Al-Mustaqbal University

Department (Biomedical Engineering)

Class (Third Stage)

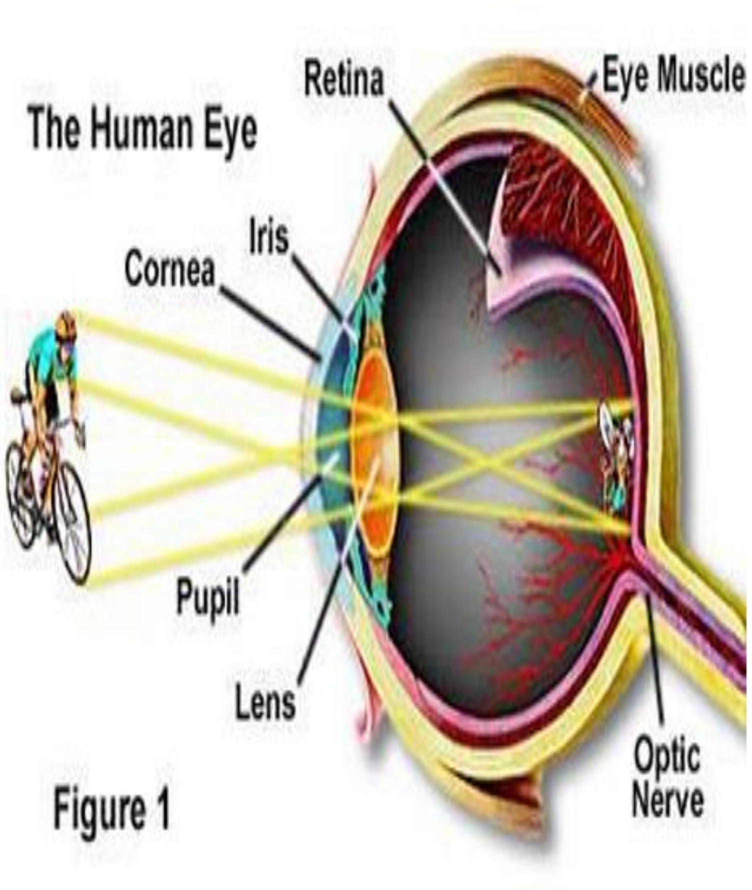
Subject (Medical Optics)

Lecturer (Asst.lec.Hiba Diaa Alrubaie)

