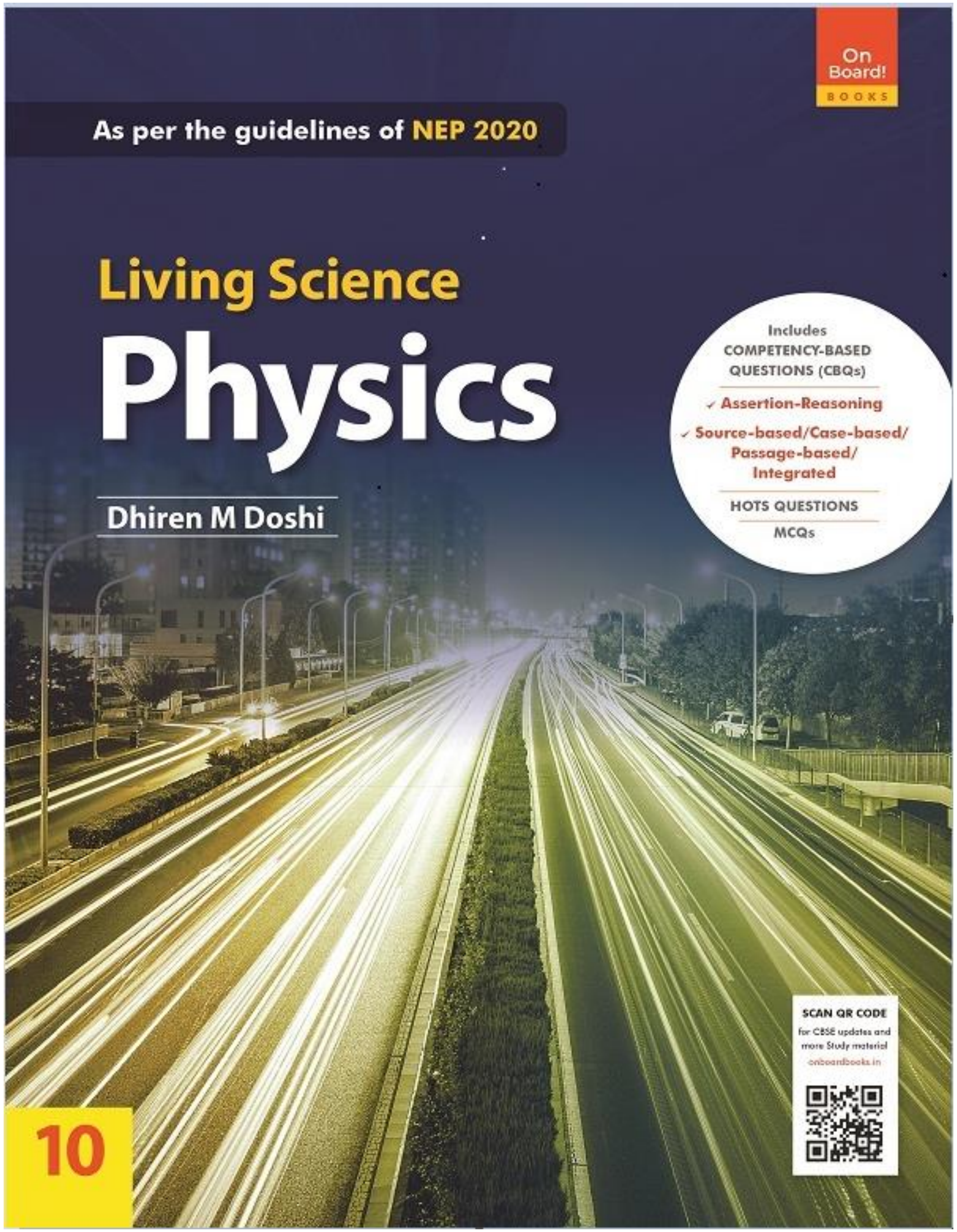
On Board!
BOOKS



CBSE Living Science Physics

Class 10

Chapter 6 The Human Eye and the Colourful World

LEARNING OBJECTIVES

The Human Eye

- ❖ Structure and function of human eye
- ❖ Working of the human eye

Power of accommodation

- ❖ Advantages of two eyes for vision

Defects of Vision and their Correction

- ❖ Myopia (near-sightedness)
- ❖ Hypermetropia (far-sightedness)
- ❖ Presbyopia (old sight)
- ❖ Cataract

Refraction of Light Through a Prism

- ❖ Dispersion of light
- ❖ Recombination of spectrum colours to give white light
- ❖ Formation of a rainbow

Atmospheric Refraction

- ❖ Twinkling of stars
- ❖ Advance sunrise and delayed sunset

Scattering of Light

Human Eye

The human eye is a light-sensitive organ, which enables us to see. The construction and working of human eye is similar to that of the photographic camera.

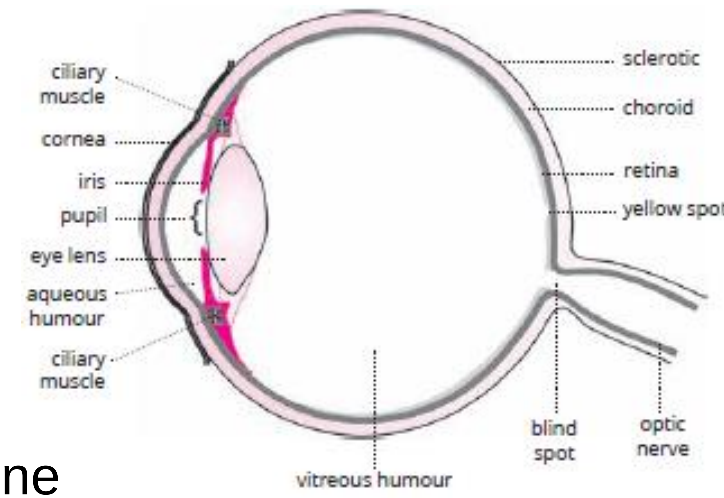
The Structure and function of the eye

1.Sclerotic: It is the outermost covering of the eye. It consists of white fibrous tissue. It protects the vital internal parts of the eye.

2. Cornea: The sclerotic layer continues in front of the eye as cornea. This is a transparent, white portion of the eye, which covers the transparent bulge on the surface of the eyeball. Light enters the eye through cornea.

3. Iris and pupil: Behind the cornea is an opaque diaphragm called the iris. It lends colour to the eye. The iris has a central circular aperture called the pupil. The iris regulates the amount of light entering the eye by adjusting the size of pupil.

4. Choroid: The dark pigmented membraneous layer attached to the sclerotic on its inner side is called the choroid. It is richly supplied with blood vessels. It darkens the eye from inside and hence prevents any internal reflection.



Human eye

5. Crystalline lens: It is a transparent crystalline double convex lens situated just behind the iris. It is held in position with the help of ciliary muscles.

The ciliary muscles, together with the suspensory ligaments, can increase or decrease the curvature and therefore, the focal length of the eye lens required to focus objects at different distances on the retina.

6. Retina: It is the innermost delicate membrane having a large number of light-sensitive cells called ‘rods’ and ‘cones’. The cones are sensitive to colour while the rods are sensitive to the intensity of light. The retina of an eye is where the image of an object is formed. The image formed on the retina is retained by it for about 1/16th of a second. The retina has two very important regions, which are called yellow spot and blind spot.

7. Optic nerve: There are about one million separate nerve fibres that connect the rods and cones of the retina to the brain. These one million separate nerve fibres make up the optic nerve.

Working of the human eye

1. The light coming from an object enters the eye through the cornea, passes through the pupil and falls on the eye lens.

2. The eye lens is a convex lens. It focuses these light rays to form a real, inverted and highly diminished image on the retina.

3. The retina is a delicate membrane having a large number of light-sensitive cells. When light rays fall on retina, the light-sensitive cells (rods and cones) get activated and generate electrical signals.

4. These electrical signals are then sent to the brain through the optic nerve.

5. The brain interprets the signals and renders the erect image of the object

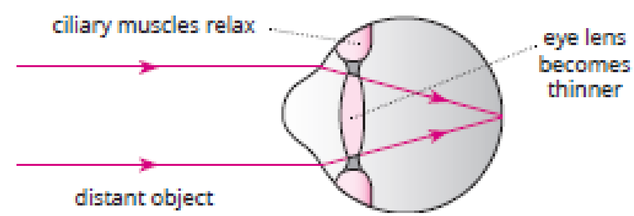
Light coming from an object enters the eye. → The lens focuses the light rays to form a real and inverted image on the retina. → Rods and cones of the retina get activated and generate electrical signals. → Optic nerve sends electrical signals to the brain. → The brain interprets these signals, processes the information so that we perceive the erect image of the object.

Power of accommodation

The ability of the eye lens to adjust its focal length so as to see the objects located anywhere is called power of accommodation.

Looking at distant objects

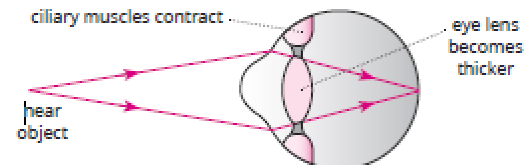
When the eye looks at a distant object, the ciliary muscles attached to the lens of the eye **relax** and the lens becomes **thinner**, i.e. less curved.



When less curved, the focal length of the eye lens **increases**. A sharp image of the distant object is formed at the retina. This enables us to see distant objects clearly.

Looking at nearby objects

When the eye looks at nearby objects, the ciliary muscles attached to the lens of the eye **contract** and the lens becomes **thicker**, i.e. more curved. When more curved, the focal length of the eye lens decreases. A sharp image of the nearby object is formed on the retina. This enables us to see nearby objects.



Near point of the eye: The minimum distance at which objects can be seen most clearly without strain is called the least distance of distinct vision. It is also called the near point of the eye. For a young adult with normal vision, the near point is about 25 cm.

Far point of the eye: The farthest point up to which the eye can see objects clearly without strain is called the far point of the eye. For a normal eye, the far point is at infinity. The distance between near point and far point of the eye is called the **range of vision**.

Advantages of two eyes for vision

1. A human being has a horizontal field of view of about 150° with one eye open. But with two eyes open, the horizontal field of view becomes 180° so that we see a much larger area in front of us (than can be seen with only one eye open).

2. Our two eyes are a few centimetres apart from each other. Due to this, the two eyes see the same object and form two slightly different images.

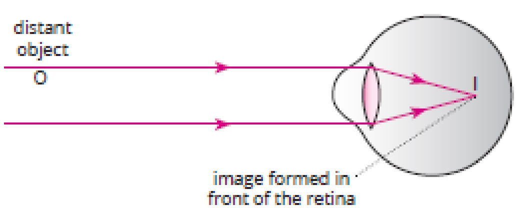
The brain combines these two images to build one three-dimensional picture of the object which enables us to know how close or far the object is more accurately. With one eye, the world would look flat and two-dimensional.

Defects of Vision and their Correction

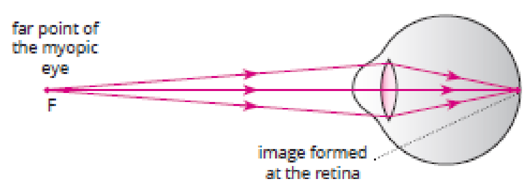
There are mainly three common refractive defects of vision. These are as follows:

Myopia (near-sightedness)

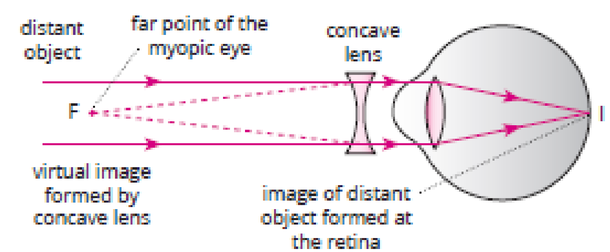
A person with myopia can see nearby objects clearly but cannot see distant objects distinctly. In a myopic eye, the image of the distant object O is formed **in front of the retina** and not at the retina itself. The myopic eye focuses rays from a point F on the retina. Thus, F is the far point of the myopic eye. To correct a myopic eye, the person has to use spectacles with a concave lens of suitable focal length. The concave lens forms a virtual image of the distant object at the far point F of the myopic eye.



Myopic eye



Far point of a Myopic eye

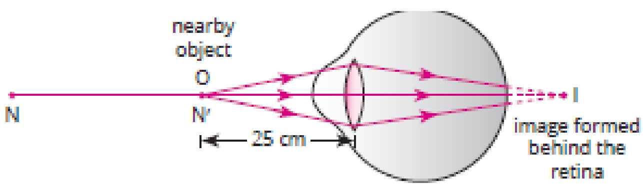


Correction for Myopic eye

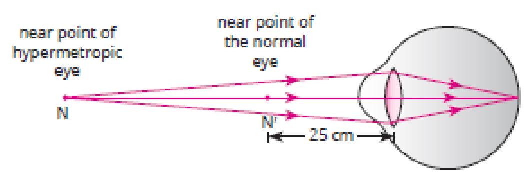
Small plants and animals living in sea which got buried in a similar manner under similar conditions are converted into **petroleum** and **natural gas**

Hypermetropia (far-sightedness)

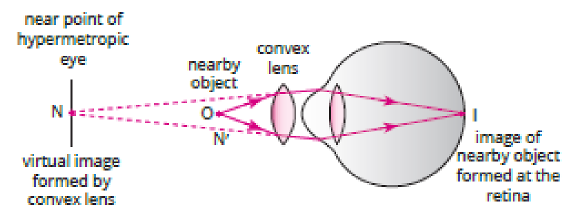
A person with hypermetropia can see distant objects clearly but cannot see nearby objects distinctly. In a hypermetropic eye, the image of the nearby object O placed at the normal near point N′ is formed behind the retina and not at the retina itself. To correct a hypermetropic eye, the person has to use spectacles with a convex lens of suitable focal length. The convex lens forms a virtual image of the nearby object at near point N of the hypermetropic eye.



Hypermetropic eye



Near point of a hypermetropic eye



Correction for a hypermetropic eye

Presbyopia (old sight)

As a person gets older, the ciliary muscles holding the eye lens weaken and the lens loses some of its elasticity. Therefore, the power of accommodation of the eye decreases with ageing. For most old people, the near point gradually recedes away. They find it difficult to see nearby objects comfortably and distinctly without corrective eye-glasses.

Dual eye defect

Sometimes, a person may suffer from both myopia and hypermetropia. In such case, one often requires **bifocal lenses**.

Cataract

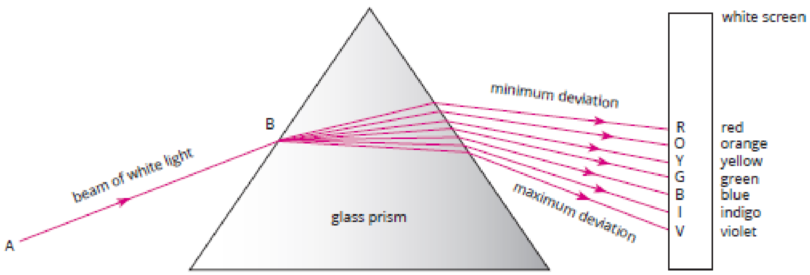
It is a defect of vision due to which an old person cannot see objects clearly due to progressive clouding of lens of the eye. Cataract occurs due to the formation of a white membrane over the eye-lens. It can even lead to total loss of vision if proper treatment (surgery) is not done in time.

Refraction of Light Through a Prism

A prism is a transparent refracting medium (glass) bounded by three plane surfaces making a triangle.

Dispersion of light

The phenomenon of splitting of white light into its component colours on passing through a glass prism is called dispersion of light. Different colours of light bend through different angles with respect to the incident ray as they pass through a prism.



A glass prism splits the white light into seven colours

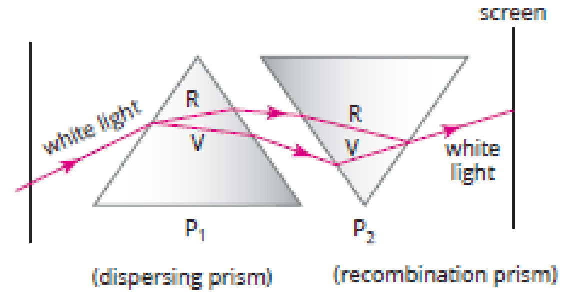
Recombination of spectrum colours to give white light

The first prism is called the dispersing prism. The second prism P2 recombined the seven constituent colours to form white light. Hence, this prism was called the **recombination prism**.

This experiment thus proved that

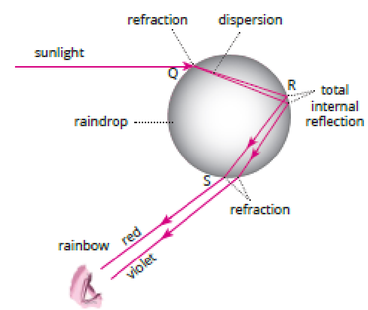
1. the prism by itself produces no colours.

2. the recombination of the seven constituent colours forms.



Formation of a rainbow

A rainbow is a natural spectrum of sunlight in the form of bows appearing in the sky when the sun shines on raindrops after a rain shower. It is formed due to the combined effect of dispersion, refraction and reflection of sunlight by tiny water droplets present in the atmosphere.



Atmospheric Refraction

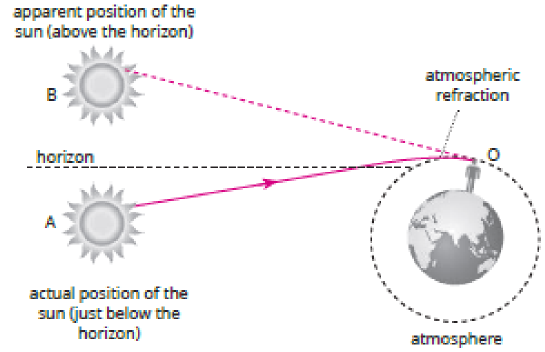
When the light rays pass through the atmosphere having layers of different densities and refractive indices, then refraction of light takes place. This refraction of light by the earth's atmosphere is called atmospheric refraction.

Twinkling of stars

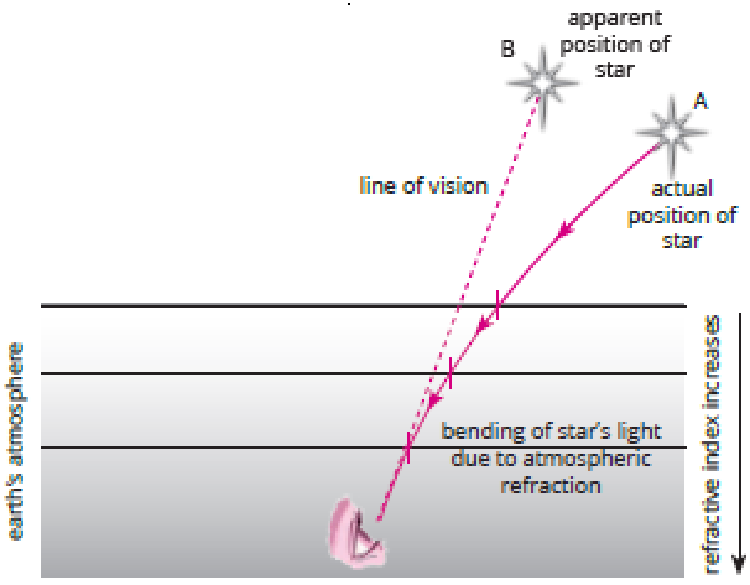
The twinkling of stars is due to atmospheric refraction of the light rays coming from them. Light ray from a star travels through the space unhindered. When it enters the earth's atmosphere, it undergoes refraction due to varying optical densities of air. The continuously changing atmosphere (due to varying atmospheric temperature and density) refracts the light from the stars by varying amounts and in different directions from one moment to the next.

Advance sunrise and delayed sunset

The sun is visible to us about two minutes before the actual sunrise and remains visible for about two minutes after the actual sunset because of atmospheric refraction.



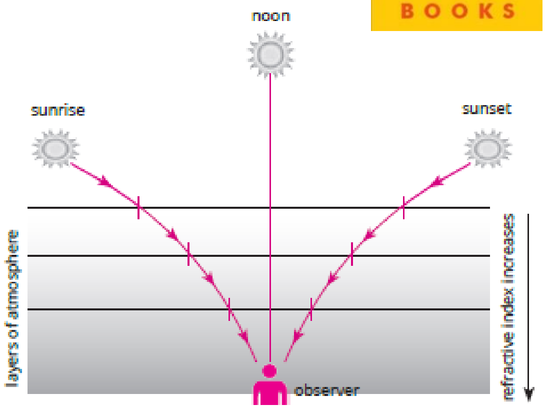
Effect of atmospheric refraction at sunrise



The stars seem higher than they actually are

The stars seem to be higher in the sky than they actually are due to atmospheric refraction (as explained in detail in the earlier example).

Sun appears oval shaped at sunrise and sunset (flattening of the sun)

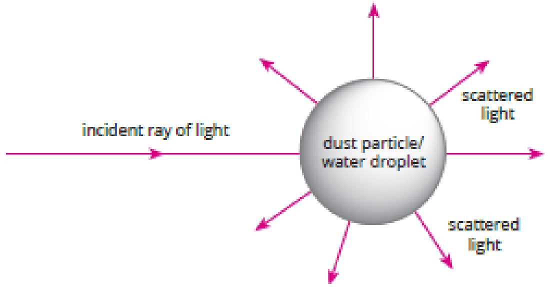


At sunrise and sunset, the sun is near the horizon. The refractive index of the layers of atmosphere decreases with height. The rays of light from lower edges of the sun are refracted more than those from the upper edges, due to passage through greater thickness of air.

