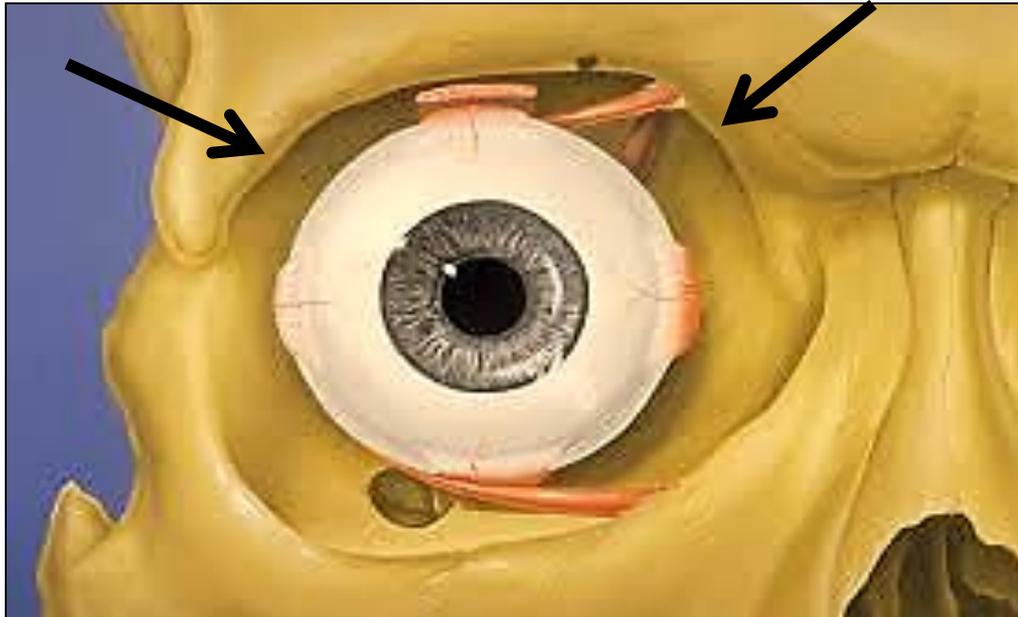


# The eye

Professor Dr . Hala El-mazar

- The eye is the **organ of vision**
- **Photosensitive:** detect light and convert it into **electro-chemical** signals that travel in neurons to the cerebrum
- The eyes located in bony cavities in the skull called **orbits**



Histologically each eye is composed of **three layers (tunics)**:

1- The external layer (**fibrous**) composed of:

**Cornea**

**Sclera**

2- The middle layer (**vascular, muscular, pigmented**) composed of:

**Iris**

**Ciliary body**

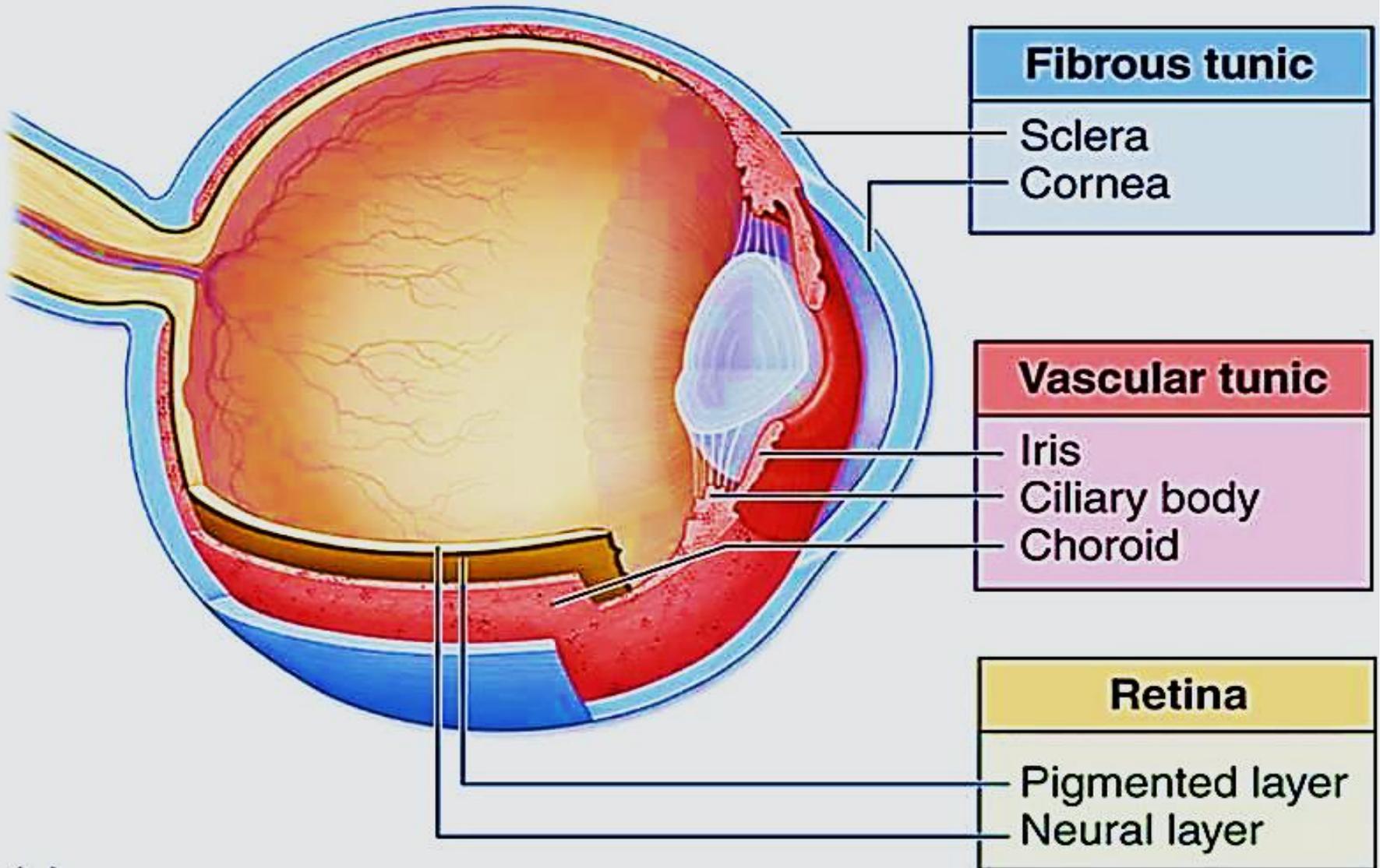
**Choroid**

3- The inner layer (**nervous**) composed of: **Retina**

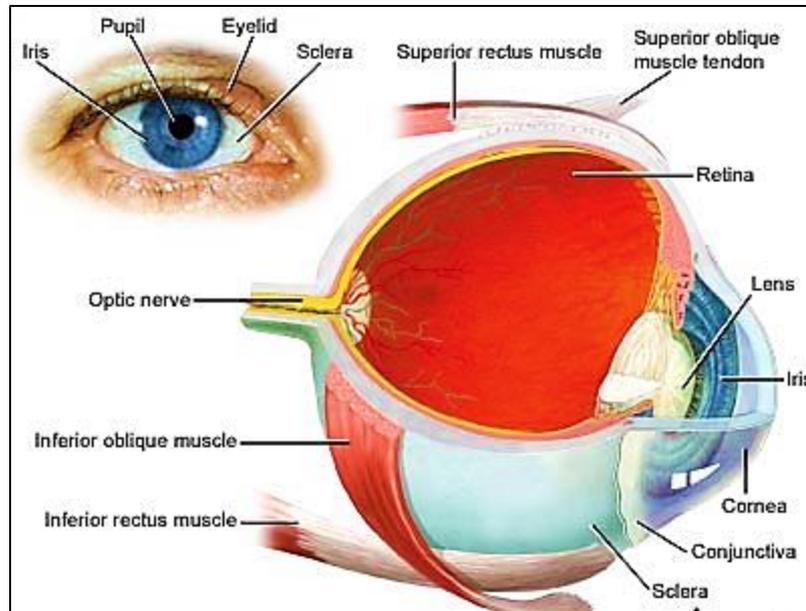
**Pigmented epithelium**

**Neural layer**

# Layers (tunics) of the eye



(a)

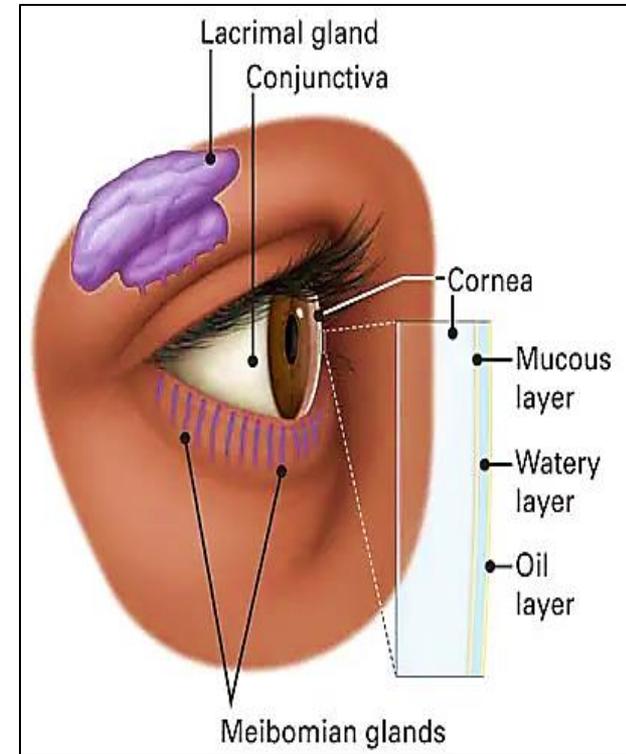
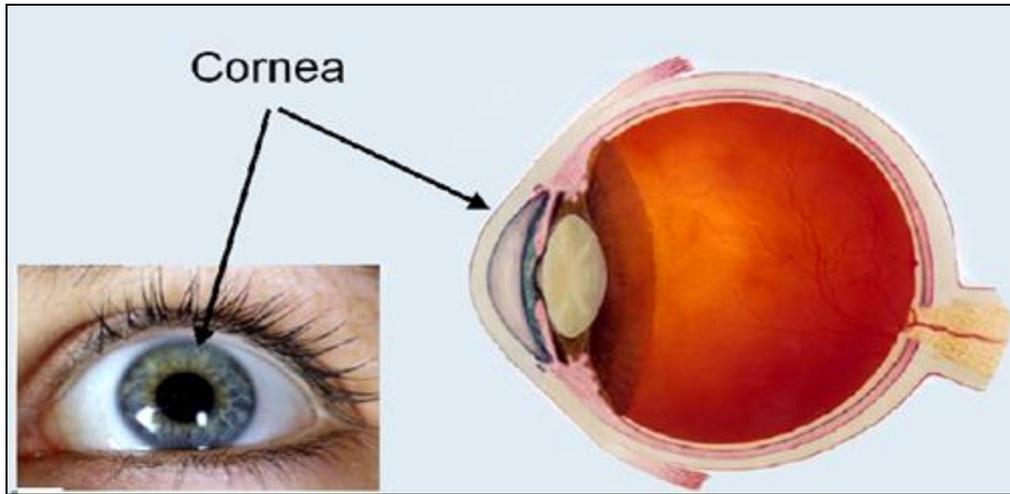


# The external (fibrous) layer

**A- the cornea**

**B- the sclera**

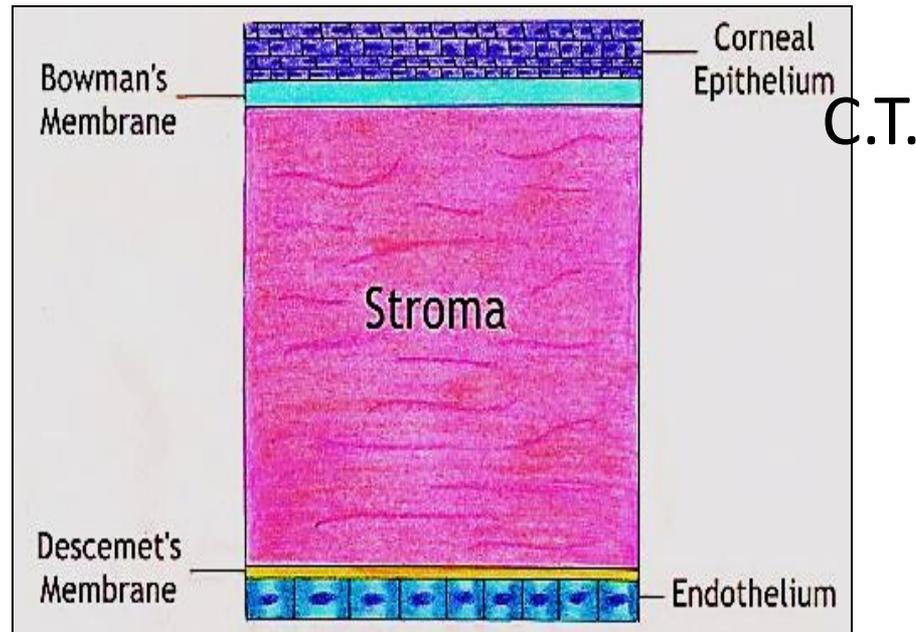
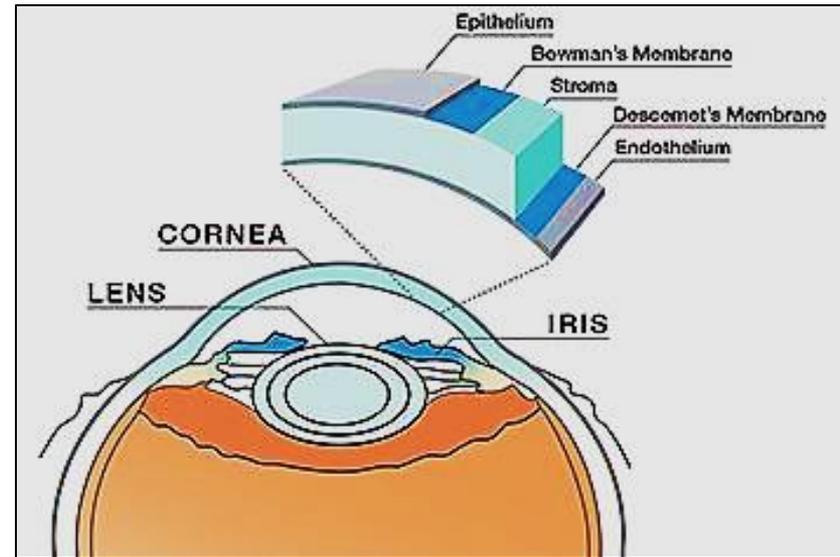
# The cornea



- Dome shape, transparent ( colorless), non vascular anterior part of the outer (fibrous) layer
- Is richly supplied with sensory nerve endings
- Is kept wet by the secretion of the tarsal & lacrimal glands

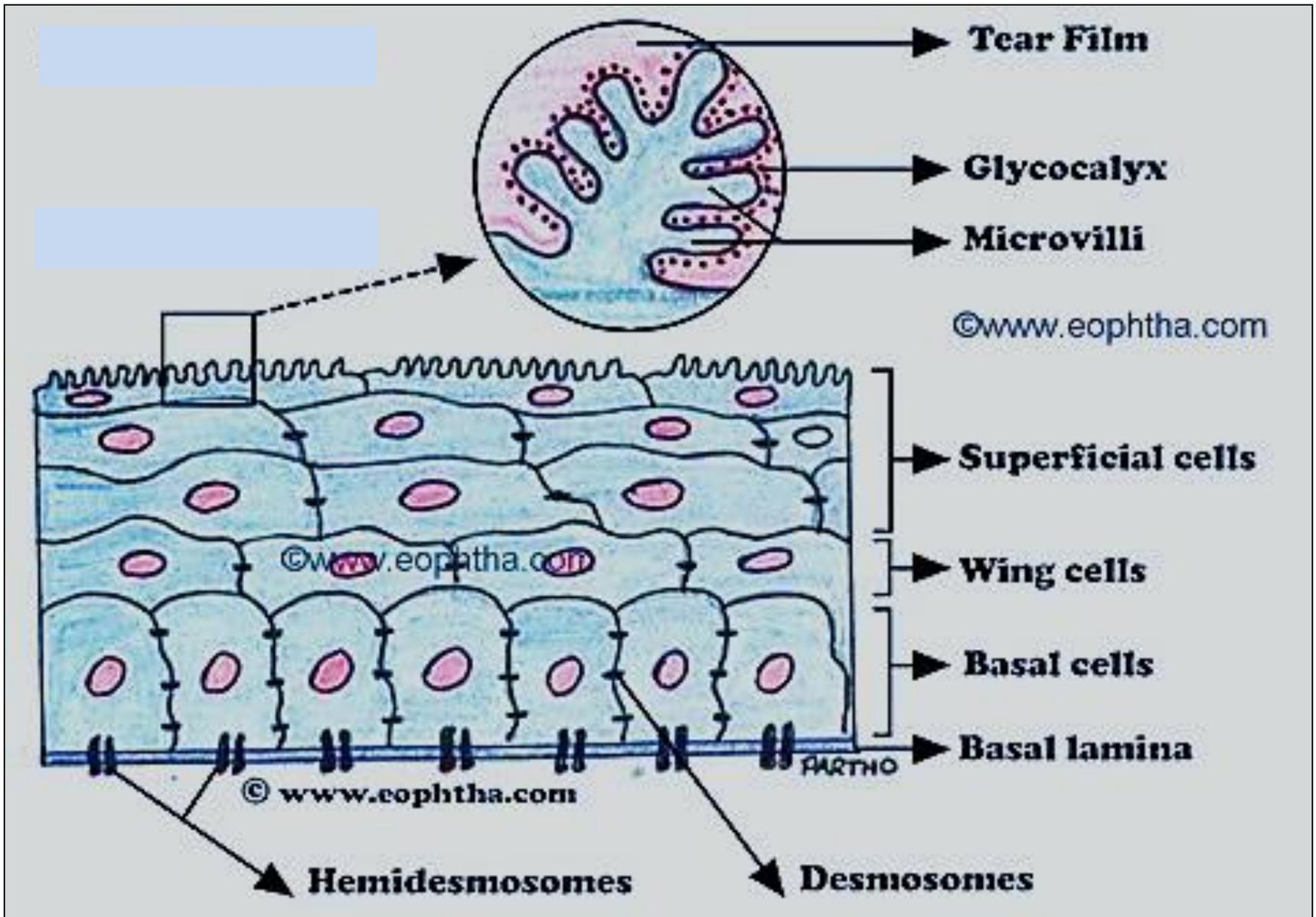
- Histologically the cornea composed of 5 layers:

- A-** Anterior epithelium
- B-** Bowman's membrane
- C-** C.T. layer or stroma
- D-** Descemet's membrane
- E-** Endothelium



# 1- Anterior epithelium (10%)

- It is non- keratinized stratified squamous epithelium
- It consists of 5-6 layers of cells
- The basal cells are **columnar**, show many mitotic figures, indicating high capacity of **cell renewal & repair**.
- intermediate layer consists of 3-4 layers of **polyhedral cells**, is **richly supplied with free nerve endings** (trigger blinking reflex)
- The surface corneal cells are **squamous** show microvilli which function to **retain a thin tear film over the corneal epithelium**.
- The epithelium is transparent due to continuous evaporation of water from its surface, & active exocytosis from endothelium



(The corneal epithelium)

# Tear film structure:

## 1- mucus layer:

covers microvilli & forms a network over the conjunctival surface, secreted by conjunctival goblet cells & the stratified squamous cells of the conjunctive & corneal epithelia.

