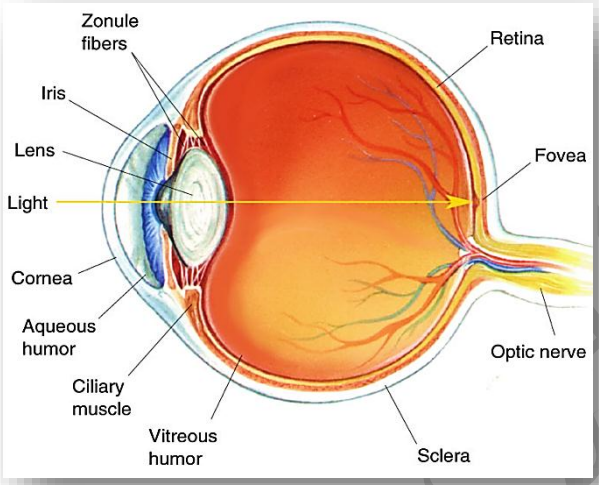
Eye

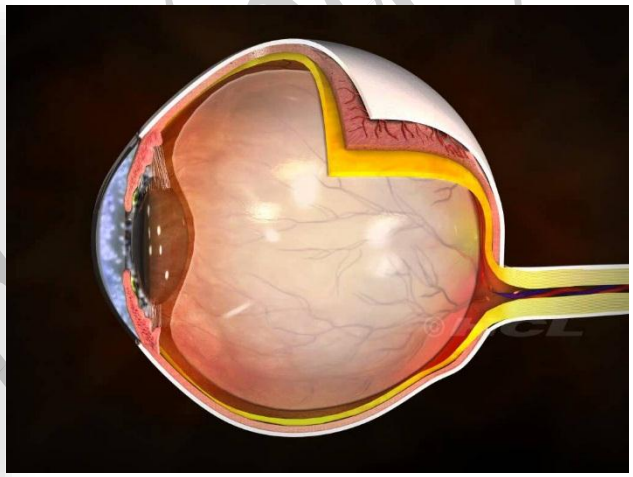
The eyes, housed in the bony orbits, are the photosensitive organs responsible for vision. Each eye is composed of **three** concentric tunics or layers:

1) A tough **external fibrous layer** consisting of the **sclera** and the transparent **cornea**.

2) A middle **vascular layer** that includes the **choroid**, **ciliary body**, and **iris**.

3) An inner **sensory layer**, the **retina**, which communicates with the cerebrum through the **posterior optic nerve**.



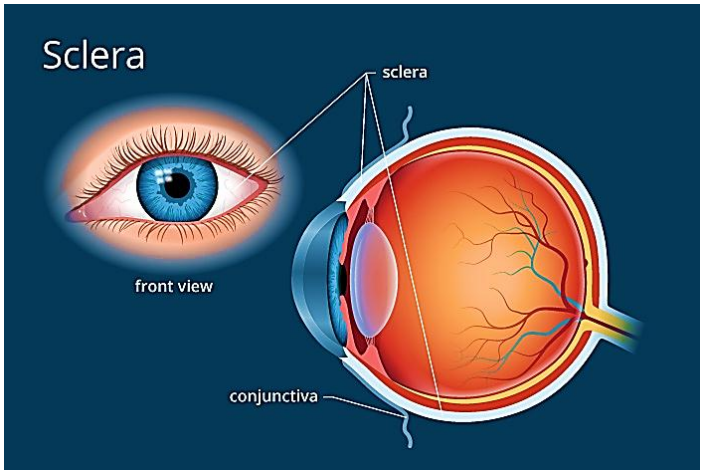


1) Fibrous Layer

This layer includes **two** major regions, the posterior **sclera** and anterior **cornea**, joined at the **limbus**.

A) Sclera

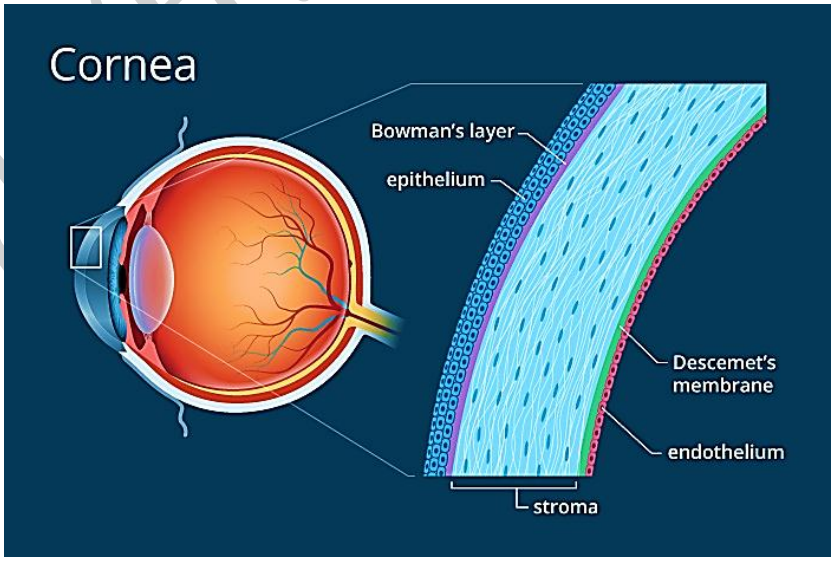
The sclera (the white of the eye) is an opaque, relatively avascular. The white posterior five-sixths of this layer is the sclera, which encloses a portion of the eyeball. The sclera consists mainly of dense connective tissue, with flat bundles of type I collagen parallel to the organ surface but intersecting in various directions; microvasculature is present near the outer surface.



