وَقُل رَّبِّ زِدْنِي عِلْمًا

النادي الطبي

PERIPHERAL NERVOUS SYSTEM

SUBJECT : Anatomy

LEC NO. : 6

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#كلينيكال_إلا_شحطة

The Abducent nerve (VI) - Motor

- Arises from the brainstem between the pons and medulla.
- Runs through the cavernous sinus lateral to the internal carotid artery.
- Enters the orbit through the SOF within the common tendinous ring.
- In the orbit, it courses laterally to supply the lateral rectus muscle.

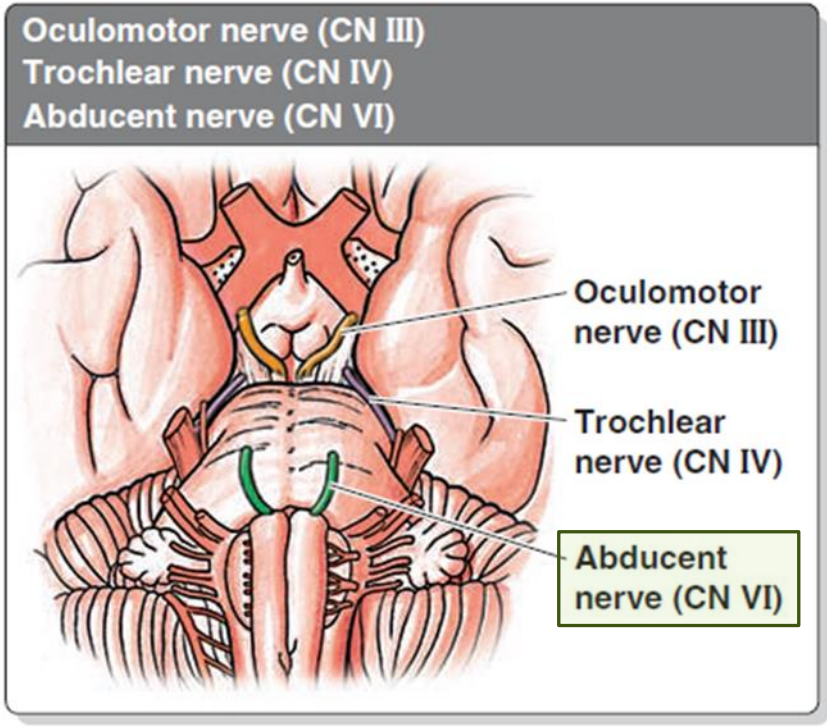


Fig.36: The brainstem. Origin of the abducent nerve.

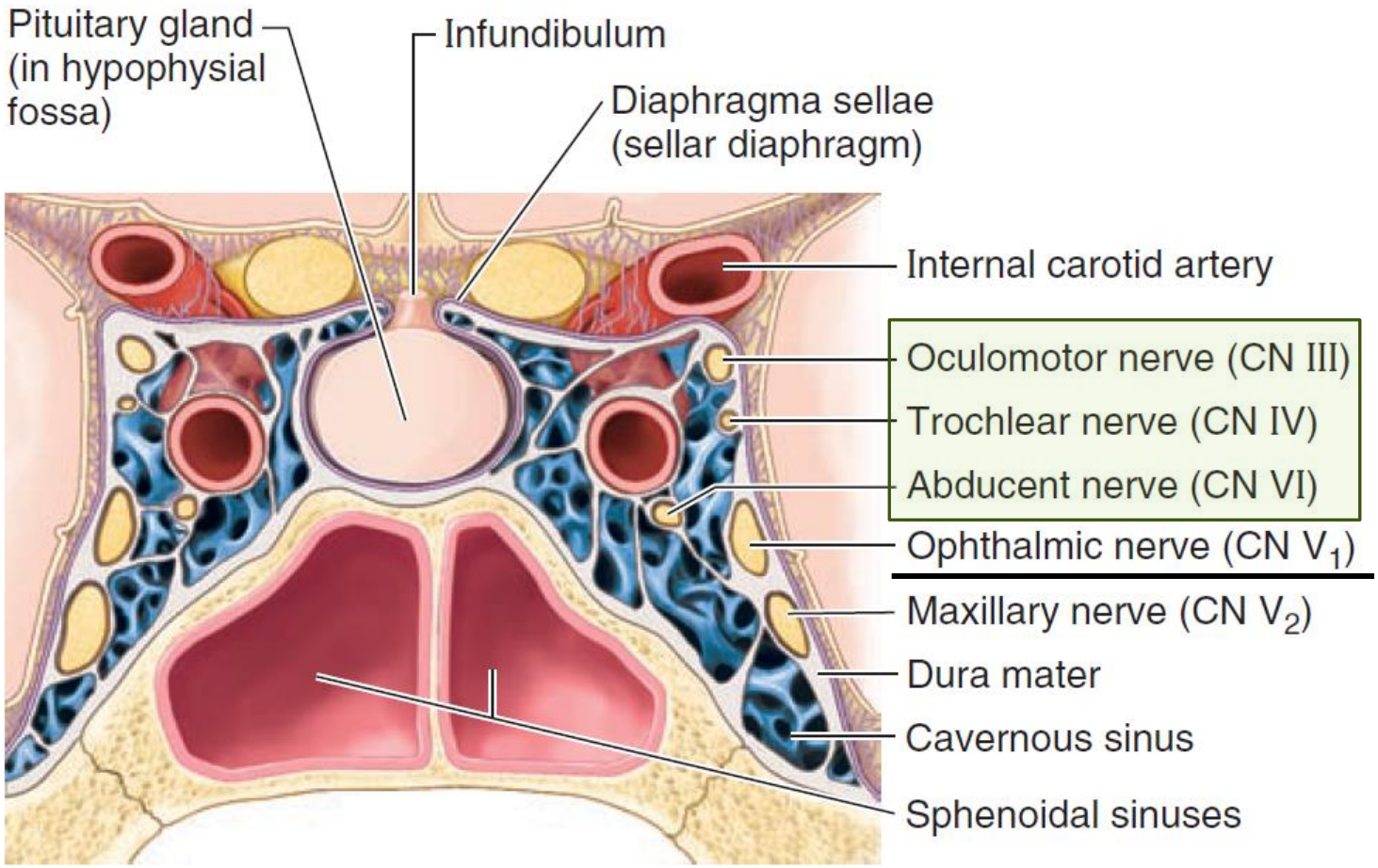


Fig.37: Posterior view of the cavernous sinus. Note the passage of the oculomotor and trochlear nerves in the lateral wall of the sinus. The abducent nerve passes through the middle of the sinus.

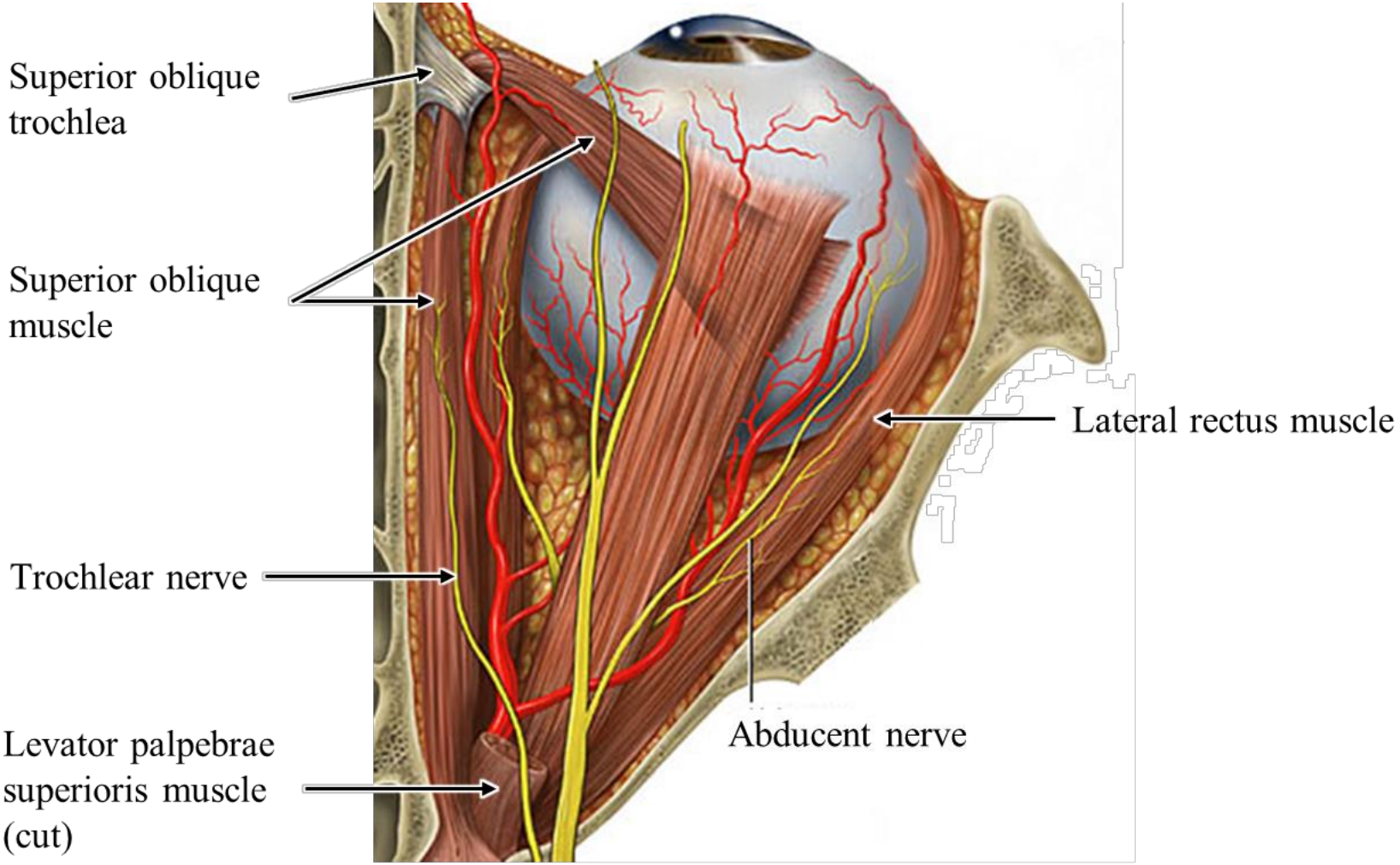


Fig.38: Superior view of the orbit showing the trochlear and abducent nerves. What is the relation of these nerves to the cone of the recti?

The Ophthalmic nerve (V_1) - Sensory

- The smallest division of the Trigeminal (V) nerve. A purely sensory nerve, It leaves the trigeminal ganglion to pass in the lateral wall of the cavernous sinus.
- Before it enters the orbit, it divides into three branches: the lacrimal, frontal, and nasociliary nerves. The nasociliary nerve enters the orbit through the SOF within the common tendinous ring. The other two pass outside the tendinous ring.

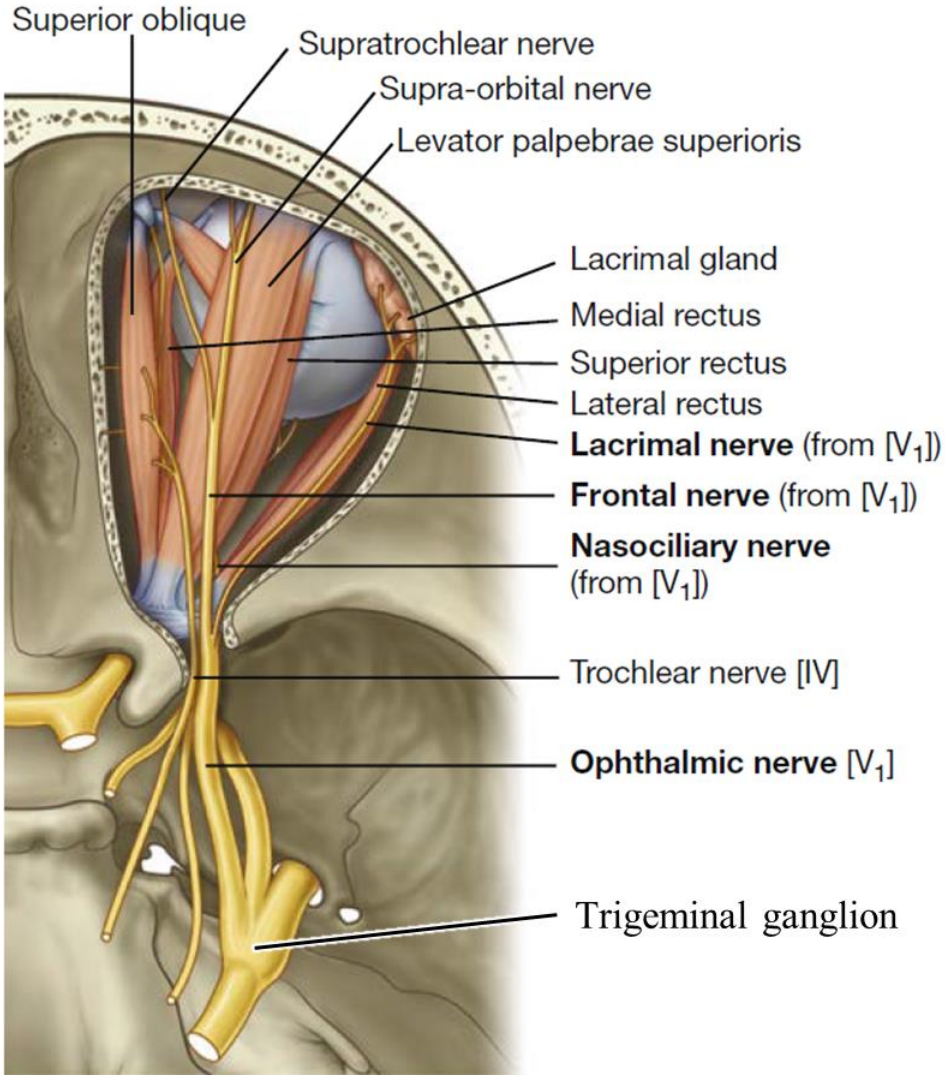


Fig.39: The ophthalmic nerve.