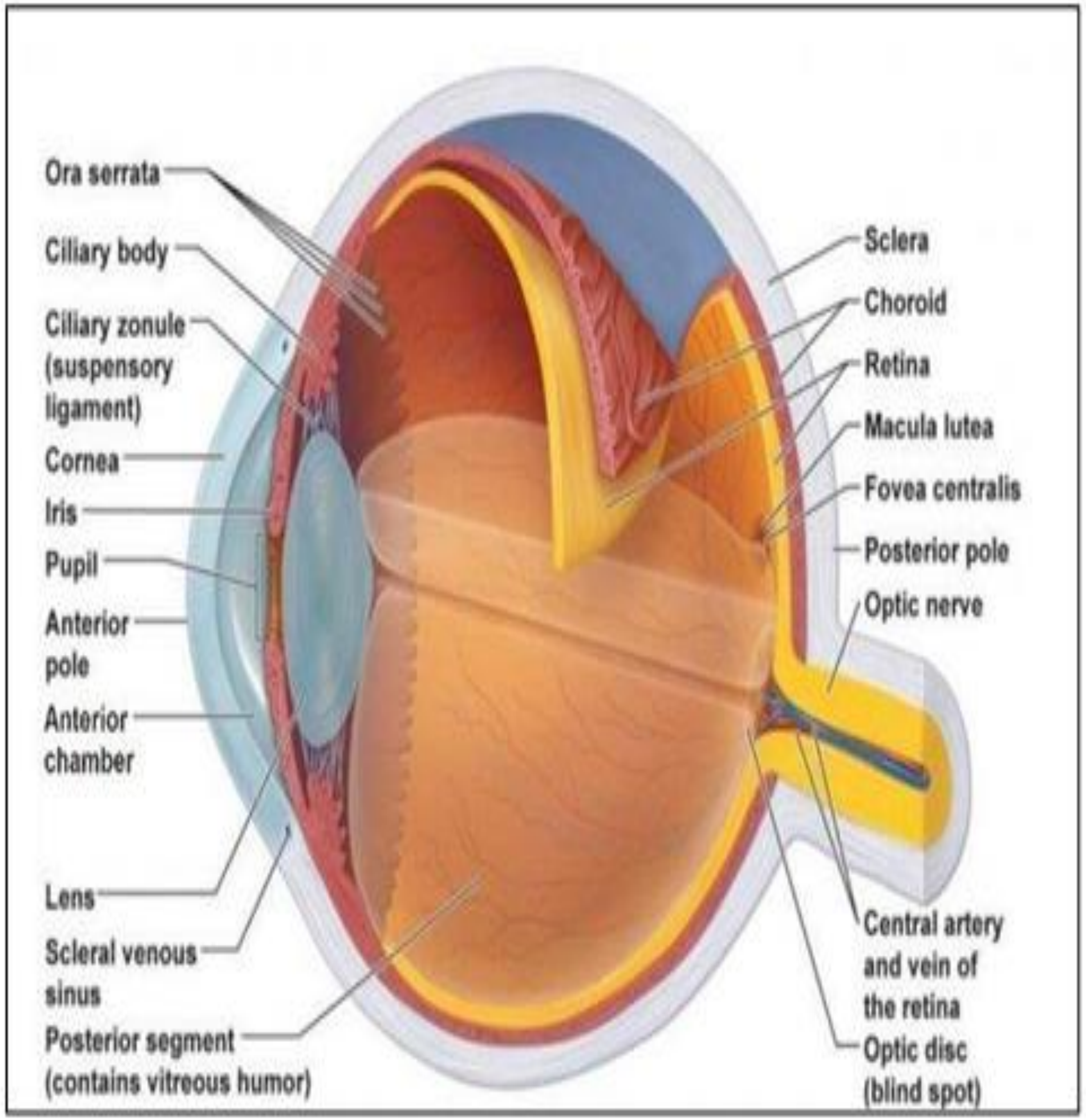
1st/3rd term – Lect. (Eye Vision)

How The Eyes Sense Light

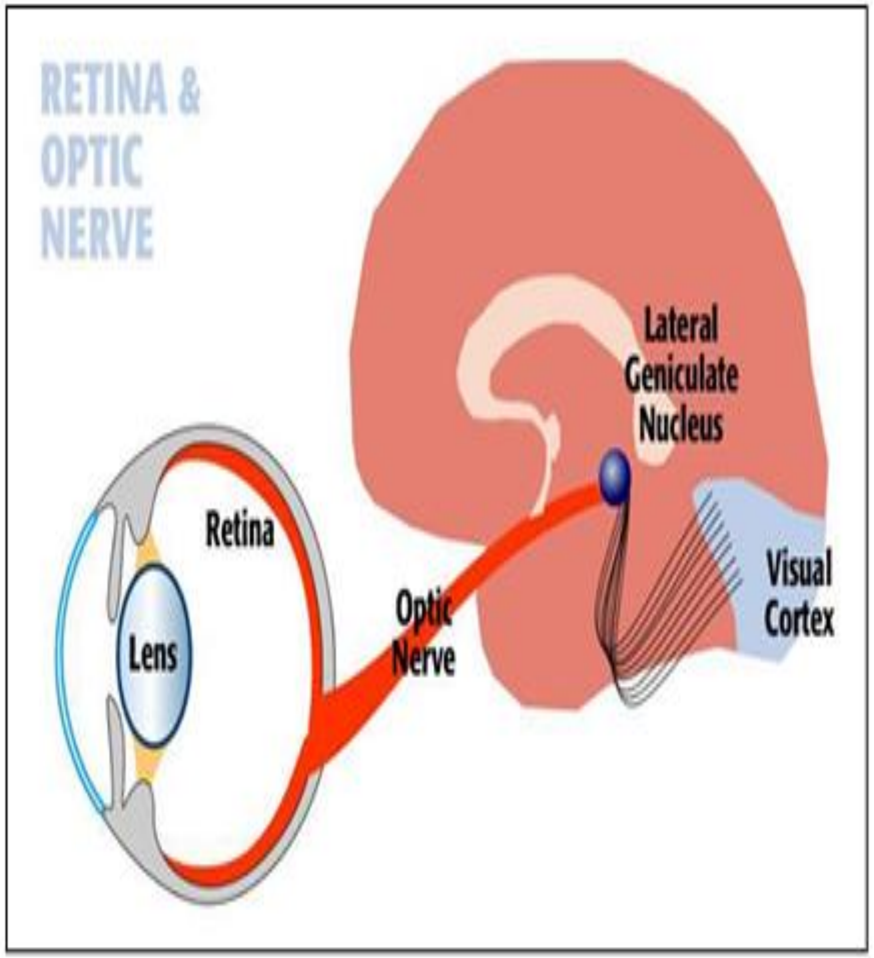
In human eye (The human eye is similar to a camera), light passes through a clear protective covering (the cornea) to enter the eye, and then passes through a small aperture (the iris) to enter the eye itself. Inside the eye and behind the iris is a small lens (Just as with a camera lens), the light is refracted and focused on the back of the eye. Finally, at the back of the eye is the retina, which plays the same role as film (in a non-digital camera) or a light-sensing CCD (Charge Coupled Device) chip (in a digital camera). The retina is filled with cells that detect the focused image, transform that into nerve impulses, and shoot the information off to the brain through the optic nerve. The brain is where the image is formed – not in the eye. The eye is simply a light detector, and the brain is where "seeing" takes place.