Scattering of Light

We know that if light is passed through a colloidal solution placed in a dark room, the path of light beam through the colloidal solution becomes visible. The size of the colloidal particles is large. When a beam of light strikes such particles, they scatter the light falling on them in all the directions making the particles illuminated. This phenomenon is known as **Tyndall effect.**

Scattering of light is the phenomenon of change in the direction of light on striking particles like water droplets, dust particles, etc.



Some examples of Tyndall effect

1. Tyndall effect can be observed when sunlight passes through the canopy of a dense forest. Tiny water droplets in mist scatter light.

2. Tyndall effect can be observed when a fine beam of sunlight enters a smoke-filled room through a small hole. The smoke particles become visible due to the scattering of light by them.

3. The earth's atmosphere consists of a large number of particles like smoke, water droplets, dust particles, etc. When a beam of light strikes such particles, its path becomes visible due to the scattering of light by these particles.

Blue colour of the sky

The colour of clear sky looks blue due to scattering of light in the earth's atmosphere.

Sky would have looked dark if the earth had no atmosphere

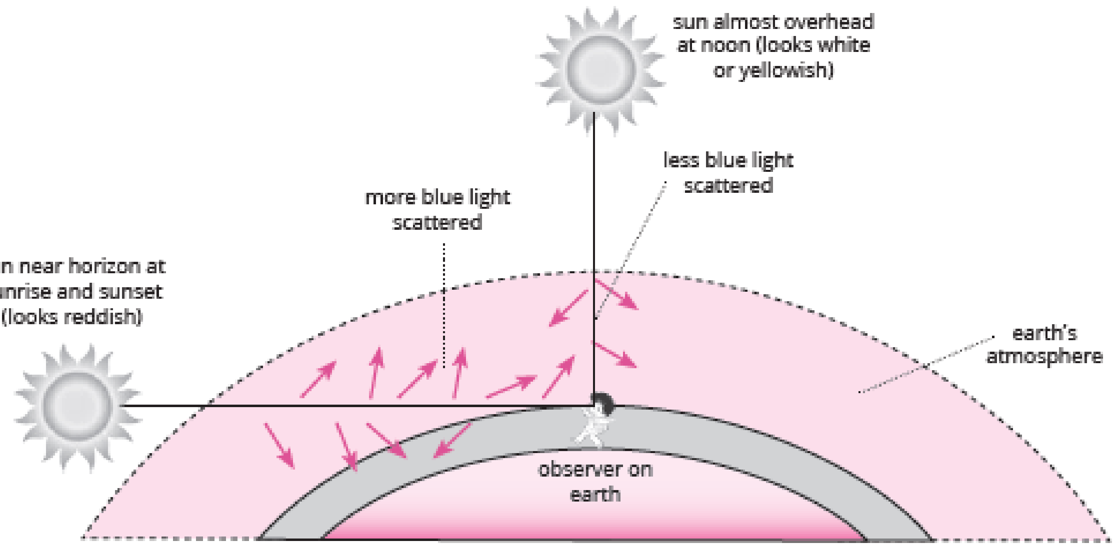
If the earth had no atmosphere, no particles would have been present either. Thus, no scattering of light would have taken place. Then, the sky would have appeared dark.

Sky appears dark to passengers flying at very high altitudes

We know as we move up to very high altitudes, the atmosphere becomes thinner. The particles present here are very less. So, scattering of light is not prominent at such heights. Thus, sky appears dark to passengers flying at very high altitudes. For similar reasons, the space appears dark to an astronaut from a spaceship as there is no scattering of light due to the lack of atmosphere.

Reddening of the sun at sunrise and sunset

At the time of sunrise and sunset, the sun is near the horizon. Light rays from the sun which are near the horizon have to pass through larger distance in the earth's atmosphere before reaching our eyes. Since the sunlight has to travel a large distance inside the earth's atmosphere, it passes through a large number of particles suspended in the air. Near the horizon, most of the blue light and other lights of shorter wavelengths (green, yellow) are scattered by these particles. The red light which has the largest wavelength is scattered the least. Among the colours of sunlight, the colour scattered the least, i.e. red colour enters our eye. This gives rise to reddish appearance of the sun, both at the time of sunrise and sunset



The sun appears yellowish

When sunlight passes through earth's atmosphere, the molecules of different gases and other finer particles present in the atmosphere scatter light of shorter wavelength like violet, indigo and blue. Although, violet and indigo lights are scattered more than blue light, our eyes are not very sensitive to both these colours. However, the white light gets deficient in violet, indigo and blue colours on account of scattering and the resultant sunlight appears yellowish instead of white. When this resultant yellowish sunlight enters our eyes, then to us sun appears yellowish instead of white. For similar reasons, the sunlight reaching the earth appears yellowish to us.

Danger signals are red

Among the colours of visible light, red colour has the largest wavelength and hence is the least scattered. Thus, red light can easily pass through fog, mist or smoke without getting scattered. It can be seen from a very long distance. That is why, red colour is used as universal danger signal.

Motorists use orange light on a foggy day rather than normal white light

On a foggy day, the air has a large amount of water droplets. If a motorist uses white light while driving in fog, then water droplets present in the air scatter large amount of blue light.

This on reaching our eyes decreases visibility and hence driving becomes extremely difficult. The orange light has longer wavelength and hence is less scattered. Thus, orange light can easily pass through fog without getting scattered and hence is visible from a longer distance. So, the driver can see ahead clearly. (Remember, red light is not permitted to be used by the motorist as it is the universal danger signal.)
For similar reasons, school buses are painted orange and rescue workers wear orange or yellow coloured suits during any rescue operations.

Smoke coming out of coal-fired chimney appears blue on a misty day

On a misty day, the air has large amount of water droplets and tiny particles of dust and smoke. These tiny particles present in the air scatter blue colour of the white light passing through it. When this scattered blue light reaches our eyes, the smoke appears blue. For similar reasons, distant hills covered with thick growth of trees appear blue and the smoke coming from an incense stick (*agarbatti*) appears blue on a misty day.

SUMMARY

1. Human eye: It is a light sensitive organ which enables us to see.

2. Sclerotic: It is the outermost covering of the eye. It protects the vital internal parts of the eye.

3. Iris: It regulates the amount of light entering the eye by adjusting the size of the pupil.

4. Eye lens: It is a double convex lens which focuses rays at different distances on the retina.

5. Retina: It is the innermost delicate membrane having a large number of light-sensitive cells called ‘rods’ and ‘cones’. The image is formed on the retina.

6. Power of accommodation: The ability of the eye lens to adjust its focal length so as to see the objects clearly located anywhere is called power of accommodation.

7. Near point of the eye: The minimum distance at which objects can be seen most clearly without straining the eyes is called the least distance of distinct vision or near point of the eye.

8. Far point of the eye: The farthest point up to which the eye can see objects clearly without strain is called far point of the eye. For a normal eye, the far point is at infinity.

9. Myopia or near-sightedness: A person with myopia can see nearby objects clearly but cannot see distant objects distinctly. It is caused by **a.** excessive curvature of the eye **b.** elongation or increase in size of the eye lens. It can be corrected by using spectacles with a concave lens of suitable focal length.

10. Hypermetropia or far-sightedness: A person with hypermetropia can see distant objects clearly but cannot see nearby objects distinctly. It is caused by **a.** increase in focal length of the eye lens **b.** shortening or decrease in size of the eye lens. It is corrected by using spectacles made from convex lenses of suitable focal lengths.

11. Presbyopia: Most of the old people suffer from long-sightedness. In this defect, the power of accommodation of the eye decreases with ageing.

12. Dispersion of light: The phenomenon of splitting of white light into its component colours on passing through a glass prism is called dispersion of light.

13. Spectrum: The band of colour components of a light beam obtained on a white screen when white light passes through a prism is called spectrum.

14. Rainbow: A rainbow is a natural spectrum of sunlight in the form of bows appearing in the sky when the sun shines on raindrops after a rain shower. The raindrops act like small prisms.

15. Atmospheric refraction: When light rays pass through the atmosphere having layers of different densities and refractive indices, then refraction of light takes place. This refraction of light by the earth's atmosphere is called atmospheric refraction.

16. Scattering of light: It is a phenomenon of change in the direction of light on striking a particle like water droplets, dust particles, etc. It explains the phenomenon like 'blue colour of the sky', 'reddening of the sun at sunrise and sunset', etc.