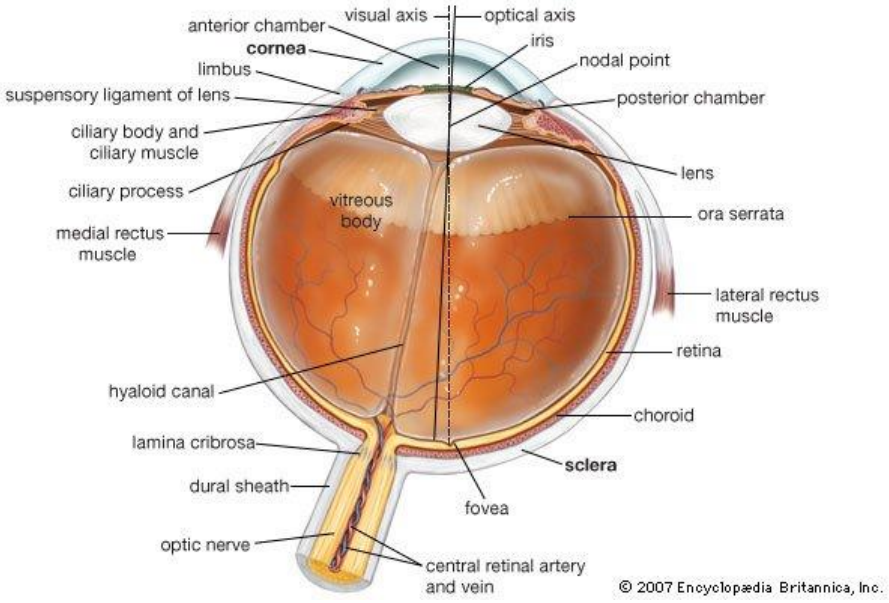
# The Human Eye




**Human eye**, in humans, specialized sense organ capable of receiving visual images, which are then carried to the brain. He human eye is the gateway to one of our five senses. The human eye is an organ that reacts with light. It allows light perception, color vision and depth perception. A normal human eye can see about 10 million different colors! There are many parts of a human eye, and that is what we are going to cover in this atom.

1. Outermost Layer – composed of the cornea and the sclera.
2. Middle Layer – composed of the choroid, ciliary body and iris.
3. Innermost Layer – the retina, which can be seen with an instrument called the ophthalmoscope.

## The retina

The retina is the part of the eye that receives the light and converts it into chemical energy. The chemical energy activates nerves that conduct the messages out of the eye into the higher regions of the brain. The retina is a complex nervous structure, being, in essence, an outgrowth of the forebrain.

Ten layers of cells in the retina can be seen microscopically. In general, there are four main layers: (1) Next to the choroid is the pigment epithelium, already mentioned. (2) Above the epithelium is the layer of rods and cones, the light-sensitive cells. The changes induced in the rods and cones by light are transmitted to (3) a layer of neurons (nerve cells) called the bipolar cells. These bipolar cells connect with (4) the innermost layer of neurons, the ganglion cells; and the transmitted messages are carried out of the eye along their projections, or axons, which constitute the optic

nerve fibres. Thus, the optic nerve is really a central tract, rather than a nerve, connecting two regions of the nervous system, namely, the layer of bipolar cells, and the cells of the lateral geniculate body, the latter being a visual relay station in the diencephalon (the rear portion of the forebrain).

## Cornea

The front transparent part of the sclera is called cornea. Light enters the eye through the cornea. The cornea is your eye's clear, protective outer layer. Along with the sclera (the white of your eye), it serves as a barrier against dirt, germs, and other things that can cause damage. It also plays a key role in vision. As light enters your eye, it gets refracted, or bent, by the cornea's curved edge. This helps determine how well your eye can focus on objects close-up and far away.

## Pupil & Iris

- **Iris:** A dark muscular tissue and ring-like structure behind the cornea is known as the iris. The colour of the iris actually indicates the colour of the eye. The iris also helps regulate or adjust exposure by adjusting the iris.
- **Pupil:** A small opening in the iris is known as a pupil. Its size is controlled by the help of iris. It controls the amount of light that enters the eye.

| Iris | Pupil |
|---|---|
| The iris is the ring-shaped membrane inside the eye. | The pupil is the black hole or opening present in the center of the iris. |
| It surrounds an opening in the center called the pupil. | It is surrounded by the tissues of iris. |
| It regulates the amount of light to enter the eye. | It is the opening through which the light enters our eye. |
| It contains the muscles that contract when the light is bright and relaxes when the light is low. | As it is a hole it does not contain any kind of tissue. |
| It determines the color of our eye. | It is not responsible for determining the color of our eye. |
| It is a curtain-like patch of tissues in our eye. | It is like a gap between the two curtains like a patch of tissues in our eye. |
| The amount of light reaching the retina of our eye is controlled by the iris. | It allows the light to strike the retina. |