**Function:** Convert corneal epithelium from hydrophobic to hydrophilic layer → stabilize the tear film, provide lubrication for eyelid movements

## 2- Aqueous layer:

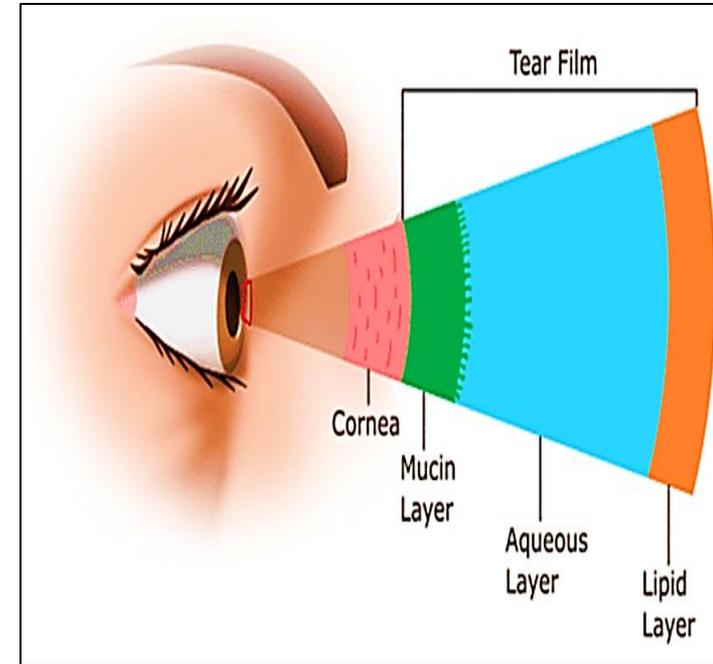
Secreted by lacrimal glands & accessory lacrimal glands (watery secretion )

**Function:** supply oxygen to the avascular corneal epithelium & maintain constant electrolyte composition over the ocular surface epithelium

## 3- Lipid layer :

Secreted by tarsal glands ( Meibomian glands, Glands of Zeis & Glands of Molls

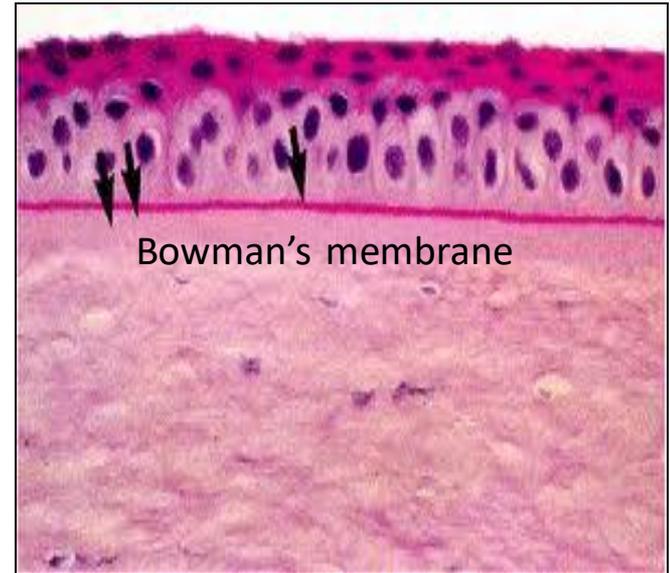
**Function:** prevent evaporation, maintain hydrophobic barrier that prevents tear overflow by increasing surface tension



## 2- Bowman's membrane

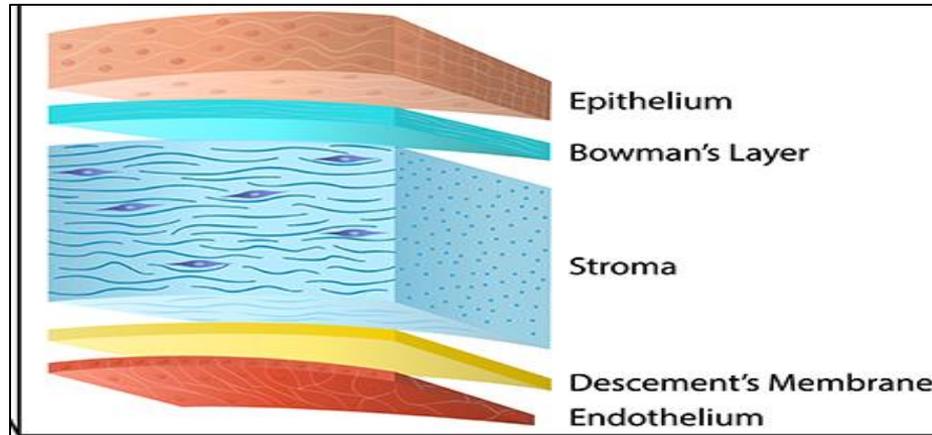
- It is a thick , **non-cellular membrane** BELOW the epithelium basement membrane
- Formed of protein fibers (collagen types I & V )

- It acts as protective barrier to the stroma( next layer) against infection & provide support to sub-epithelial nerve plexus  
→ protect the epithelial innervation



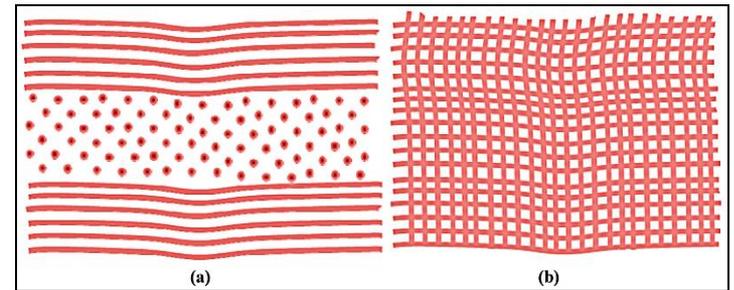
- If injured heals by scar, and causes corneal opacity

### 3- C.T. (Stroma)



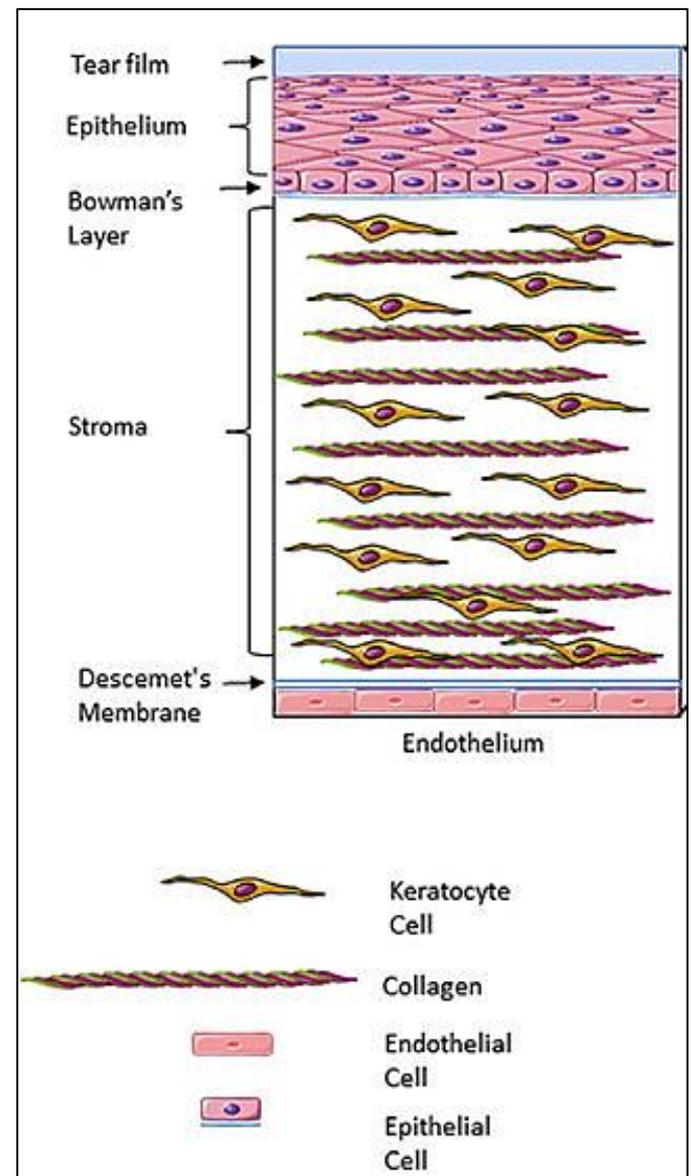
- The thick layer of cornea (90% of the corneal thickness)

- It is formed of layers of **parallel collagen fibers** (types I predominantly ) arranged at right angles with each other.



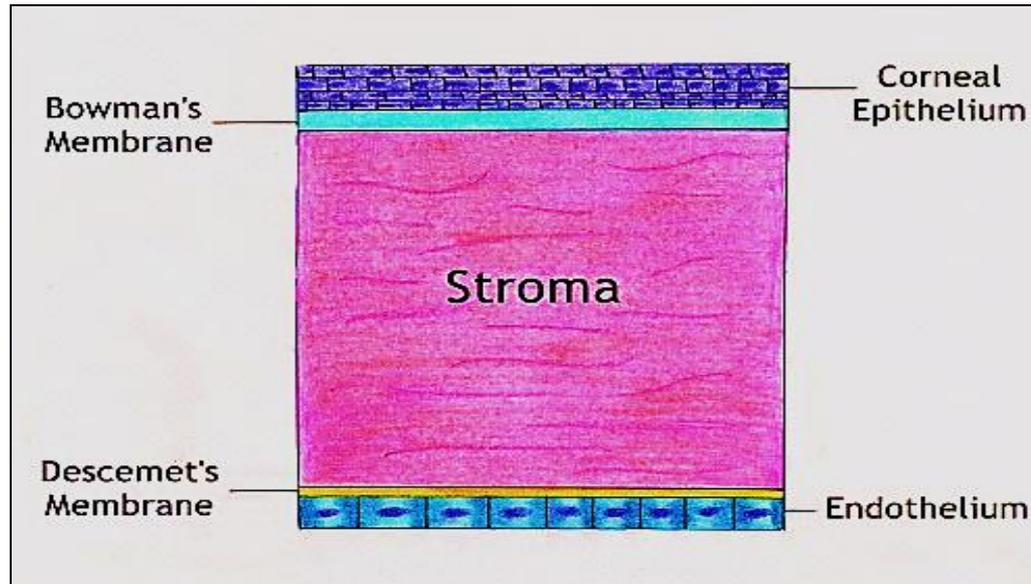
- the uniform arrangement of the collagen fibers contributes to the corneal transparency

- Between the collagen fibers there are fibroblast- like cells Called **keratocytes**. they have role in keeping cornea transparent, wound healing & synthesizing its components.
- the ground substance secreted by these cells maintain the organization & spacing between stroma collagen fibers



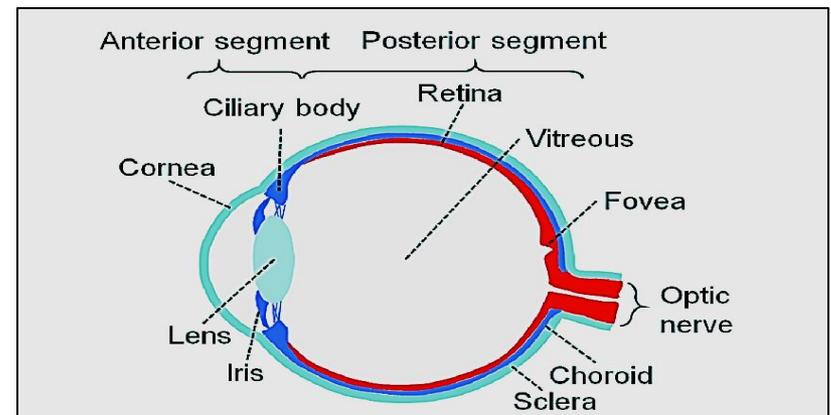
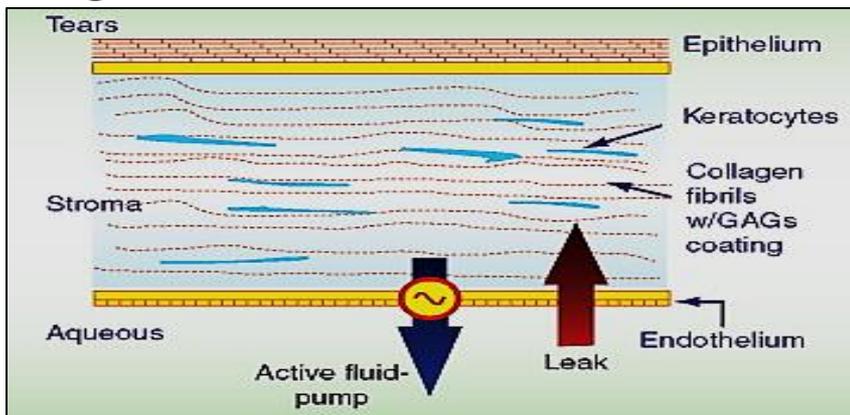
## 4- Descemet's membrane

- It is a thick homogenous, non-cellular membrane composed of fine collagen fibers (type IV & VIII )
- Formed by the endothelial cells of the next layer (the basement membrane of the endothelial cells)
- Membrane breaks occur in congenital glaucoma



# 5- Endothelium

- A layer of simple squamous cells (regenerate)
- Cells of this layer are active in:
  - **protein synthesis** to maintain the Descemet's membrane
  - **pumping sodium ions** into the adjacent anterior chamber  
→ dispose of any excess fluid in stroma → maintain corneal transparency
  - The endothelium responsible for maintaining state of hydration within the cornea that provide maximum transparency & optimal light refraction

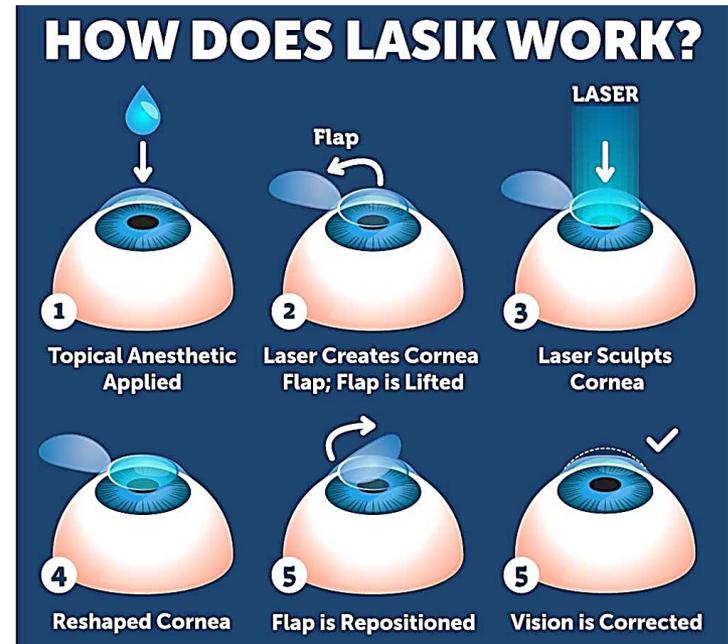


# Why is the cornea transparent?

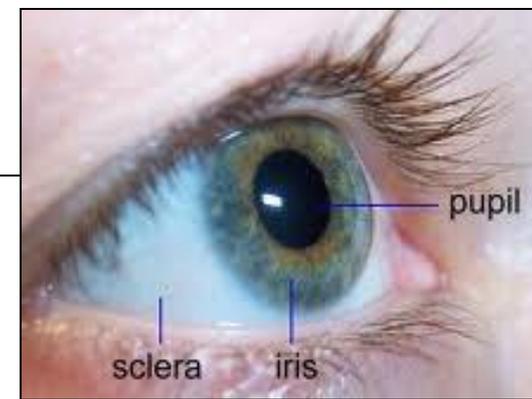
1. Avascular, no lymphatics
2. The surface epithelium is non-keratinized
3. Regular arrangement of C.T. fibers & cells in the stroma
4. Cells, fibers & matrix of corneal stroma have the same refractive index
5. The degree of hydration of the cornea is perfectly regulated

# LASIK:

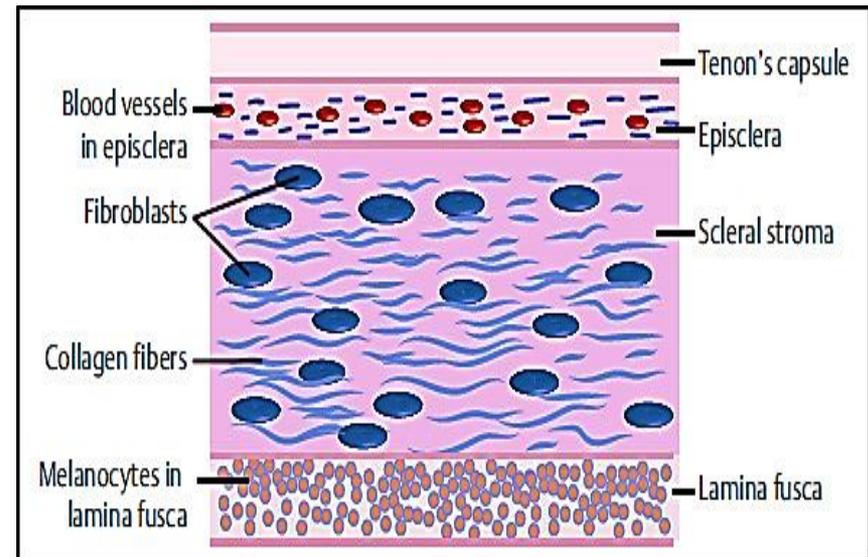
- Surgical technique used to improve the shape or curvature of cornea to correct certain visual abnormalities
- In this technique the corneal epithelium is displaced as a flap and the stroma is reshaped by an excimer laser which parts of the stroma in a highly controlled manner with no damage to adjacent cells or ECM
- Then the epithelium is repositioned and the rapid regenerative response of the epithelium will reestablish normal corneal physiology



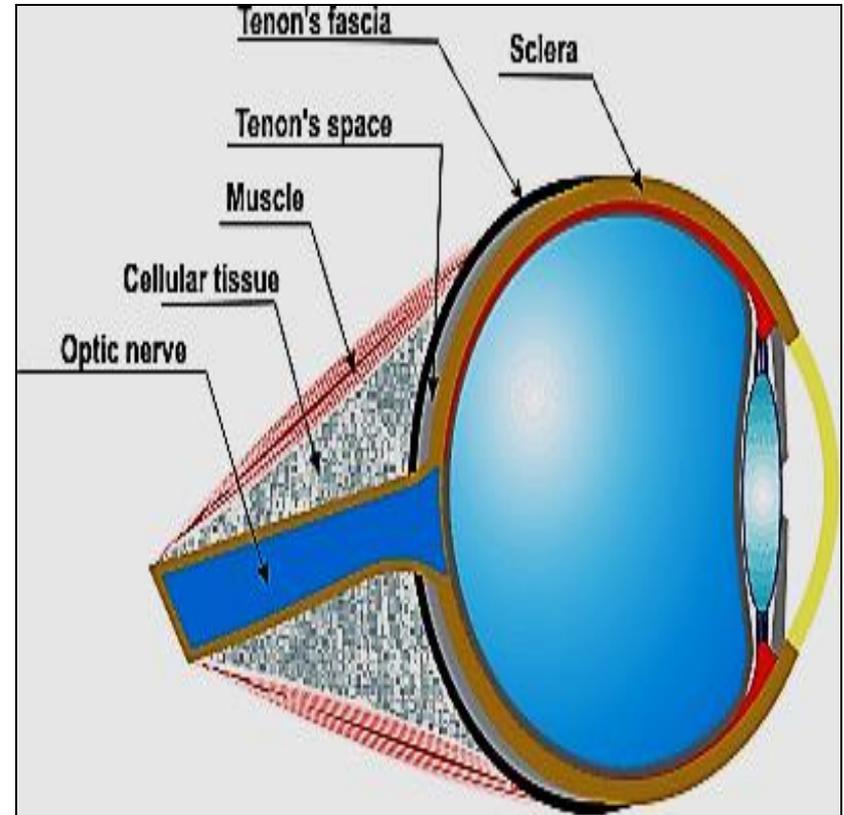
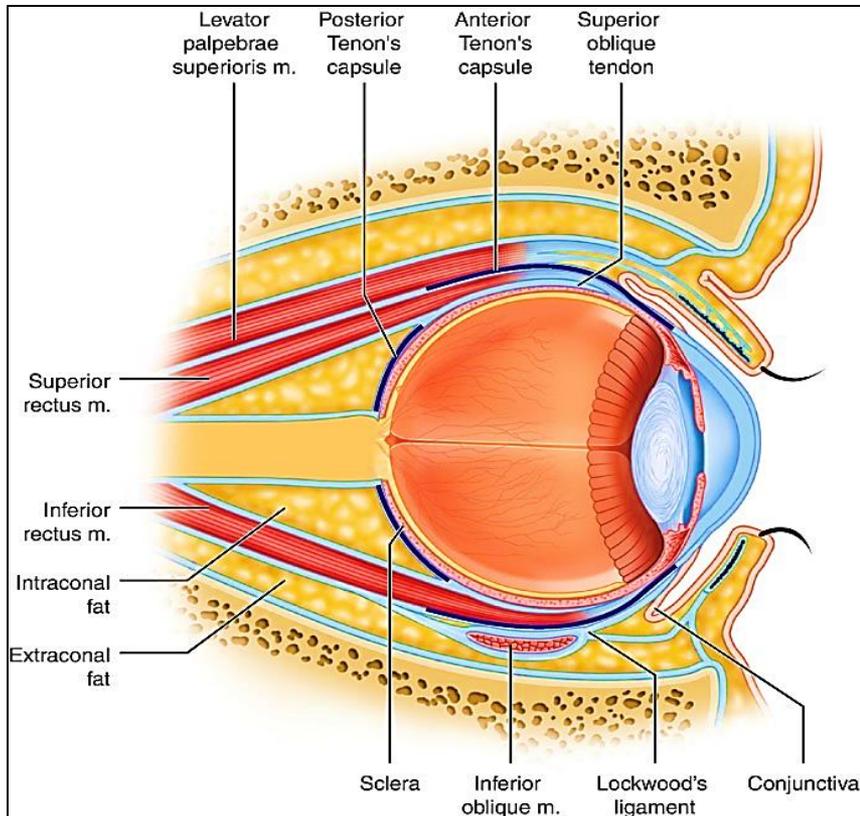
# The sclera



