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The Human Eye And The Colourful World

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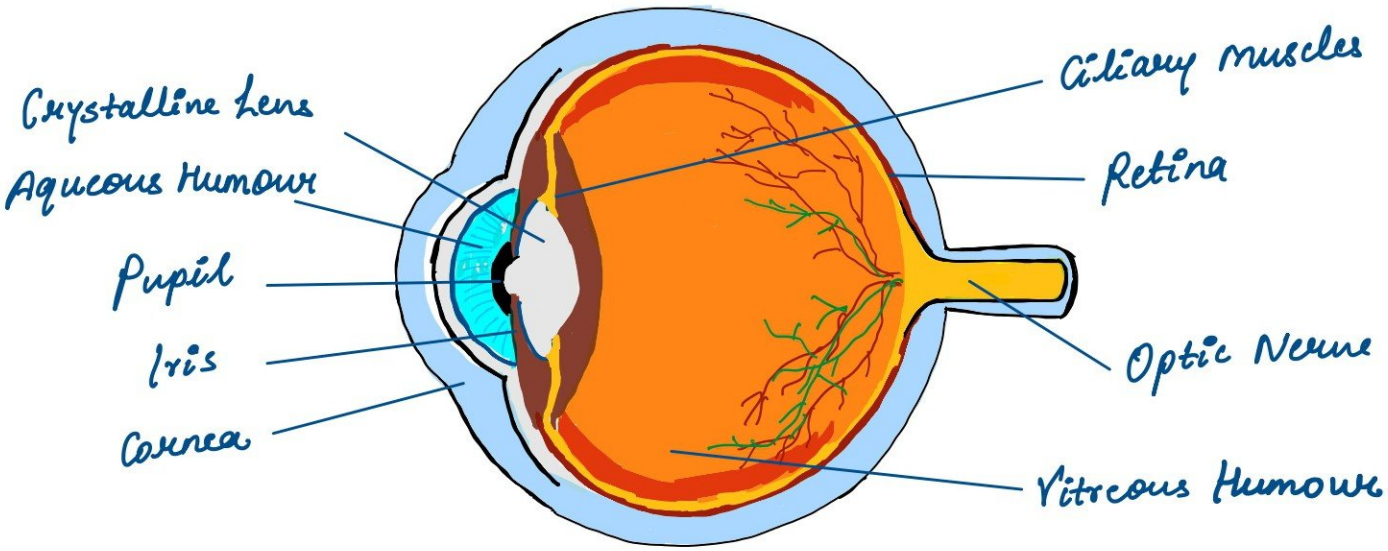
Human Eye



The eyes perform three function:

- It make adjustment to admit appropriate amount of light.
- It bends the rays of light to form a sharp image.
- It collects and sends information about the image to the brain for further "processing".

Parts of eyes and working

- The lens system forms an image on a light-sensitive screen called the **retina**.
- Light enters the eye through a membrane called the **cornea**.
- It forms the transparent bulge on the front surface of the eyeball.
- The **eyeballs** is approximately spherical in shape with a diameter of about 2.3 cm.
- Most of the refraction for the light rays entering the eye occurs at the outer surface of the cornea.
- The **Crystalline lens** merely provides the finer adjustment of focal length required to focus objects at different distance on the retina.
- **Iris** is a dark muscular diaphragm that controls the size of the pupil.
- The **pupil** regulates and controls the amount of light entering the eye.
- The eyes lens forms an inverted real Image of the object on the retina.
- The retina is a delicate membrane having enormous number of light Sensitive cells.
- The light Sensitive cells get activated upon illumination and generate electrical signals.
- These signals are sent to the brain via the optic nerve.

P.Y.Qs

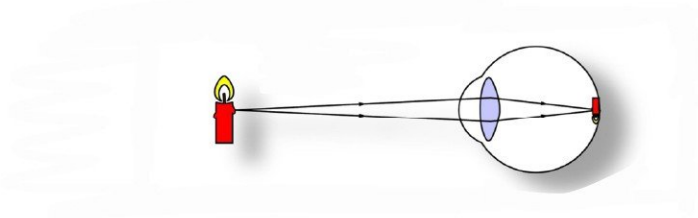
Question: Why we are not able to see objects clearly, when we enter from bright to dim lights.

