جامعة الملك سعود
King Saud University

Basic Anatomy and Physiology of the Eye

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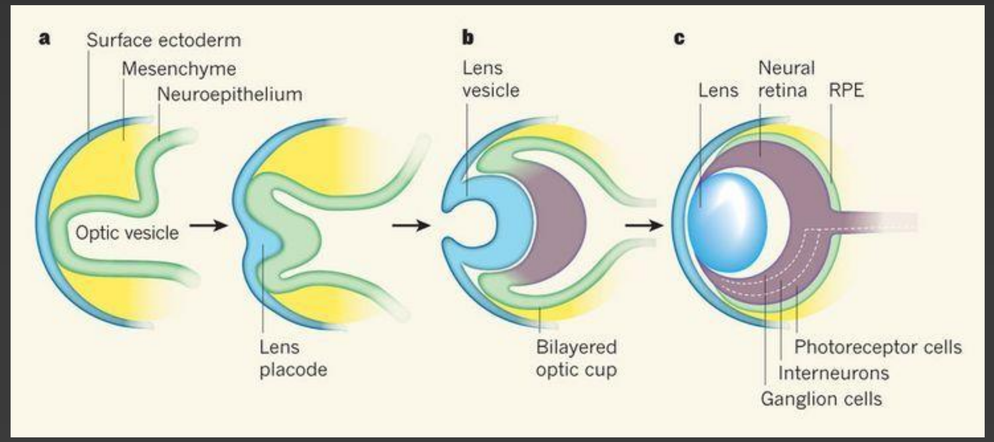
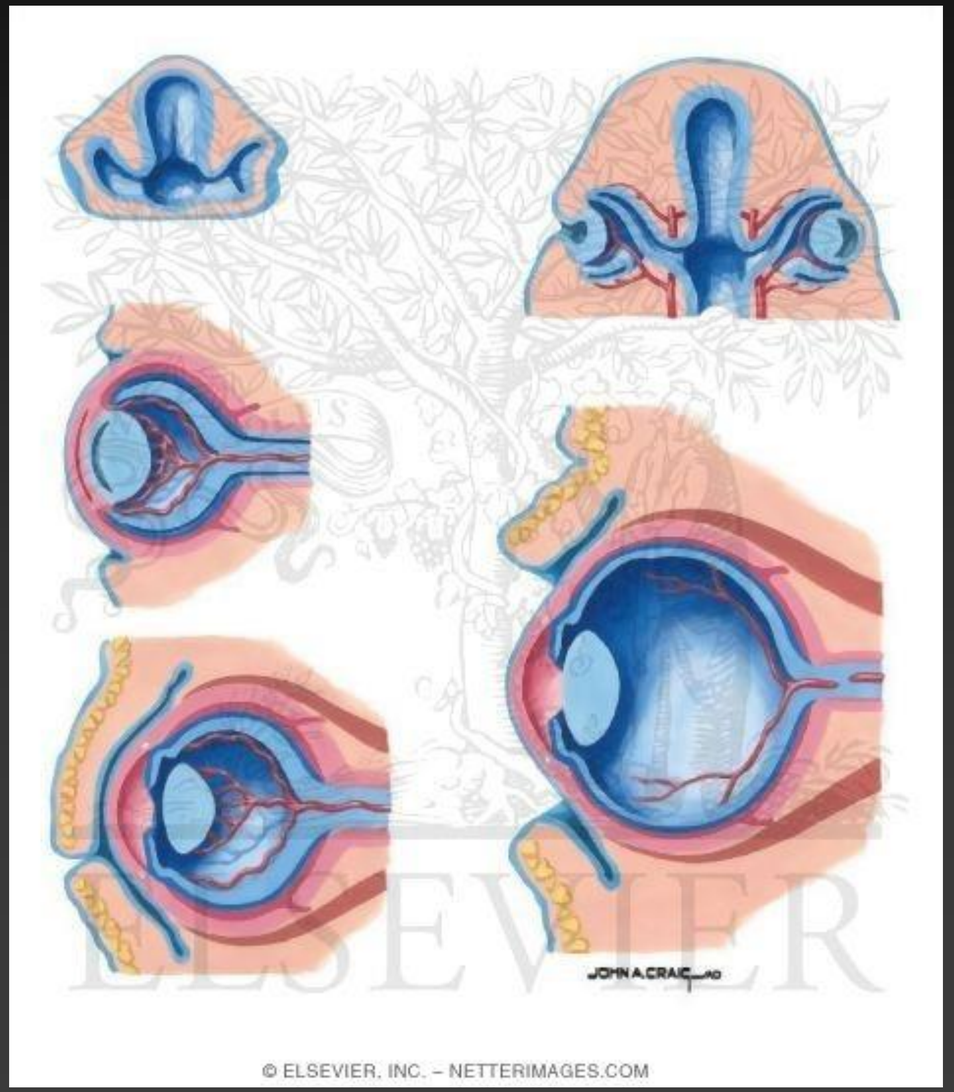
Embryological development of human eye

- Starts at about day 22 of gestation on the side of the forebrain.
- These groves grows and then invaginated to form optic vesicle and optic cup and its proximal part is connected to the forebrain by optic stalk. Part of the ectoderm form the lens.
- It becomes separated from surface ectoderm in day 33

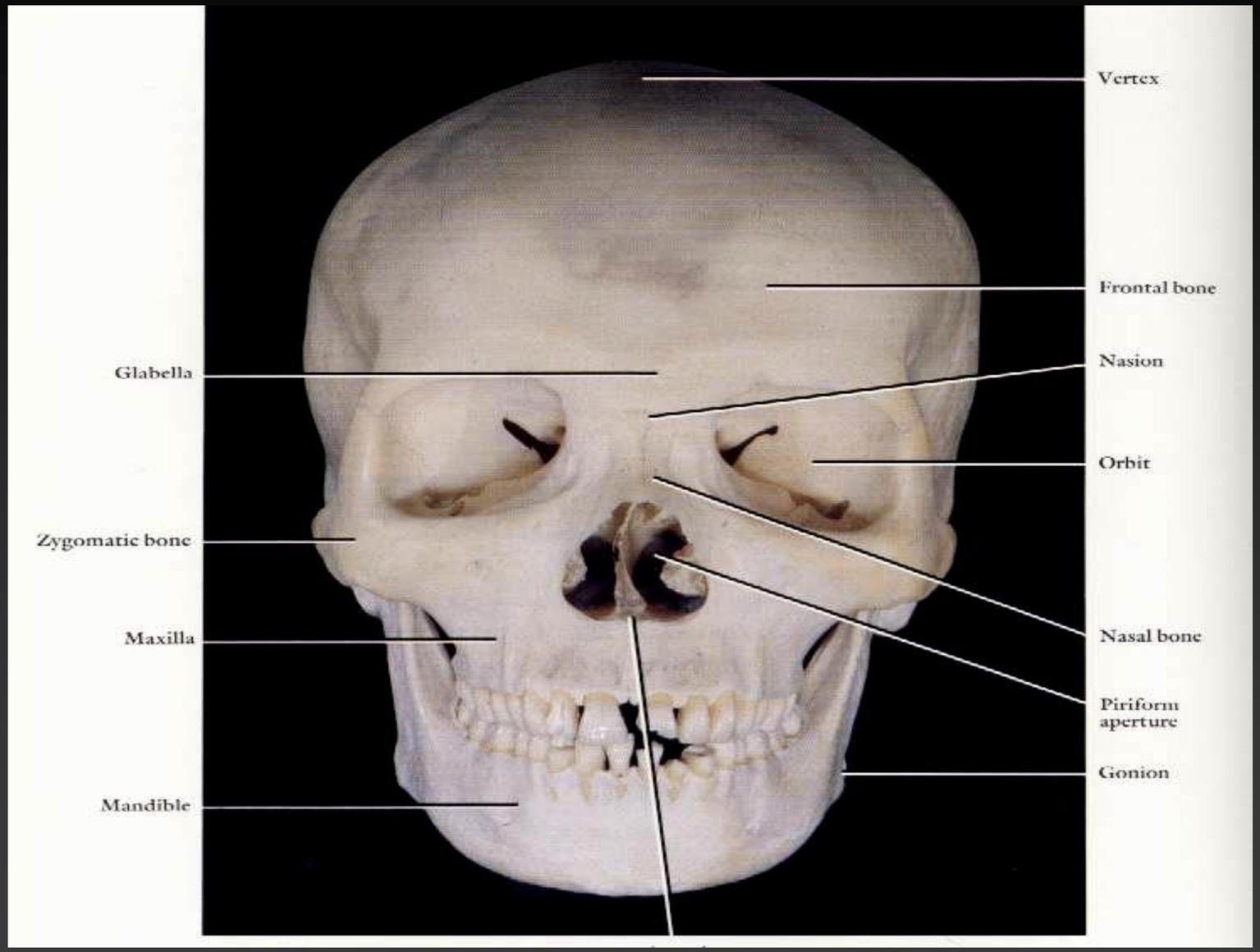




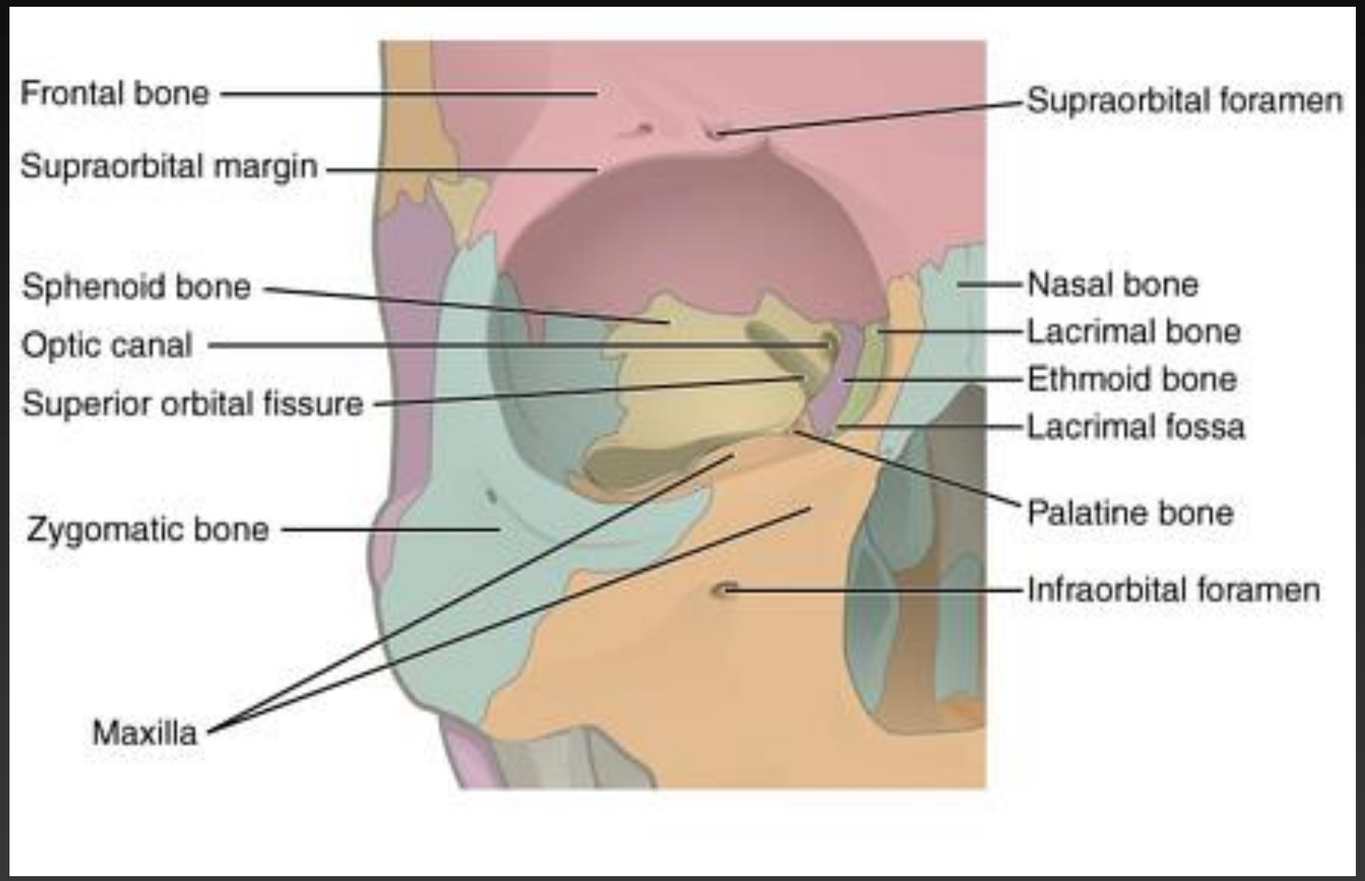
Embryological development of human eye

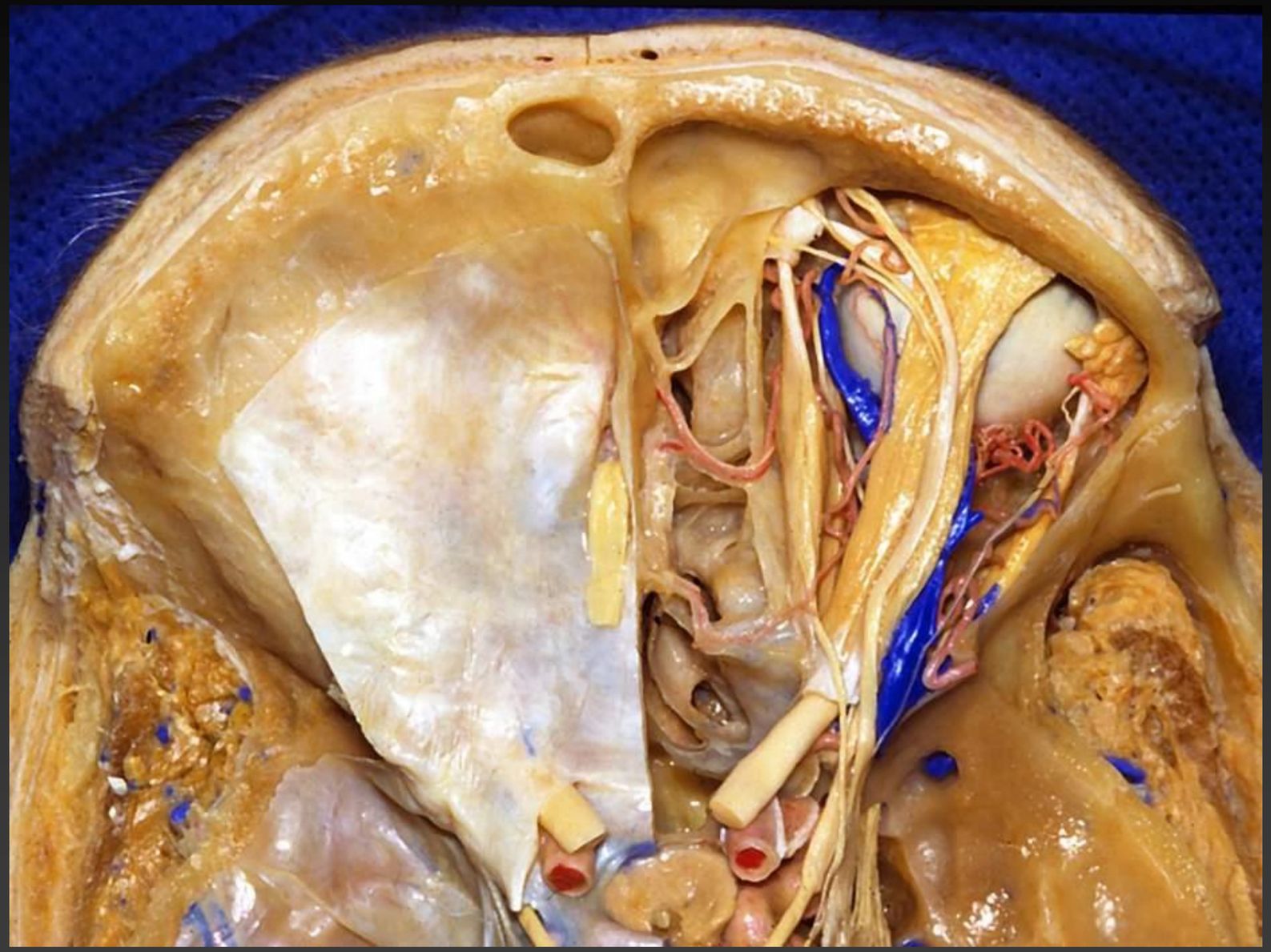
Summary of various part of the eye ball.

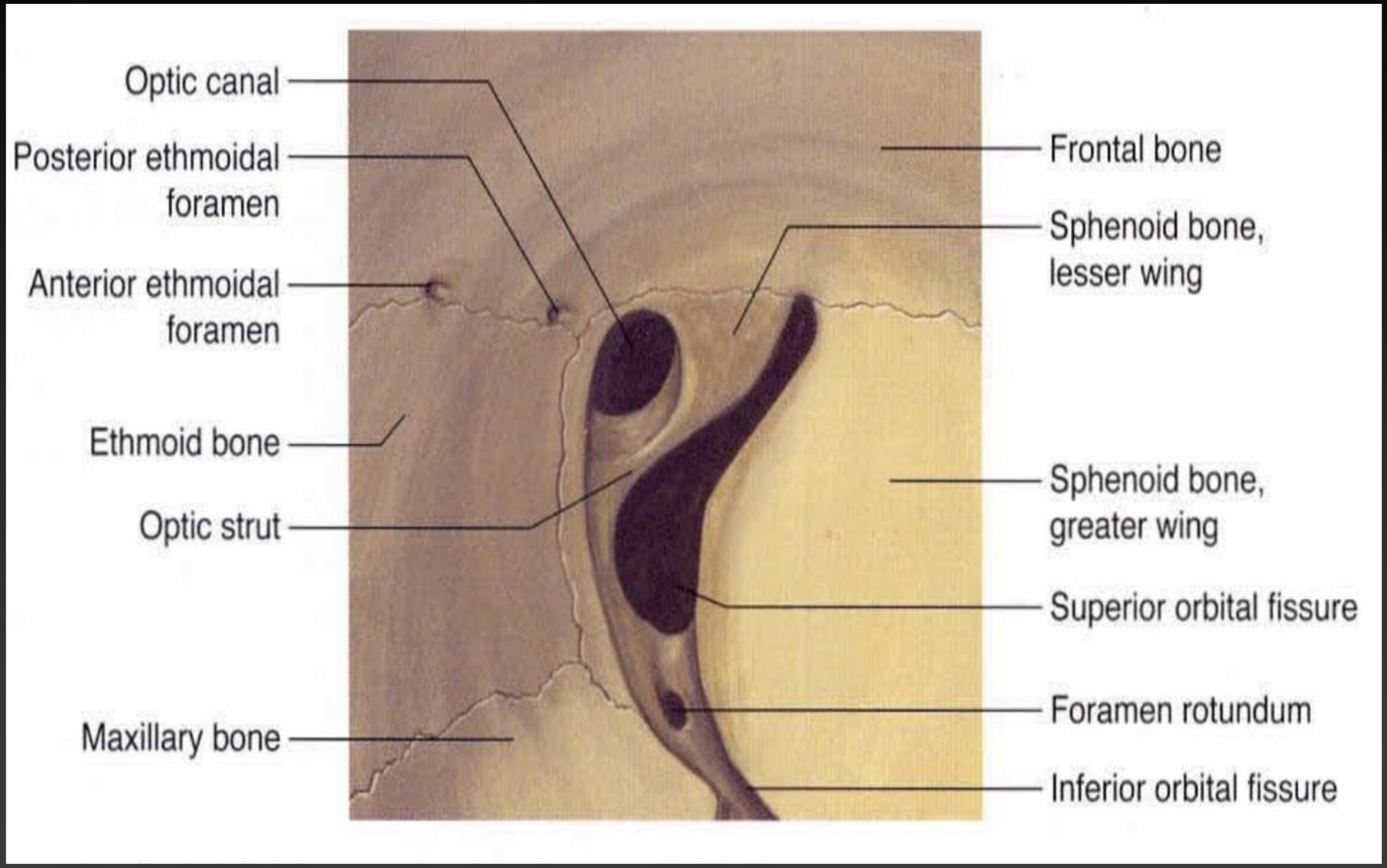
Part	Derived from
Lens	**Surface ectoderm**
Retina	Neuroectoderm (optic cup)
Vitreous	Mesoderm
Choroid	**Mesoderm (infiltrated by neural crest cells?)**
Ciliary body	Mesoderm
Ciliary muscles	Mesenchymal cells covering the developing ciliary body (neural crest)
Iris	Mesoderm
Muscles of the iris	Neuroectoderm (from optic cup)
Sclera	Mesoderm (infiltrated by neural crest cells?)
Cornea	Surface epithelium by ectoderm, substantia propria and inner epithelium by neural crest
Conjunctiva	Surface ectoderm
Blood vessels	mesoderm
Optic nerve	Neuroectoderm. Its covering (pia, arachnoid and dura) are derived from mesoderm