- Is thick white, opaque, fibrous layer (5/6)
- It provides sites for ocular ms. Insertion, protection & shape to the eye
- It consists of irregular white (**type I collagen fibers**), intersect in various directions, elastic fibers & fibroblasts
- Formed of **3 layers** : **Episclera**  
**Sclera proper (stroma) &**  
**Lamina fusca**)
- Is covered by **conjunctiva** (clear mucus membrane)



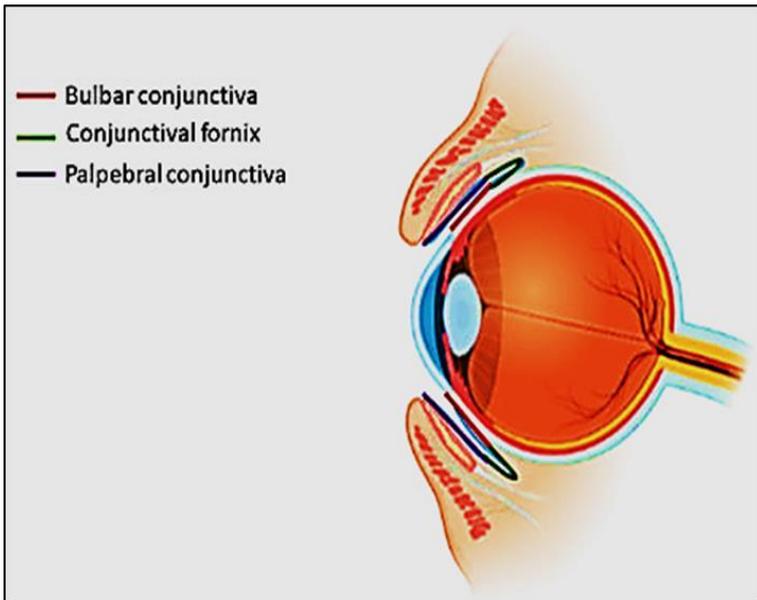
- The sclera is surrounded with Tenon's capsule (fascia) which provides attachment to the extra-ocular muscles



(Sclera and orbital muscles)

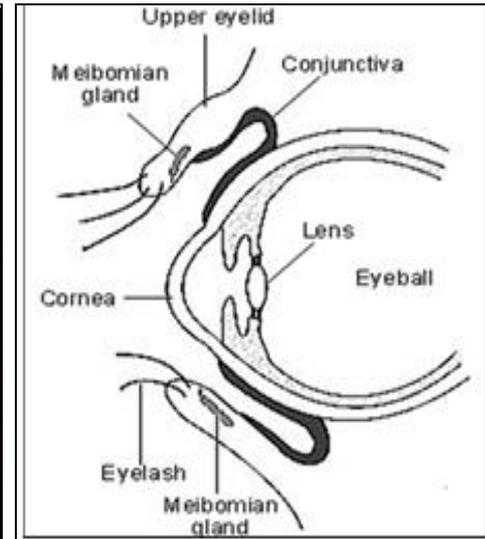
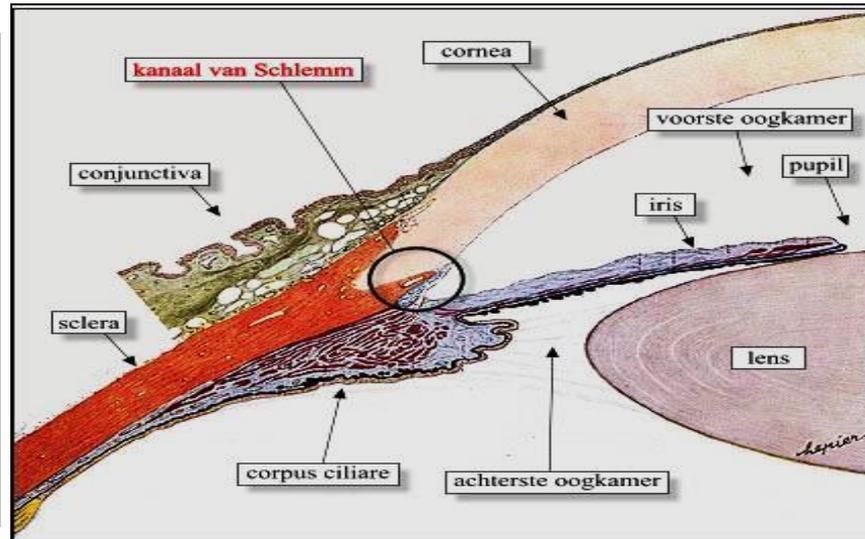
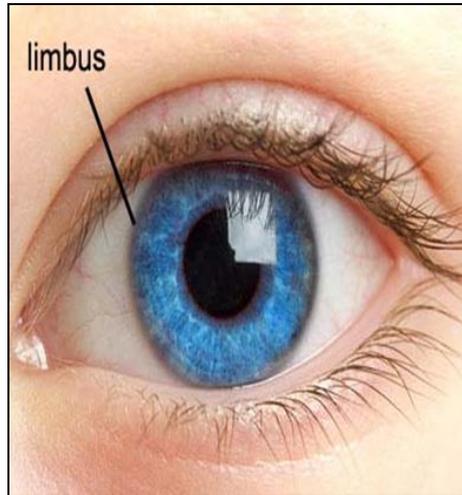


**Conjunctiva**



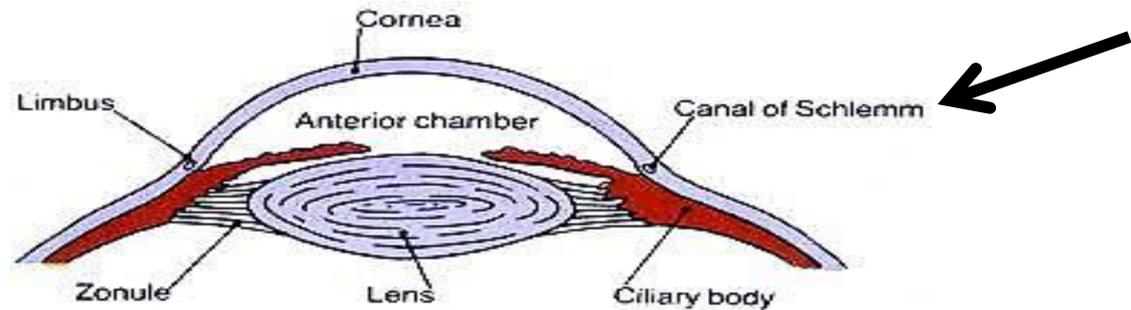
**Jaundice**

# The corneo- scleral junction ( limbus)

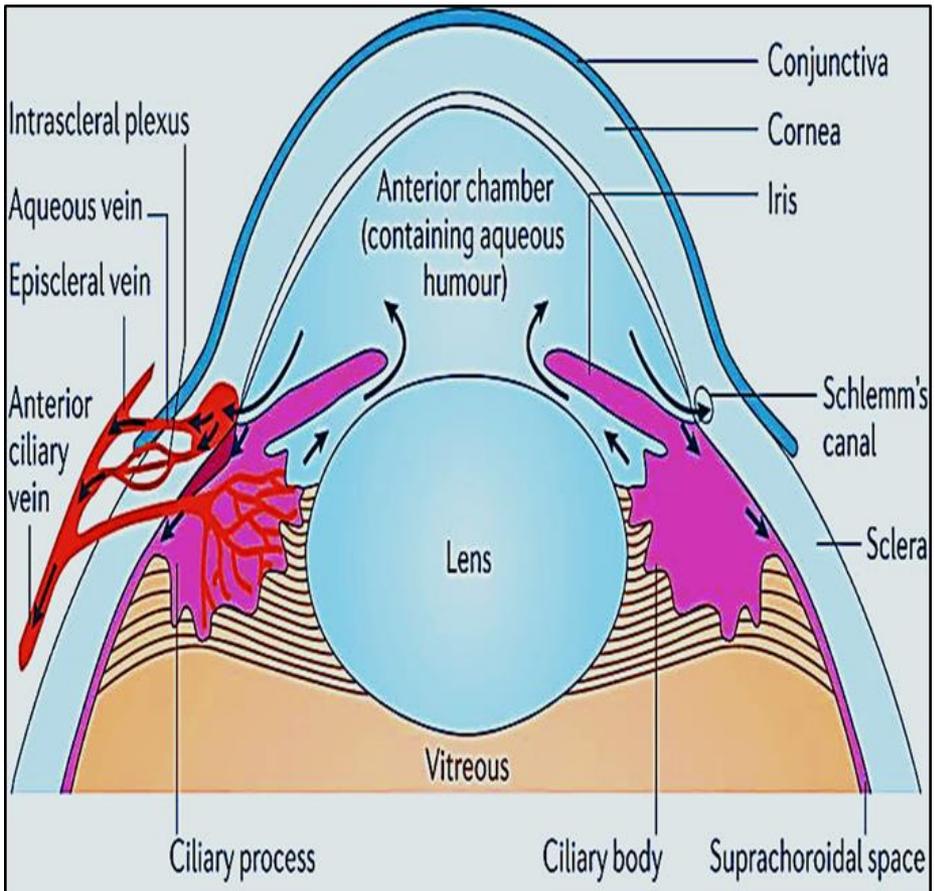
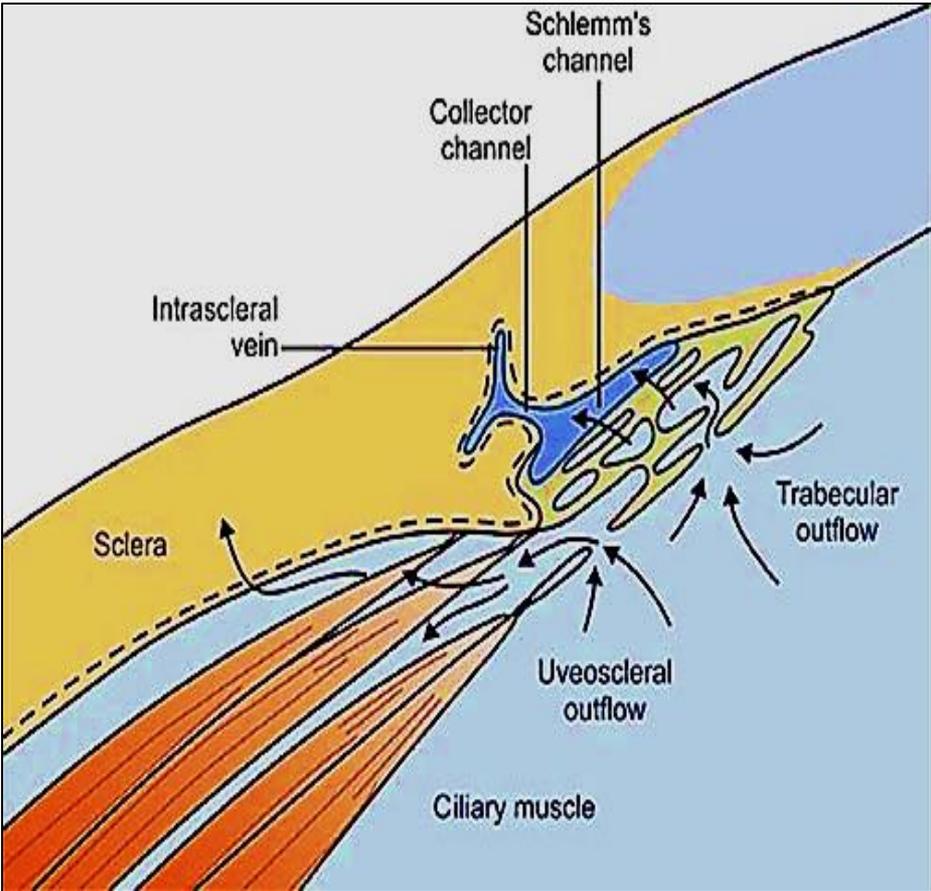


- Transitional area between cornea & sclera, contains **stem cells** for the corneal epithelium (Palisades of Voget)
- Site for surgical incisions for cataract & glaucoma
- **Is a highly vascular zone**
- **The corneal epithelium** is continuous at the Limbus with the bulbar conjunctiva which covers the sclera
- **Bowman's membrane** stops abruptly at Limbus

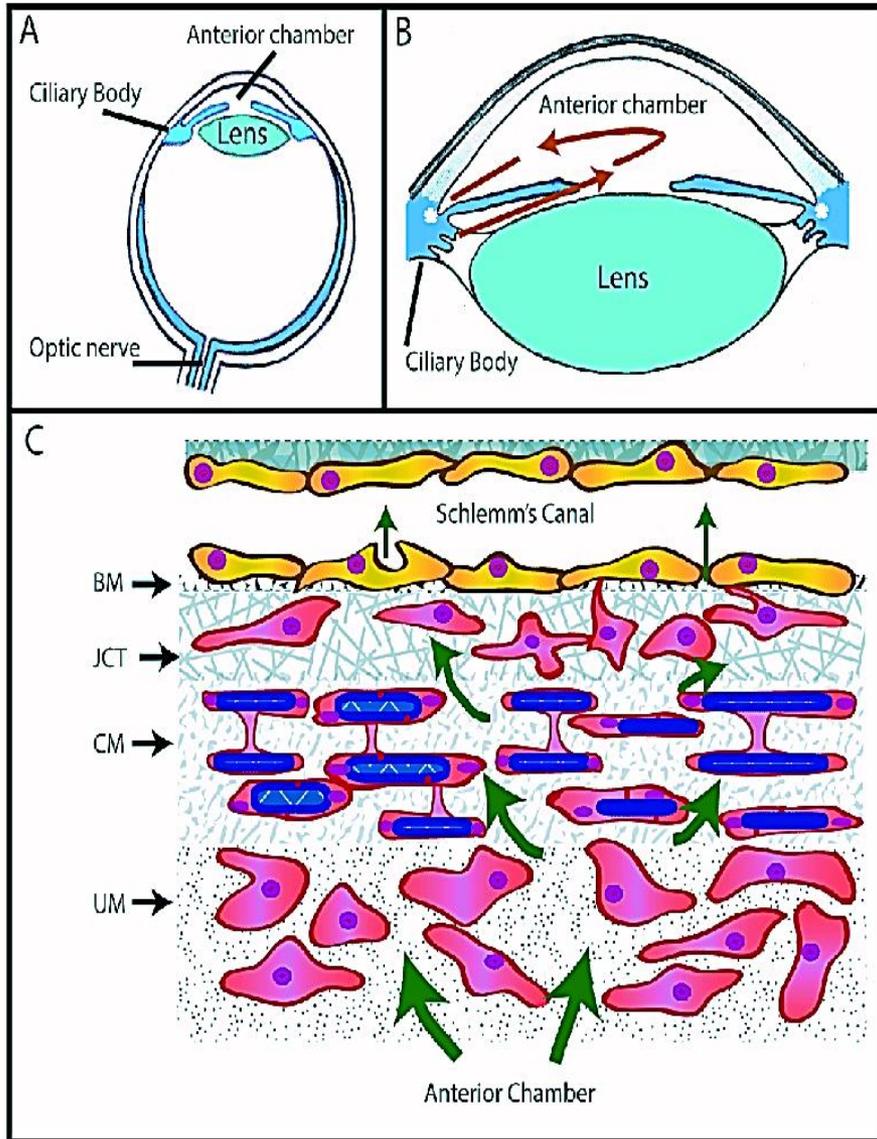
- The regular **stroma of the cornea** is continuous with the irregular stroma of the sclera. At that point locate **the canal of Schlemm**( the aqueous humor is drained through that canal → venous system) .. (**Glaucoma**)



- Descemet's membrane become continuous with the Trabecular meshwork (**spaces of Fontana**)
- The endothelium on the posterior surface of the cornea extend & become reflected on the anterior surface of iris



**Canal of Schlemm & Spaces of Fontana**

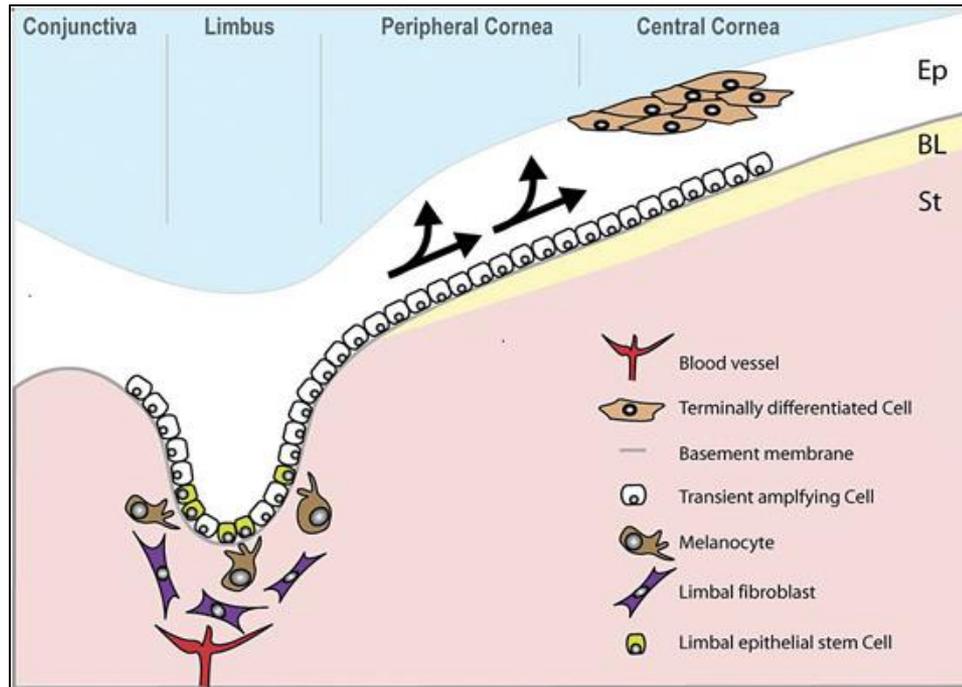


- **Schematic of the trabecular meshwork and Schlemm's canal**

Aqueous humor flows from the anterior chamber through the 3 layers of the trabecular meshwork called :

- 1- Uveoscleral meshwork (UM)
- 2- Corneoscleral meshwork (CM)
- 3- The juxtacanalicular tissue (JCT)

Aqueous humor (arrows) then crosses the basement membrane (BM) of Schlemm's Canal either paracellularly or transcellularly and enters into Schlemm's Canal.



**The limbal epithelial stem cells are** important for corneal epithelial cell renewal and closure of wound defects. **Corneal epithelial cells have a lifespan of 7–10 days**

**Limbal stem cell deficiency (LSCD)** causes include: chemical & thermal burns, multiple ocular surgeries involving the limbal region, contact lens wear, and ocular surface inflammatory diseases.