The optic nerve is a bundle of nerve fibers that goes directly from the retina to the brain. Every single light receptor cell in the eye has its own nerve, and every nerve is attached to a specific cell in the brain. This is an important fact – every single light detecting cell in the retina is in direct communication with a single cell in the brain.



When light strikes the retina, that information goes directly to the brain and “lights up” a corresponding cell in the visual part of our brain. In effect, there is a virtual replica of our retina in our brain tissue. This visual part of the brain scans these cells (which make up the virtual retina) to record what each of them is sensing. When this process is completed, an image finally forms. Only then, have we truly “seen” what we are looking at.



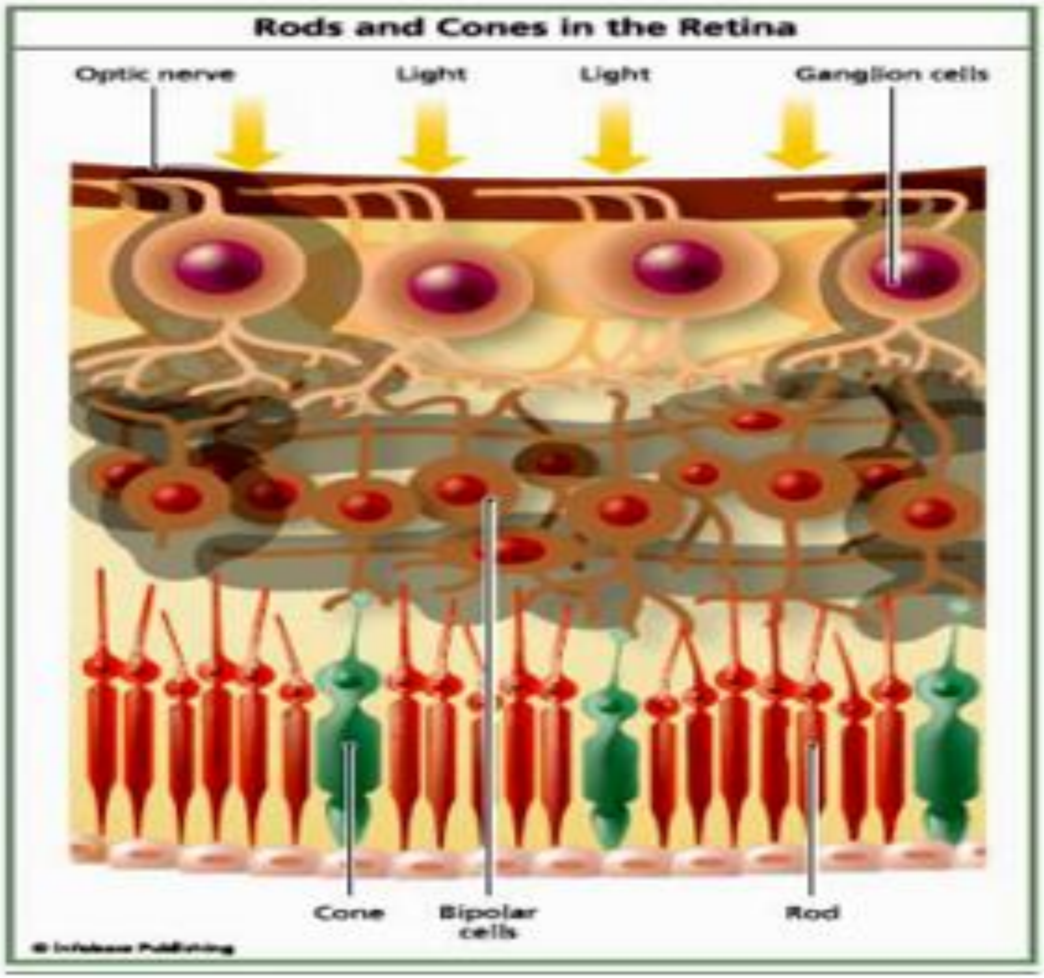
This is where the retina comes in. The retina is made of specialized cells that can detect light. What's interesting is that our retinas have two different kinds of light – detecting cells; they are called rods and cones.

