HUMAN EYE AND COLOURFUL WORLD

INTRODUCTION OF EYES

INTRODUCTION

All of us have experienced how difficult it becomes when there is complete darkness and nothing can be seen! We are not talking about a scarymovie here but we are talking about vision which is facilitated by our Eyes.

We know EYES makes it possible to see all the beautiful things around us, but ever wondered how?

Why do some of you or your friends needs spectacles to see the black board in the class room or to read the book?

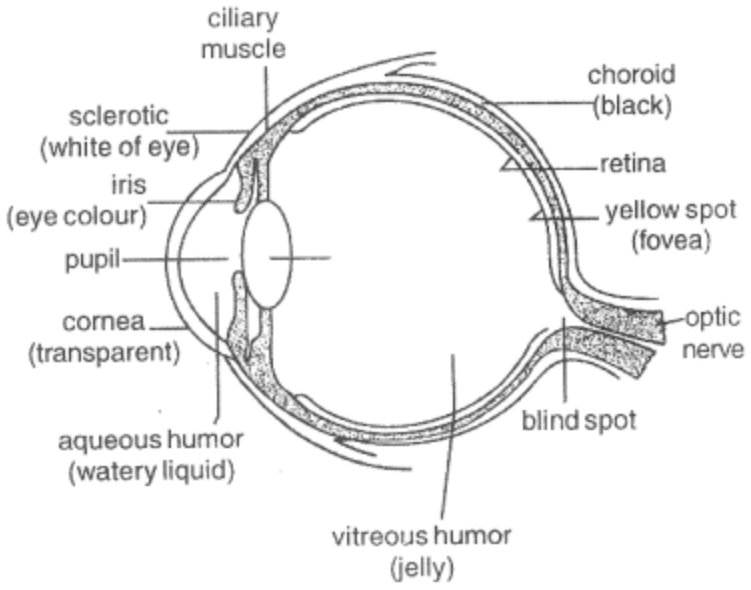
Why do we squint when someone suddenlyflashes a stronglight on our face? How can things look bigger when kept under a plane glass like magnifying lens?

Or how do we see various colours coming out of a pyramid shaped glass object called prism?

In this chapter we will try to find out all these answer and study one of the most sensitive organ of our body and how it works.

HUMAN EYE

Human eye is a natural optical instrument which gives the sensation of vision. It forms an inverted, real image ona light sensitive surface called **theretina**. The vertical section of the human eyes is an optical system is shown in the given diagram. The main parts of human eye are as follows.



1. Sclerotic :

It is the outer most covering of the eye. It consist of white tough fibrous tissues. Its function is to protect the internal parts of the eye.

2. Cornea : (Window to the World)

It allows the light to enter into the eye ball. The front of the eye is sharply curved and is made of hard transparent membrane, known as cornea. It is a thin membrane covering the surface of eye-ball through which lightenters. Maximum part of refraction occurs at cornea.

3. Vitreous Humor:

It is a dense, jellylike fluid, slight lygreyin colour, filling the posterior part of the eye ball. It has the following functions:

(a) It prevents the eye ball from collapsing, due to the changes in the atmospheric pressure.

(b) It partiallyhelps in focussing the image clearlyon the retina.

4. Aqueous Humor:

It is a watery, saline fluid, filling the anterior portion of the eye. It has the following functions. It prevents the anterior portion of the eye from collapsing, due to the changes in the atmospheric pressure.

When we wink our eyes, a tiny drop of the aqueous humor flowers out from the side

of the eye. Then it washes the eye and keeps the cornea moist. Otherwise, the cornea will shrivel and become opaque.

5. Iris:

Behind the cornea there is an opaque colored diaphragm known as iris. The color of the eye depends on the color of the iris. There is a circular hole in it, known as pupil. The action of iris is involuntary, so that, when radiating fibres contract, the pupil dilates.

The light entering the eye is adapted by the pupil. The pupil dilates or contract depending upon the amount of light available.

Its function is to control the amount of light entering the eye. This is achieved by the muscles present in the diaphragm. When the muscles contract, they increase the size of the pupil, thus allowing more light to enter the eye and vice versa.

6. Eye Lens:

The eye lens is double convex lens or (bi-convex) and made of transparent and flexible tissues. It is behind the pupil and held by the muscles called ciliary muscles.

It is a transparent, crystalline structure made up of many concentric layers. It is kept in its position by a strong elastic frame called the suspensory ligaments.