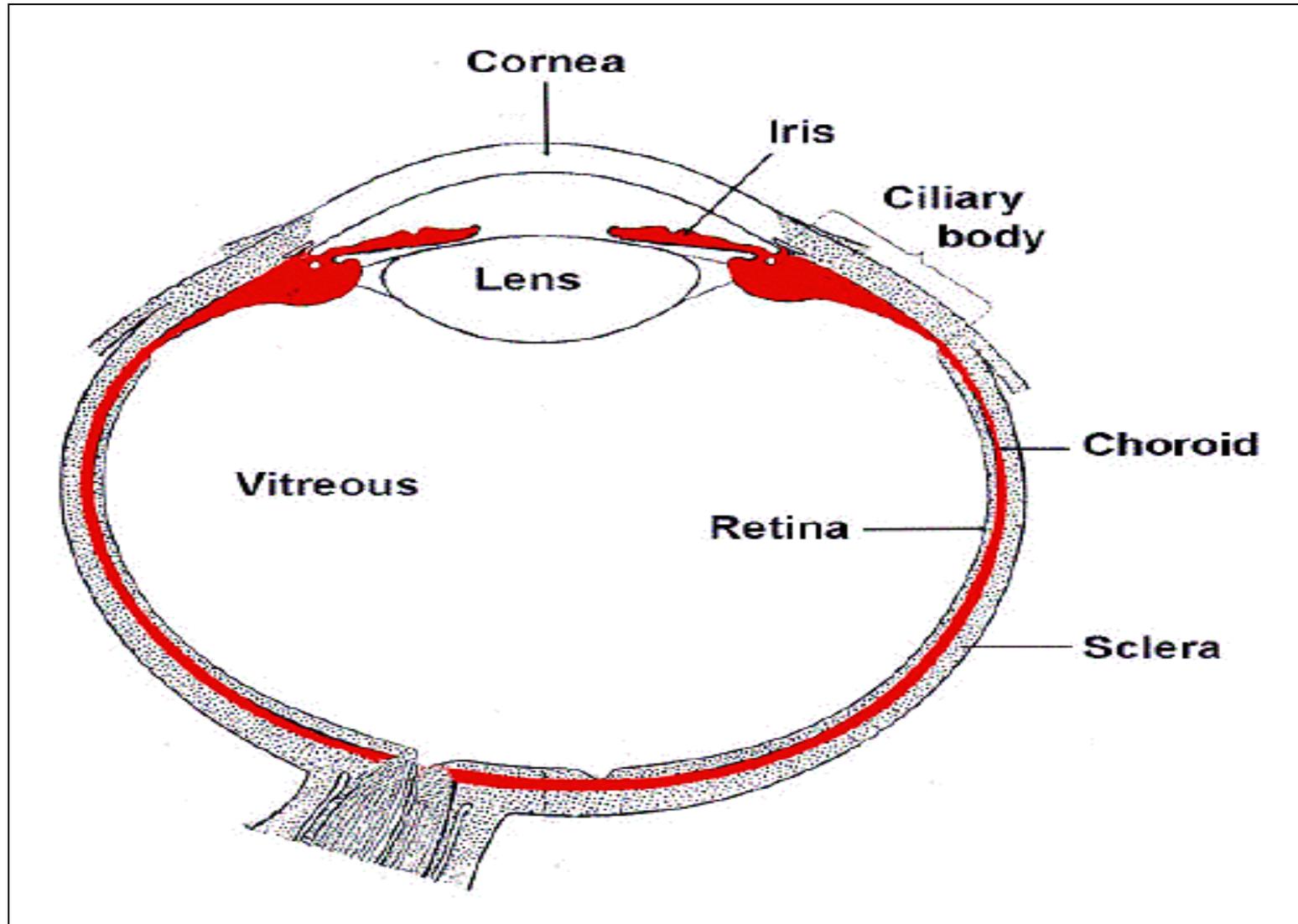
# **The middle (vascular) layer: uvea**

**A- Iris**

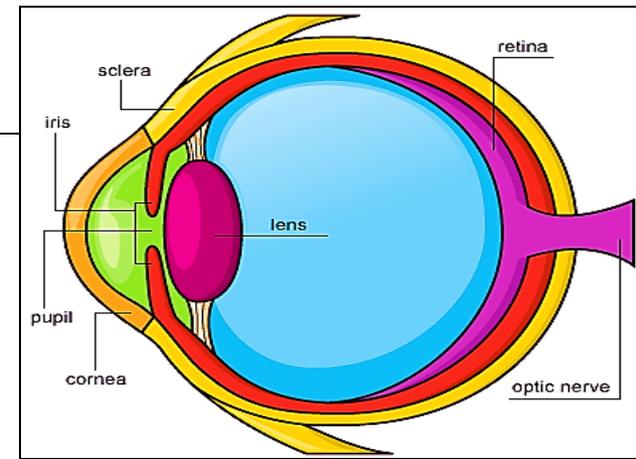
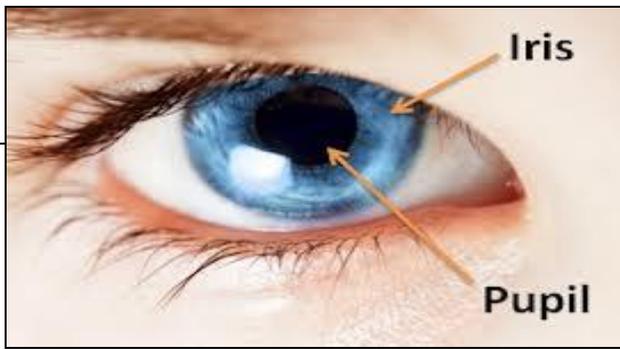
**B- Ciliary body**

**C- Choroid**

# The middle (vascular, muscular, pigmented) layer of the eye



# The Iris



- is the **colored disc** present between the anterior & posterior chambers of the eye (diaphragm of the eye )
- The **pupil** is the round open in the center of the iris
- The iris changes the pupil size to control amount of light & the depth of focus
- Its **posterior surface** share in the formation of aqueous humor

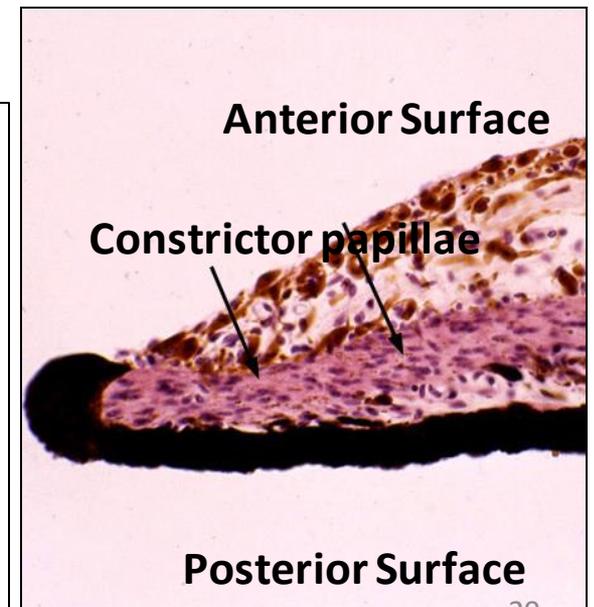
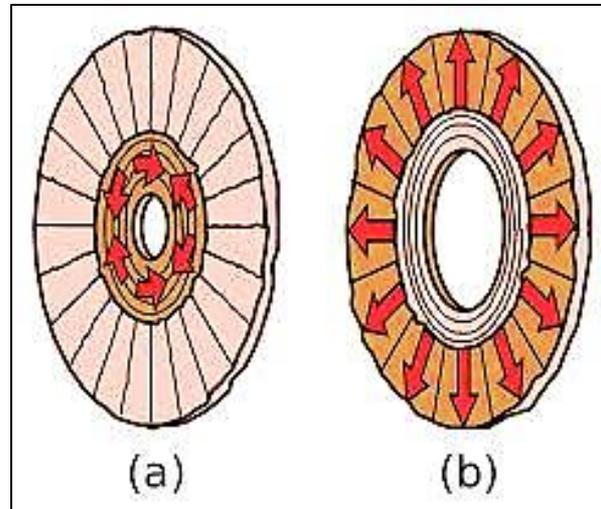
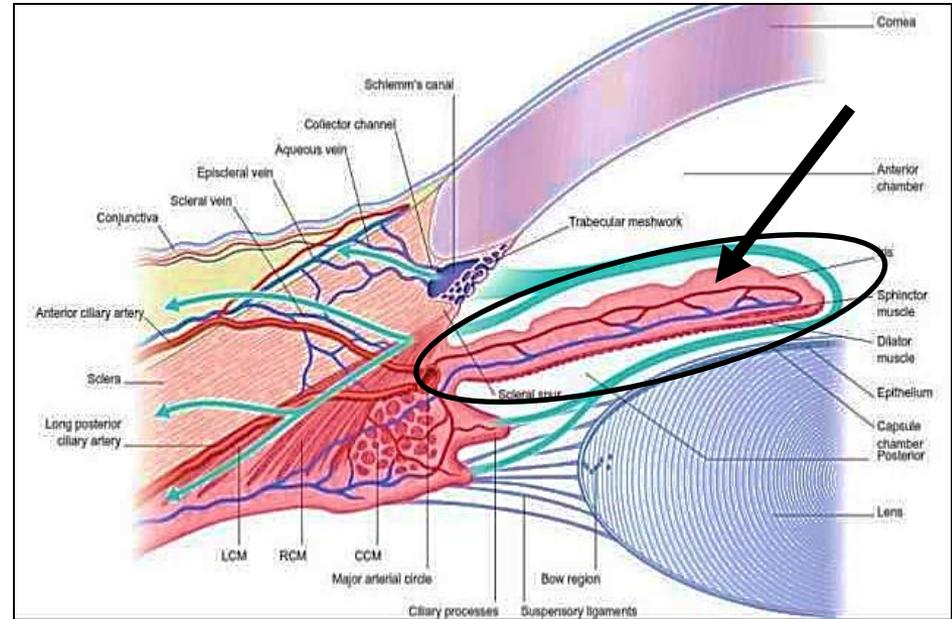
# Structure of the iris

## 1- Anterior surface

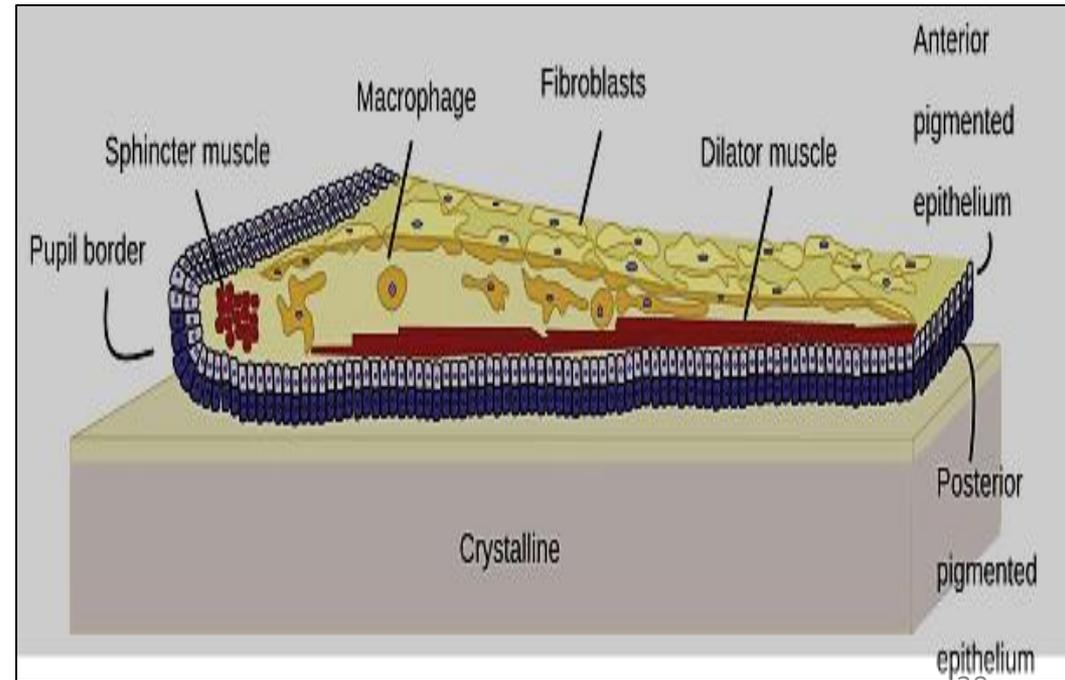
## 2- Stroma

- a. Loose vascular C.T.
- b. Muscles of the iris (2 ms)

## 3- Posterior surface



- **Anterior surface**: lined by **fibroblast & melanocytes**  
is continuous with that covering the posterior surface of the cornea
- **Posterior surface**: made of **2 layers of pigmented cuboidal epithelium** continuous with that covering the Ciliary body, which prevents stray light rays from interfering with image formation

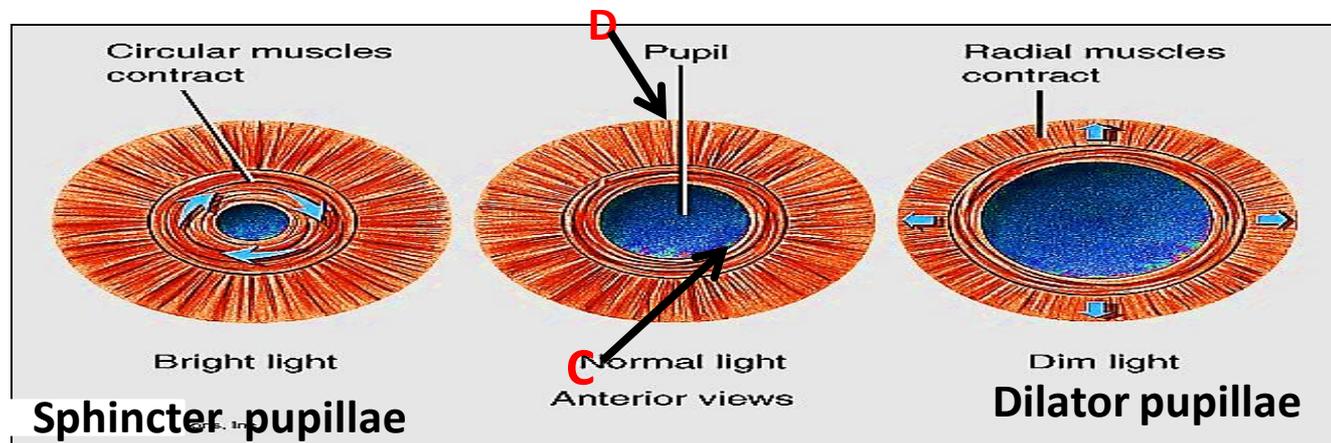


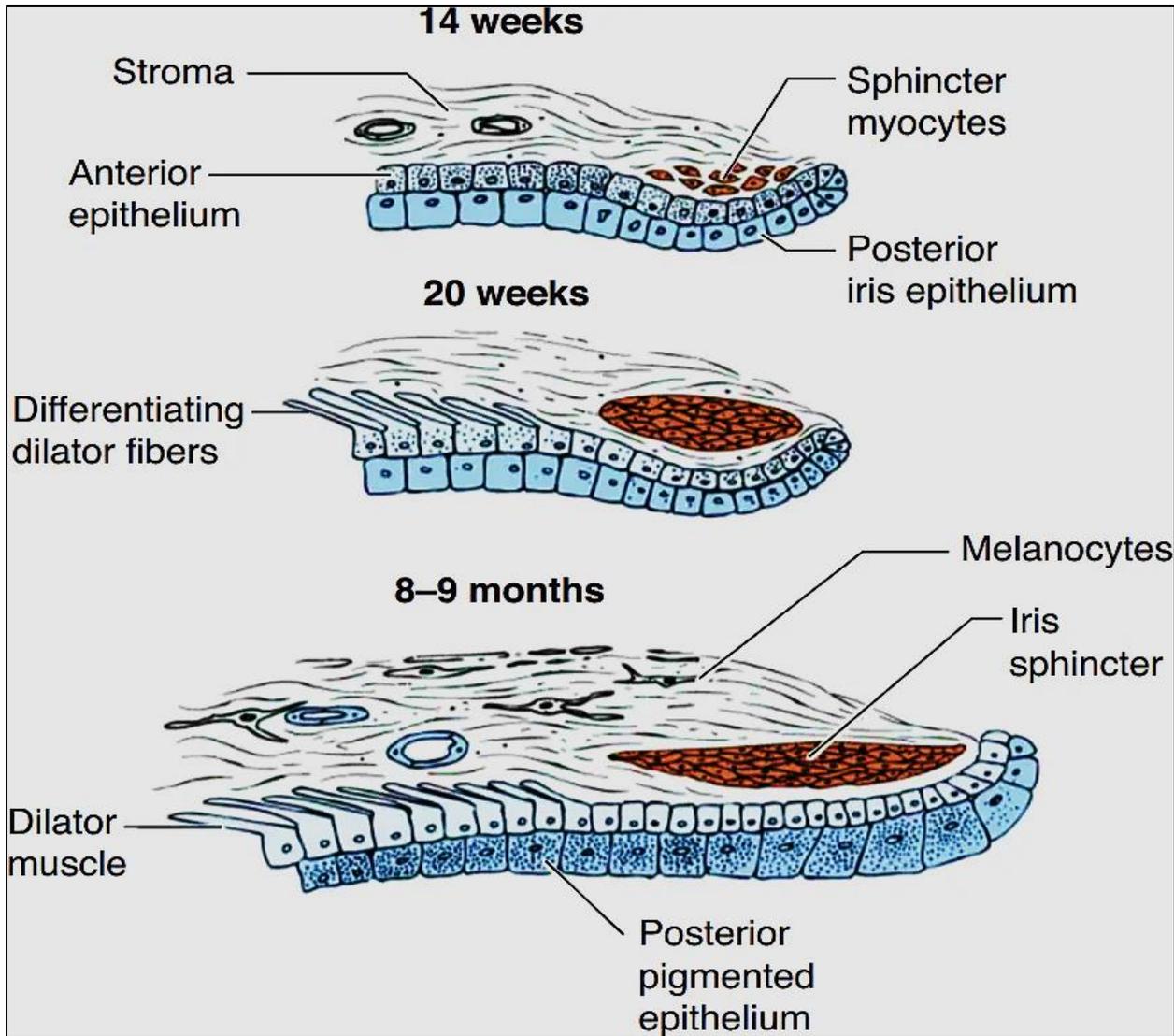
- Inside of iris (Stroma):

- a. *Loose vascular C.T.*, rich in B.V. , fibroblasts, melanocytes

- a. *Muscles of the iris:*

- **The dilator pupillae muscle:** is **myoepithelial cells partially pigmented** **Radially arranged** at the periphery of the iris. Its contraction → dilate pupil ( sympathetic)
    - **The sphincter pupillae muscle:** **circular band of smooth ms**, encircling the pupil. Its contraction → constrict the pupil ... (parasympathetic)

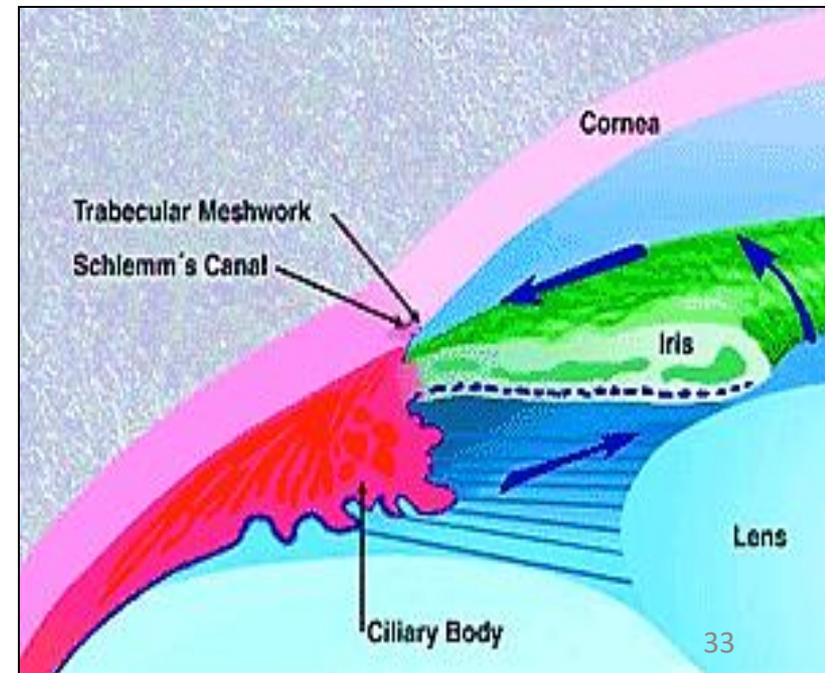




Dilator pupillae muscles are myoepithelial

# The ciliary body

- Is a thick, triangular part at the level of the lens (composed of *Ciliary processes* & *Ciliary muscles*)
- The Ciliary processes are attached to the suspensory ligaments of the lens & its epithelium form aqueous humor
- Ciliary body has 3 functions:
  1. Accommodation
  2. Production of aqueous humour
  3. Maintenance of lens zonules (ligaments)