Answer: The pupil of an eye acts like a variable aperture whose size can be varied with the help of the Iris. When the light is very bright, the Iris contracts the pupil to allow less light to enter the eye. However, in dim light the Iris expands the pupil to allow more light to enter the eye. Thus, the pupil opens completely through the relaxation of the Iris.

power of accomodation

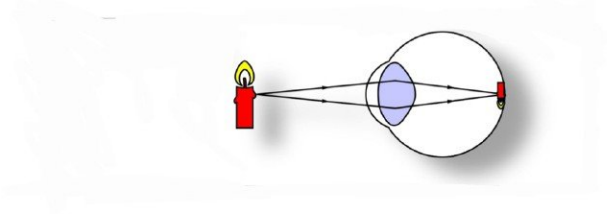
Accomodation is the process by which the eye change the focal length of the eye lens such that a Sharp image is always formed on the retina.

- The farthest point up to which the eye can see properly is called the **far point of the eye.**



When we are looking at a distant objects (usually farther than 6m) the ciliary muscles are in their most relaxed state. Then the focal length of the eye-lens is such that rays coming from the distant object are focused on the retina and we see the object clearly.

- The closest point at which an object can be placed and seen clearly is called the **near point of the eye.**



When we are looking at a nearby object the ciliary muscle contract to increase the curvature of the crystalline lens. The thickness of this lens increases, which decrease its focal length. The ciliary muscle adjust the focal length in such a manner that a sharp image is formed on the retina.

- Normal eye can see objects clearly that are between 25cm and infinity.

P.Y.Qs

Account for the following
(a) Part of the human eye that helps in changing the focal length of the eye lens.
(b) The condition resulting due to the eye lens becoming cloudy.
Answer: (a) Ciliary muscles helps in changing the focal length of the eye lens.
(b) Cataract: The crystalline lens of the eye is made of proteins that are arranged in a regular pattern, which make the lens transparent. When a group of these protein molecules get lumped in the region in the form of a membrane, they make the reason opaque. Gradually this membrane grows and the whole lens become opaque.

There are mainly three common refractive defect of vision:

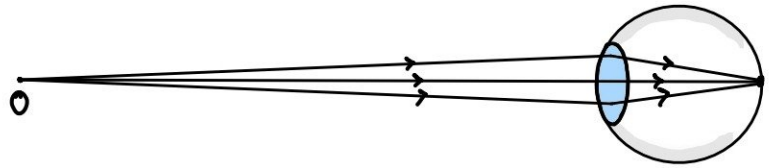
Myopia (Near Sightedness)

Near-sightedness is a defect of vision due to which a person is not able to see distant objects clearly. In myopia eye, the image of a distant object is formed in front of the retina and not at the retina.

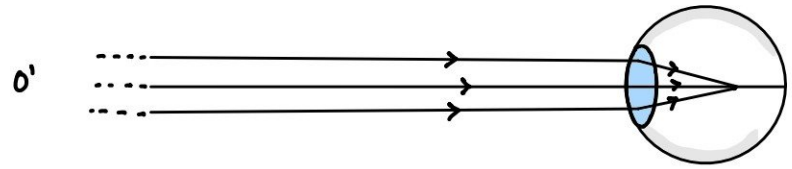
It is due to

- Excessive curvature of the eye lens.
- Elongation of the eyeball.

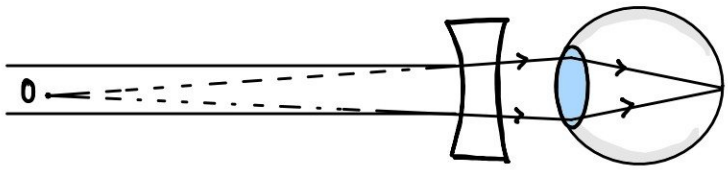
A concave lens of suitable power will bring the image back on to the retina, and thus the defect is corrected.



Far point of Myopic eye



Myopic eye



Correction for myopia

P.Y.Qs

Question: A person cannot see the objects distinctly, when placed beyond 2 m.
(a)Identify the eye defect.
(b)Give two reason for this defect.
(c) calculate the power and nature of the lens he should be using to see the distant object clearly.
Answer: (a) Myopia
(b) i)Either the eyeball is longer than normal or
ii)the maximum focal length (due to excessive curvature of the eye lens) of the lens is insufficient to produce a clearly formed image on the retina.
(c) $P=\frac{1}{f}=\frac{1}{-2}=-0.5\,D$

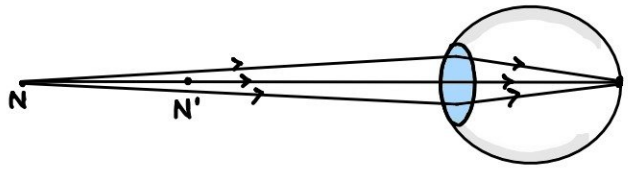
Hypermetropia (Far sightedness)

Far sightedness is a defect of vision due to which a person is not able to see nearby object clearly.
In hypermetropia, the Image of nearby object is formed behind the retina.