Vertex
Frontal bone
Nasion
Glabella
Orbit
Zygomatic bone
Nasal bone
Maxilla
Piriform aperture
Gonion
Mandible

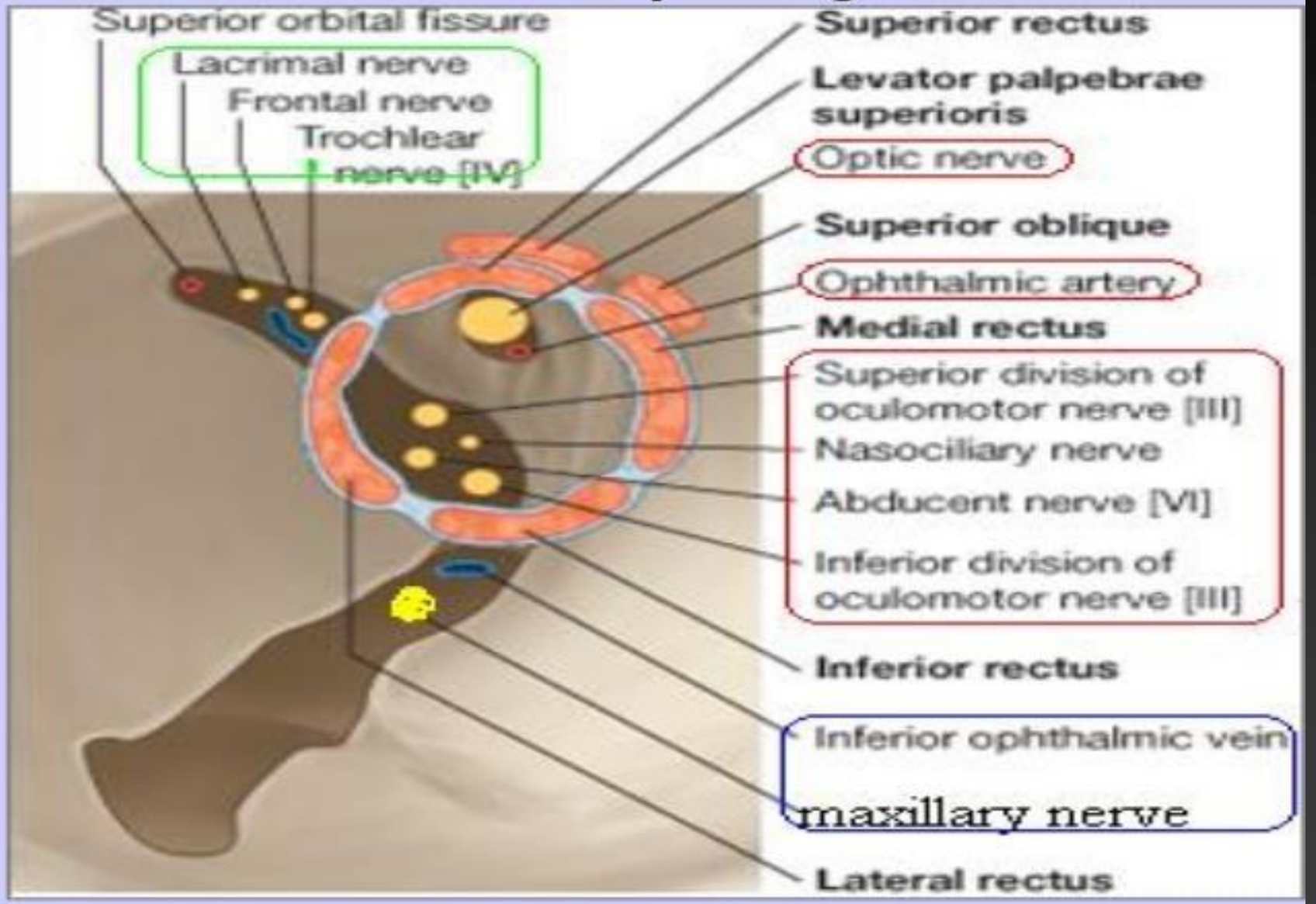
- Latera orbital wall is the thickest and strongest
- Medial wall is the thinnest






Optic canal
Posterior ethmoidal foramen
Anterior ethmoidal foramen
Ethmoid bone
Optic strut
Maxillary bone
Frontal bone
Sphenoid bone, lesser wing
Sphenoid bone, greater wing
Superior orbital fissure
Foramen rotundum
Inferior orbital fissure

Orbital openings



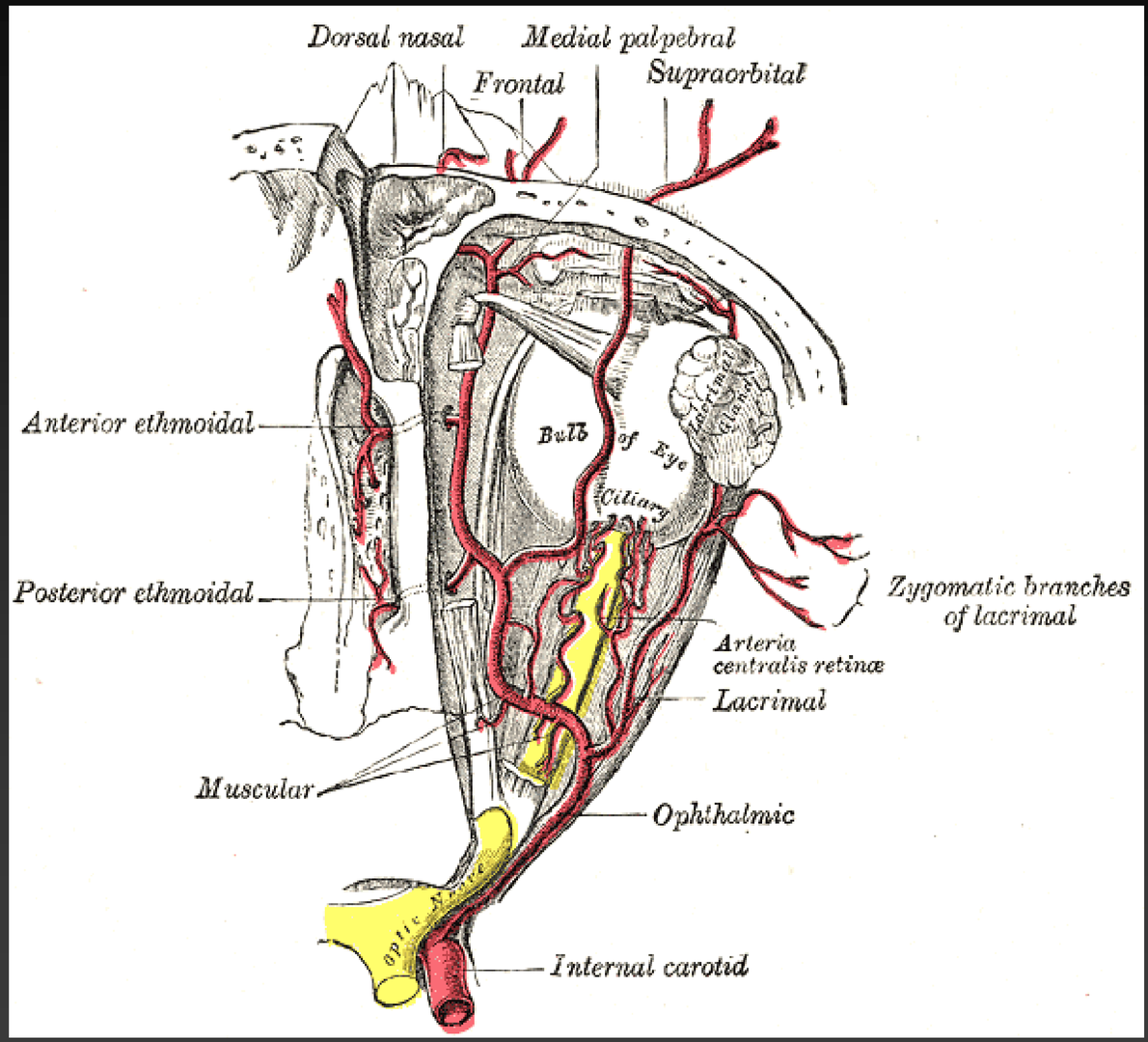
Orbital dimensions:

- Orbital volume: 30cm3
- Entrance height: 35mm
- Entrance width: 40mm
- Medial wall length: 45mm

- **Craniosynostosis: eg Crouzon syndrome**

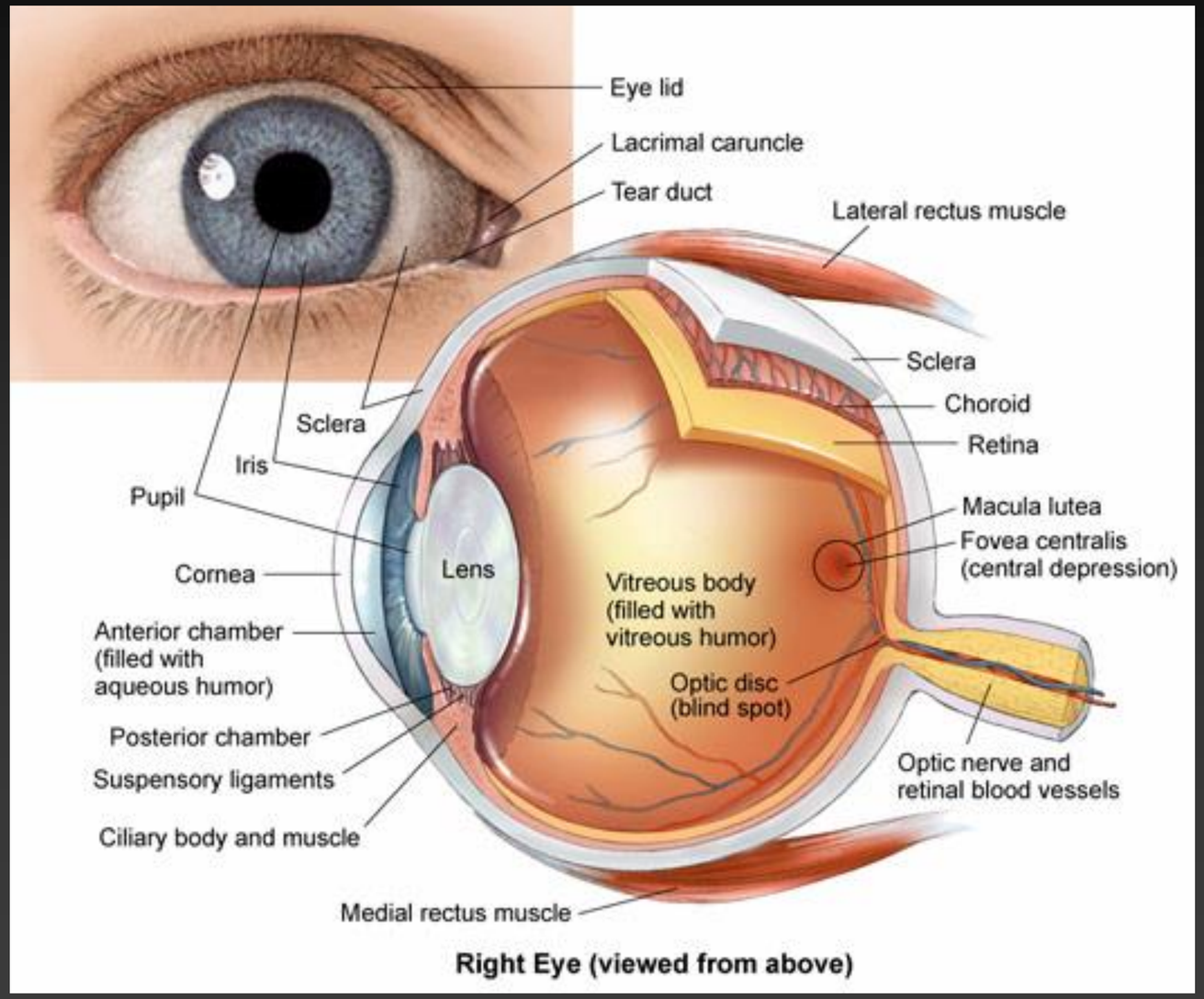
The eyeball takes up about one-fifth of the orbital volume.

The remaining is taken up by the extraocular muscles, fascia, fat, blood vessels, nerves and the lacrimal gland.



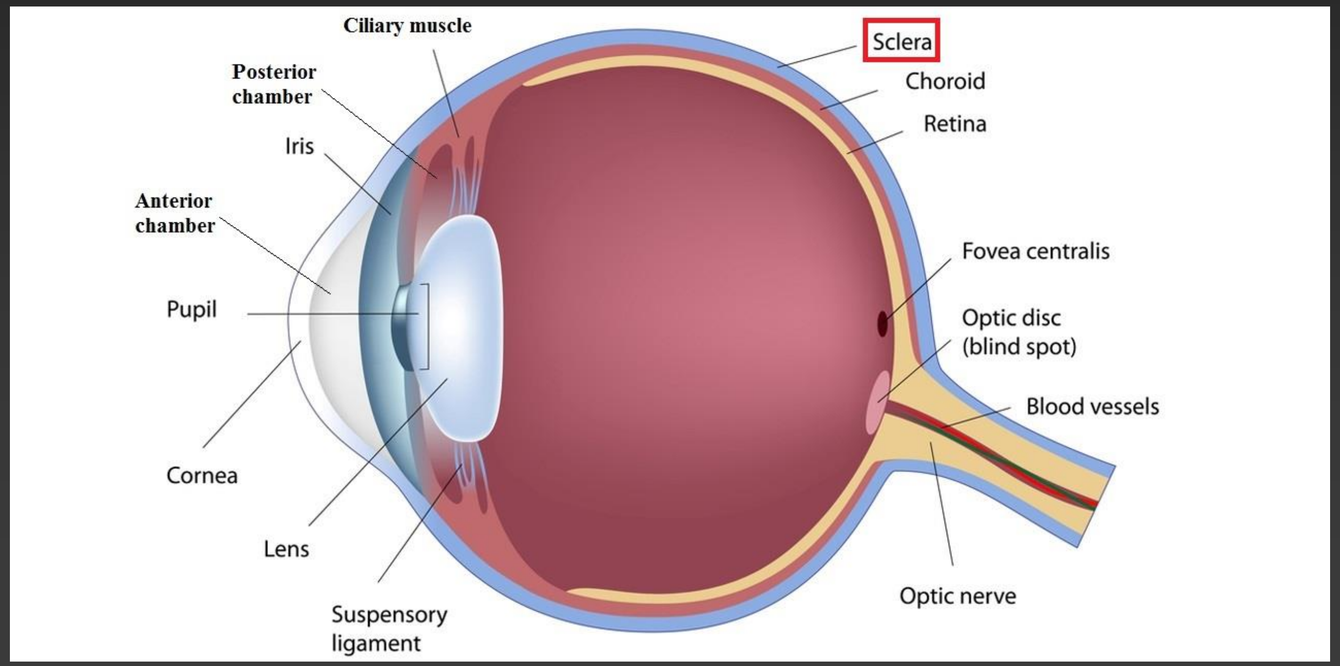
The Globe

- The eye has three layers:
- (a) Outer fibrous layer:
  - cornea
  - sclera
  - lamina cribrosa.
- (b) Middle vascular layer (“uveal tract”):
  - iris
  - ciliary body – consisting of the pars plicata and pars plana
  - • choroids.
- (c) Inner nervous layer:
  - pigment epithelium of the retina
  - retinal photoreceptors
  - retinal neurons.



Outer Layer:

- The anterior one-sixth of the fibrous layer of the eye is formed by the cornea.
- The posterior five-sixths are formed by the sclera and lamina cribrosa.
- The junction of cornea and sclera is as the limbus.



Outer layer:

Cornea:

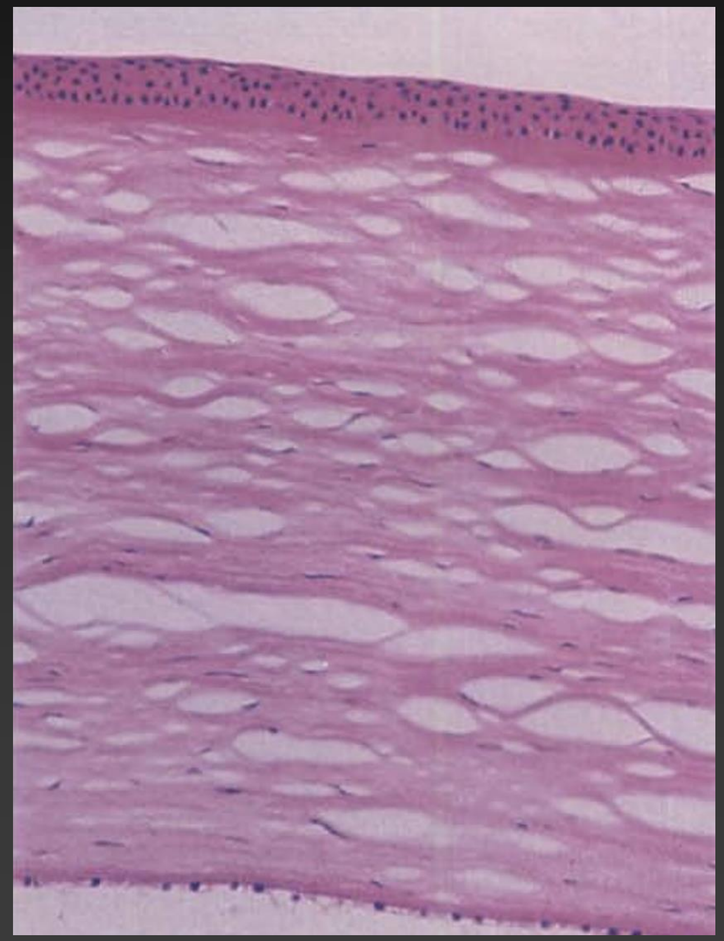
The cornea has five layers antero-posteriorly:

1. **Epithelium and its basement membrane**
2. **Bowman's layer – homogeneous sheet of modified stroma.**

3. Stroma – consists of approximately 90% of total corneal thickness. Consists of lamellae of collagen, cells and ground substance.