The eye -lens helps to divide the eye chamber into two parts. The front chamber between the cornea and the eye-lens is called the anterior chamber and isfilled with a fluidcalled the aqueous humor. Refractive index of aqueous humor is 1.337. The back chamber between the eye lens and the retina is called the posterior chamber and is filled with a jelly-like material called the vitreous humor. Refractive index of vitreous humor is also 1.337.

7. Ciliary Muscles:

These muscles settle the position of the eye lens. They also control the focal length of the eye lens. These muscles together with suspensoryligaments control position of the eye lens.

When these muscles contract, they decrease the focal length of the crystalline lens.

Similarly, when these muscles relax, theyincrease the focal length of the crystalline lens.

Its function is the alter the focal length of the crystalline lens, so that the image of the objects at various distances is clearly focussed on the retina.

8. Retina:

There is a thin delicate membrane made of optical nerve fibers which covers most of the interior part of the eye. This is known as retina. Optical nerve spread throughout, end in the form of rods and cones to form the retina .At the centre of retina, there is a yellow spot which is most sensitive to the light. The yellow spot is a patch of about 2 mm in diameter spread over the retina. The center of the yellow spot is slightly depressed and is a portion of about 0.25 mm diameter known as fovea centralis which contains onlycones.
The spot where the optic nerves enters into the retina, there is no rod or cone and so this spot is insensitive to light. This is known as blind spot.

Fovea is depression in the center of the macula that contains onlycones and constitutes the area of maximum visualacuity.

Macula :

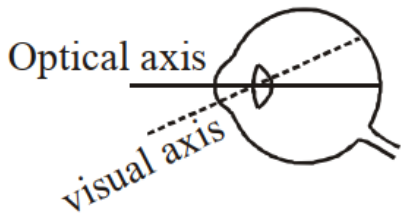
The macula is a very small area at the center of the retina. This is a thin layer of light Sensitive tissue that lies at the back of the eye.
The inside surface of the rear part of the eyeball where the light entering the eye is focussed is called retina. The surface of retina consists of about 125 million light - sensitive receptors. These receptors are of two types rods and cones shapes. When light falls on these receptors, they send electrical signals to the brain through optic nerve.

9. Choroid :

There is black membrane behind the retina composed of many blood vessels and lined internallywith pigment cells, knownas choroid. Its functionis to darken theeye from inside and hence, prevent anyinternal reflection.

10. Optical axis :

The optical axis is the most direct line through the centre of cornea to the pupil, the lens and the retina. This is the line that draws sharpest focus when we look at an object However this line inter sects the retina below the fovea and is not the most light and color sensitive image



11. Visual axis :

The visual axis draws a line from the center of the pupil to the fovea. This axis gives the best color vision but because it doesn't intersect the cornea and lens at their exact centers therefore image is not as clear as light passing through the optical axis.

Construction:

The eye is nearly spherical in shape having a diameter of about 25 mm (1 inch). The walls of eyeball consists of two major layers. The outer covering is known as sclerotic layer. It is a tough, opaque white substance. It forms the white of the eye. The front of this coating forms a curved section known as cornea. The cornea protects the eye and helps in refraction of light. The second layer also called the inner layer is known as the choroid. It is black to prevent internal reflection and protects the light-sensitive parts of the eye.

Working of the Eye:

The light rays coming from the object kept in front of us enter the pupil of the eye and fall on the eye lens. The eye-lens is a biconvex lens, so it converges the light rays and produces a real and inverted image of the object on the retina. The image formed on the retina is conveyed to the brain by the optic nerve and gives rise to the sensation of vision.

RODS AND CONES CELLS:

The cells on the retina are of two shapes :

rod-shaped and cone shaped. The rod cells of our retina respond to the intensity of light.

YELLOW SPOT:

The most sensitive point on the retina is called the yellow spot. It is situated at the centre of the retina and is lightly raised. It has a little depression called fovea-centralis, whichis extremely sensitive to light. Its function is to for man extremely clear image.

BLIND SPOT:

The least sensitive point is known as the blind spot. There are no rods and cones at the point where optic nerves leave the eyeball to go to the brain.

