

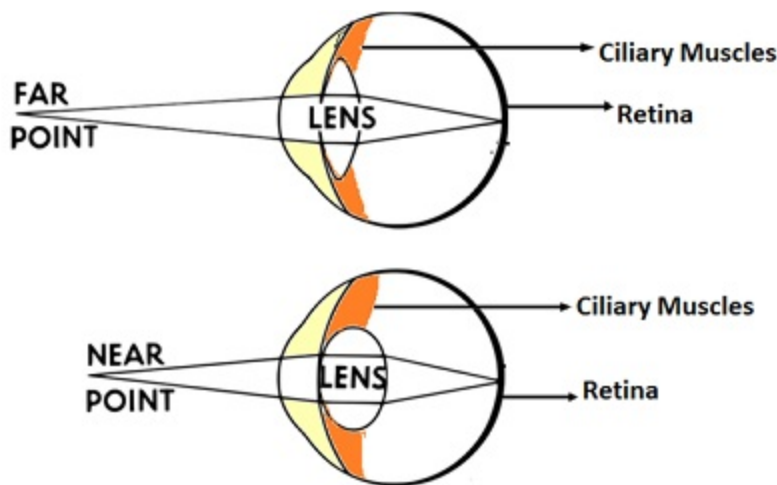
## HUMAN EYE

## HUMAN EYE AND COLORFUL WORLD

- **Cornea:** Light mainly falls on the cornea, the white clear front part of the eye which is slightly bulging forward. It is tough and protects the interior of the eye from accidents.
- **Iris:** The iris (a muscular structure behind the cornea) of the eye controls the amount of light reaching the interior of the eye by automatically adjusting the size of the pupil. The iris is that part of the eye which gives it the color such as black, brown, green eyes commonly called cat-eyes etc
- **Pupil:** The pupil regulates and controls the amount of light entering the eye.
- **Lens:** The eye's crystalline biconvex shaped lens is located behind the pupil. It further focuses the light on the retina.
- **Ciliary Muscles:** The lens is contracted and relaxed by the ciliary muscles. The focal length is varied by this movement.
- **Retina:** The lens forms an inverted real image of the object on the retina. The retina contains several nerve cells which convert the optical images to signals to the brain via the optic nerve.
- **Nerve Cells:** There are 2 types of nerve cells. (i) **Cones** : which are sensitive to bright light and help us recognize color (ii) **Rods**: which are sensitive to dim light.
- **Brain:** The brain again inverts the image, decodes this signal and then we see the image.

Note : The light is focused by the cornea, then the iris by controlling the opening of the pupil and then the lens. In dim light, your pupil expands to allow more light to enter your eye. In bright light, it contracts.

### Power of Accommodation



- The ability of the human eye to adjust itself such that it can see objects which are nearby and faraway is called **Accommodation**.
- It primarily involves the lens and ciliary muscles.
- The ciliary muscles are capable of modifying the curvature of the lens and thereby affecting the focal length of the lens.
- When viewing **objects which are nearby**, the ciliary muscles **contract**, the **lens becomes thicker**. It is squeezed into a **more convex shape** and the **focal length decreases** (curvature increases). The images again falls on the retina. Note that here the eye is '**accommodating**' by taking a thicker shape so that the image falls on the retina.
- When viewing objects which are far away, the ciliary muscles expand, the lens becomes thinner. It is relaxed/loosened into a less convex shape and the focal length increases (curvature decreases). The images again falls on the retina. Note that here the eye is 'accommodating' by taking a thinner shape so that the image falls on the retina.
- However, the focal length of the eye cannot be reduced below a certain minimum limit. If you read a book very close to your eye, it will appear blurred. The minimum distance, at which objects can be seen most distinctly without strain is called the '**Least Distance of Distinct Vision**' or the '**Near point of the eye**'. For a young adult with normal vision, the near point is about **25cm**.
- The farthest point up to which the eye can see objects clearly is called the '**Far point of the eye**'. For a normal eye, **it is infinity**.