4. Descemet's membrane – the basement membrane of the endothelium.

5. Endothelium – a single layer of cells lining the inner surface of Descemet's membrane.



Outer layer:

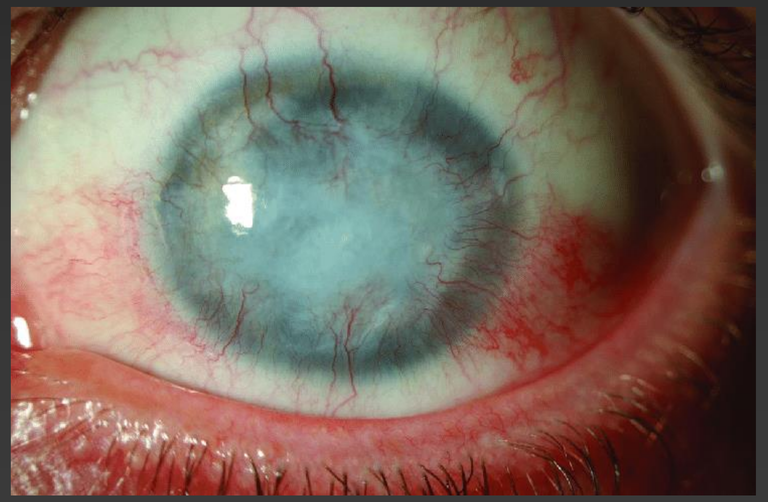
Cornea:

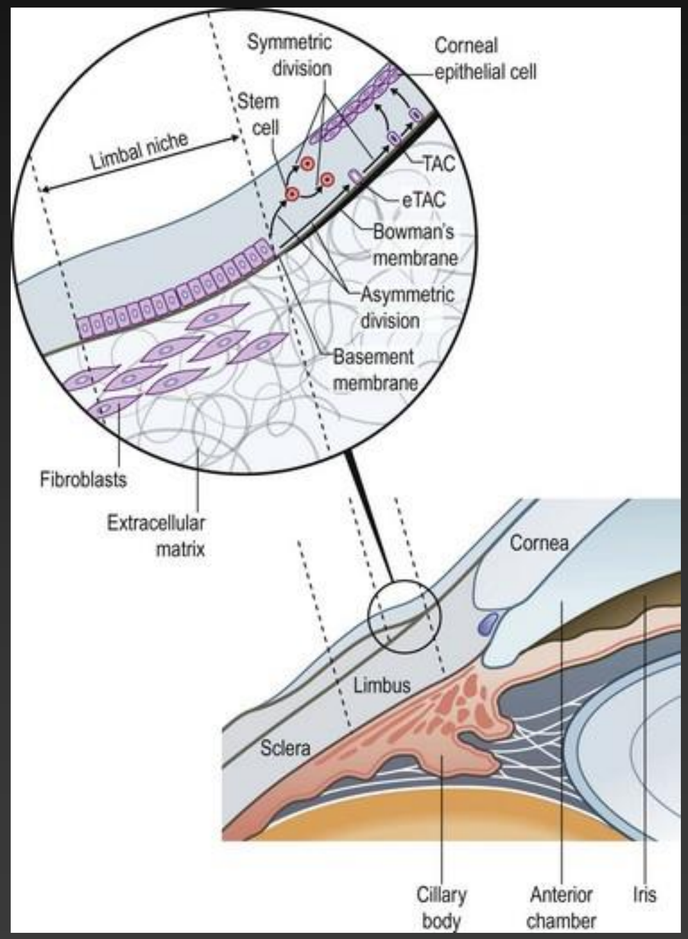
Characteristics of the cornea:

- Clear, What structure maintains clarity?
- Avascular: supplied from tearfilm and aqueous.
- rich in sensory neurons.
- Main refractive surface of the eye.

Limbus

- The junction between the cornea and sclera
- Area of corneal epithelial stem cells
- Stem cell deficiency: eg chemical burns

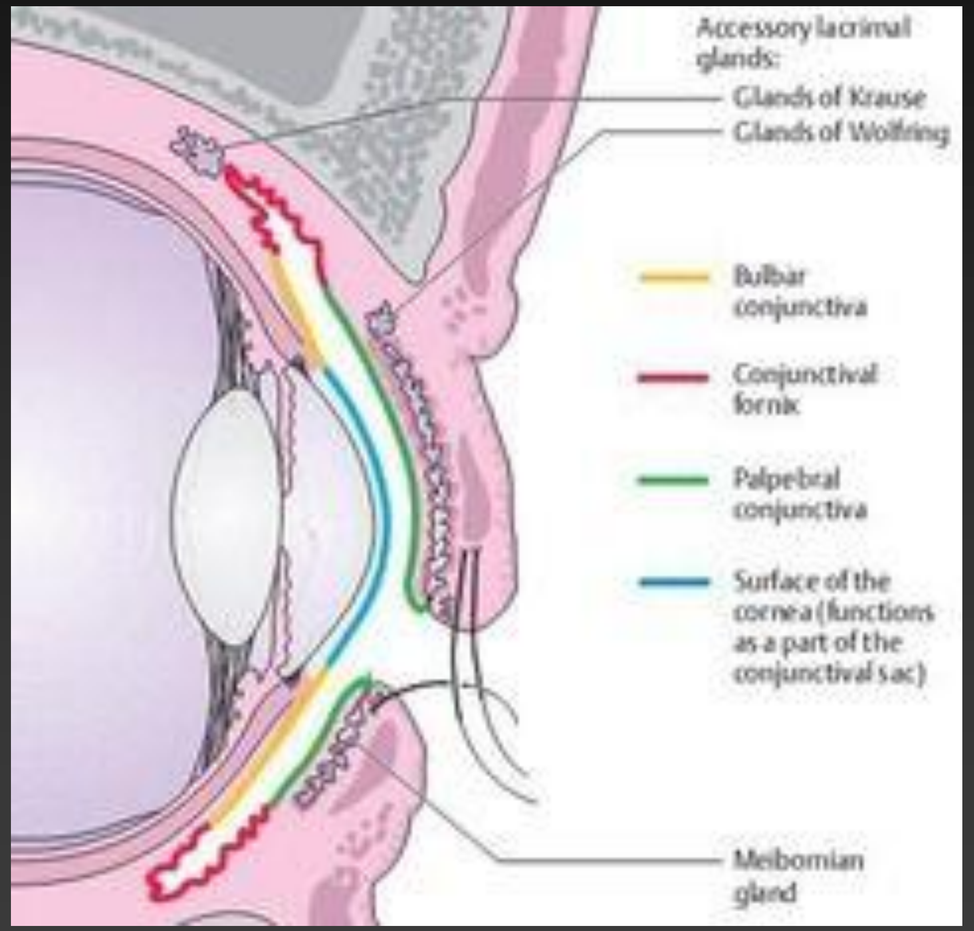




Outer layer:

conjunctiva:

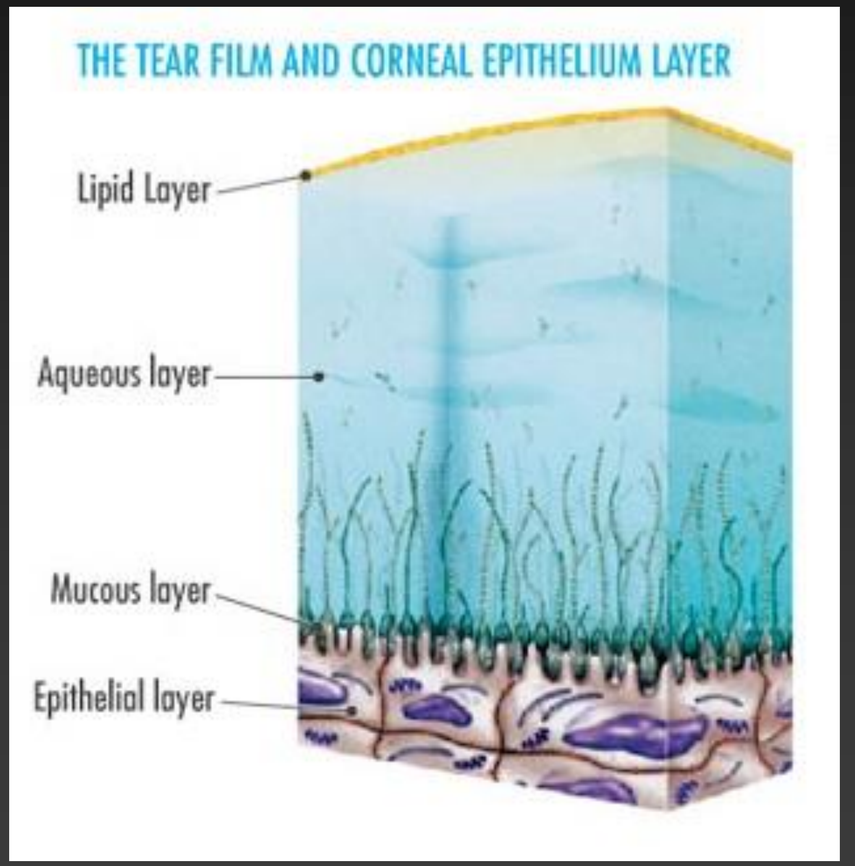
- At the limbus, the epithelium on the outer surface of the cornea becomes continuous with that of the conjunctiva.
- Conjunctiva is a thin, loose transparent nonkeratinizing epithelium that contains mucin-secreting goblet cells.
- It covers the anterior part of the sclera, from which it is separated by loose connective tissue (tenon).
- The conjunctiva can be divided descriptively into three parts: palpebral (tarsal), bulbar and fornix.



Tear film

The tear film is composed of three layers:

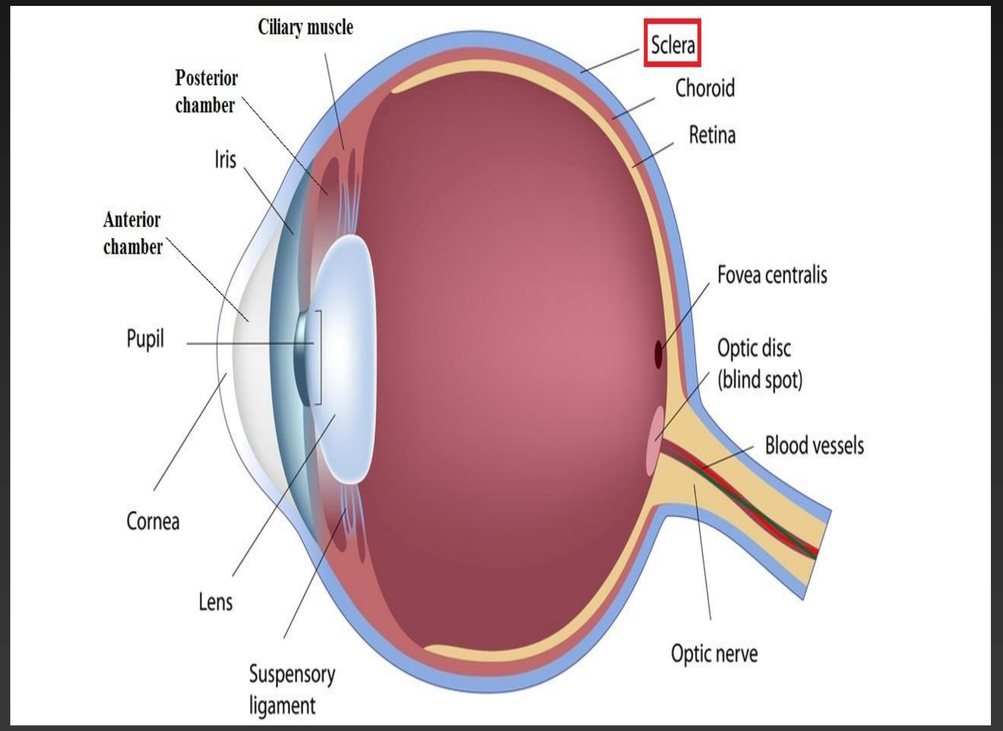
- **The innermost mucous layer is secreted by the conjunctival goblet cells.**
- **The middle aqueous layer is secreted by the main lacrimal gland and accessory lacrimal glands.**
- **The outer lipid layer is secreted by the meibomian glands.**



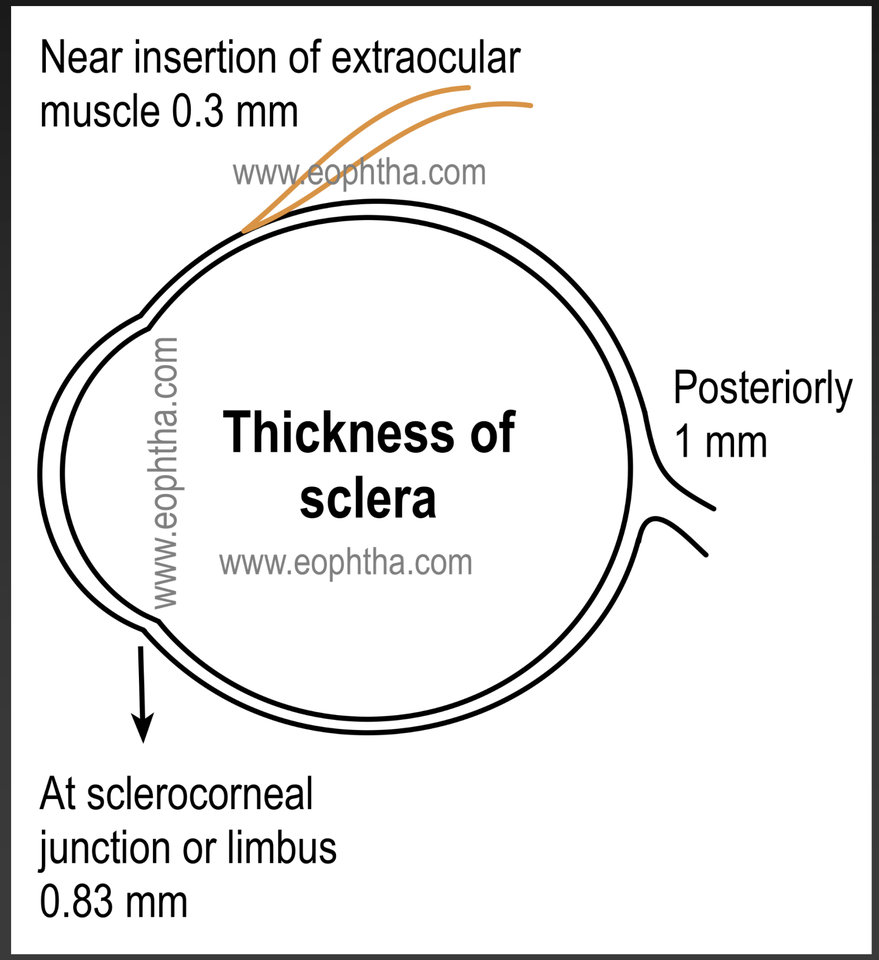
Outer layer:

Sclera:

- **The sclera consists of irregular lamellae of collagen fibres.**
- **Posteriorly, the external two- thirds of the sclera become continuous with the dural sheath of the optic nerve.**
- **The inner one-third becomes the lamina cribrosa**
- **The episcleral is a layer of loose connective tissue deep to the conjunctiva, overlying the sclera.**

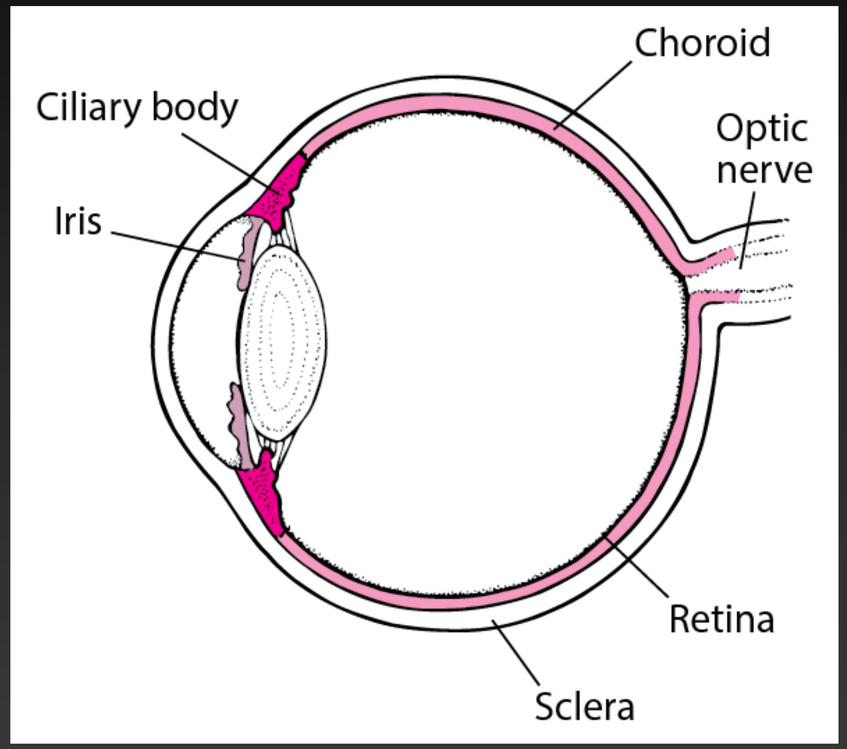


The sclera is thickest posteriorly and thinnest beneath the insertions of the recti muscles.



Middle layer:

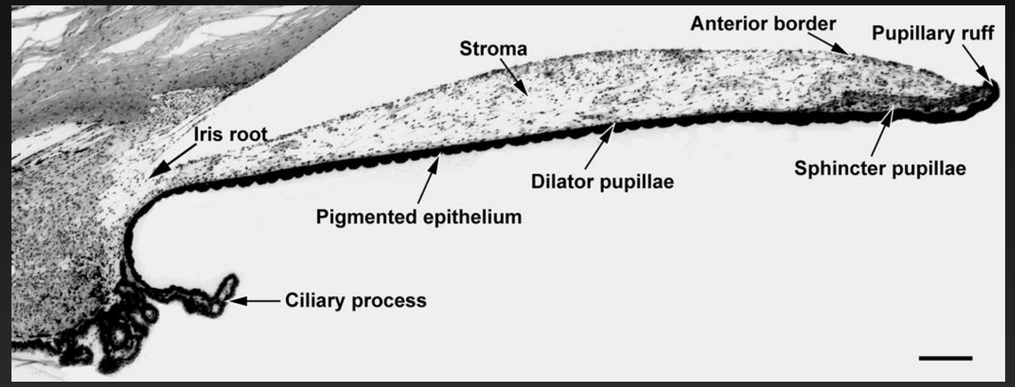
- **The middle layer is highly vascular, called uvea tract**
- **It is heavily pigmented.**
- **The anterior part of the uvea forms the bulk of the iris body and hence inflammation of the iris is called either anterior uveitis or iritis.**
- **The intermediate part is the ciliary body.**
- **The posterior part of the uvea is called the choroid.**

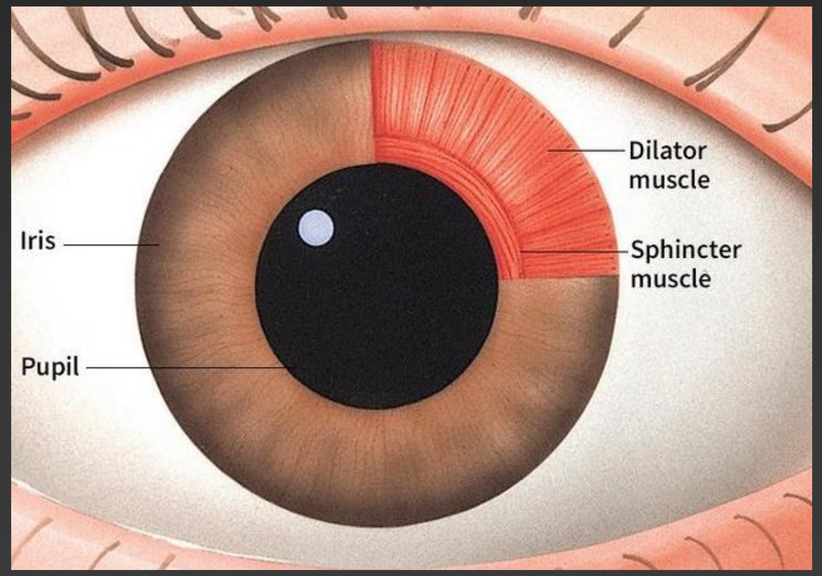


Middle layer:

Iris:

- **Most anterior part of the uvea.**
- **Contraction of the iris sphincter muscle constricts the pupil. (parasympathomemtics, 3rd cranial nerve)**
- **Contraction of the dilator pupillae muscle dilates the pupil. (sympathetic, superior cervical ganglion)**

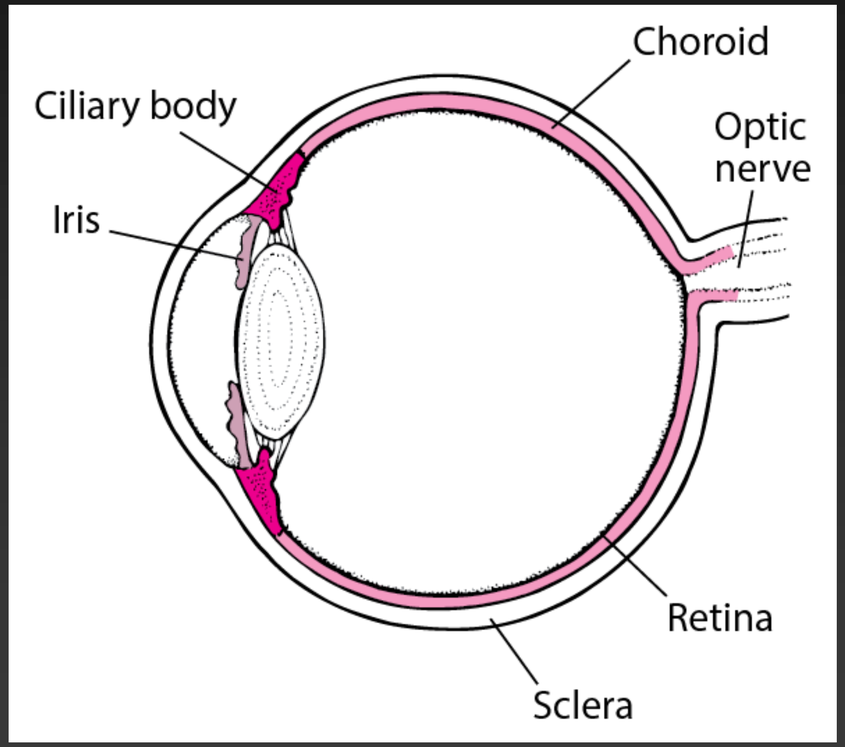




Middle layer:

Ciliary body:

- **The ciliary body is also referred to as the intermediate uvea**
- **It is attached anteriorly to the iris and the scleral spur; posteriorly it is continuous with the choroid and retina.**
- **The ciliary body is triangular in cross- section.**



Middle layer:

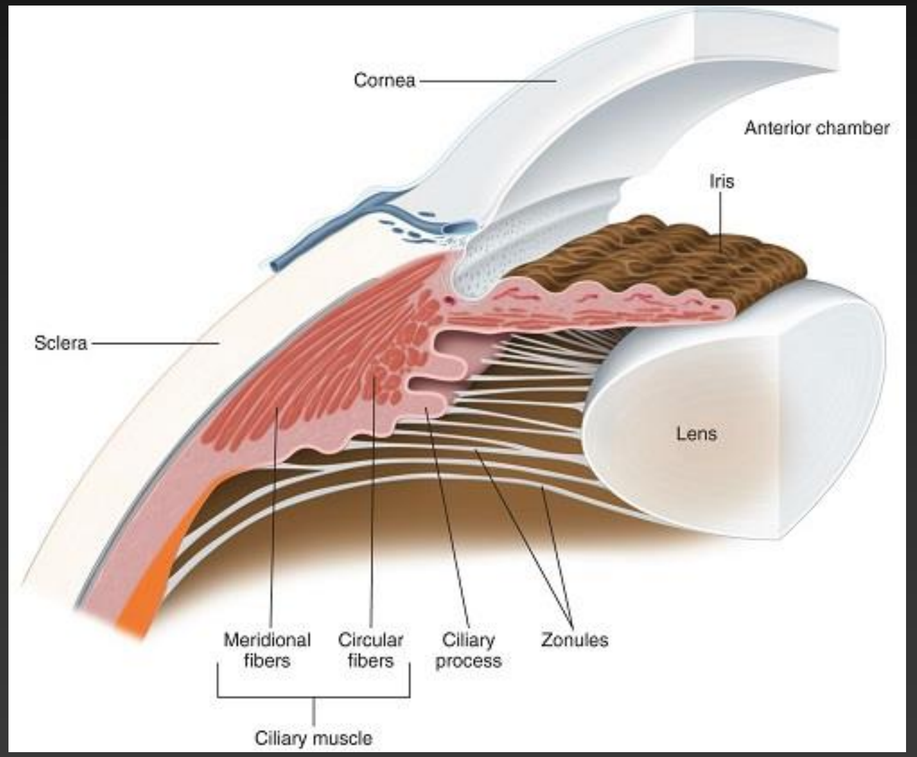
Ciliary body:

The inner side is divided into two zones:

- (1) the **pars plicata** forms the anterior 2 mm and is covered by ciliary processes

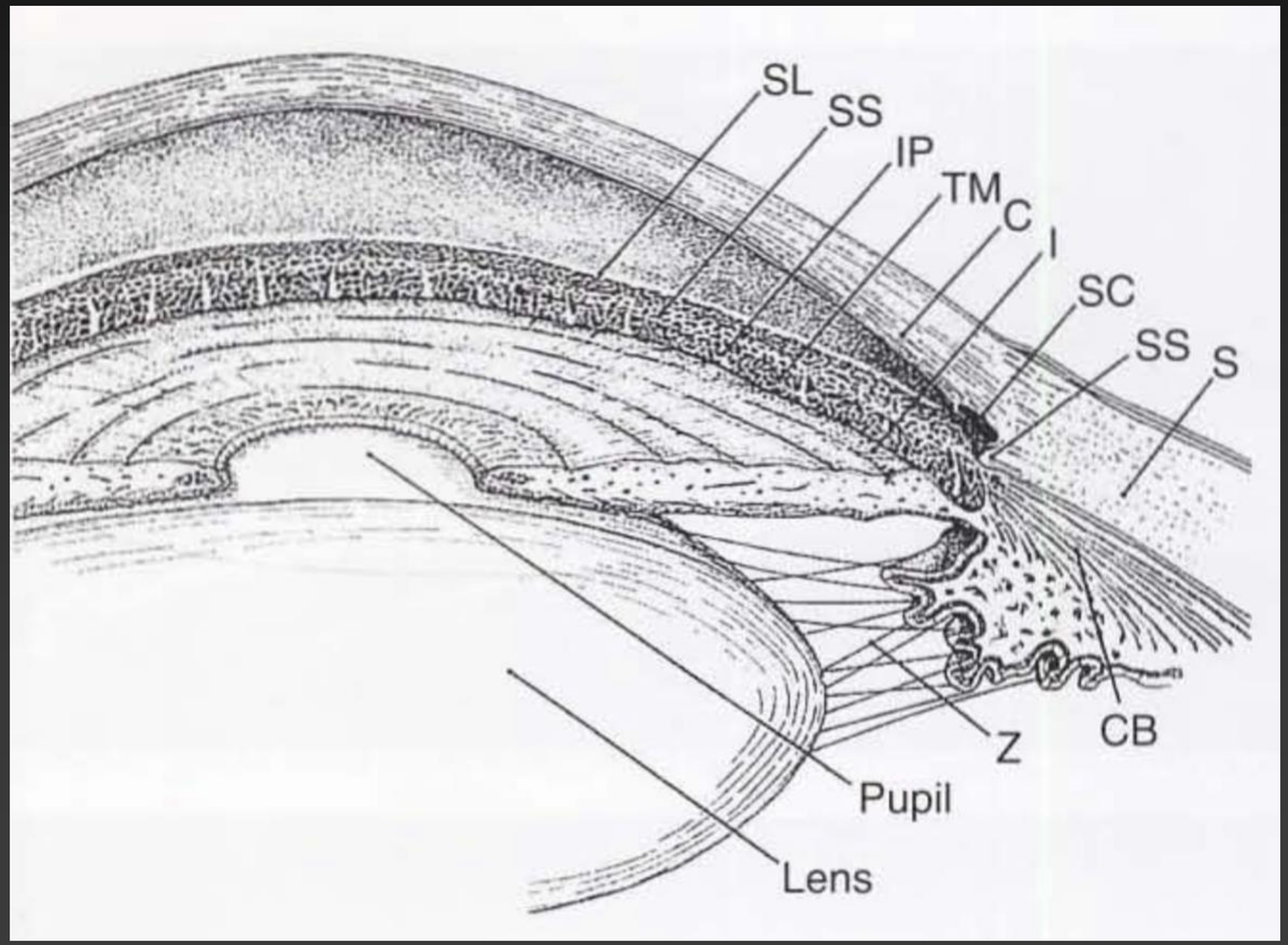
(2) the **pars plana** constitutes the posterior 4.5-mm flattened portion of the ciliary body.

- The pars plana is continuous with the choroid and retina.



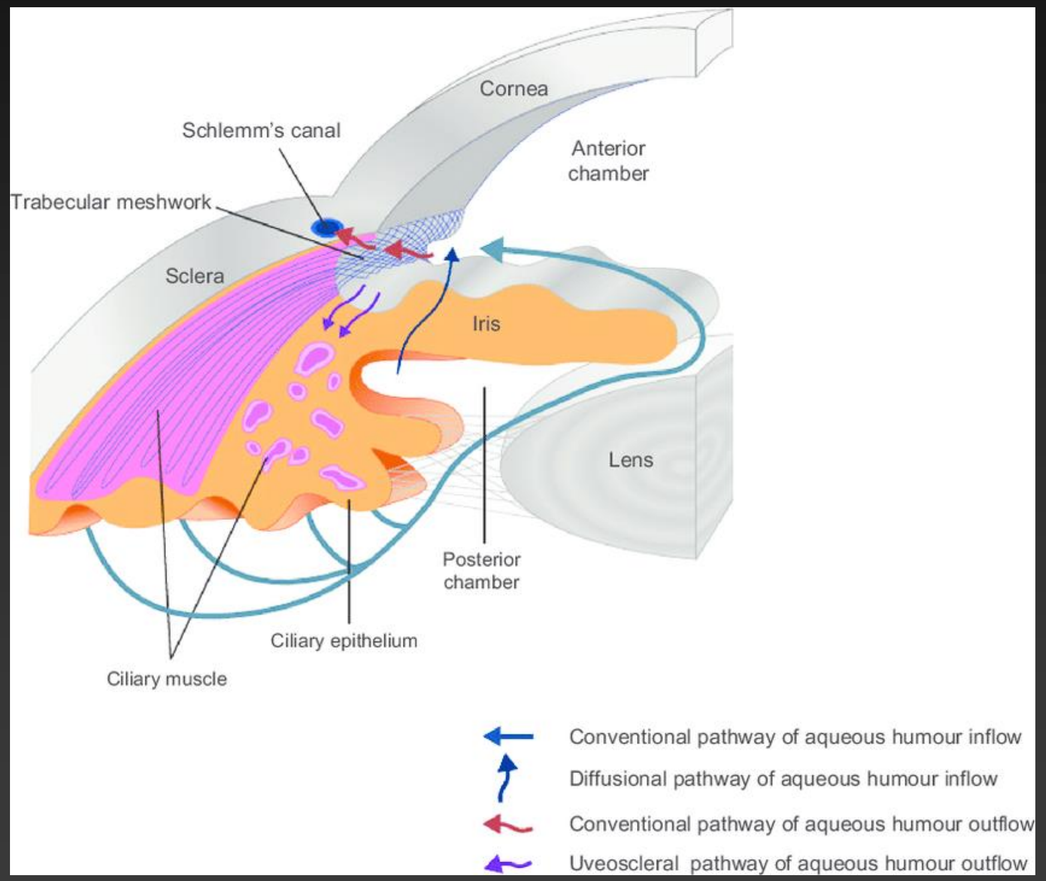
Middle layer:

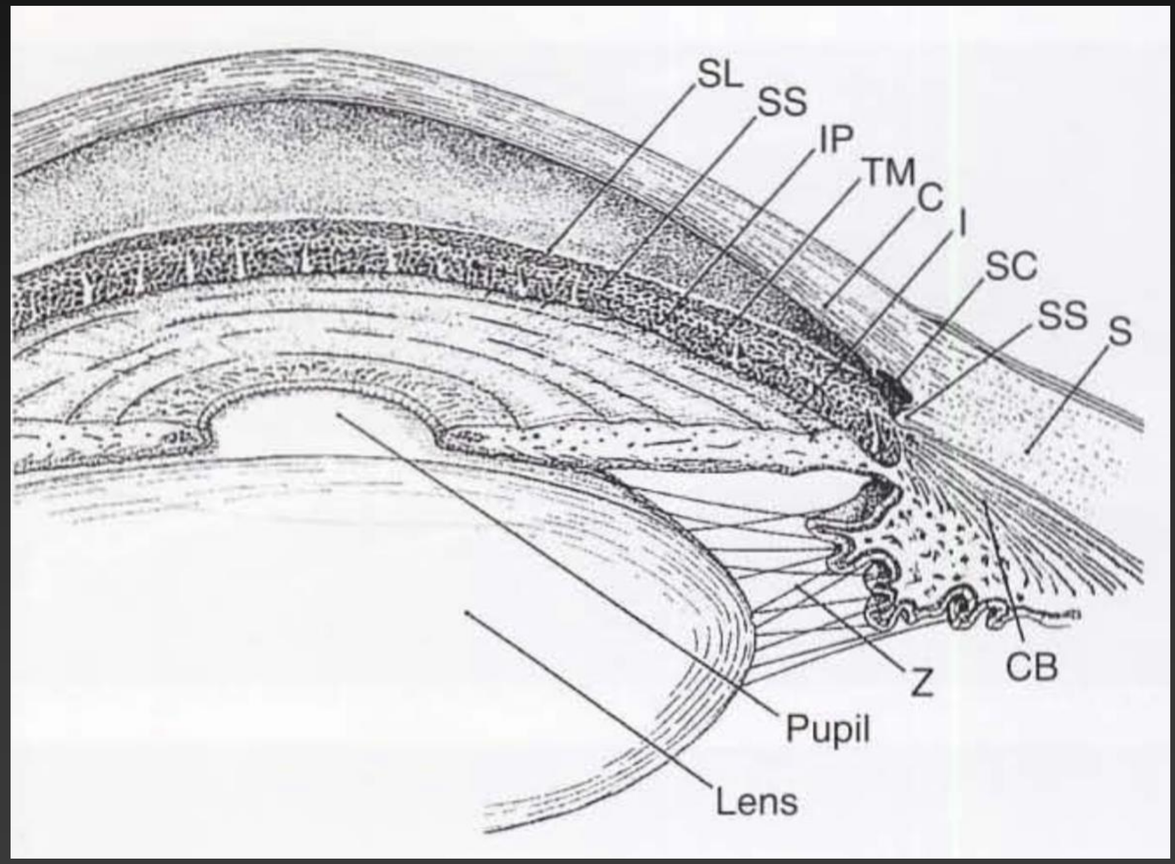
Ciliary body:



Middle layer:

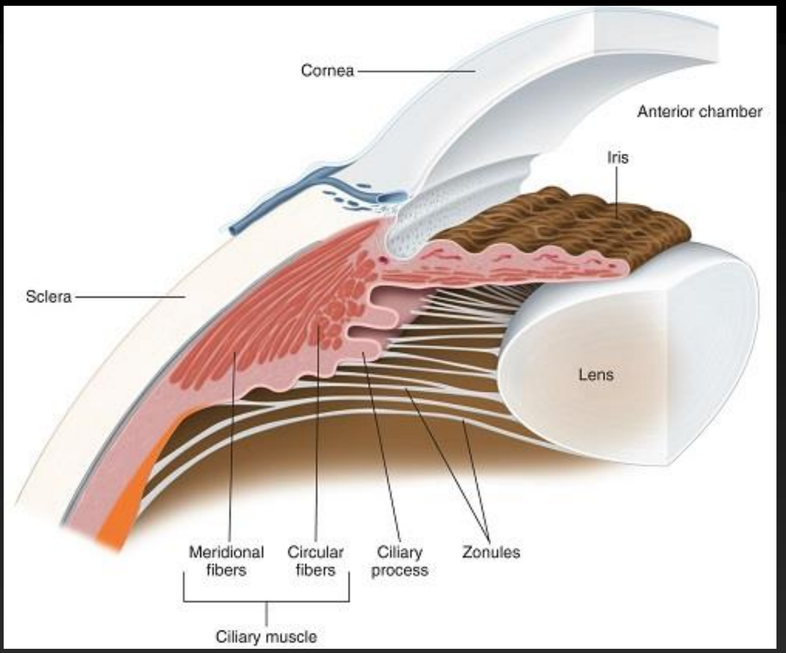
Intraocular pressure

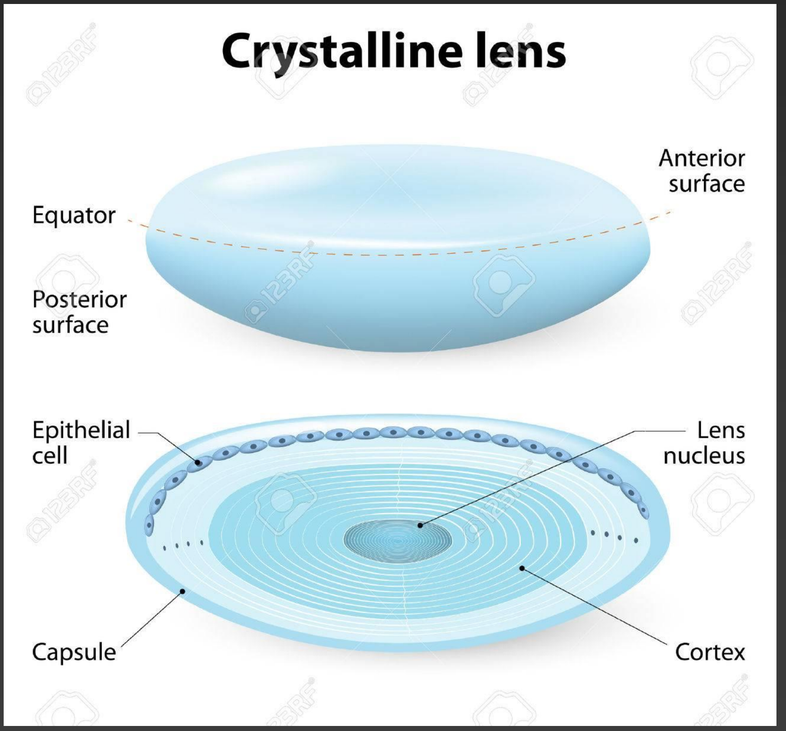




Crystalline lens:

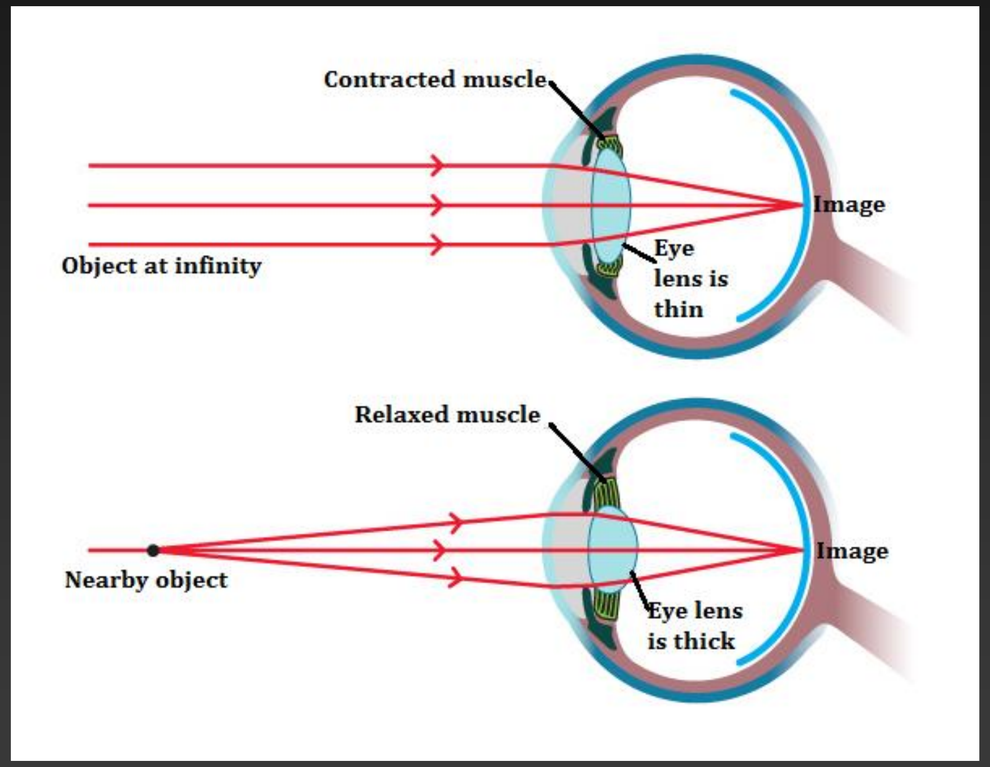
- Transparent avascular part, helps to focus the light on the retina.
- The only part of body that continue its enlargement thorough life.
- Suspended by the zonules.
- Changes in its structure leads to cataract.

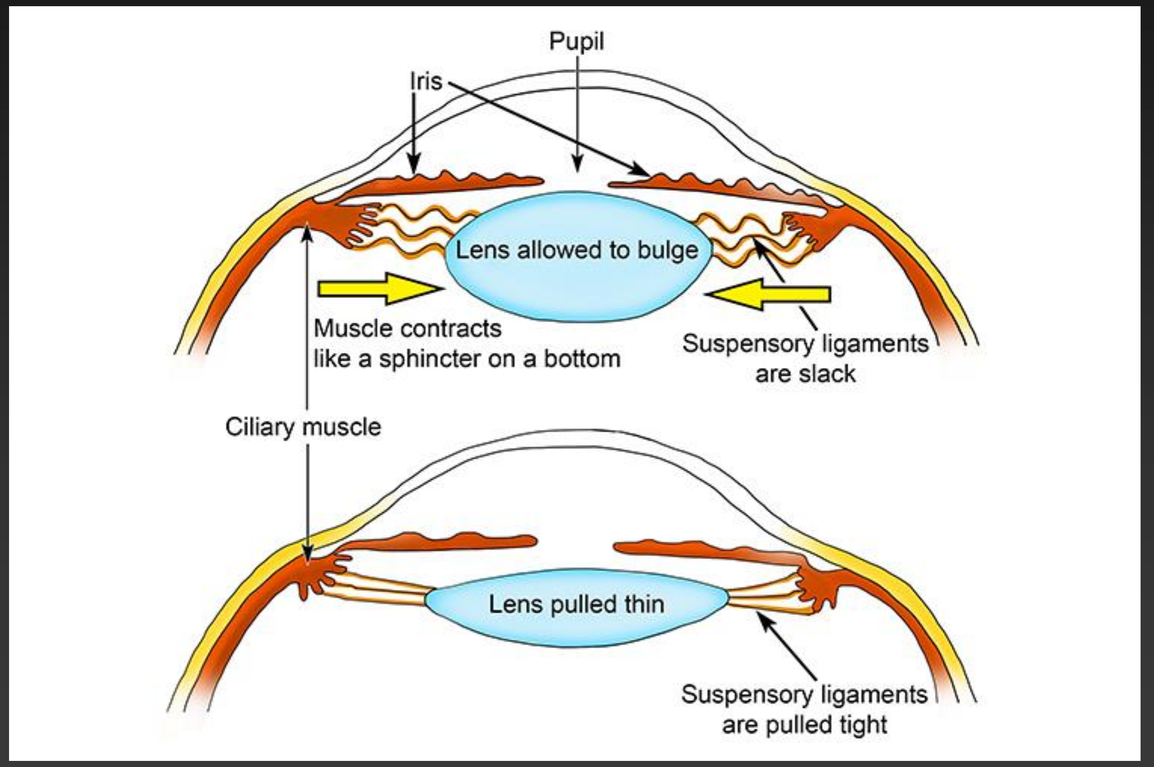




Accommodation:

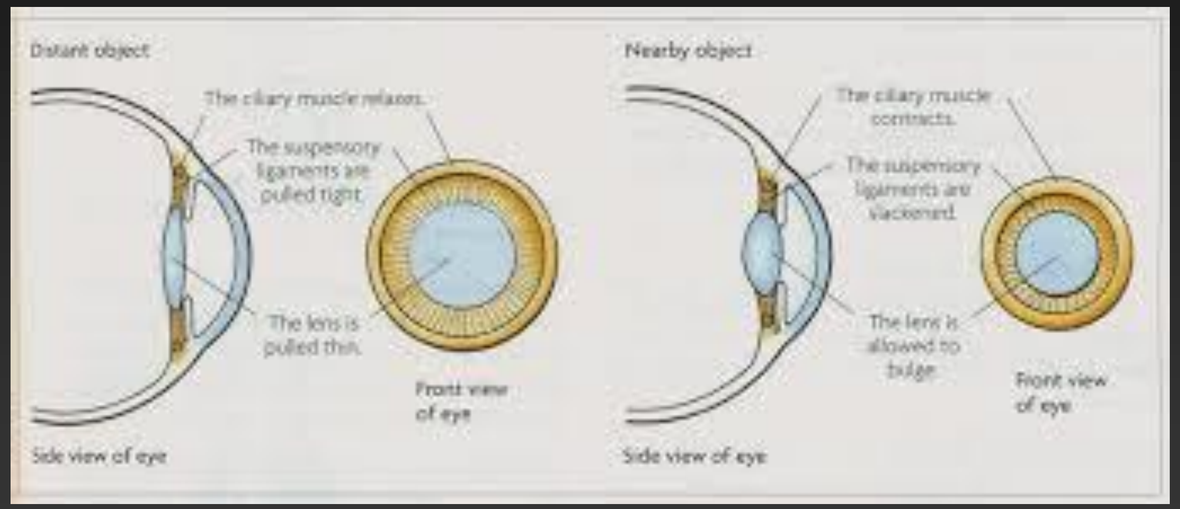
- **What happens during accommodation?**



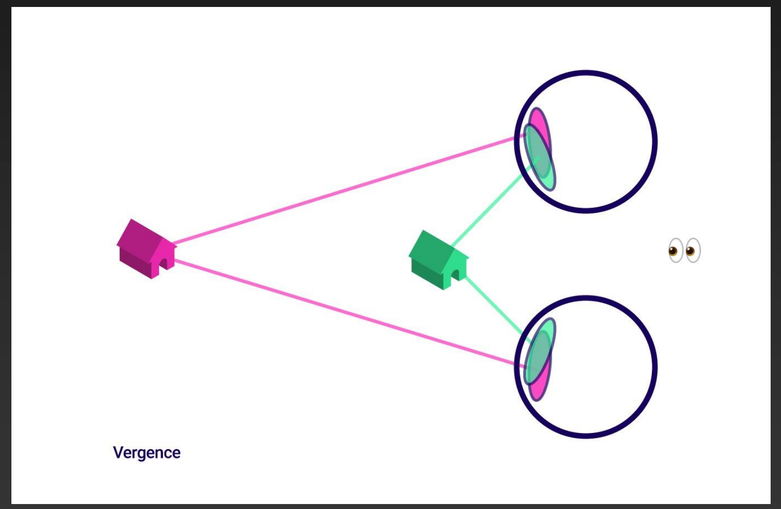


Accommodation:

- **Other elements of accommodation:**



miosis



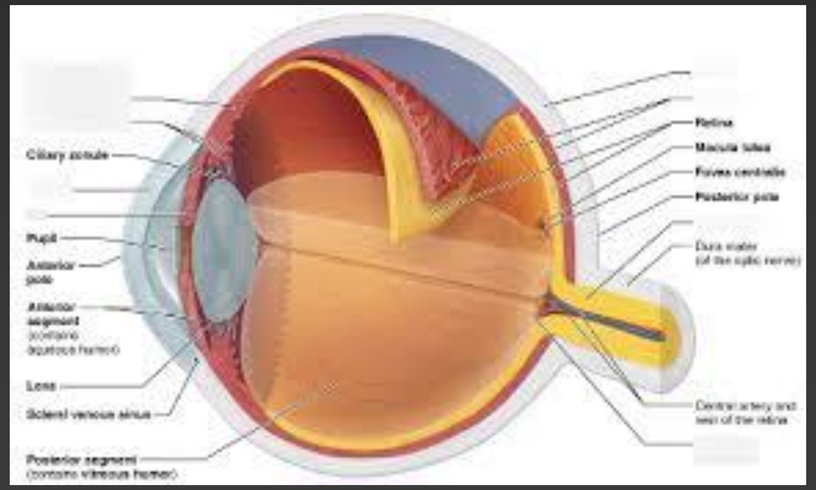
convergence

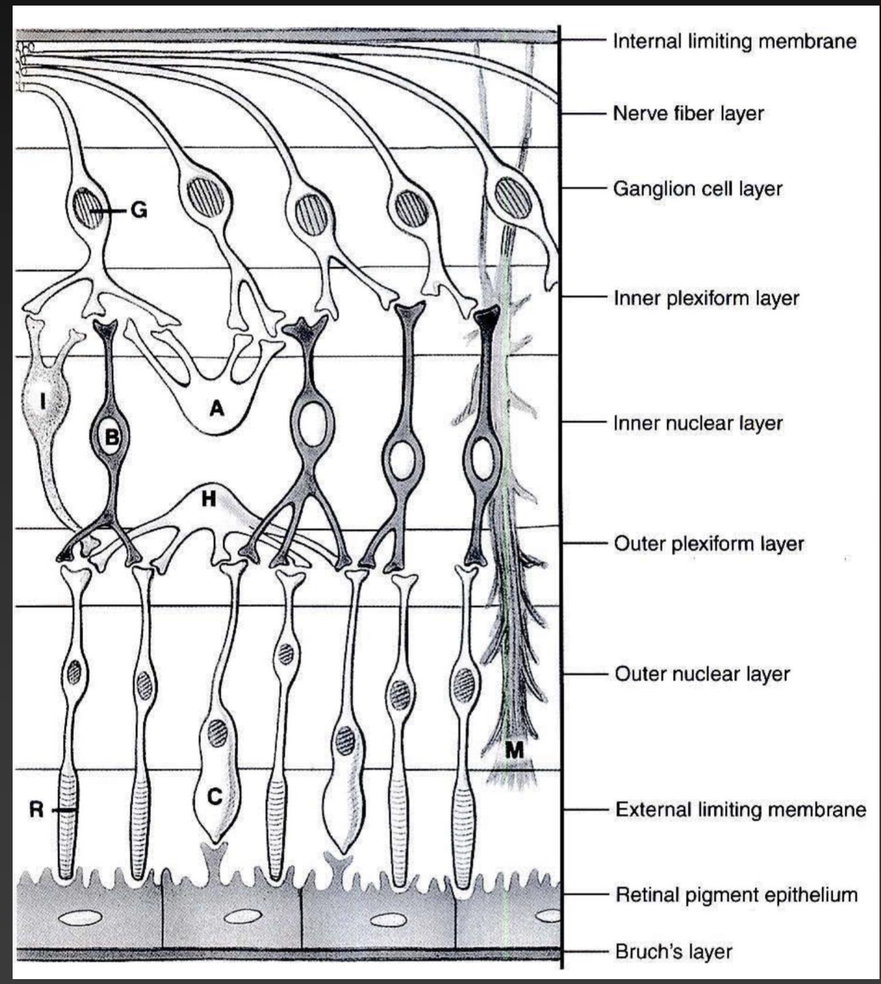
What is the relationship between accommodation and horizontal strabismus?

Inner layer

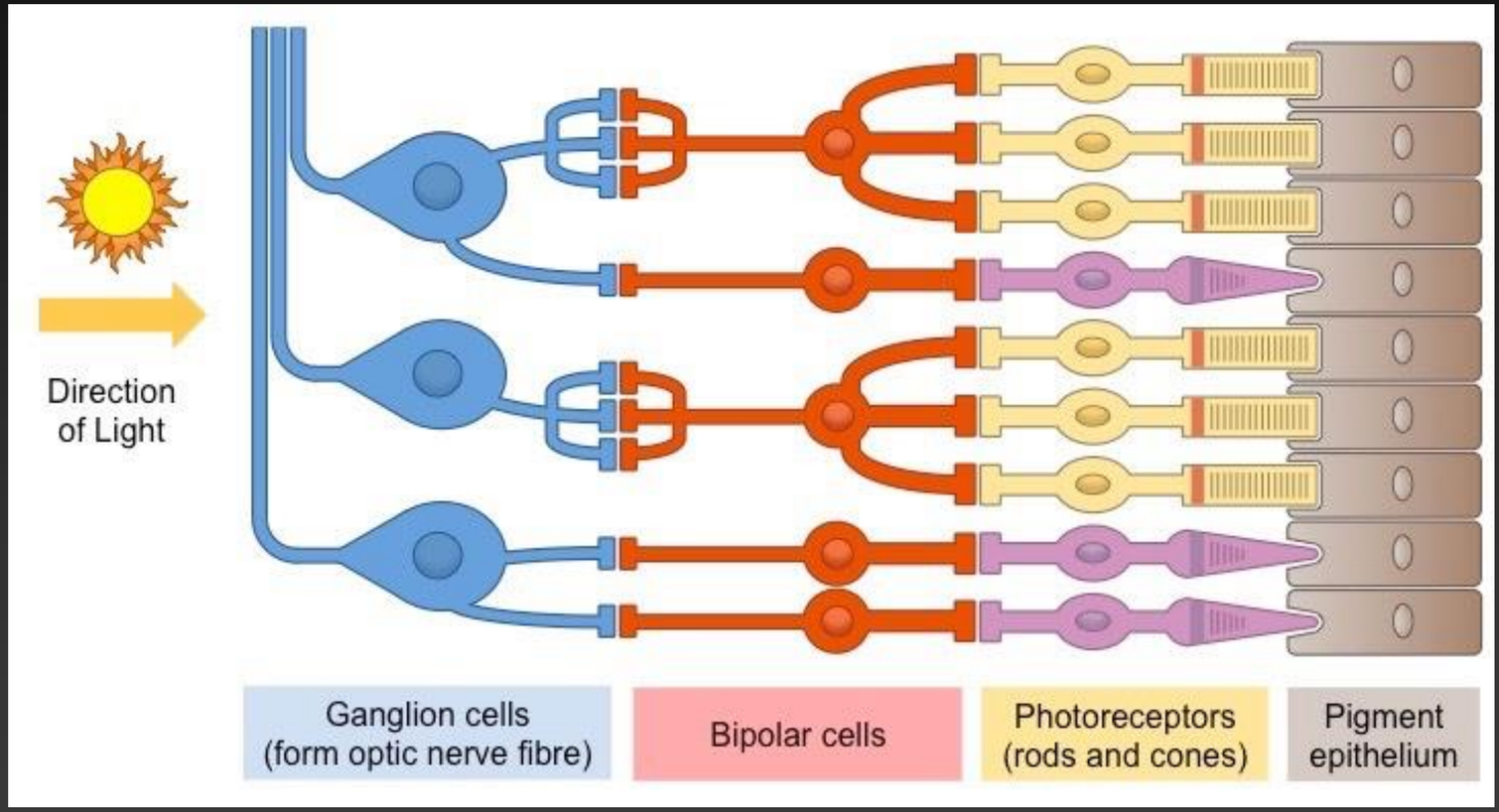
The retina:

- outer pigment epithelium
- an inner sensory part

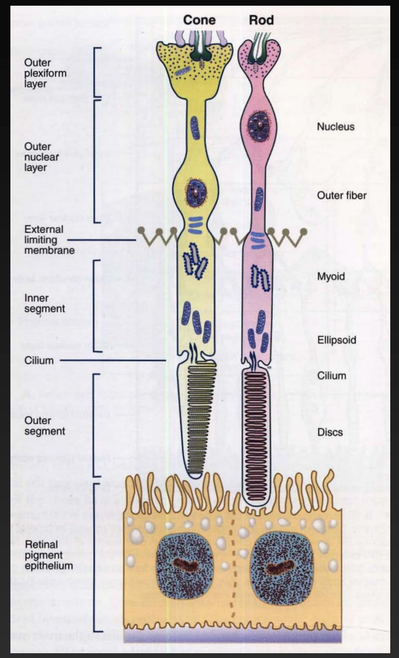


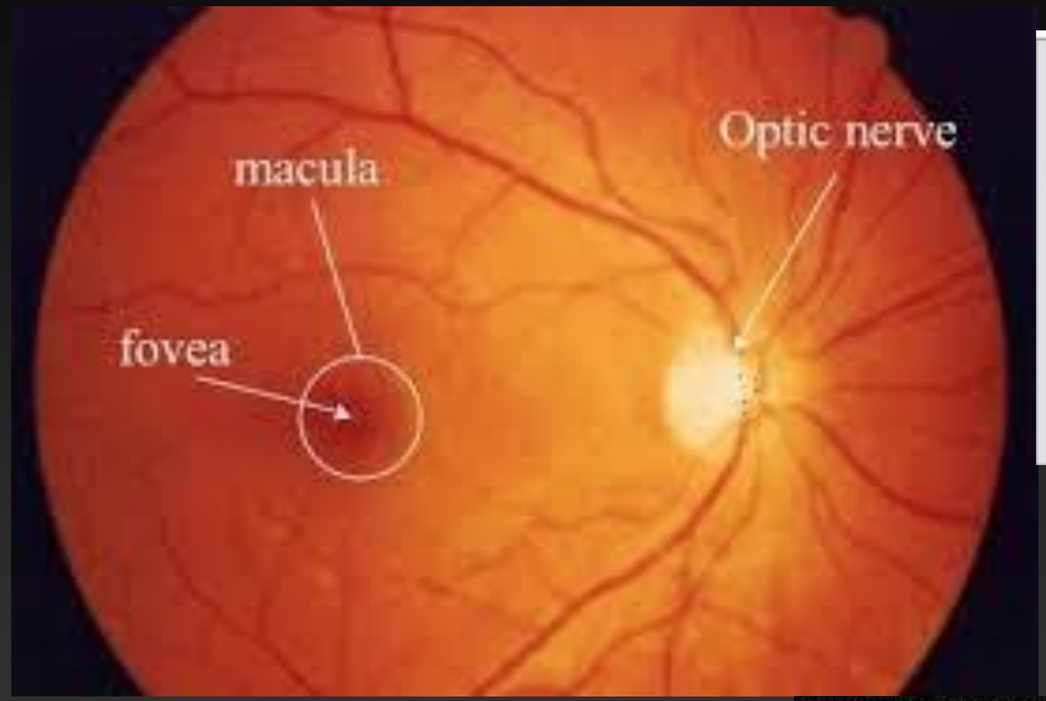


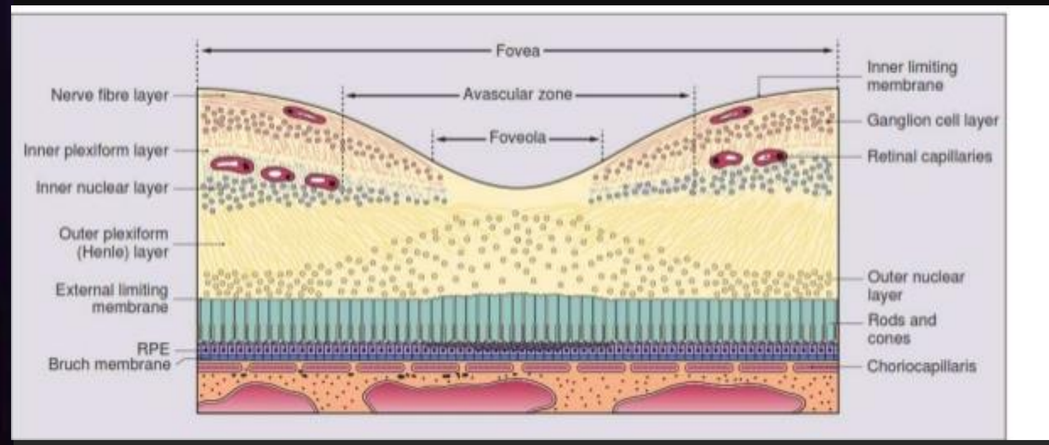
Inner layer


Direction
of Light
Ganglion cells
(form optic nerve fibre)
Bipolar cells
Photoreceptors
(rods and cones)
Pigment
epithelium