Colour perception ofAnimals :

Different animals have different colour perception due to different structure of rod shaped cells and cone shaped cells. For example, bees have some cone-shaped cells that are sensitive to ultraviolet. Therefore bees can see objects in ultraviolet light and can perceive colors which we cannot do. Human beings cannot see in ultraviolet light as their retina do not have cone-shaped cells the tare sensitive to ultra violet light.

The retina of chicks have mostly cone shaped cells and onlya few rod shaped cells. As rod shaped cells are sensitive to bright light only therefore, chicks wake up with sunrise and sleep in their resting place by the sunset.

Visual impairment

means that the eye does not work properly. Visual impairment occurs when any part of an eye involved in the transmission of light like cornea, pupil, eye lens, vitreous humor or the part of eye responsible for the conversion of light into electrical impulse or signal like retina of the part of eye responsible for carrying electrical impulses to the brain like optic nerve is damaged.

What happens when we enter a dim lit room from the region of very bright light?

When we enter a room with dim – light from the region of verybright light, we do not see anything in the room. This is because of the following facts. In a verybright light, the iris contracts the pupil so that less light enter the eye. When we enter the dim – light room, the iris takes some time to expand the pupil or increase the size of the pupil so that more light

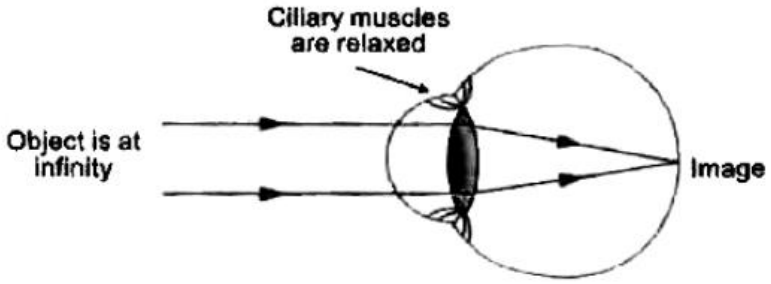
enters the eye to make the things in the room visible.

Accommodation of an eye:

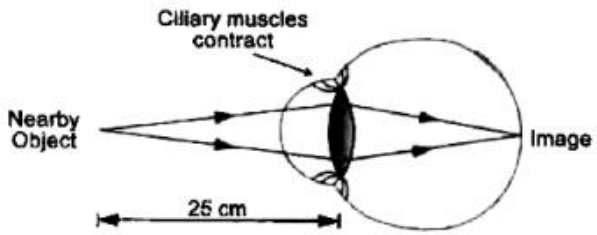
Anormal eye can see the near and far off objects clearlyif the sharp images of these objects are formed on the retina. Since the distance between the eye lens and retina is fixed (i.e v = constant), so to see the object different position from the eye lens the focal length of the lens has to be changed accordingly to form the sharp images of these objects.

$-\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$

If the object to be seen is far off(i.e. at infinity), then the sharp image of this object can before med on the retina of the eye by increasing the focal length of the eye lens.
The focal length of a lens increases if its thickness decreases. Thus, to decrease the thickness of the eye lens and hence to increase its focal length, ciliary muscles are completely relaxed. Now the parallel beam of light coming from the far off object is focussed on the retina and hence the object is seen clearly.



If the object to be seen is close to the eye i.e., near the eye, then the sharp image of this object can be formed on the retina of the eye by decreasing the focal length of the eye lens. The focal length of a lens decreases if its thickness increases. Thus to increase the thickness of the eye lens and hence to decrease its focal length, ciliary muscles contract. Now the beam of light coming from the near object is focused by the lens on the retina. Hence the object is seen clearly (Figure)



Conclusion:

Thus, we observe that the focal length of the eye lens is adjusted automatically by the action of ciliary muscles such that a sharp image of the object at different positions from the eye are formed on the retina. This process is known as accommodation of an eye.

Least distance of distinct vision for a normal eye of different age groups.

Babies = 7 cm

Adult = 25 cm

Person of age 55 years and above = 100 cm.

However in our discussion we are concerned with a normal eye of an adult so least distance of distinct vision is taken as 25 cm.

Power of Accommodation:

For a normal eye, the near point is 25 cm from the eye lens i.e. u = –25 cm.