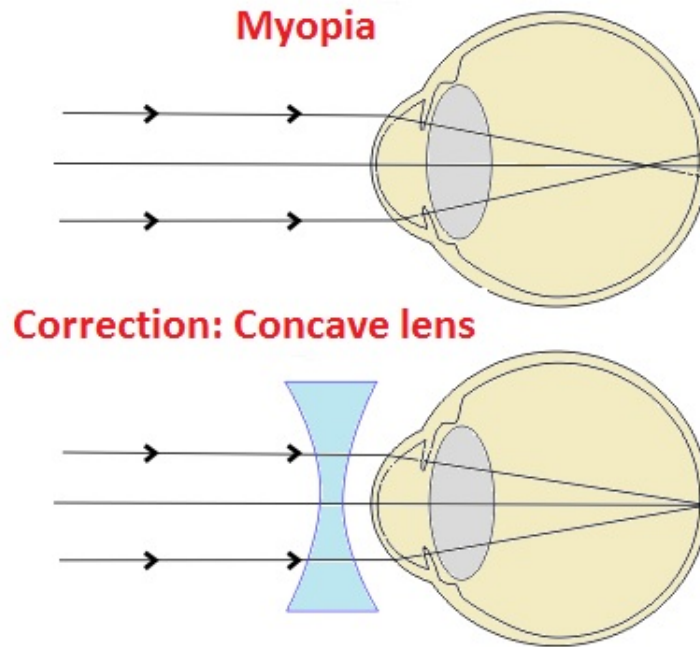
### Defects of Vision and their Correction

Three common **refractive defects** of the eye:

- **Myopia or Near-sightedness**
- **Hypermetropia or Farsightedness**
- **Presbyopia**

#### Myopia

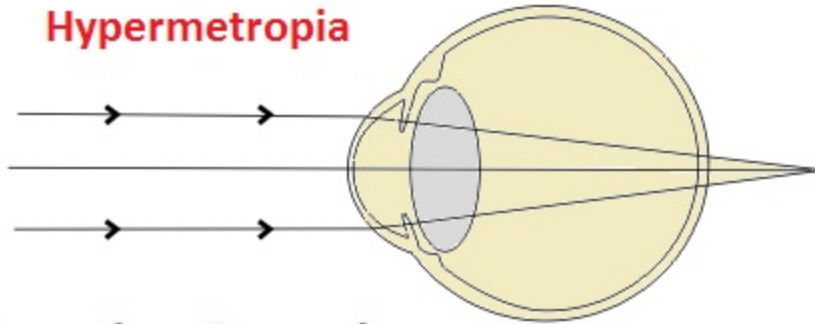
- **Near-sightedness** : A person with Myopia can see nearby objects clearly
- A person with myopia cannot **see faraway objects clearly**.
- The far point for the myopic eye is **nearer than infinity**
- Occurs due to
  - Excessive curvature of the eye lens
  - Elongation of eyeball
- The image of a distance object is formed in **front of the retina** and not on the retina
- Defected is corrected by using **Concave lenses** such that the lens will bring the image back on to the retina.



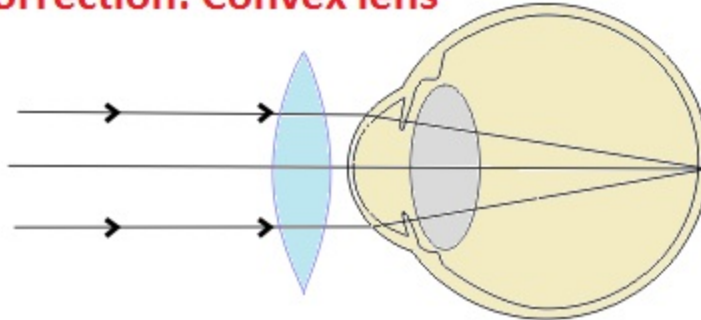
### Hypermetropia

- **Far sightedness** : A person with Hypermetropia can see faraway objects clearly.
- A person with **Hypermetropia** cannot see **nearby objects clearly**.
- The near point of the eye is more than 25cm
  - This arises mostly during latter stages in life, as a result of the weakening of the ciliary muscles and/or the decreased flexibility of the lens.
  - Focal length of the eye lens is too long
  - Eyeball has become too small.
- The image of a distance object is formed in **behind the retina and not on the retina**
- Defected is corrected by using **Convex lenses** such that the lens will bring the image back on to the retina.