B) Cornea

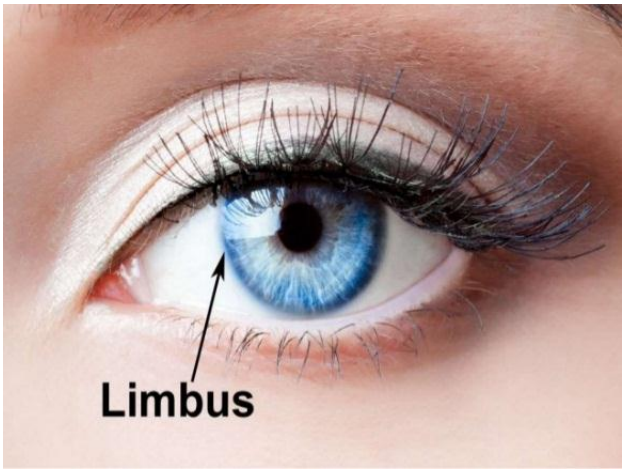
In contrast to the sclera, the anterior one-sixth of the eye—the cornea—is transparent and completely avascular. A section of the cornea shows **five** distinct layers:

1. **An external stratified squamous epithelium** is non-keratinized, **5 or 6 cell layers** thick, and comprises about **10%** of the corneal thickness.
2. **An anterior limiting membrane** (**Bowman's membrane**), which is the basement membrane of the external stratified epithelium, helping to protect against infection of the underlying stroma.
3. **The thick stroma**, or substantia propria, makes up **90%** of the cornea's thickness and consists of approximately **60 layers** of parallel collagen bundles aligned at approximately right angles to each other and extending almost the full diameter of the cornea.
4. **A posterior limiting membrane (Descemet's membrane**).The posterior surface of the stroma is bounded by another thick basement membrane, called **Descemet's membrane**, which supports the internal simple squamous corneal endothelium.
5. **An inner simple squamous endothelium.**



C) Limbus

Encircling the cornea is the **limbus**, a transitional area where the transparent cornea merges with the opaque sclera. Here Bowman's membrane ends and the surface epithelium becomes more stratified as the conjunctiva that covers the anterior part of the sclera (and lines the eyelids).

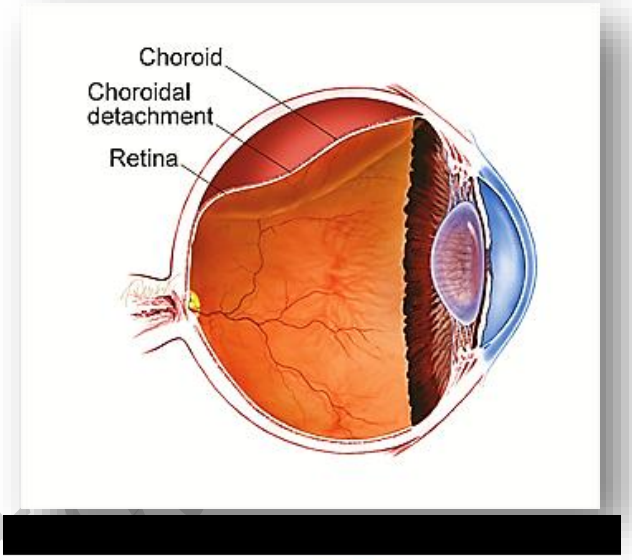


2) Vascular Layer

The eye's more vascular middle layer, known as the **Uvea**, consists of **three** parts, from posterior to anterior: the **choroid**, the **ciliary body**, and the **iris.**

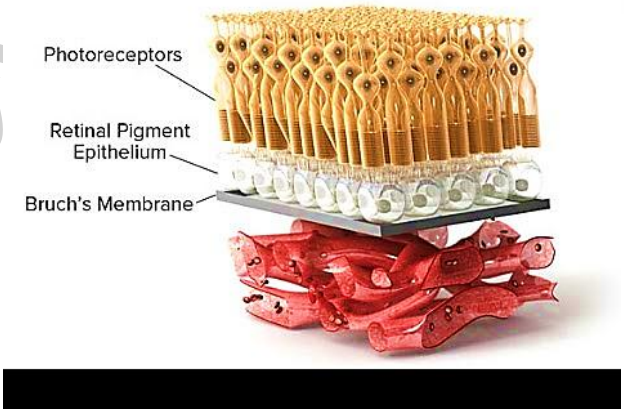
A) Choroid

Located in the posterior two-thirds of the eye, the choroid consists of **loose,well-vascularized connective tissue** and contains numerous **melanocytes**. These form a characteristic black layer in the choroid and **prevent light from entering the eye except through the pupil**.