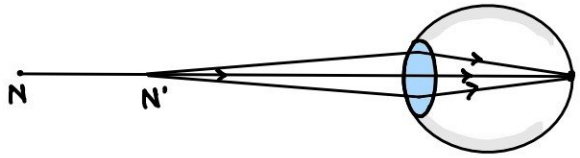
It is due to

- The focal length of the eye lens is too long.
- The eyeball has become to small.

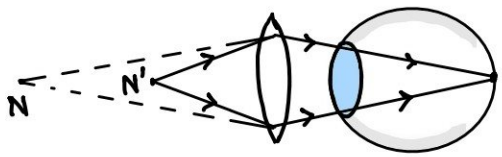
convex lens provide the additional focussing power required for forming the image on the retina.



Near point of a Hypermetropic eye



Hypermetropic eye



Correction for Hypermetropic eye

P.Y.Qs

Question: A person cannot see the objects distinctly, when placed at a distance less than 50cm.
(a)Identify the defect of vision.
(b)Give two reason for this defect.
(c) calculate the power and nature of the lens he should be using to see clearly the object placed at a distance of 25cm from his eyes.

Answer: (a) Hypermetropia
(b) i)Either the hyperopic eyeball is too short or
ii) the ciliary muscle is unable to change the shape of the lens enough to properly focus the image i.e, the focal length of the eye is too long.
(c) $P=\frac{1}{v}-\frac{1}{u}=\frac{100}{-50}-\frac{100}{-25}=-2+4=+2D$

Presbyopia

In old age, the ciliary muscle become weak and are not able to contract enough to decrease the focal length adequately. Objects at the normal near point are not focused on the retina. When far sightedness occur due to this reason, it is presbyopia.

It is due to

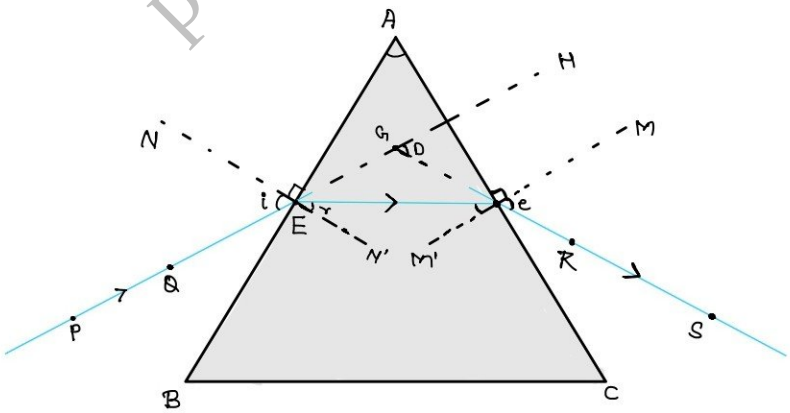
- Gradual weakening of the ciliary muscle.
- Diminishing flexibility of the eyes lens.

⇒ A person may suffer from both myopia and hypermetropia - they require bi-focal lens. (concave and convex lens).

=> To correct refractive defects

- Contact lenses
- Surgical intervention

Refraction of light through a prism

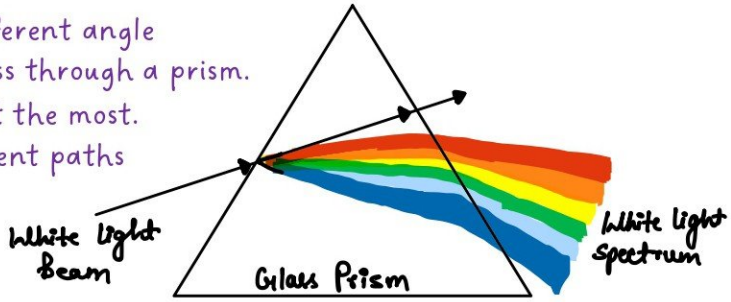


The peculiar shape of the prism makes the emergent ray bend at an angle to the direction of the incident ray. This angle is called the angle of deviation(S).