## Hypermetropia



## Correction: Convex lens



### Presbyopia

- The **power of accommodation of the eye usually decreases with ageing**. The ciliary muscles weaken and thereby the flexibility of the eye lens reduces.
- The near point moves away.
- Spectacles with convex lenses are recommended

### Myopia and Hypermetropia

- Sometimes a person may suffer from both **near sightedness and far-sightedness**.
- Such people are advised to use **bifocal lenses**.
- Bifocal lenses consist of **concave on the upper portion and convex on the lower portion**.
- Concave supports distinct vision and convex supports near vision

Refractive eye defects can also be corrected using **contact lenses or through specific surgical procedures**.

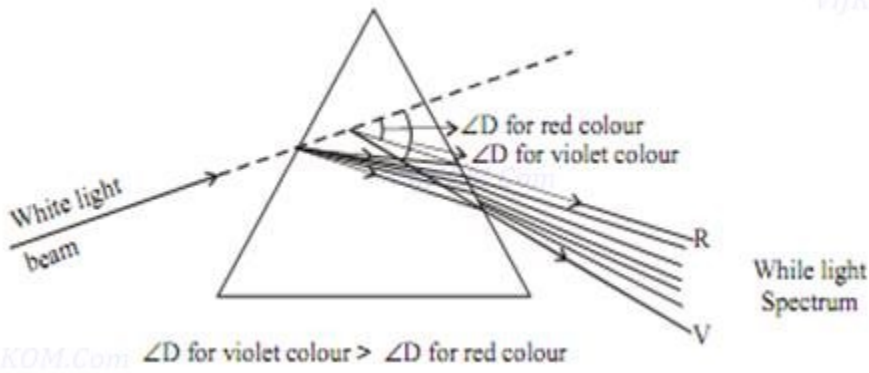
**Prism** : It has two triangular bases and three rectangular lateral surfaces.

These surfaces are inclined to each other. The angle between its two lateral faces is called **Angle of Prism**.



**Angle of Deviation (D)** is the angle between the incident ray and emergent ray.

Dispersion of white light by a Glass Prism



Inclined refracting surfaces of glass prism show exciting phenomenon.

**Splitting of White Light into Band of Colours**

The band of the coloured components of light beam is called **Spectrum** i.e. **VIBGYOR**

The splitting of light into its component colours is called **Dispersion**.

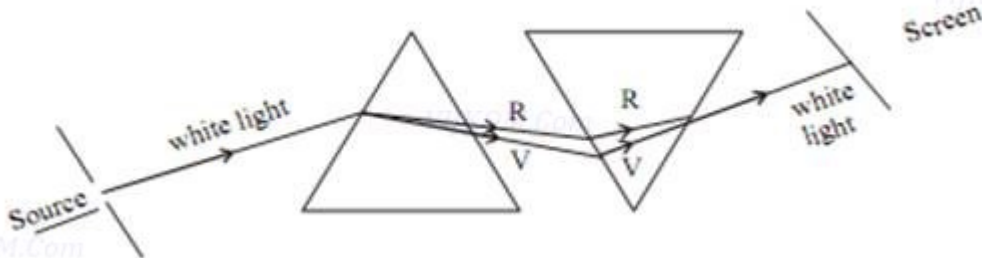
The different component colour of light bends at different angle with respect to incident angle, the red light bends the least while the violet bends most.