Two layers make up the choroid:

1. **The inner choroido-capillary lamina** has a rich microvasculature important for nutrition of the outer retinal layers.
2. **Bruch's membrane**, a thin extracellular sheet, is composed of collagen and elastic fibers surrounding the adjacent microvasculature and basal lamina of the retina's pigmented layer.

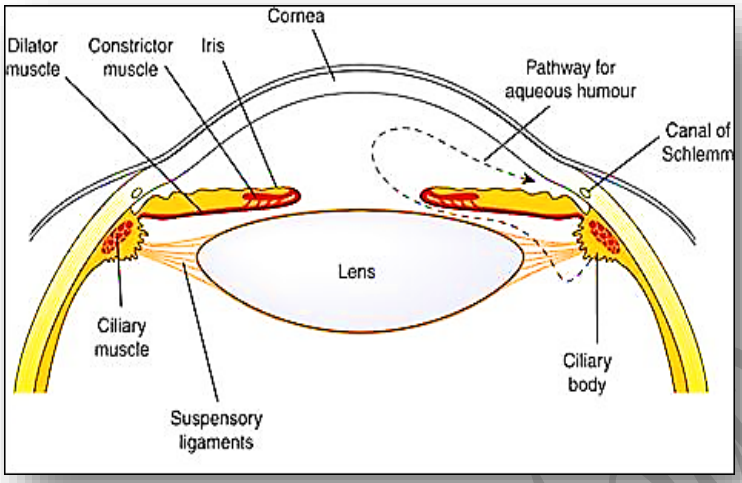


B) Ciliary Body

The ciliary body, the anterior expansion of the uvea that encircles the lens, lies posterior to the limbus. Like the choroid, most of the ciliary body rests on the sclera.Important structures associated with the ciliary body include the following:

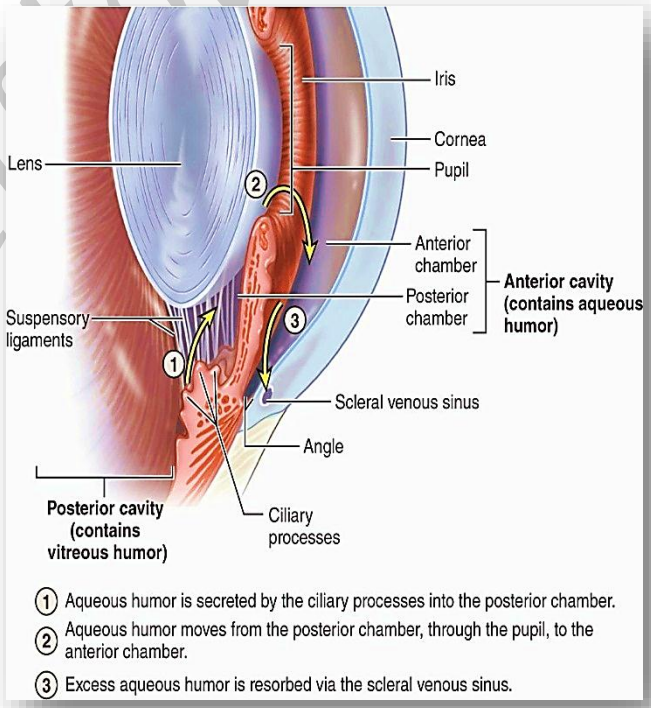
- **Ciliary muscle** makes up most of the ciliary body's stroma and consists of three groups of smooth muscle fibers. Contraction of these muscles affects the shape of the lens and is important in **visual accommodation**.
- **Ciliary processes** are a radially arranged series of about 75 ridges extending from the inner highly vascular region of the ciliary body. These provide a large surface area covered by a double layer of low **columnar epithelial cells**, the **ciliary epithelium**. The epithelial cells directly covering the stroma contain much melanin and correspond to the anterior projection of the pigmented retina epithelium. The surface layer of cells lacks melanin

and is contiguous with the sensory layer of the retina. Cells of this dual epithelium are specialized for secretion of **aqueous humor.**