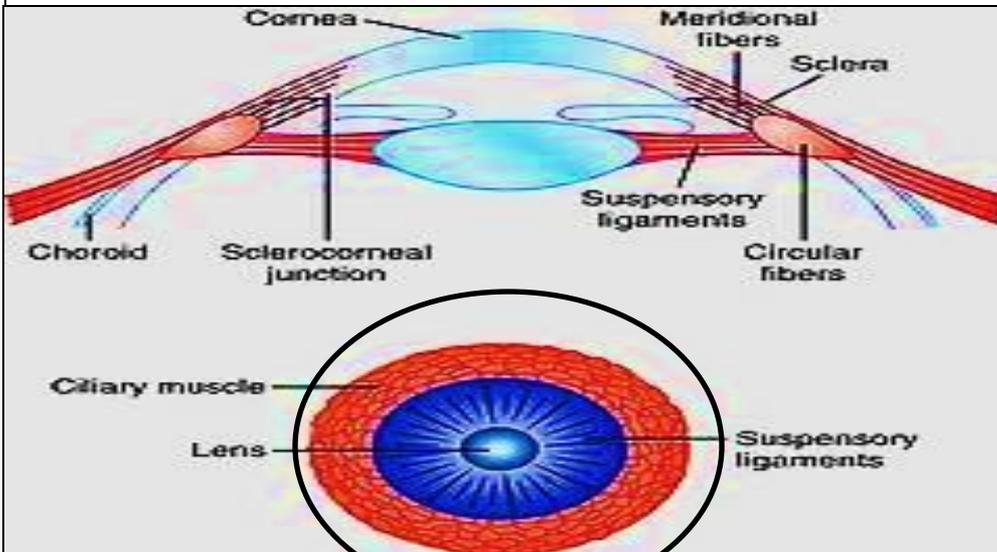
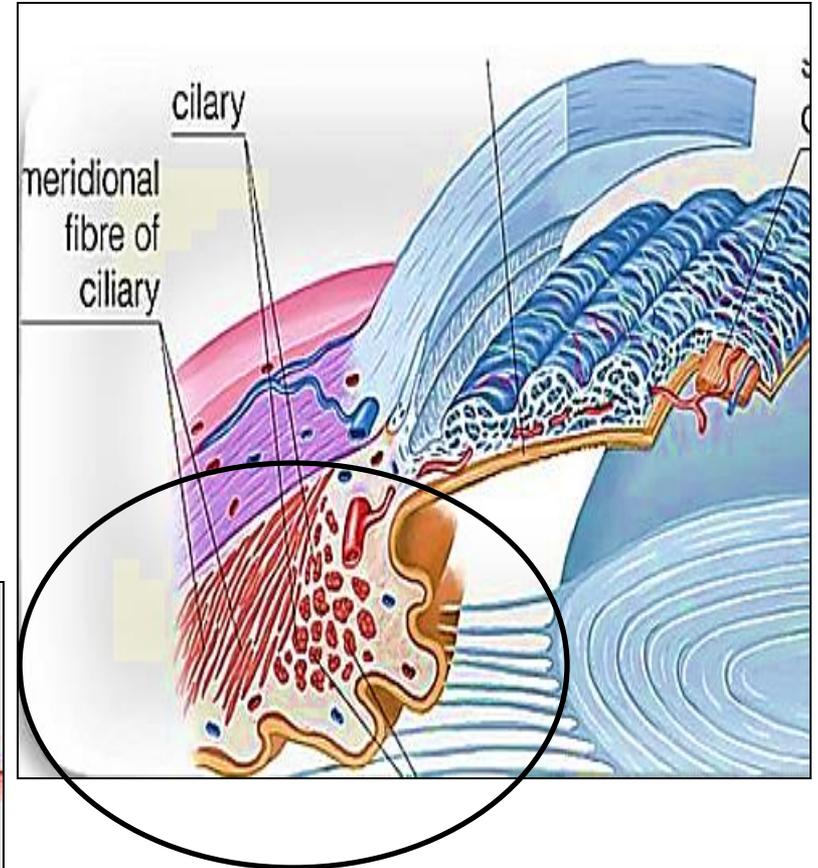


# Histological structure of Ciliary body :

1- The ciliary epithelium

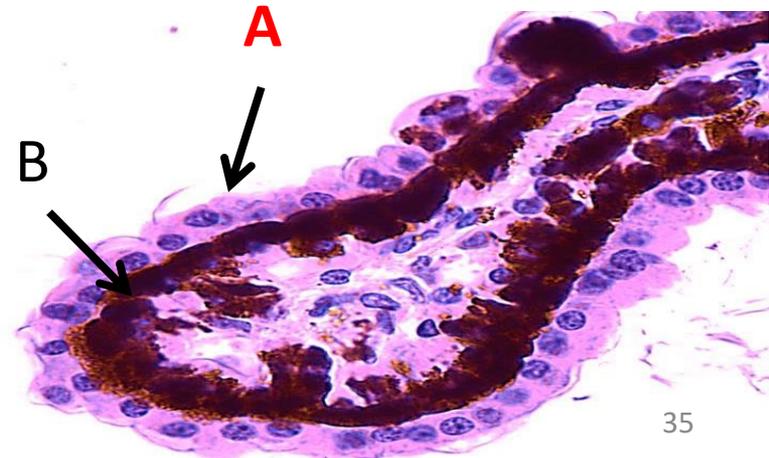
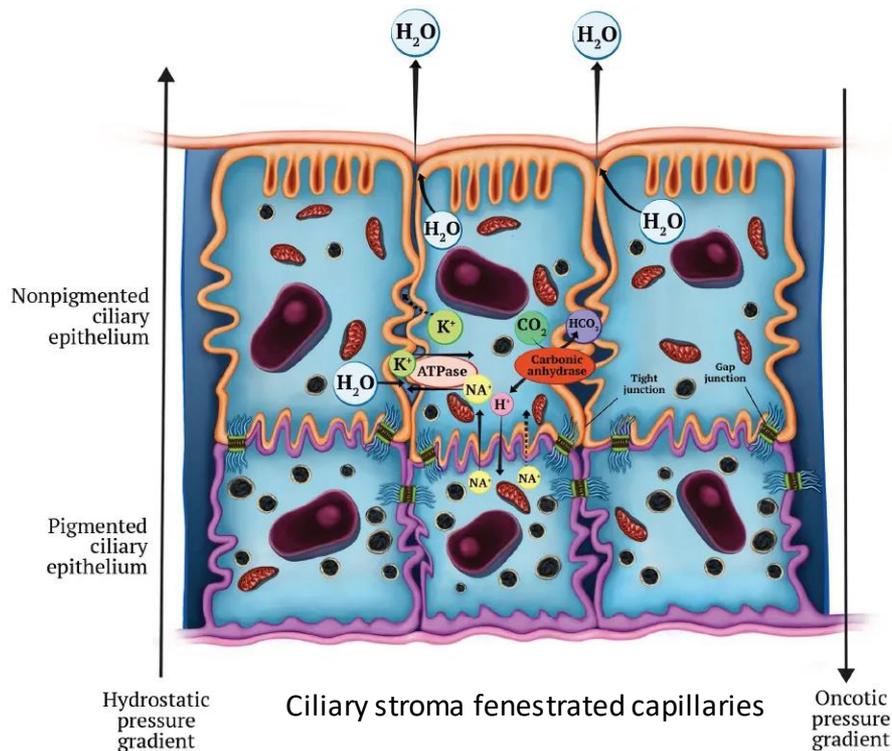
2- Vascular stroma

3- The ciliary muscle



# 1- The ciliary epithelium:

- a) It composed of two layers of cuboidal epithelium.
- b) The surface cell layer is **non-pigmented (A)** ???  
while the deep cell layer is **pigmented (B)** rich in melanin  
& continues with retinal pigmented epithelium
- c) It secretes the **aqueous humor**

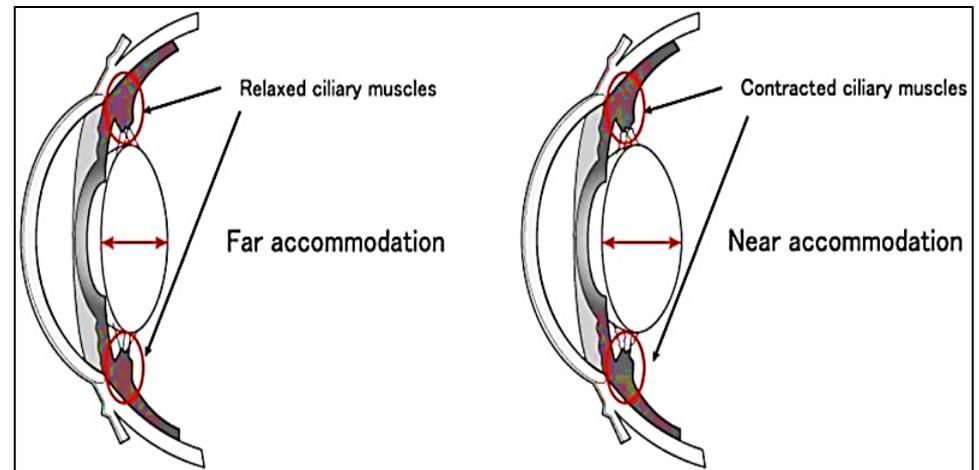
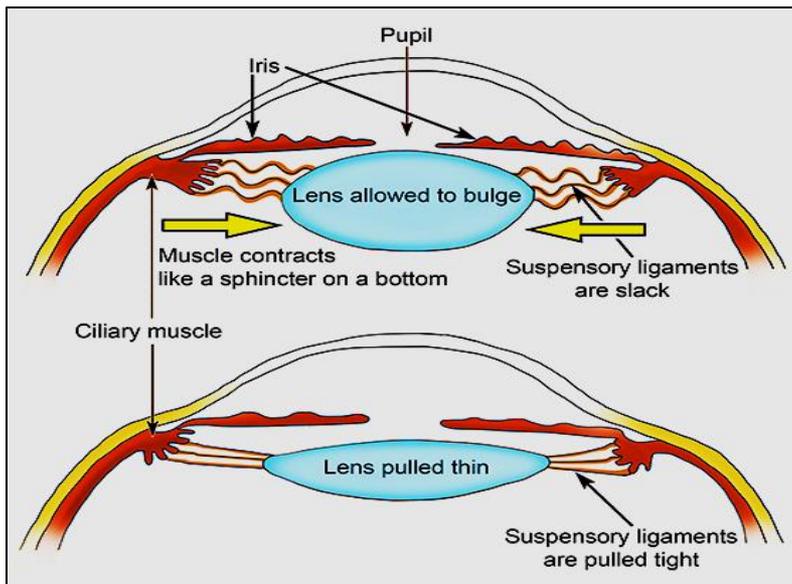


## 2- Stroma:

loose, highly vascular C.T., elastic fibers, & melanocytes

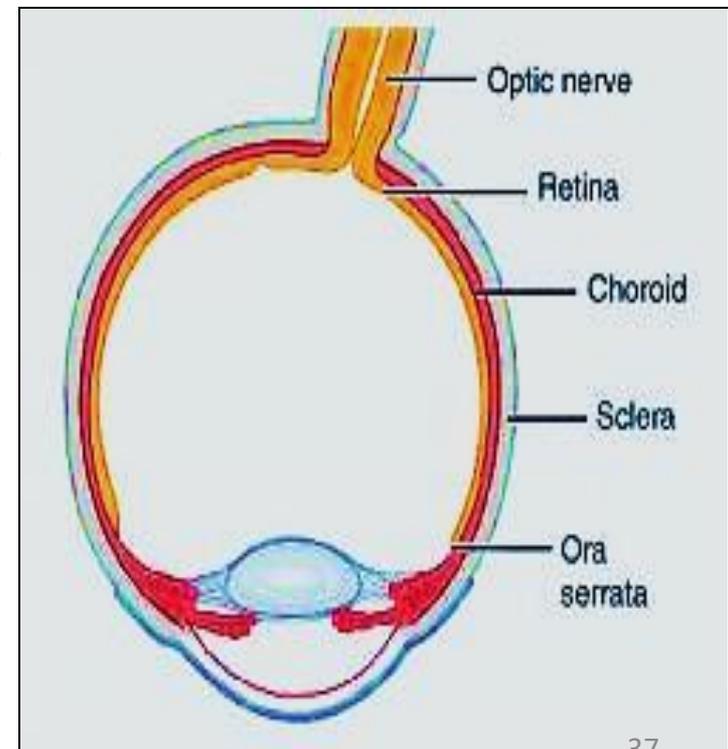
## 3- The ciliary muscle:

- smooth muscles attached to the suspensory ligament of the lens.
- They are responsible for the process of Accommodation



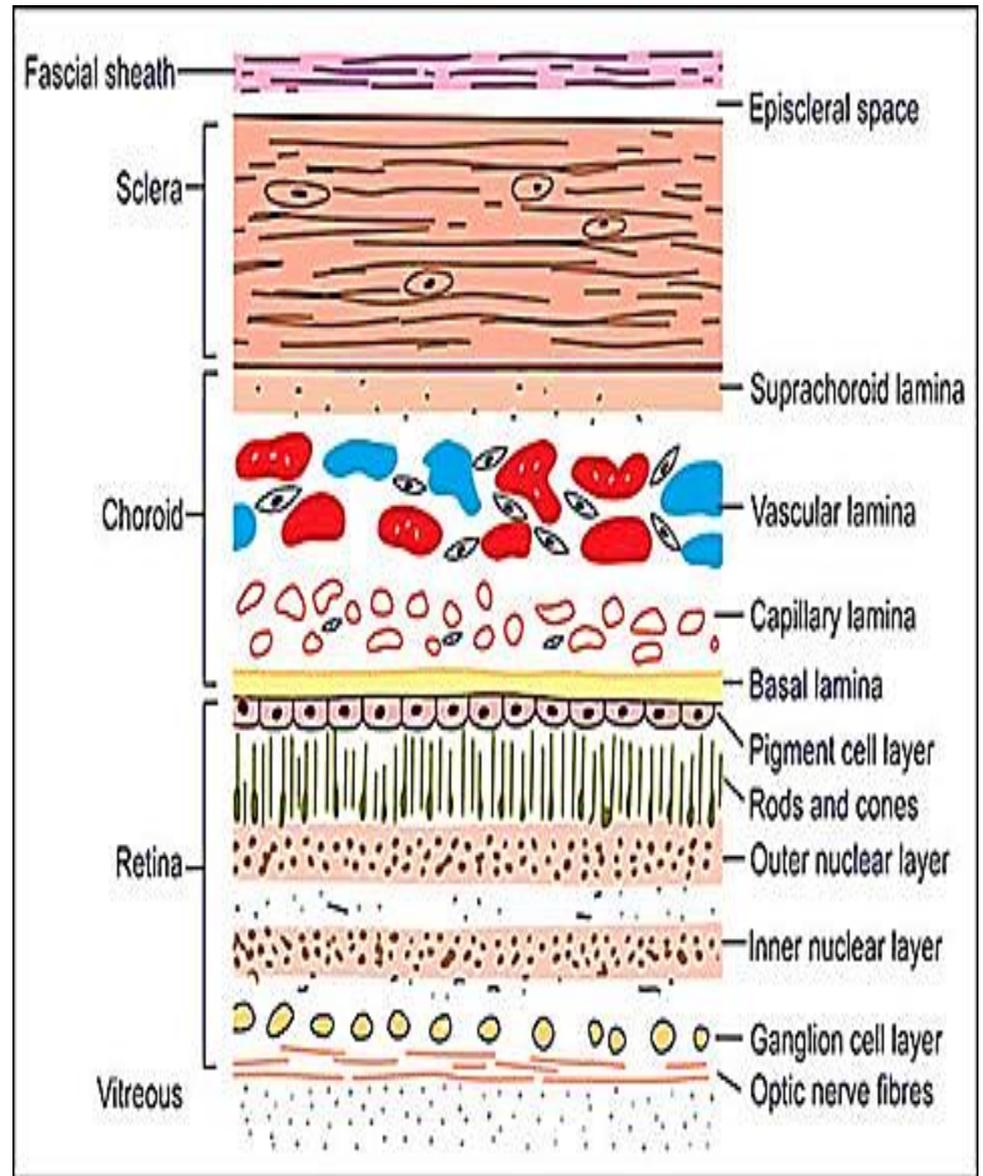
# The choroid

- Is the highly vascular, pigmented part of the uvea. lies posterior to the Ciliary body
- Presents between the sclera & the retina
- Highly pigmented & highly vascular it absorbs light & provides retina with O<sub>2</sub> & nutrients



## Structure of the Choroid

- **Outer layer:** The suprachoroidal lamina (SCL)
- **Middle layer:** The choriocapillary lamina (CCL)
- **Inner layer:** Bruch's membrane



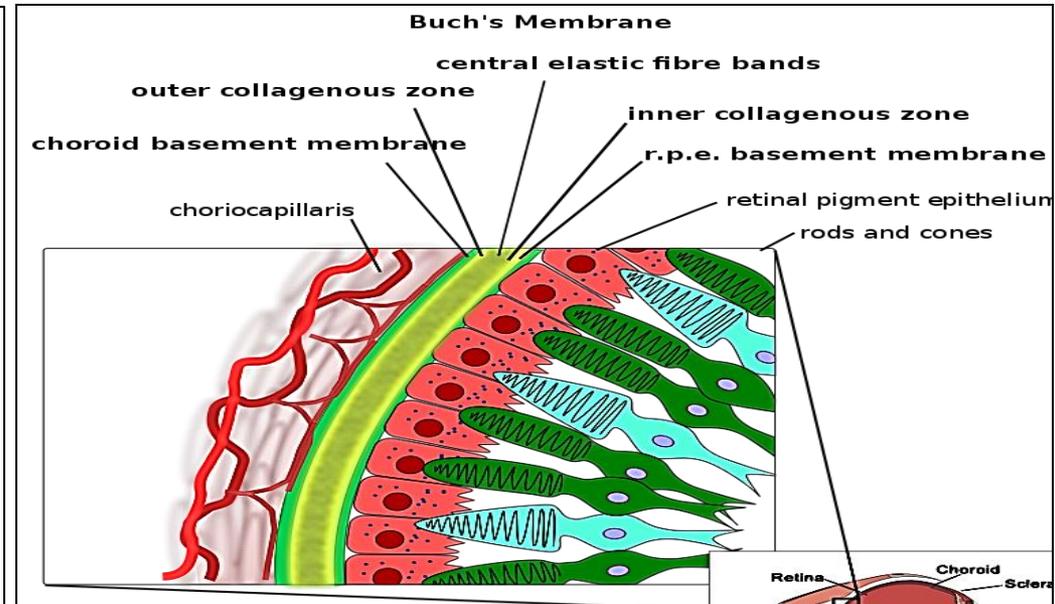
- **The suprachoroidal lamina:** (the outer layer)
  - beneath the sclera
  - Thin, ↑ with melanocytes, fibroblasts & macrophages
- **The choriocapillary lamina:** (the middle layer)
  - dense network of fenestrated capillaries which is essential for nutrition & maintenance of the retina
- **Bruch's membrane :** (the innermost layer – 5 layers)  
A hyaline sheet composed of 5 layers (no cells)

## Layers of Bruch's membrane 5 layers :

1. **Elastic fibers ... middle layer**
2. **Collagen fibers .. on each side of the elastic fiber**
3. **Basal lamina of endothelial cells of chorio- capillary B.V. at one side**
4. **Basal lamina of pigmented epithelium of the retina on the other side**

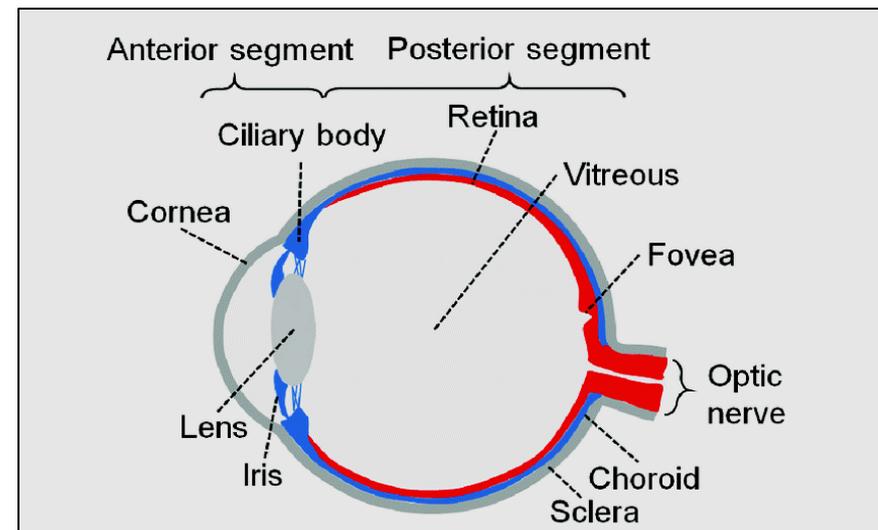
- ✓ Is inner most layer of the choroid
- ✓ Acts as a blood-retinal barrier
- ✓ Acts as a support structure to the choroid - the vascular layer The RPE transports metabolic waste from the photoreceptors across Bruch's membrane to the choroid.