**ISSAC NEWTON** He was the first, who obtained spectrum of sunlight by using glass prism.

He tried to split the spectrum of white light more by using another similar prism, but he could not get any more colours.

He repeated the experiment using second prism in an inverted position with respect to the first prism.

Allowed all the colours of spectrum to pass through second prism. He found white light emerges on the other side of second prism.



He concluded that sun is made up of seven visible colour 'VIBGYOR'

**RAINBOW** It is the spectrum of sunlight in nature It is formed due to the dispersion of sunlight by the tiny water droplet, present in atmosphere.

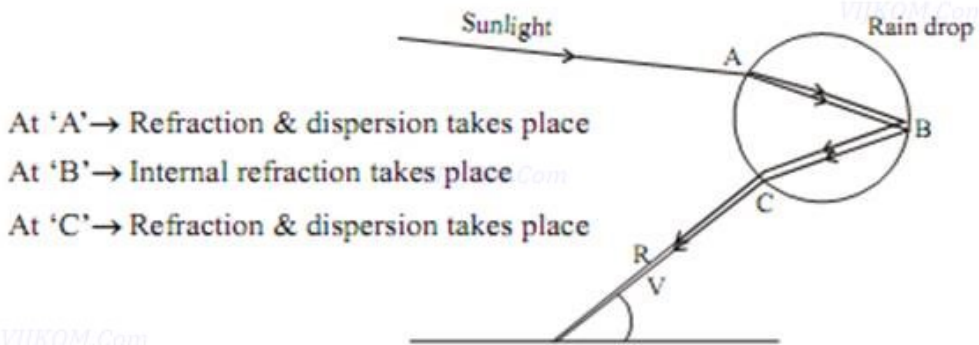
**Water Droplet Act like Prism**

It refracts and disperses the incident sunlight, then reflects it internally (internal reflection) and finally refracts it again, when it emerges out of the water droplet.

A rainbow is always formed in a direction opposite to that of sun.

Due to dispersion and internal reflection of light, different colours reach the observer's eye.

Red colour appears on top violet at the bottom of rainbow



**Atmospheric Refraction**

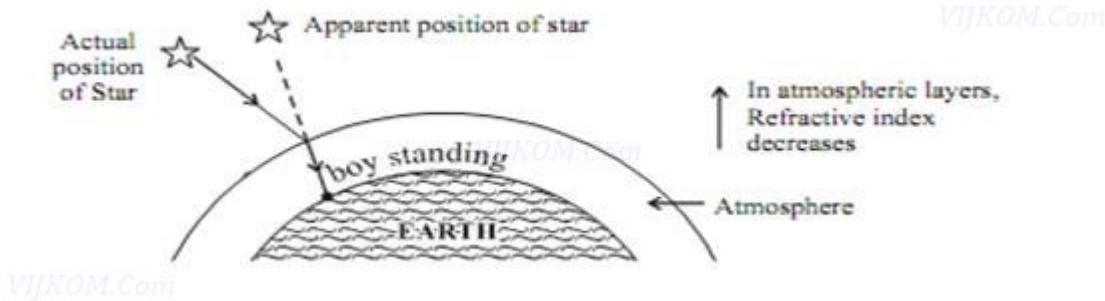
**1. Apparent Star Position :** It is due to atmospheric refraction of starlight.

The temperature and density of different layers of atmosphere keeps varying. Hence we have different medium.

Distant star act as point source of light. When the starlight enter the earth's atmosphere it undergoes refraction continuously, due to changing refractive index i.e. from Rarer to denser, it bends towards the normal.

Due to this the apparent position of the star is different from actual position.

The star appears higher than its actual position.