## Near point of Distant Vision

- The near point is the nearest point within the eye's accommodation range at which an object can be positioned and still form a focused image on the retina.
- The far point is the limit to the eye's accommodation range.
- The near point of the eye is the minimum distance of the object from the eye, which can be seen distinctly without strain. For a normal human eye, this distance is 25 cm.

- Far point

- The far point of visual perception is the farthest point from which an object's image can be projected to the retina within the eye's accommodation.
- It's often referred to as the image's clearest point away from the eye. The near point is the other limit of eye accommodation.
- The far point of the eye is the maximum distance at which the eye can see the objects clearly. The far point of the normal human eye is infinity.

# Myopia

Myopia is an eye defect or common abnormality of the eye in which the near vision is clear while distant vision is blurred. This condition is known as myopia also it is called as near or short-sightedness.
Retina is that part of the eye which provides a surface for image formation. In myopia what happens is light rays entering the eyes converge too soon and are brought to focus before reaching the retina hence the image cannot be formed on the retina.

### Myopia Causes

This eye defect called as myopia can be caused basically due to the defected eye structure.
Structure of eye causing myopia can have two defects:

- The eye lens becomes too convex or curved
- Depth of the eyeball is too much i.e. eyeball lengthened from front to back. When the length of the eyeball is too long as compared to the focusing power of the lens of the eye and cornea. Because of this, the light rays focus at a point in front of the retina and not on the retina itself.

### Myopia Correction

Myopia isn't a very complex disability. It can be corrected easily by wearing concave lenses. Concave lenses because parallel rays of light to diverge before they converge and focus on the retina.

# Hypermetropia

Hypermetropia is also referred to as hyperopia or long-sightedness or far-sightedness.
Hypermetropia is the condition of the eyes where the image of a nearby object is formed behind the retina. Here, the light is focused behind the retina instead of focusing on the retina.

The person suffering from hypermetropia will have difficulty in focusing on nearby objects, but can clearly see distant objects. Accommodation is the process used to treat hypermetropia without any defects in vision in the early stages.

Hypermetropia is mainly caused due to certain structural defects in the retina. Structural defects include:

- Small-sized eye-ball
- Non-circular lenses

- The cornea is flatter than usual
- Defective blood vessels in the retina
- Weakness in ciliary muscle
- Changes in the refractive index of the lens
- Alterations in the position of the lens or absence of lens
- Low converging power of eye lens

Risk factors include:

- Cancer around the eye
- Some medications
- Diabetes
- Small eye syndrome (microphthalmia)

### Symptoms

This problem shows no major symptoms initially but later leads to a mild aversion to light, blurry vision, watering, tiredness in eyes, inward turning of the eyes and causes headaches too.

### Treatment

- Usage of proper corrective lenses and spectacles as prescribed by the ophthalmologist can help to overcome Low Hypermetropia.
- High degree hypermetropia is corrected using intraocular lens implantation.
- Surgery like LASIK (Laser-Assisted In situ Keratomileusis) Laser eye surgery, PRK (Photo-Refractive Keratectomy) and LASEK (Laser Subepithelial Keratomileusis).

## Presbyopia

- Presbyopia is a common defect of vision, which generally occurs at old age. A person suffering from this type of defect of vision cannot see nearby objects clearly and distinctively. A presbyopic eye has its near point greater than 25 cm and it gradually increases as the eye becomes older.
- Presbyopia is caused by the :
  1. weakening of the ciliary muscles
  2. reduction in the flexibility of the eye lens
- A person with presbyopia cannot read letters without spectacles. It may also happen that a person suffers from both myopia and hypermetropia. This type of defect can be corrected by using bi-focal lenses. A bifocal lens consists of both convex lens (to correct hypermetropia) and concave lens (to correct myopia).

## Astigmatism

Astigmatism: It is a defect of vision in which a person cannot simultaneously see both the horizontal and vertical views of an object with the same clarity.

Cause of astigmatism: This defect occurs when the cornea of the eye is not perfectly spherical. This results in objects in one direction being well focussed while those in perpendicular direction are not well focussed.