Dispersion of white light by a glass prism

- The prism has probably split the incident white light into a band of colours.
- The various colours seen are violet, Blue, Indigo, Blue, green, Yellow, Orange, Red. (VIBGYOR).
- The band of the coloured components of a light beam is called its spectrum.
- The splitting of light into its component colours is called dispersion.

- Different colours of light bend through different angle With respect to the Incident ray as they pass through a prism.
- The red light bends the least while the violet the most.
- The rays of each colour emerge along different paths and thus become distinct.



activity 11.1

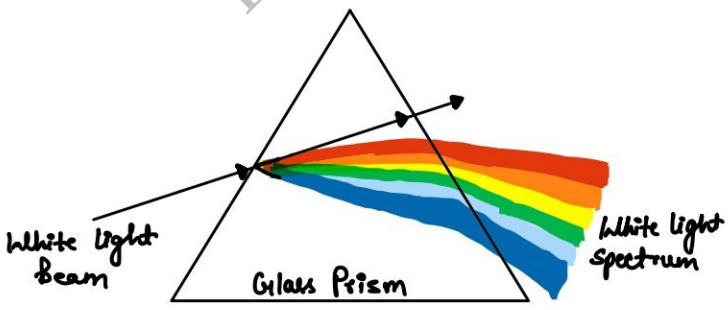
Answer: A light ray is entering from air to glass at the first surface AB. The light ray, on refraction, bends towards the normal. At the second surface AC, the light ray enters from glass to air. Hence it bends away from normal. Compare angle of incidence and angle of refraction at each refracting surface of the prism. The peculiar shape of the prism makes the emergent ray bend at an angle to the direction of the incident ray. This angle is called the angle of deviation (<D).

activity 11.2

Answer: The prism splits the incident white light into a band of 7 colours. They are Violet, Indigo, Blue, Green, Yellow, Orange and Red (VIBGYOR).
The splitting of light into its component colours is called dispersion.

P.Y.Qs

Question: (a) Demonstrate an activity with a well labelled diagram to prove that white light is made up of seven colours.
(b) Which colour of light bends least and which one the most while passing out from the prism. Also state the reason for the same.
Answer: (a) Take a thick sheet of cardboard and make a small hole or narrow slit in its middle. Allow sunlight to fall on the narrow slit. This gives a narrow beam of white light. Now, take a glass prism and allow the light from the slit to fall on one of its faces as shown in figure.



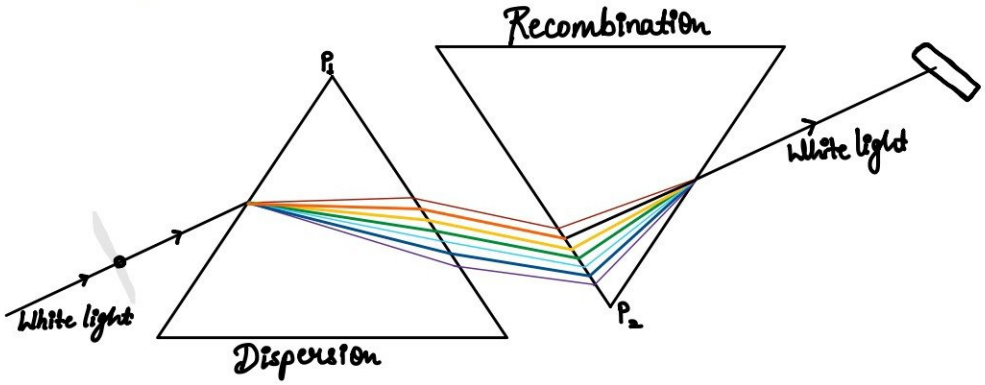
Turn the prism slowly until the light that comes out of it appears on a nearby screen. We will observe that sunlight has split into
seven colours. This shows that sunlight is made-up of seven colours.
(b) Red colour bends least while violet colour bends the most.
The different colours bend at different angles with respect to the incident ray due to refraction.

P.Y.Qs

Question: Explain with the help of a labelled diagram how can a combination of two prisms be used so that an incident white light emerge out of second prism as white light.
(b) Name the scientist who first performed this activity.