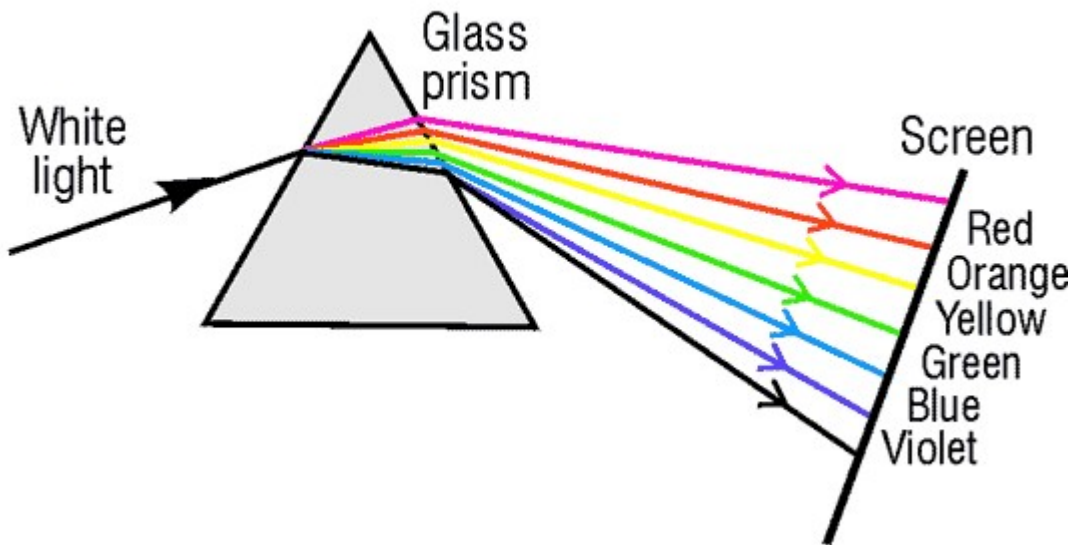
1. **Twinkling of Star** : It is also due to atmospheric refraction.

Distant star act like a point source of light. As the beam of starlight keeps deviating from its path, the apparent position of star keeps on changing because physical condition of earth's atmosphere is not stationary. Hence the amount of light enters our eyes fluctuate some time bright and sometime faint. This is the "Twinkling effect of star".

**Blue Sky**

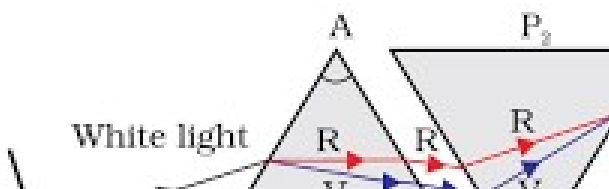
The blue color of the sky is caused by the scattering of sunlight off the molecules of the atmosphere. This scattering, called Rayleigh scattering, is more effective at short wavelengths (the blue end of the visible spectrum). Therefore the light scattered down to the earth at a large angle with respect to the direction of the sun's light is predominantly in the blue end of the spectrum. **Spectrum:-** The band of seven coloured components of light is called spectrum.

Dispersion of white light by a glass prism:-



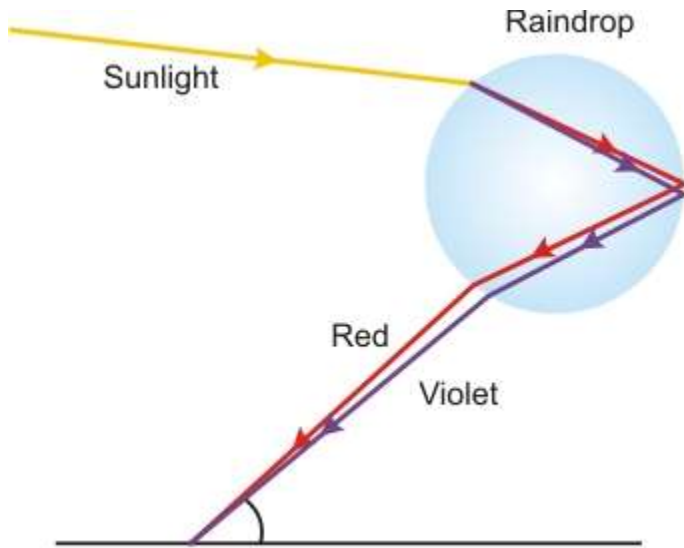
- When Newton placed a second identical prism in an inverted position with respect to the first prism, he found a beam of white light emerging from the other side of the second prism. This shows that **sunlight is made up of seven colours**.