Correction of astigmatism: Astigmatism can be corrected by using cylindrical lenses. They have different curvatures in horizontal and vertical directions and so they can be oriented suitably to compensate for the irregularities in the cornea

## Microscope

### Microscope

- Microscope is an instrument that gives an enlarged image of minute object.

- There are 2 types of microscope:-
  - Simple
  - Compound

### Simple Microscope

- An instrument that gives an enlarged image of a minute object.

- A simple magnifier or microscope is a converging lens of small focal length.
- There are 2 types of Microscopes:-

1. Simple Microscope 2. Compound Microscope

Simple Microscope

- The lens is held near the object, one focal length away or less, and the eye is positioned close to the lens on the other side.
- Image which we will get is an erect, magnified and virtual image of the object at a distance so that it can be viewed comfortably, i.e., at 25 cm or more.

To Increase Magnifying Power of Simple Microscope

- If the object is at a distance f, the image is at infinity. However, if the object is at a distance slightly less than the focal length of the lens, the image is virtual and closer than infinity.

- Although the closest comfortable distance for viewing the image is when it is at the near point (distance

D ≅ 25 cm), it causes some strain on the eye.

- Therefore, the image formed at infinity is often considered most suitable for viewing by the relaxed eye.

- The linear magnification m, for the image formed at the near point D, by a simple microscope can be obtained by using the relation:-
  - $m=(v/u) = v((1/v)-(1/f))$
  - $=(1- (v/f))$
  - Using the sign conventions, v= (-) ive and same as D.
- Therefore, magnification will be $m =(1 +(D/f))$
- Since D is about 25 cm, to have a magnification of six, one needs a convex lens of focal length, f = 5 cm.
- Magnification when the image is at infinity.
  - Suppose the object has a height h. The maximum angle it can subtend, and be clearly visible (without a lens), is when it is at the near point, i.e., a distance D.
  - The angle subtended is then given by:-
  - $\tan \theta_0 =(h/D)\approx \theta_0$
  - To find the angle subtended at the eye by the image when the object is at u.
  - Therefore, $(h'/h) = m = (v/u)$
  - Angle subtended by the image will be;-
  - $\tan \theta_i= (h'/-v) = (h/-v) \times (v/u)$
  - $= (h/-u) \approx \theta$.
  - The angle subtended by the object, when it is at u=-f.
  - $\theta_i =(h/f)$.
  - The angular magnification is $m =( \theta_i/ \theta_0) =(D/f)$

**Compound Microscope**

- In order to have large magnifications compound microscope is used.
- The lens nearest the object, called the objective, forms a real, inverted, magnified image of the object. This serves as the object for the second

lens, the eyepiece, which functions essentially like a simple microscope or magnifier, produces the final image, which is enlarged and virtual.

- The first inverted image is thus near (at or within) the focal plane of the eyepiece, at a distance appropriate for final image formation at infinity, or a little closer for image formation at the near point.
- Clearly, the final image is inverted with respect to the original object.
- Using $\tan\beta = (h/f_0) = (h'/L)$
- Magnification ($m_o$) due to objective = $(h'/h) = (L/f_0)$
  - Where h' = size of the first image
  - h= size of the object
  - $f_o$ = focal length of the objective lens
  - $f_e$= focal length of the eye-piece
  - L (tube length) = Distance between focal length of the second objective lens and the first focal length of the eye-piece.
- When the final image is formed at the near point, then the angular magnification will be :-
- $m_e=(1+(D/f_e))$
- When the final image is formed at infinity, the angular magnification due to the eyepiece is:-
- $m_e = (D/f_e)$
- Total magnification will be given as:-
- $m=(m_o m_e) =(L/f_0)(D/f_e)$

## Telescope

### Telescope

- An instrument used to view distant objects clearly.
- It consists of:- (a) Objective lens (b) Eyepiece

Working of Telescope

- The telescope is used to provide angular magnification of distant objects. The objective has a large focal length and a much larger aperture than the eyepiece because object is very far away.
- Light from a distant object enters the objective and a real and inverted image is formed at its second focal point.
- This image acts as an object for the eyepiece; it magnifies this image producing a final inverted image.

Magnification

- The magnifying power m is the ratio of the angle β subtended at the eye by the final image to the angle α which the object subtends at the lens or the eye.
- Therefore, $m \approx (\beta / \alpha) \approx (h/f_e) \times (f_o/h) = (f_o/h)$.
- In this case, the length of the telescope tube is $(f_o + f_e)$.
- In addition, a pair of inverting lenses to make the final image erect.
- Refracting telescopes can be used both for terrestrial and astronomical observations.