(c) Explain the term spectrum in brief.

Answer: (a) A prism P_1 in the path of white light disperses it into various colours. The red rays are deviated least and the violet rays are deviated most. The prism P_2 is placed on the right side with its refracting edge at the lower side. The second refracting surface of P_1 and the first refracting surface of P_2 are parallel. The dispersion produced by P_1 is now neutralised by P_2. The colours recombine in prism P_2 and a white image is seen on the screen.



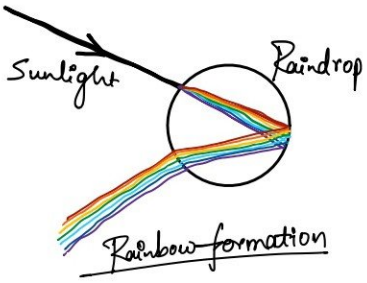
(b) Issac Newton

(C) Spectrum : It is the fan shaped beam or the band of the coloured components of light which come out of a prism when white light is made incident on it.

Rainbows

A rainbow is a natural spectrum appearing in the sky after a rain shower. It is caused by dispersion of Sunlight by tiny water droplets, pesent in the atmosphere.

A rainbow is always formed in a direction opposite to that of the Sun. The water droplet act like Small prison. They refract and disperse the incident sunlights, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colours reach the observers eye.

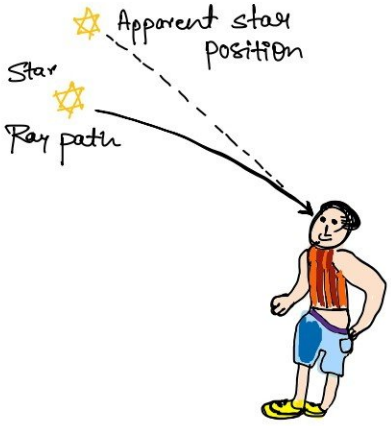


Atmospheric Refraction.

Twinkling of stars

The refractive index of air varies between different masses (or pockets) of air, even at the same altitudes. Thus, there exists air pockets whose refractive index is different from that of the air surrounding it.

When a ray of light passes through such a pocket of air, it bends due to refraction. Light from a Star may pass through one or more air pockets before reaching the eye. But the air pockets keep moving. So, the direction of the ray reaching the eye keeps changing, causing the image of the star to shift in random direction or even disappear for an instant. The amount of starlight reaching the eye also keeps changing due to the shift in the direction of the light. So, the brightness of the stars seems to change.



The star near the horizon twinkle more than those that are overhead. This is because light from a star near the horizon has to cover much more distance in the atmosphere than that from stars which are overhead. Therefore, it has greater Chances of encountering air pockets whose density is different from the Surrounding air.

P.Y.Qs

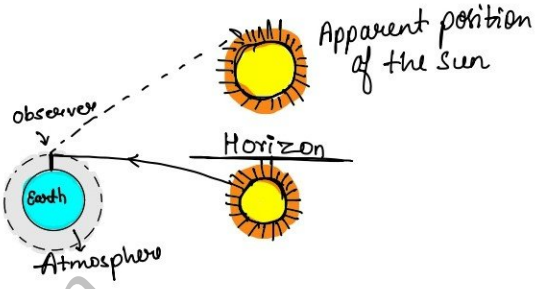
Question: Why don't the planet twinkle?

Answer: The planets are much closer to the earth, and are thus seen as entended Sources. If we consider a planet as a collection of a large number if point sized source of light, the total variation in the amount of light entering our eye from all the individual point Sized sources will average out to zero, thereby nullifying the twinkling effect.

P.Y.Qs

Question: Explain Advanced Sunrise and delayed Sunset.

Answer: By actual Sunrise, we mean the actual crossing of the horizon by the sun. The time difference between actual sunset and the apparent sunset is about 2 minutes. The apparent flattening of the Sun's disc at sunrise and sunset is also due to the same phenomenon.



Scattering of light

The phenomena in which a part of the light incident on a particle is redirected in different direction is called scattering of light.

Tyndall effect

The phenomena of scattering of light by the colloidal particles give rise to Tyndall effect. This phenomena is seen when a fine beam of sunlight enters a smoke filled room through a small hole. Thus scattering of light makes the particles visible. Tyndall effect can also be observed when sunlight passes through a canopy of a dense forest. Here, tiny water droplets in the mist scatter light.