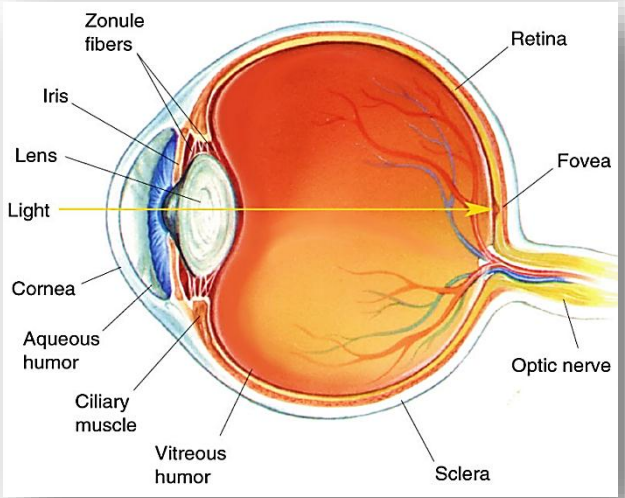
Aqueous humor

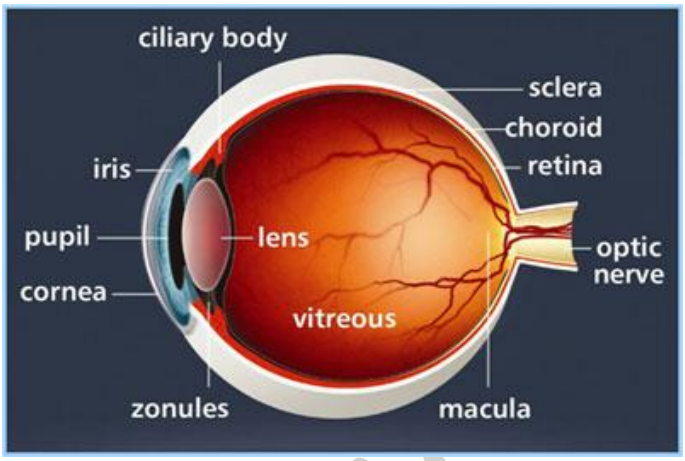
Aqueous humor is a continuously flowing liquid that carries metabolites to and from cells and **helps maintain an optimal microenvironment within the anterior cavity of the eye**, it is secreted from **ciliary processes** into the posterior chamber of the anterior cavity، flows into the anterior chamber through the pupil, and drains into the scleral venous sinus (canal of Schlemm).



Ciliary zonule

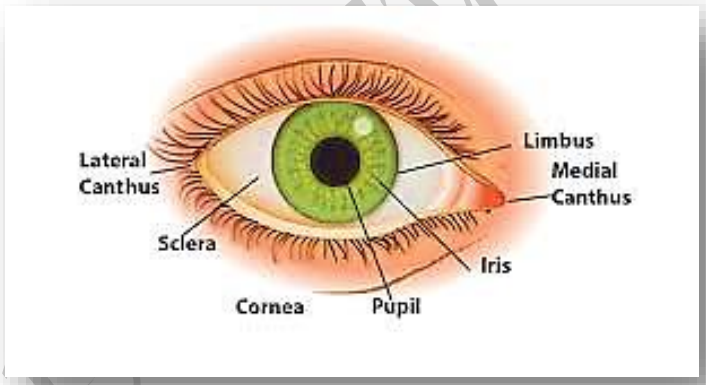
Ciliary zonule is a system of many radially oriented fibers composed largely of **fibrillin-1 and 2** produced by the non-pigmented epithelial cells on the ciliary processes. The fibers extend from grooves between the ciliary processes and attach to the surface of the lens, holding that structure in place.





C) Iris

The iris is the most anterior extension of the middle uveal layer which covers part of the lens, leaving a round central pupil. The anterior surface of the iris, exposed to aqueous humor in the anterior chamber, consists of a dense layer of fibroblasts and melanocytes with interdigitating processes and is unusual for its lack of an epithelial covering. Deeper in the iris، the stroma consists of loose connective tissue with melanocytes and sparse microvasculature.



The posterior surface of the iris has a **two-layered epithelium** continuous with that covering the ciliary processes, but very heavily filled with **melanin**. The highly pigmented posterior epithelium of the iris blocks all light from entering the eye except that passing through the **pupil**.

Eye color is blue only if few melanocytes are present. Increasing amounts of pigment impart darker colors to the eye. As the number of melanocytes and density of melanin increase in the stroma, the iris color changes through various shades of green, gray, and brown. Individuals with **albinism** have almost no pigment and the pink color of their irises is due to the reflection of incident light from the blood vessels of the stroma.