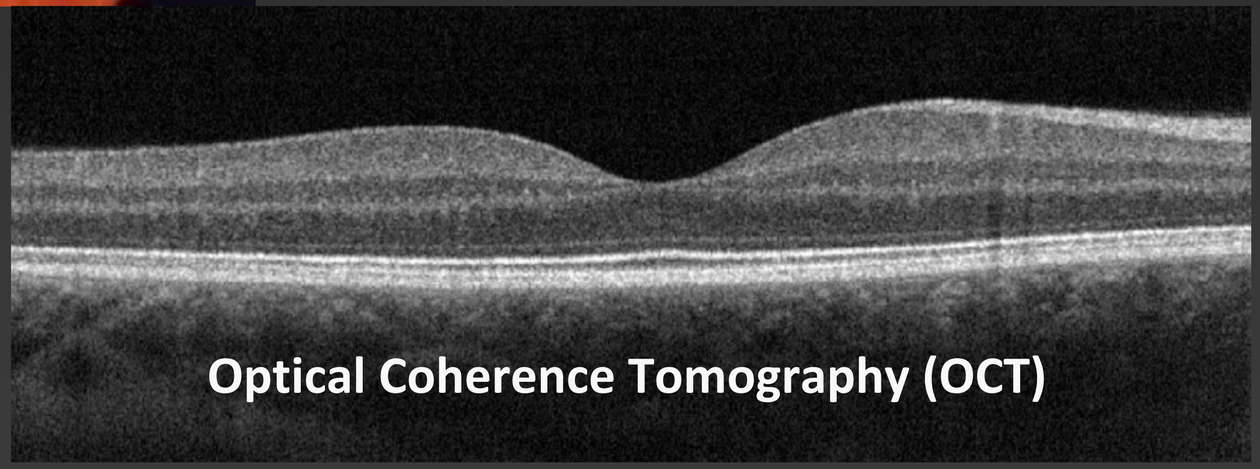
Inner layer





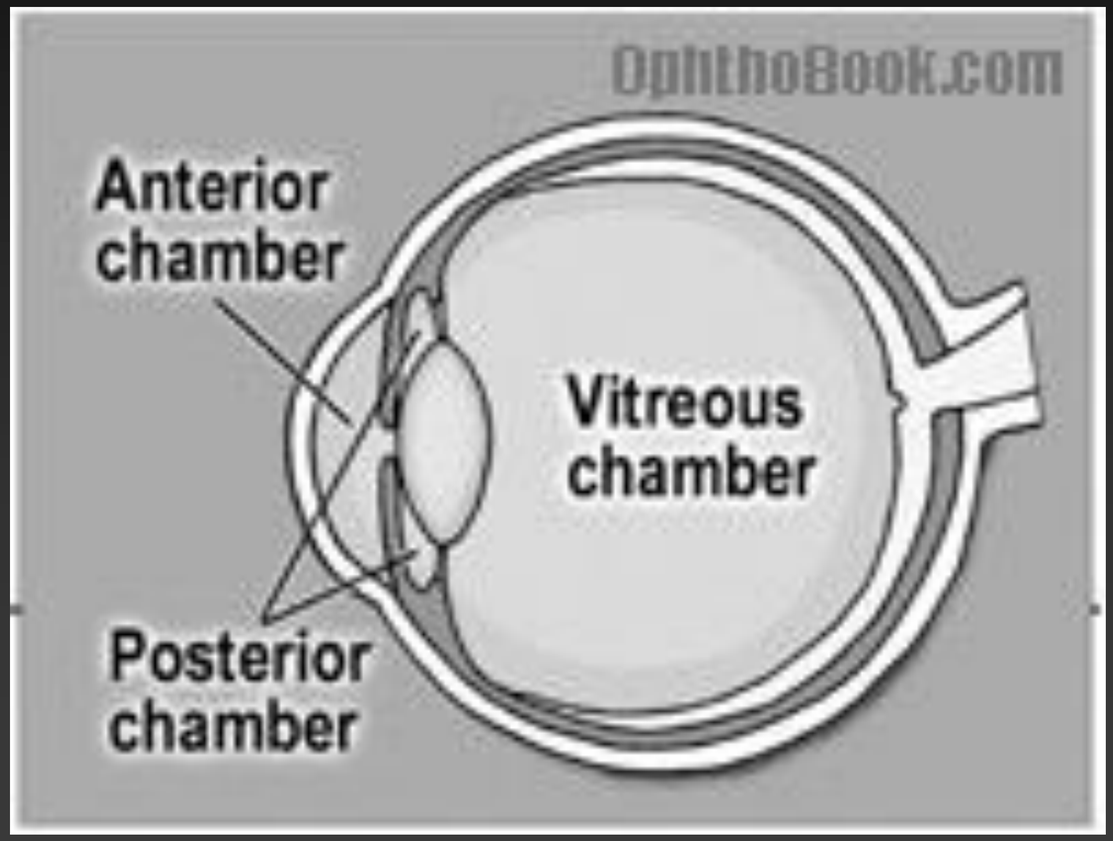


- **Highest density of cons is in the fovea and decrease rapidly outside the fovea. However the total number of cons outside the fovea is more than that in the fovea.**
- **Fovea has no rods.**



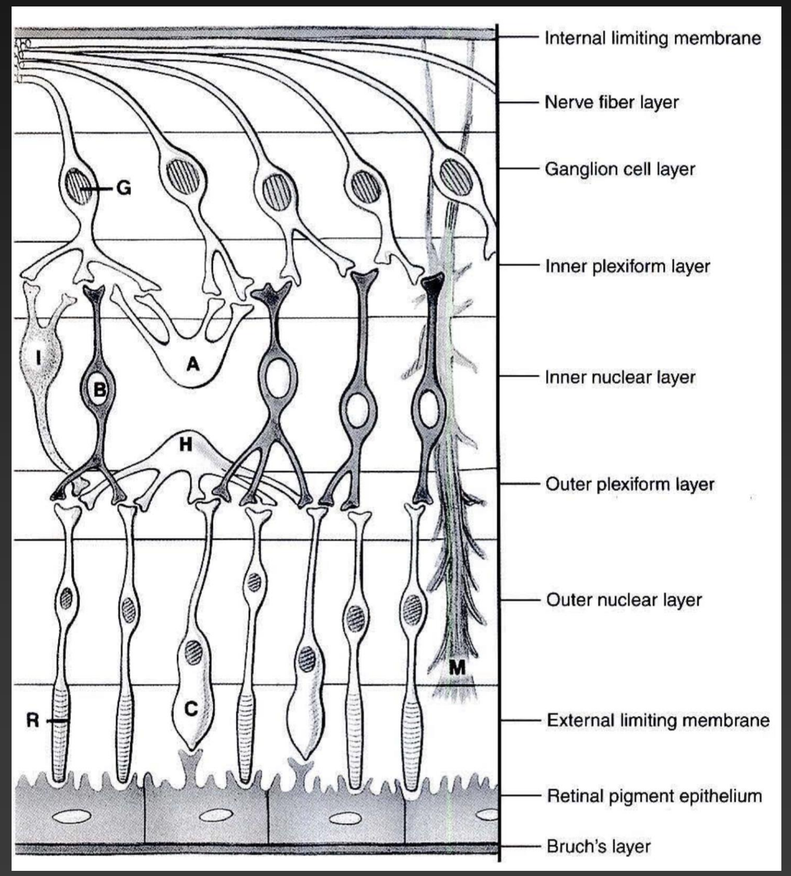
Optical Coherence Tomography (OCT)

Chambers of the Eye

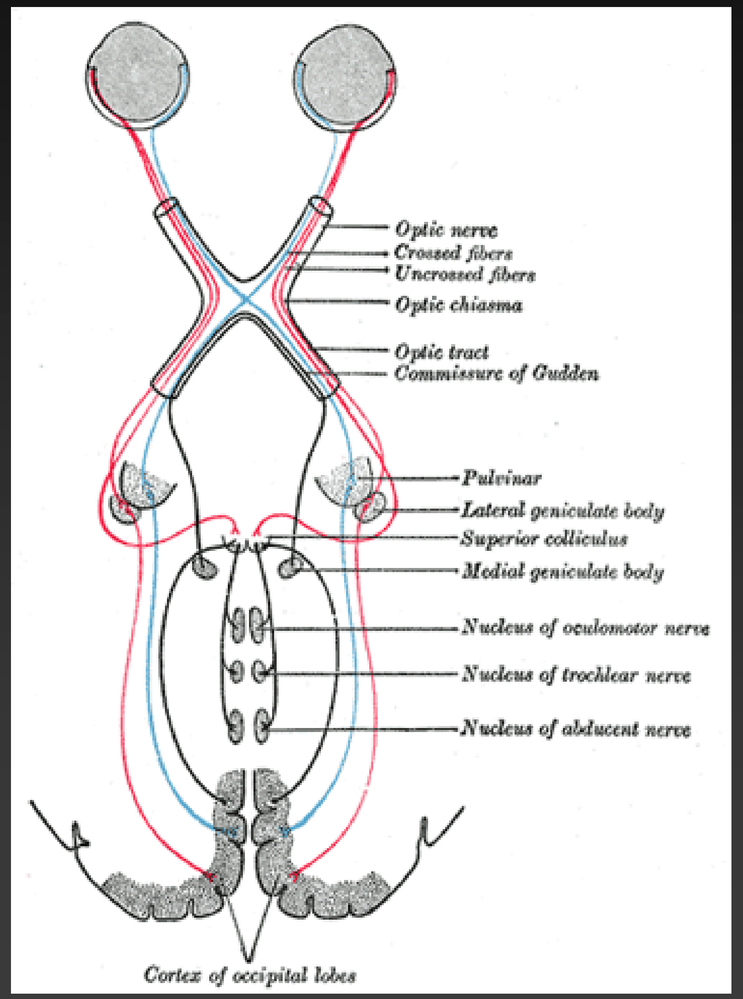


Optic Nerve

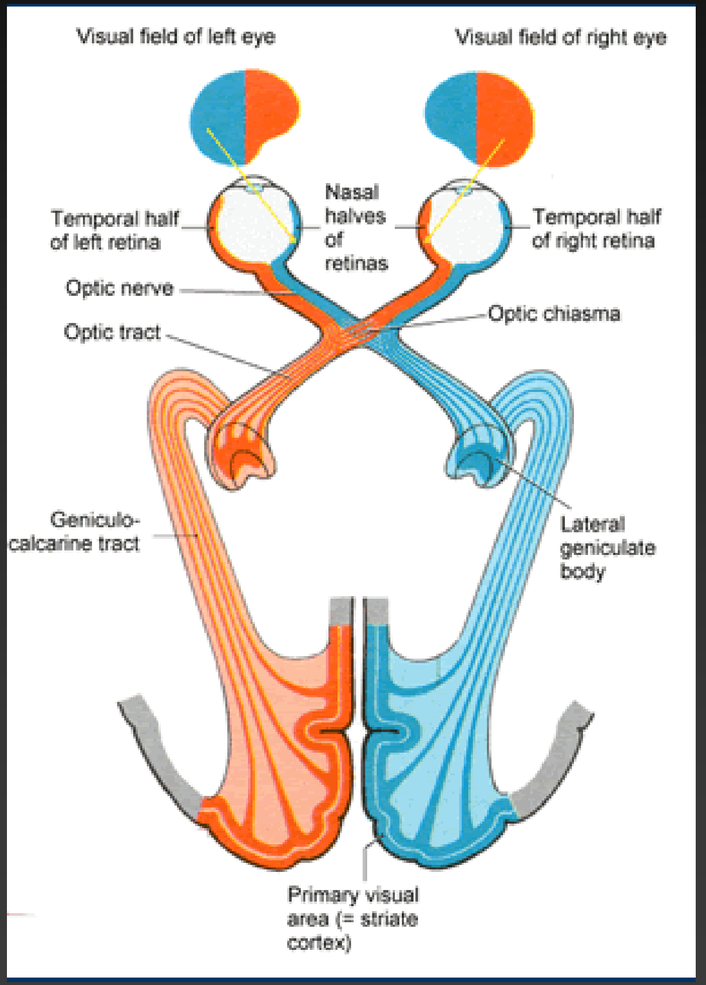
- **contains around 1.2 million nerve fibers, which are axons of the retinal ganglion cells.**
- **1 mm in the globe.**
- **25 mm in the orbit.**
- **9 mm in the optic canal.**
- **16 mm in the cranial space**



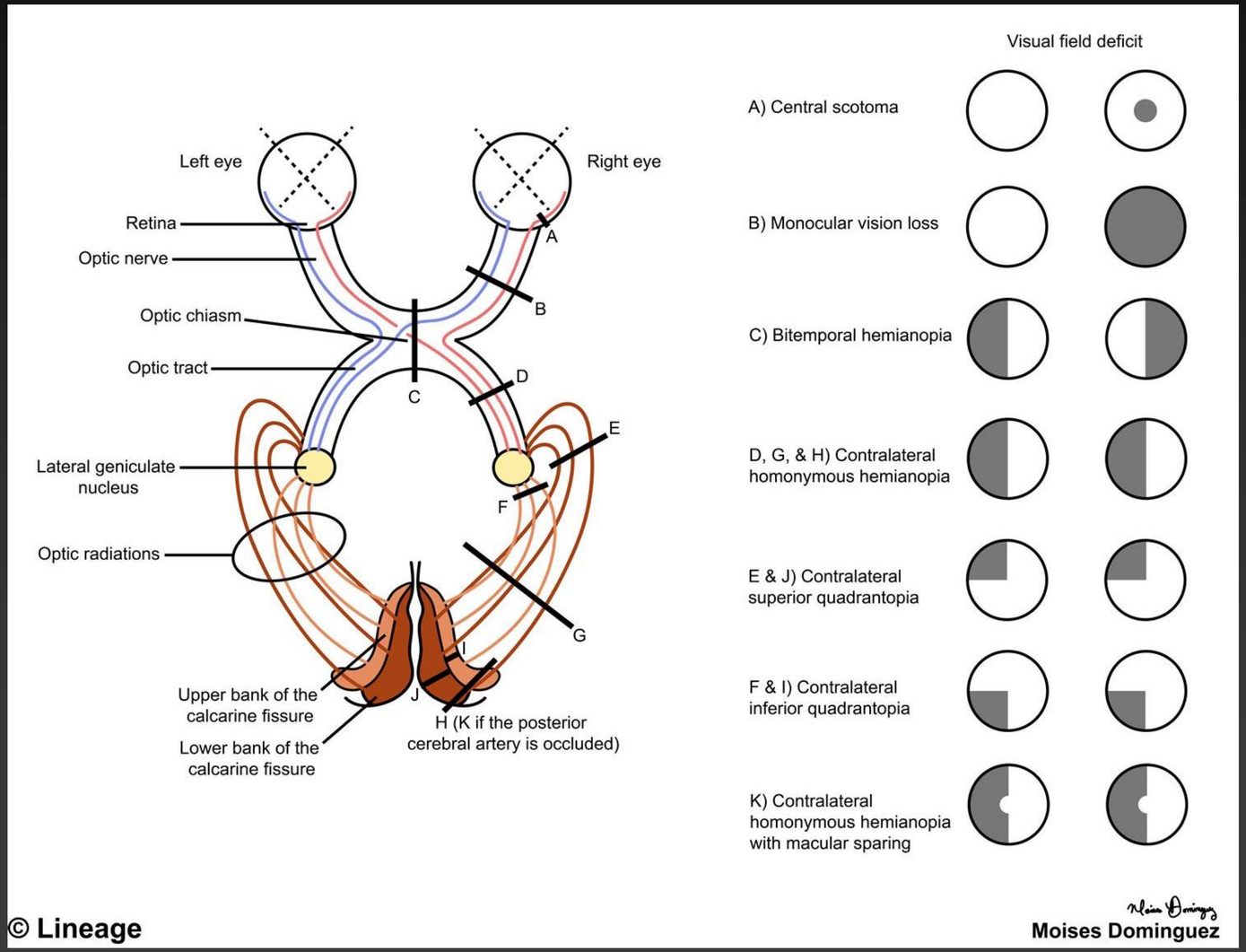
Visual pathway



about 53% of the optic nerve fibers cross to the opposite optic tract at the chiasm



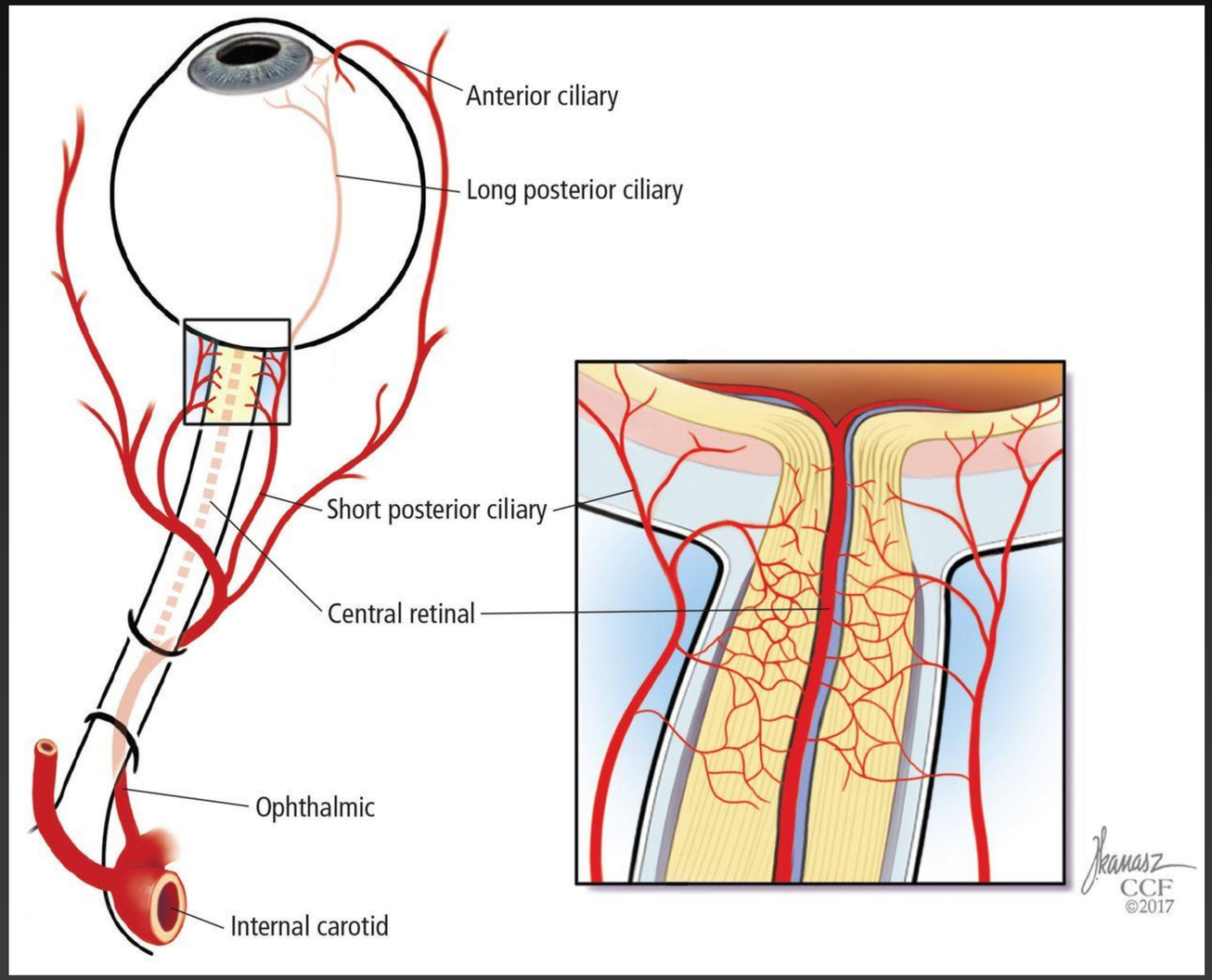
Visual pathway



Blood Supply

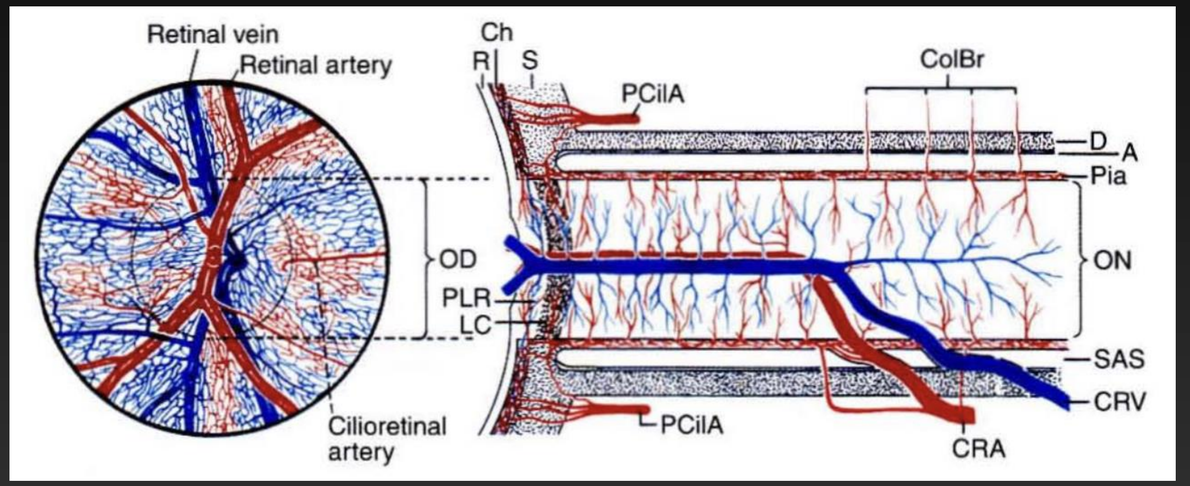
The blood supply of the globe is derived from the ophthalmic artery, which is a branch of the internal carotid artery:

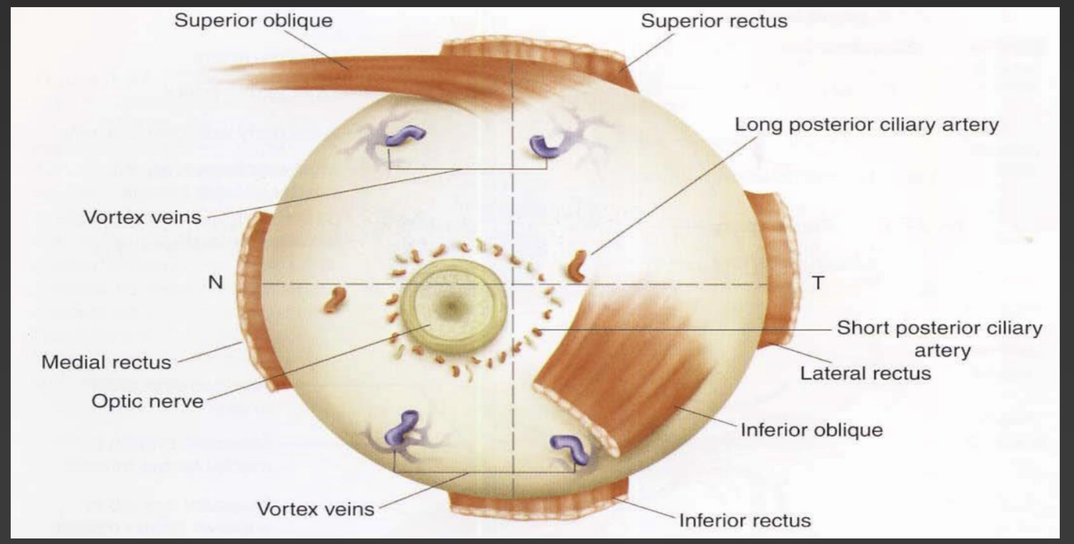
- The central retinal artery,
- The anterior ciliary arteries
- The posterior ciliary arteries.



