

Eye

Orbit and eyeball

Orbit

- A pair of pyramidal-shaped bony cavities.
- Located one on either side of the root of the nose
- Provides sockets for rotatory movements of the eyeballs.

Boundaries of the orbit

- **Medial wall (thinnest):**
 - Frontal process of maxilla.
 - Lacrimal process of maxilla.
 - Orbital plate of ethmoid.
 - Body of sphenoid.
- **Lateral wall (*strongest*):**
 - Orbital surface of the zygomatic bone in front.
 - Orbital surface of greater wing of sphenoid behind.

Boundaries of the orbit

- **Floor:**

- Orbital surface of the body of maxilla.
- Orbital surface of the zygomatic bone, anterolaterally.
- Orbital process of the palatine bone, posteromedially.

- **Roof:**

- Orbital plate of the frontal bone in front.
- Lesser wing of the sphenoid behind

Features of the wall of orbit

- **Medial wall:**
 - Lacrimal fossa
 - Anterior and posterior ethmoidal foramina
- **Lateral wall:**
 - Zygomatic foramen
 - Whitnall's tubercle
- **Floor:**
 - Infraorbital groove and canal
 - Small rough impression in anteromedial angle for origin of inferior oblique muscle

Features of the wall of orbit

- **Roof:**
 - Fossa for lacrimal gland in the anterolateral part.
 - Trochlear notch or spine at the anteromedial angle.
 - Optic canal at the extreme posterior part of the roof.
- **Apex:**
 - Lies at the posterior end of the orbit
 - Formed by sphenoid
- **Base:** Open and quadrangular

Orbital Margins

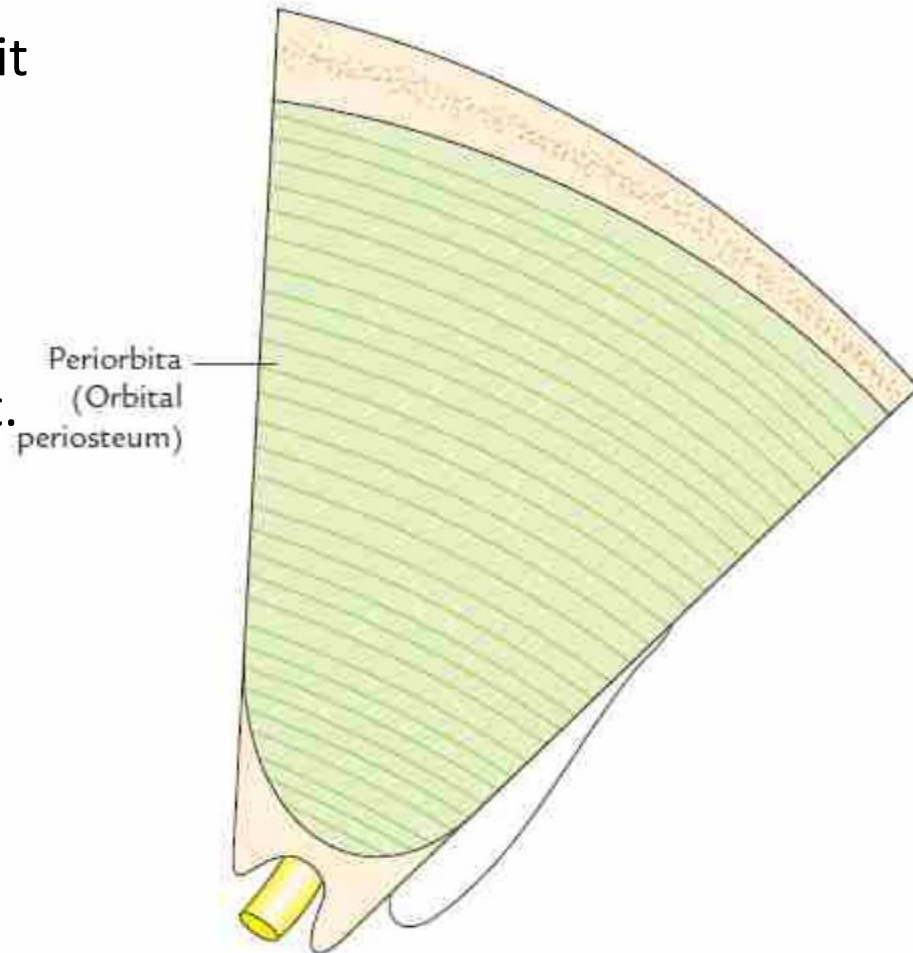
- **Supraorbital margin**
- **Infraorbital margin**
- **Medial orbital margin**
- **Lateral orbital margin**

Relations

- *Above:*
 - *Anterior cranial fossa and frontal air sinus (usually).*
- *Lateral:*
 - *Temporal fossa in front and middle cranial fossa behind.*
- *Below:*
 - *Maxillary air sinus.*
- *Medial:*
 - *Ethmoidal air sinuses*

Orbital fascia or periorbita

- Periosteum of the bony orbit.
- Lines the bony boundaries of the orbit and forms a funnel-shaped fascial sheath that encloses the orbit contents.
- Loosely attached to the bones, hence can be easily stripped off specially from medial wall and roof of the orbit.
- At the optic canal and superior orbital fissure, it becomes continuous with the periosteum lining the interior of the skull (*endocranium*).
- *At the infraorbital fissure and orbital margins, it becomes continuous with the periosteum covering the external surface of the skull (periosteum).*

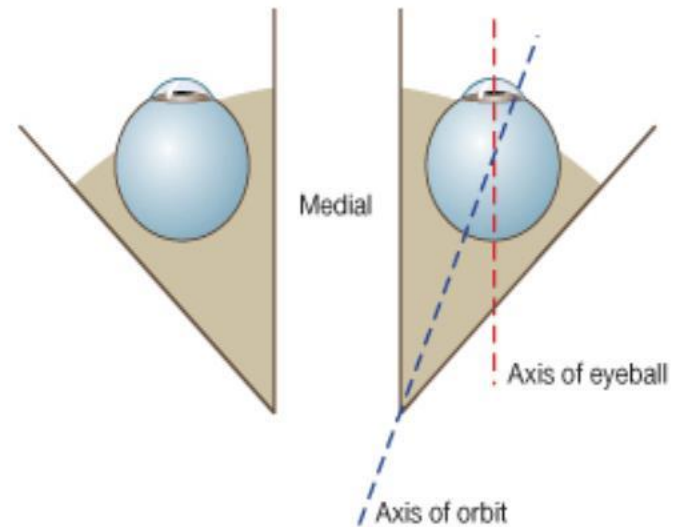


Contents

- Eyeball (most important content).
- Muscles.
- Fascia bulbi.
- Nerves
 - Optic
 - Oculomotor
 - Trochlear
 - Abducent
 - Ophthalmic
 - Ciliary ganglion.
- Ophthalmic artery.
- Ophthalmic veins.
- Lacrimal gland.
- Orbital fat.

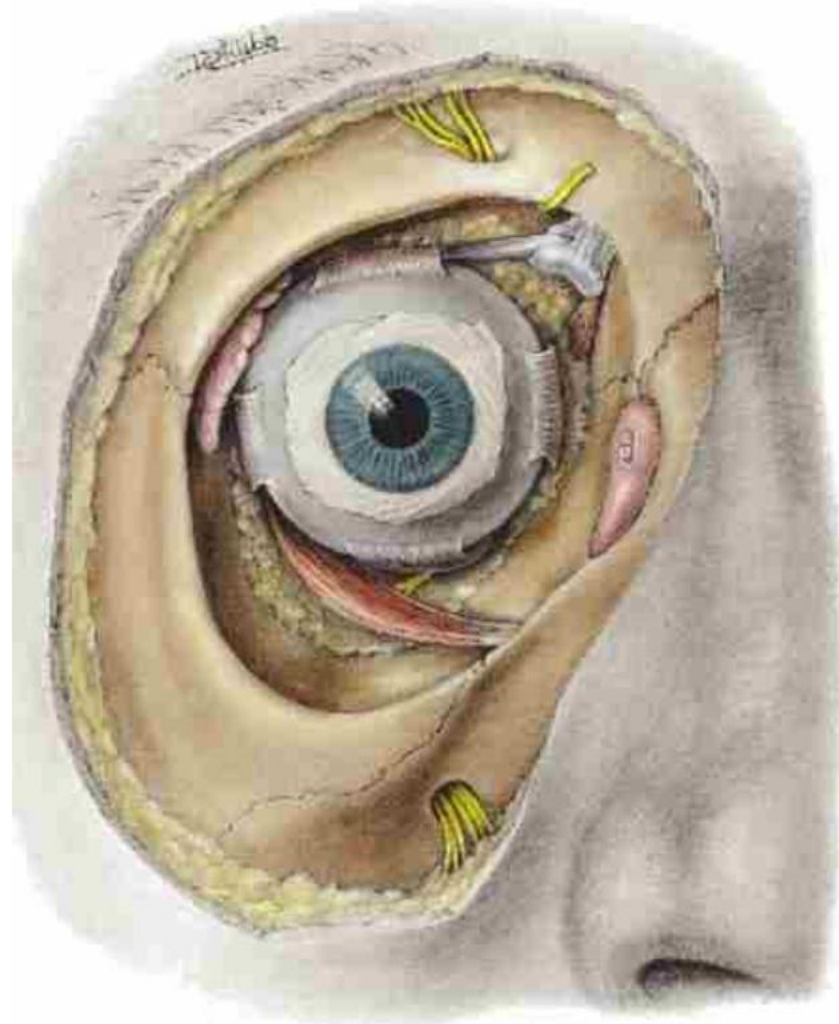
Visual and orbital axis

- **Visual axis:** line passing through the center of anterior and posterior poles of the eyeball.
- **Orbital axis:** line passing through the optic canal and the center of the base of the orbit.
 - Visual and orbital axis make an angle of 20-30° with each other



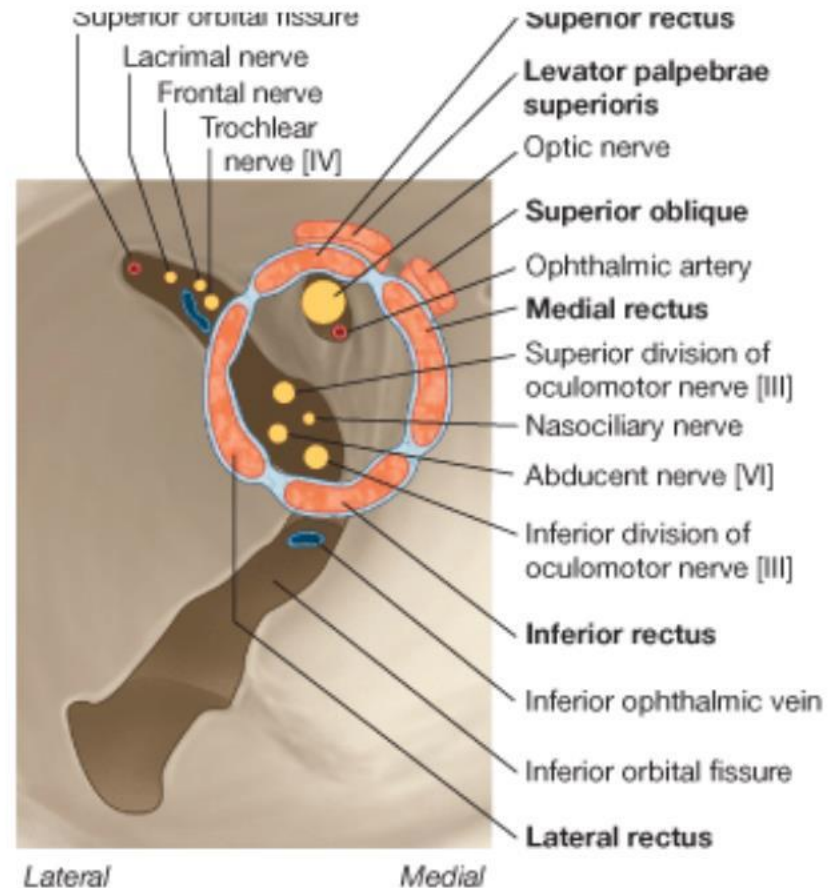
Extraocular muscles

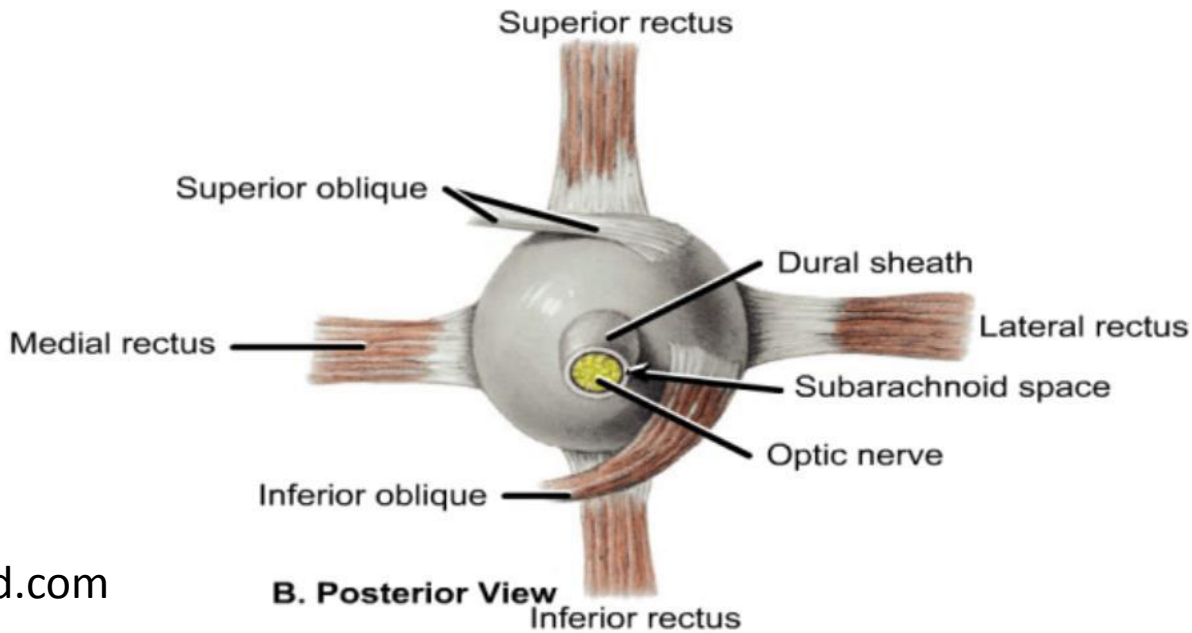
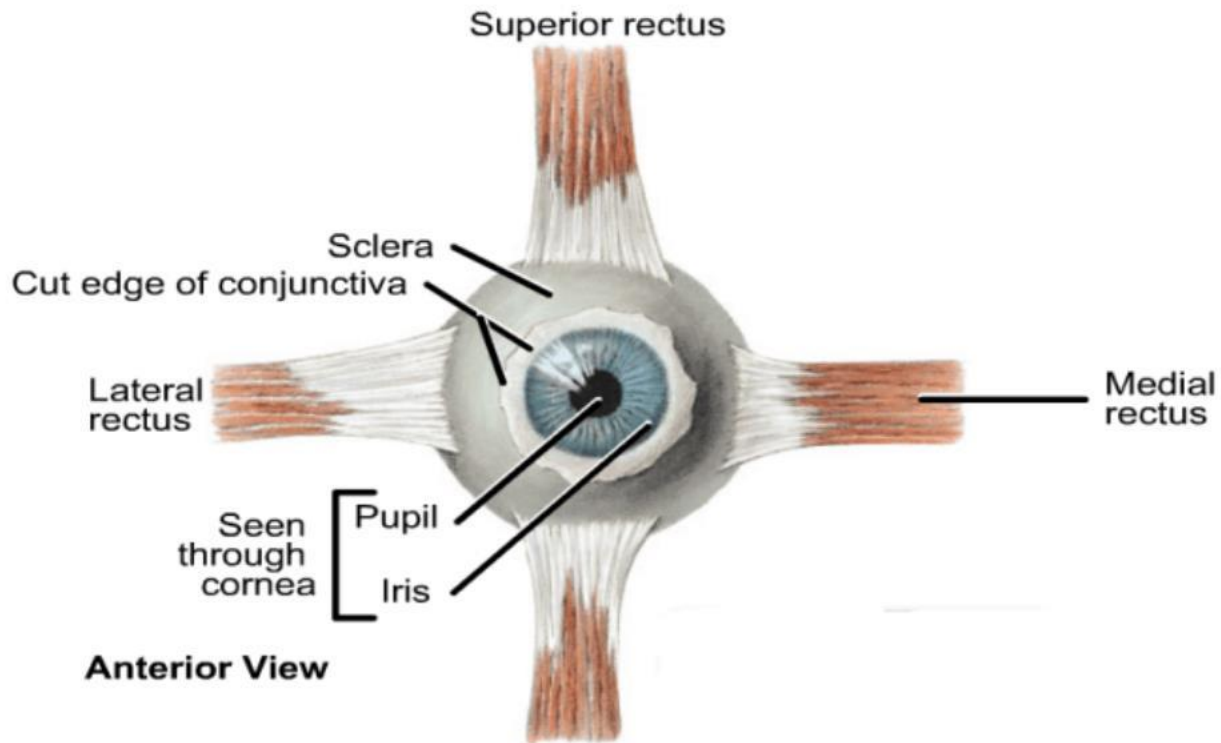
- **Voluntary muscles:**
 - 1. Four recti muscles**
 - Superior rectus,
 - Inferior rectus,
 - Medial rectus, and
 - Lateral rectus.
 - 2. Two oblique muscles**
 - Superior oblique,
 - Inferior oblique.
 - 3. One levator palpebrae superioris**



Rectus muscles

- Origin: from the common tendinous ring
 - Common tendinous ring encloses the optic canal and the medial part of superior orbital fissure
- Insertion: into the sclera a little behind the sclero-corneal junction





A

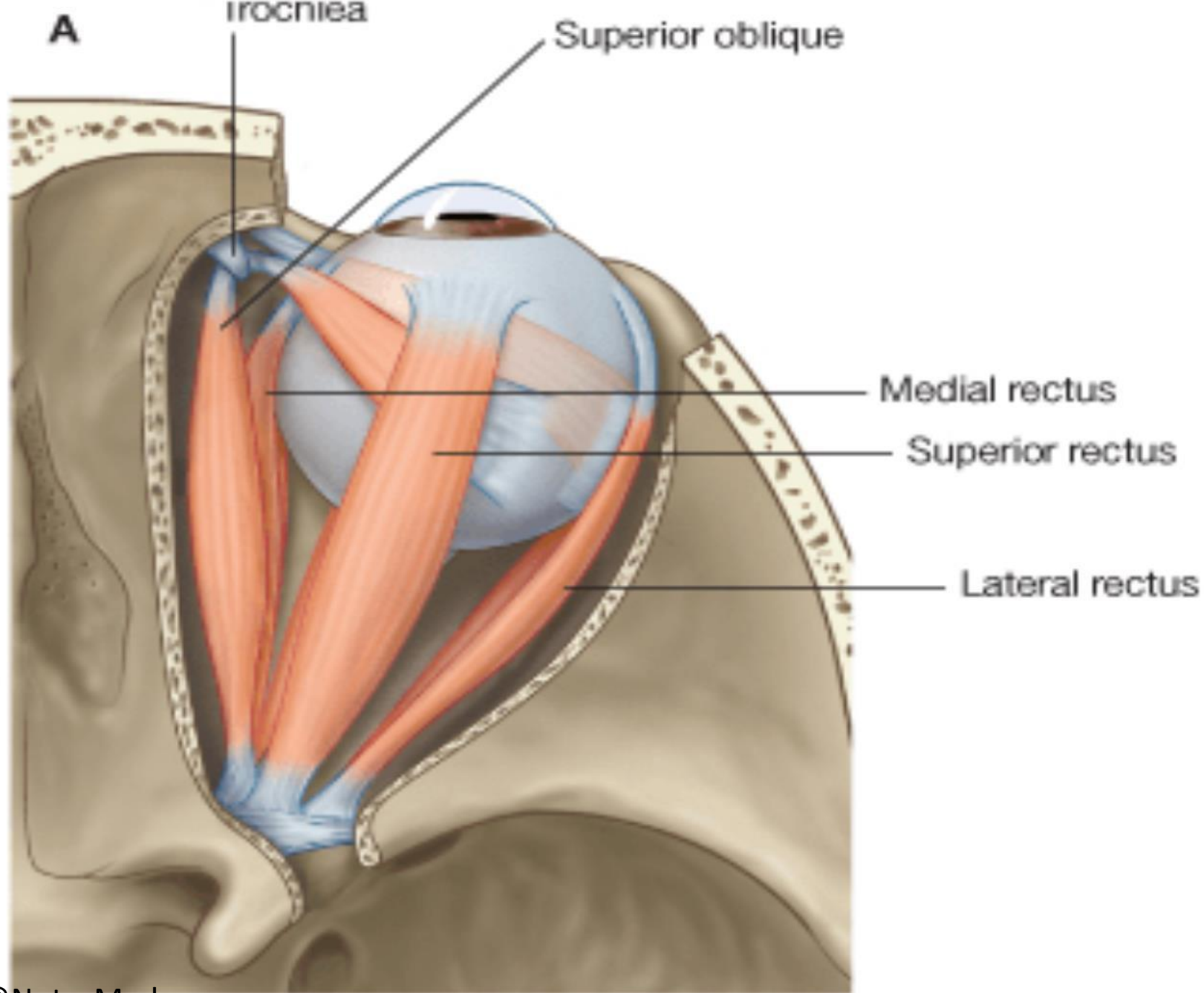
Irochnea

Superior oblique

Medial rectus

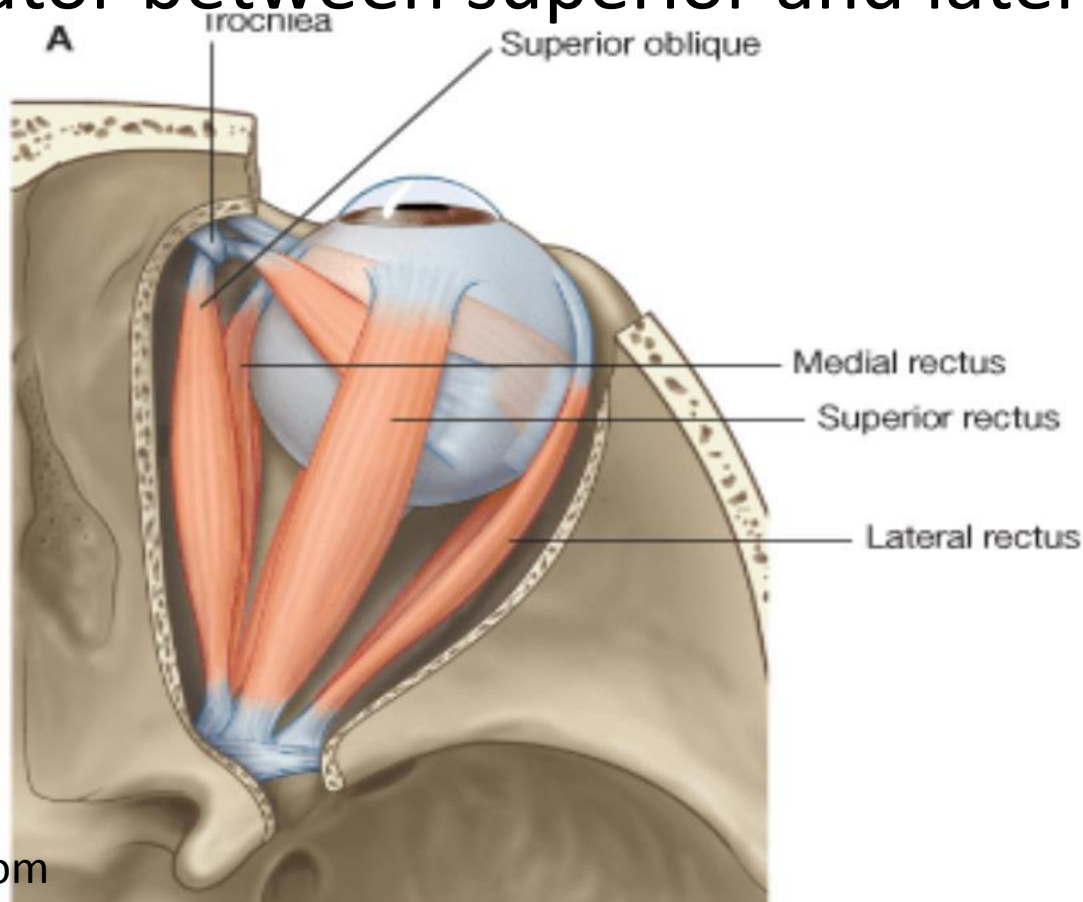
Superior rectus

Lateral rectus



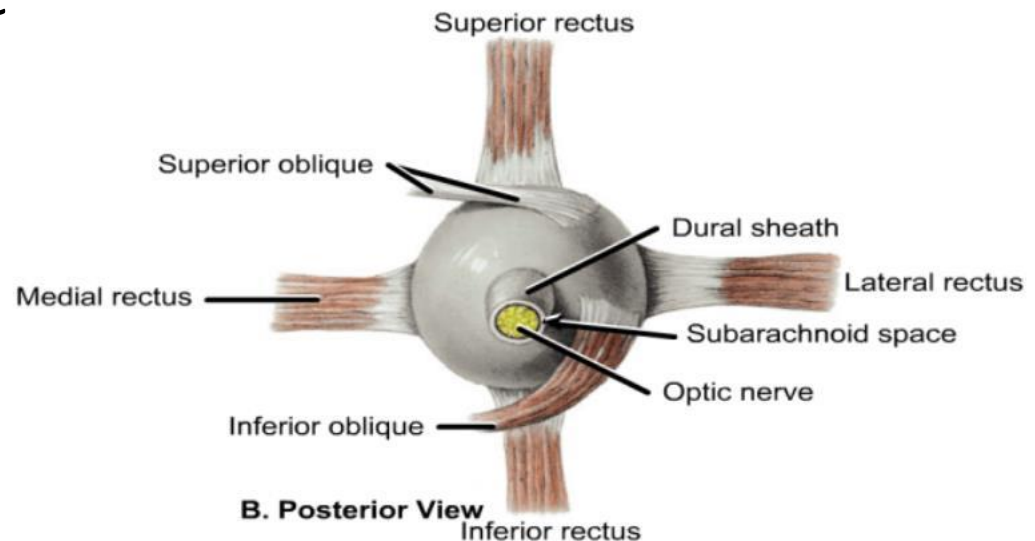
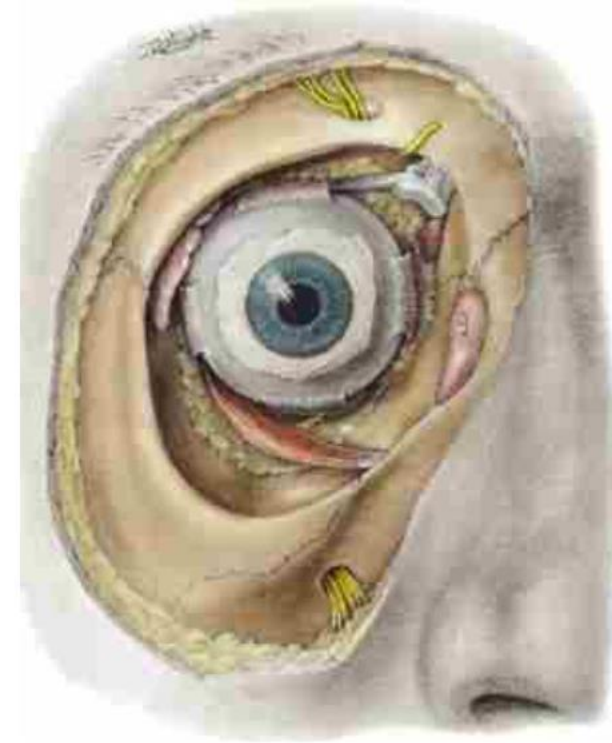
Superior oblique

- Origin: Common tendinous ring
- Insertion: Inserted into the sclera behind the equator between superior and lateral rectus



Inferior oblique

- Origin: orbital surface of the maxilla
- Insertion:
 - Passes backward, upwards and laterally below the inferior rectus and deep to the lateral rectus
 - Inserted close to the superior oblique little below and behind the latter



Nerve supply

- LR6, SO4 rest by 3
- Lateral rectus by VI cranial nerve.
- Superior oblique by IV cranial nerve.
- Rest muscle by III cranial nerve.

Action

- The movements of the eyeball
 - Transverse axis: elevation and depression
 - Vertical axis: adduction and abduction
 - Anteroposterior axis: intortion and extortion
 - Intortion:
 - Extortion:

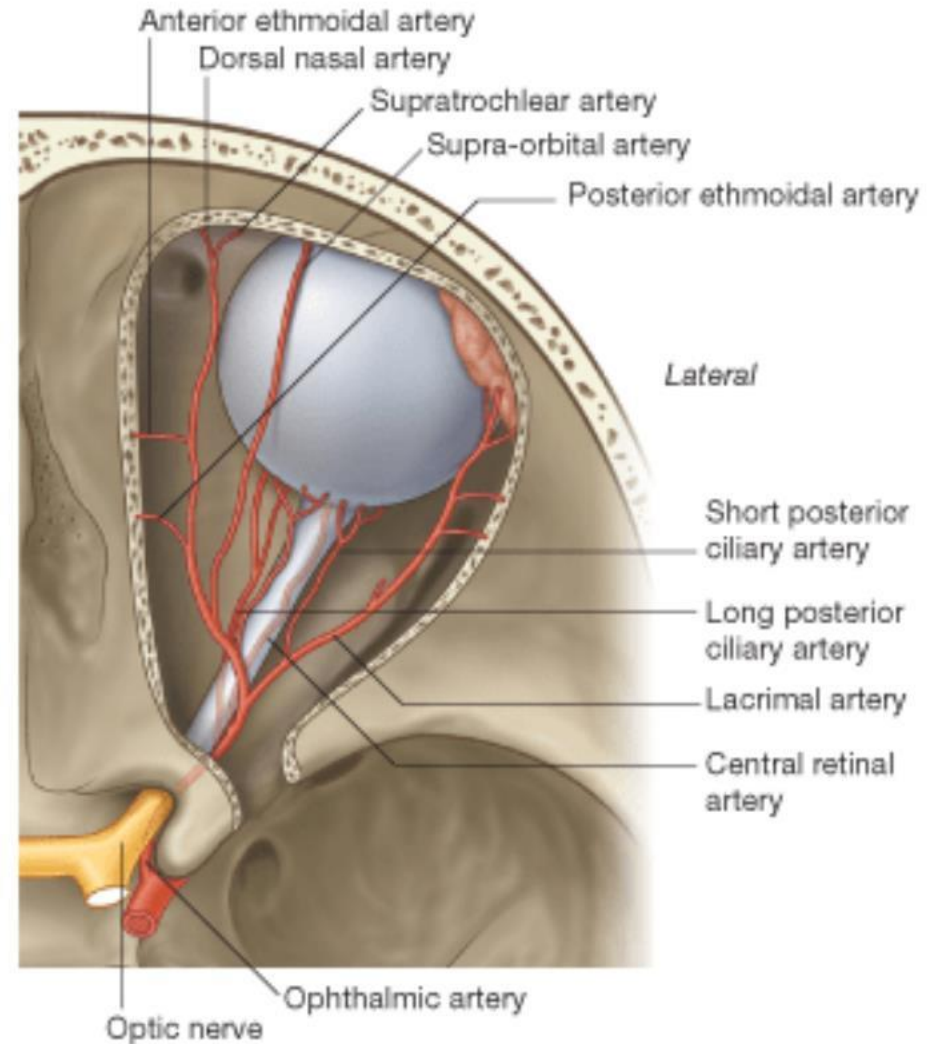
Combined movement

- Conjugate movement: when both eyes move in same direction
- Disjconugate movement: when both eyes move in opposite direction
 - convergence and divergence: when both eye move in around vertical axis
- Weakness or paralysis of a muscle causes squint or **strabismus** which may be concomitant or paralytic
 - Concomitant squint is non-paralytic and congenital due to imbalance in the action of opposing muscles. There is no diplopia

Blood vessels of the orbit

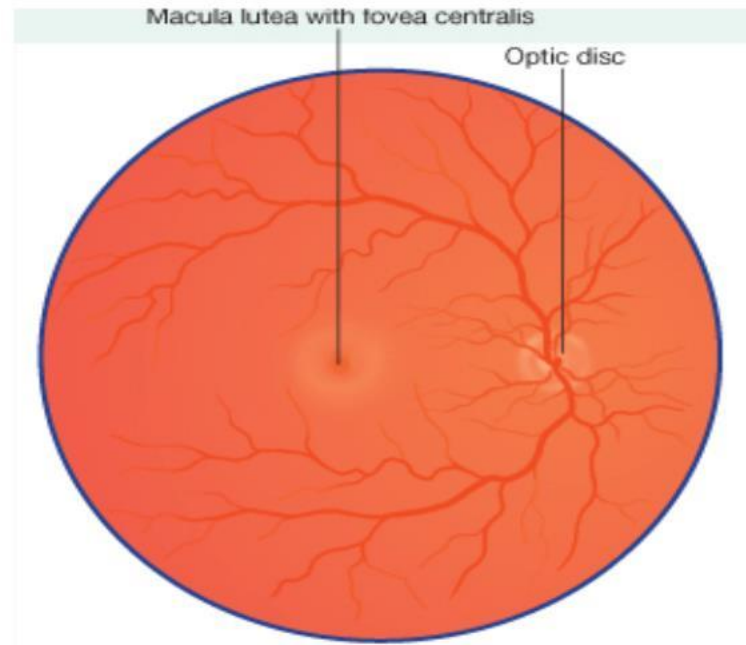
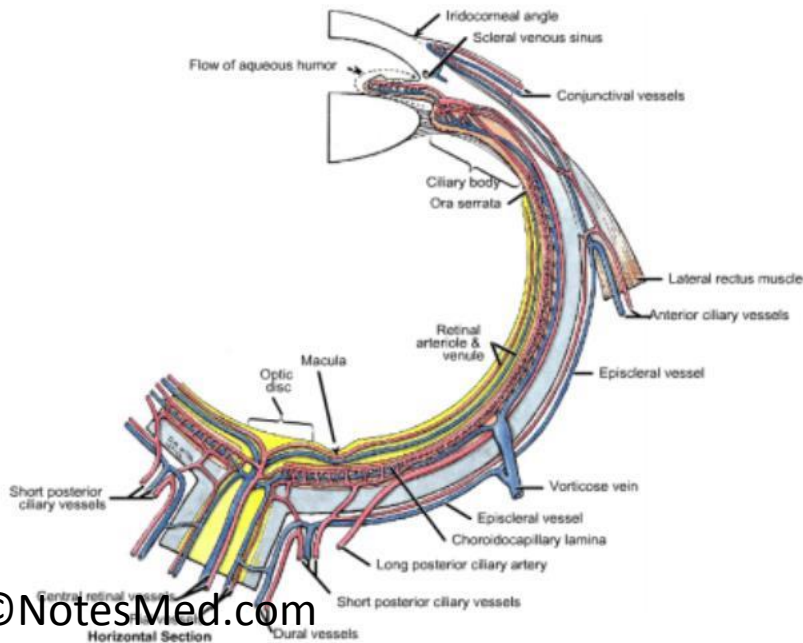
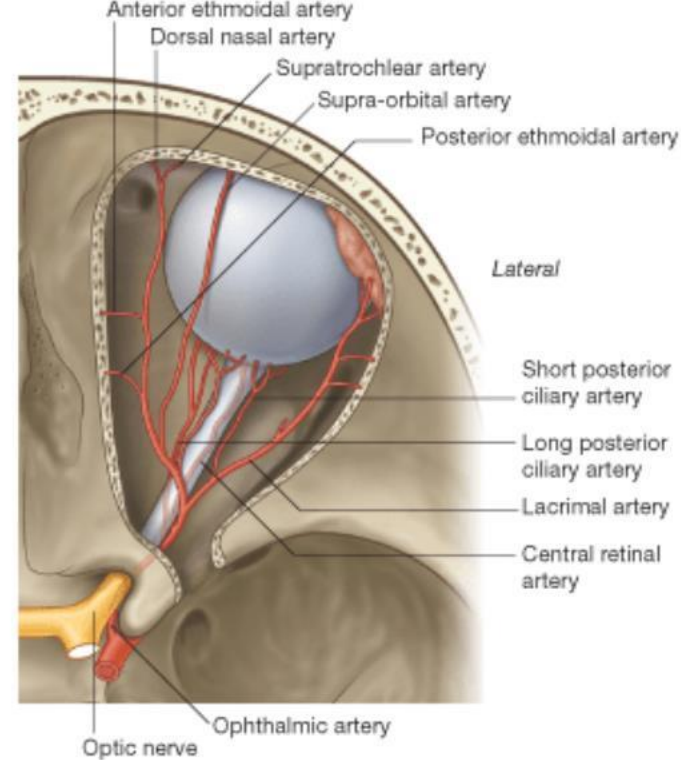
Ophthalmic artery:

- Branch of the internal carotid artery
- Optic canal inferolateral to the optic nerve
- Both optic nerve and artery lie within the same dural sheath



Branches

- Central artery of retina:
 - arise below the optic nerve within the dural sheath
 - Runs forward within dural sheath, pierces the optic nerve behind the eyeball to enter the substance of the optic nerve
 - Runs forward within the substance of the optic nerve and supplies the retina
 - This artery is an end artery and obstruction of it leads to total blindness

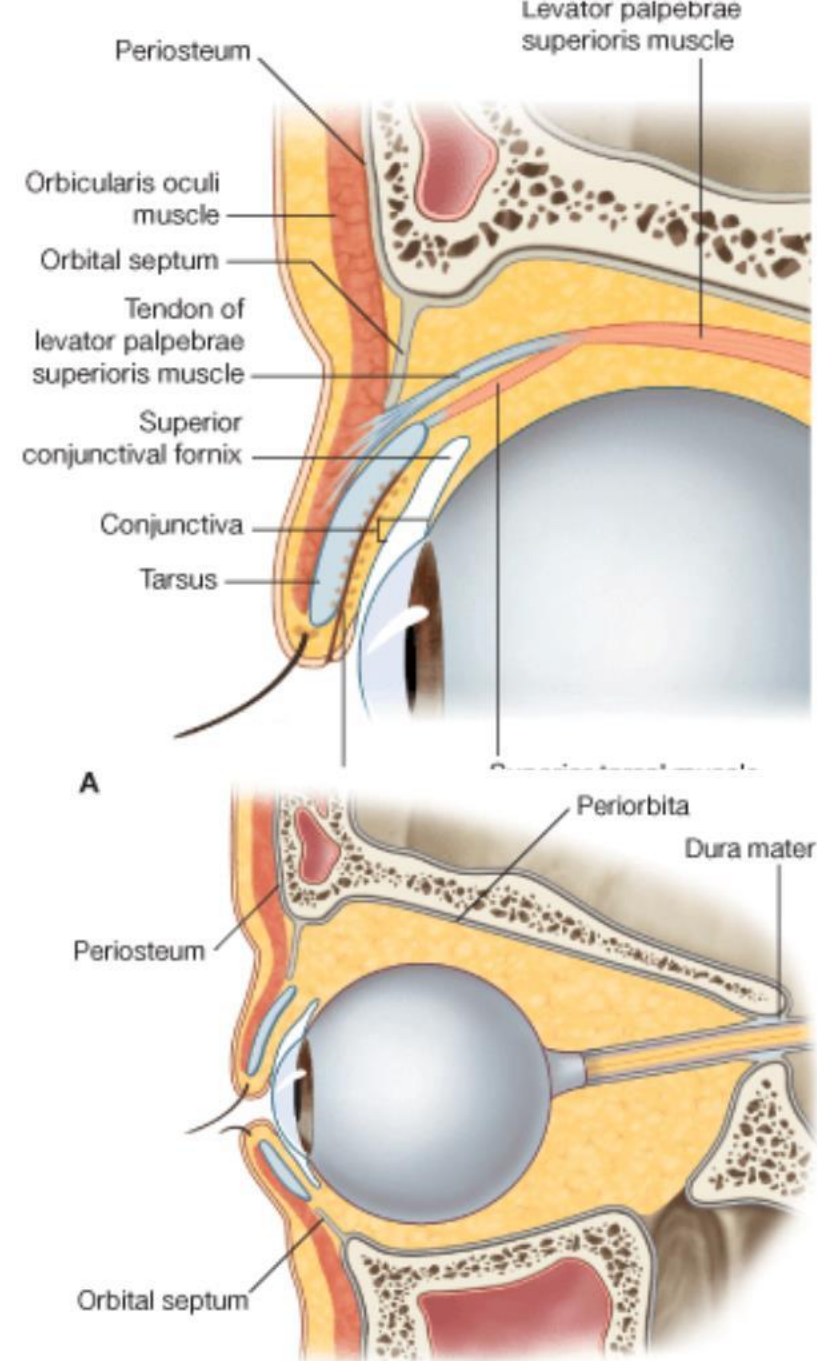


Involuntary muscles

- Three involuntary/ smooth muscles:
 - **Superior tarsal or Muller's muscle,**
 - **Inferior tarsal**
 - **Orbitalis**

Involuntary muscles

- **Superior tarsal muscle:** derived from the intermediate fibers of the levator palpebrae superioris and assists in elevation of upper eye lid.
- **Inferior tarsal muscle:** extends from the sheath of inferior rectus and inferior oblique muscle to inferior tarsal plate and possibly assists in depression of lower eye lid.
- **Orbitalis:** bridges across the inferior orbital fissure. Its function is unknown