The distance of the retina (screen) from the eye lens is about 2.5 cm i.e., v = 2.5 cm. Now using

$$\frac{1}{f}=-\frac{1}{u}+\frac{1}{v}$$

We get

$$\frac{1}{f}=-\frac{1}{(-25)}+\frac{1}{2.5}$$

$$=\frac{1}{f}=\frac{1}{25}+\frac{1}{2.5}=\frac{1}{25}cm^{-1}$$

Power of eye lence $p=\frac{100}{f\,(in\ cm)}=100\times\frac{11}{25}=44D$

The far point of the normal eye is at infinity i.e., u = – ∞, Since image is formed at the retina, so v = 2.5 cm

$$\frac{1}{f} = -\frac{1}{u} + \frac{1}{v} = \frac{10}{25} cm^{-1}$$

Hence, power of eye - lens, $p = \frac{100}{f} = 100 \times \frac{10}{25} = 40D$

Thus we find that the maximum variation in the power of eye lens = 44 D – 40 D = 4D

Therefore, for a normal eye, the power of accommodation is about 4 diopter (D)

1 Advantage of Having Two Eyes in Humans

1. A single human eye has a horizontal field of view of 150°. However, with two eyes, separated by few centimeters, the horizontal field of view increases to 180°. Furthermore, the ability to detect faint objects is enhanced with two eyes.
2. The two eyes separated byfew centimeters, in the front portion of head, no doubt limits the field of view to 180°. However, this position ingincreases our ability to judge the depth,a phenomenon called sterops is.

With one eye, the world is two dimensional and flat, much the same, as you see images or television screen or a movie. With both eyes open, the world takes on a third dimension of depth. As our eyes are separated by few centimeters, each eye receives an image which is slightly different. When our brain combines these images into one, the sensation of depth is produced. Here, it is interesting to note that most of the animals and birds have two eyes, placed almost diametrically on the irhead .Thus,animalsorbirdshavealmost360°view.However,theydonothavesensation of depth.

ACCOMMODATION OFEYE

The process by which the ciliary muscles alter the focal length of the crystalline lens, so as to focus nearer or far-off objects clearly on the retina is called the accommodation of the eye.

POWER OFACCOMMODATION

The human eye in its normal condition, can enable us to see objects from a nearby distance D up to objects at far off or ‘infinite distance’. This becomes possible because of the ability of the ciliary muscles to alter the focal length of the eye lens and thus make it bring into sharp focus the images of objects at varying distances right on the retina. We call this ability a ‘power’ of the eye or its power of accommodation.

NEAR POINTAND FAR POINT

There is a limit to the power of accommodation of the eye. Anormal eye can see any object which is at a distance of 25 cm to in finity by using its power of accommodation. The point nearest to the eye at which an object is visible distinctly is called the near point of the eye. It is 25 cm for a normal eye. The maximum distance up to which the normal eye can see the things clearly is called the far point of the eye. It is infinity for a normal eye.

RANGE OF VISION

The distance between the near point and far point of an eye is known as range of vision. For a normal eye, the range of vision is 25 cm to infinity.

PERSISTENCE OF VISION

The image formed on the retina of the eye does not fade away in stantaneously, when the object is removed from the sight. The impression (or sensation) of the object remains on the retina for about (1/16)th of a second, even after the object is removed from the sight. This continuance of the sensation of eye is called the persistence of vision.

Let a sequence of still pictures be taken by a moving camera. If the sequence of these still pictures is projected on a screen at a rate of 24 images or more per second then the successive impressions of the image on the screen appear to blend or an image (or a scene) on the screen appears just before the impression of previous image on the retina is lost. Hence, the sequence of images blend into one another giving the impression of a moving picture. This principle is use din motion picture projectionor in cinematography.

Ex. How does the change in curvature of the eye lens help us to see the distant as well as nearer objects clearly?

Sol. When we have to see the distant objects, the ciliary muscles relax and thus the eye lens become thin, resulting in a larger focal length. On the other hand, to see the nearby objects, the ciliary muscles contract thus making the eye lens thicker in the centre. This decreases the focal length of the eye lens, thus making it possible to see the nearby object clearly.

1. In a prism:

(A) rays deviate towards the base of the prism.

(B) rays deviate away from the base of the prism.

(C) rays are reflected internally toward the vertex of the prism.

(D) rays are diffracted around the prism.

2. Dispersionis:

(A) bending of light toward the normal when it enters from a rarer medium to denser medium.

(B) splitting of light into its component colours when it passes through a prism.

(C) redistribution of energy of a beam of light when it passes through a slit.

(D) bending of light around an obstacle when the size of the obstacle is comparable to the wavelength of the light.