**Recombination of WI**



Rainbow Formation:-

It is a natural spectrum appearing in the sky after a rain shower. A rainbow is always formed in a direction opposite to that of the Sun.



Three phenomena which are involved in rainbow formation are:-

- refraction
- dispersion and
- total internal reflection

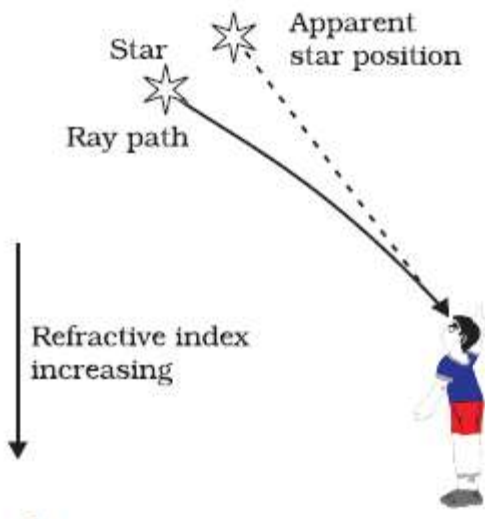
Atmospheric Refraction:-

The refraction of sunlight by different layers of atmosphere is called atmospheric refraction.

Phenomena caused by atmospheric refraction:-

Apparent position of star:-

The refractive index of earth's atmosphere increases from top to bottom. So, the light coming from a star near the horizon has to travel from rarer to denser medium & it bends towards the normal. As a result the star appears higher than its actual position.

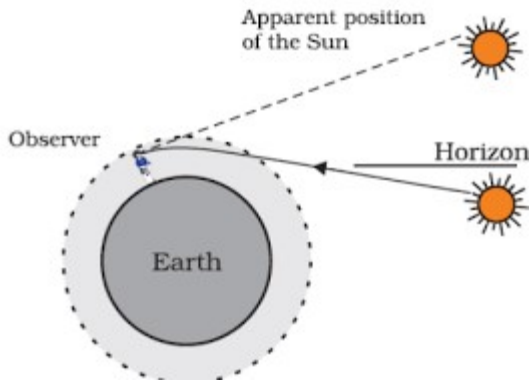


Twinkling of stars:-

Since the physical conditions of the earth's atmosphere are not constant, so the light from stars appears to come from different directions. This results in fluctuation of apparent position of star. Also the amount of light coming from stars vary due to changing refractive index of atmosphere. So the stars sometimes appear brighter and sometimes fainter. These two effects are responsible for twinkling of stars.

Advanced sunrise and delayed sunset:-

When the sun is below horizon, the rays have to pass from rarer to denser medium. So rays bend towards normal. As a result, the sun appears higher than its actual position. So the sun rises two minutes earlier than actual sunrise and remains visible for about two minutes after the actual sunset.



Phenomena based on scattering of light:-

**Tyndall effect:-** The phenomenon of scattering of light by colloidal particles so that its path becomes visible is called Tyndall effect.

Blue appearance of the sky:-

The upper layer of atmosphere contains very fine particles. These particles are more effective in scattering light of shorter wavelength mainly upto blue end. These scattered light enter our eyes and the sky appears blue.

Reddish appearance of the sun at sunrise and sunset:-

During sunset and sunrise, the sun is near horizon and the sunlight has to travel larger distance in atmosphere. Due to this most of the light of shorter wavelengths are scattered away by the particles and light of longer wavelengths reaches our eyes. This gives reddish appearance of the sun at sunrise and sunset.