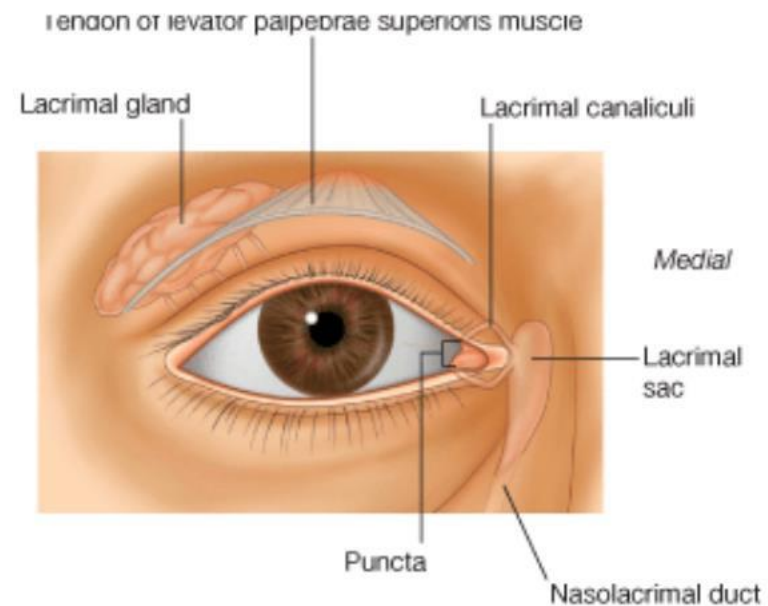
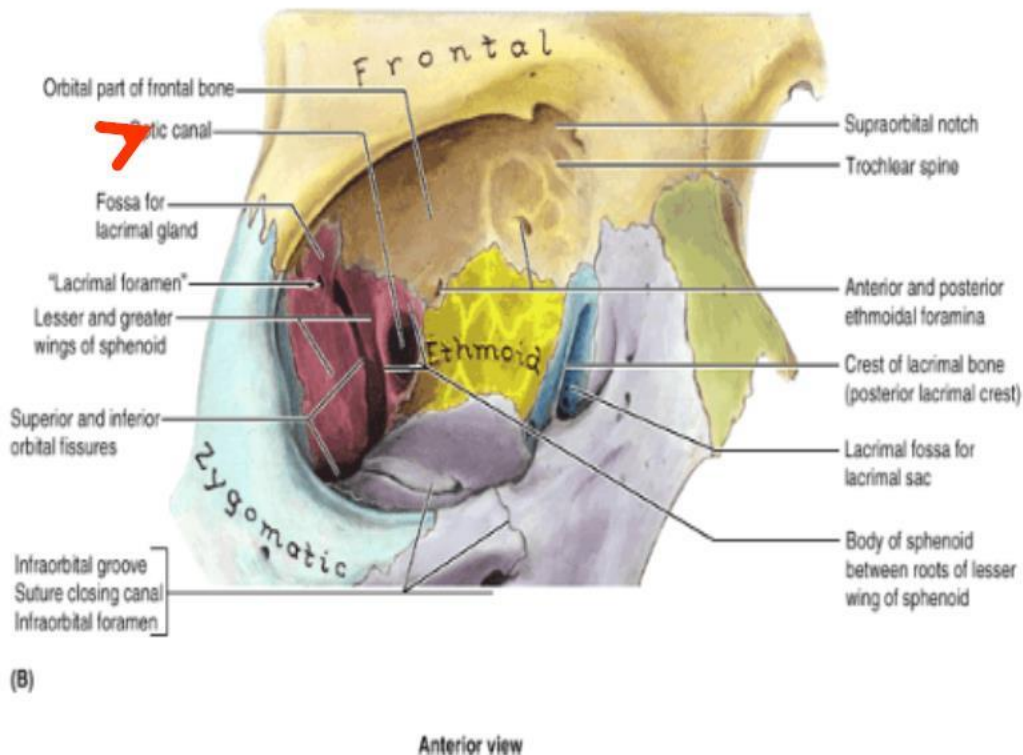
Lacrimal apparatus

- Concerned with secretion and drainage of tear
- Includes following parts
 - Lacrimal gland and its ducts
 - Conjunctival sac
 - Lacrimal puncta and lacrimal canaliculi
 - Lacrimal sac
 - Nasolacrimal duct

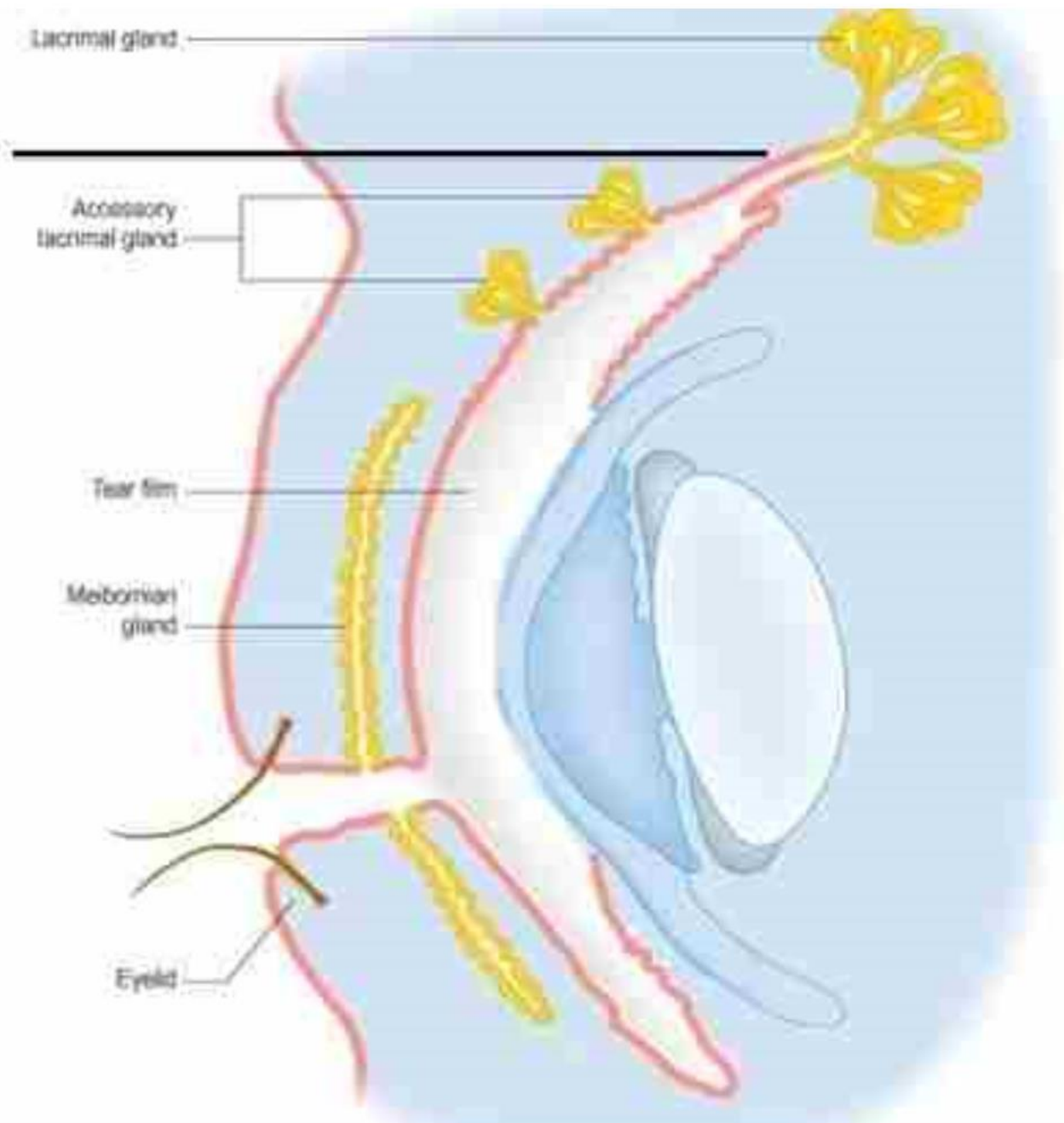
Lacrimal Gland

- Compound tubulo-alveolar gland and secretes serous fluid
- Situated in the lacrimal fossa above the eyeball in the anterior and upper part of the orbit
- Orbital and palpebral parts

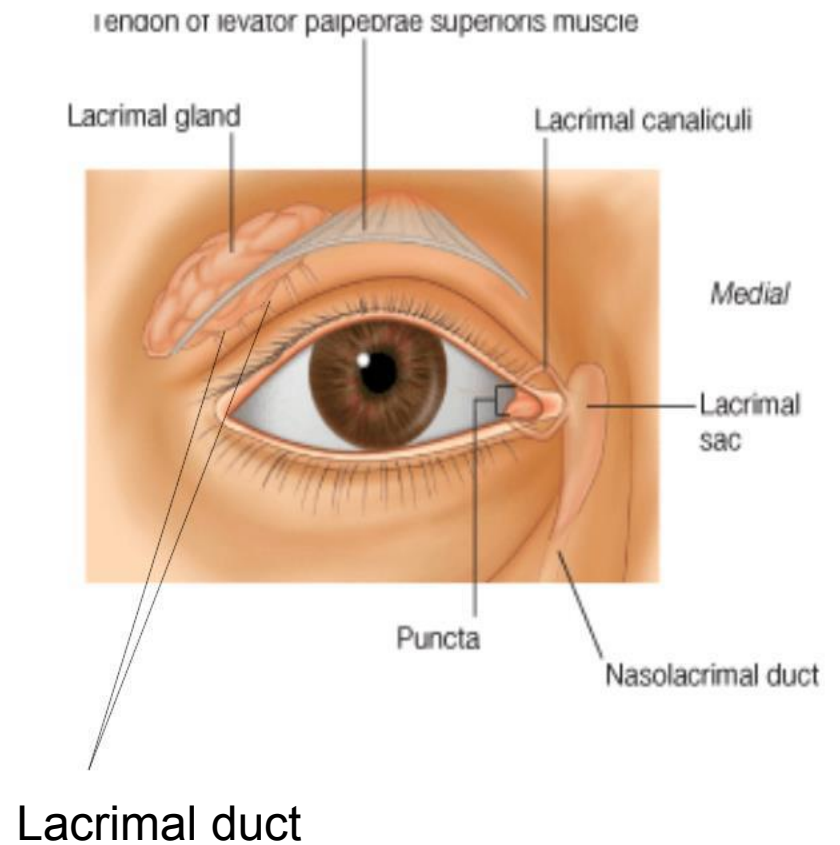
Lacrimal gland



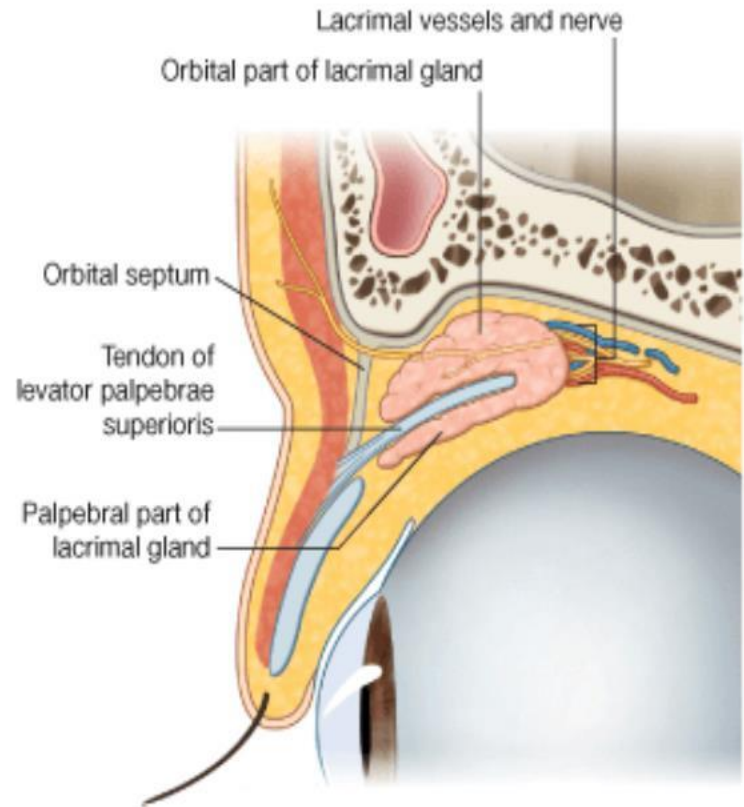
Lacrimal duct



Lacrimal ducts



- Arterial supply:
 - Lacrimal branch of ophthalmic artery (branch of internal carotid artery)
- Nerve supply: through lacrimal branch of ophthalmic nerve
 - Sensory innervation: return to the CNS through the lacrimal branch of the ophthalmic nerve
 - Parasympathatic innervation: stimulate fluid secretion from the lacrimal gland
 - Sympathatic innervation: vasomotor



The parasympathetic secretomotor nerves run as follows:

Preganglionic fibers from lacrimatory nucleus of the facial nerve (situated in the pons)



nervus intermedius



Geniculate ganglion of the facial nerve



Greater petrosal nerve



Nerve of pterygoid canal



Pterygopalatine ganglion
(where fibers are relayed)



Post-ganglionic fibers joins
the maxillary nerve



zygomatic nerve



Zygomaticotemporal nerve

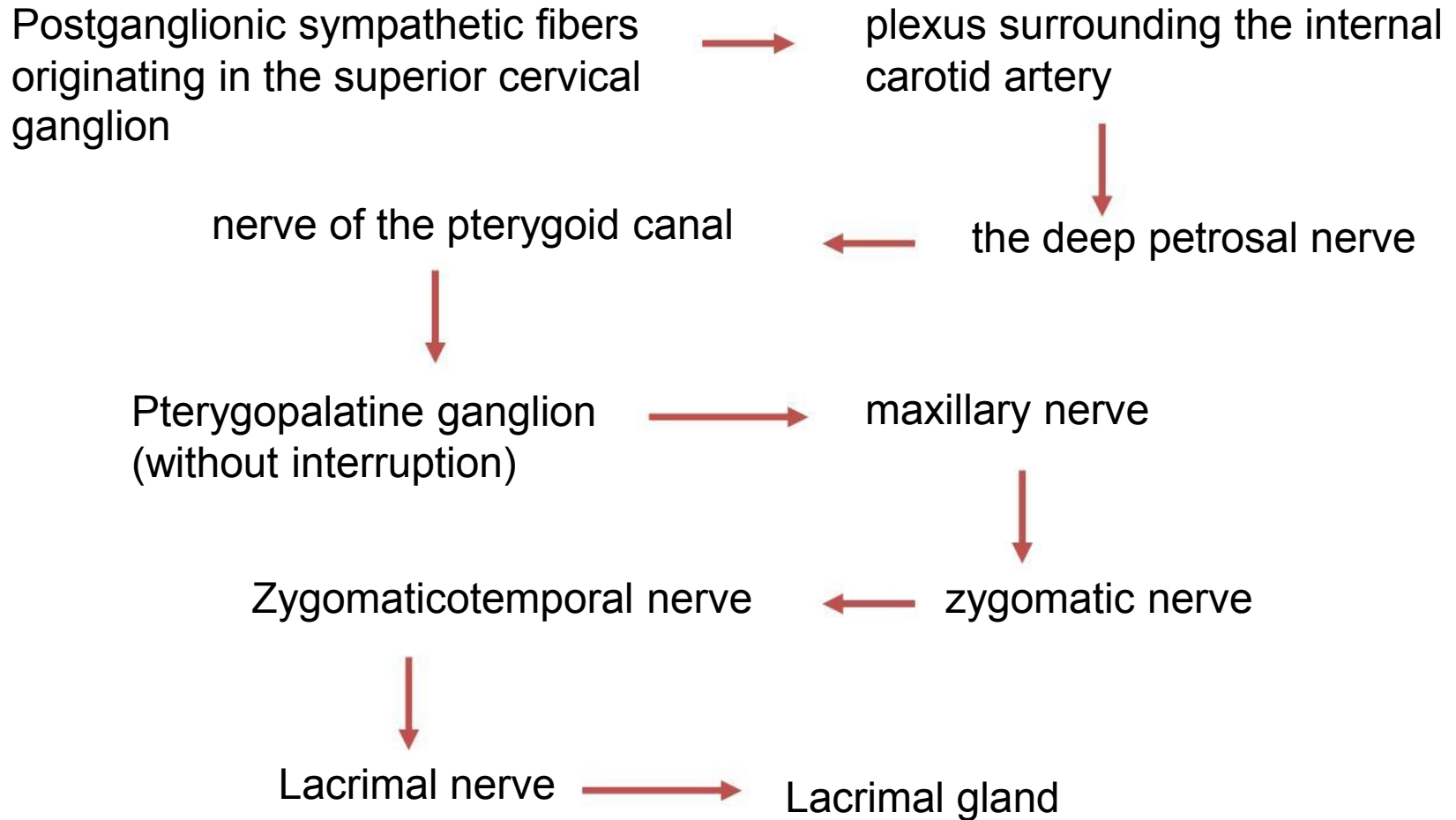


Lacrimal nerve



Lacrimal gland

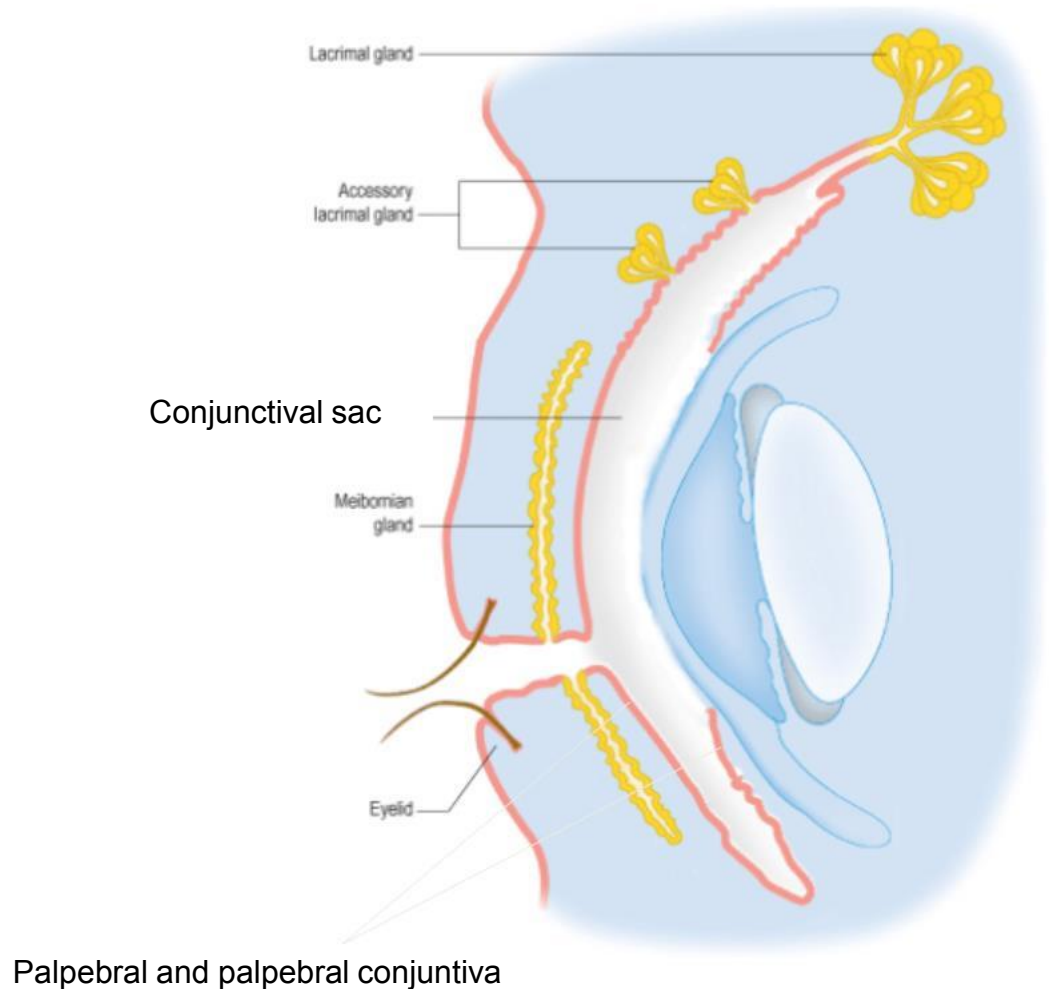
Sympathatic fibers follow similar path as parasympathetic innervation



Conjunctival sac

Conjunctiva:

- Mucous membrane
- Bulbar and palpebral
- conjunctival sac
- Fornices



Tendon of levator palpebrae superioris muscle

Lacrimal gland

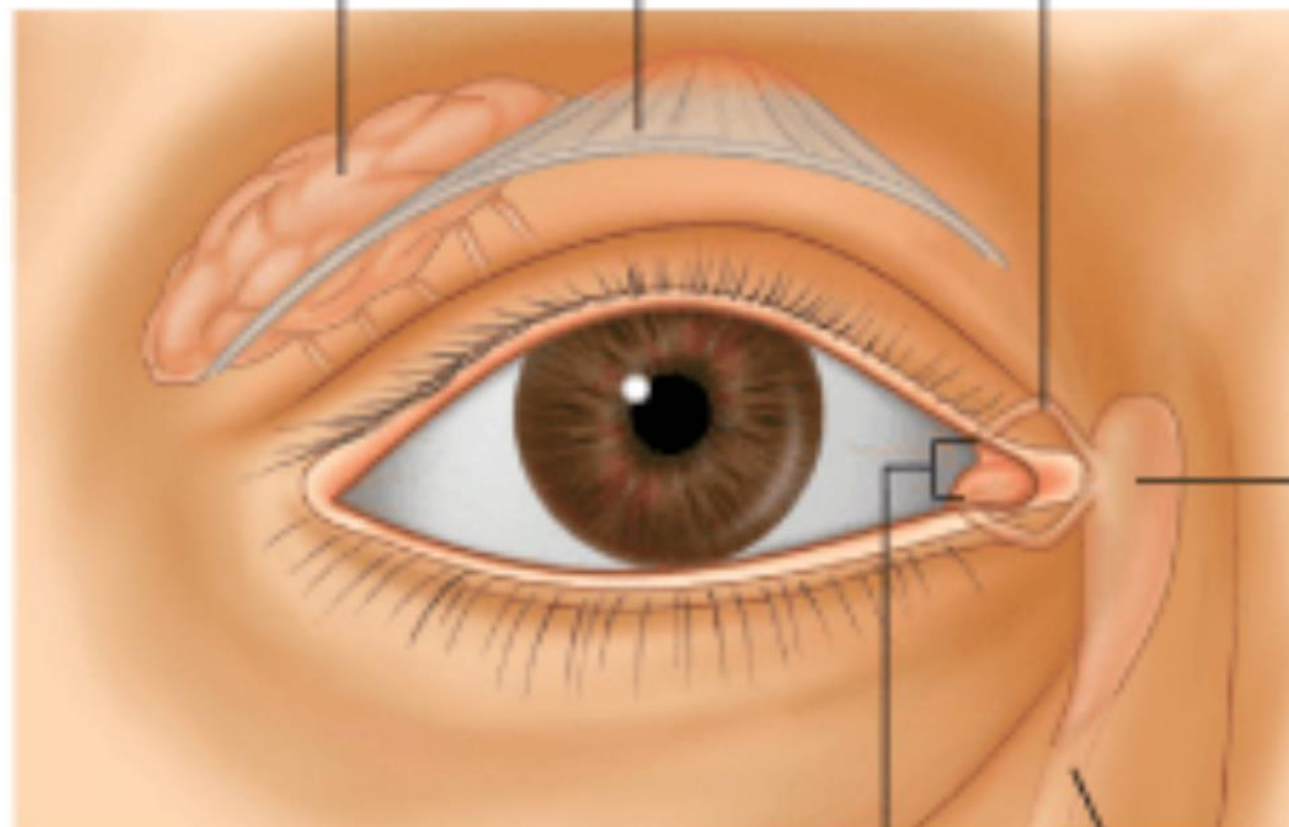
Lacrimal canaliculi

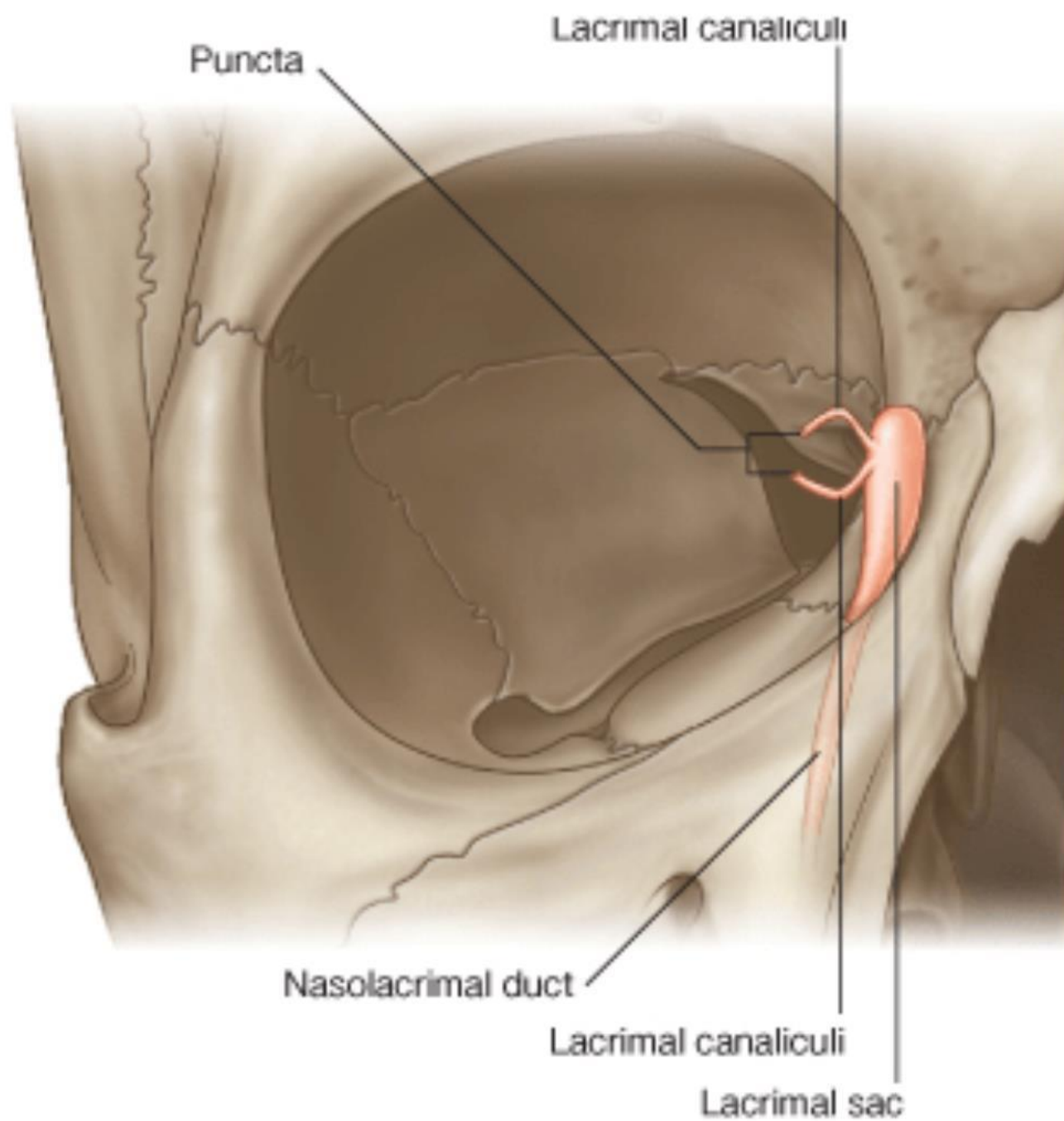
Medial

Lacrimal
sac

Puncta

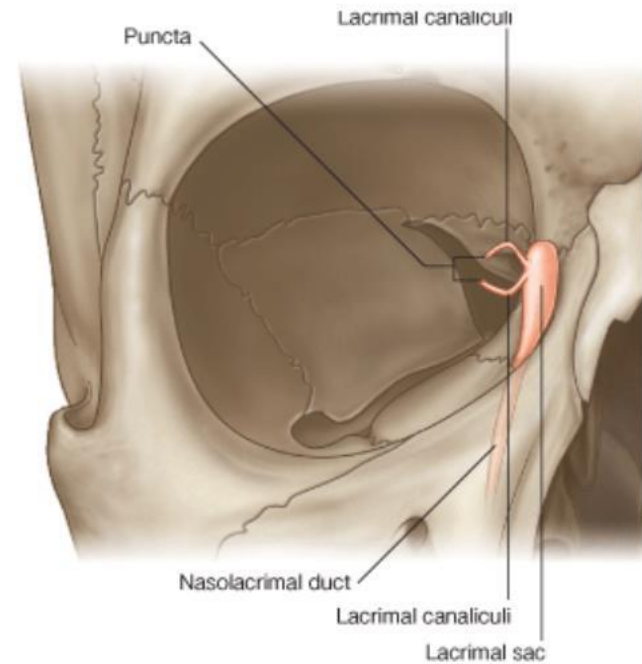
Nasolacrimal duct





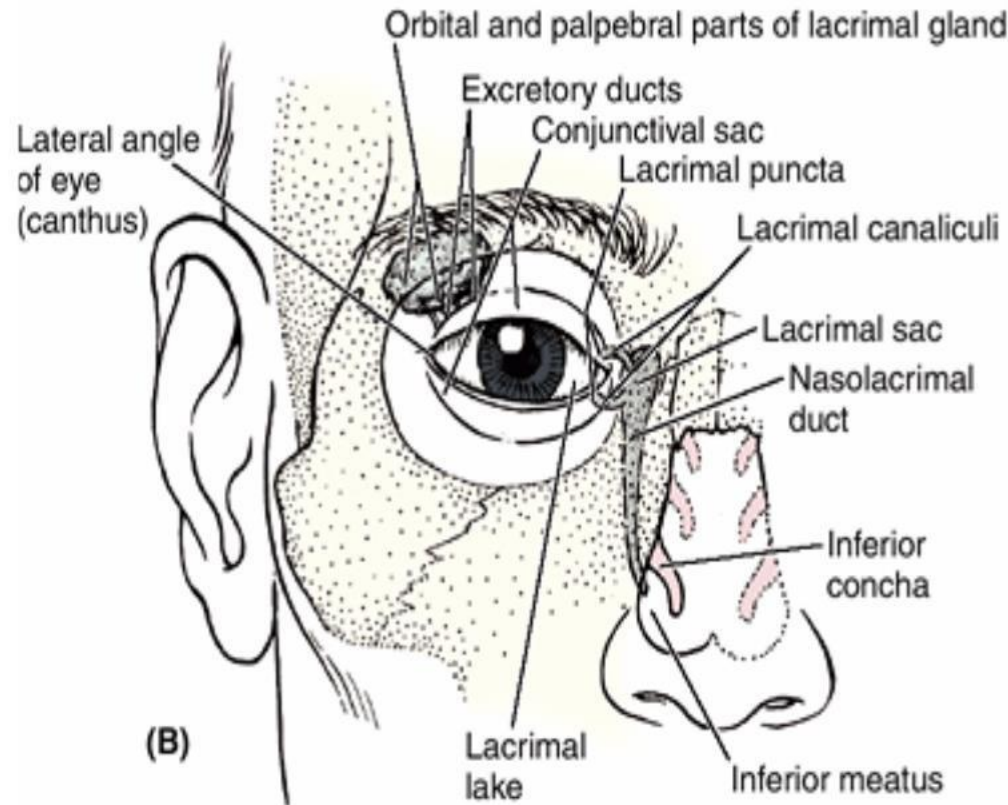
Lacrimal sac

- Upper blind end of the naso-lacrimal duct
- 12 mm in length
- Situated in the lacrimal fossa

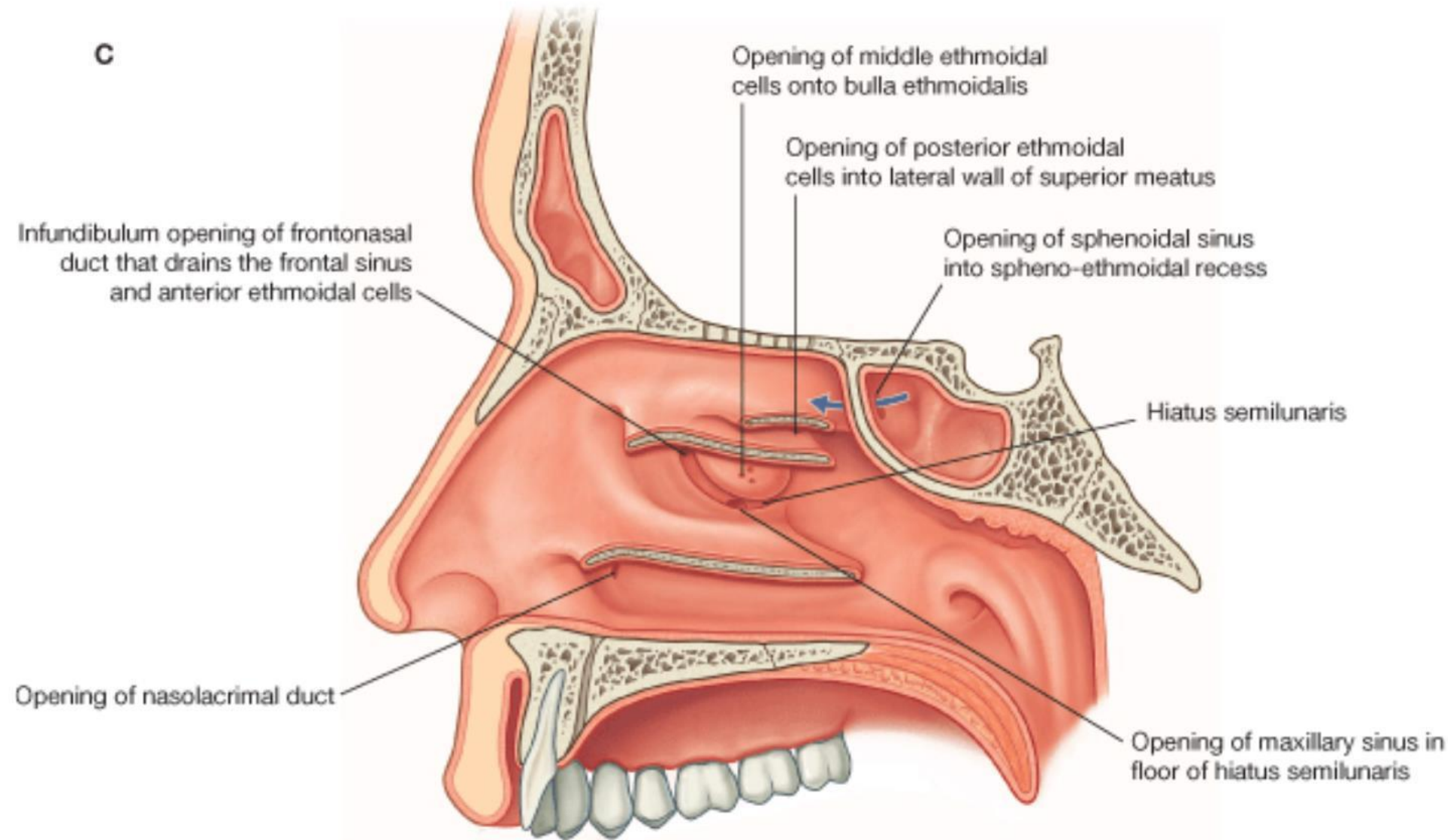


Nasolacrimal duct

- 18 mm in length
- opens into the inferior meatus of the nose.
- The lower opening is guarded by a fold of mucous membrane known as the **lacrimal fold or valve of Hasner**



C



Fascia bulbi or fascial sheath of the eyeball

- The fascia bulbi (**Tenon's capsule**) is a loose **membranous** sheath that envelops the eyeball
- Extends from optic nerve to the sclerocorneal junction.
- Separated from the sclera by the episcleral space.
- The Tenon's capsule forms a socket for the eyeball to facilitate free ocular movements.
- Separates the eyeball from orbital fat.
- The fascia bulbi is pierced by:
 - Tendons of four recti and two oblique muscles of the eyeball.
 - ciliary nerves and vessels

Eyeball (bulbus oculi)

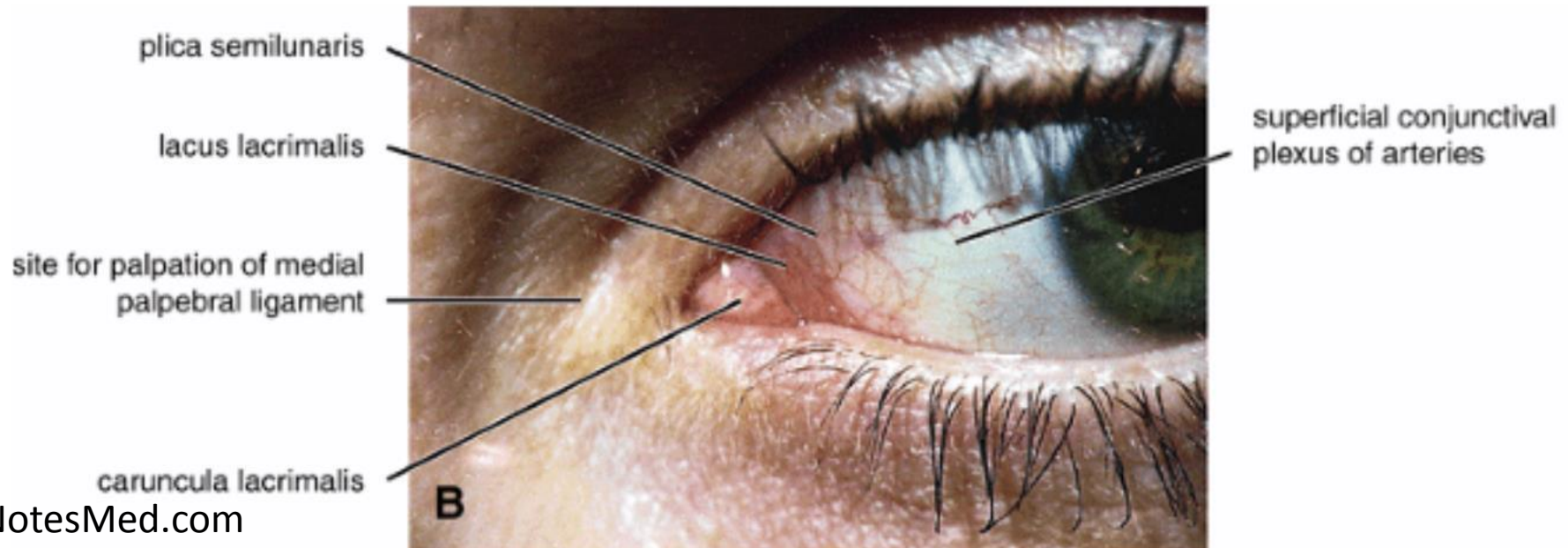
- Spherical and diameter about 24 mm of an Organ of sight
- **Location**
 - The eyeball occupies the anterior one-third of the orbital cavity and is embedded in the fat. It is enclosed in the thin fibrous sheath (Tenon's fascia), which separates the eyeball from the fat. The optic nerve emerges from it, a little medial **to its posterior pole.**

Eyelid/palpebrae

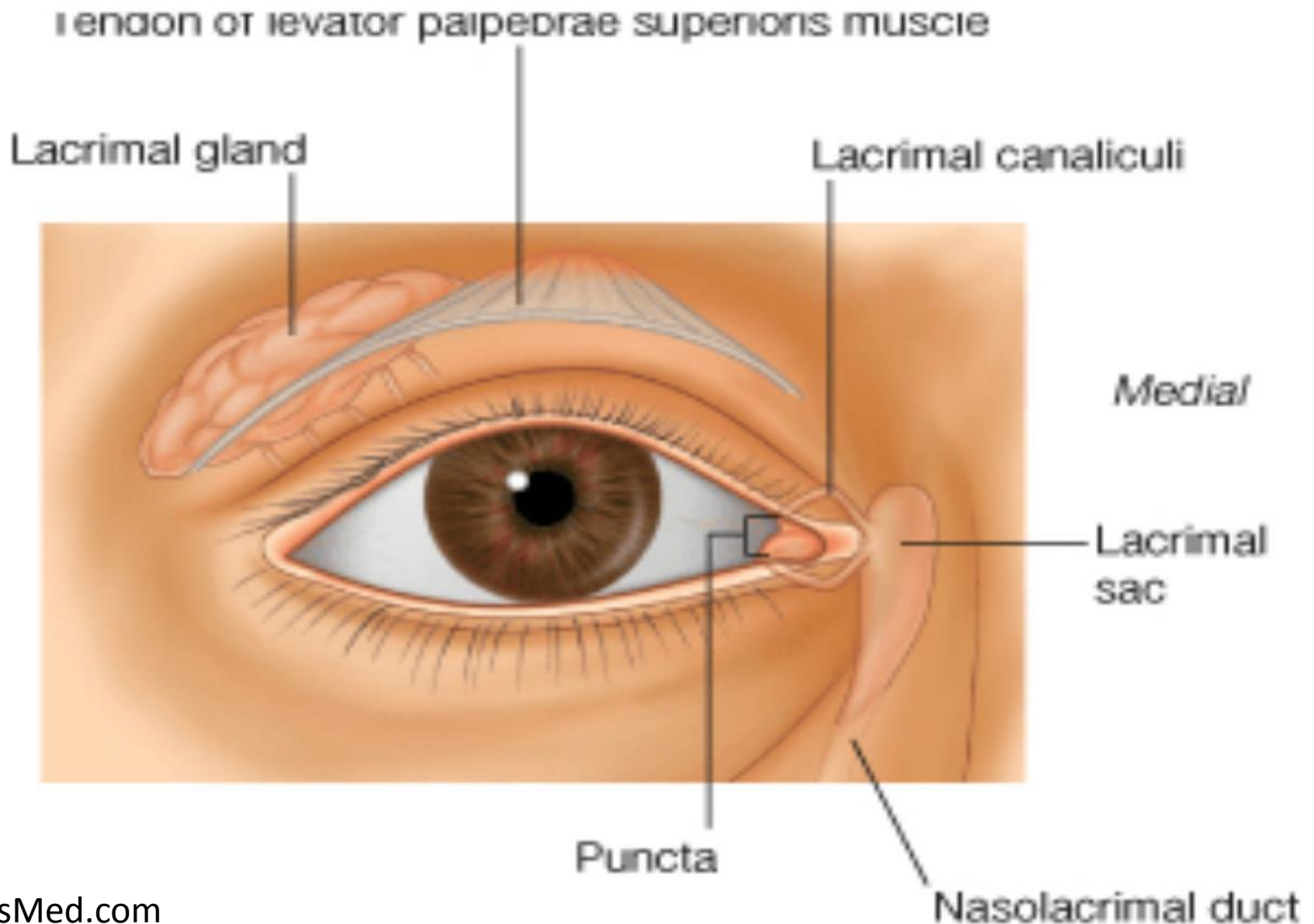
- Two movable curtains placed in front of the orbit- for protection of eye
- The upper eyelid is larger and more movable
- The space between the two eyelids- palpebral fissure
- At two ends of fissure, the eyelids meet forming medial and lateral angle/canthi of eye

Eyelid/palpebrae

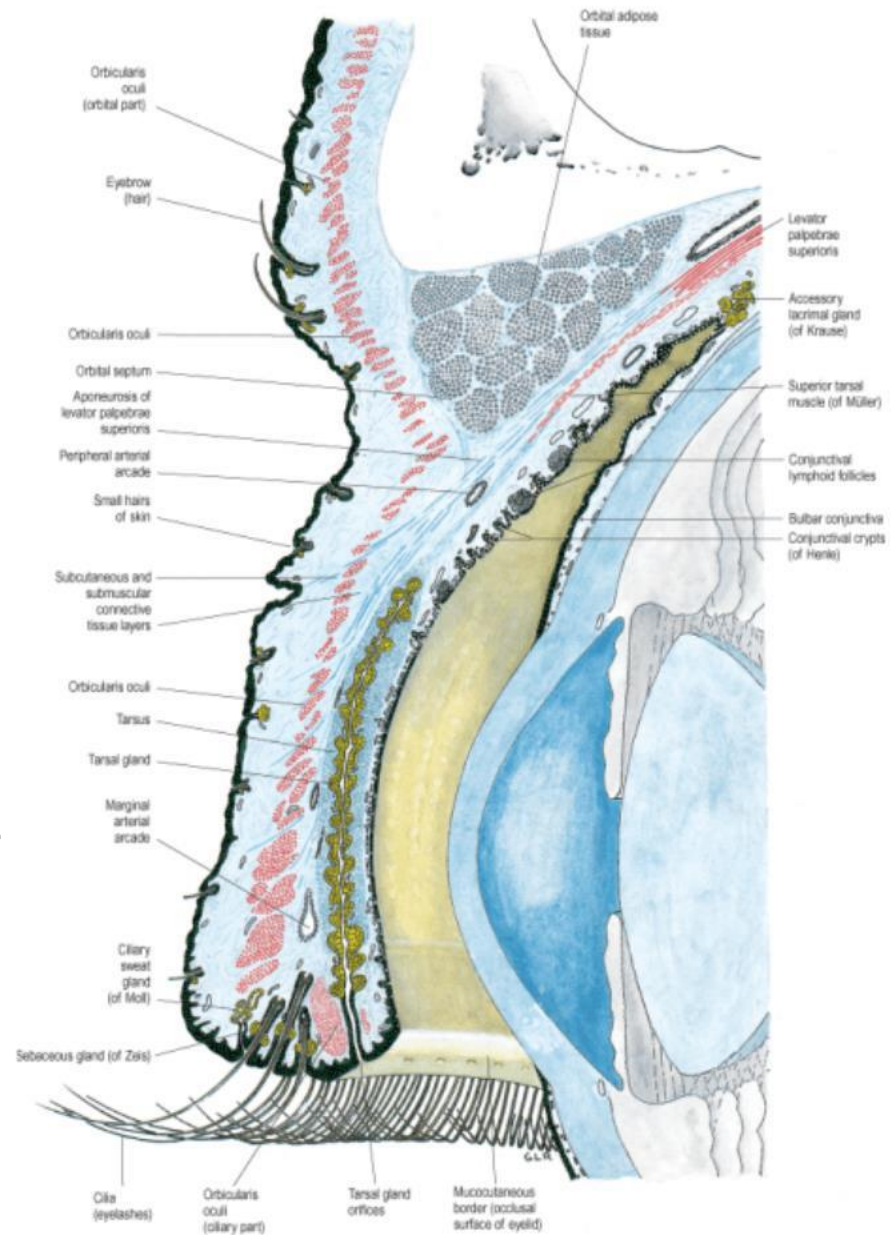
- At the medial angle of eye there is a reddish triangular area called **lacus lacrimalis** (L. **lacrimal lake**) - where the tears collect
- Within the lake (in the center of the lacus lacrimalis), there is a small elevation called **lacrimal caruncle** (**caruncula lacrimalis**)
- Lateral to the caruncle, bulbar conjunctiva is pinched up to form a semilunar fold called the **plica semilunaris**



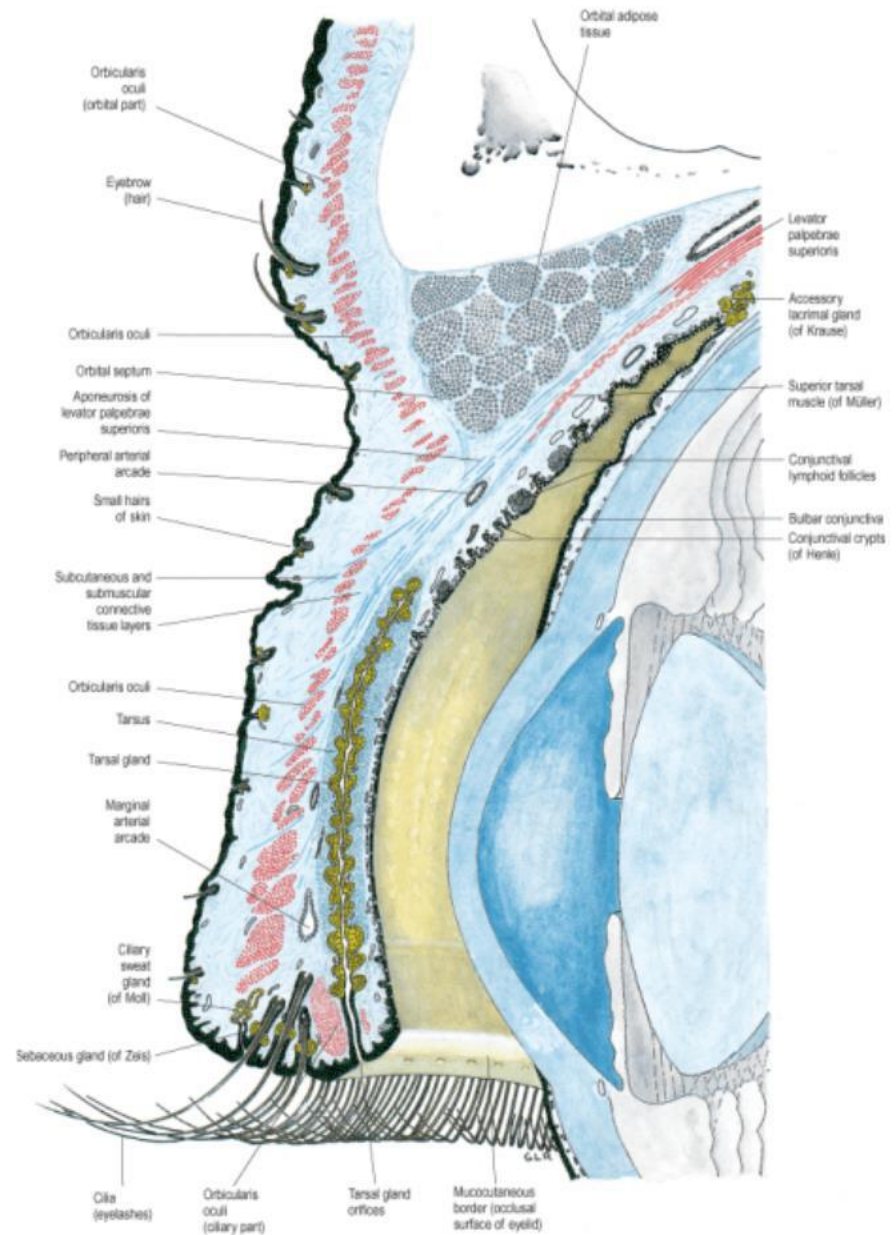
- The free margin of each eyelid can be subdivided into lateral $\frac{5}{6}^{\text{th}}$ and medial $\frac{1}{6}^{\text{th}}$ part



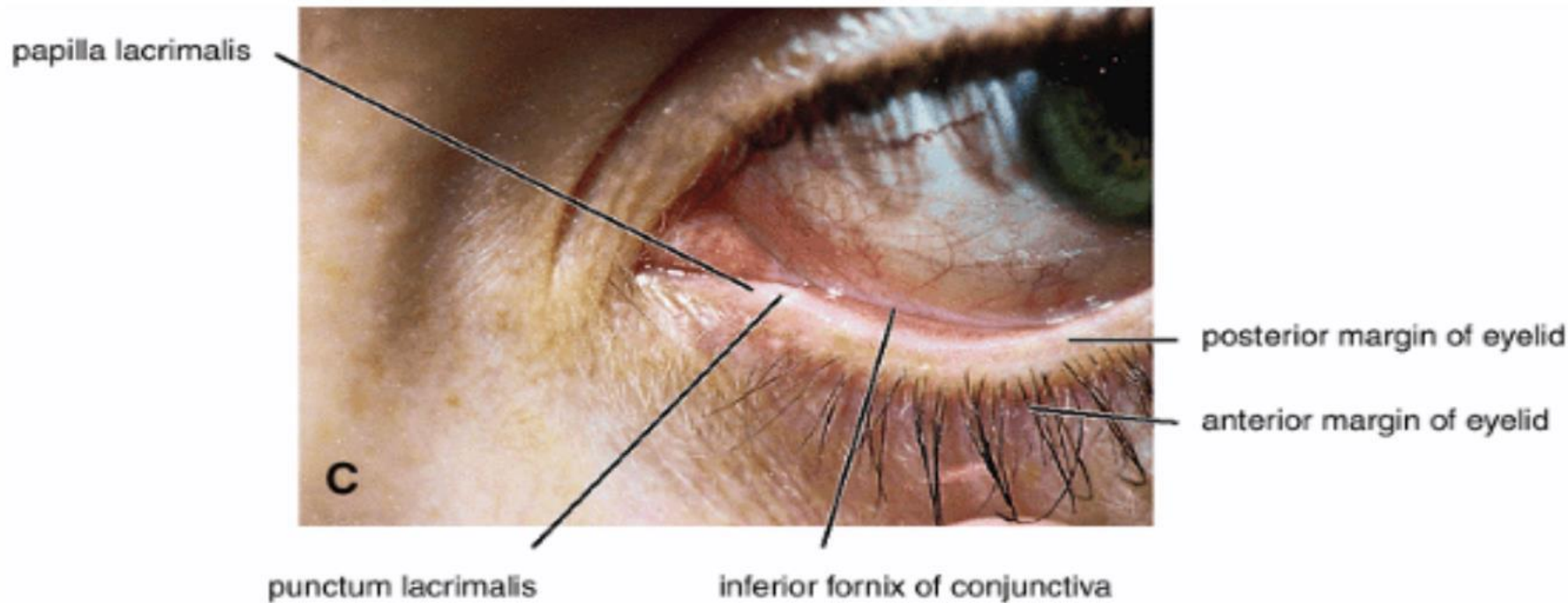
- Lid margin presents rounded outer and sharp inner lip
- Outer lip is provided with two or more rows of eyelashes or cilia which is associated with the
 - Ciliary sweat gland (of Moll)
 - Sebaceous gland (of Zeis)
 - Inflammation of these gland called **stye**- the gland is swollen, painful and make the eyelid edematous



- Inner lip:
- Presents the row of opening of modified sebaceous gland called tarsal glands (Meibomian gland)
 - Inflammation of tarsal gland is called **chalazion**

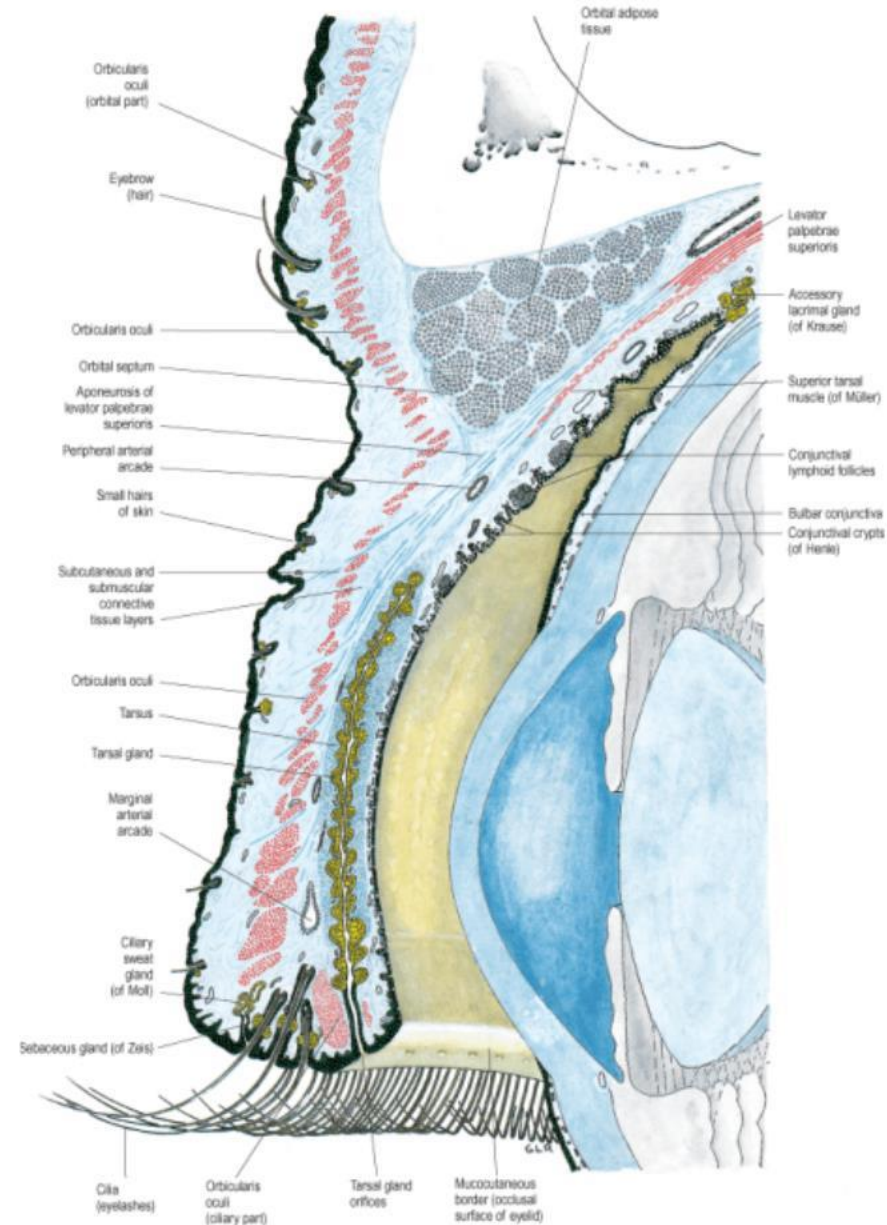


- Medial 1/6th part
 - Rounded and devoid of eye lashes
 - Traversed by lacrimal canaliculi
- At the junction of lateral 5/6th and medial 1/6th of lid margin, there is a small elevation called **lacrimal papilla**
- **lacrimal punctum** opens on the summit of the papilla

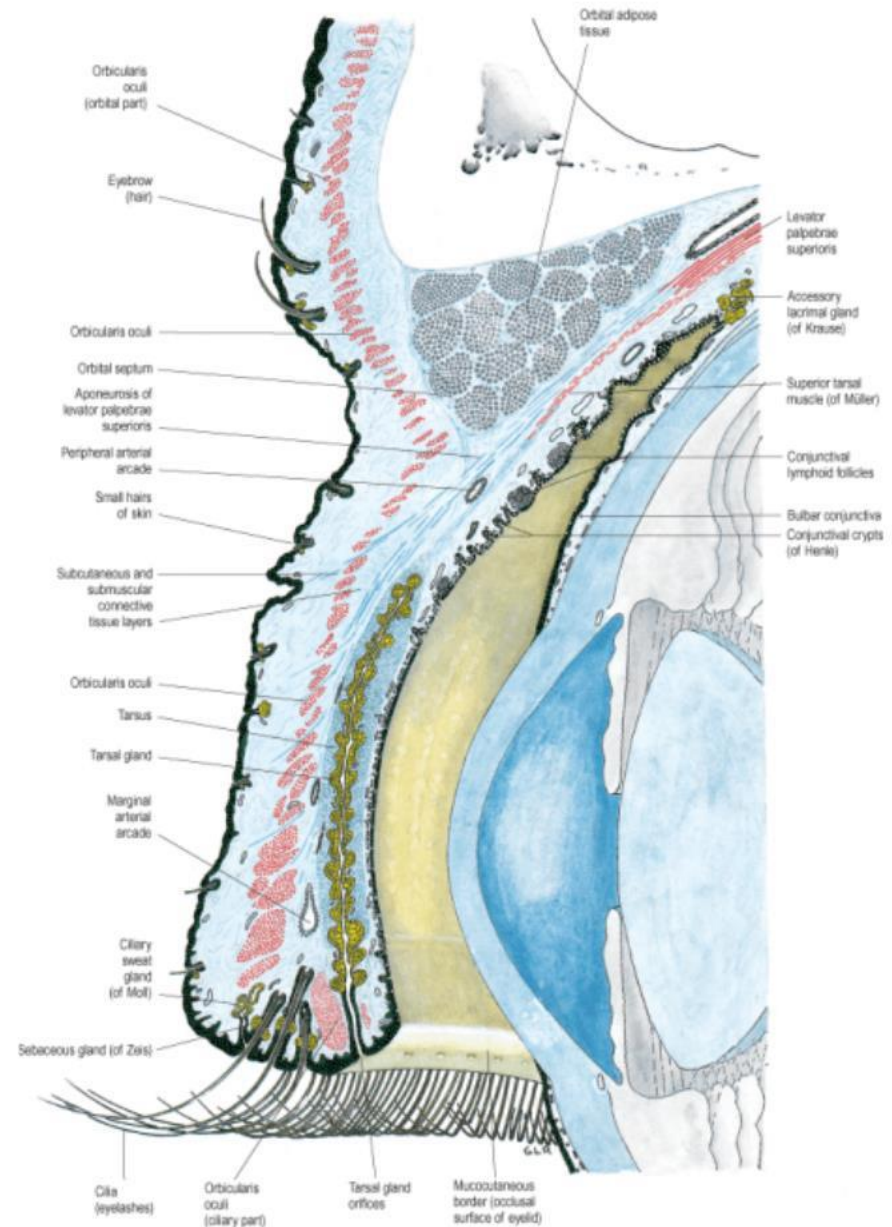


Structure of eyelid

- Skin
- Superficial fascia: of loose areolar tissue and devoid of fat
- Palpebral fibers of orbicularis oculi

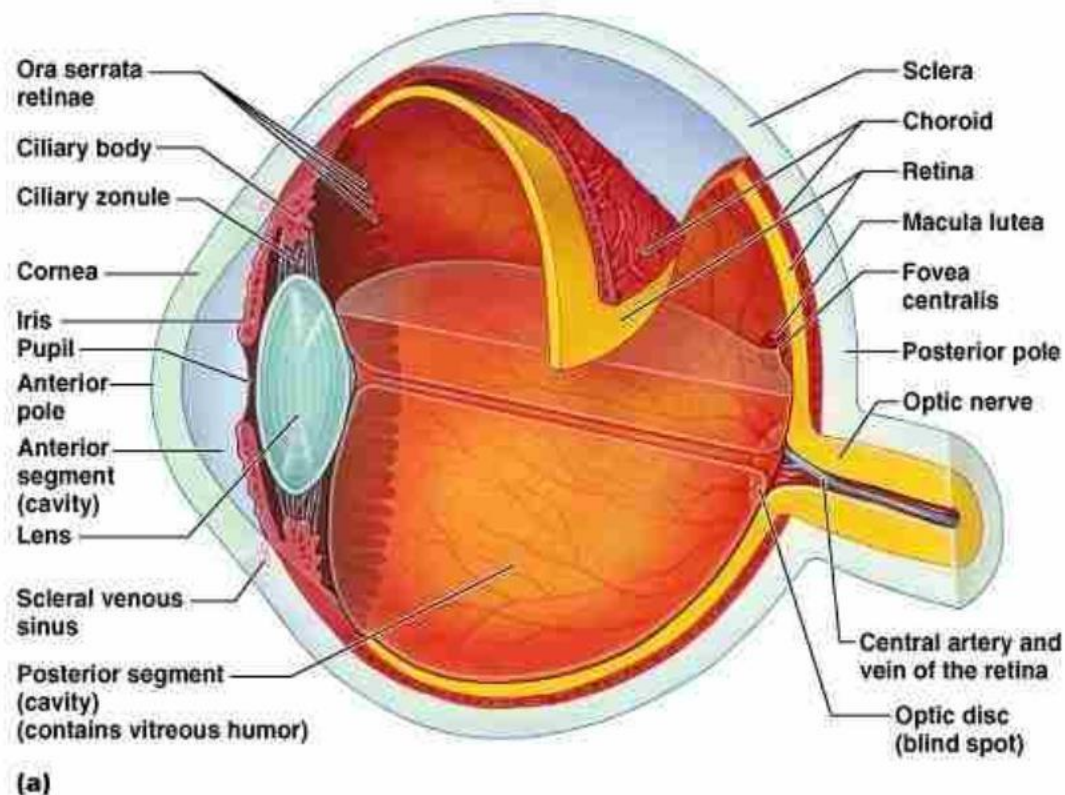


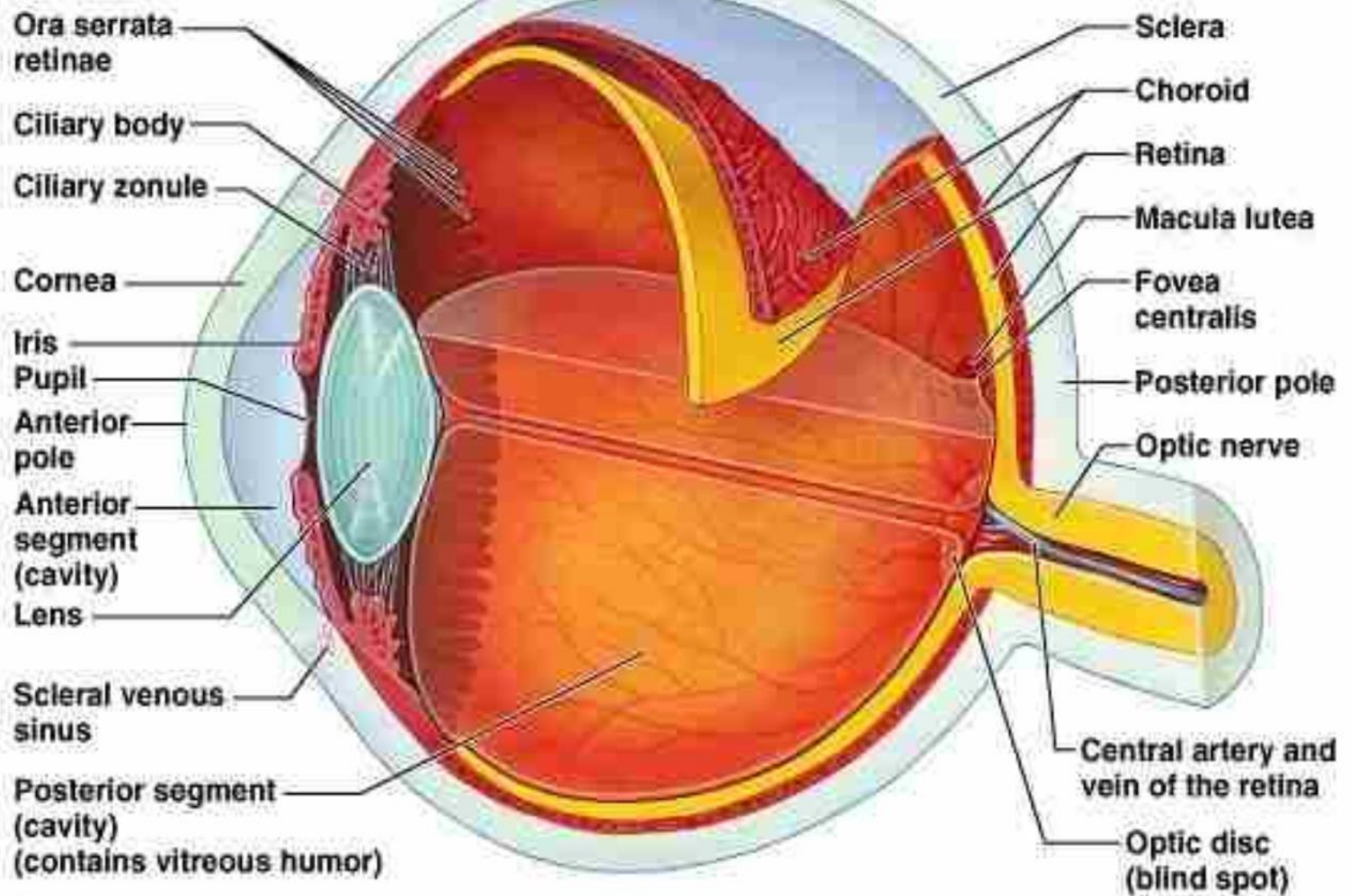
- Tarsal plate/tarsus: condensed mass of fibrous tissue near the lid margin giving stiffness to it
 - Tarsal glands lie within it
- Conjunctiva: lining the posterior surface of tarsal plate



Tunics of the eyeball

- Three concentric coats:
 - An outer fibrous coat (sclera and cornea).
 - A middle vascular coat (choroid, ciliary body, and iris).
 - An inner nervous coat (retina).

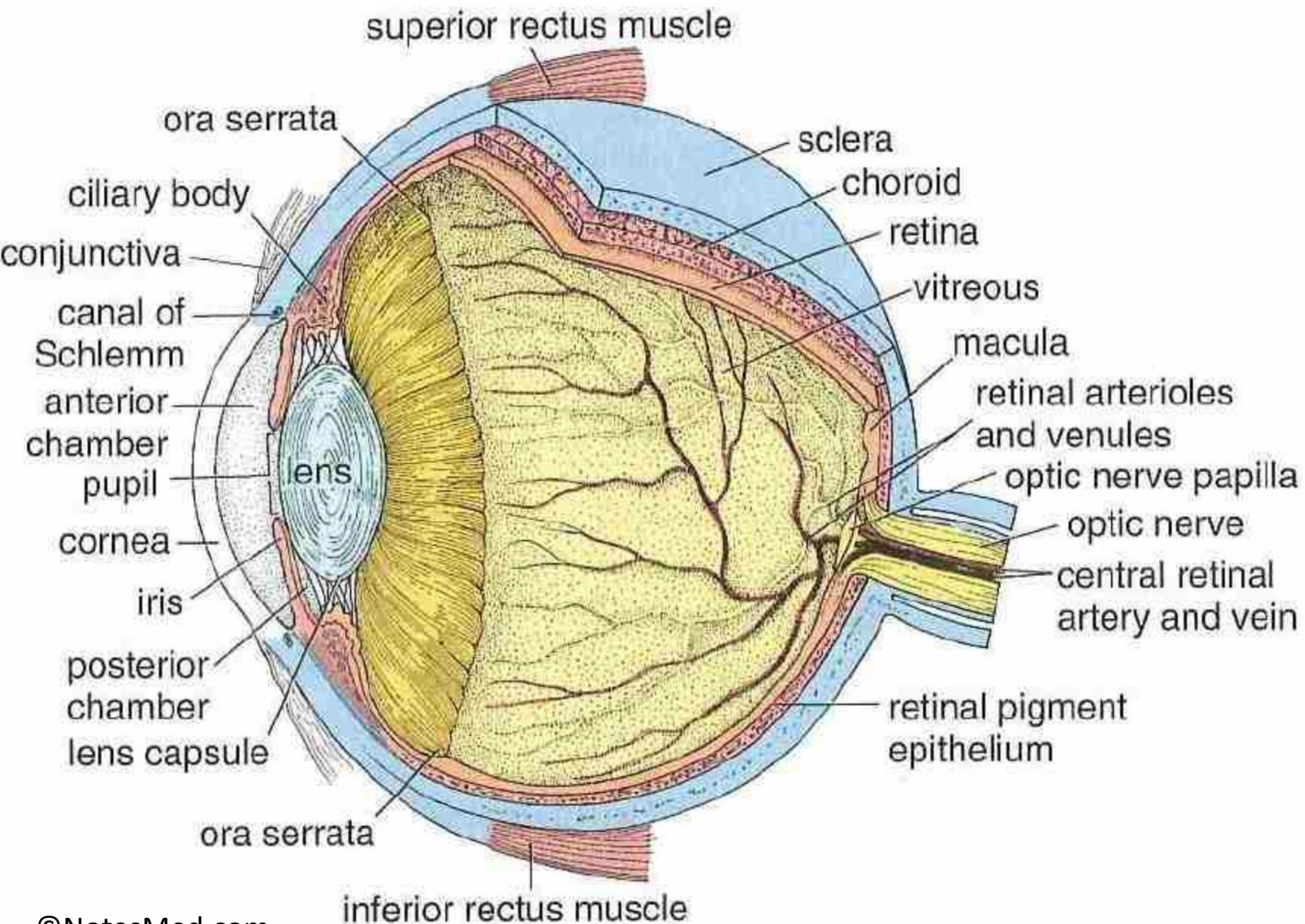




(a)

Sclera

- Posterior five-sixth of the outer coat
- Consists of dense fibrous tissue.
- Opaque and a small portion of it is seen as the **white of the eye in the palpebral fissure**.
- The sclera is continuous anteriorly with the cornea.
- The junction between the sclera and cornea is termed **corneoscleral junction**.
- Just behind the corneoscleral junction, within the sclera is a circularly running canal called **sinus venosus sclerae (canal of Schlemm)**.



Sclera

- **Functions**

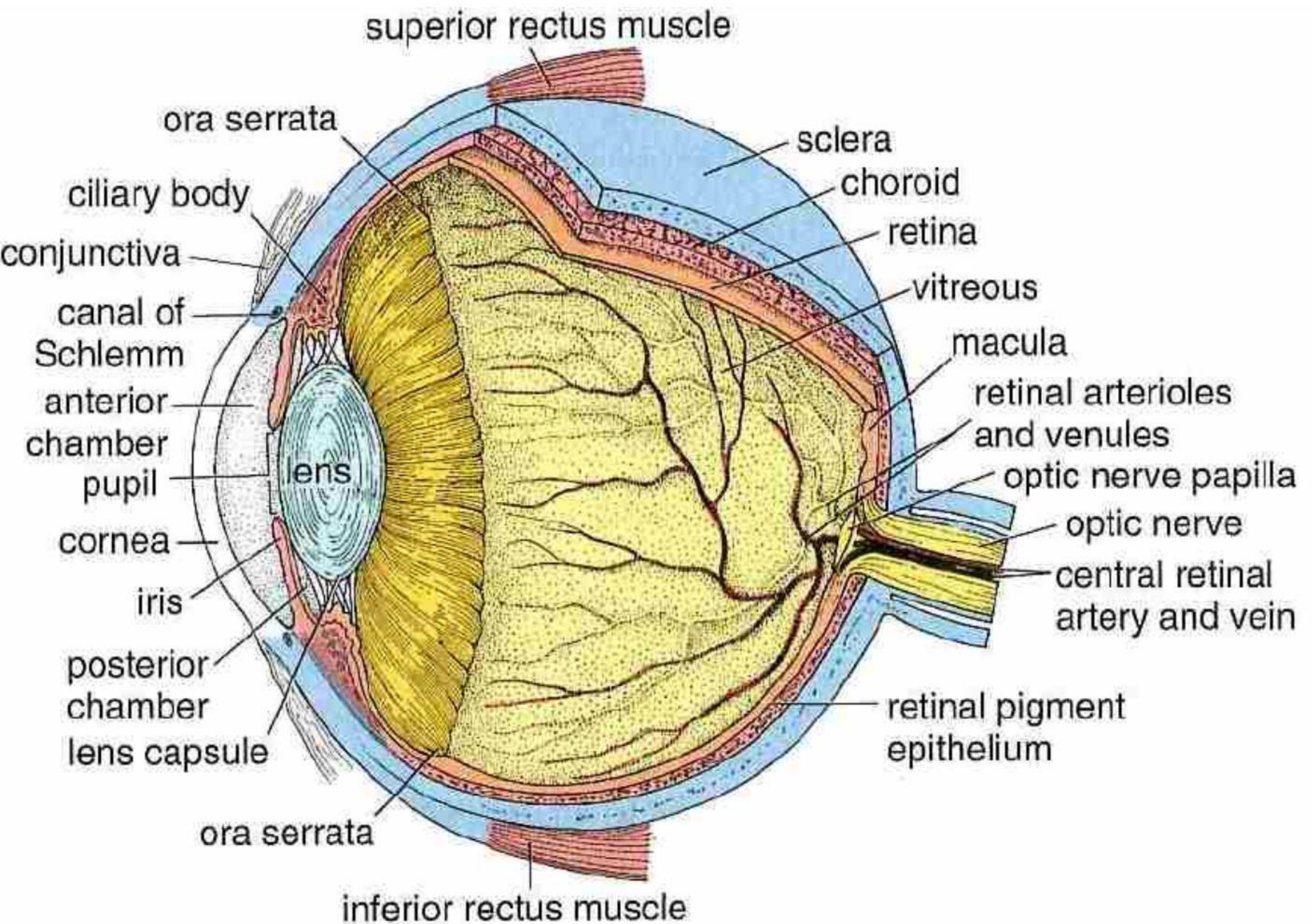
- Helps to maintain the shape of the eyeball.
- Protects internal structures.
- Provides attachment to muscles that move the eyeball.

- **Structure Piercing the Sclera:**

- **Optic nerve**
- **Posterior ciliary vessels and nerves**
- **Anterior ciliary arteries**
- **Four choroidal veins (also called venae vorticosae)**

Cornea

- Anterior one-sixth of the outer coat.
- Bulges forwards from the sclera at the *corneoscleral junction called limbus*.
- Transparent and more convex than sclera because it represents the segment of a smaller sphere.
- Avascular and highly sensitive and devoid of lymphatics.
- Gets nutrition from the
 - Capillaries at the conjunctivo-corneal junction and
 - Aqueous humor and also
 - Lacrimal secretion spreading as fluid over the anterior surface of cornea



Cornea

- Five layers, from outside inwards
 - **Corneal epithelium**
 - **Anterior limiting membrane (or Bowman's membrane)**
 - **Substantia propria (corneal stroma)**
 - **Posterior limiting membrane/Descemet's membrane**
 - **Endothelium**

Middle vascular coat of the eyeball

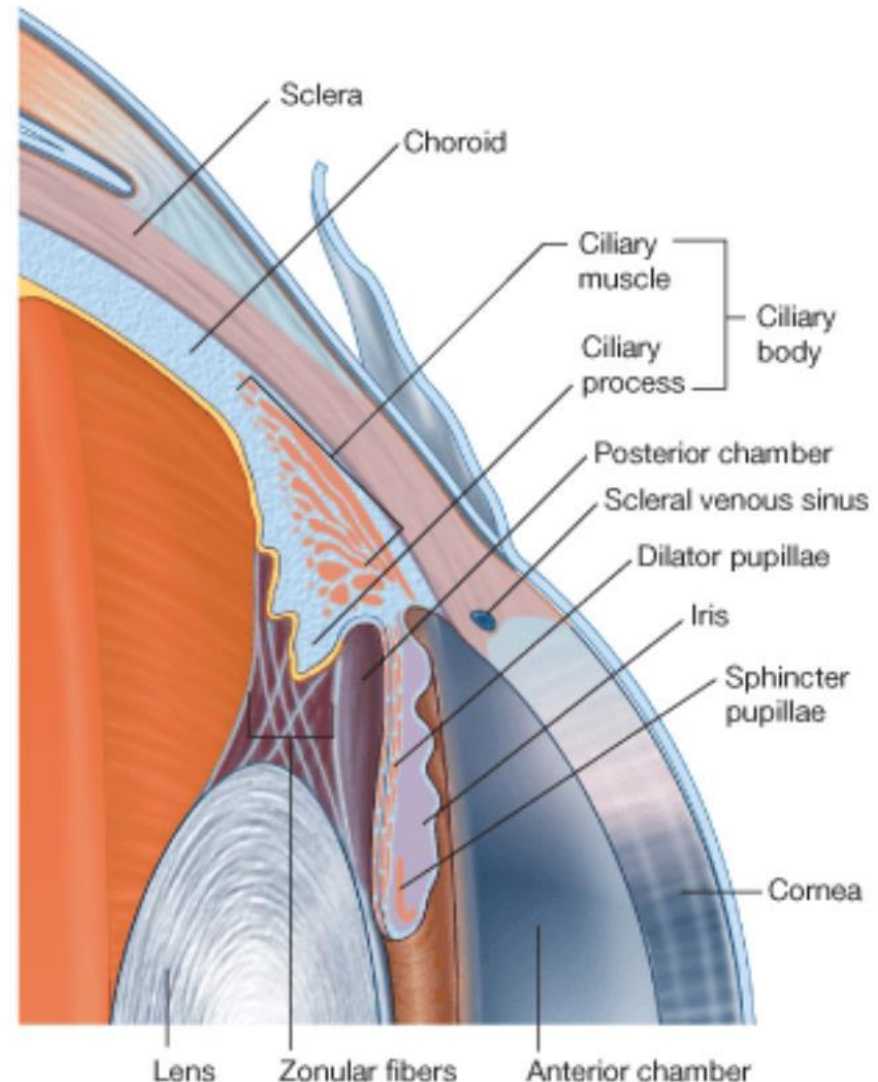
- Contains most of the blood vessels of the eyeball.
- Clinicians called **uveal tract**.
- Consists of three parts (from behind forwards)
 - **Choroid**
 - **Ciliary body**
 - **Iris**

Choroid

- Posterior part of the vascular coat.
- Brown, thin, and highly vascular membrane lining the inner surface of the sclera.
- Anteriorly-connected to the iris by the ciliary body
- Posteriorly-optic nerve.
- Structure: four layers (from outside inwards);
 - **Suprachoroid lamina (lamina fusca)**
 - **Vascular lamina**
 - **Capillary lamina (capillary layer of choroid)**
 - **Basal lamina (membrane of Bruch)**
- Functions:
 - Supports the retina and provides nutrition to the outer layer of retina
 - Absorbs light and prevents scattering of light rays (reflection) within the eye

Ciliary body

- Thickening in the vascular tunic.
- Continuous with the choroid behind and the iris in front.
- Parts: ciliary ring, ciliary processes, and ciliary muscle.
 - **Ciliary ring**: posterior part of the body
 - Ciliary muscle: smooth muscle fibers
 - Ciliary processes: radially arranged folds or ridges which provides attachment to the suspensory ligament of lens
- Main function is to focus the lens for near vision.



Iris

- Visible colored part of the eye
- Circular, pigmented and contractile part whose peripheral part is attached to anterior surface of the ciliary body
- It has central aperture called **pupil**
- Composed of smooth muscle
 - Sphincter pupillae muscle (constrictor or circular): innervated by parasympathetic fibers
 - Dilator pupillae muscle (dilator or radial): innervated by the sympathetic fibers

Inner nervous coat of the eyeball (retina)

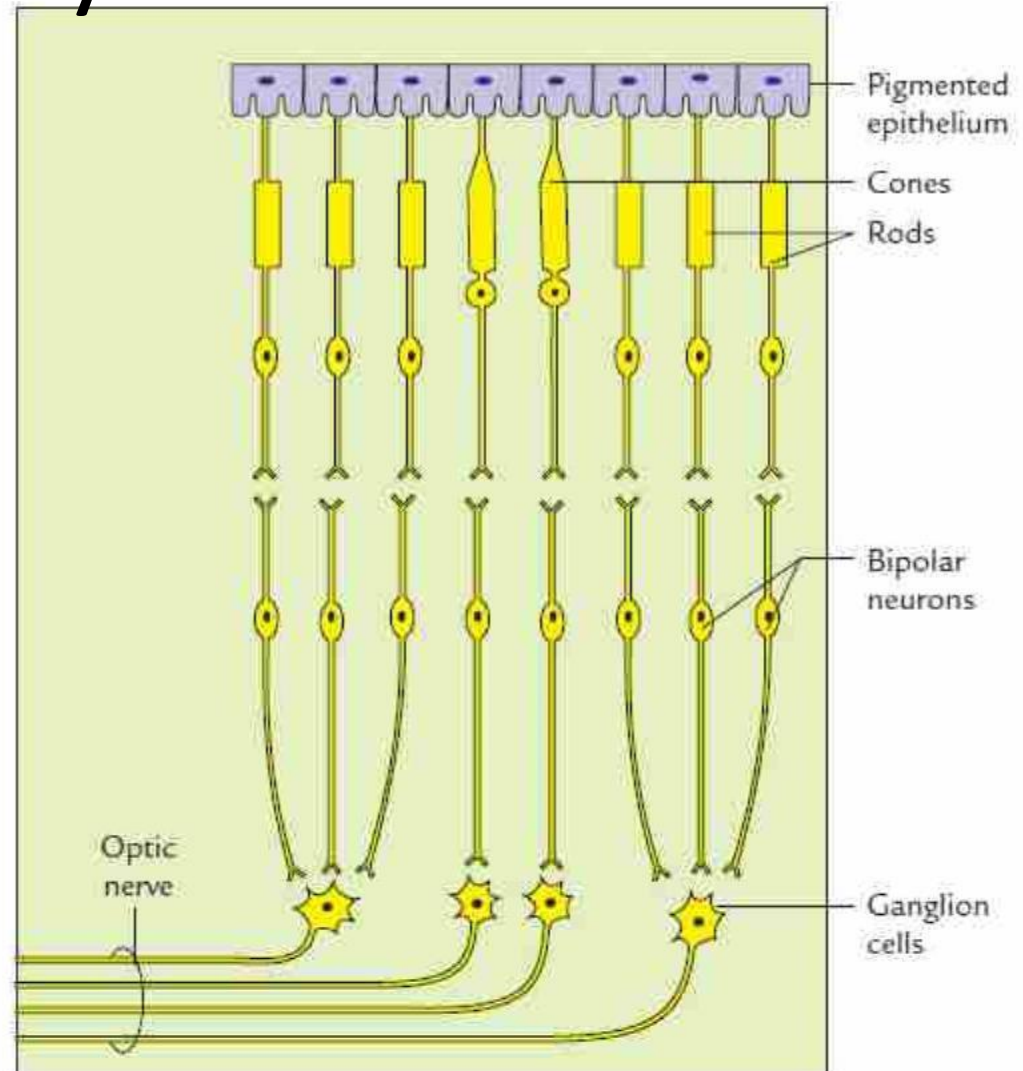
- Retina –deepest layer
- Its anterior edge forms a wavy ring called **ora serrata**
 - Parts anterior to the ora serrata is nonvisual part (nonphotosensitive region) and contains merely pigmented layer which lines the inner surface of ciliary body and posterior surface of iris
 - Parts posterior to the ora serrat is visual part (photosensitive region)

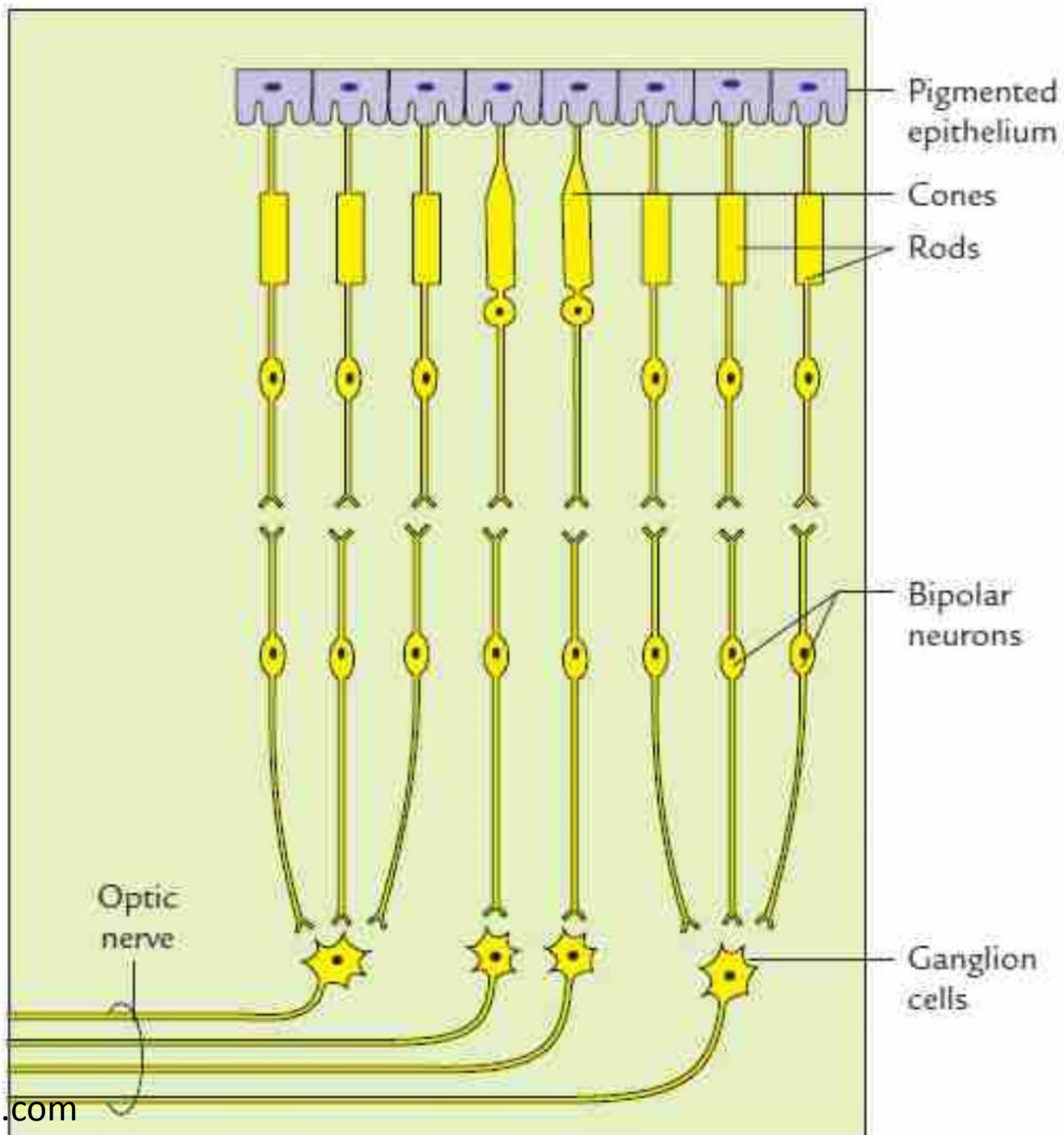
Nervous coat (Retina)

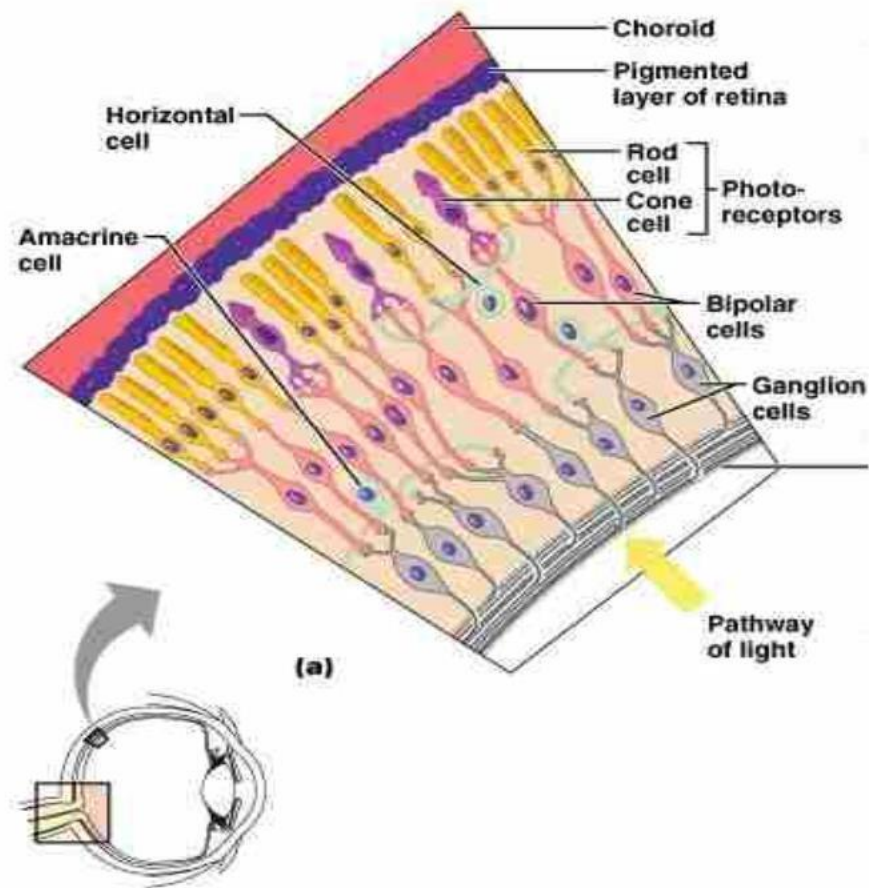
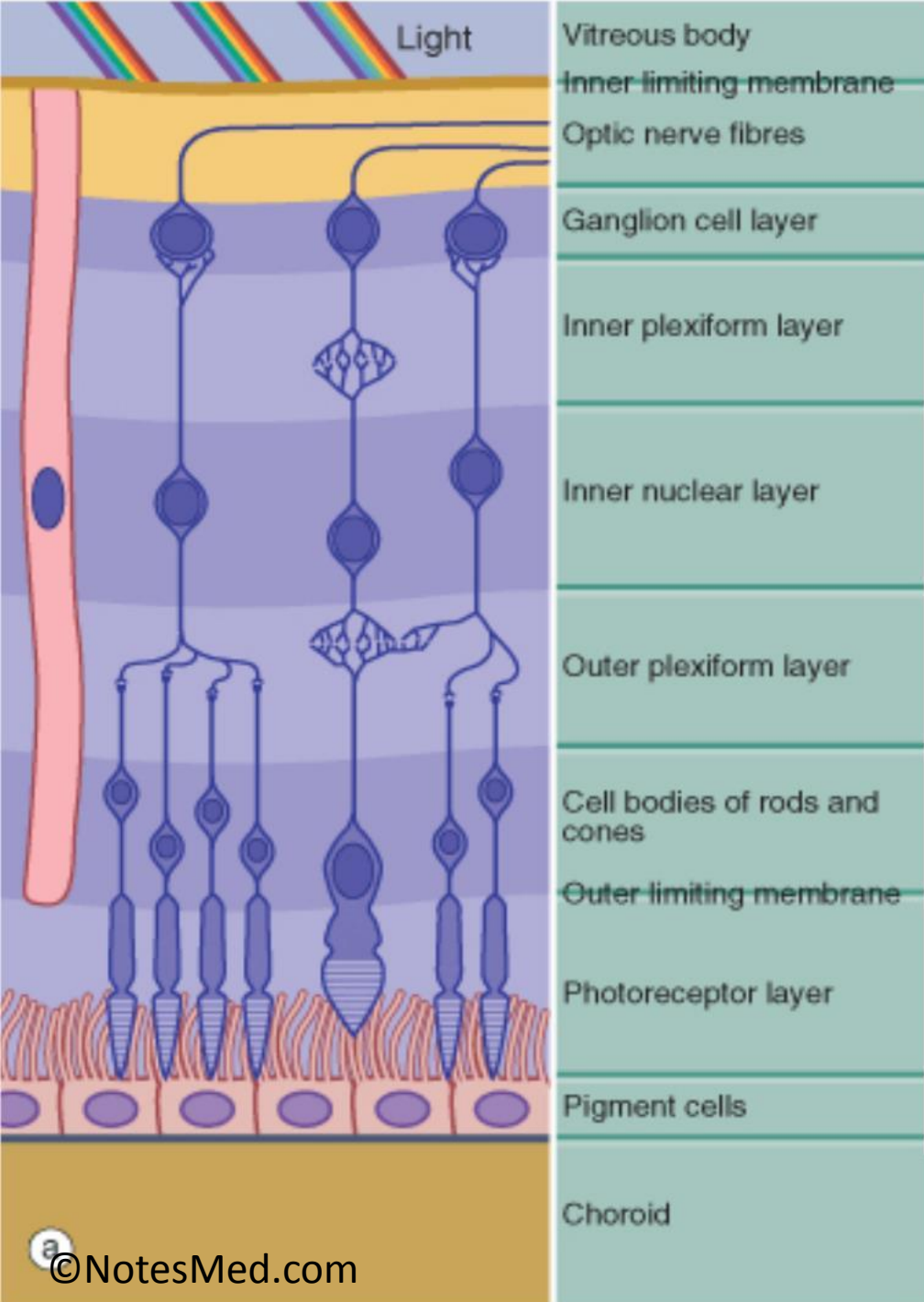
- Composed of two layers
 - Outer pigmented layer – single layer of cuboidal cells containing melanin
 - attached to the choroid
 - Absorb the light rays and prevents back reflection
 - Inner nervous layer – in contact with the vitreous body and contains three main types of neurons
 - Photoreceptor cells
 - Bipolar cells
 - Ganglion cells

Histologically of the retina

- Outer pigmented layer
- Layer of rods and cones (photoreceptor cells)
- External limiting membrane
- Outer nuclear layer (Cell bodies of rods and cones)
- Outer plexiform layer
- Inner nuclear layer (Cell bodies of bipolar neurons)
- Inner plexiform layer
- Ganglion cell layer
- Nerve fibre layer
- Internal limiting membrane





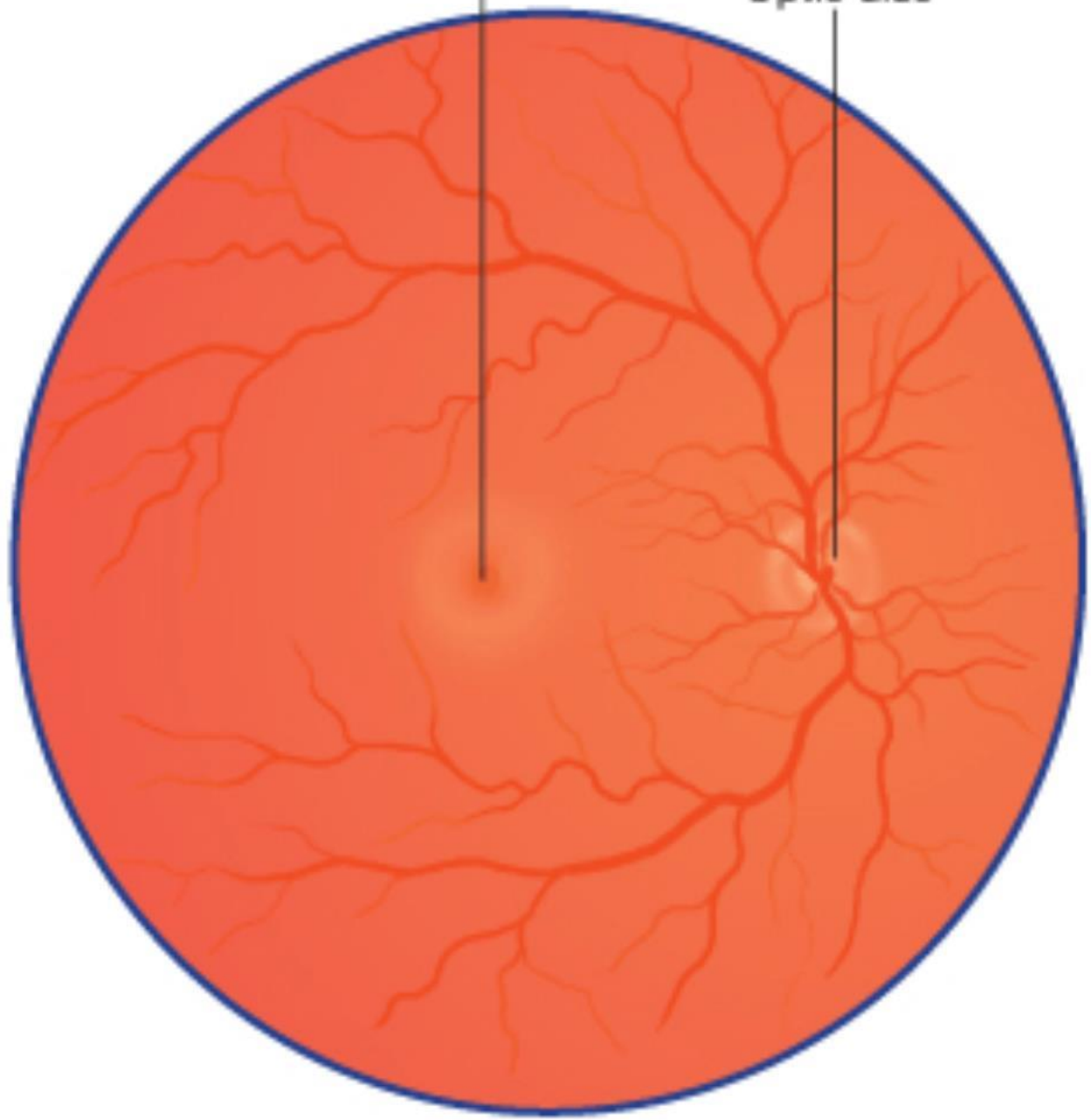


Photoreceptors

- Two main types
 - Rod cells : more than 100 million
 - Respond to dim light (allow vision in dim light),
 - They form images without clear details
 - Cone cells: about 7 millions
 - Respond in bright light
 - Responsible for sharp images and color vision

Macula lutea with fovea centralis

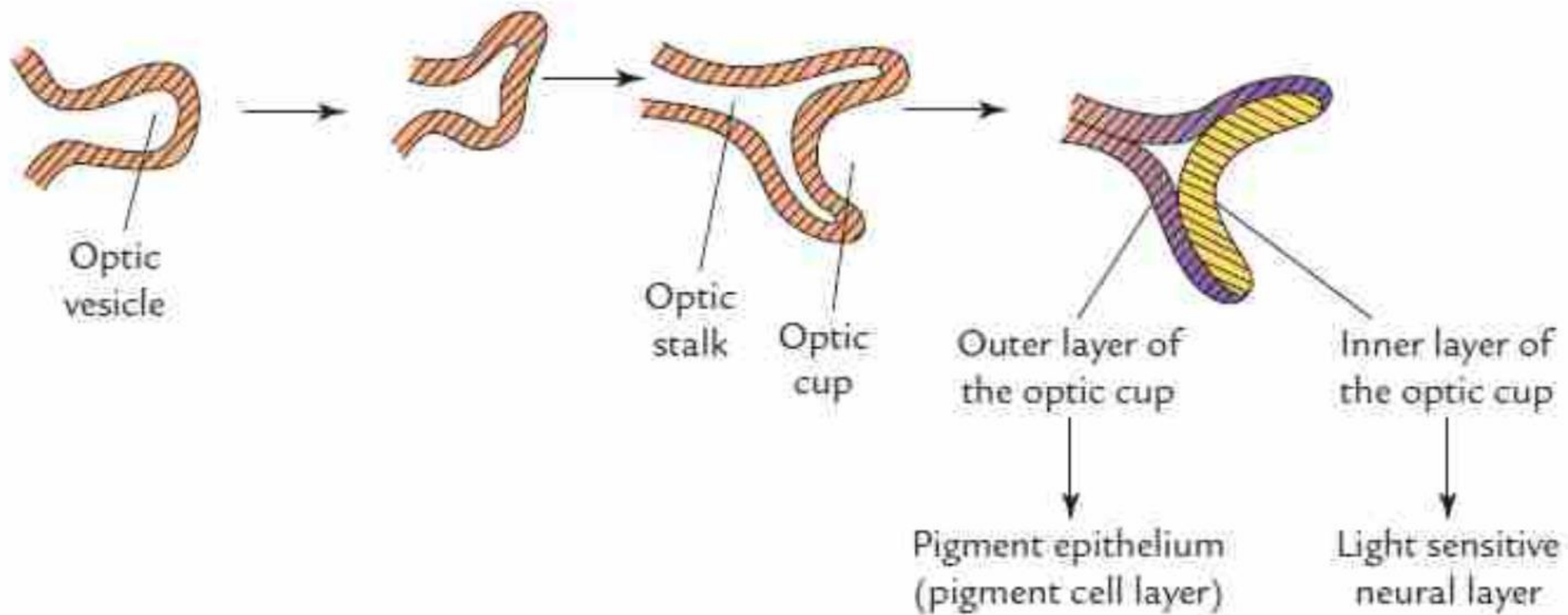
Optic disc



Regional Specializations of the Retina

- **Optic disc**
- **Macula lutea:** depressed area at the center of the retina about 3 mm lateral to the optic disc which contains mostly cones
- **Fovea centralis:** central depression of the macula lutea which contains only cones
 - Region of the most distinct vision

Development of the Retina



Arterial supply of the eyeball

- Central artery of the retina.
- Long and short posterior ciliary arteries.
- Anterior ciliary arteries.

Functions of the eye

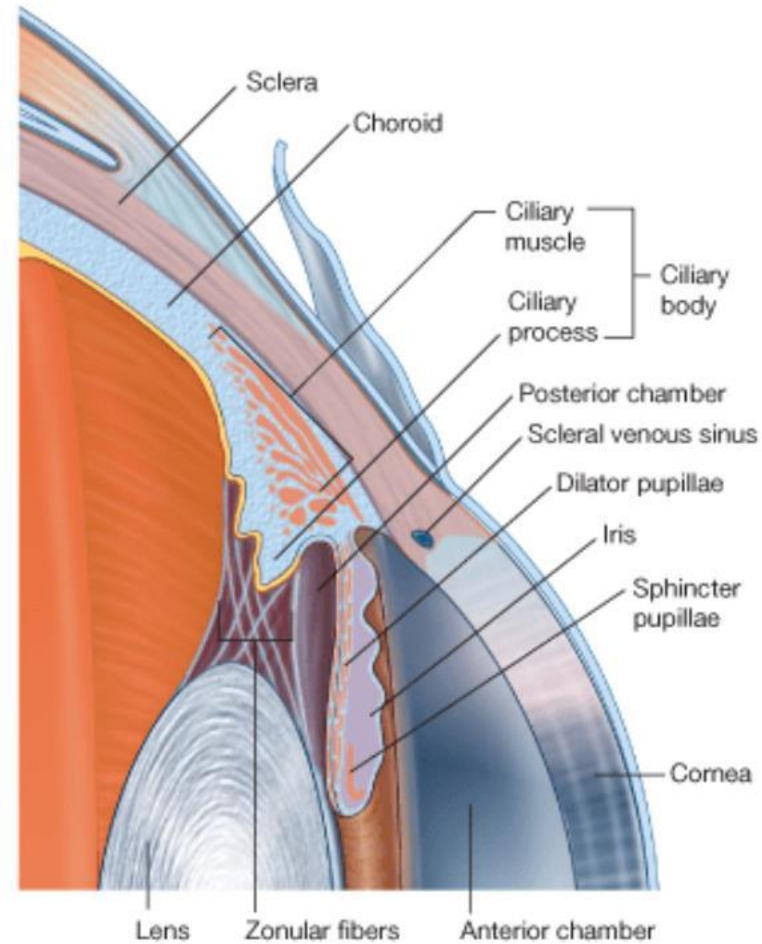
- Transmission of light waves through transparent media of the eyeball.
- Refraction (bending) of light waves through different refractive media of different densities.
- Accommodation of the lens to focus the light waves.
- Regulation of amount of light entering the eye through pupil by iris diaphragm.
- Convergence of eyeballs

Refractive media of the eye

- Cornea (very refractive but not adjustable).
- Aqueous humour.
- Lens (refractive and adjustable).
- Vitreous humour/vitreous body.

Refractive media of the eye

- Cornea
- Aqueous humor
 - Clear fluid that fills the anterior and posterior chambers of the eye ball
 - Anterior chamber – between the cornea and iris
 - Posterior chamber – between the iris and lens
 - Freely communicate with each other through pupil
 - Supplies nutrients to the lens and cornea

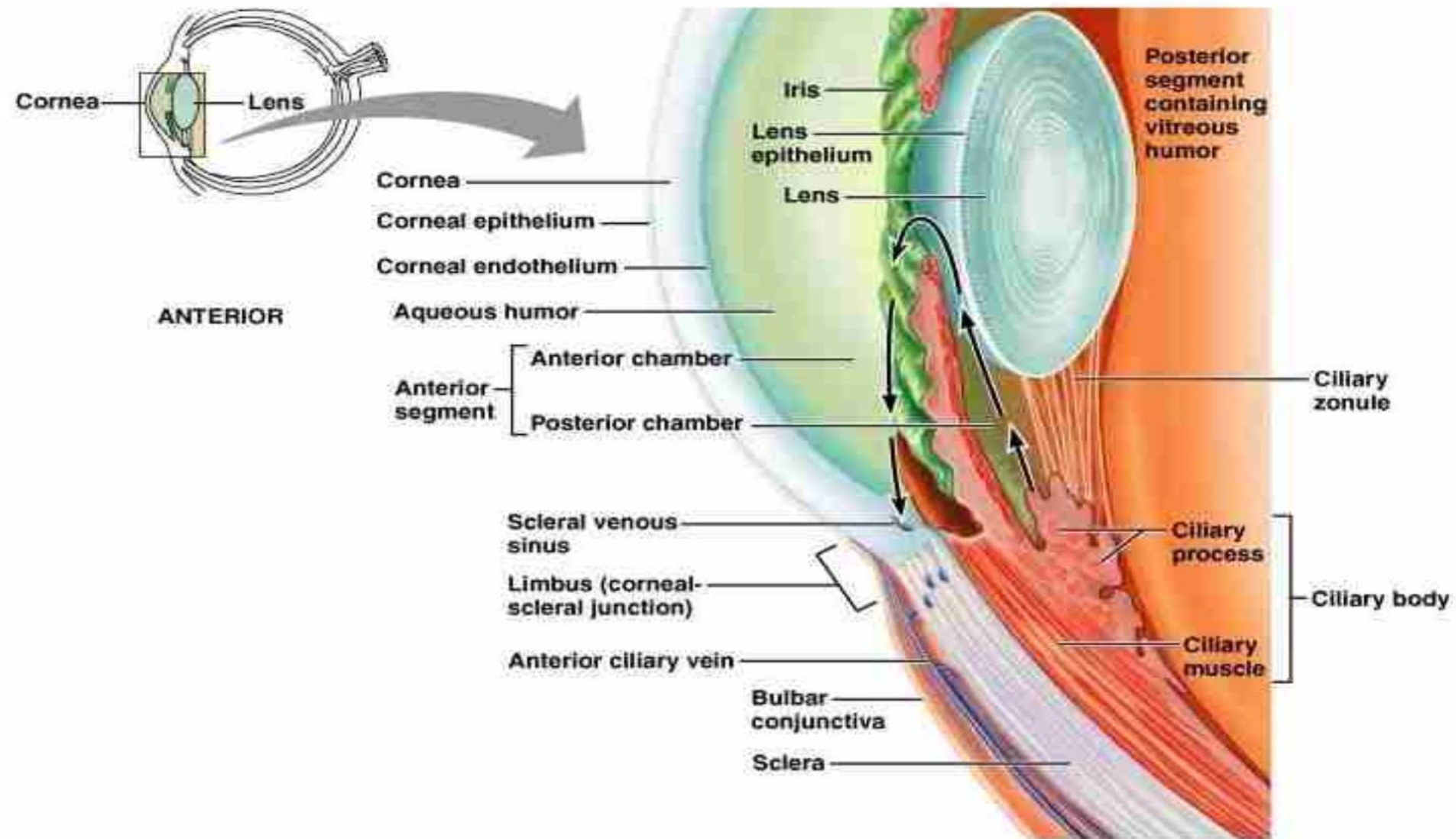


Vitreous body

- Clear, transparent jelly-like substance that fills the eyeball behind the lens (99% water, with some salts and meshwork of collagenous fibers, mucopolysaccharide, hyaluronic acid)
- Functions:
 - Supports the posterior surface of the lens
 - Helps maintain intraocular pressure

Lens

- Unusual biological structure.
- Thick, transparent, biconvex disc
- Circular in outline and
- Held in place by its attachment with the ciliary process of the ciliary body with the help of suspensory ligament.
- **External Features:**
 - Anterior and posterior surfaces
 - Anterior and posterior poles
 - A circumference—the equator.

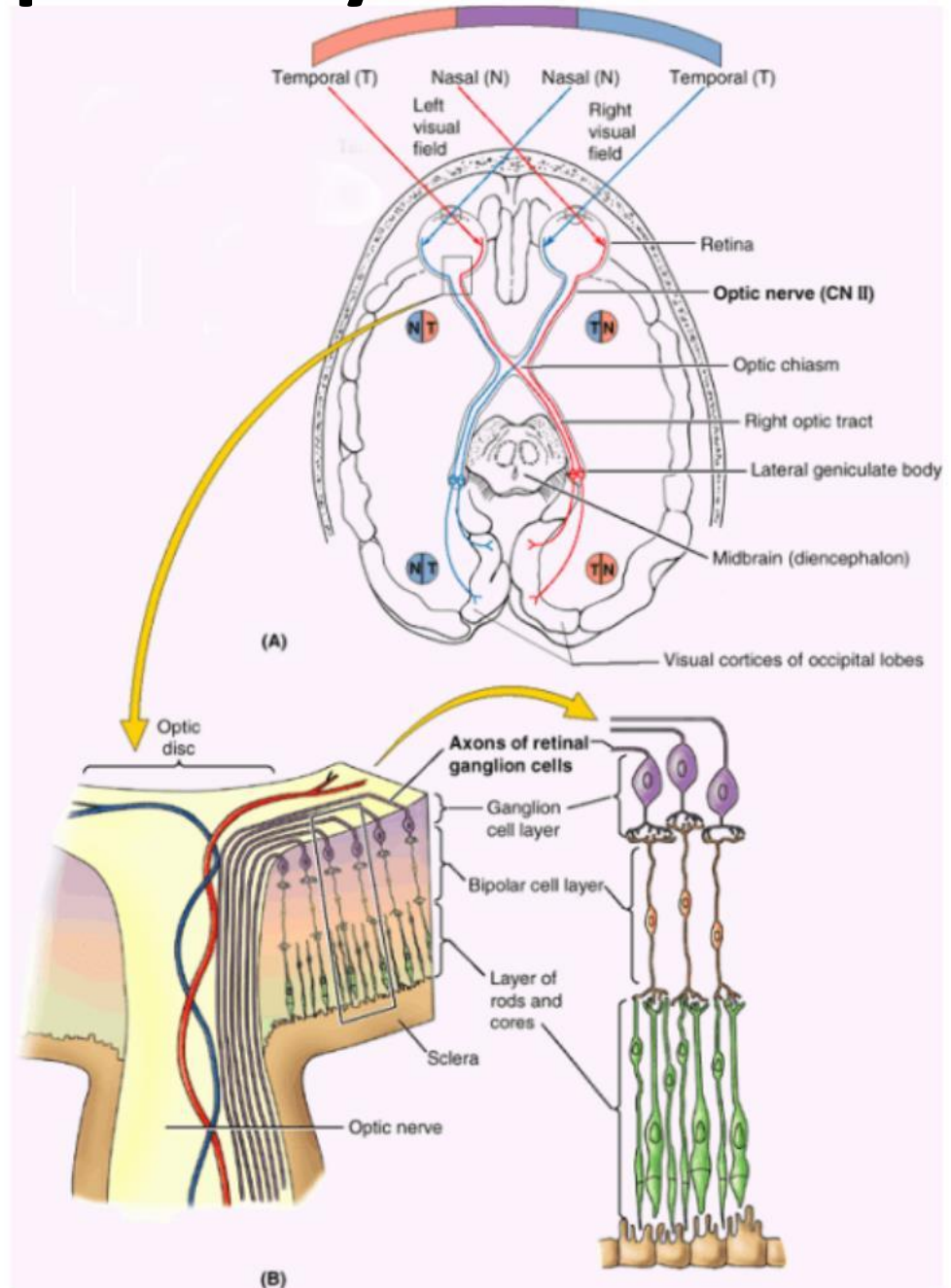


Applied anatomy

- **Glaucoma**
- **Presbyopia (short vision)**
- **cataract**

Visual pathway

- 3 sets of neurons convey the impulses from the rods and cones to the visual cortex (area 17)
 - **1st order neurons:** bipolar cells of retina
 - **2nd order neurons:** ganglionic cells
 - **3rd order neurons:** lateral geniculate body



Optic nerve

- 2nd cranial nerve having only special sensory component
- Formed by the axon of ganglionic cells
- Peculiarities of optic nerve
 - Not a peripheral nerve
 - Covered by the three meninges with sub-dural and sub-arachnoid spaces.
 - Myelination is derived from the oligodendrocytes
 - Devoid of neurolemma

Optic chiasma

- Situated in the floor and anterior wall of 3rd ventricle
- Anterolateral angle is continuous with the optic nerve while posterolateral angle is with optic tract
- In the chiasma
 - Fibers from the temporal (lateral) half of each retina does not cross.

Optic tract

- Winds around the cerebral peduncle
- Termination:
 - Most of the fibers terminate in the cells of lateral geniculate body
 - Few fibers pass to the pretectal nucleus and superior colliculus of midbrain through superior brachium and are concerned with light reflexes

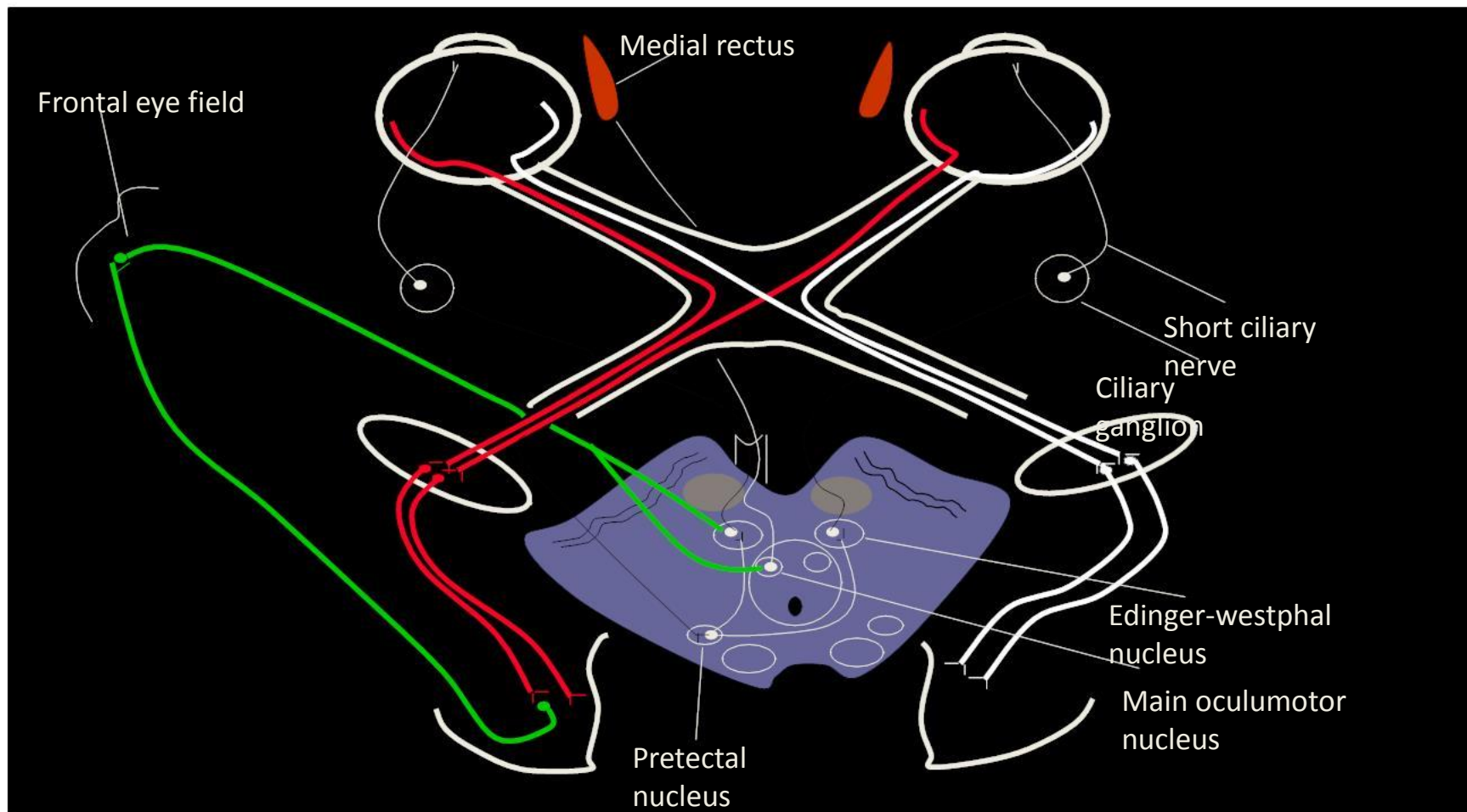
Optic radiation

- Are the axons of the nerve cells of lateral geniculate body
- The fibers passes posteriorly to reach primary visual cortex (area 17)
- Visual cortex occupies upper and lower lips and walls of calcarine sulcus.
- Visual association area cortex (area 18 and 19) is responsible for recognition of objects and perception of colour

Visual reflex

Pupillary light reflex:

- Constriction of pupil of same eye **direct light reflex**
- Constriction of opposite pupil **consensual light reflex**
- Mediated through optic nerve--optic chiasma--optic tract--pretectal nucleus of midbrain-- Edinger-Westphal nucleus--oculomotor nerve (preganglionic fibers)--ciliary ganglion--short ciliary nerve (postganglionic fibers)--constrictor pupillae
- Consensual light reflex is due to bi-lateral connection of pretectal nucleus with Edinger-Westphal nucleus

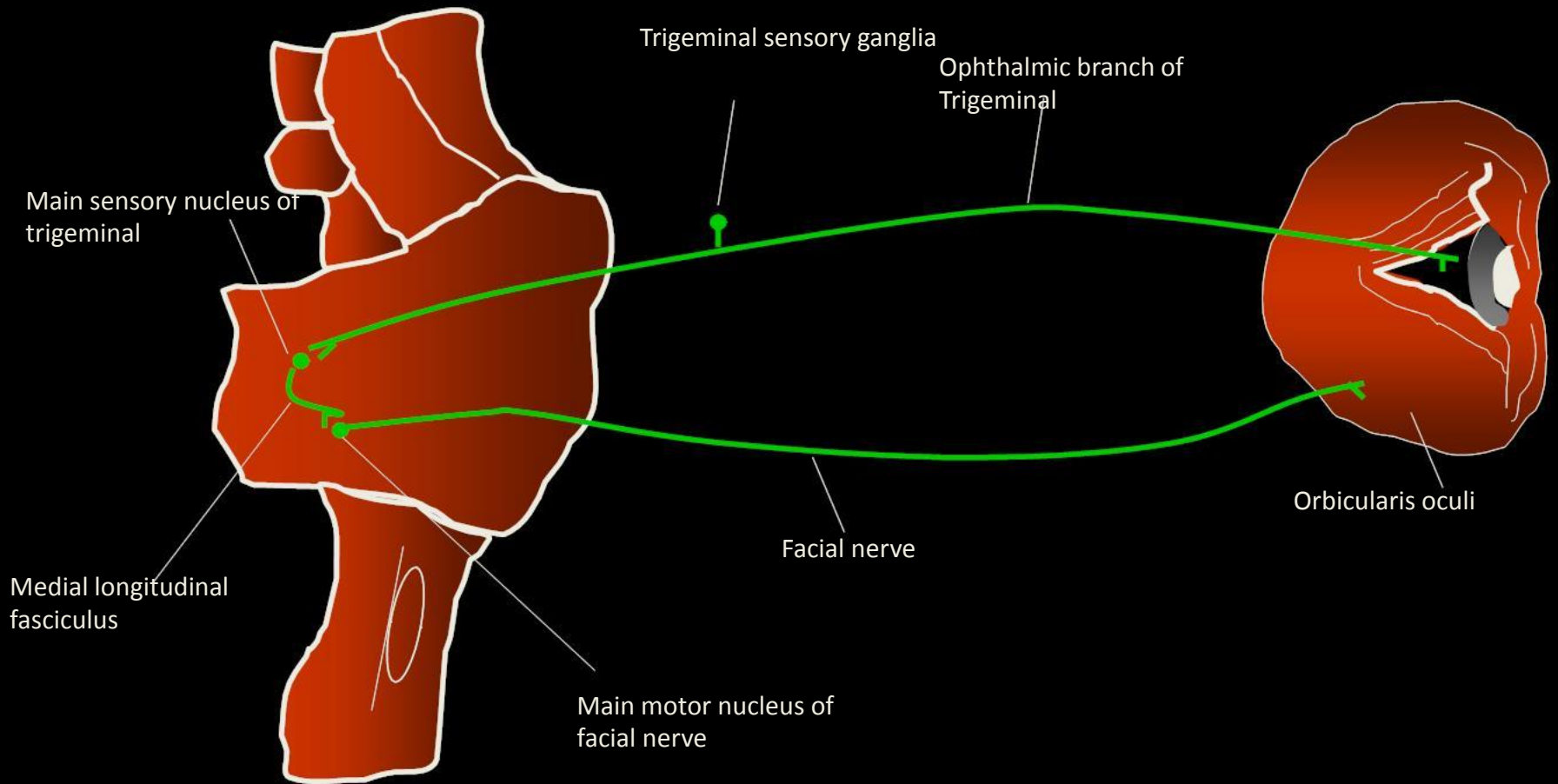


Accommodation reflex

- For near vision
 - Convergence of eye: by contraction of medial recti
 - Constriction of pupil: to reduce entry of more light
 - Thickening of lens: to change the refractive index
- Mediated through: optic nerve→optic chiasma→optic tract→lateral geniculate body→visual cortex (area 17, 18 and 19)→frontal eye field (area 8) through association fibers→oculomotor nuclear complex (both motor and Edinger-Westphal nuclei)
 - Activate medial recti
 - Activate ciliaris and sphincter pupillae muscles through ciliary ganglion
- In case of damage of pre-tectal nucleus, light reflex is absent but pupil constrict during accommodation as there is no connection with pretectal nucleus. This is called Argyll-Robertson pupil

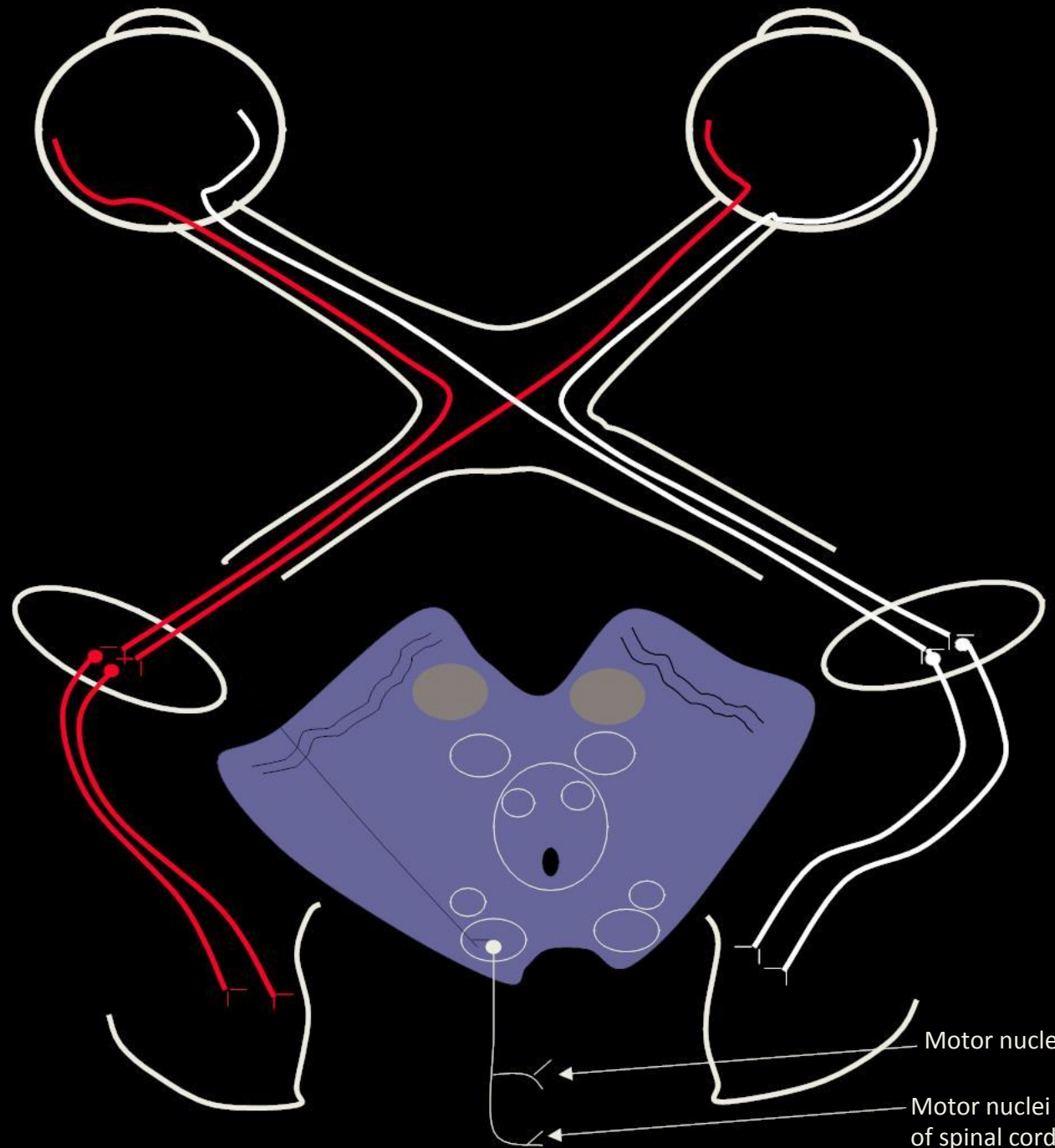
Corneal/conjunctival reflex

- Light touching of eye (corneal or conjunctiva) results blinking of eye
- Mediated through
 - afferent fibers from cornea and conjunctiva through ophthalmic division of trigeminal nerve
 - Principal sensory nucleus of trigeminal nerve
 - Main facial motor nucleus through medial longitudinal fasciculus
 - Orbicularis oculi muscle



Visual body reflex

- Automatic movement of head, neck and eye during reading, towards light stimulus, closing of eye and even raising of arm for protection
- Mediated through
 - Optic nerve, optic chiasma, optic tract
 - Superior colliculus through superior brachium
 - Cranial motor nuclei and neurons of anterior grey column of spinal cord through tectobulbar (tectonuclear) and tectospinal tract



Lesions of visual pathway

- May have many pathological causes like expanding tumors of brain and neighboring structures like pituitary gland and the meninges, cerebrovascular accidents
 - Complete blindness of one eye: due to complete section of one optic nerve
 - Hemianopia: loss of one half (either left or right) of visual field
 - Homonymous: when visual field of same side of both eye loss
 - Heteronymous: when visual field of opposite half loss

