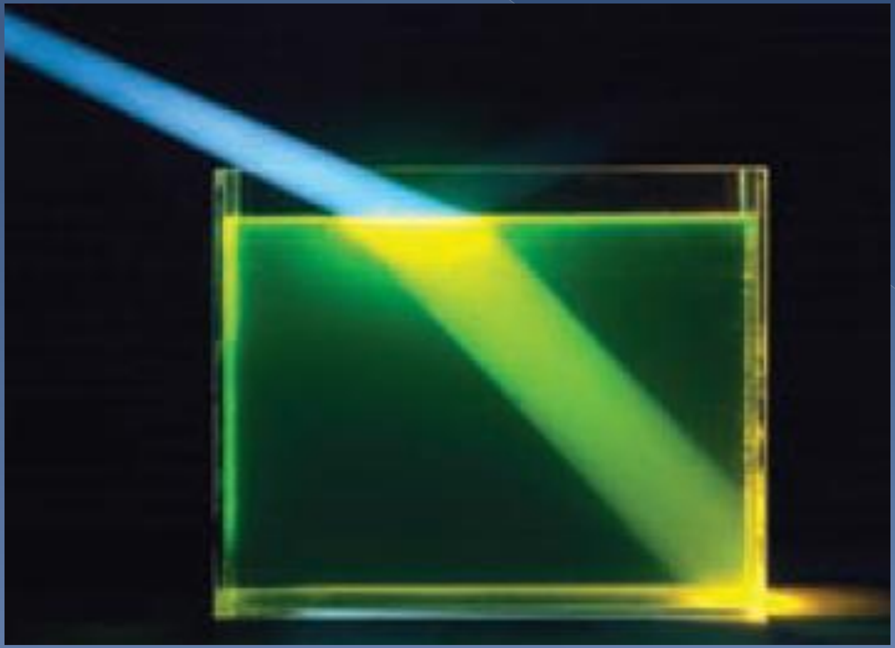




Da=Apparent depth
Dr=Real depth
i=angle of incident ray
r=angle of refracted ray

Refraction

- From Ch 4: **refraction** is the **bending** of a wave, such as light, when it travels from **one medium (material)** to another.



- Waves bend because their **speed** changes when travelling from one medium to another.
- When one end of the wave front **slows down**, the direction of the wave changes.

Questions

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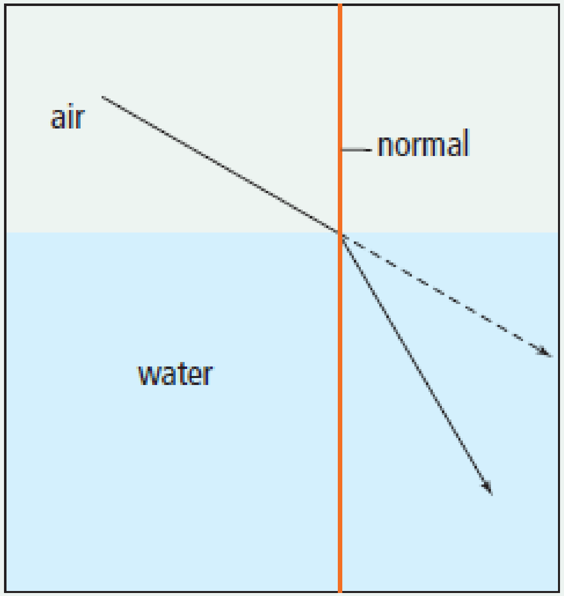
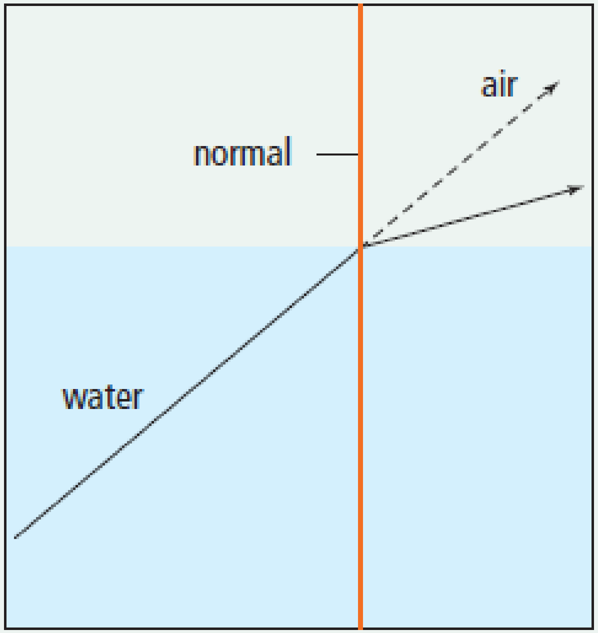
How can the medium effect the speed of light?

- When light travels from one medium to another medium of ***greater*** density, it will **slow down** and refract **towards** the normal (for example, from air to water).



A Light slows down and refracts toward the normal as it passes from air into water.

- When light travels from one medium to another medium of ***lower*** density, it will **speed up** and bend **away** from the normal.



B Light speeds up and bends away from the normal as it passes from water into air.

Lab - Refraction

Lens

- A curved piece of transparent material, such as glass or plastic, that refracts light in a predictable way.