Blood Supply

- The central retinal artery branches are accompanied by equivalent veins into central retinal vein.
- The choroid, ciliary body and iris are drained by approximately four
- vortex veins. These leave the posterior four quadrants of the globe





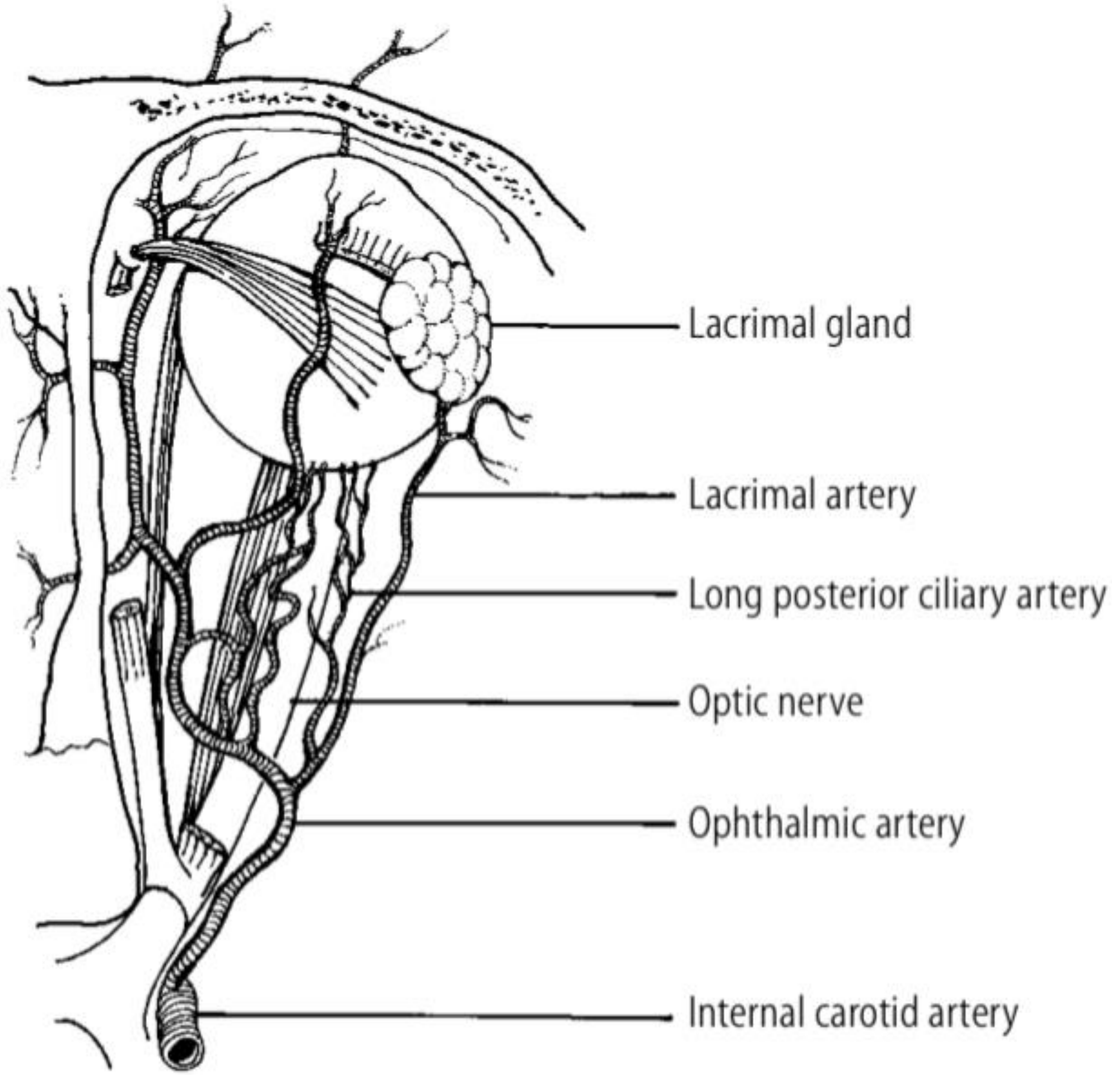
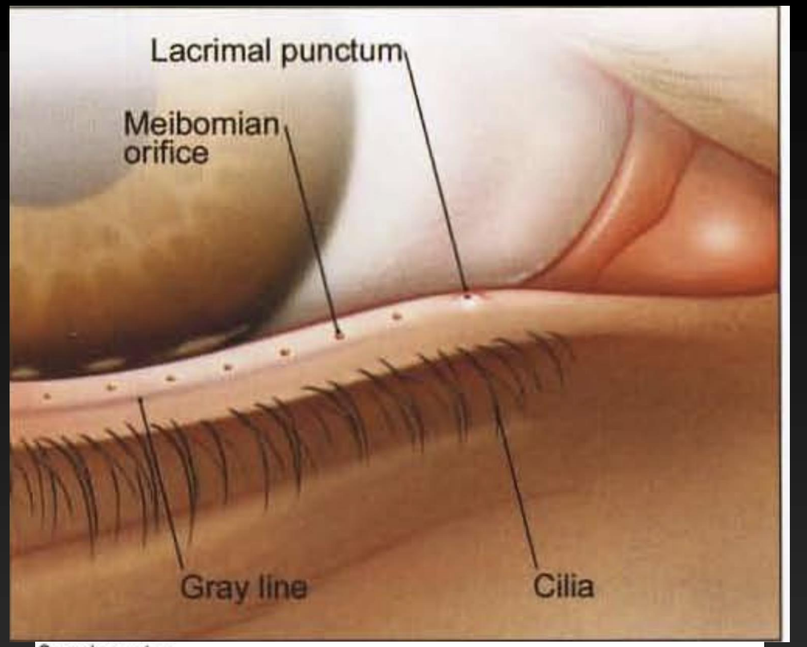
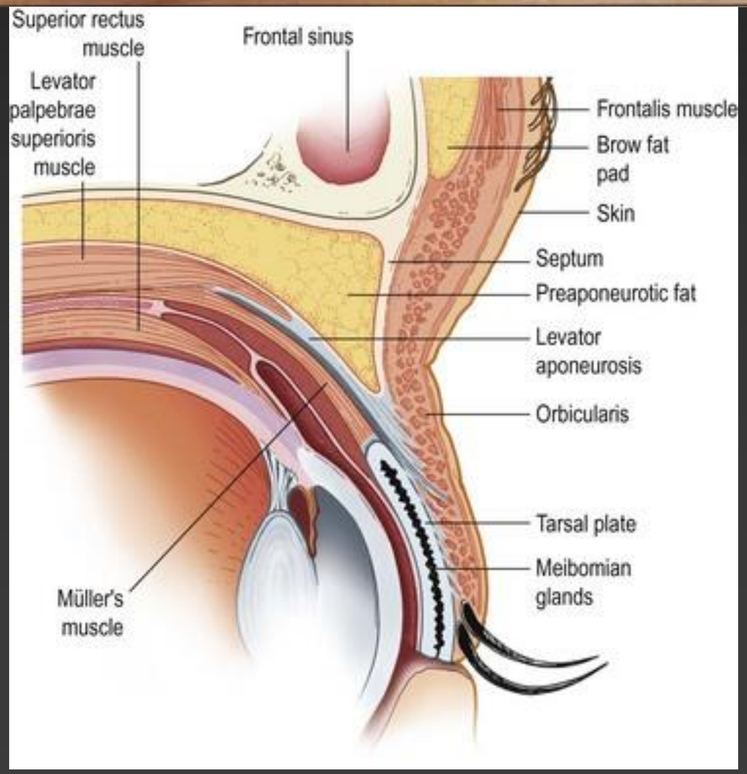


Figure 2.5. Blood supply of the eye.

The Eyelids

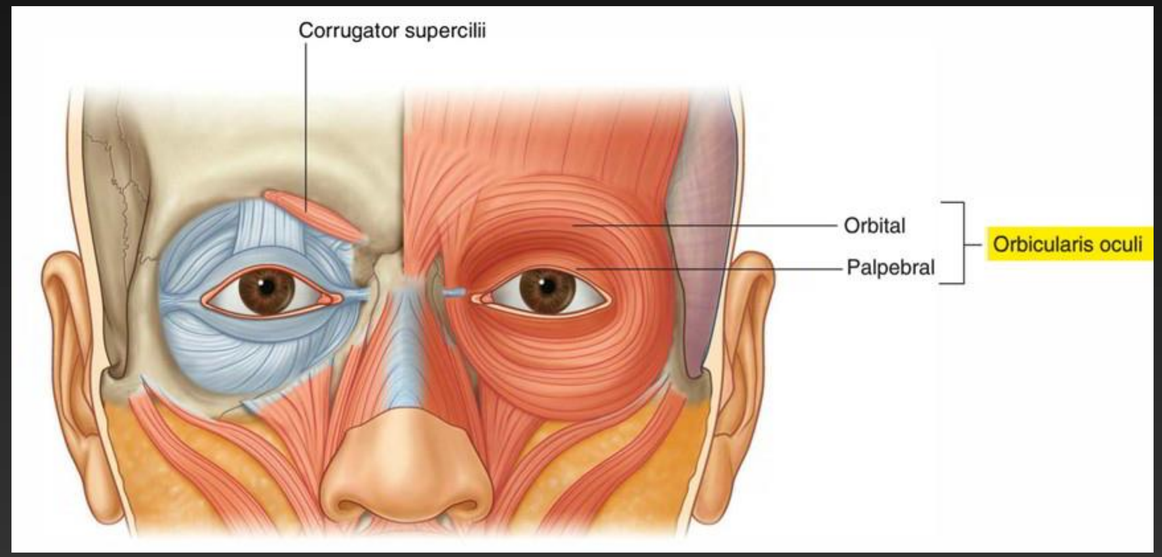
- The eyelids may be divided into anterior and posterior parts by the mucocutaneous junction, the grey line.
- The eyelashes arise from hair follicles anterior to the grey line, while the ducts of the meibomian glands (modified sebaceous glands) open behind the grey line.
- The tarsal plate gives stiffness to the eyelids and helps maintain its contour. The upper and lower tarsal plates are about 1 mm thick.



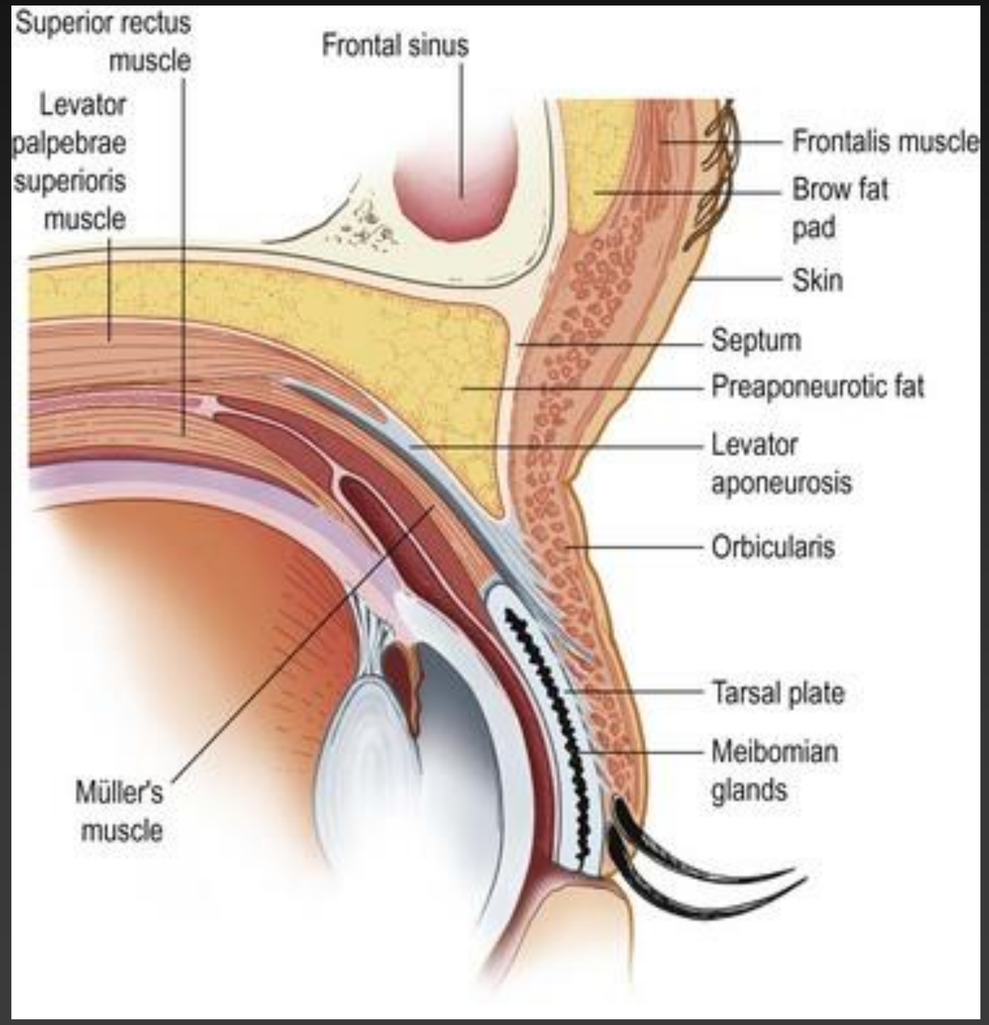


The Eyelids

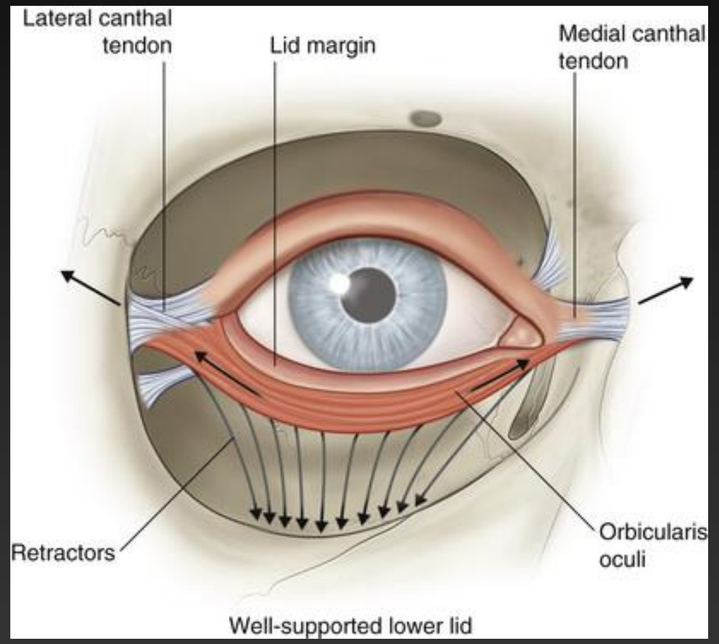
- The orbicularis oculi muscle lies between the skin and the tarsus and serves to close the eyelids. It is supplied by the facial nerve.
- Facial nerve palsy leads to lagophthalmos and dryness.

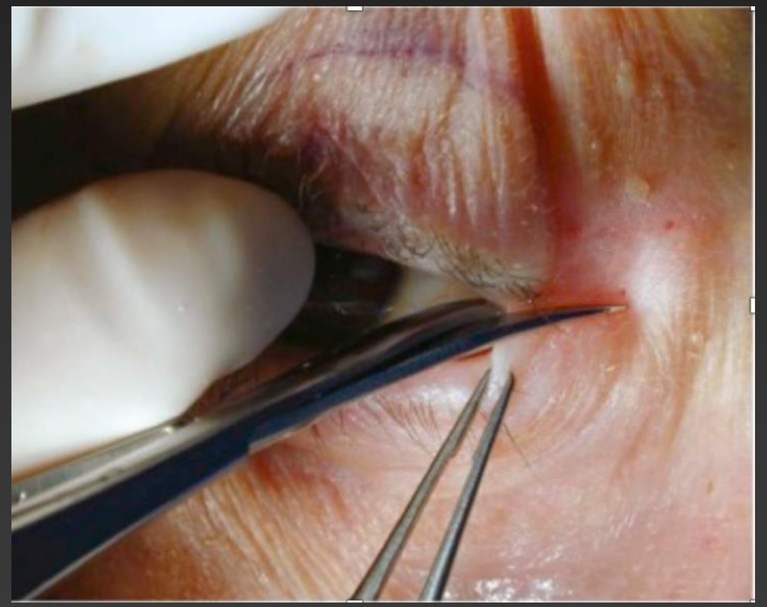


The Eyelids


Superior rectus muscle
Frontal sinus
Levator palpebrae superioris muscle
Frontalis muscle
Brow fat pad
Skin
Septum
Preaponeurotic fat
Levator aponeurosis
Orbicularis
Tarsal plate
Meibomian glands
Müller's muscle

The Eyelids


Lateral canthal tendon
Lid margin
Medial canthal tendon
Retractors
Orbicularis oculi
Well-supported lower lid