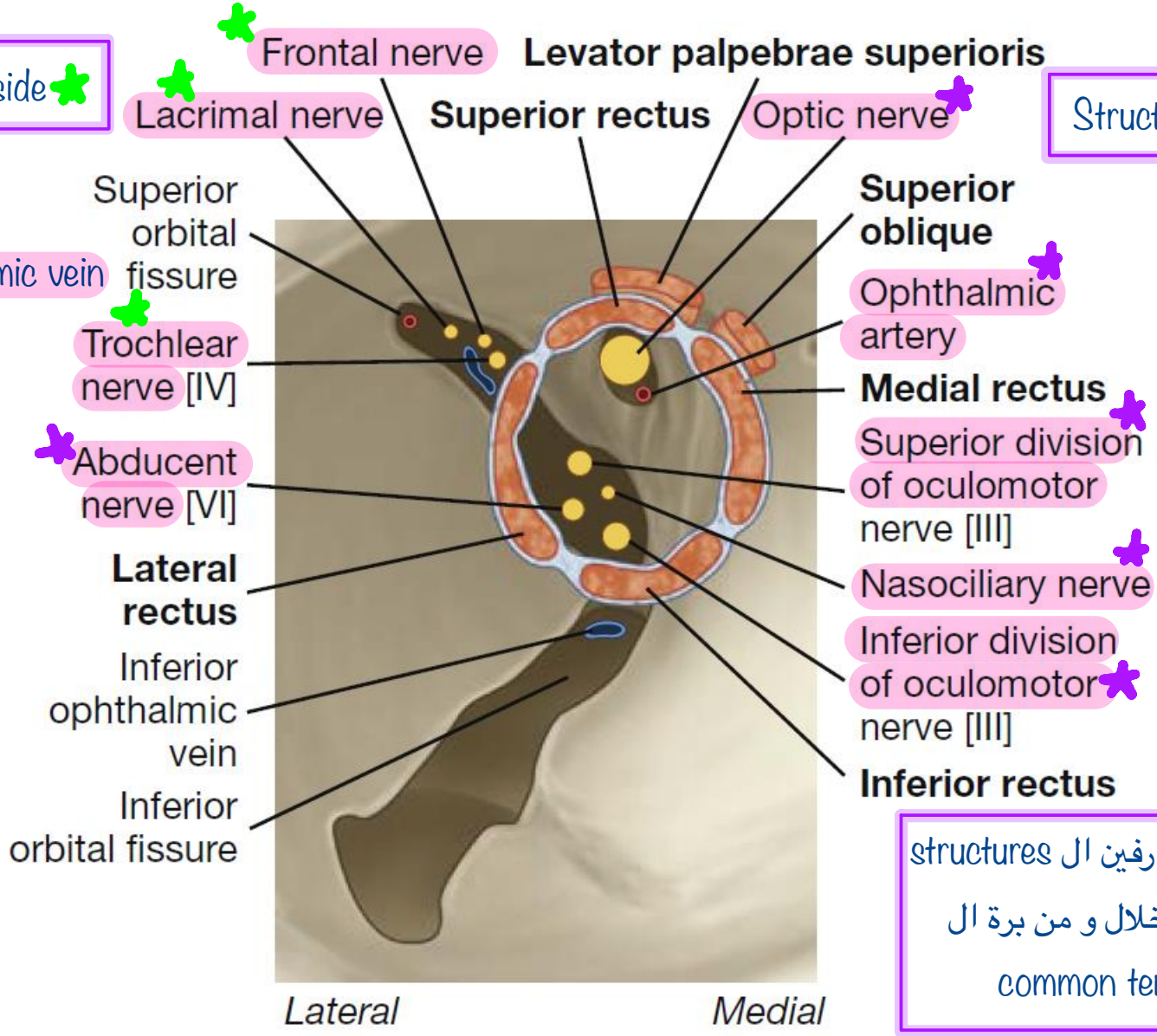


Fig.40: Structures passing through the SOF and their relation to the common tendinous ring.

Nerve	Notes	Supply
Lacrimal	• Passes over the upper border of the lateral rectus. • Receives communicating branch from the zygomaticotemporal nerve.	• Lacrimal gland • Upper eyelid • Conjunctiva

Frontal	• Largest branch.
	• Passes superior to the LPS.
	• Midway in the orbit, divides into terminal branches:
	  ○ Supraorbital nerve
	  ○ Supratrochlear nerve
		• Upper eyelid
		• Conjunctiva
		• Skin of forehead

LPS » elevator palpebrae superioris, 2 nerves that run superior to the elevator »trochlear and supraorbital

Nerve	Notes	Supply
Nasociliary	• Crosses medially superior to the optic nerve (with?) → With the ophthalmic artery • Runs along the medial wall of the orbit. • Gives off: 1. Communicating branch to ciliary ganglion 2. Long ciliary nerves (pierce sclera) → They carry general sensations from the eyeball 3. Posterior ethmoidal nerves 4. Anterior ethmoidal nerves 5. Infratrochlear nerve → Supplies	• Sensory root • Sensations from orbit • Eyelids • Lacrimal sac • Skin over nose

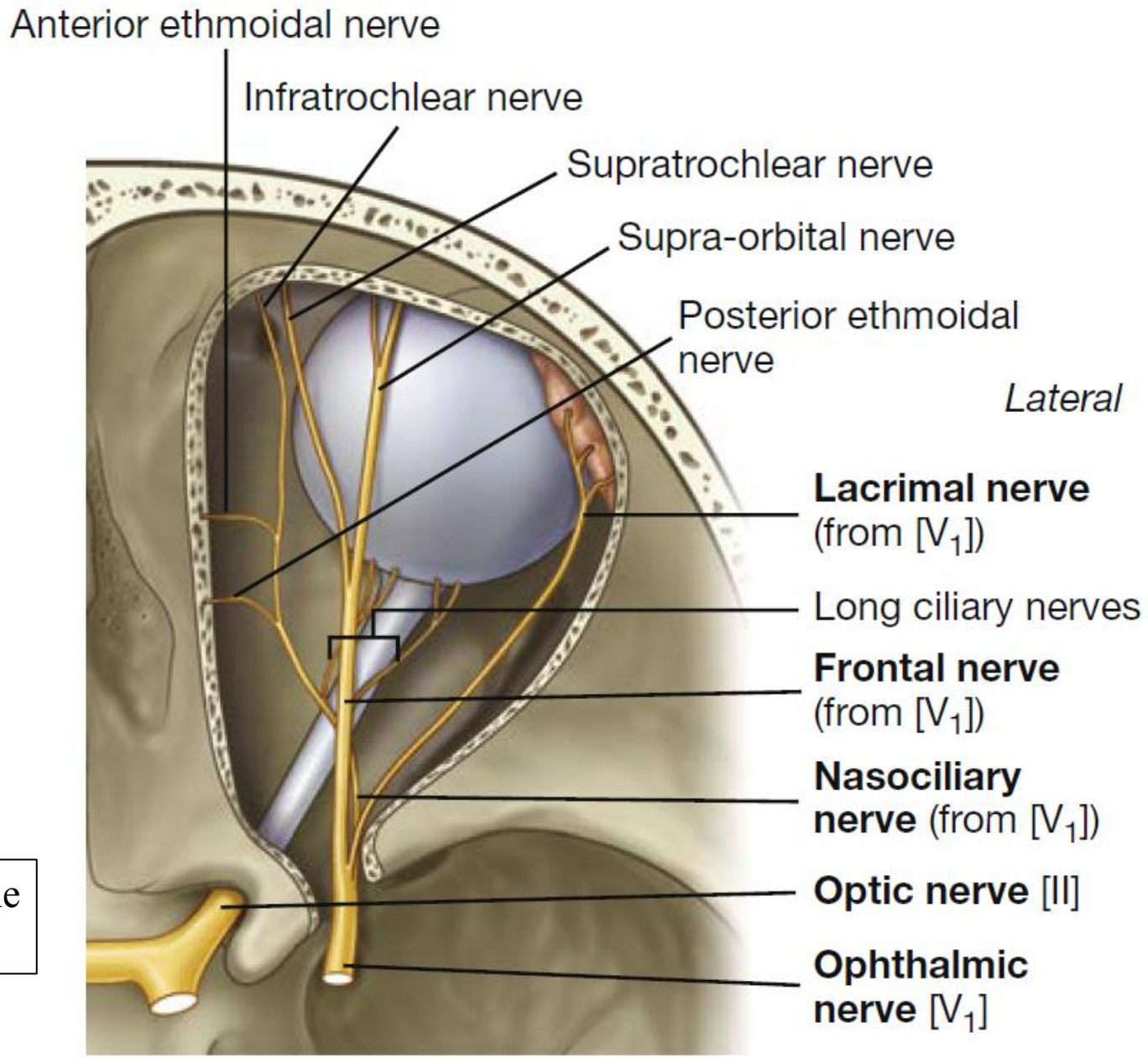


Fig.41: Branches of the ophthalmic nerve.

The Ciliary ganglion

- A small parasympathetic ganglion in the posterior part of the orbit.
- Located lateral to the optic nerve, between it and the lateral rectus muscle.
- It gives off the short ciliary nerves and has three roots:

1) Parasympathetic root:

- Preganglionic parasympathetic fibers pass through the inferior division of the oculomotor nerve, the branch to the inferior oblique, and then enter the ciliary ganglion through the parasympathetic root.
- Thes fibers synapse with postganglionic parasympathetic neurons in the ganglion.
- Postganglionic fibers leave the ganglion through the short ciliary nerves which enter the orbit around the optic nerve.
- They supply the *sphincter pupillae* and *ciliary* muscles.

2) Sensory root:

- A branch of the nasociliary nerve that carries sensory fibers.
- The fibers pass through the ciliary ganglion (without synapsing) to reach the orbit through the short ciliary nerves.

3) Sympathetic root

- Postganglionic sympathetic fibers from the superior cervical ganglion pass through the plexus around the internal carotid artery.
- Enter the orbit around the ophthalmic artery.
- Form the sympathetic root of the ciliary ganglion. They pass through the ganglion (without synapsing) to reach the orbit through the short ciliary nerves.
- They supply the *dilator pupillae* muscle.
- Sympathetic fibers may pass through the long ciliary nerves.

Another pathway for them

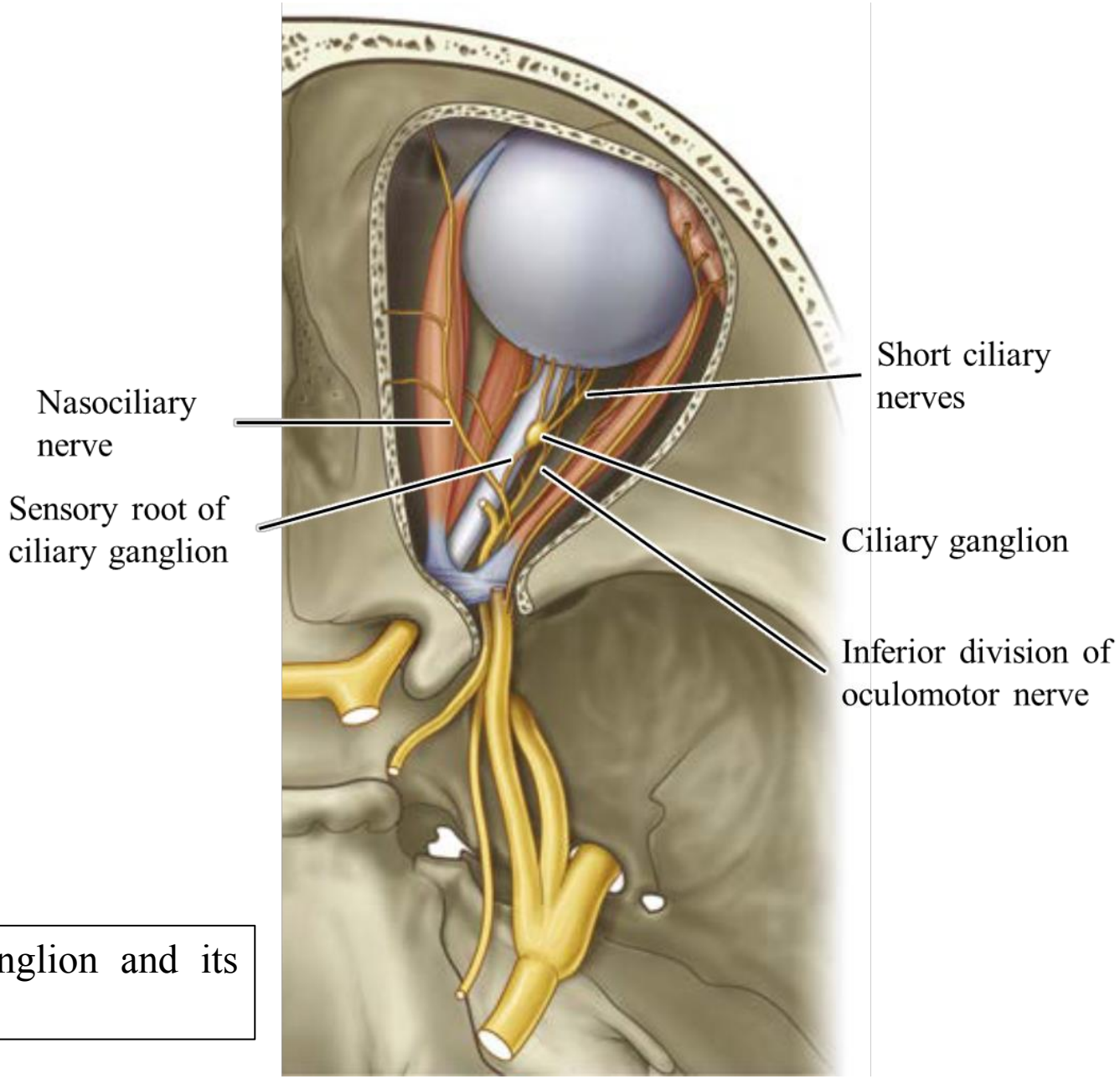


Fig.42: The ciliary ganglion and its connections.

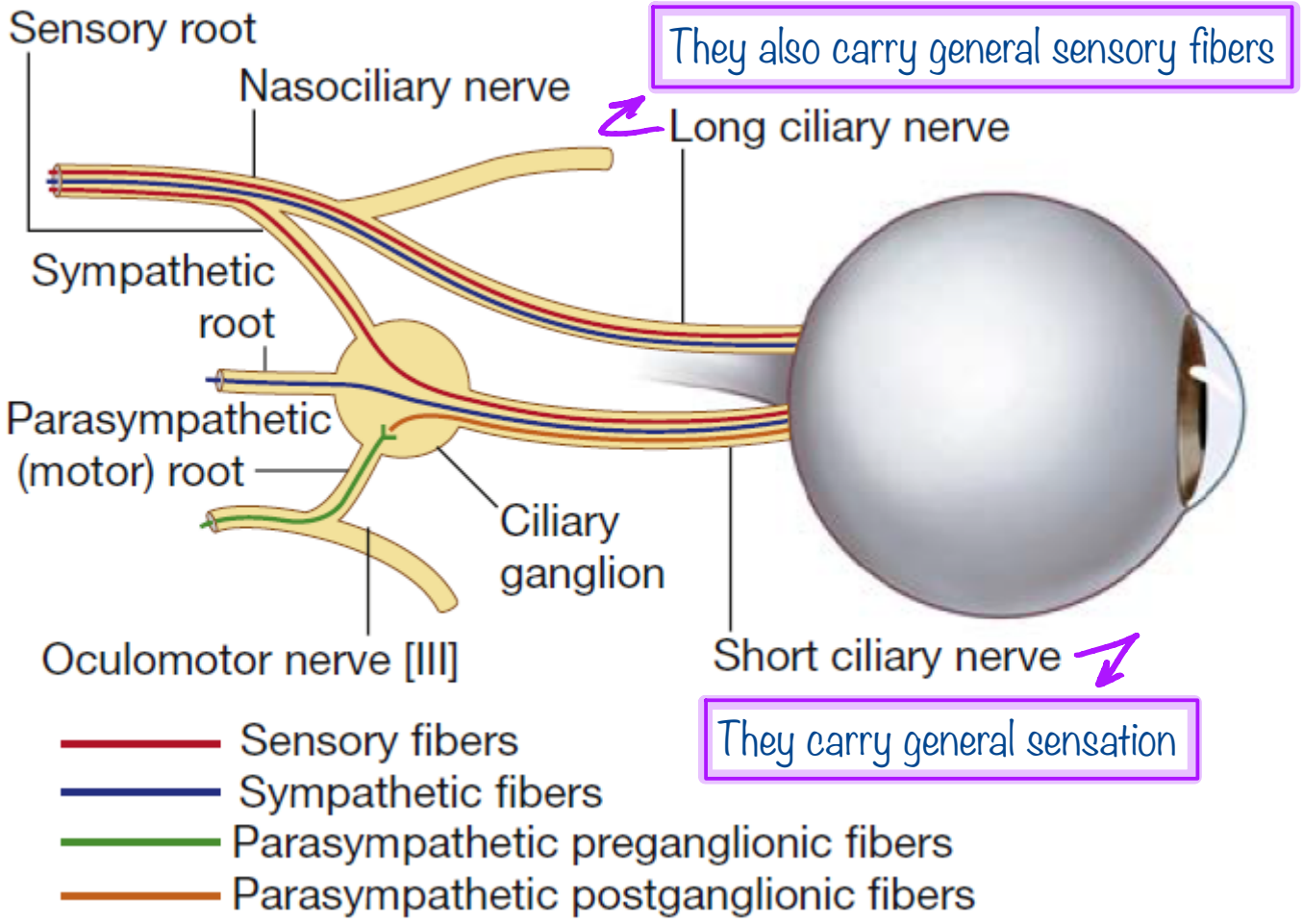


Fig.43: Fibers passing though the ciliary ganglion.

The eyeball

- The eyeball is a globe-shaped structure within the orbit that's responsible for the sensation of vision.
- The wall of the eyeball is formed of three layers:
  1. Fibrous tunic → Sclera + Cornea
  2. Vascular tunic → Choroid + Ciliary body + Iris
  3. Retina → Neural layer + Pigmented layer

- Within the eyeball, we have:
  - Anterior chamber
  - The lens
  - Posterior chamber
  - Vitreous chamber

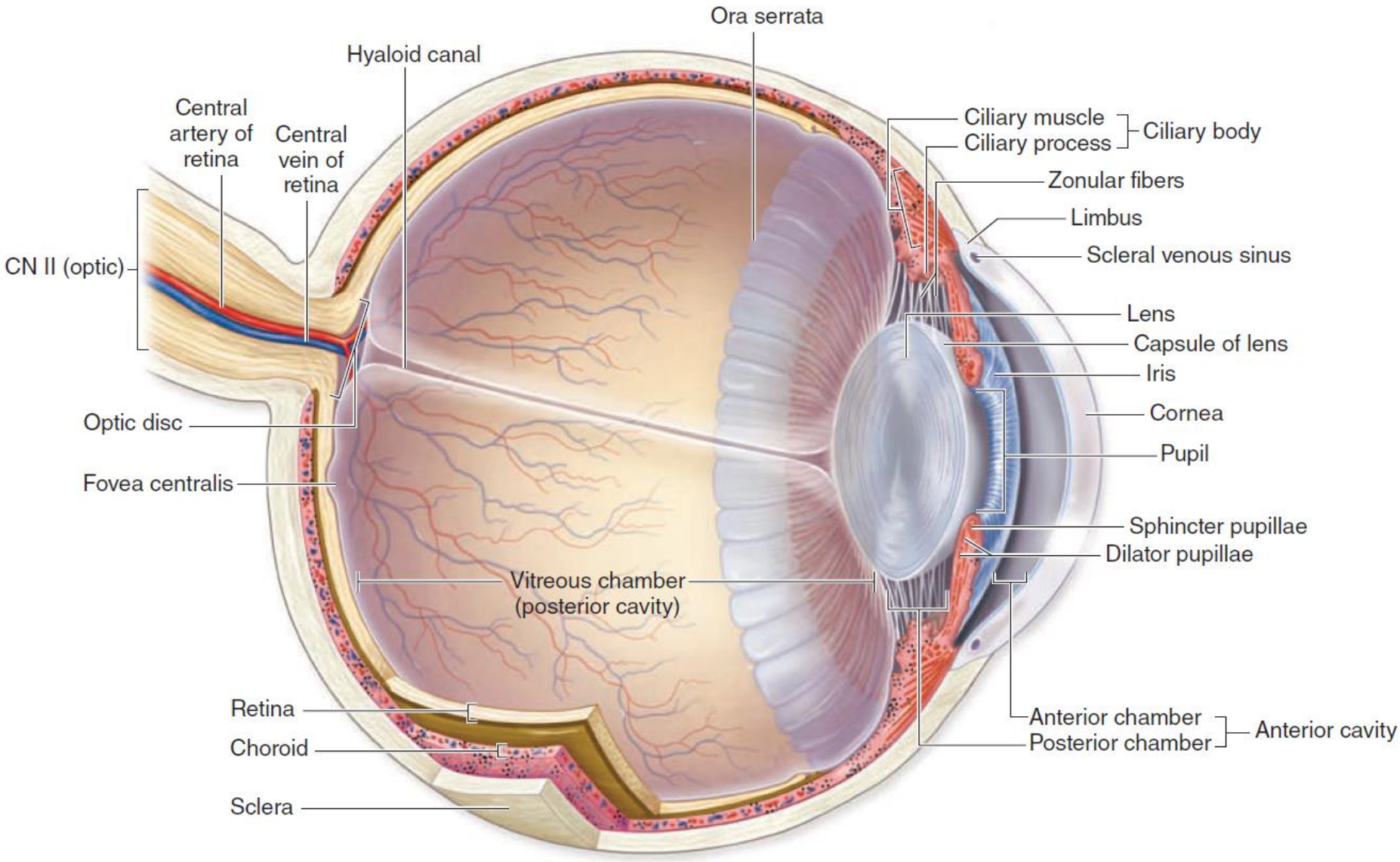


Fig.44: The eyeball.

1. The fibrous tunic

a. Sclera

- Commonly known as the '*white of the eye*', the sclera is an opaque layer of dense connective tissue that forms the posterior part of the fibrous tunic.

- Functions:
  - Support the eyeball
  - Sight of entry of vessels and nerves
  - Provides attachment for various muscles

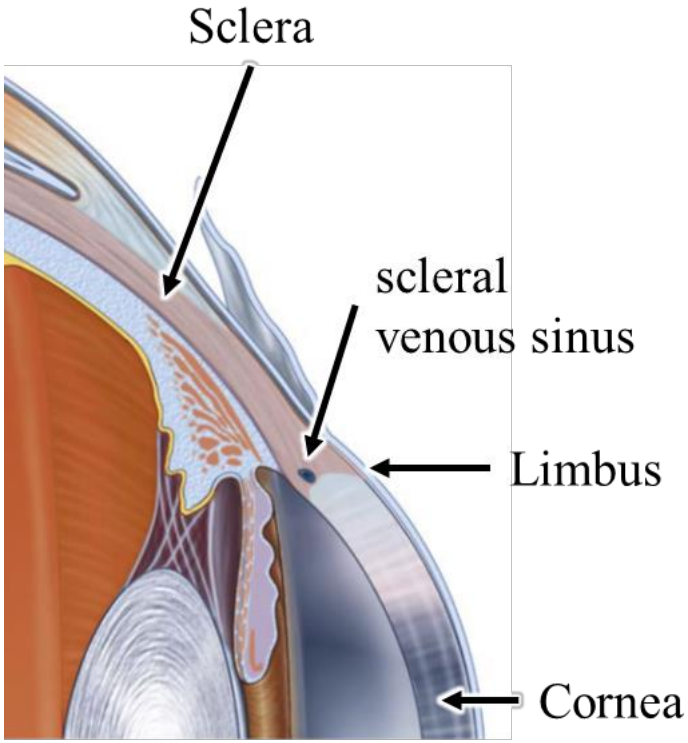


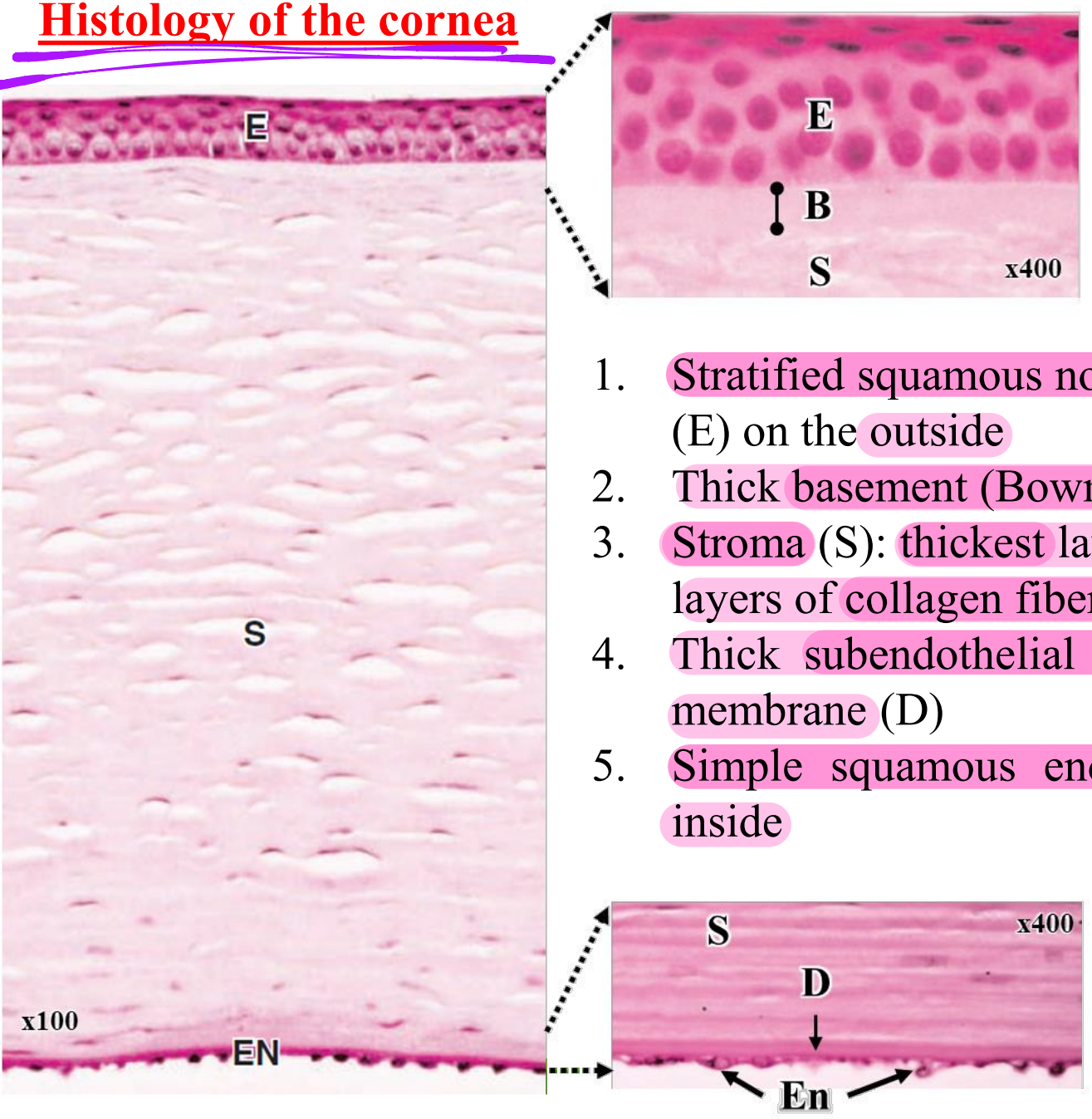
Fig.45: The fibrous tunic of the eyeball.

b. Cornea

- Continuous with the sclera anteriorly is the transparent cornea. The sclera and cornea meet at the ***corneoscleral junction*** or ***limbus***.
- At the corneoscleral junction, there is a circular venous channel called the ***scleral venous sinus*** (canal of Schlemm) through which the aqueous humor passes into the circulation.
- The cornea is avascular. It receives its nutrient from: (1) vessels at the limbus, (2) the tear film on its outer surface, and (3) aqueous humor on its inner surface.

- Functions:
  - Allows light to enter the eyeball
  - Responsible for the refraction of light

Histology of the cornea



1. Stratified squamous nonkeratinized epithelium (E) on the outside
2. Thick basement (Bowman's) membrane (B)
3. Stroma (S): thickest layer formed of numerous layers of collagen fibers and fibroblasts
4. Thick subendothelial basement (Descemet's) membrane (D)
5. Simple squamous endothelium (En) on the inside

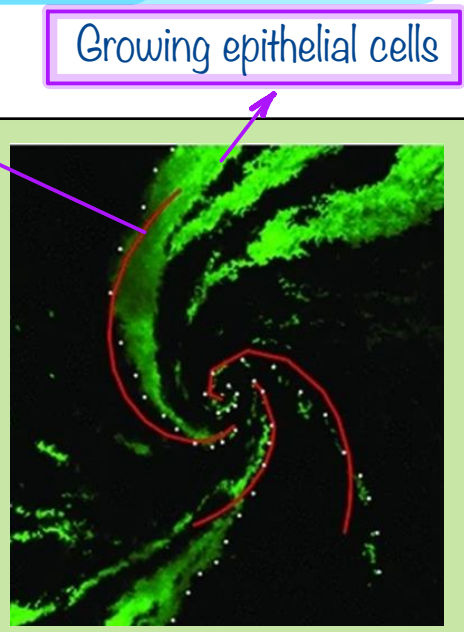
Fig.46: Histological layers of the cornea.

Notes:

- The squamous cells of the epithelium extends microvilli into the tear film to help it take nutrients. The epithelium is rich with sensory nerve endings.
- In the stroma, the collagen fibers in each layer are parallel to each other and at right angle to the adjacent layer. This arrangement makes the cornea transparent.
- The endothelium pumps Na (followed by water) into the anterior chamber. This keeps the stroma relatively dehydrated in order to maintain transparency

Interesting – Corneal epithelial vortex

- Epithelial cells are replaced by stem cells in the limbus. Research have indicated that the cells grow towards the center in a logarithmic spiral pattern that can be estimated.
- This can be used to understand certain corneal diseases and for tissue-engineering corneas.



2. The vascular tunic

a. Choroid

- The posterior two-thirds of the vascular layer.
- Thin, highly vascular, and pigmented (due to presence of melanocytes). The pigment absorbs scattered light.

b. Ciliary body

- A triangular-shaped structure between the choroid and the iris.
- Forms a complete ring around the eyeball.
- Its components include :
  - The ***ciliary muscle***: a smooth muscle controlled by parasympathetic fibers.
  - The ***ciliary processes***: longitudinal ridges projecting from the inner surface of the ciliary body. Extending from them are *zonular fibers (suspensory ligament of the lens)* attached to the lens and suspending it in its proper position.

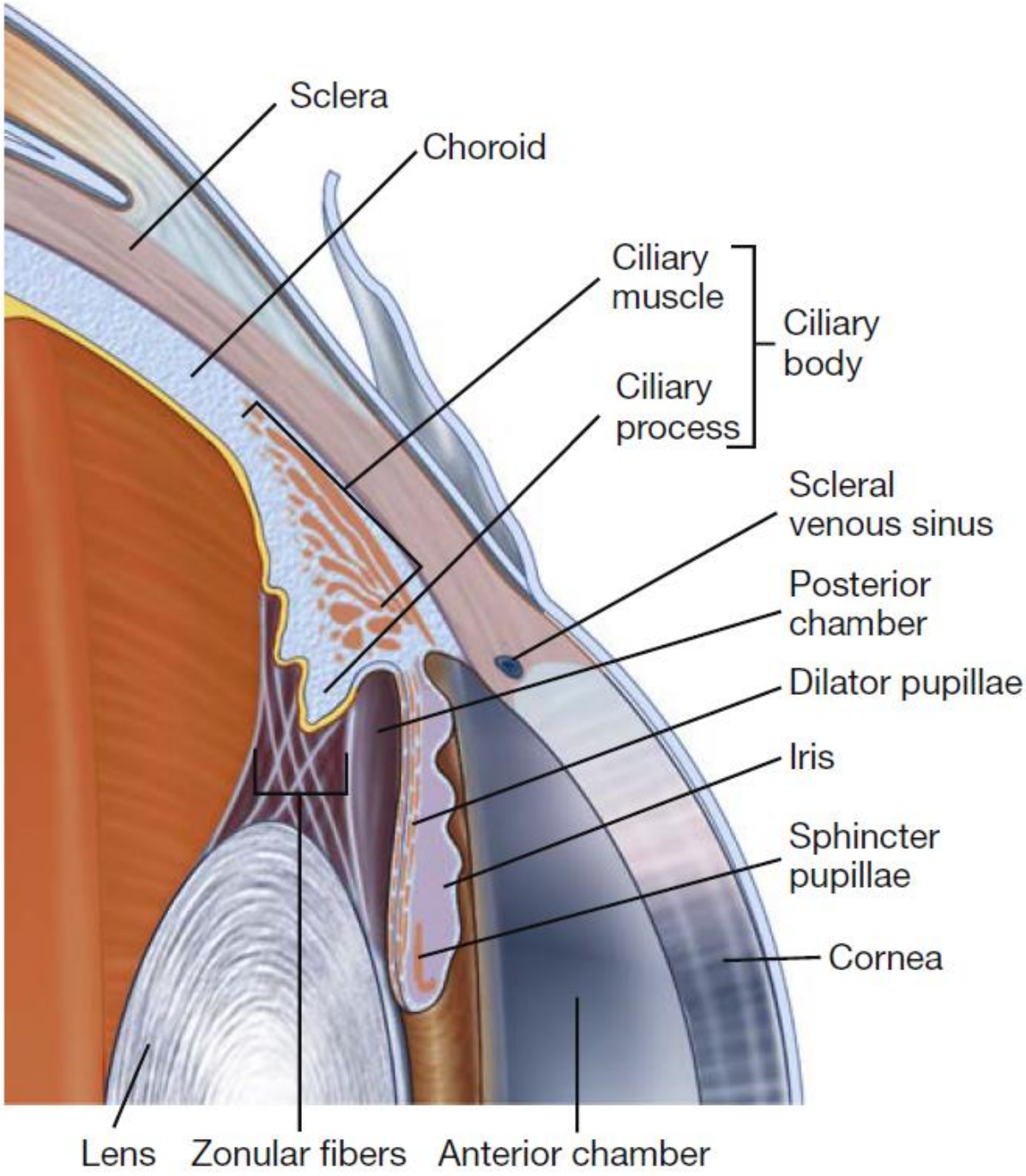


Fig.47: The vascular tunic of the eyeball.

If ciliary muscle was relaxed it will increase the diameter of the ring this will pull the zonula fibers increasing their tension which will make the lens more flattened » accommodation for far vision

- Functions:
  - Contraction of the ciliary muscle decreases the diameter of the ring formed by the ciliary body reducing the tension on the suspensory ligament of the lens. The lens therefore becomes more rounded (relaxed), resulting in accommodation of the lens for near vision.
  - Ciliary processes also contribute to the formation of aqueous humor.

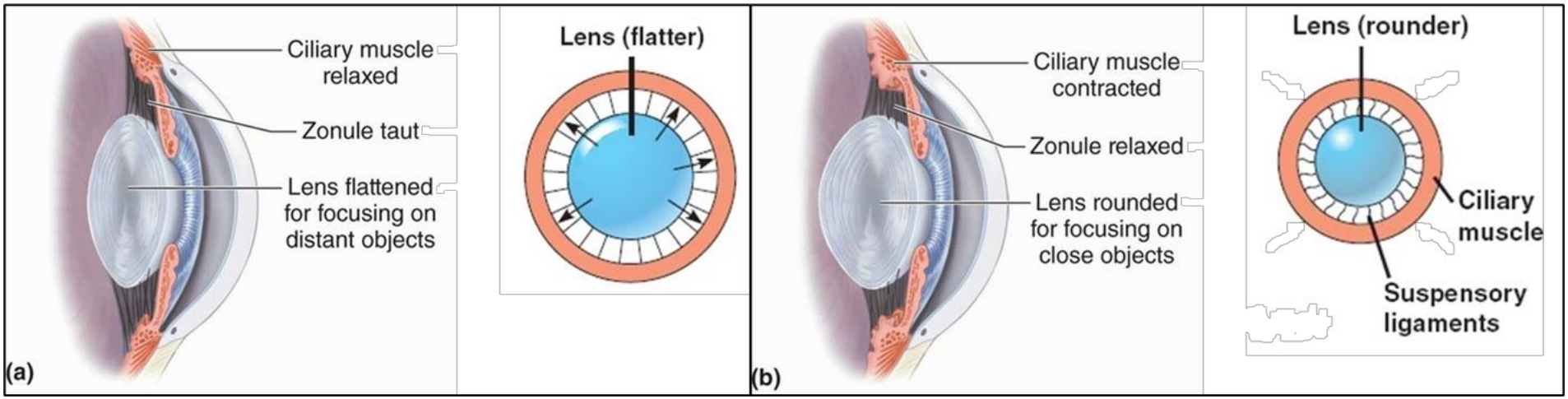


Fig.48: The action of ciliary muscle and its role in accommodation: (a) for distant object, and (b) for close objects.

b. The iris

- The colored anterior part of the vascular tunic.
- Projecting outward from the ciliary body, it is a circular structure with a central opening (the pupil).
- Controlling the diameter of the pupil are:
  - ***Sphincter pupillae*** muscle with fibers arranged in a circular pattern and supplied by parasympathetic fibers. Contraction of this muscle constricts the pupil.
  - ***Dilator pupillae*** muscle (formed of myoepithelial cells) with fibers arranged in a radial pattern and innervated by sympathetic fibers. Contraction of this muscle dilates the pupil.

Cells have the ability to contract and act like muscles

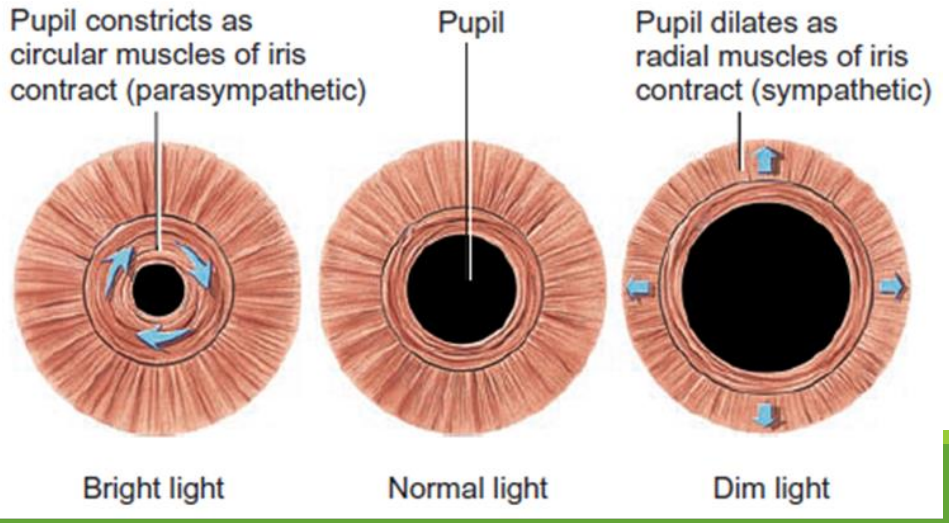


Fig.49: The action of muscle of the iris.

3. The inner tunic - Retina

The inner layer of the eyeball consists of two parts.

a. Optic/visual part:

- In the posterior ¾ of the eyeball. This part is sensitive to light.
- Formed of an outer pigmented layer attached to the choroid, and an inner neural layer.

b. Non-visual part:

- In the anterior ¼ of the eyeball. It lines the posterior surface of the ciliary body and iris. Formed of the pigment layer to the outside and non-pigmented epithelium on the inside.

- The two parts meet at a wavy line called the ***ora serrata***.