**Bruch's membrane gets thicker as we get older.** This may **impede some of the transportation of waste material** which can cause a build up of deposits. The thickening also prevents nutrients and oxygen from being delivered to the retina



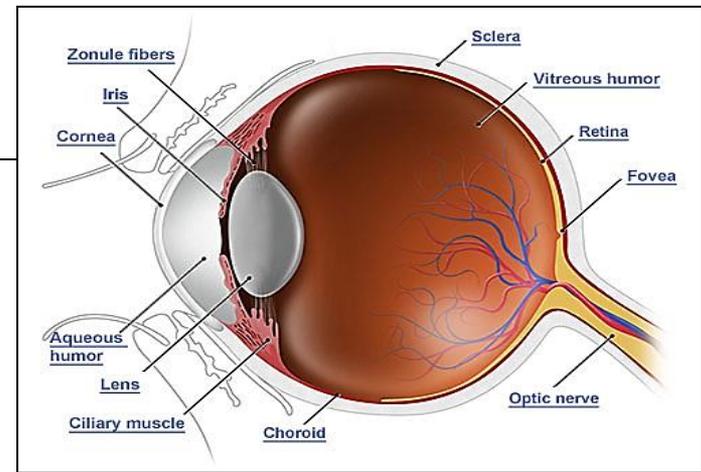
# chambers of the eye

- **Anterior chamber:** between the cornea & iris contains Aqueous humor
- **Posterior chamber:** between the iris & lens contains aqueous humor
- **The vitreous chamber:** between the lens & retina contains transparent, colorless gelatinous mass called vitreous body  
Eye floaters ....?

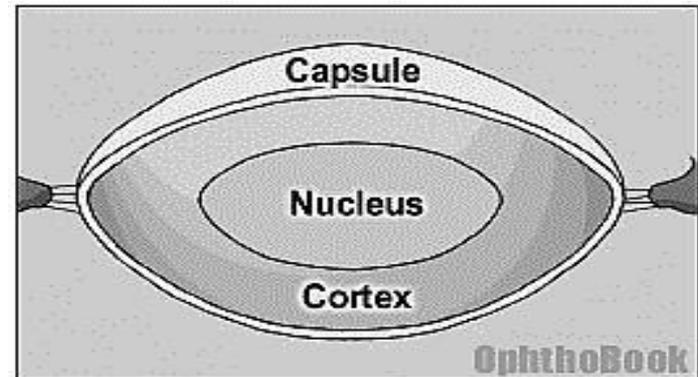


# The lens

- Is transparent, avascular, lacks nerves, biconvex disc, behind the pupil



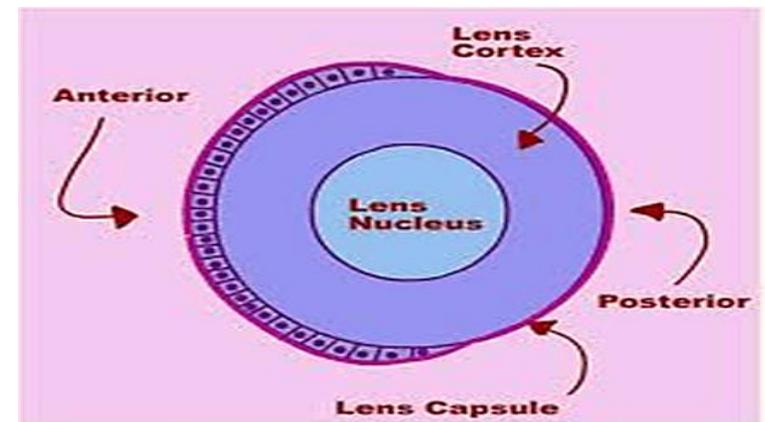
- Attached to the Ciliary body by **zonule** (suspensory ligament of lens)
- Lens composed of 3 parts :  
*capsule, cortex, nucleus*



- The capsule is transparent, surrounds the lens completely, elastic & is composed of **type IV collagen**. It is synthesized by the lens epithelium

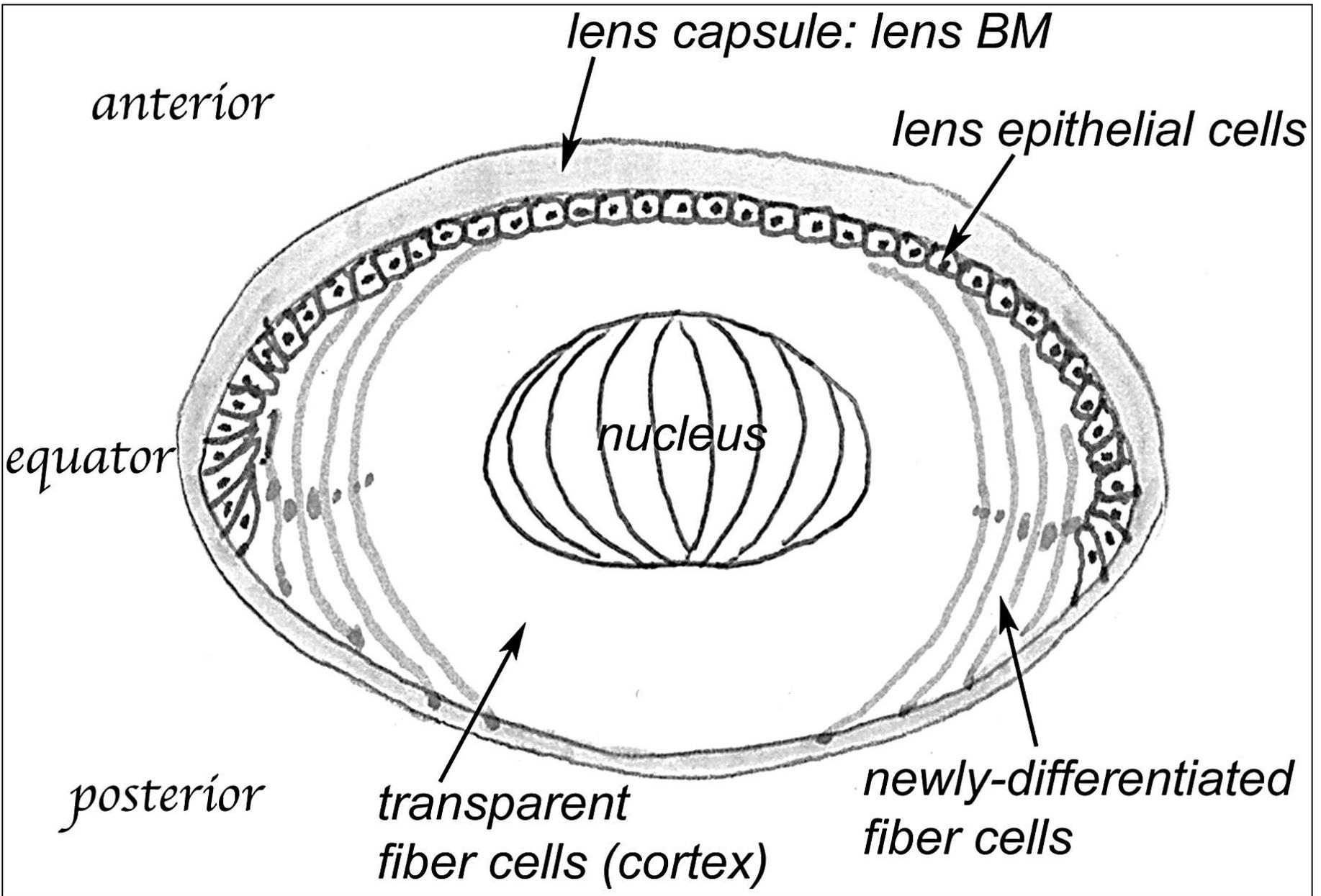
## Structure of the lens:

- I. Capsule
- II. Subcapsular (lens) epithelium
- III. Lens fibers



- **Lens epithelium:** single layer of cubical cells covers the anterior & lateral surfaces of the lens located between the lens capsule & cortex (lens fibers) = subcapsular
- The lens epithelium regulate most of the homeostatic functions of the lens, providing the lens fibers with nutrients and removing
- The lens epithelium also serve as the progenitors for new lens fibers

- The lens fibers **form the bulk of the lens** (cortex). They are long, thin cells, which lost their nuclei & organelles and change to transparent fibers contain only microtubules & ribosomes.
- Mature lens fibers have no organelles or nuclei
- the fibers filled with proteins ( Crystallins) which highly **specialized for light reflection**
- The lens fibers stretch lengthwise from the posterior to the anterior poles and. If cut along the equator, it appears as a honeycomb.
- The lens lays down fibers from when it first forms in embryo until death.

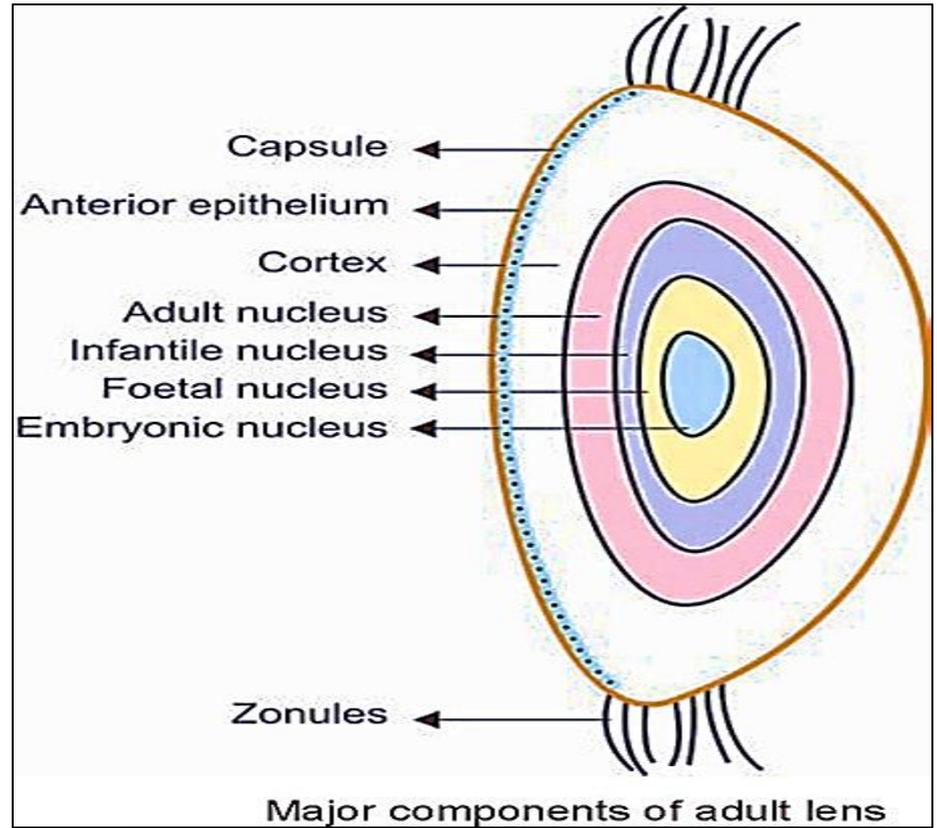


**(Lens fibers)**

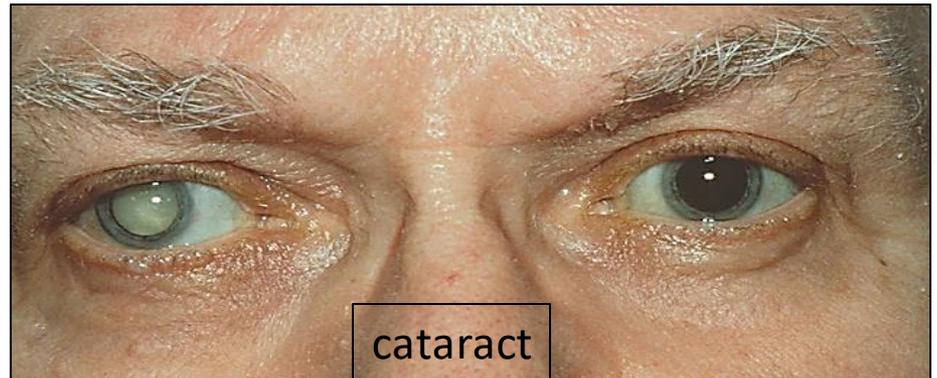
The lens is divided into regions depending on the *age of the lens fibers*.

Layers from in to out:

- Embryonic nucleus
- Fetal nucleus
- Infantile nucleus
- Adult nucleus then outer cortex.



Arrangement of layers lens nucleus

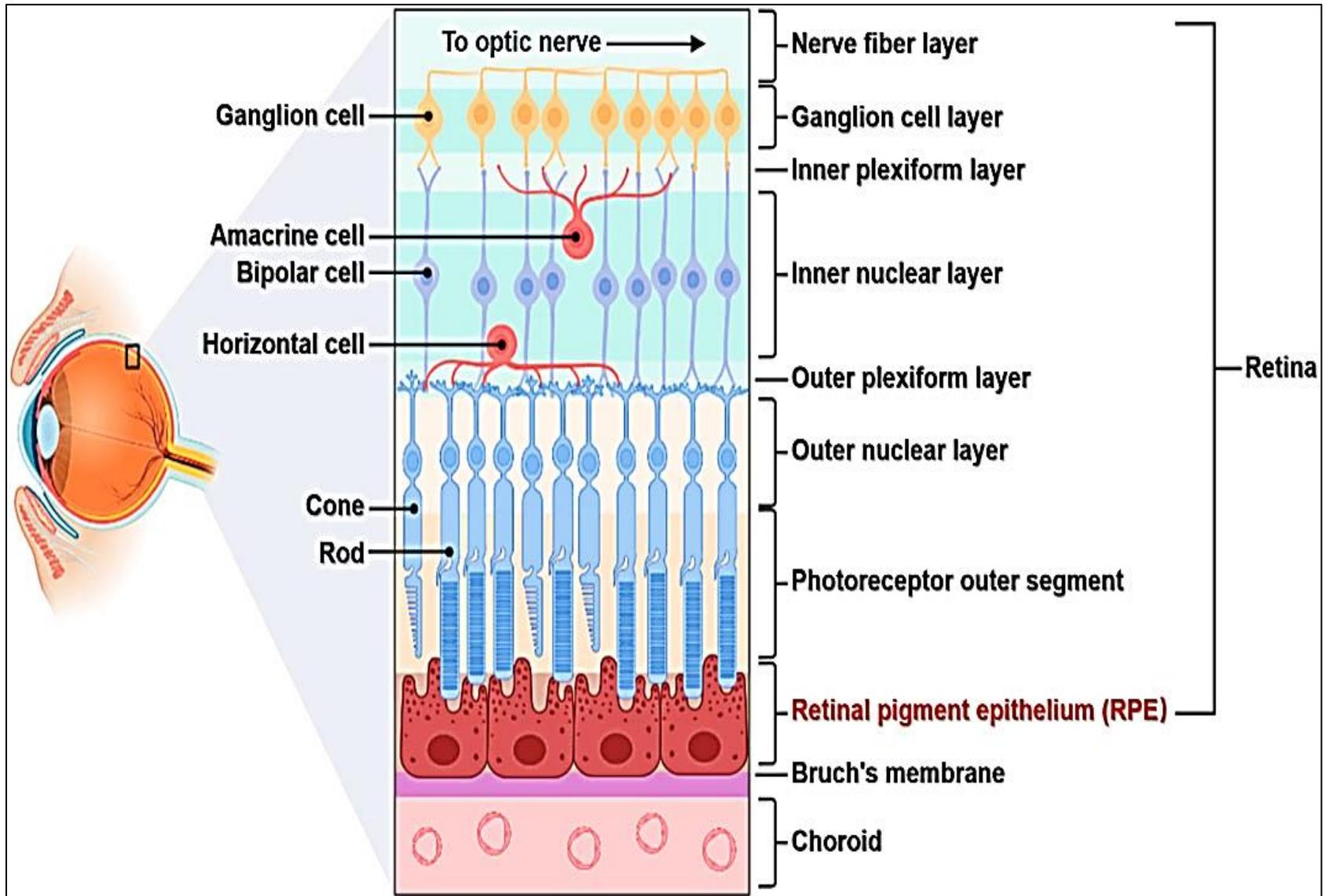


**The inner ( nervous ) layer**

**The retina**

# The retina

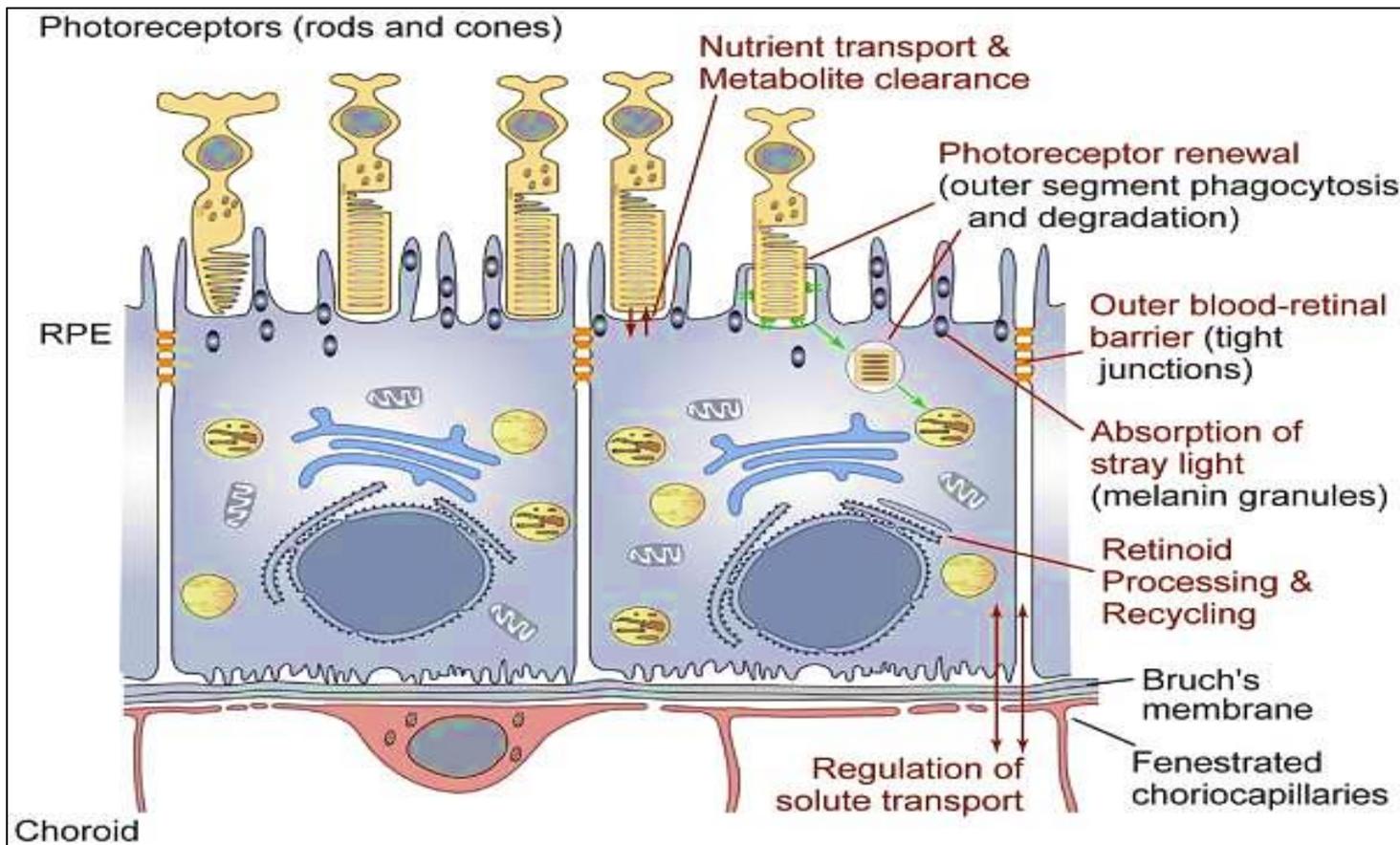
- is the inner most layer , responsible for Photoreception
- Composed of 2 layers : pigmented epith. & photosensitive layers
- Photosensitive layers consists of layers of neurons interconnected with each other by synapses
- It contains the **photoreceptor cells** : **Rods** & **Cones**
- **Rods** function mainly in dim light and black & white vision
- **Cones** support day time and the perception of color vision



The retina

## 1- Pigmented epithelium:

- Single layer of cuboidal cells e basal rounded nuclei their basal surface attached to the Bruch's membrane of choroid
- Their apical surface has many microvilli which interdigitate with the tips of rods & cones (**Retinal detachment**)
- They contains numerous melanin granules
- The lateral membrane of adjacent cells shows tight junctions together with Bruch's membrane form blood-retinal barrier
- Their cytoplasm contains mitochondria, **phagocytic vacuoles**, **2ry lysosomes**, sER



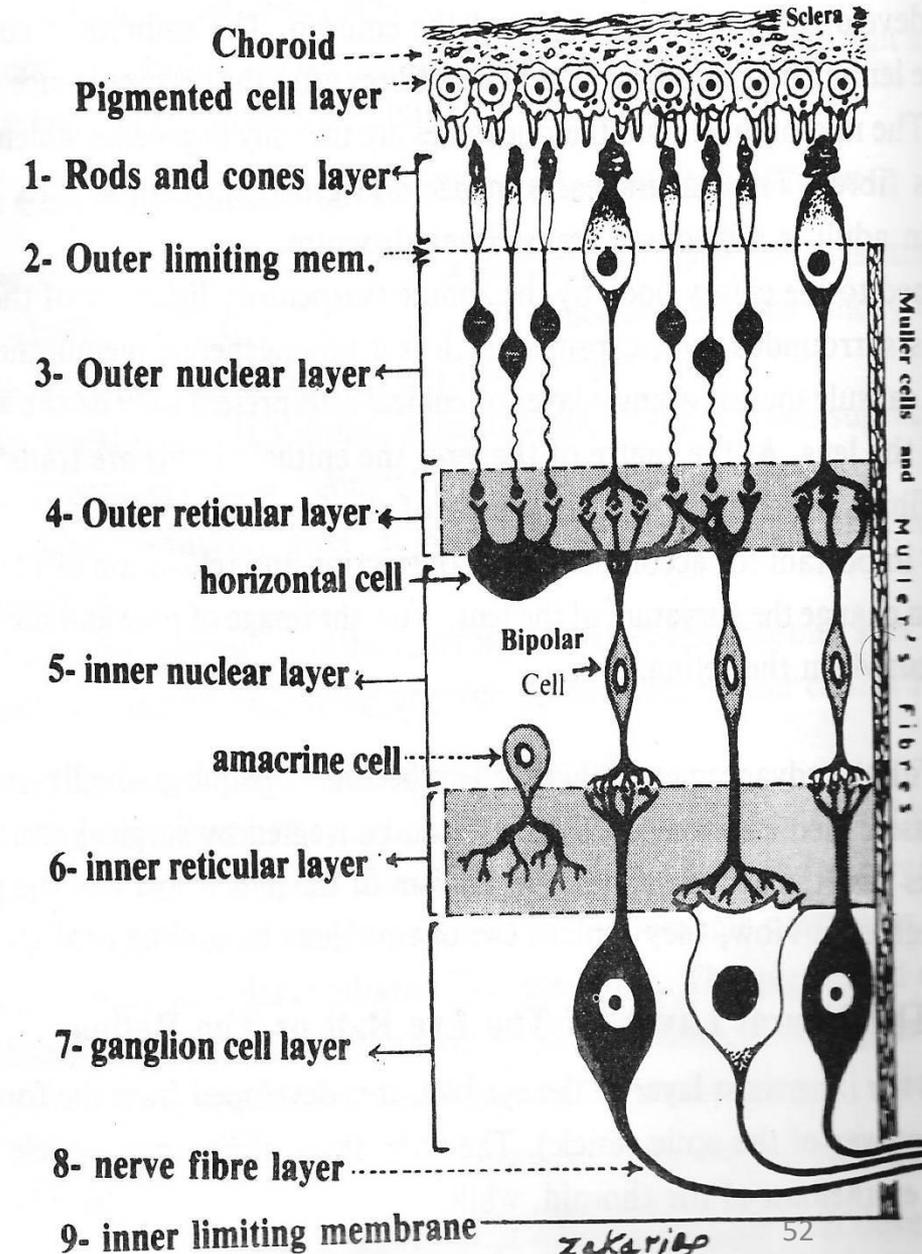
## Function of Pigmented epithelium:

- Form a dark layer that absorb light & prevent glaring (melanin G)
- Store , release, transport **vit. A** to rods & cones
- Form the blood –retinal barrier
- Phagocytize old discs present at the tips of rods & cones

## Layers of the retina (10):

1. pigmented epithelium
2. Rods & cones layer
3. Outer limiting membrane
4. Outer nuclear layer
5. Outer plexiform layer
6. Inner nuclear layer
7. Inner plexiform layer
8. Ganglion layer
9. Optic nerve layer
10. Inner limiting membrane

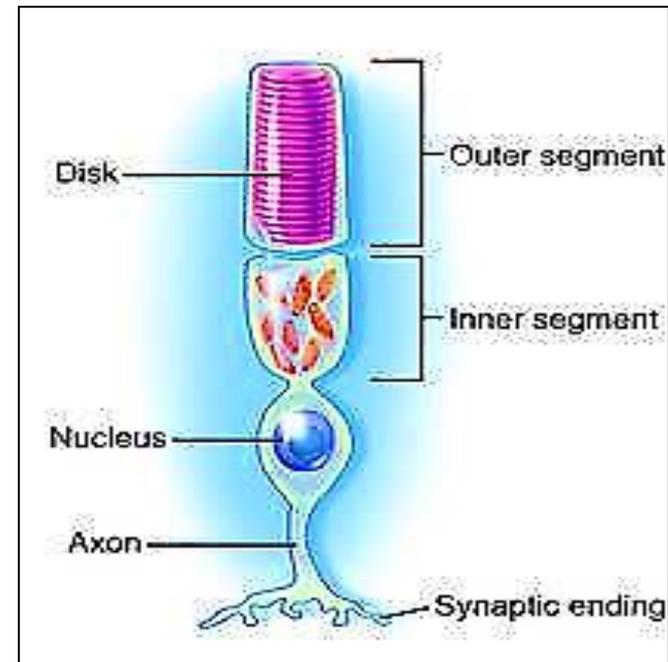
## 1- The Retina



## 2- Rods & Cones layer: photoreceptors

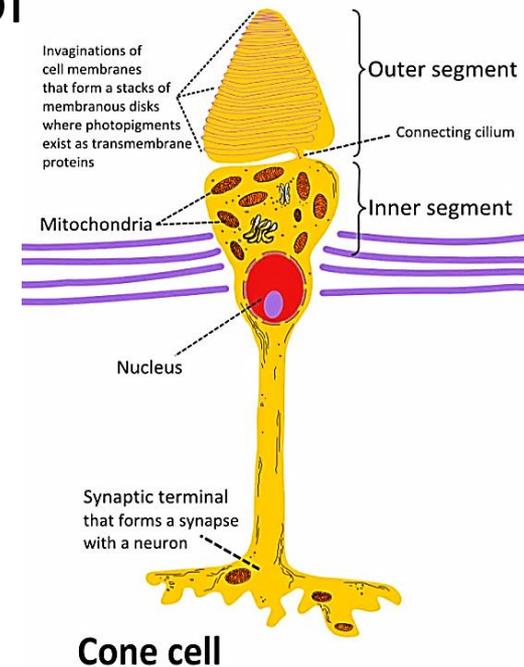
### a- Rods : dim light vision (↑ in #)

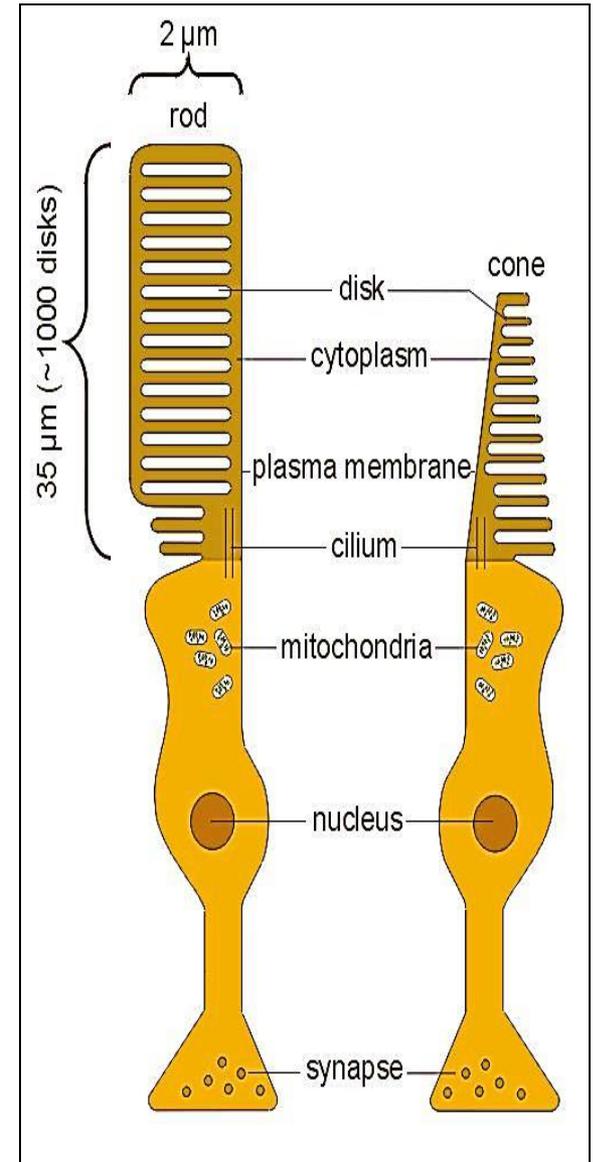
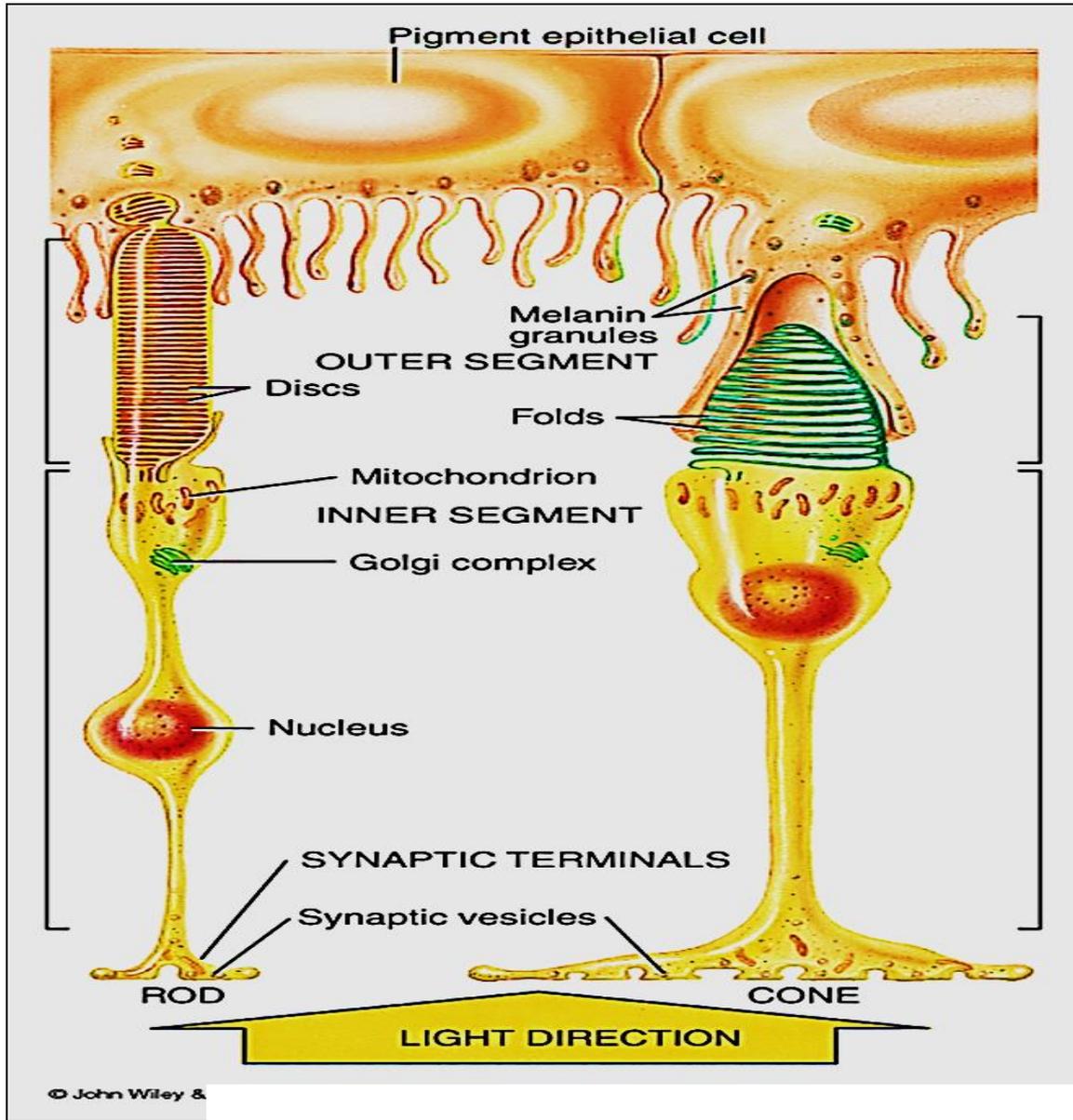
- **Outer thin segment**: contains transverse discs filled with Rhodopsin, discs are continuously renewed & separated from cell membrane
- **Connecting stalk**: contain modified cilium
- **Inner segment**: contains cell organelles that form the Rodopsin
- **Cell body**: contains nucleus
- **Synaptic region**: which synapse with bipolar nerve cells & horizontal cells



## b- Cones : bright light & color vision

- **Outer cone shaped segment**: contains flat discs which contains iodopsin pigment. These discs are infolding of cell membrane
- **Connecting stalk**: contains cilium
- **Inner segment** : contains all cell organelles & forms iodopsin
- **The nuclei** of cones are arranged in one horizontal level near the outer limiting membrane
- **Synaptic region** :which synapse with bipolar nerve cells & horizontal cells





**Structure of rods and cones**

### 3- outer limiting membrane

Dark line represent junctional complexes between processes of Muller cells ( glial cells) & the photoreceptors

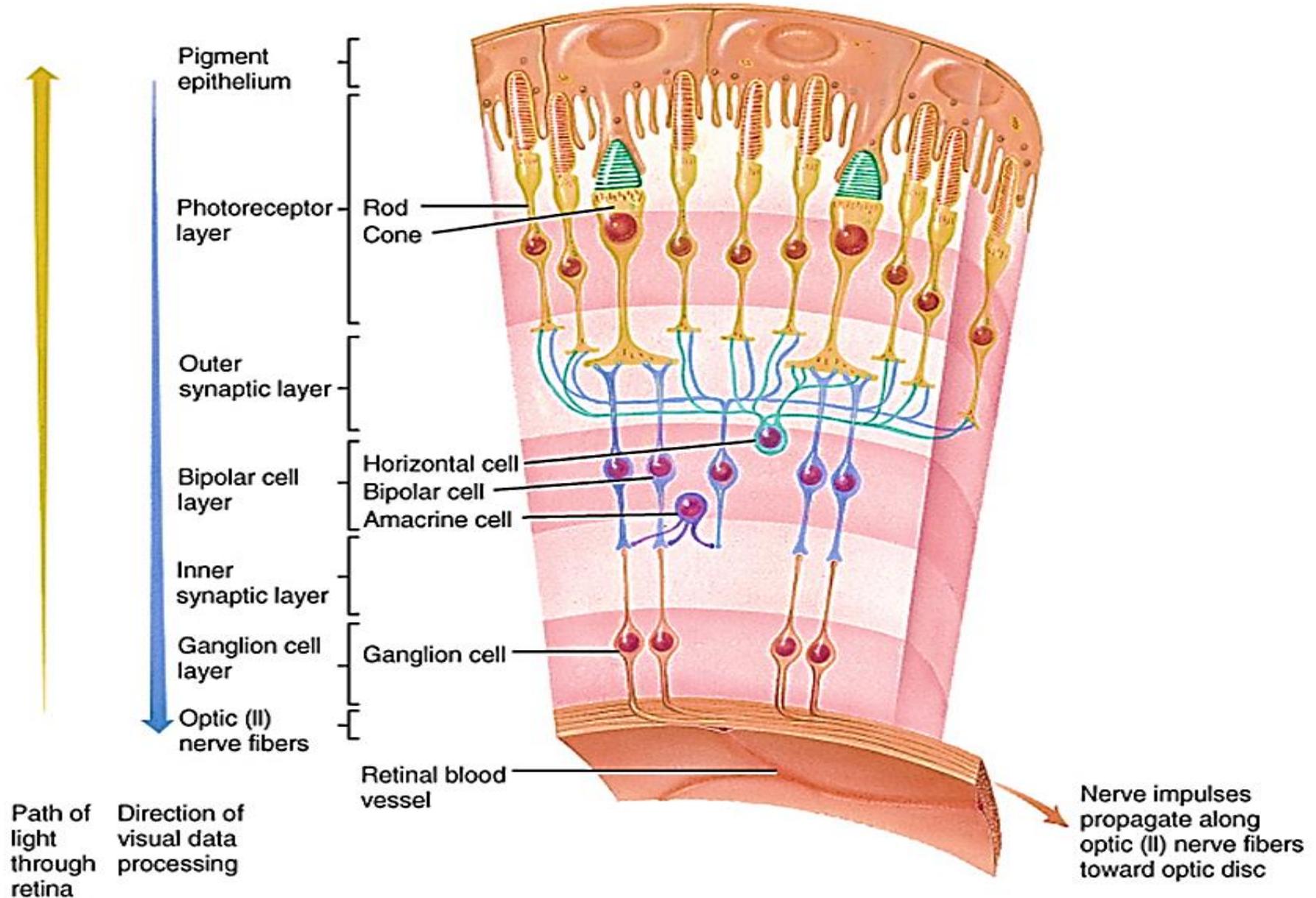
### 4- outer nuclear layer:

Contains the cell bodies of rods & cones

### 5- outer plexiform layer:

contains the synapses between synaptic processes of rod & cone cells and the dendrites of the bipolar & horizontal cells

# sclera



6- Inner nuclear layer: contains the cell bodies of 4 cells:

- **Bipolar nerve cells** (**1<sup>st</sup> order neuron**) : its dendrites synapse with the synaptic processes of rods & cones
- **Horizontal cells:** large branched cells, interconnect the synaptic terminals of **rods & cones** with **bipolar cells**
- **Amacrine cells:** interconnect axons of **bipolar nerve** cells & dendrites of **ganglion cells**
- **Muller cells:** **neuroglia**, their processes extend from the inner limiting membrane to the outer limiting membrane

## 7- inner plexiform layer:

- contains synapses between axons of bipolar nerve cells & dendrites of ganglion cells which also synapses with amacrine cells

## 8- ganglion layer (RGCs):

- Ganglion cells (**2<sup>nd</sup> order neuron**), are nerve cells with vesicular nuclei & basophilic cytoplasm. Their dendrites synapse with axons of bipolar cells . End at LGN
- Their axons form the fibers of **optic nerve**. Retinal B.V. present between ganglion cells

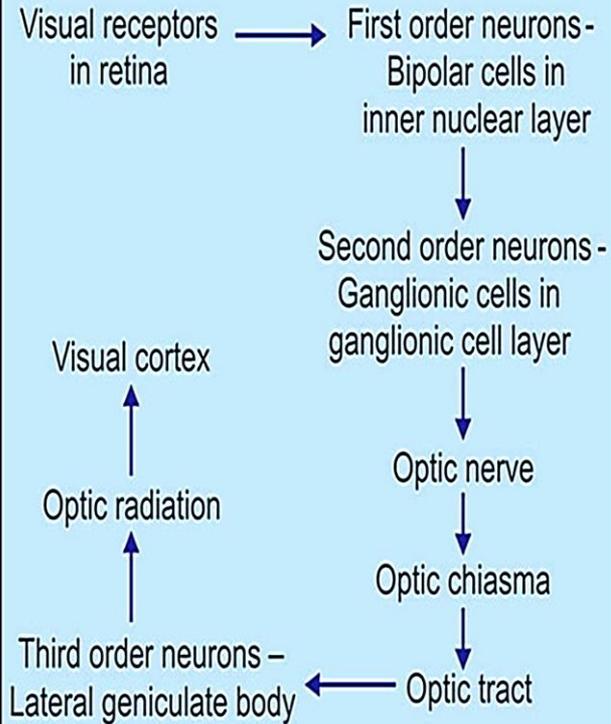
## 9- optic nerve layer:

- The axons of ganglion cells pass at right angle to form optic nerve. The optic nerve fibers are non myelinated at their origin , then they become myelinated after they traverse the sclera

## 10- inner limiting membrane:

- Dark line formed by terminal processes of Muller cells
- Optic nerve → optic chiasma → optic tract → Lateral geniculate body ( 3<sup>rd</sup> order neuron) → optic radiation → visual cortex

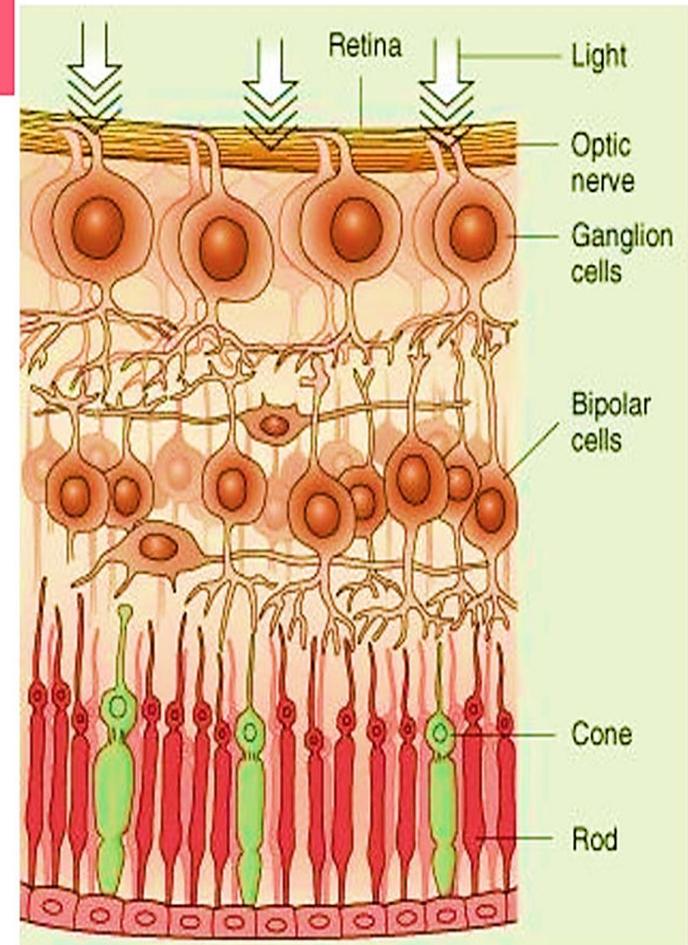
# Visual Pathway



➤ **Photoreceptors:**  
Rods & Cones of retina

➤ **3 neuron pathway**

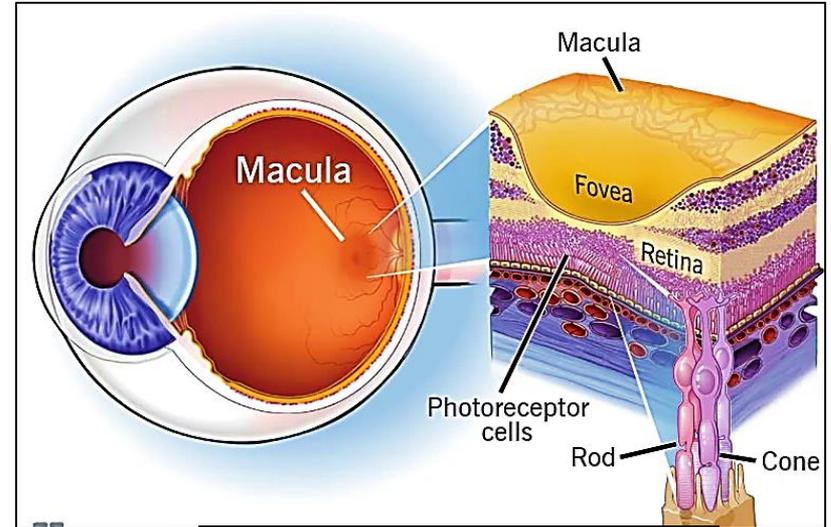
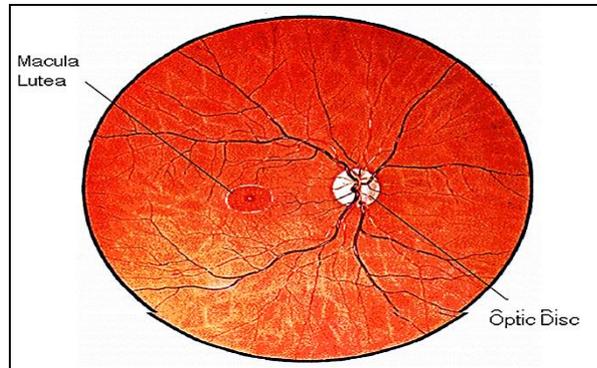
- **1<sup>st</sup> order neurons:**  
Bipolar cells of retina.
- **2<sup>nd</sup> order neurons:**  
Ganglion cells of retina. Their axons form the **optic nerve**
- **3<sup>rd</sup> order neurons:**  
Neurons in the lateral geniculate body. Their axons terminate in **primary visual cortex**.





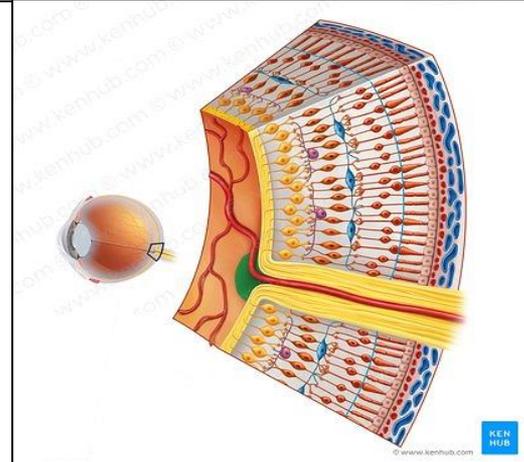
## Fovea centralis:

- It is the area of **highest visual acuity** (sharp vision)
- Is a central shallow depression of **macula** of the retina
- Lacks retinal blood vessels
- Contains Cones only



## Optic disc ( blind spot):

- has no photoreceptors .
- Consists of optic nerve fibers

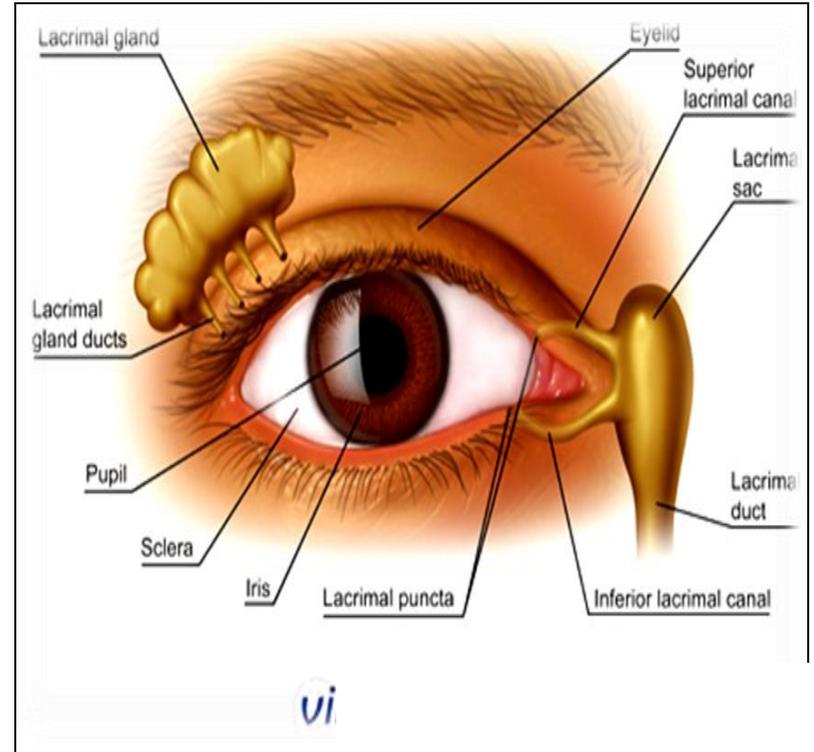


# Accessory structures of the eye

1- the conjunctiva

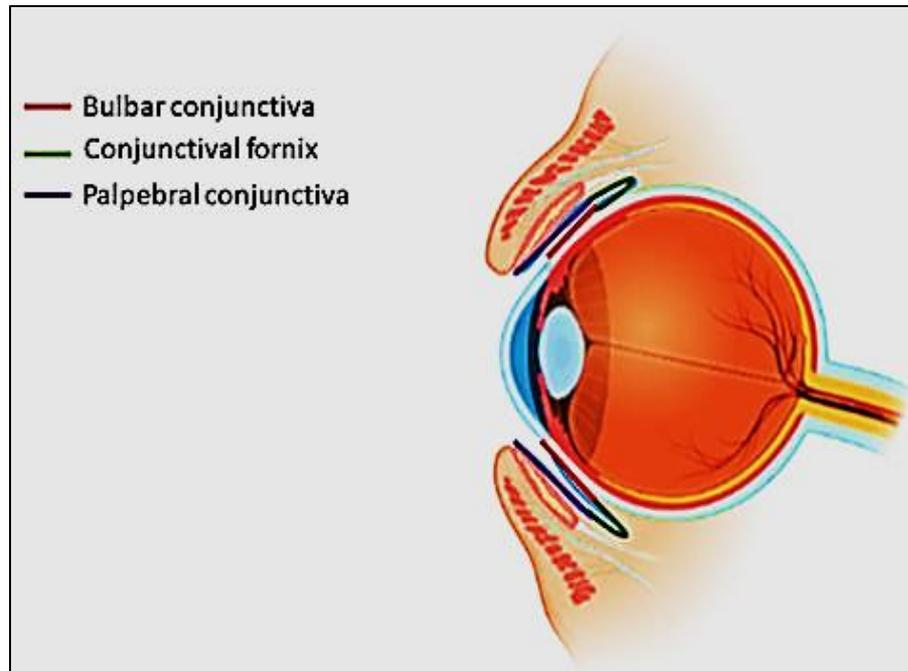
2- the eye lids

3- the lacrimal apparatus



# Conjunctiva

- Very thin transparent mucus membrane
- Covers the anterior part of the eye except the cornea & lines internal surface of the eye lids

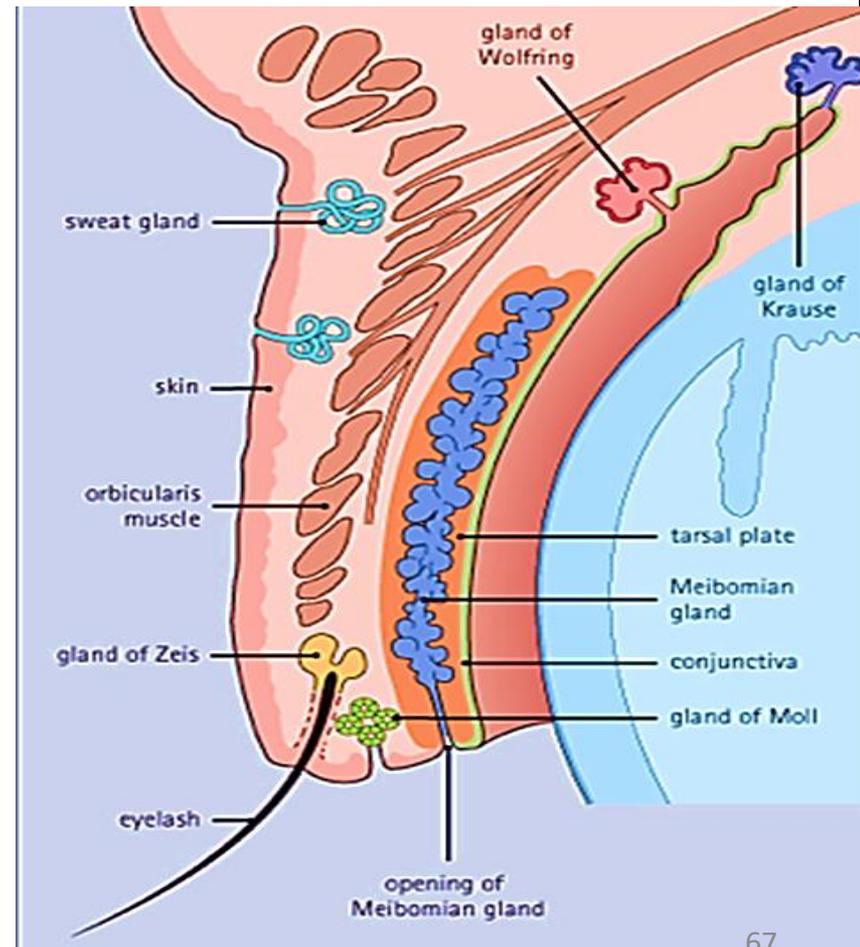


## Parts of conjunctiva:

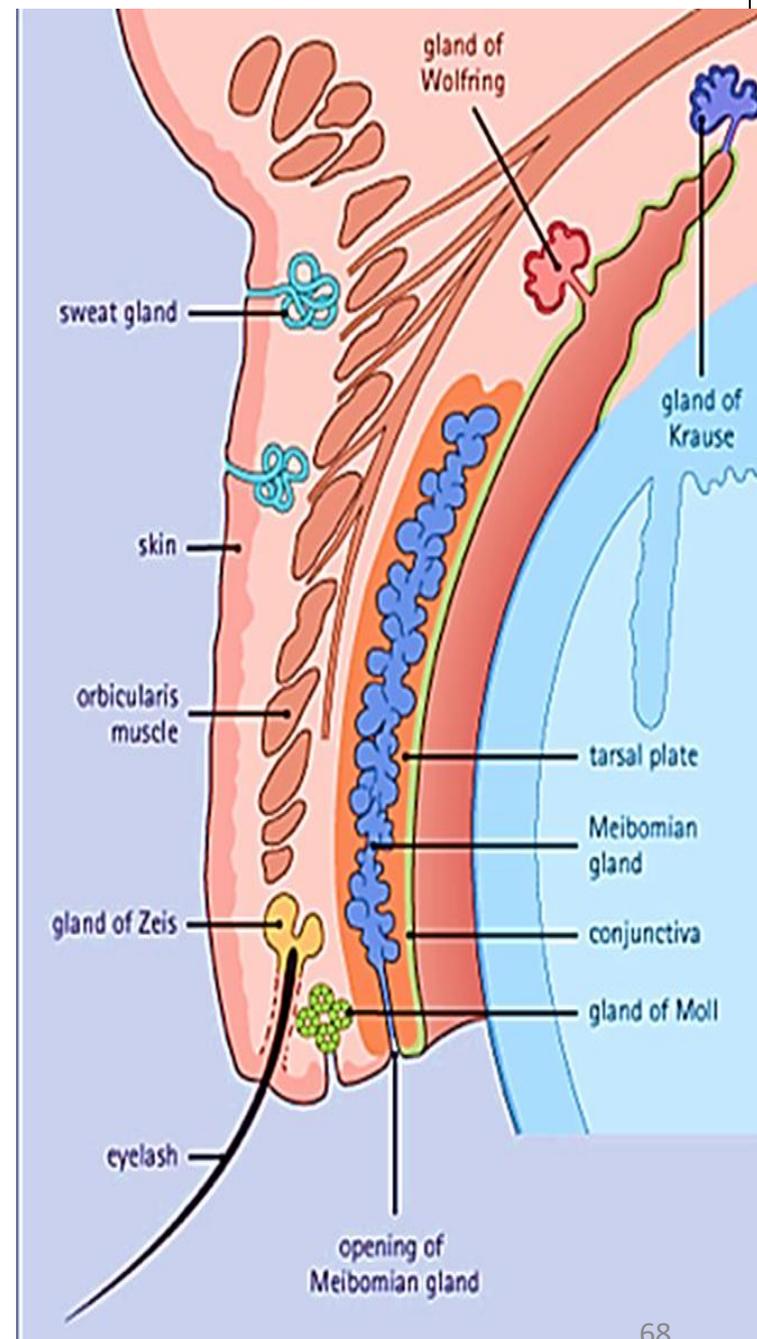
- **Bulbar conjunctiva:** attached to anterior part of sclera. Formed of **st. columnar epith** e **goblet-like cells** supported by a thin lamina propria of loose vascular C.T. secretion of goblet cells share in the formation of the mucin layer of the tear film
- **Fornix:** is the junction between the bulbar & palpebral parts .
- **Palpebral conjunctiva:** lines the eye lid from inside.

# Eye lid

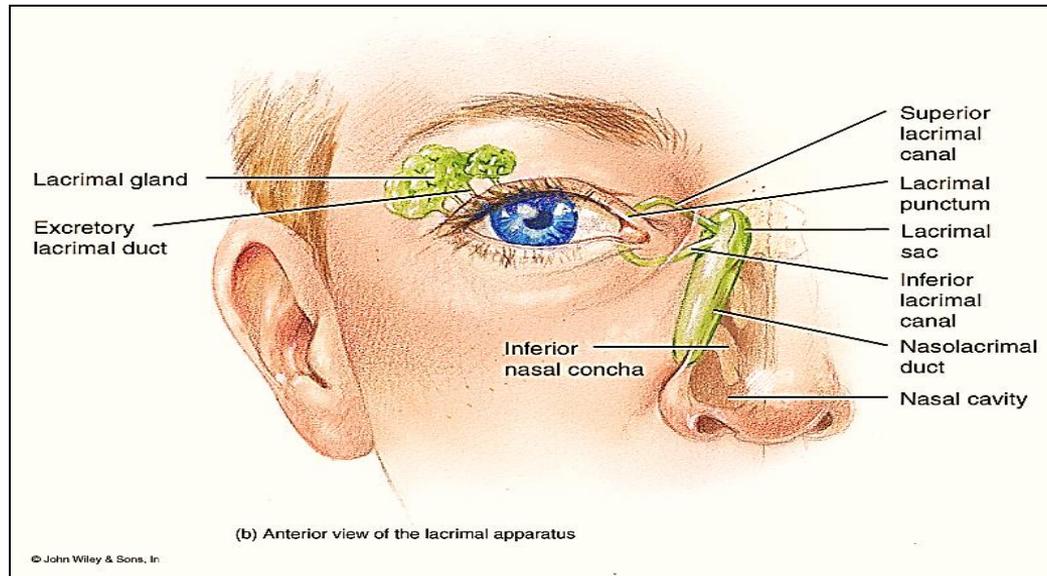
- From outside is covered by **thin skin that has no subcutaneous fat**. From inside is lined with palpebral conjunctiva.
- 3-4 rows of eye lashes at lid margin. **Zeis glands** are sebaceous glands open at the follicles of eye lashes. **Moll glands** are sweat glands open between the eye lashes



- bundles of Skeletal muscle: orbicularis oculi
- **The tarsal plate** is fibrous plate contains the **Meibomian gland** (modified sebaceous gland- oily secretion) which add to the surface of tear to minimize evaporation



# Lacrimal apparatus



- The lacrimal glands: are compound tubulo- alveolar. They secrete tears
- Lacrimal canaliculi: present on the medial aspect of both upper & lower eyelid margins. They open into lacrimal sac. They drain the tears. Lined with **stratified squamous epithelium**
- Lacrimal sac: wide tube, lined with **pseudo- stratified columnar ciliated epithelium (motile cilia) & goblet cells**
- Nasolacrimal duct: opens in the nasal cavity below **inferior concha**

**Thank you**