Lens

The lens is a transparent biconvex structure suspended immediately behind the iris, which focuses light on the retina. The lens is a unique avascular tissue and is highly elastic, a property that normally decreases with age. The lens has **three** principal components:

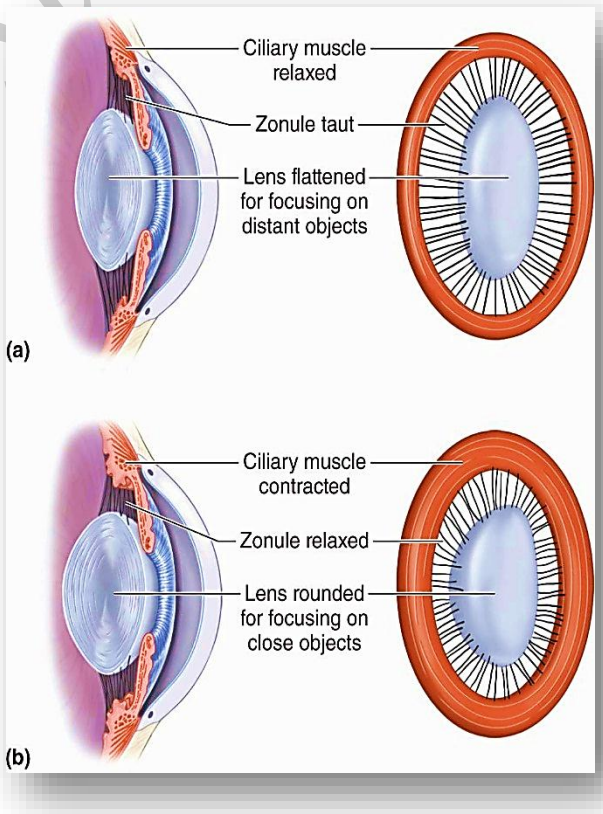
1. A thick, homogeneous lens capsule composed of proteoglycans and type IV collagen surrounds the lens and provides the place of attachment for the fibers of the ciliary zonule.

2. A subcapsular lens epithelium consists of a single layer of **cuboidal cells** present only on the anterior surface of the lens.
3. Lens fibers are highly elongated, terminally differentiated cells that appear as thin, flattened structures.

The lens is held in place by fibers of the ciliary zonule, which extend from the lens capsule to the ciliary body. Together with the ciliary muscles, this structure allows the process of **visual accommodation**, which permits focusing on near and far objects by changing the curvature of the lens:

A. When the eye is at **rest or gazing at distant objects**, ciliary muscles **relax** and the resulting shape of the ciliary body puts tension on the zonule fibers, which pulls the **lens into a flatter shape**.

B. To focus on a **close object** the ciliary muscles **contract**, causing forward displacement of the ciliary body, which relieves some of the tension on the zonule and allows the lens to return to a more **rounded shape** and keep the object in focus.



Presbyopia

Presbyopia is the inability of the eye to focus on close objects (accommodation). This is usually associated with aging. In the fourth decade of life presbyopia normally causes the lenses to lose elasticity and their ability to undergo accommodation, which prevents it from assuming a spherical shape. This condition can usually be corrected with eyeglasses.

Vitreous Body

The vitreous body occupies the large vitreous chamber behind the lens. It consists of transparent, **gel-like connective tissue** that is 99% water (vitreous humor), with collagen fibrils and hyaluronate, contained within an external lamina called the **vitreous membrane**. The only cells in the vitreous body are a small mesenchymal population near the membrane called **hyalocytes**, which synthesize the hyaluronate and collagen, and a few macrophages.

3) Sensory layer

A. Retina

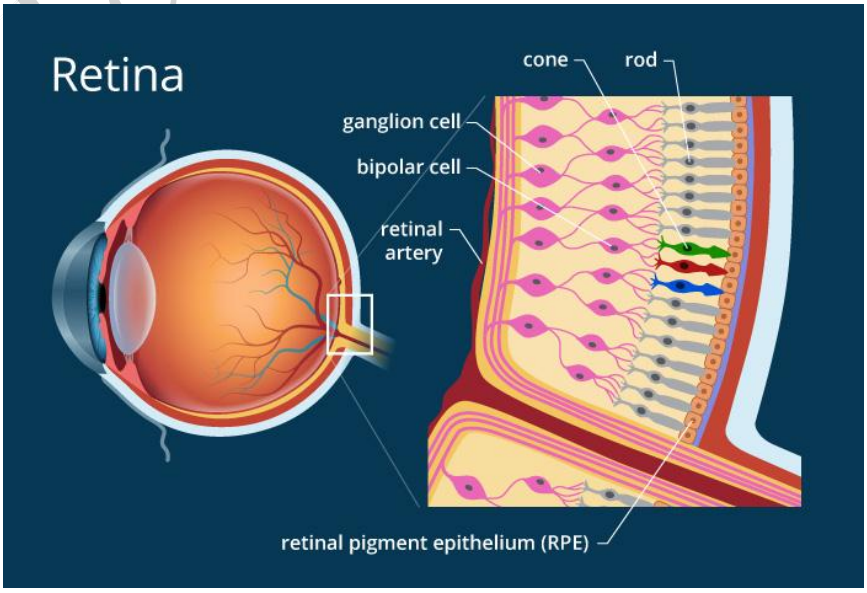
The retina is the innermost of the three tunicae of the eye and is responsible for photoreception. It is interposed between the choroid and the vitreous humor. It is composed of **two** layers:

1. **Pigmented Epithelium layer**

The pigmented epithelial layer consists of **cuboidal or low columnar** cells with basal nuclei and surrounds the neural layer of the retina. The cells have well-developed junctional complexes, **gap junctions**, and numerous invaginations of the basal membranes associated with mitochondria. The apical ends of the cells extend processes and sheath-like projections that surround the tips of the photoreceptors. Melanin granules are numerous in these extensions and in the apical cytoplasm. This cellular region also contains numerous phagocytic vacuoles and secondary lysosomes, peroxisomes, and abundant smooth ER (SER) specialized for retinal (vitamin A) isomerization. Retinal pigment epithelial cells esterify vitamin A (used in the formation of visual pigment by rods and cones.