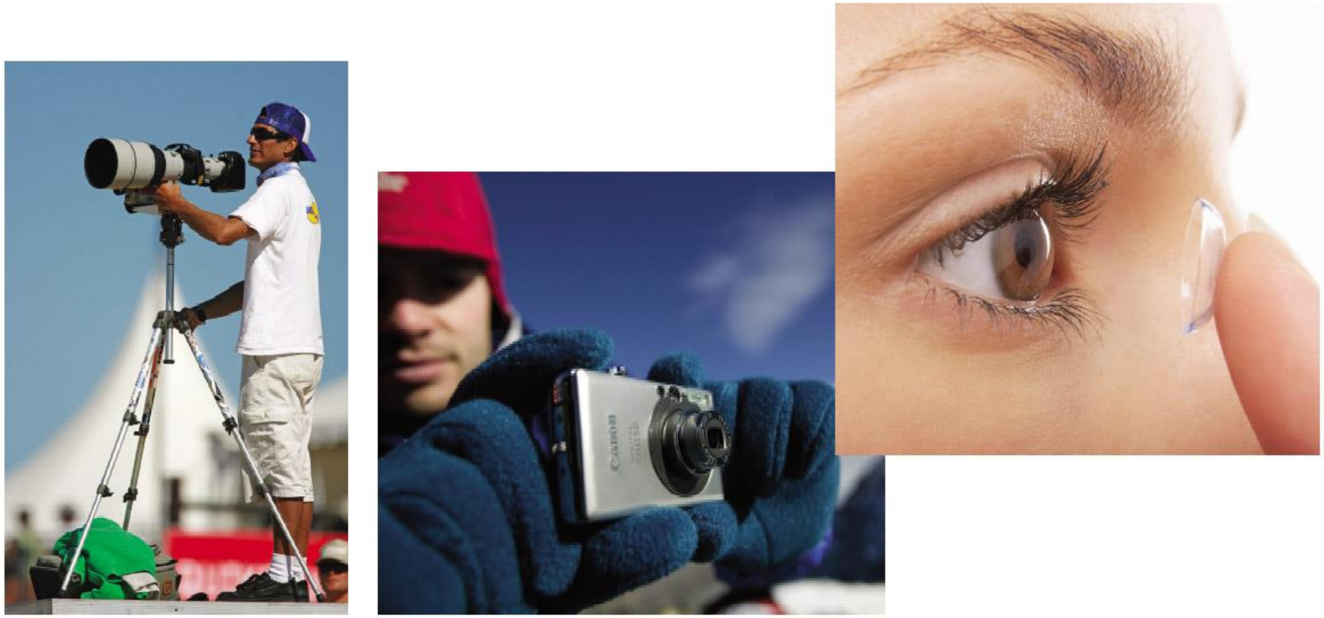
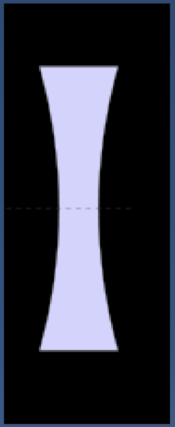


Figure 6.1 Cameras come with many sizes and types of lenses. Some lenses are for distant objects and some are for close up objects. A large lens collects more light so the photographer can take pictures without extra lighting. Contact lenses correct a person's vision.

2 Types of Lenses

1. ***Concave lenses:***
   - curve **inwards**
   - cause light rays to bend **away** from each other, or ***diverge***.

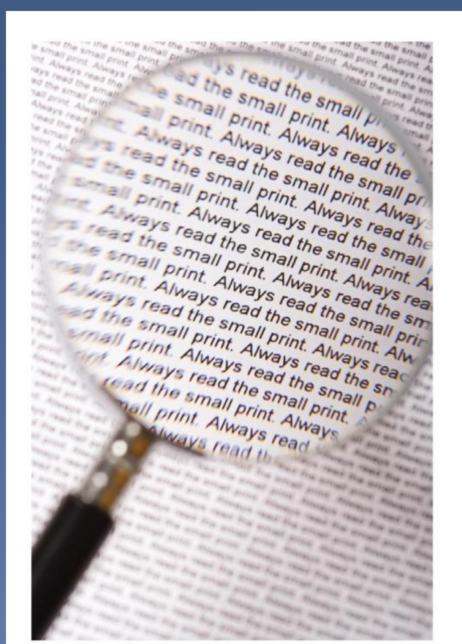
   Ex: Eyeglasses for nearsightedness

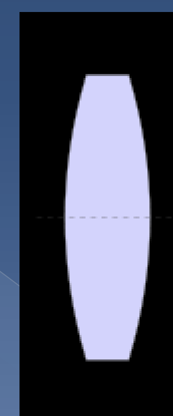


2. *Convex lenses:*

- Curve **outward**
- cause light rays to bend **toward** each other, or ***converge***

Ex: Eyeglasses for farsightedness, magnifying glasses





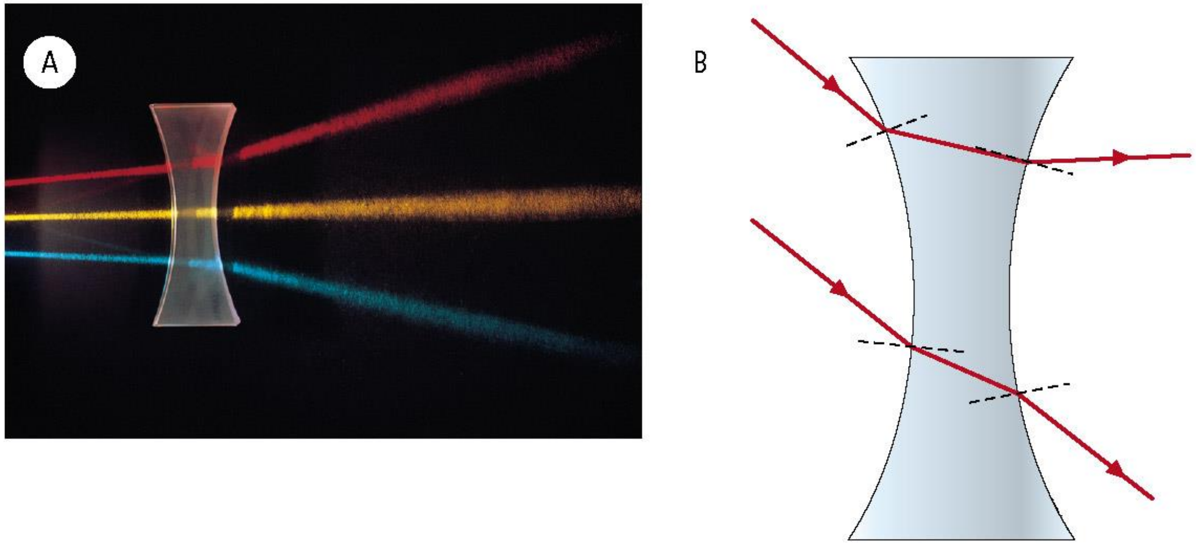


Figure 6.4 (A) Light rays diverge when they pass through a concave lens. (B) Rays bend toward the normal (shown by dotted lines) as they enter the lens, and away from the normal as they exit the lens.

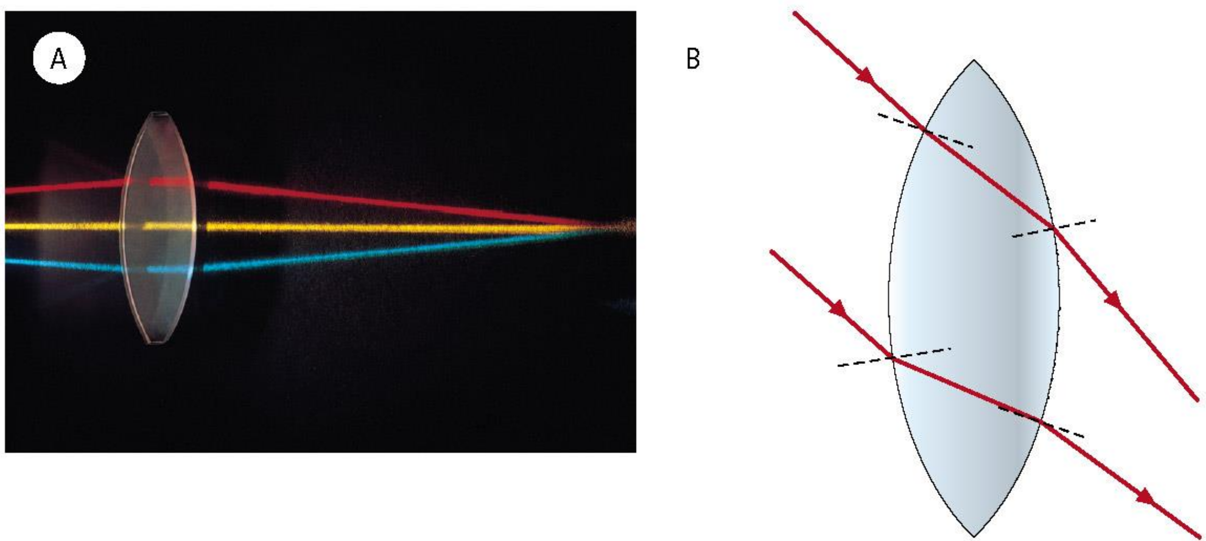


Figure 6.3 (A) Light rays converge when they pass through a convex lens. (B) Rays bend toward the normal (shown by dotted lines) as they enter the lens, and away from the normal as they exit the lens.

****Homework: Look on the internet and find two more examples of each type of lens****

Human Vision

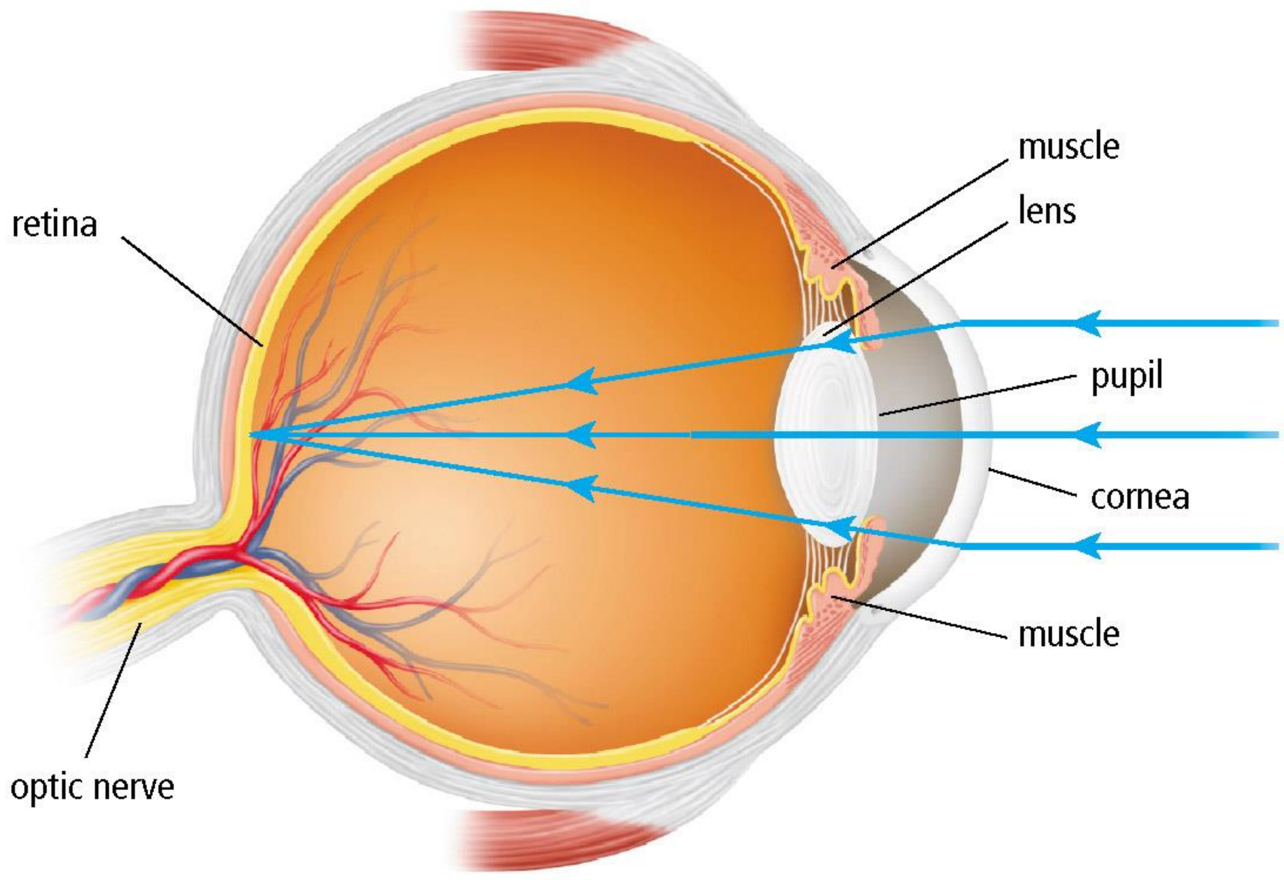


Figure 6.15 The eye in cross section

1. Normal Vision

- When light rays from a distant object enter the eye, the rays are **parallel**.

- The lens, which is **convex**, causes the rays to **converge** at the retina, producing a sharp image.