Cones, which help us to see colors, are concentrated in the central part of the retina. Each human eye has about 6 million cones, which means that our color vision is similar to a 6 Megapixel digital camera.

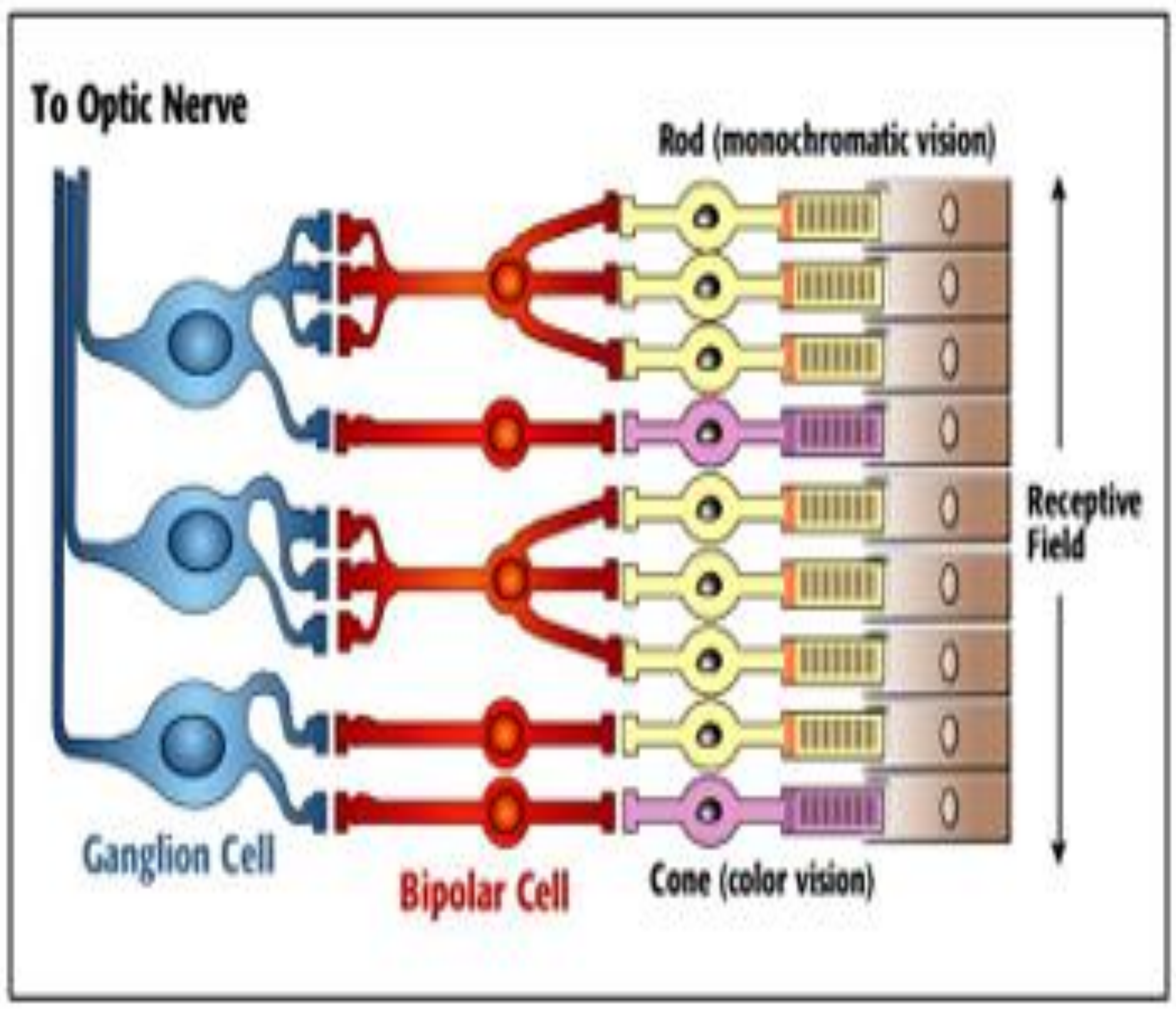
The rods only detect black and white and work best at night because they are very sensitive to low levels of light. There are about 125 million rods located throughout the entire retina, but most of them are concentrated in the retina's outer parts. For this reason, the rods also give us much of our peripheral vision. In fact, it is sometimes easier to see things by using our peripheral vision at night or in very dim light.