2. **Neural Retina (photoreceptor layer)**

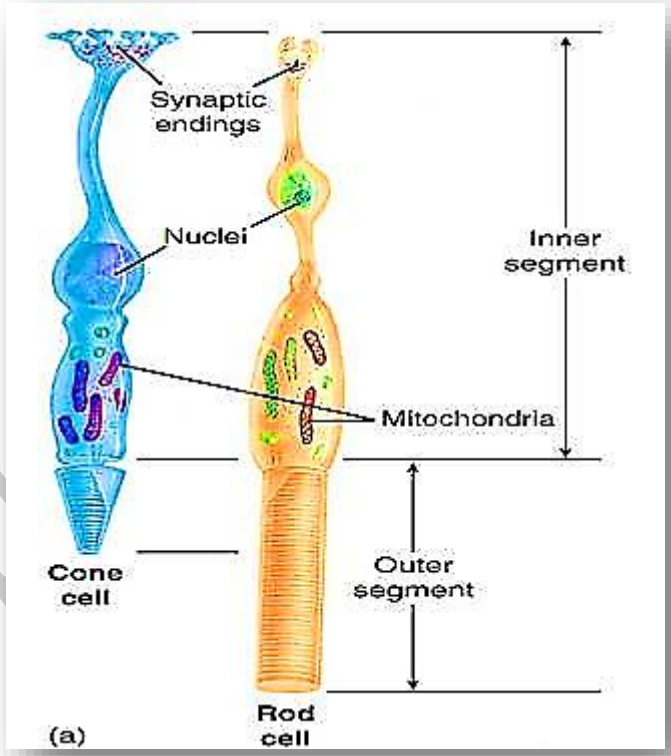
The inner retinal region, the neural layer, is thick and **stratified** with various neurons and photoreceptors. Although its neural structure and visual function extend anterior only as far as the ora serrata, this layer continues as part of the dual **cuboidal epithelium** that covers the surface of the ciliary body and posterior iris.



The photoreceptor layer consists of neurons (photoreceptor cells) called **rods** and **cones**.

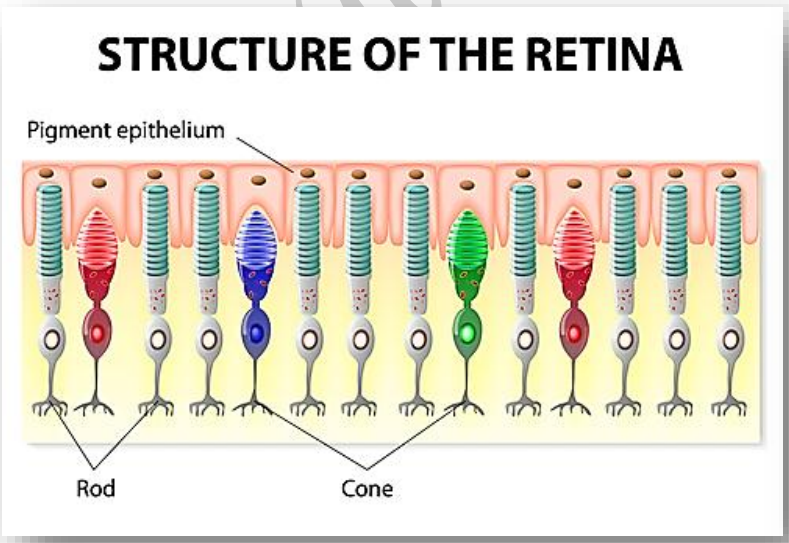
A. Rod Cells

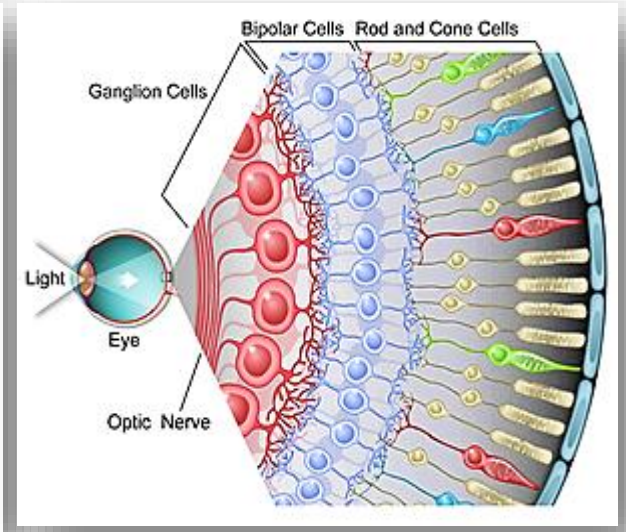
The human retina has on average **92 million** rod cells. They are extremely sensitive to light، responding to a single photon, and allow some vision even with light low levels, such as at dusk or nighttime. Rod cells are thin, elongated cells, composed of **two** functionally distinct segments:



1. The **outer segment** is a modified primary cilium, photosensitive and shaped like a short rod.
2. The **inner segment** contains glycogen, mitochondria, and polyribosomes for the cell's biosynthetic activity.

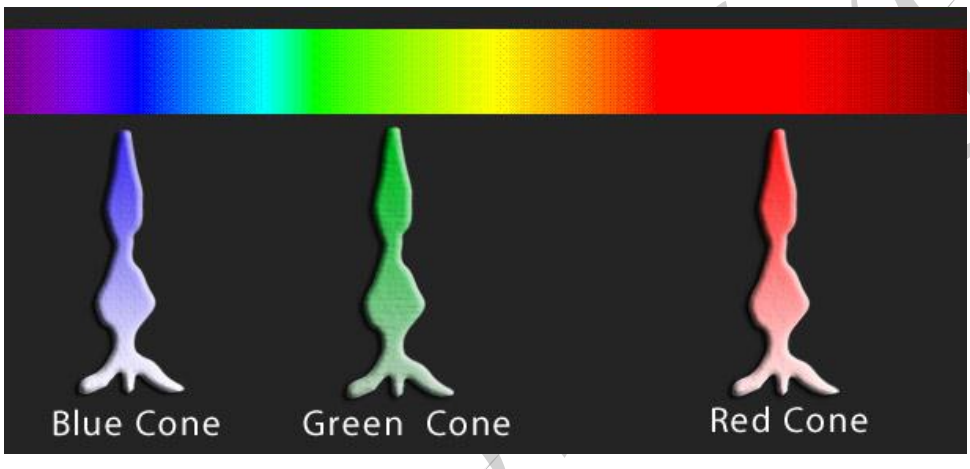
   The rod-shaped segment consists mainly of **600 to 1000** flattened membranous discs stacked like coins and surrounded by the plasma membrane.



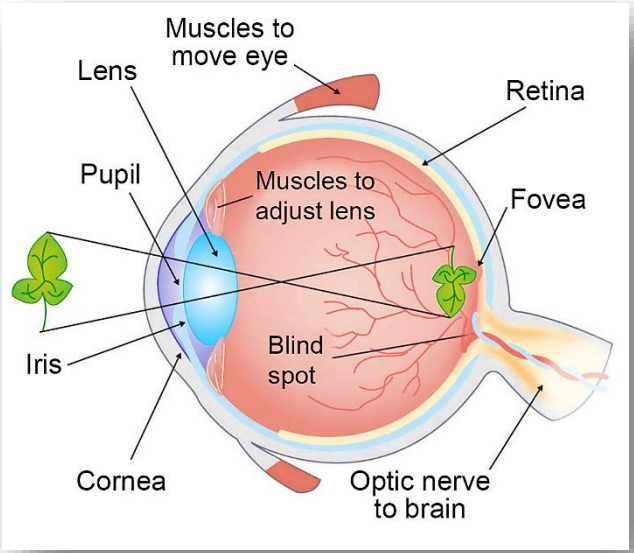


B. Cone Cells

Less numerous and less light-sensitive than rods, the average **4.6 million** cone cells in the human retina produce color vision in adequately bright light. There are **three** morphologically similar classes of cones, each containing one type of the visual pigment **iodopsin (or photopsins)**. Each of the three iodopsins has maximal sensitivity to light of a different wavelength, in the **red**, **blue**, or **green** regions of the visible spectrum, respectively. By mixing neural input produced by these visual pigments, cones produce a color image.



Like rods, cone cells are elongated, with **outer and inner segments**, a modified cilium connecting stalk, and an accumulation of mitochondria and polyribosomes. The outer segments of cones differ from those of rods in their shorter, more conical form and in the structure of their stacked membranous discs, which in cones remain as continuous invaginations of the plasma membrane along one side. Also, newly synthesized **iodopsins** and other membrane proteins are distributed uniformly throughout the cone outer segment and, although iodopsin turns over, discs in cones are shed much less frequently than in rods.