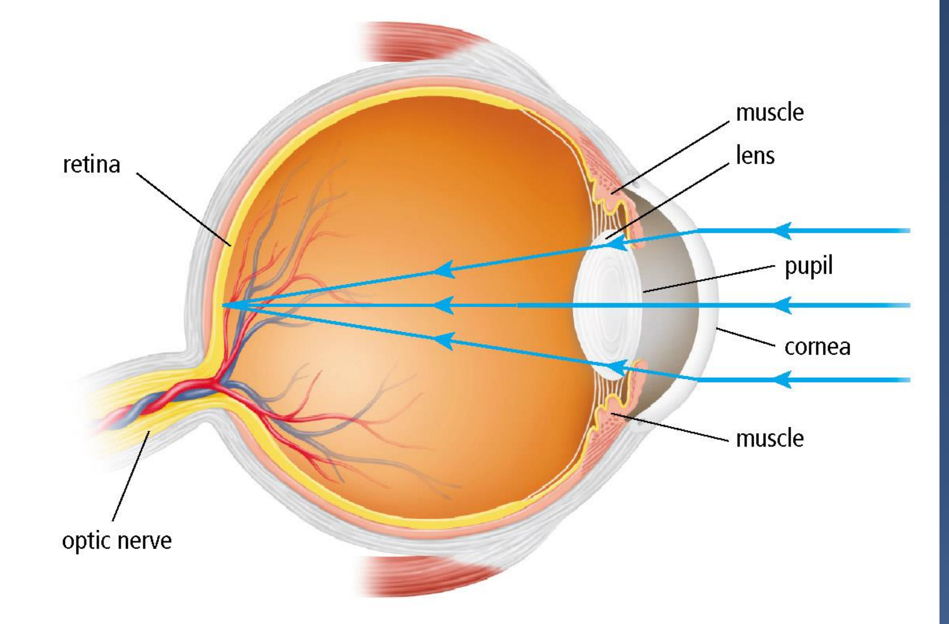
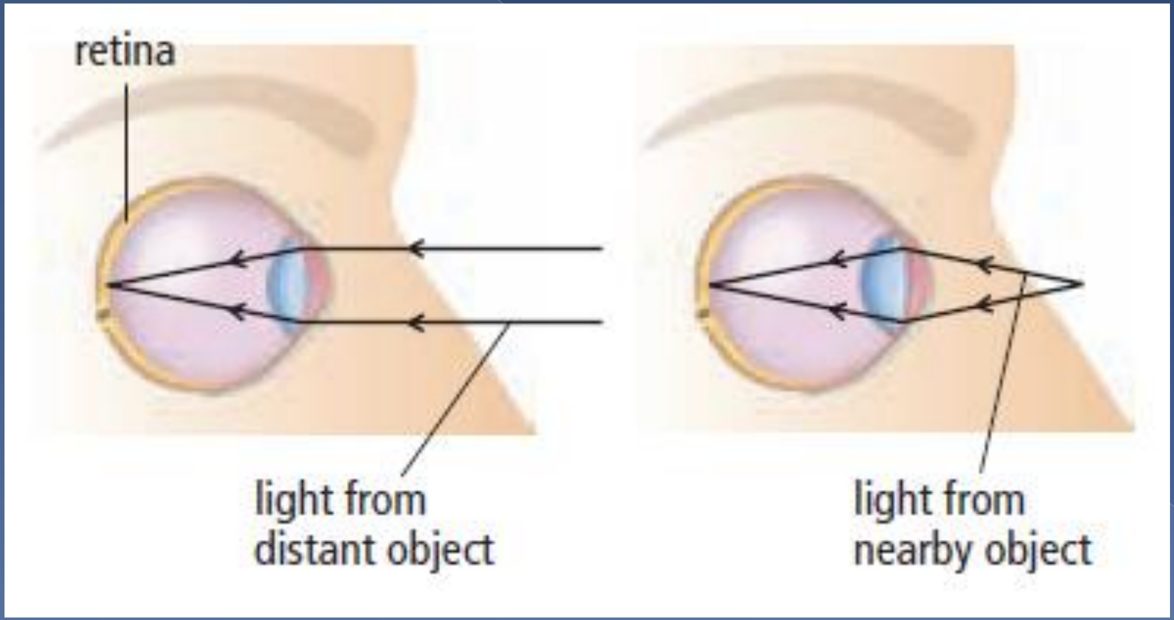
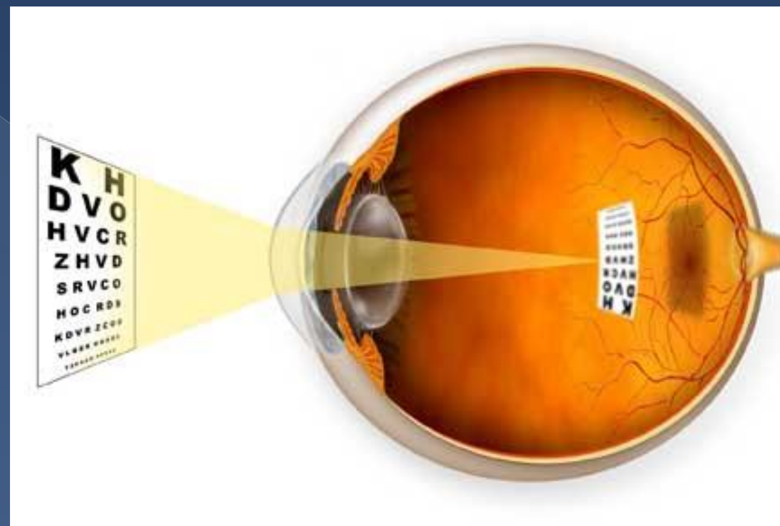


Figure 6.15 The eye in cross section

- Muscles in the eye cause the lens to get **thicker** to focus close up objects.

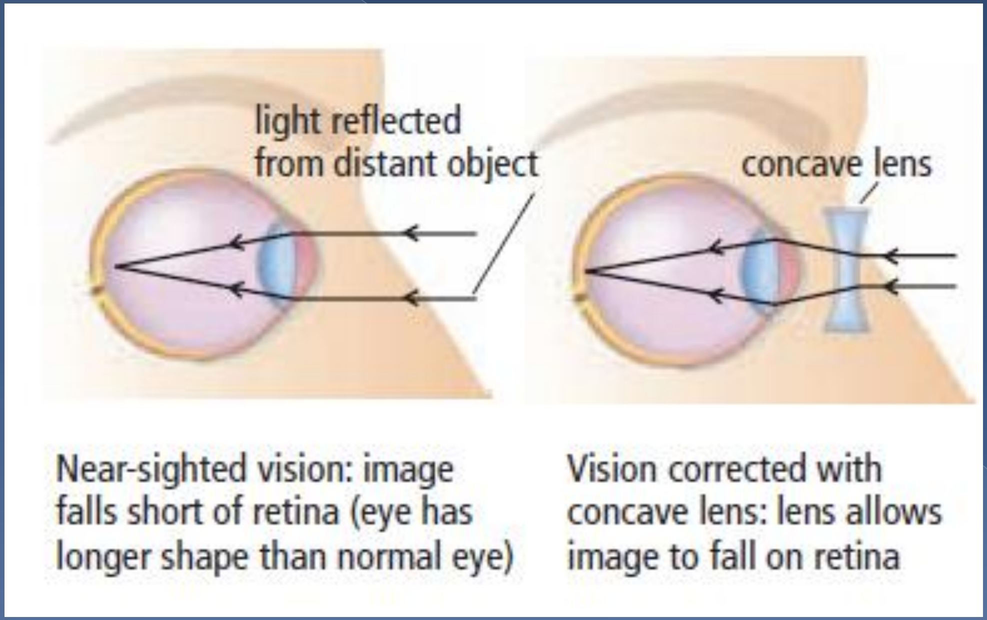


2. Near-sightedness (myopia)

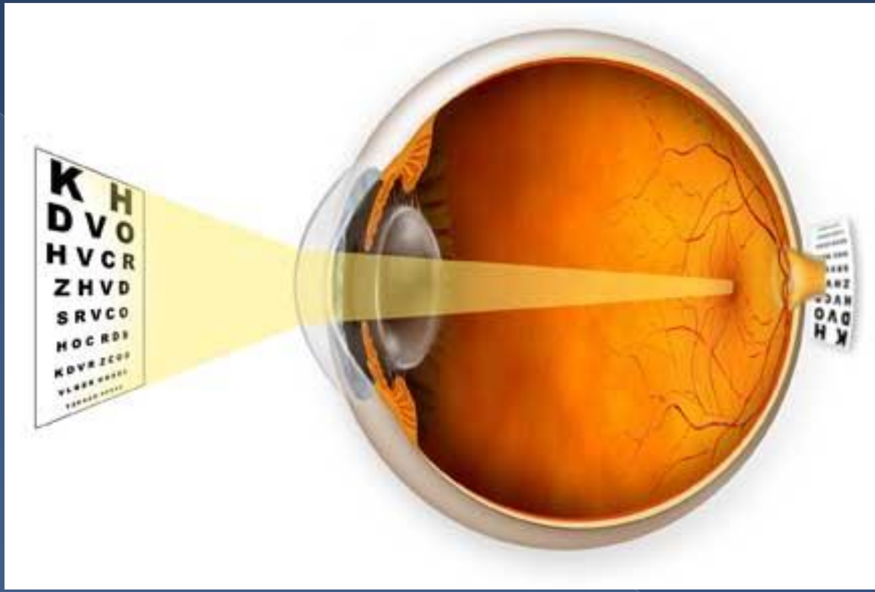


- Near-sighted people can see **<u>nearby</u>** objects clearly but cannot bring **<u>distant</u>** objects into focus. The lens converges the light rays to form an image **<u>in front of</u>** the retina.

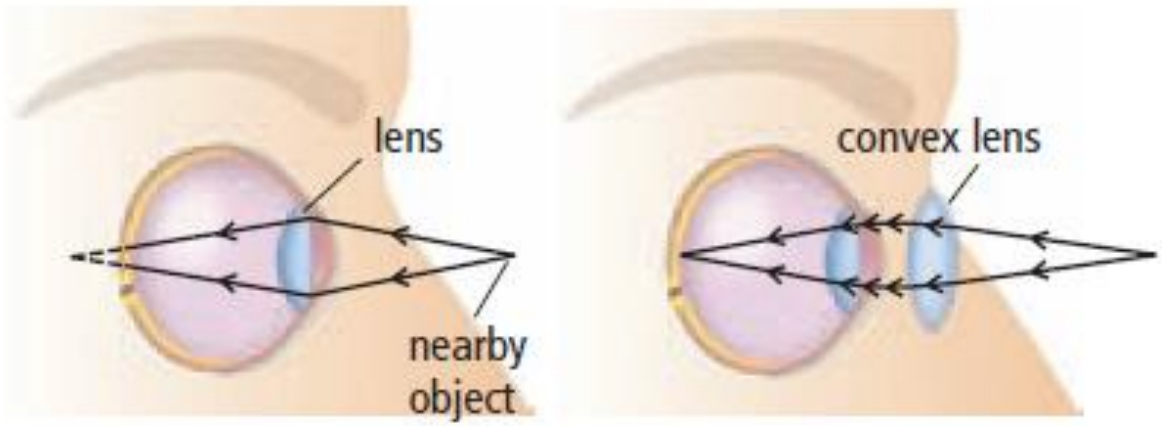
- A **concave** lens is used to **diverge** the parallel rays slightly so that the image forms farther back, on the retina.



3. Far-Sightedness (hyperopia)



- Far sighted people see **<u>distant</u>** objects clearly but find that **<u>nearby</u>** objects remain fuzzy. The image falls **<u>behind</u>** the retina.



Far-sighted vision: image falls behind retina (eye has shorter shape than normal eye)

Vision corrected with convex lens: lens allows image to fall on retina

- A **convex** lens is needed for the light rays to come into focus exactly on the retina.

Questions

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Optical Technologies

- Until optical technologies were developed, our knowledge was limited to what we could see with our eyes.

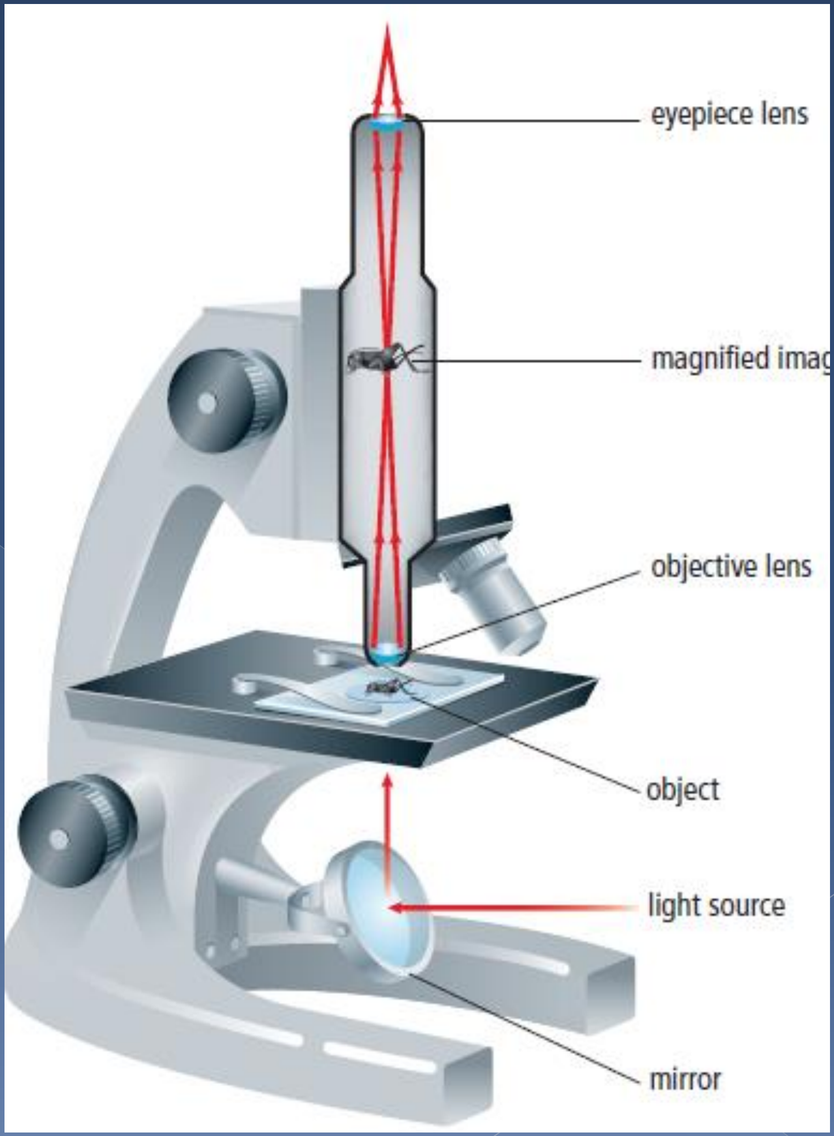
- We can now use optical technologies to see the tiniest organism or far away in outer space.

- Optical technologies are all based on the same understanding of **light, mirrors and lenses.**

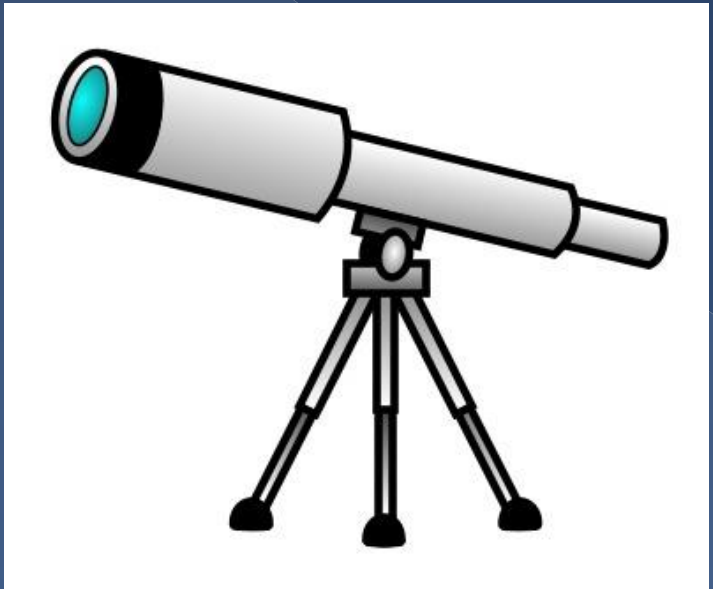
- You can use **ray diagrams** to determine the image produced, but they would be very complicated. We use simplified diagrams to explain how optical instruments work.

Microscopes

- A compound light microscope uses two **convex** lenses with relatively short **focal lengths** to magnify small, close objects.