P.Y.Qs

Question: Why is the colour of the clear sky Blue?

Answer: On a clear, sunny day, the Sky looks blue. Sunlight travelling through the atmosphere is scattered by the molecules of gases in the air, water droplets, dust particles and so on. of these, the smaller once (like gas molecule) is scatter more of the bluish light. When the scattered light reaches our eyes, it makes the sky look blue.

activity 11.3

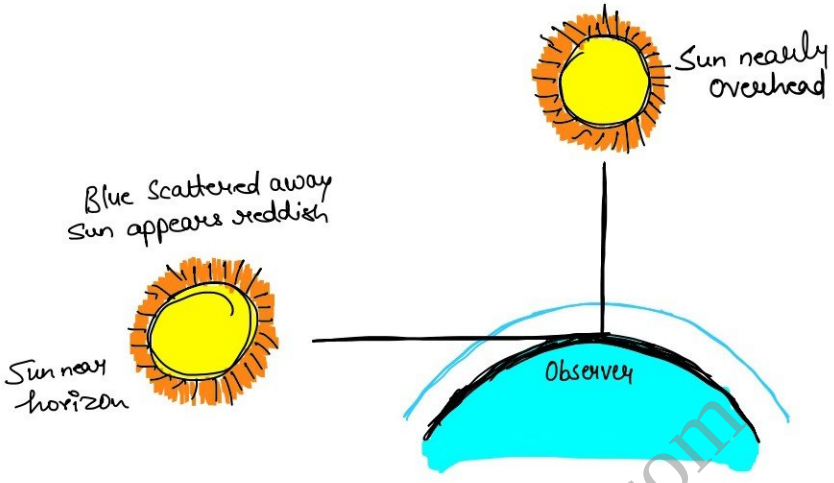
Answer: Fine microscopic sulphur particles precipitate in 2 - 3 minutes. As a result, blue light can be observed from the three sides of the glass tank. This is due to scattering of short wavelengths by colloidal sulphur particles.

Observe the colour of the transmitted light from the fourth side of the glass tank facing the circular hole. It is observed at first the orange red colour and then bright crimson red colour on the screen.

Colour of the Sun

At noon when the sun is directly overhead, the distance travelled by sunlight through the atmosphere is short as compared to other times.So, sunlight comes across lesser number of particles, resulting in lesser scattering. Thus, around, noon, the sun looks close to its actual colour i.e white.

At sunset or sunrise, sunlight has to travel a larger distance. So it comes across more number of particles which scatter mostly the bluish light. Thus, the light reaching our eyes has more of the reddish lights. This makes the sun look orange or red.



Examplar

Question: A student sitting on the last bench can read the letters written on the blackboard but is not able to read the letters written in his text book. Which of the following statements is correct?
(a) The near point of his eyes has receded away
(b) The near point of his eyes has come closer to him
(c) The far point of his eyes has come closer to him
(d) The far point of his eyes has receded away

Answer: (a) The near point of his eyes has receded away

Question: At noon the sun appears white as
(a) light is least scattered
(b) all the colours of the white light are scattered away
(c) blue colour is scattered the most
(d) red colour is scattered the most

Answer: (b) all the colours of the white light are scattered away

Question: Which of the following phenomena of light are involved in the formation of a rainbow?
(a) Reflection, refraction and dispersion
(b) Refraction, dispersion and total internal reflection
(c) Refraction, dispersion and internal reflection
(d) Dispersion, scattering and total internal reflection

Answer: (c) Refraction, dispersion and internal reflection

Question: Twinkling of stars is due to atmospheric
(a) dispersion of light by water droplets
(b) refraction of light by different layers of varying refractive indices
(c) scattering of light by dust particles
(d) internal reflection of light by clouds

Answer: (b) refraction of light by different layers of varying refractive indices

Question: Is the position of a star as seen by us its true position? Justify your answer.
Answer: Star light undergo continuous refraction on entering earth's atmosphere. Refraction occurs in a medium of gradually changing refractive index. Since the atmosphere bends starlight towards the normal, the apparent position of the star is slightly different from its actual position. The star appears slightly higher (above) than its actual position.

Question: Why do we see a rainbow in the sky only after rainfall?
Answer: Rainbow is caused by dispersion of sunlight by tiny water droplets, present in the atmosphere. A rainbow is always formed in a direction opposite to that of the Sun. The water droplets act like small prisms. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop.