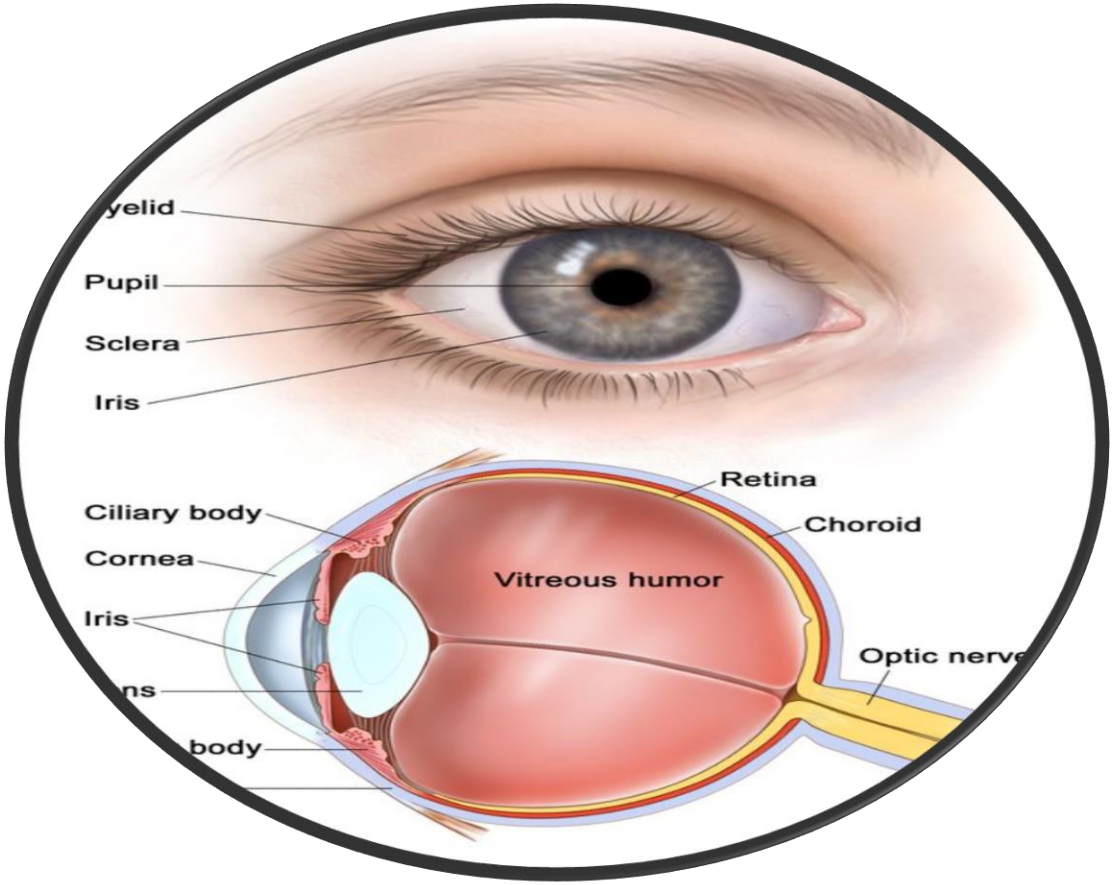
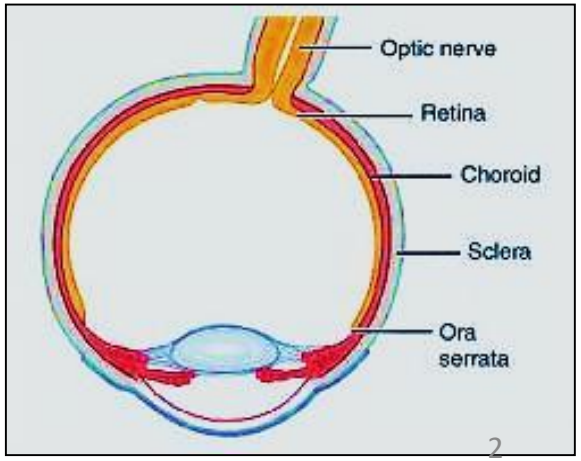


The eye (Part II)

Professor Dr . Hala El-mazar

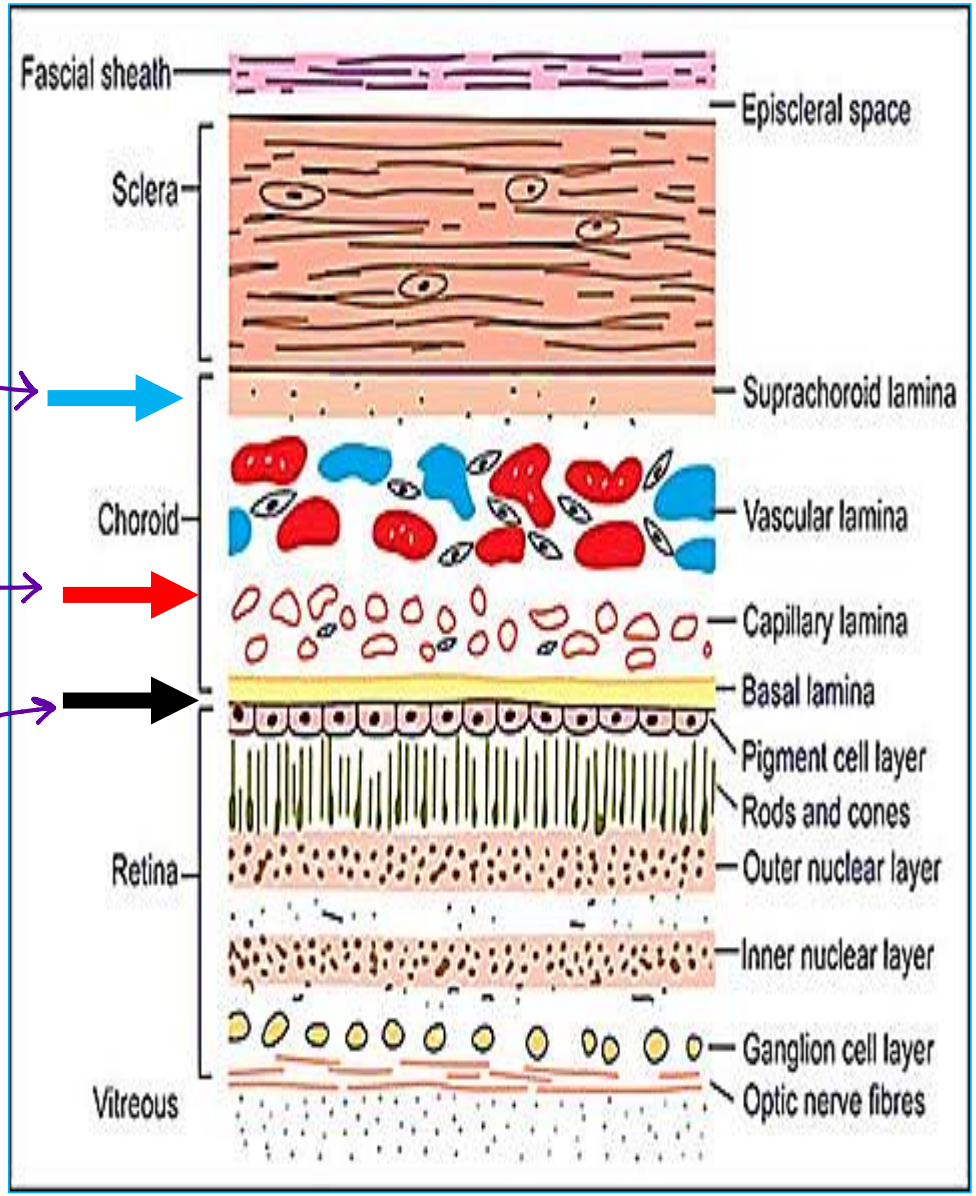
The choroid

- Is the **highly vascular & pigmented**
- part of the uvea. lies posterior to the Ciliary body & between the sclera & the retina
- Highly pigmented & highly vascular, it absorbs light & provides retina with O_2 & nutrients. Retinal cells are highly metabolic require a steady supply of O_2 & nutrients (cones and rods)
- Thermal regulation to the retinal Temp.
- The choroidal circulation accounts for 85% of the total blood flow in the eye



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)
  - loose CT beneath the sclera
  - Thin, ↑ with melanocytes, fibroblasts & macrophages

- **The choriocapillary lamina**: (the middle layer)
  - dense network of fenestrated capillaries which is essential for easy exchange of nutrition & maintenance of the retina

Since the photoreceptors of retina doesn't directly receive blood flow from retinal blood vessels, the choriocapillary BV is essential for its wellbeing

- **Bruch's membrane** : (the innermost layer – 5 layers)
  A sheet composed of 5 layers (NO cells) separates between the retinal pigmented epithelium & the choroid. Plays role in transport of nutrients & waste between retina & choroid BV

Layers of Bruch's membrane 5 layers :

1- Basement membrane of endothelial cells of chorio- capillary B.V.

2- Inner collagenous layer

3- Elastic layer … between the collagen layers

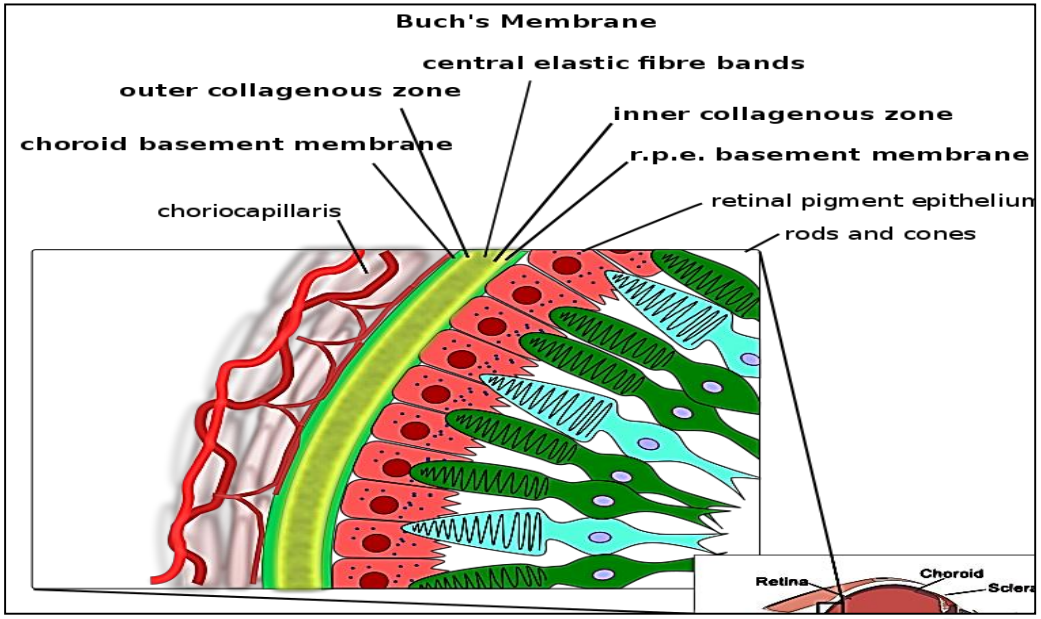
4- Outer collagenous layer

5- Basal lamina of pigmented epithelium of the retina

Act as **blood –retinal barrier**

- ✓ 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

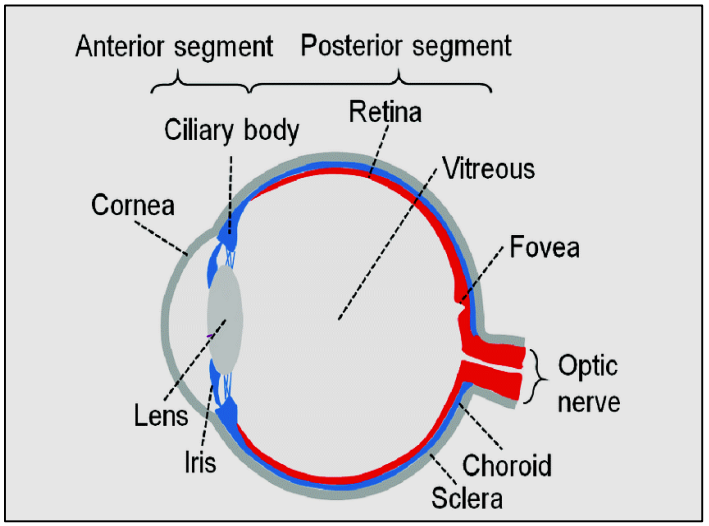
- The vitreous chamber: between the lens & retina

  contains transparent, colorless

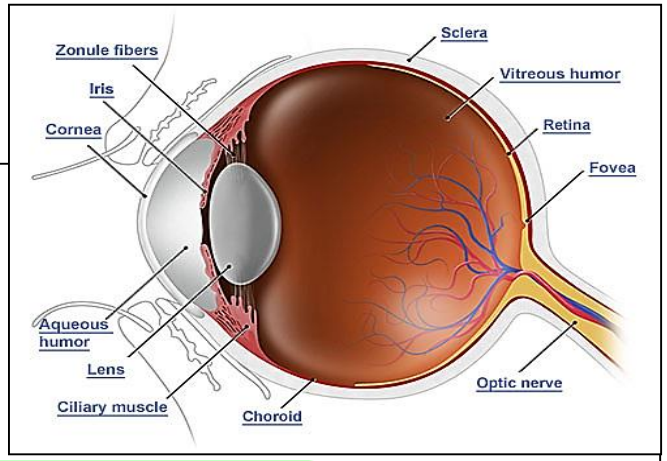
  jelly- like mass called vitreous body

  Doesn't recycle

  Eye floaters ….?

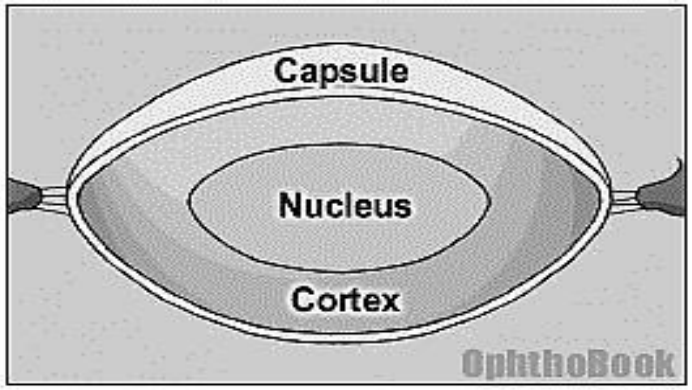


The lens



- Is transparent, avascular, flexible lacks nerves ,biconvex disc, behind the iris & pupil.
  its main function is to focus light on the retina

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



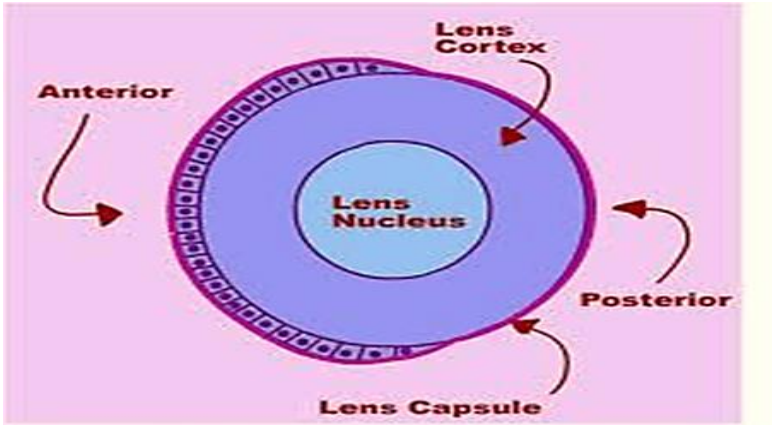
- The capsule is transparent, surrounds the lens completely, elastic & is composed of type IV collagen. It is synthesized by the lens epithelium

Histological Structure of the lens:

I. Capsule

II. Subcapsular (lens) epithelium

III. lens cortex (consist of Lens fibers)



its basement membrane is the capsul

- **Lens epithelium:** single layer of cubical cells covers the anterior & lateral surfaces of the lens located between the lens capsule & cortex = 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**

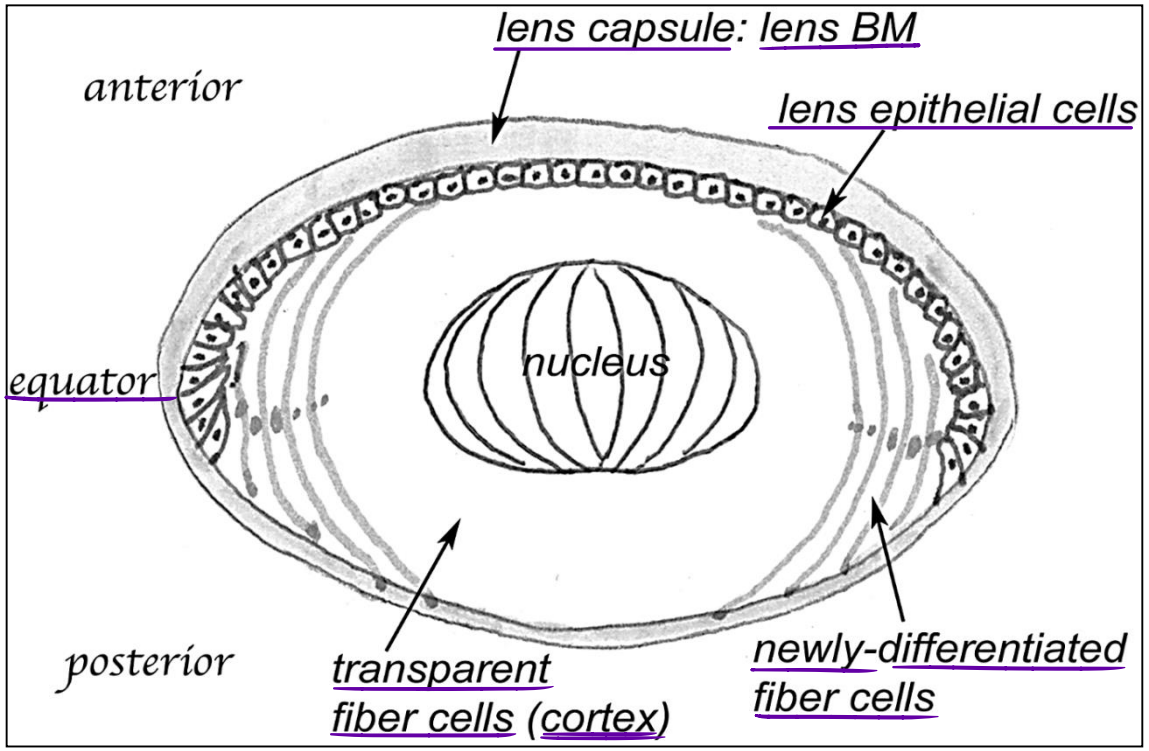
- **The lens cortex (fibers)**
- these fibers make up the bulk of the lens. They are long, thin cells, which lost their nuclei & organelles and change to transparent fibers able to focus light, arranged concentrically in layers

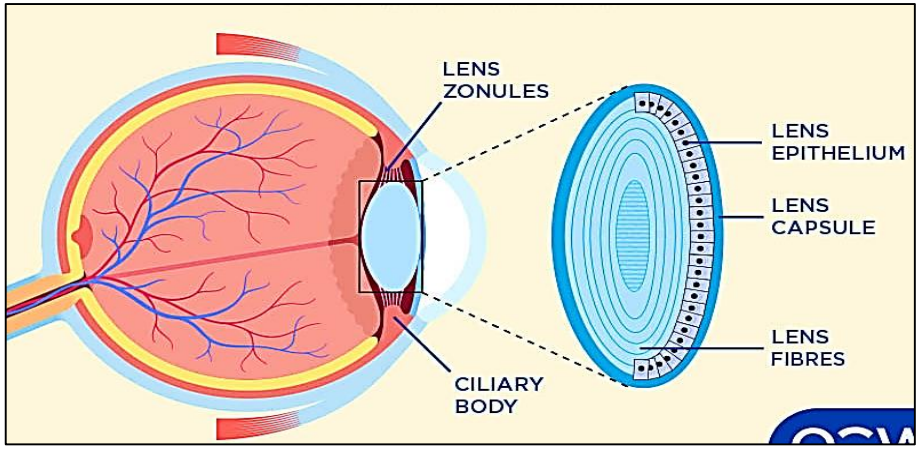
- The new fibers being added at the periphery of the lens just beneath the lens epithelium. as the new fibers added the old fibers move toward the center.

- Mature lens fibers have no organelles or nuclei. They are filled with proteins (Crystallins) which is the key for transparency & refractive properties of the lens
- The cytoskeleton of the lens are actin filaments & intermediate filaments (Vimentin)

- The lens fibers adhere to one another with gap junctions & desmosomes. They depend on aqueous humor or nutrition

(Lens fibers)





The lens lays down fibers from embryo stage until death. Old fiber will form the nucleus

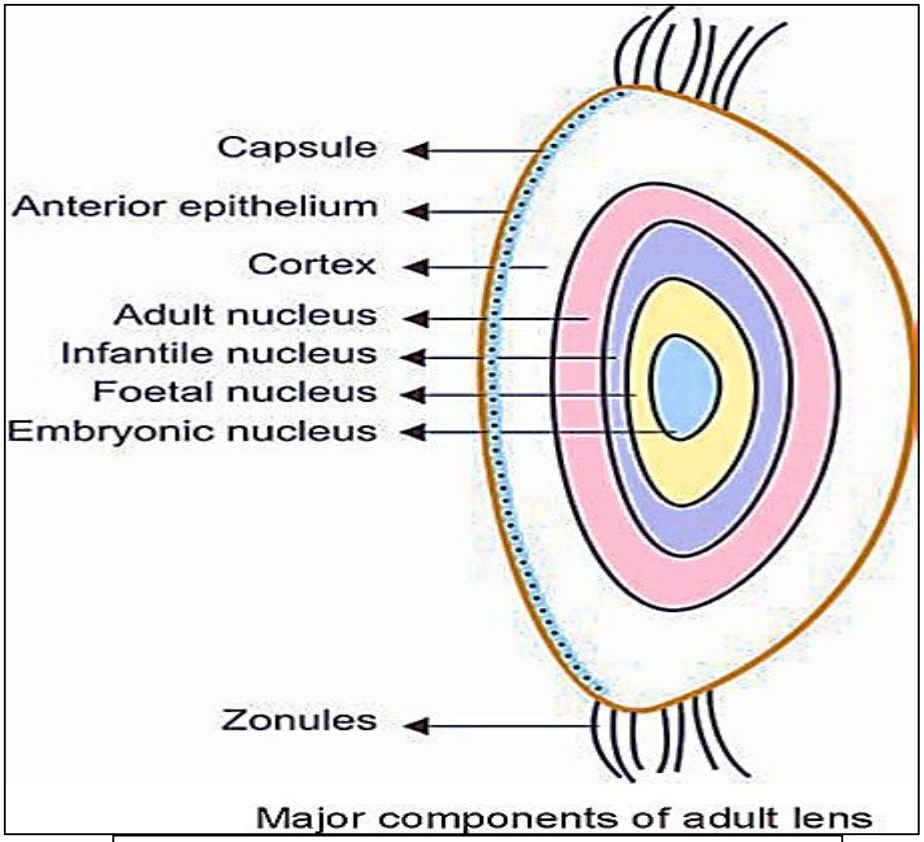
The nucleus of the lens is the innermost part of lens formed by the oldest lens fibers which have been progressively pushed toward the center of the lens as the new fibers added at the periphery

Function of the nucleus like the entire lens is to focus light

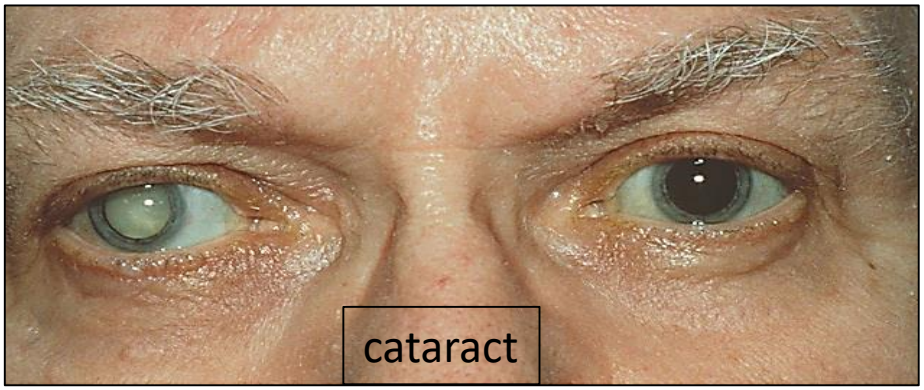
Layers from **in to out:**

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

Presbyopia: occur when the nucleus become rigid & opaque



Arrangement of layers lens nucleus



cataract

The inner (nervous) layer

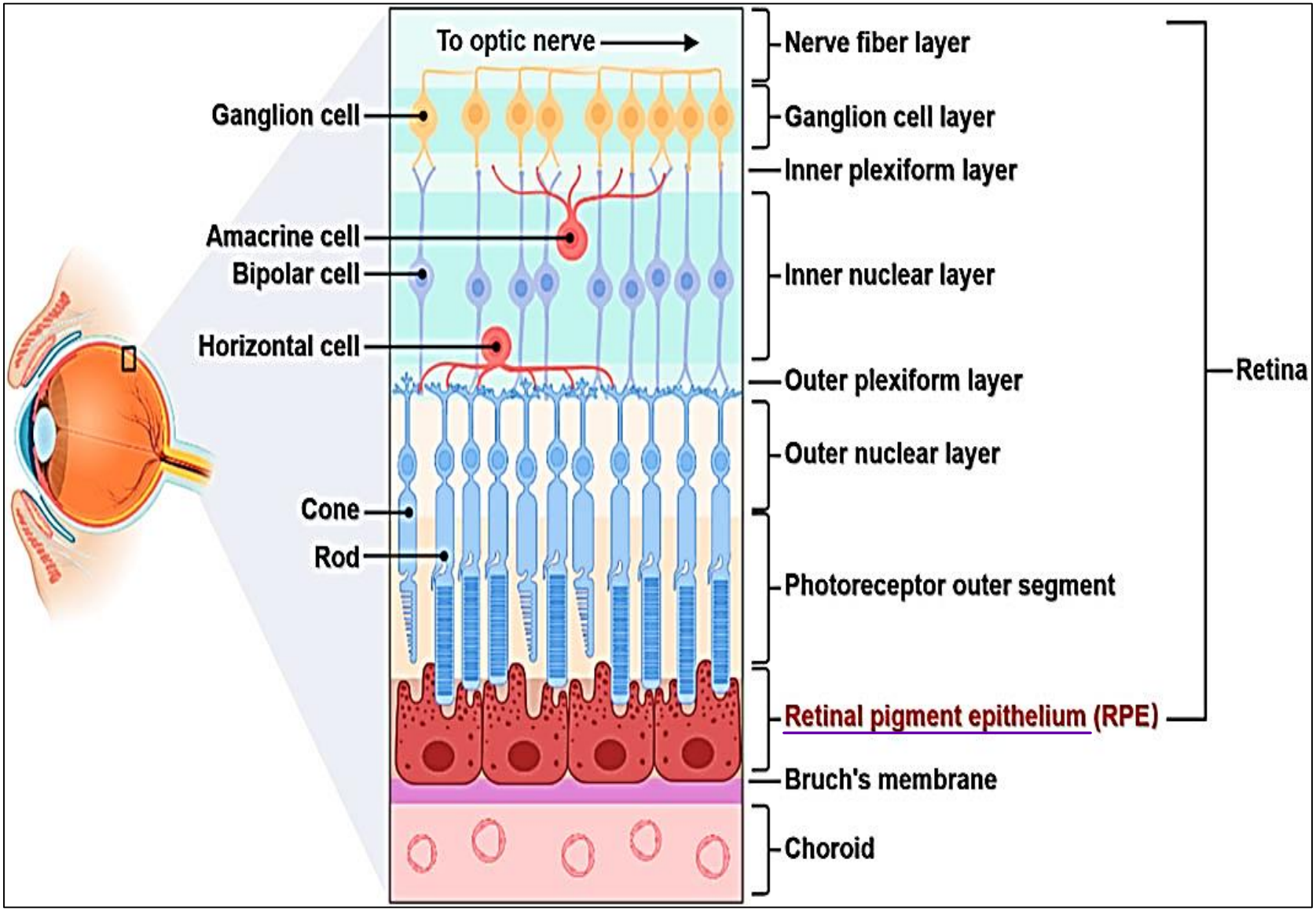
The retina

The retina

- is the inner most layer of eye , responsible for **Photoreception**
- Composed of 2 layers : pigmented epith. & photosensitive (neuronal) layers
- Neuronal layer consists of layers of neurons interconnected with each other through synapses
- **The photoreceptor cells are : Rods & Cones**

العصي
- **Rods** function mainly in dim light and black & white vision

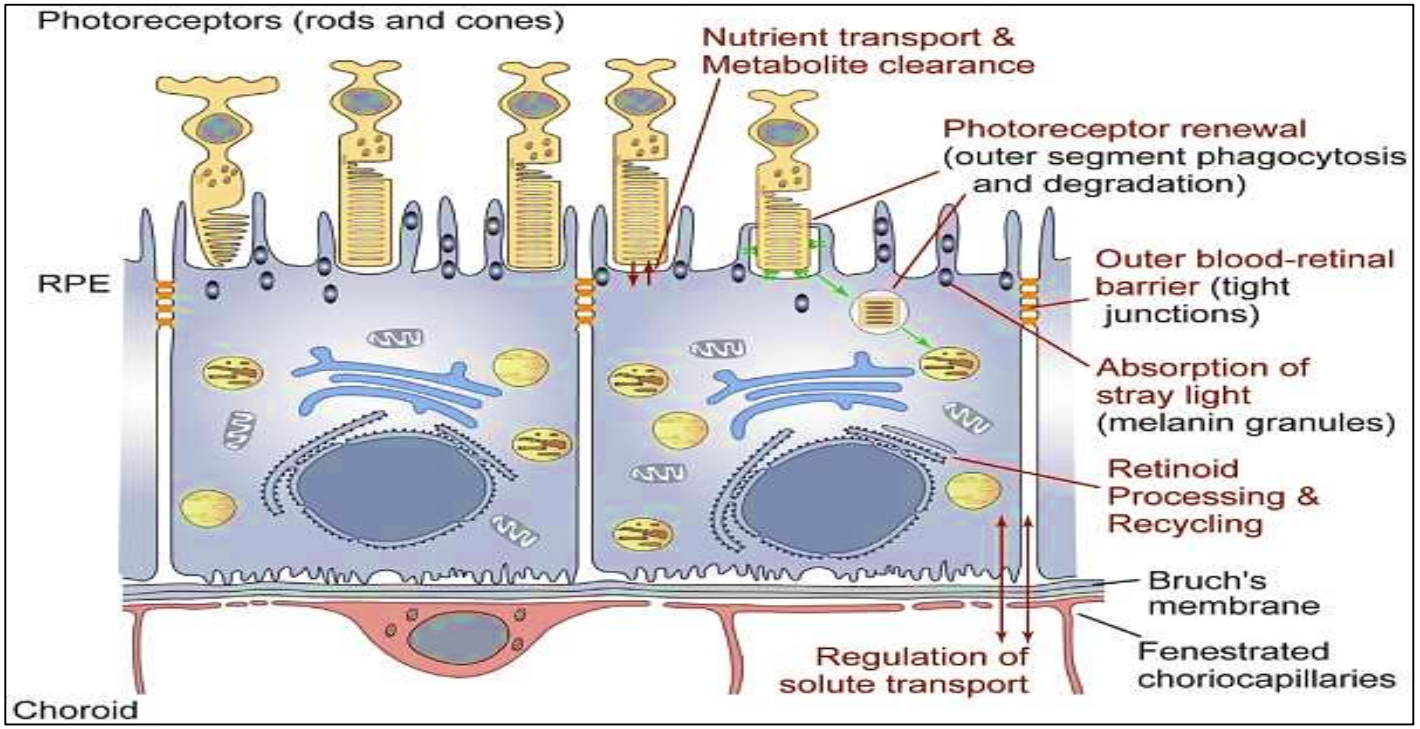
المخاريط
- **Cones** support day time and the perception of color vision


To optic nerve
Ganglion cell
Amacrine cell
Bipolar cell
Horizontal cell
Cone
Rod
Nerve fiber layer
Ganglion cell layer
Inner plexiform layer
Inner nuclear layer
Outer plexiform layer
Outer nuclear layer
Photoreceptor outer segment
Retinal pigment epithelium (RPE)
Bruch's membrane
Choroid
Retina

The retina

1- Pigmented epithelium:

- Single layer of cuboidal cells their basal surfaces attached to the Bruch's membrane of choroid
- Their apical surface has many microvilli which interdigitate & support the tips of rods & cones (**Retinal detachment**)
- They contains numerous **melanin granules** → cells dark → filter the UV light → reduce oxidative damage to retina
- The lateral surfaces of adjacent cells shows tight junctions together with Bruch's membrane form **blood- retinal barrier**
- Their cytoplasm contains mitochondria, **phagocytic vacuoles i.e. phagocytose old photoreceptor outer segments**

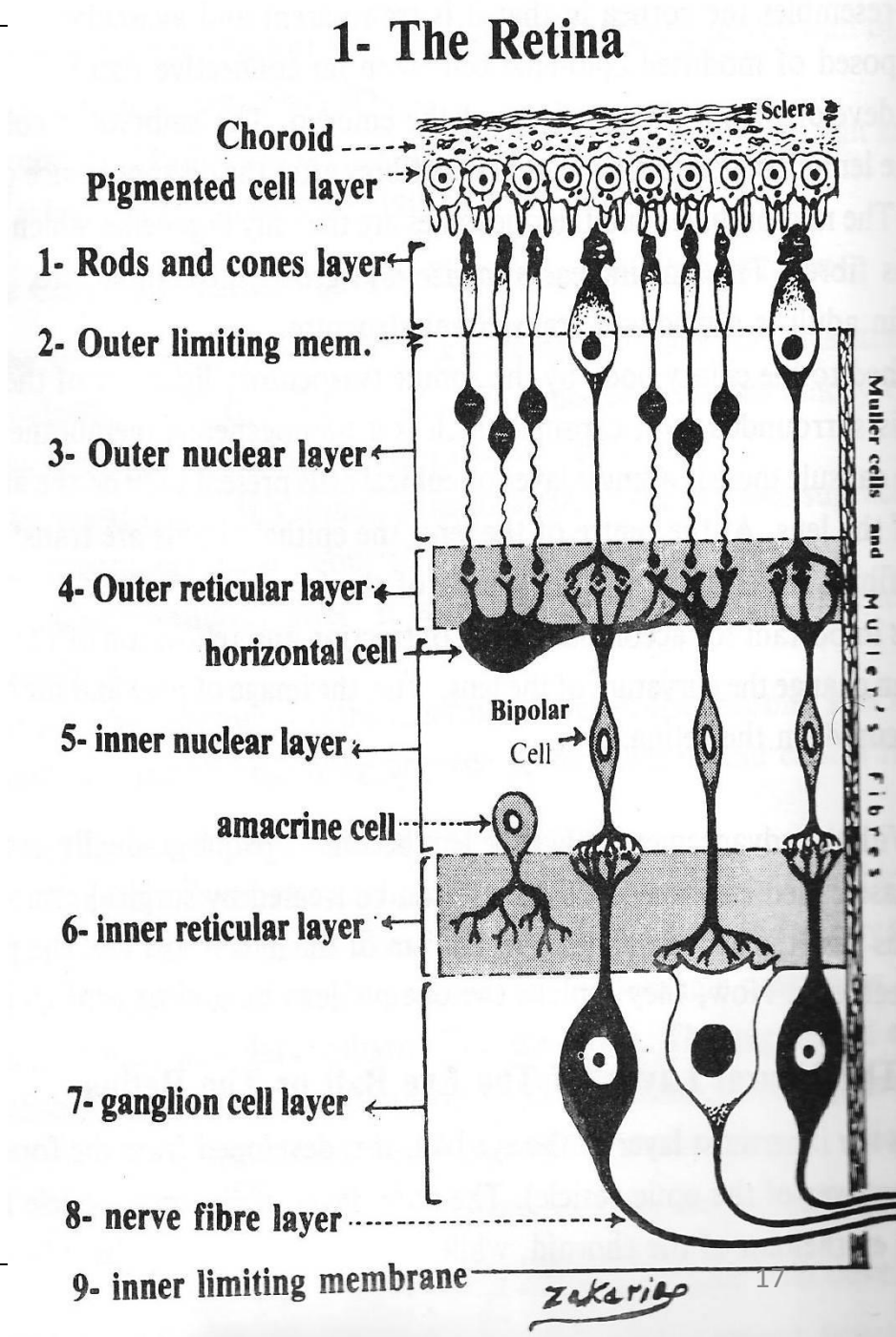


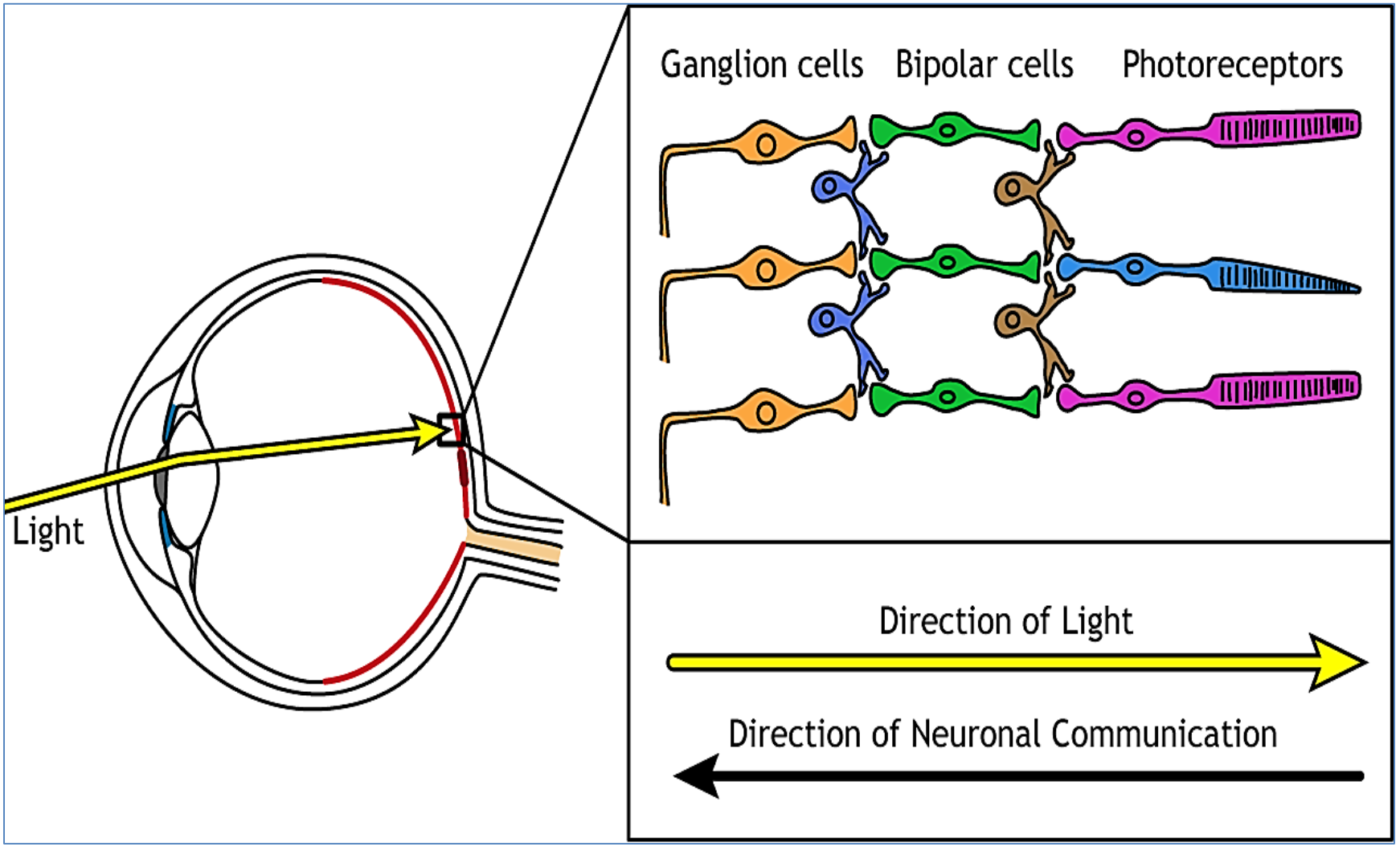
Function of Pigmented epithelium:

- Support thr photoreceptors
- 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 photoreceptoes

Layers of the retina (10):

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



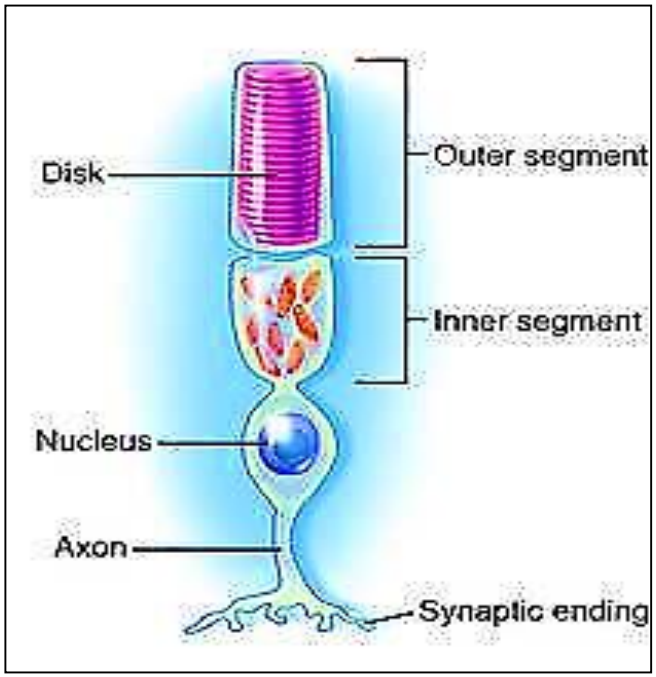

Ganglion cells
Bipolar cells
Photoreceptors
Light
Direction of Light
Direction of Neuronal Communication

2- Rods & Cones layer: photoreceptors

more than cones

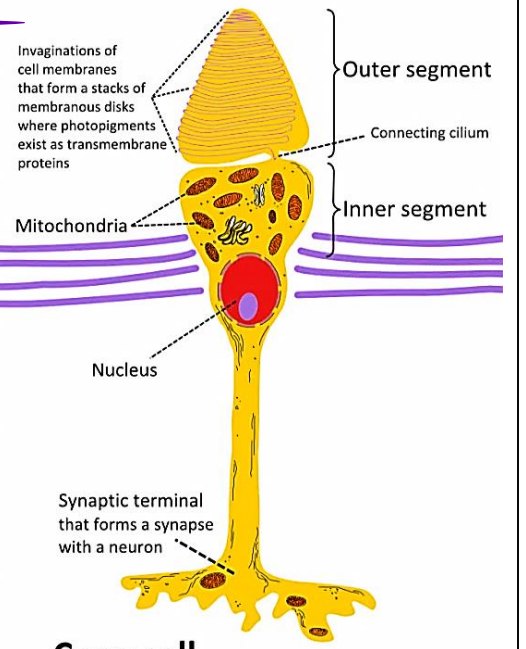
a- **Rods : dim light vision (black & white)** (↑ in #)

- 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

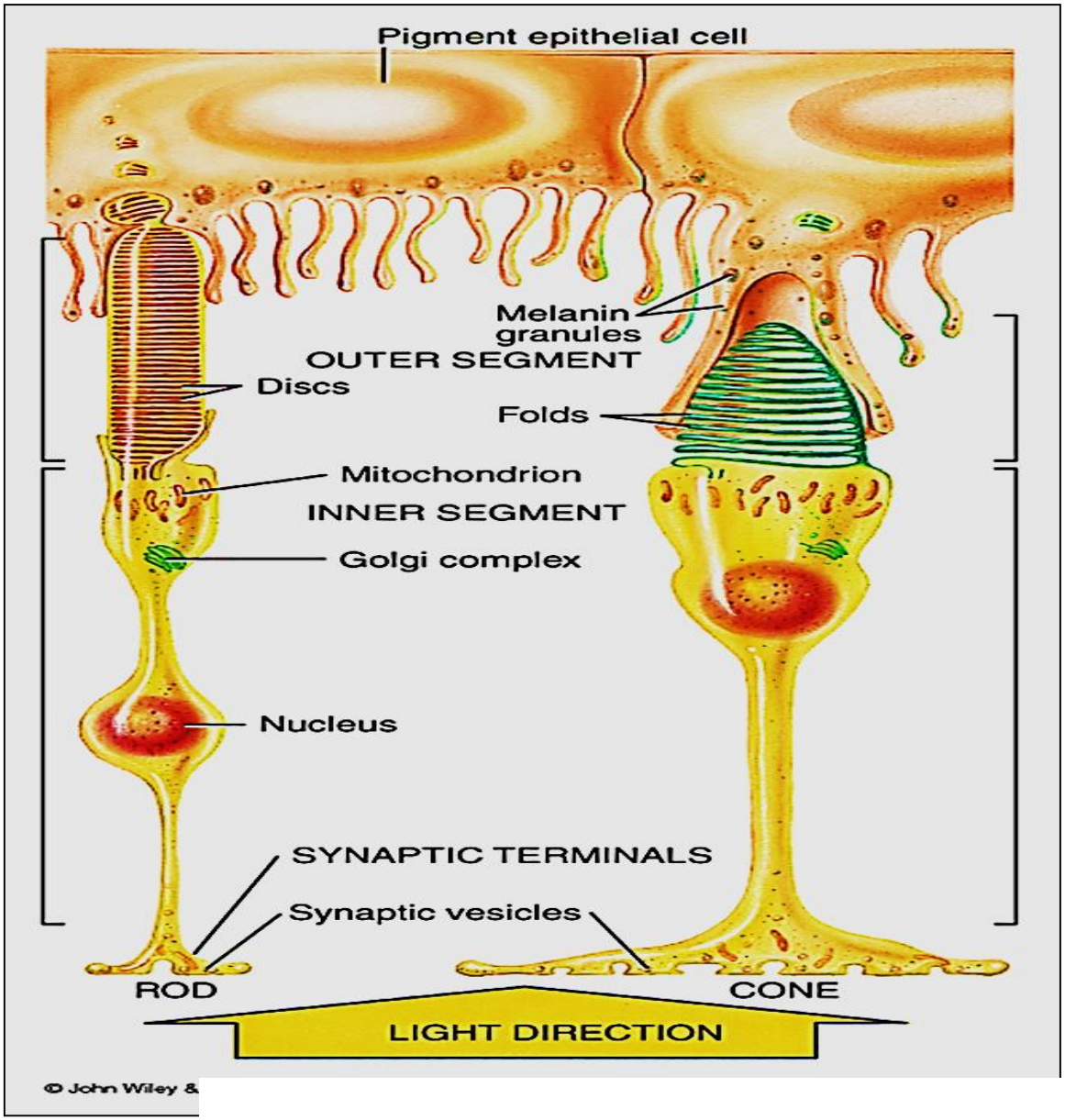


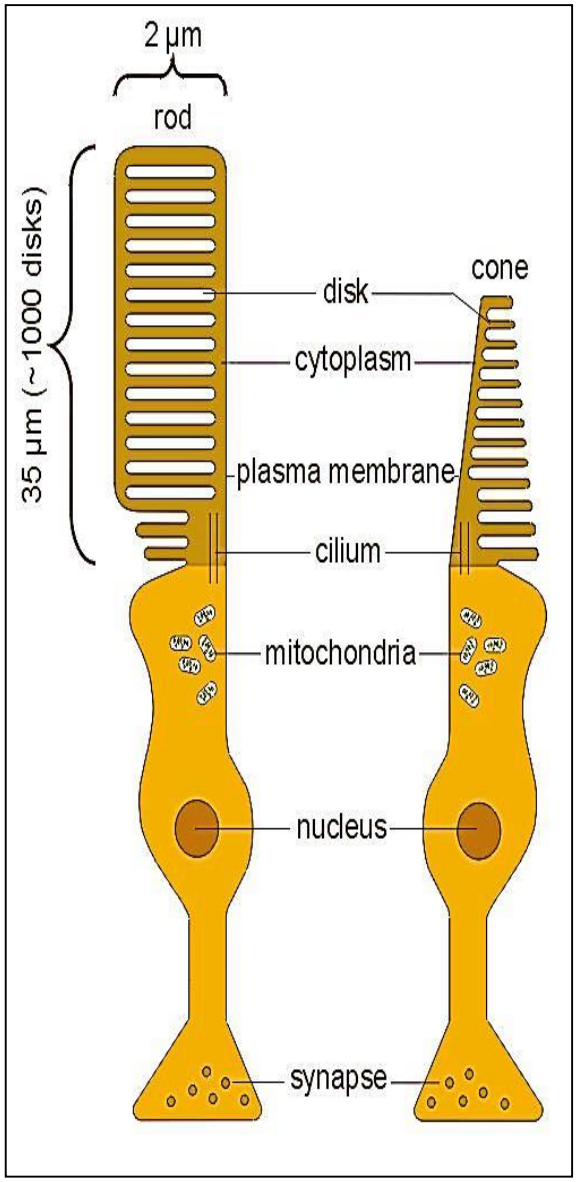
b- **Cones** : **bright light & color vision**

- 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



Cone cell





Structure of rods and cones

3- outer limiting membrane

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

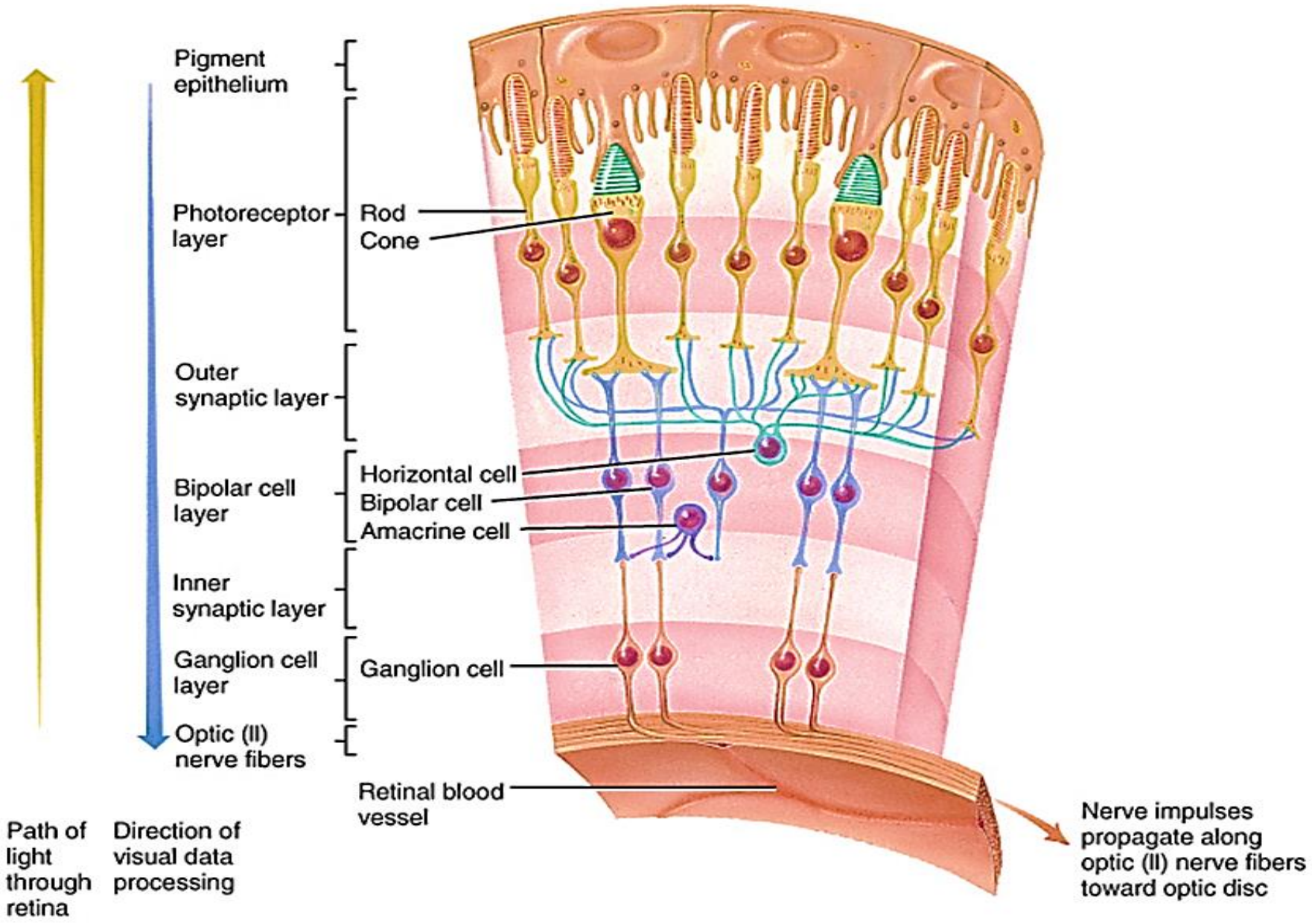
4- outer nuclear layer:

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


Pigment epithelium
Photoreceptor layer
Rod
Cone
Outer synaptic layer
Bipolar cell layer
Horizontal cell
Bipolar cell
Amacrine cell
Inner synaptic layer
Ganglion cell layer
Ganglion cell
Optic (II) nerve fibers
Retinal blood vessel
Path of light through retina
Direction of visual data processing
Nerve impulses propagate along optic (II) nerve fibers toward optic disc
© John Wiley & Sons, Inc.

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

- Bipolar nerve cells (1st 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^{nd} order neuron), are nerve cells with vesicular nuclei & basophilic cytoplasm. Their dendrites synapse with axons of bipolar cells . End at LGN

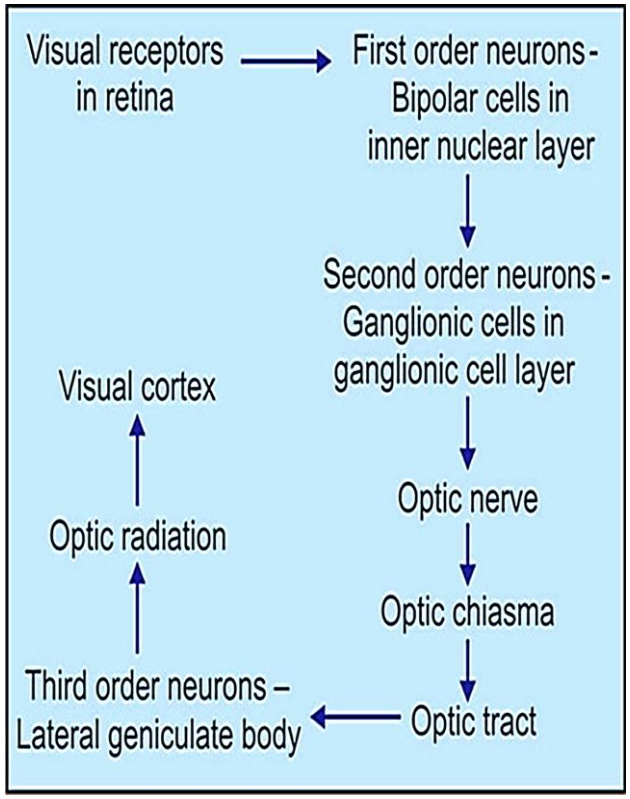
- Their axons form the fibers of **optic nerve**. Retinal B.V. present between ganglion cells

9- optic nerve layer:

- The axons of ganglion cells pass at right angle to form optic nerve. The optic nerve fibers are non mylinated at their origin , then they become mylinated 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 (3rd order neuron) →optic radiation → visual cortex



Visual Pathway

- **Photoreceptors:**

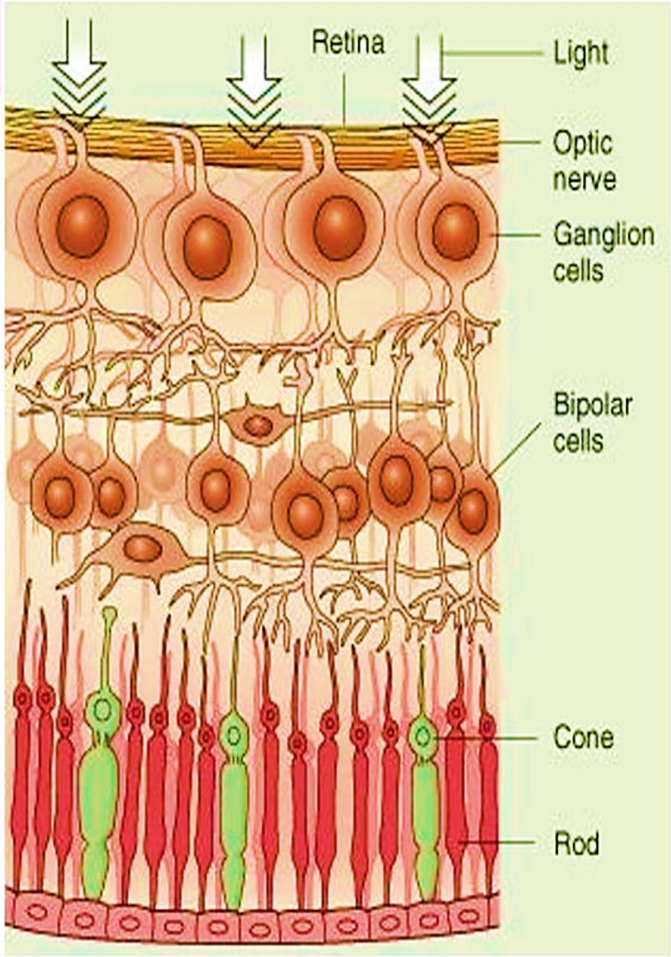
  Rods & Cones of retina

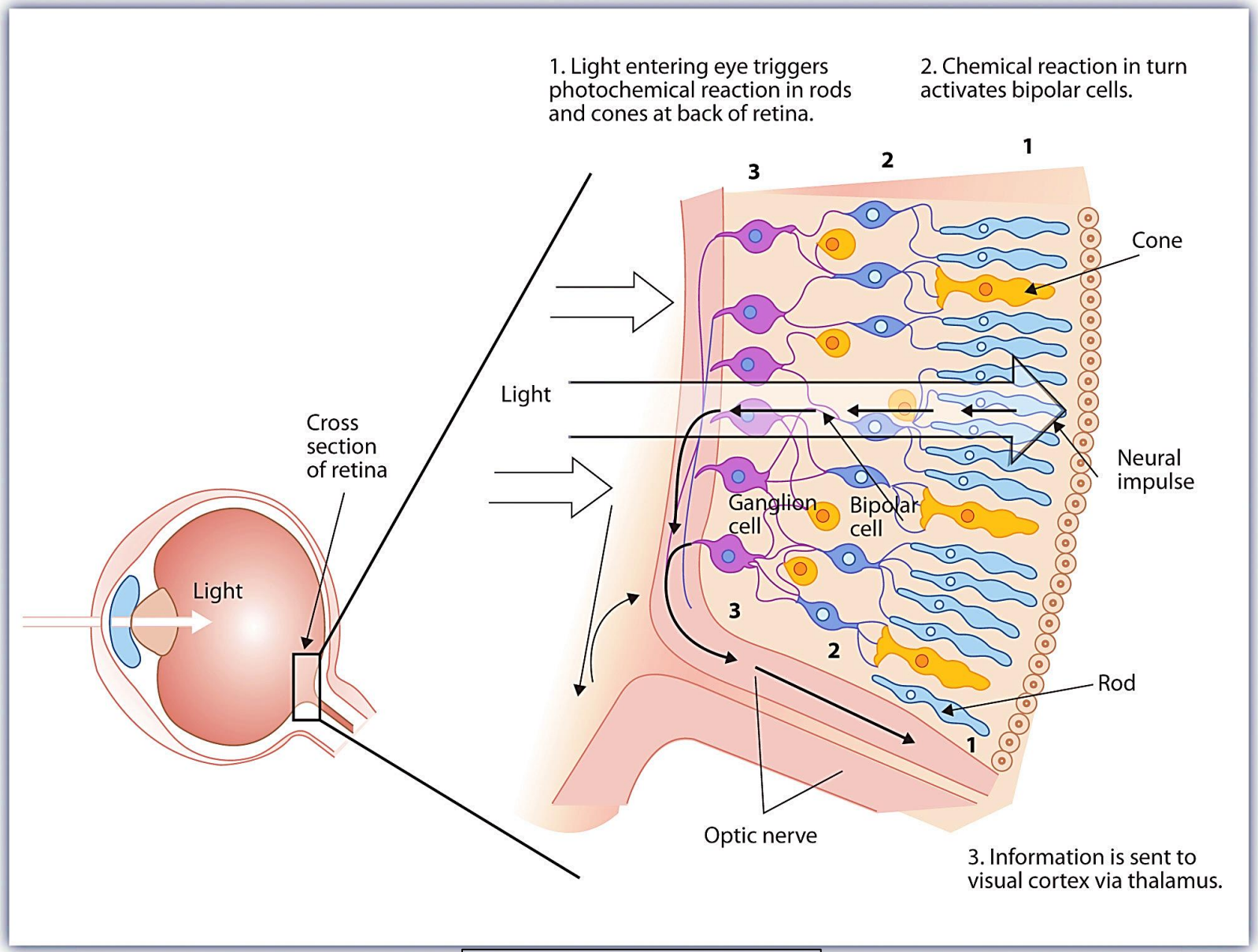
- **3 neuron pathway**
  - **1st order neurons:**

    Bipolar cells of retina.
  - **2nd order neurons:**

    Ganglion cells of retina. Their axons form the **optic nerve**
  - **3rd order neurons:**

    Neurons in the lateral geniculate body. Their axons terminate in **primary visual cortex.**

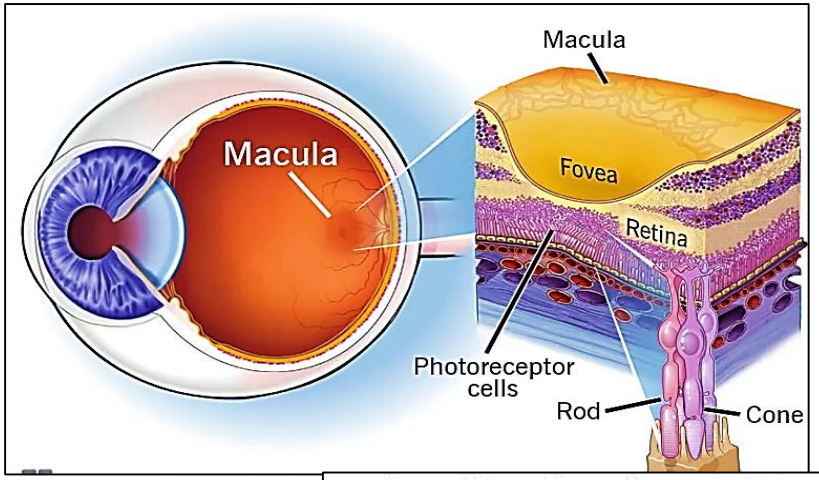


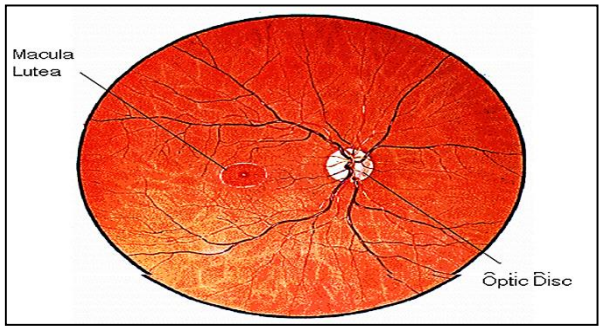


Mechanism of vision

Fovea centralis: → contain all layers

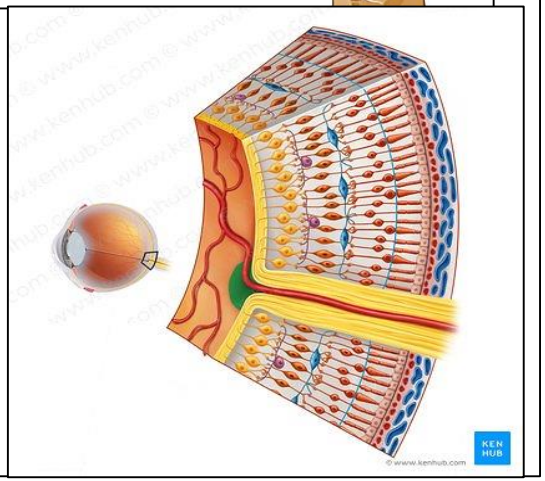
- It is the area of **highest visual acuity** (sharp vision)
- Located in center of retina
- Is a central shallow depression called **macula**
- Lacks retinal blood vessels
- Contains Cones only





Optic disc (blind spot):

- has no photoreceptors .
- Consists of optic nerve fibers
- Entry point of the central retinal A & V

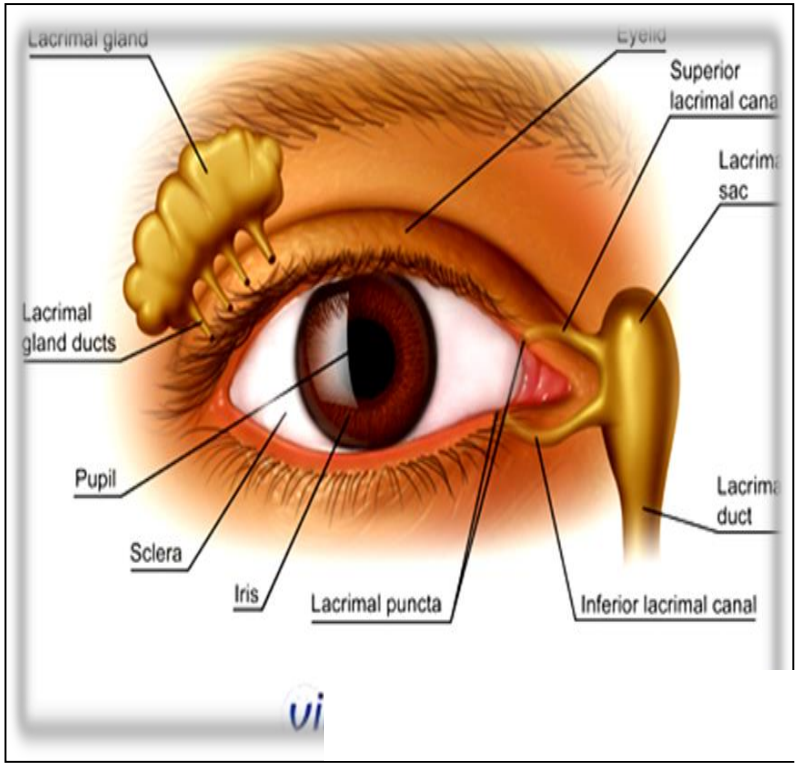


Accessory structures of the eye

1- the conjunctiva

2- the eye lids

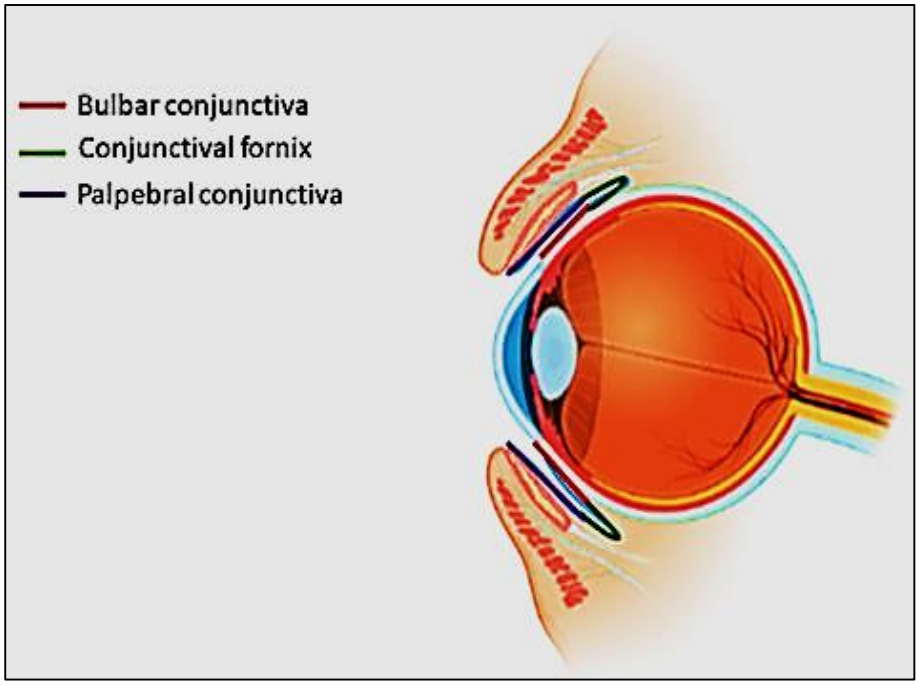
3- the lacrimal apparatus



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:

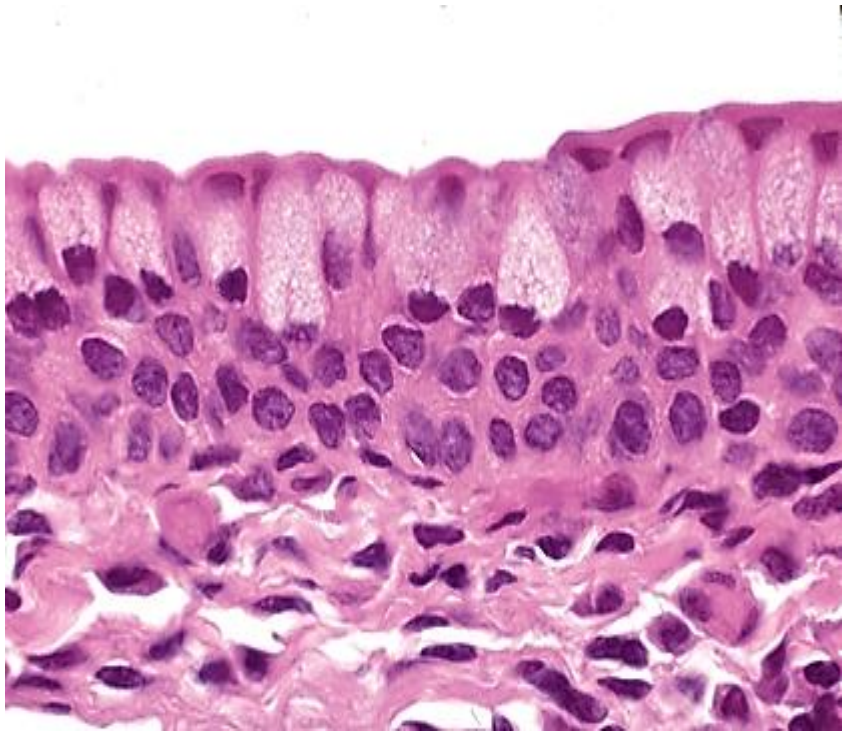
Conjunctiva composed of 3 parts:

- Bulbar conjunctiva: attached to anterior part of sclera.

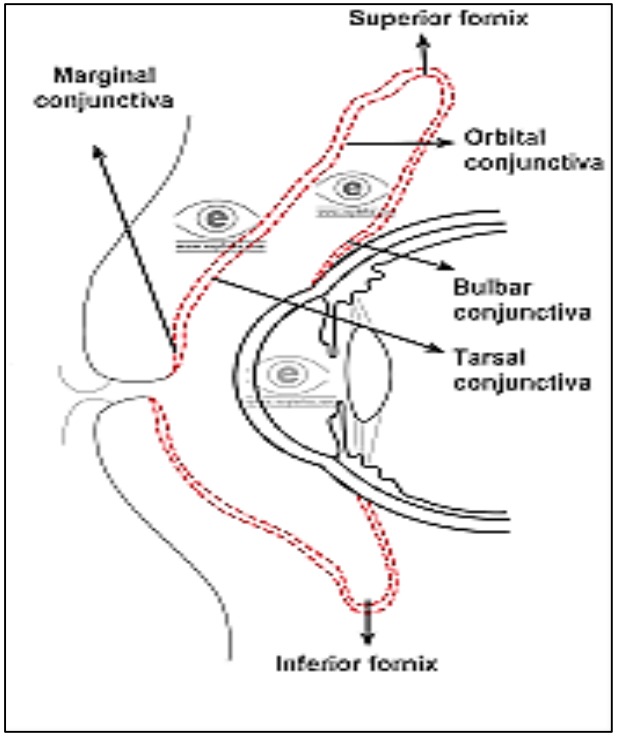
- Fornix: is the junction between the bulbar & palpebral parts .

- Palpebral conjunctiva: lines the eye lid from inside.

The epithelium of the conjunctive is 3 - 5 layers, the outermost layer is non- K st. Sq. epith. and the deeper layers are made of stratified columnar with goblet cells these cells secrets mucus which form part of the tear film



Parts of the conjunctiva



Conjunctival epithelium. The stratified squamous epithelium of the conjunctiva is Non-keratinized and contains mucin-producing goblet cells that are most numerous in the nasal bulbar conjunctiva.

Function of the conjunctiva:

- Protection: the epithelium acts as a protective barrier against pathogens & foreign bodies

- Lubrication : goblet cells produce mucus, which helps spread tear film over surface of eye

- Immune defense conjunctiva contains immune cells contributes to immune surveillance of the eye

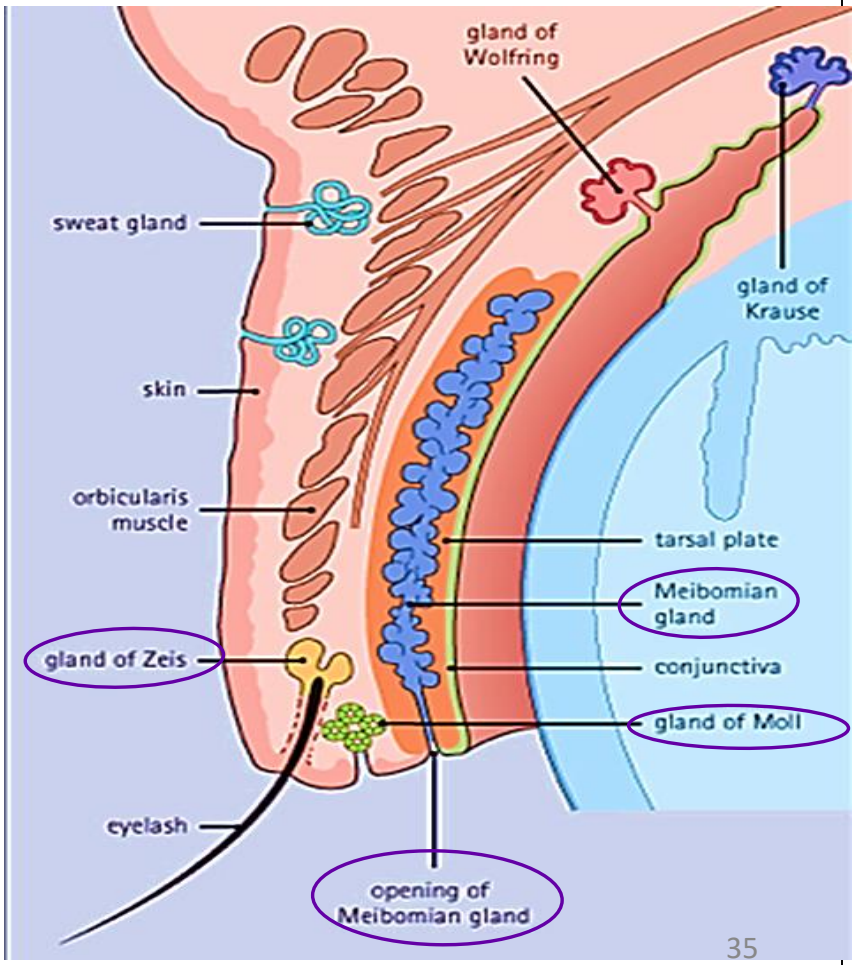
- The epithelium is well vascularized especially palpebral conjunctiva which helps with nutrition & immunity

Eye lid

- From outside is covered e thin skin that has no subcutaneous fat. From inside is lined with palpebral conjunctiva.

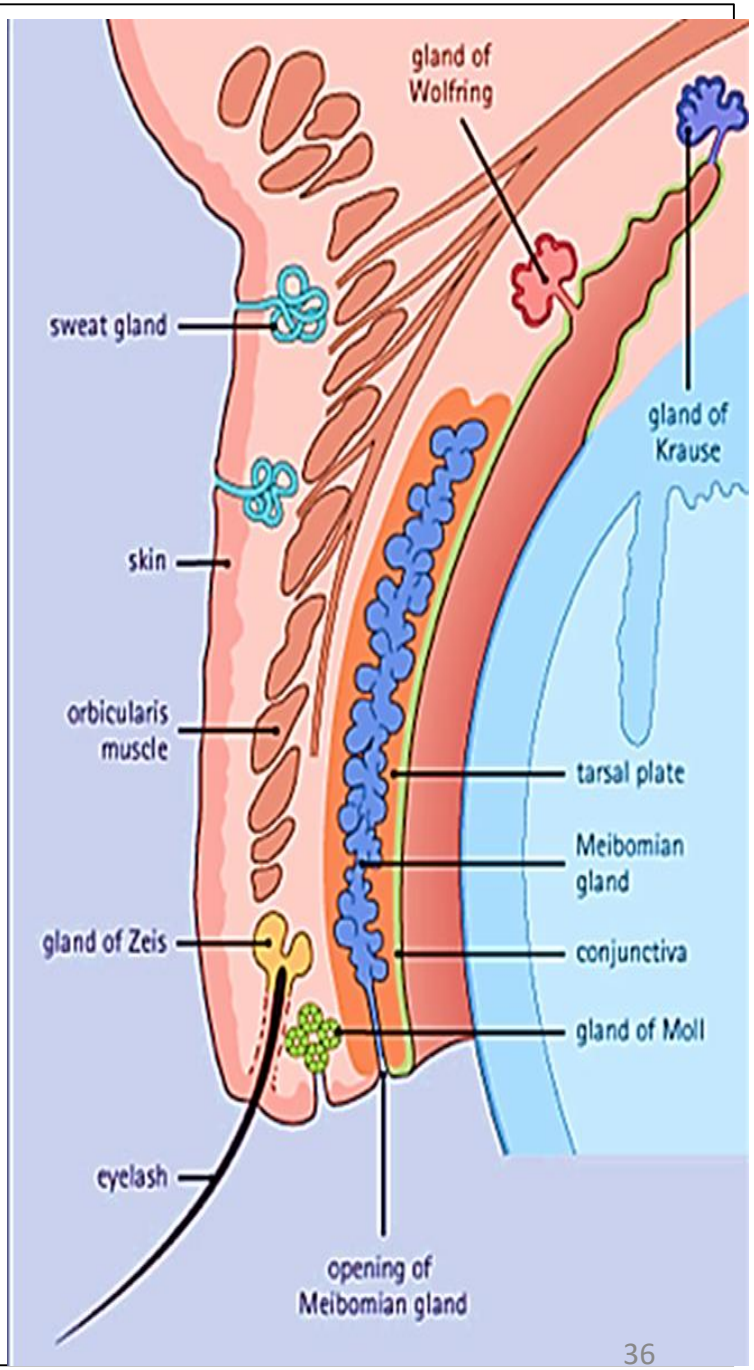
- 3-4 rows of eye lashes at lid margin. Zeis glands are sebaceous glands open at the follicles of eye lashes.

Moll glands are sweat glands open between the eye lashes

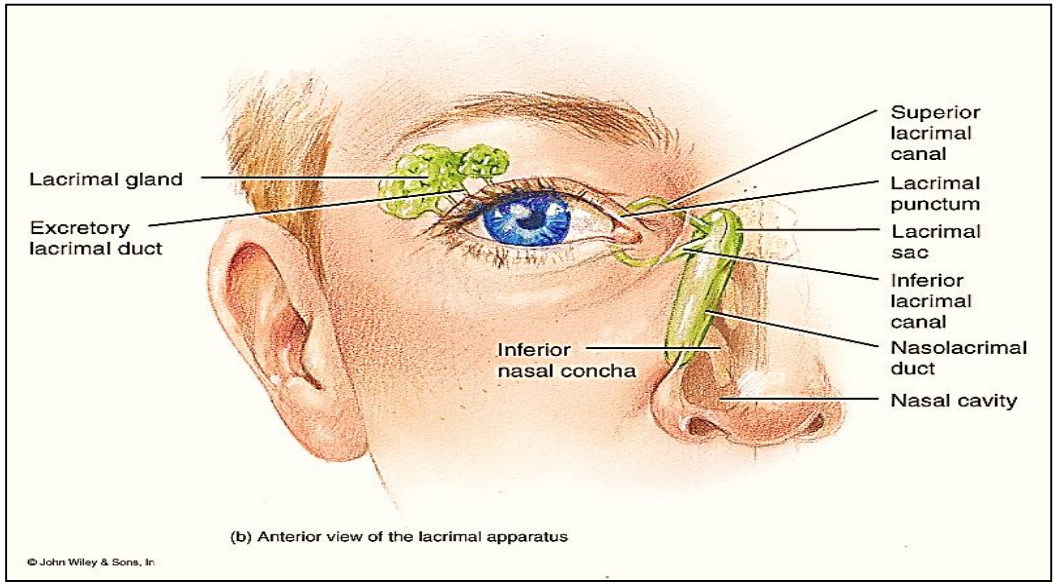


- bundles of Skeletal muscle: orbicularis oculi (function both voluntary & involuntary)

- The tarsal plate is fibrous plate contains the Meibomian gland (modified sebaceous gland- oily secretion) which adds to the surface of the tear film 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 (Respitatory epith)
- Nasolacrimal duct: opens in the nasal cavity below inferior concha

Thank you