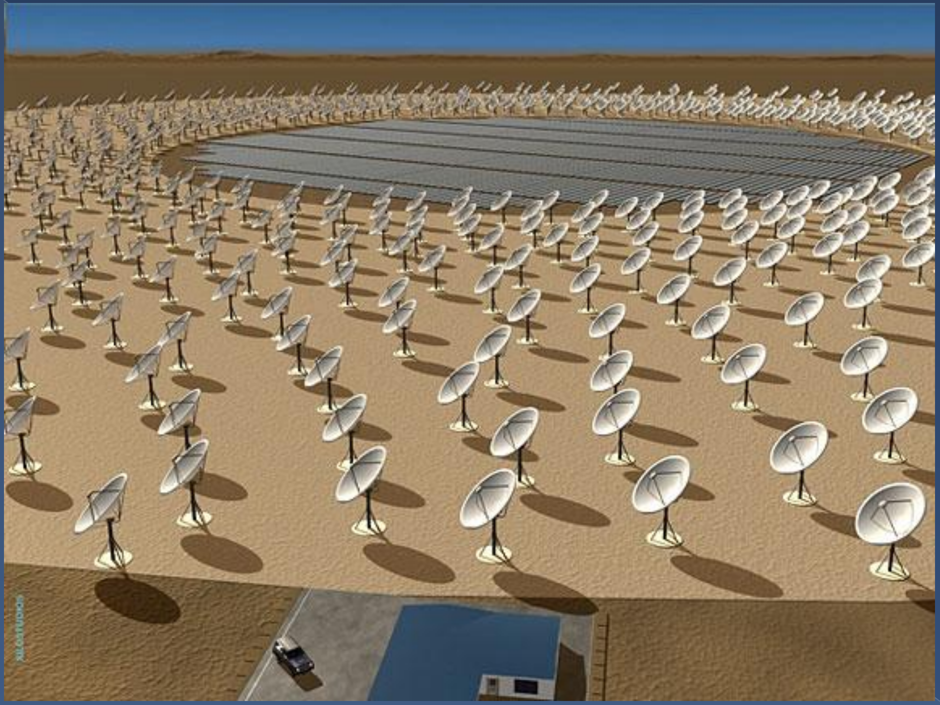
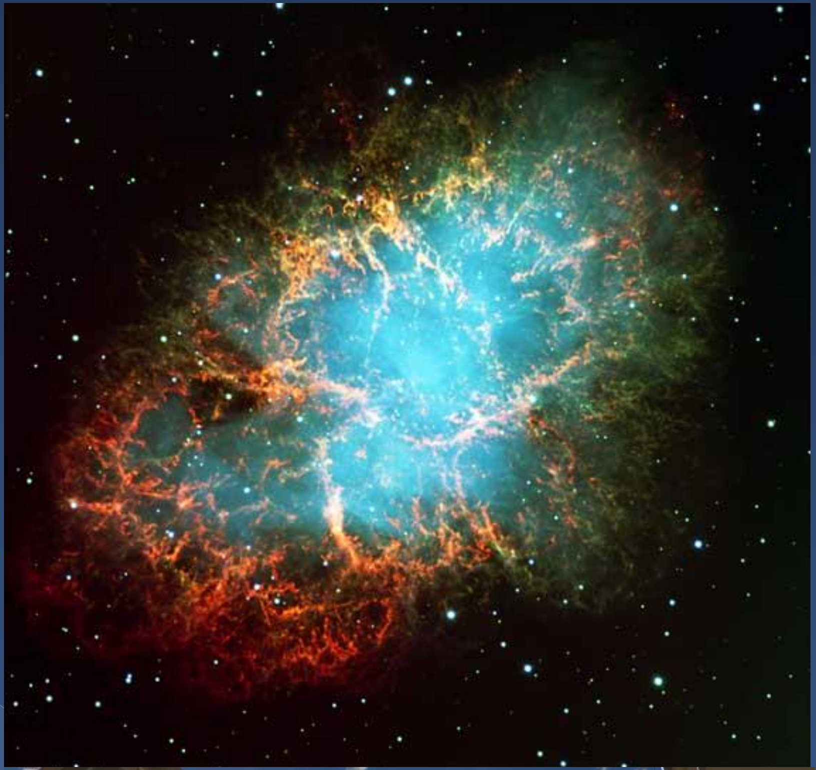
Telescopes



- Far away objects look dim because the amount of light reflecting off of that object **decreases** as it gets further away.
- Scientists have been developing telescopes for more than **400** years to gather and focus light from faraway stars.

- A telescope uses a **lens** or **concave** mirror that is much **larger** than your eye to gather more of the light from distant objects.

- The **largest** telescope can gather over a **million** times more light than the human eye. Thus, distant galaxies appear much **brighter**.

Two types of Telescopes

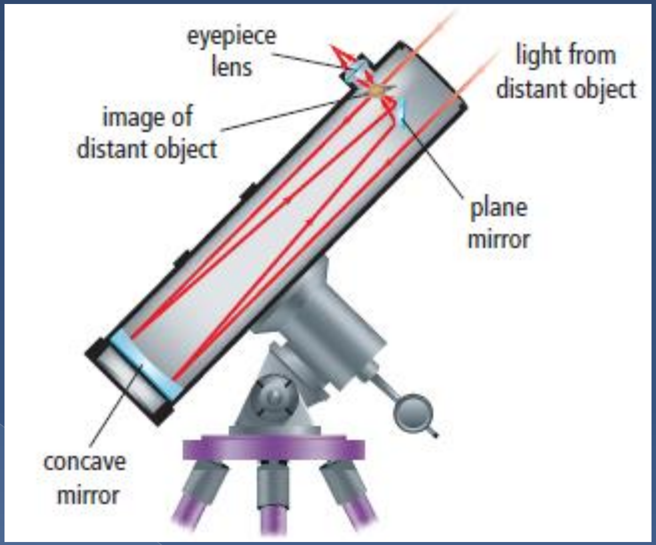
1. Refracting Telescopes

- The simplest telescopes that have only two lenses

- The lenses ***bend*** light to focus it (that's why it's called a ***refracting*** telescope).

Reflecting Telescopes

- Because of the problems with making large lenses, most large telescopes today are ***reflecting telescopes***.
- A reflecting telescope uses a **concave mirror**, **a plane mirror and a convex lens** to collect and focus light from distant objects.



- Some telescopes collect light rays from several **mirrors** and then combine them into a **single** image (example: the Keck telescope in Hawaii)

- http://www.dnatube.com/video/7816/Hubble-Space-Telescope--Chapter-1
- https://www.youtube.com/watch?v=Bx7RXNepGis