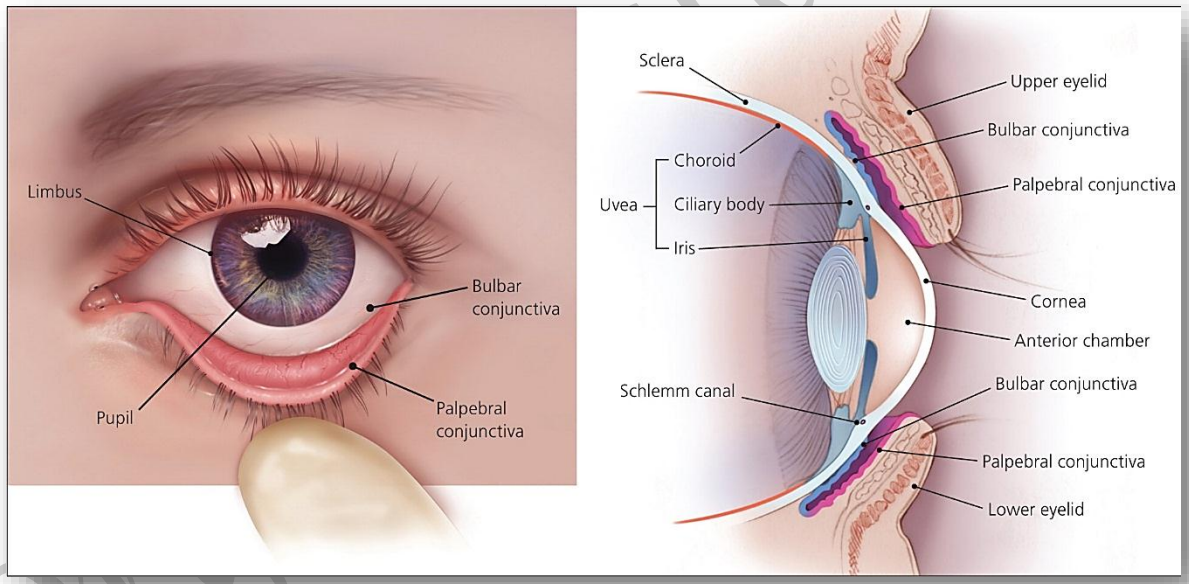
The **fovea** (a small pit) is a shallow depression with only **cone cells** at its center; ganglion cells and other conducting neurons are located only at its periphery.

Cone cells in the fovea are long, narrow, and closely packed. Blood vessels do not cross the fovea and light falls directly on its cones. The locations and structural adaptations of the fovea together account for the extremely precise visual acuity of this region.

Accessory Structures of the Eye

a) Conjunctiva (transparent mucous membrane)

The conjunctiva lines the eyelids and is reflected onto the anterior portion of the eyeball to the cornea, where it becomes continuous with the corneal epithelium. It is a stratified columnar epithelium possessing many goblet cells. It is separated by a basal lamina from an underlying lamina propria of loose connective tissue.



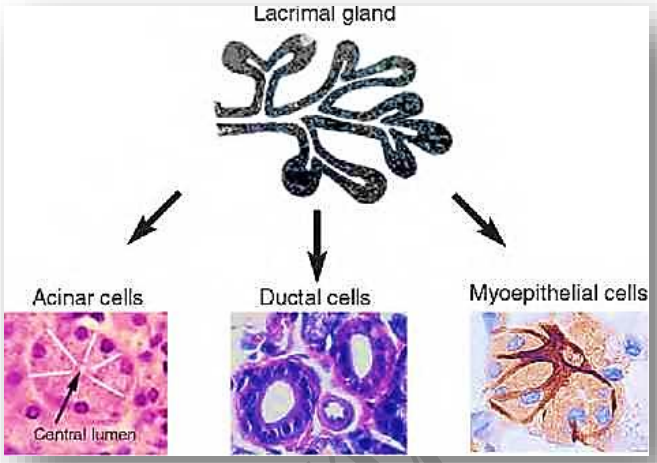
b) Eyelids

The eyelids are lined internally by conjunctiva and externally by skin that is elastic and covers a supportive framework of **tarsal plates**. Eyelids contain highly modified **sebaceous glands** (meibomian glands), smaller modified sebaceous glands (glands of Zeis), and **sweat glands** (glands of Moll).

c) Lacrimal apparatus

1. Lacrimal gland

The lacrimal gland is a compound **tubuloalveolar** gland with secretory units that are surrounded by an incomplete layer of myoepithelial cells.



2. **Lacrimal fluid (tears)** is mostly water, and contains lysozyme, an antibacterial enzyme. Tears drain from the lacrimal gland via **6** to **12** ducts into the conjunctival fornix, from which the tears flow over the cornea and conjunctiva, keeping them moist. Tears then enter the lacrimal puncta, leading to the lacrimal canaliculi.

3. **Lacrimal canaliculi** are lined by a **stratified squamous epithelium** and unite to form a common canaliculus, which empties into the **lacrimal sac**.The lacrimal sac is lined by a **pseudostratified ciliated columnar epithelium**.The **nasolacrimal duct** is the inferior continuation of the lacrimal sac and is also lined by a **pseudostratified ciliated columnar epithelium**. The duct empties into the floor of the nasal cavity.