When light hits these light-detecting cells, it deposits energy into the cells’ molecules, causing chemical changes. The cells register these chemical changes and give off small electrical impulses that travel along the optic nerves to the brain, where they activate the corresponding cells in the visual cortex.

The retina consists of a large number of cells, including rod and cone photoreceptors at the back of the eye. Cells process the signals from photoreceptors and send the findings to the visual part of the brain via the optic nerve. Light passes through the transparent layers of cells before being intercepted by photoreceptors.



The receptive field shown on the right is where light hits the inside of our eye. Embedded in the receptive field are rod and cone cells. Rod cells (shown in yellow) detect monochromatic vision (black and white). Cone cells detect color. These nerves send impulses to the bipolar cells. There is some logic processing at the bipolar level. Then the output is sent to the ganglion cells where information is processed further. Then the data is sent out the optic nerve to the brain.



Common Visual Defects in The Human Eye (Errors of Refraction):

Normal visual acuity is referred to as 6/6 or 20/20; that is, the eye should and does clearly see an object 20 feet (6 meters) away, and is able to separate contours that are approximately 1.75 mm apart. Vision of 6/12 corresponds to lower, vision of 6/3 to better performance. Normal individuals have acuity of 6/4 or better (depending on age and other factors). An error of refraction is a problem with focusing of light on the retina due to the shape of the eye (eye defect). The most common types of refractive error are: nearsightedness, farsightedness, astigmatism, and presbyopia.

Refractive errors are corrected with eyeglasses, contact lenses, or surgery. Eyeglasses are the easiest and safest method of correction. Contact lenses can provide a wider field of vision; however, are associated with a risk of infection. Refractive surgery permanently changes the shape of the cornea.

Nearsightedness (myopia) means that the eye sees near objects well but not distant ones. If an eye has 20/80 vision, this means that what the normal eye can see at 80 feet, the nearsighted eye can see only if the object is brought to 20 feet away. The nearsighted eye focuses images from distant objects in front of the retina, because the eyeball is too long or the lens too thick. These structural characteristics of the eye are hereditary.

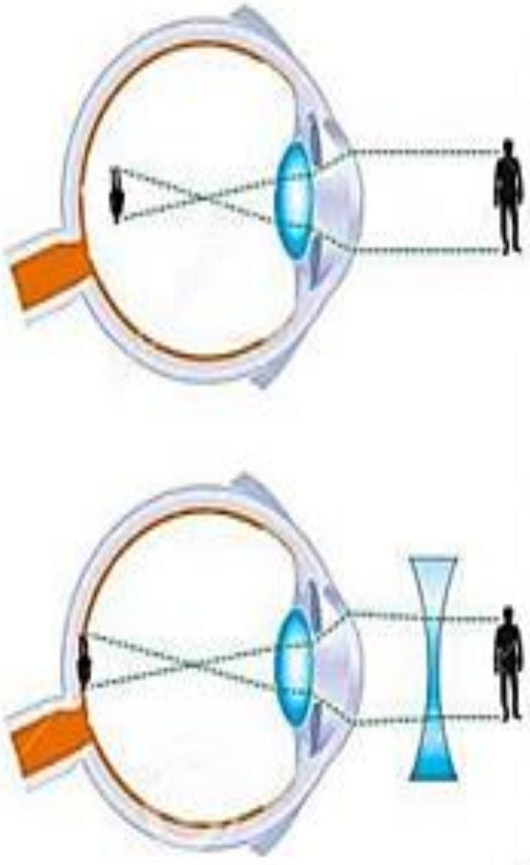
Correction requires a concave lens to spread out light rays before they strike the eye.

Farsightedness (hyperopia) means that the eye sees distant objects well. Such an eye may have an acuity of 20/10, that is, it sees at 20 feet what the normal eye can see only at 10 feet. The farsighted eye focuses light from near objects "behind" the retina, because the eyeball is too short or the lens too thin.

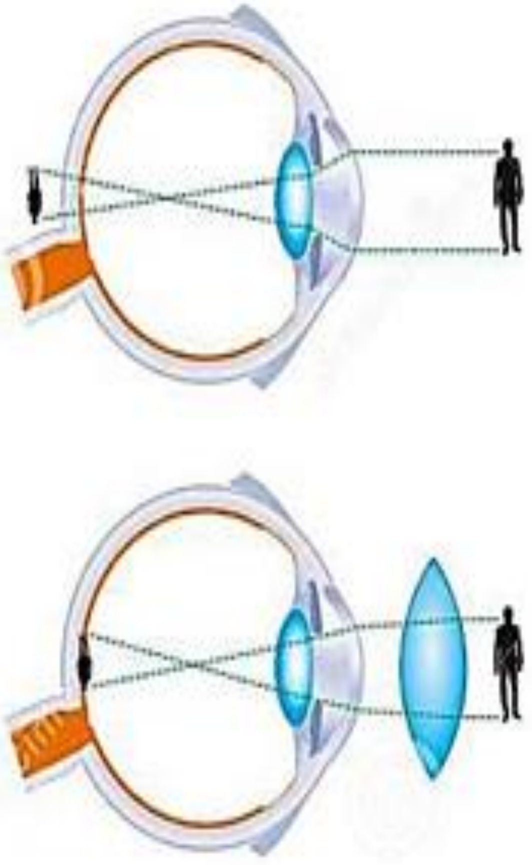
Correction requires a convex lens to converge light rays before they strike the eye.

Presbyopia As we get older, most of us will become more farsighted. As the aging lens loses its elasticity, it is not as able to recoil and thicken for near vision, and glasses for reading are often necessary.

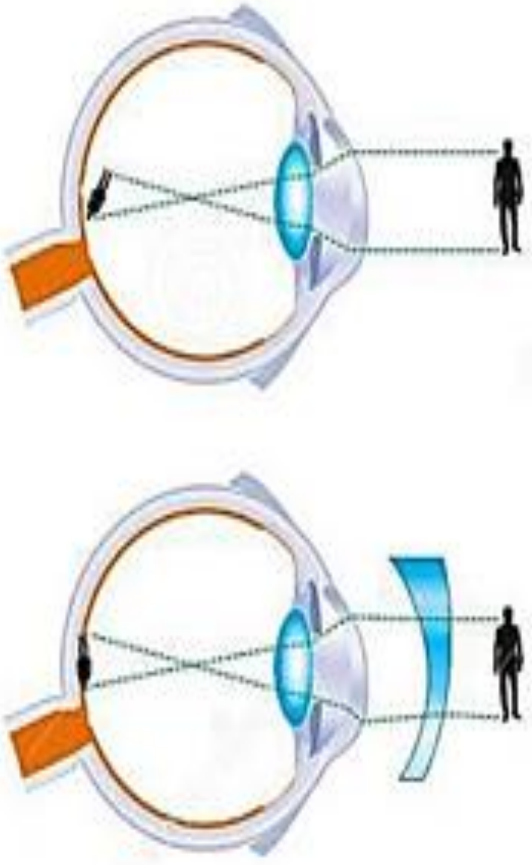
Astigmatism is another error of refraction, caused by an irregular curvature of the cornea or lens that scatters light rays and blurs the image on the retina. **Correction** requires a lens ground specifically for the curvature of the individual eye.



Myopia



Hyperopia



Astigmatism