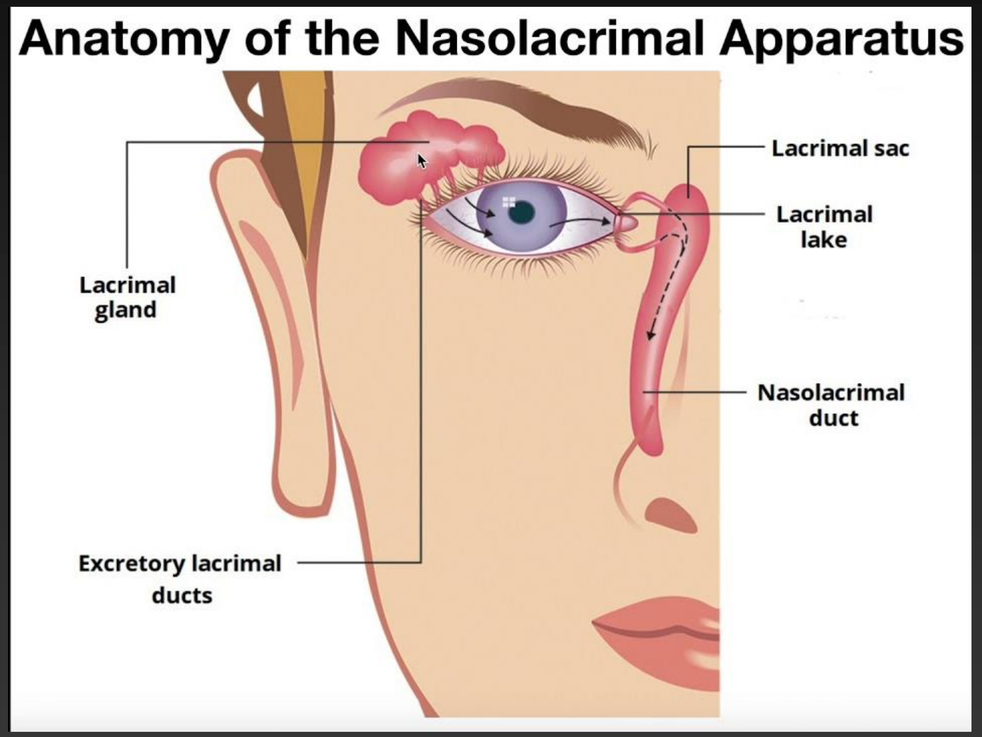


Lacrimal Apparatus

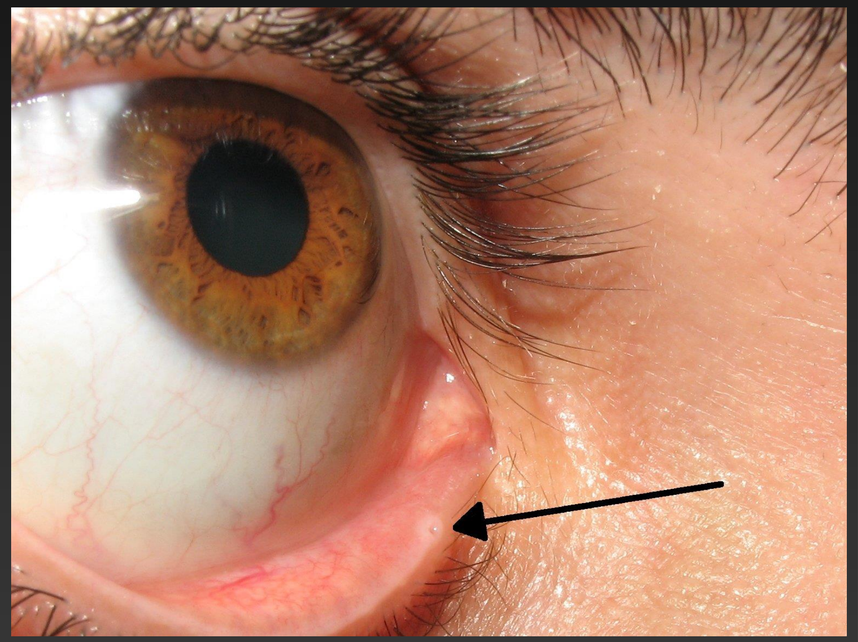
- **The major lacrimal gland occupies the superior temporal anterior portion of the orbit. It has ducts that open into the palpebral conjunctiva.**

- **Tears collect at the medial part of the palpebral fissure and pass through the puncta and the canaliculi into the lacrimal sac, which terminates in the nasolacrimal duct inferiorly.**

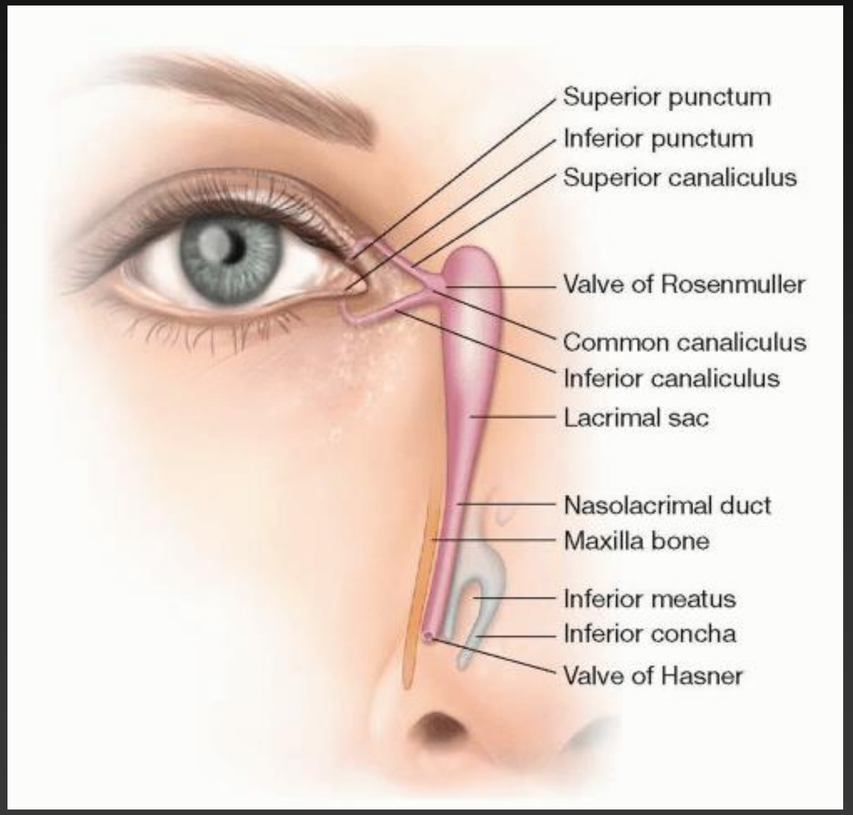
- **The nasolacrimal duct opens into the inferior meatus of the nose.**



Lacrimal Apparatus
Canalicular laceration



Lacrimal Apparatus
Congenital Nasolacrimal Duct Obstruction

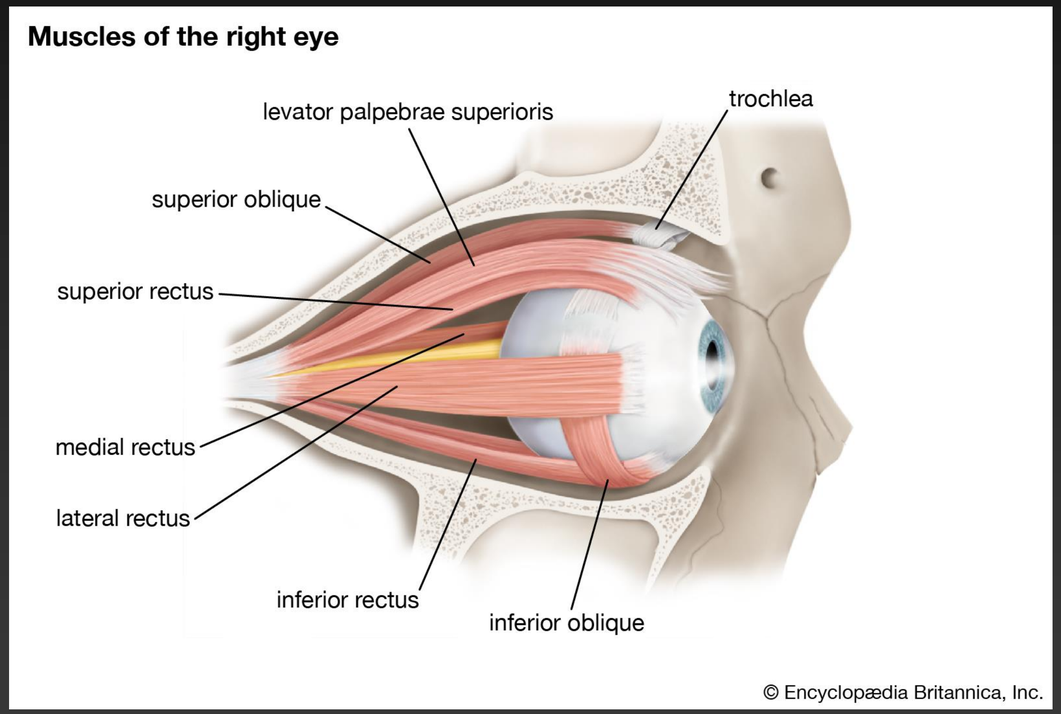


Extraocular muscles

- There are six extraocular muscles moving the eye:

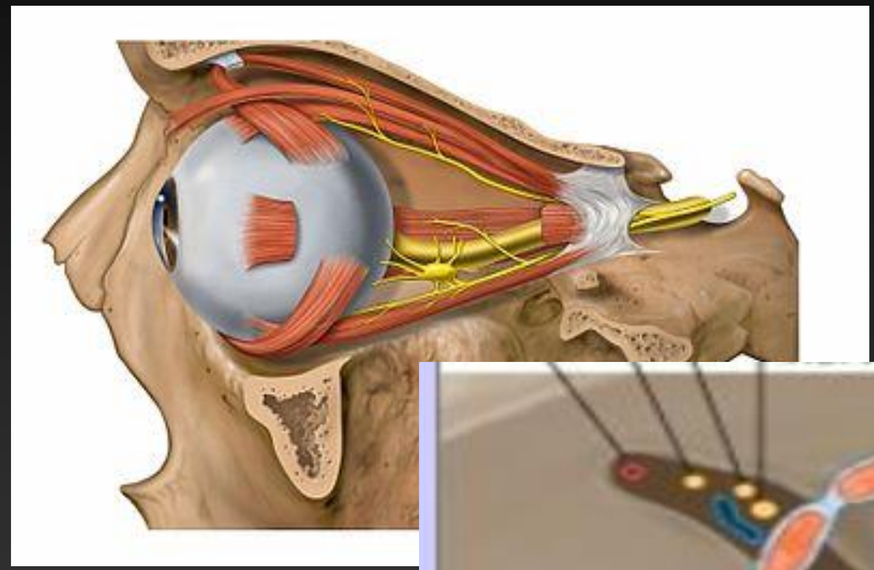
  superior, inferior, medial and lateral recti, and the superior and inferior obliques.

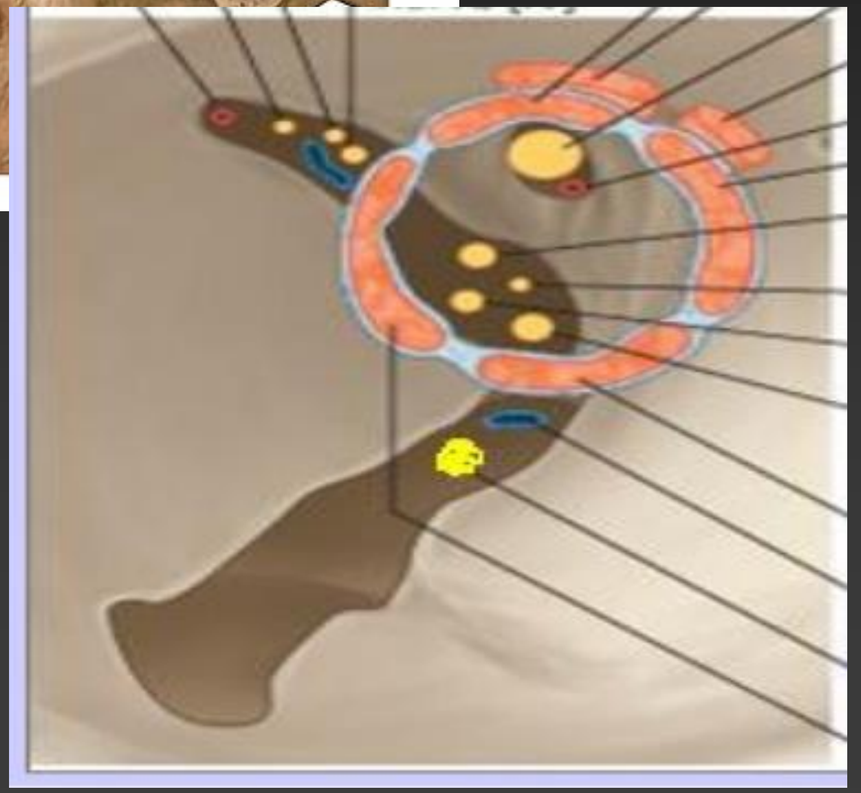
- All these muscles are supplied by the third cranial nerve except the lateral rectus (supplied by the sixth nerve) and superior oblique (fourth nerve).



Extraocular muscles

- All the extraocular muscles except the inferior oblique originate from a fibrous ring around the optic nerve (annulus of Zinn) at the orbital apex.
- All the recti muscles attach to the eyeball anterior to the equator while the oblique muscles attach behind the equator.
- The optic nerve, the ophthalmic blood vessels and the nerves to the extraocular muscles (except fourth nerve) are contained within the muscle cone

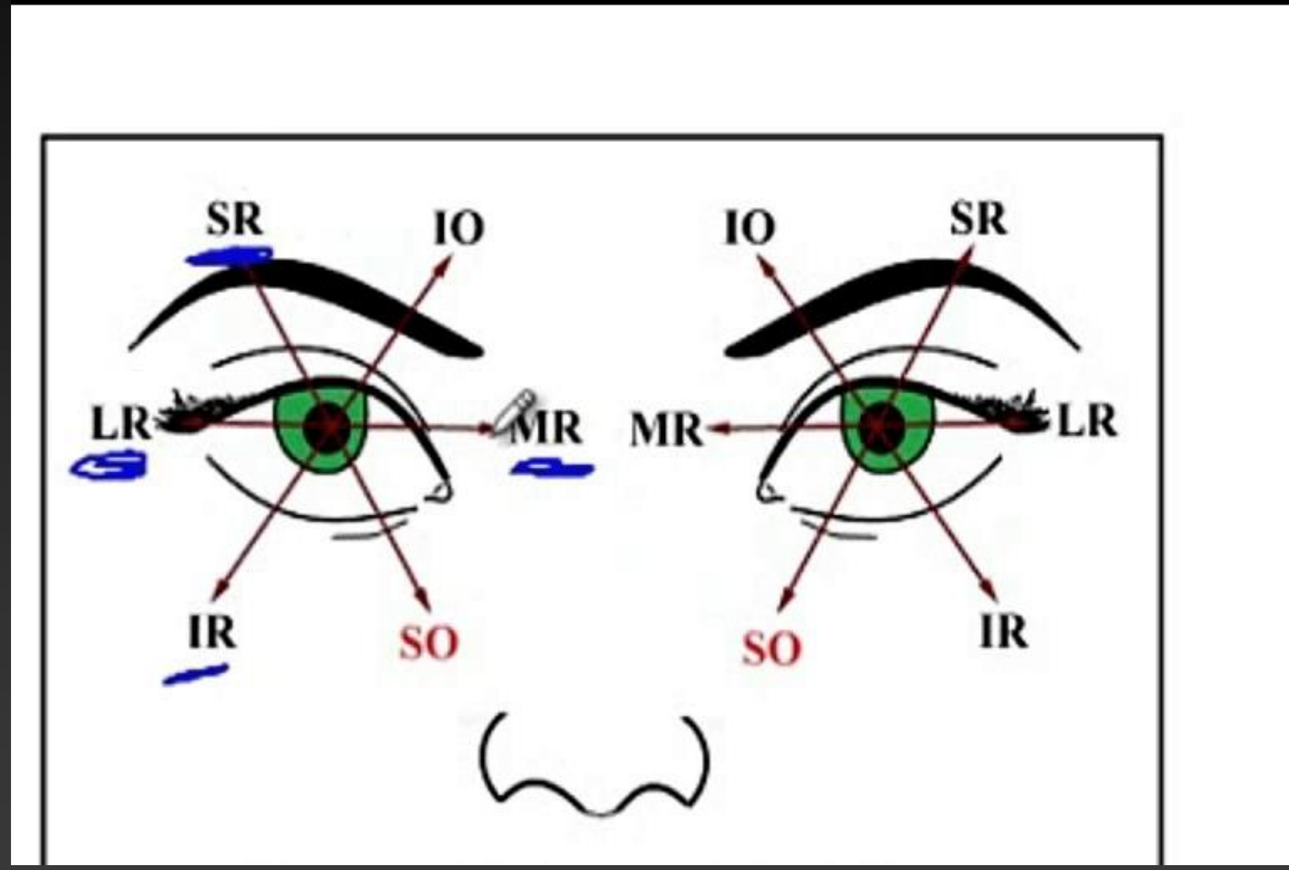




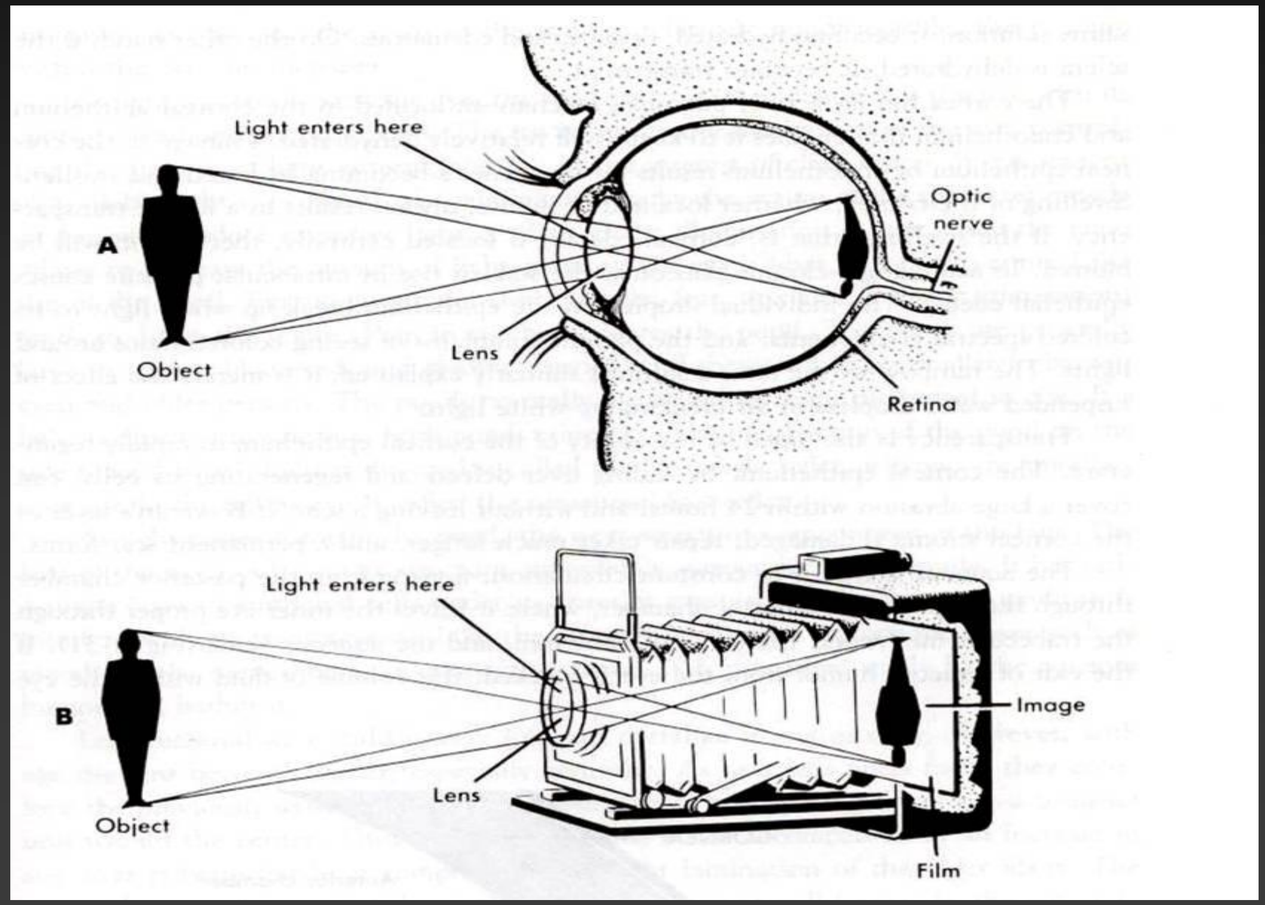
Extraocular muscles

Extraocular muscles function

Muscle	Primary function	Secondary function	Tertiary function
Medical rectus	Adduction	_	_
Lateral rectus	Abduction	_	_
Superior rectus	Elevation	Intorsion	Abduction
Inferior rectus	Depression	Extorsion	Abduction
Superior Oblique	Intorsion	Depression	Adduction
Inferior Oblique	Extorsion	Elevation	Adduction



Optics of the eye



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- Parson’s Disease of the Eye, by Radhika Tandon