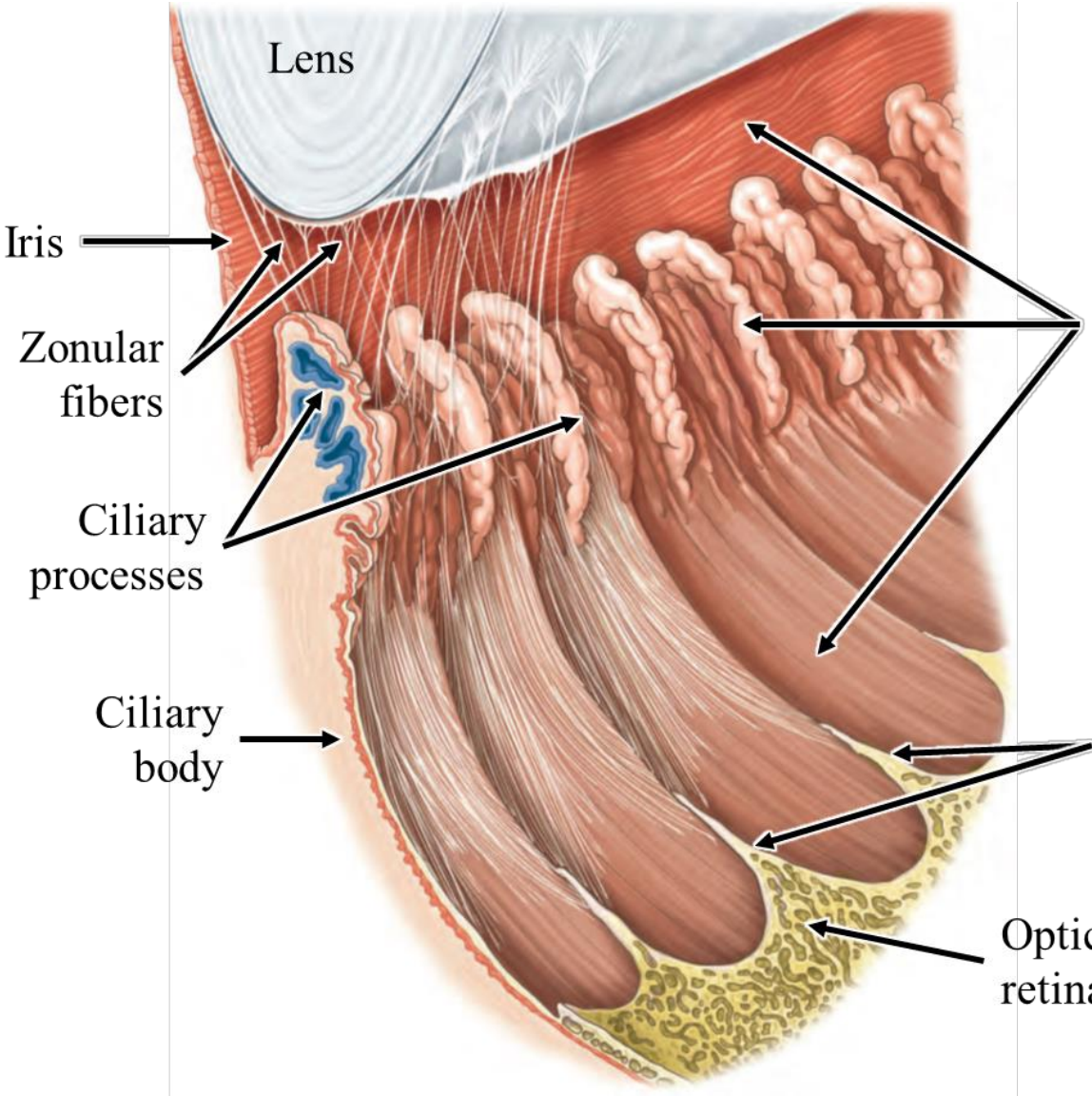


Fig.50: Above, posterior view of the iris, lens, and ciliary body. To the left, an enlarged view of part of the image above.

- The ***macula lutea*** is a yellowish small area lateral to the optic disc with a central depression called the ***fovea centralis***. This is the thinnest area of the retina. Visual sensitivity here is higher than elsewhere in the retina because it has cones only.

- The ***optic disc*** is where the optic nerve leaves the retina. It is lighter than the surrounding retina, and branches of the central retinal artery spread from this point outward to supply the retina. As there are no photoreceptor cells in the optic disc, it is referred to as a '*blind spot*' in the retina.

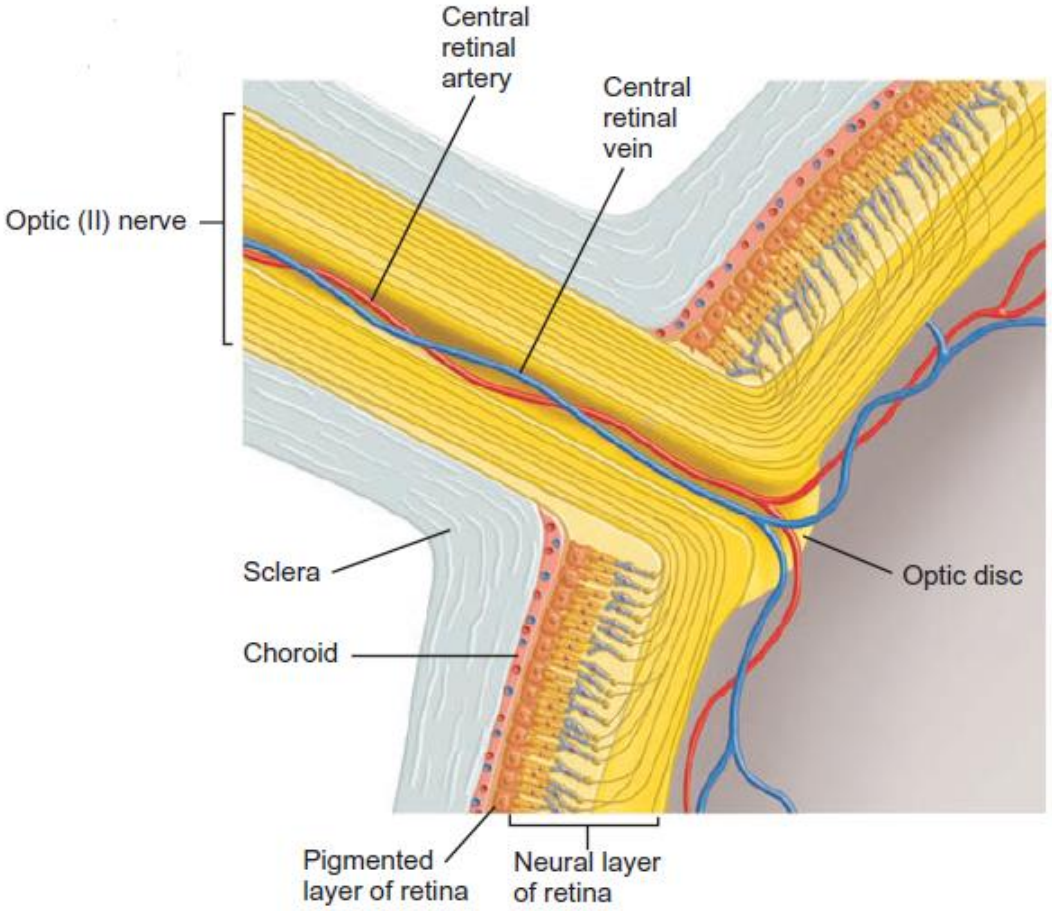


Fig.51: The optic disc.

Histology of the retina

Retinal pigment layer (epithelium)

- Cuboidal or low columnar cells.
- Well-developed junctional complexes and gap junctions.
- Apical processes surrounding the tips of the photoreceptors.
- Melanin granules numerous in the processes and apical cytoplasm.

Neural layer

With several types of neurons and glia cells. As seen under the microscope, it's divided into nine layers (from the outside-in):

1. ***Rods and cones layer (RCL):*** contain the outer and inner segments of rods and cones.
2. ***Outer limiting membrane (OLL):*** the apical boundary of Müller's glia cells that form adherent junctions with the rods and cones.
3. ***Outer nuclear layer (ONL):*** contains the cell bodies (nuclei) of rods and cones.

4. ***Outer plexiform layer (OPL):*** contains the processes of rods and cones and processes of the horizontal, amacrine, and bipolar cells that connect to them.
5. ***Inner nuclear layer (INL):*** contains the cell bodies (nuclei) of horizontal, amacrine, bipolar, and Müller's cells.
6. ***Inner plexiform layer (IPL):*** contains the processes of horizontal, amacrine, bipolar, and ganglion cells that connect to each other.
7. ***Ganglion cell layer (GL):*** contains the cell bodies (nuclei) of ganglion cells.
8. ***Nerve fibers layer (NFL):*** contains processes of ganglion cells that lead from the retina to the brain as the optic nerve.
9. ***Inner limiting membrane (ILL):*** composed of the basal processes of Müller's cells that form the inner boundary of the retina separating it from the vitreous body.

- Some ganglion cells of the retina act as *non-visual photoreceptors* that are connected to the pineal gland. Their light-detection ability, thus, assist in controlling the circadian rhythm of the body.

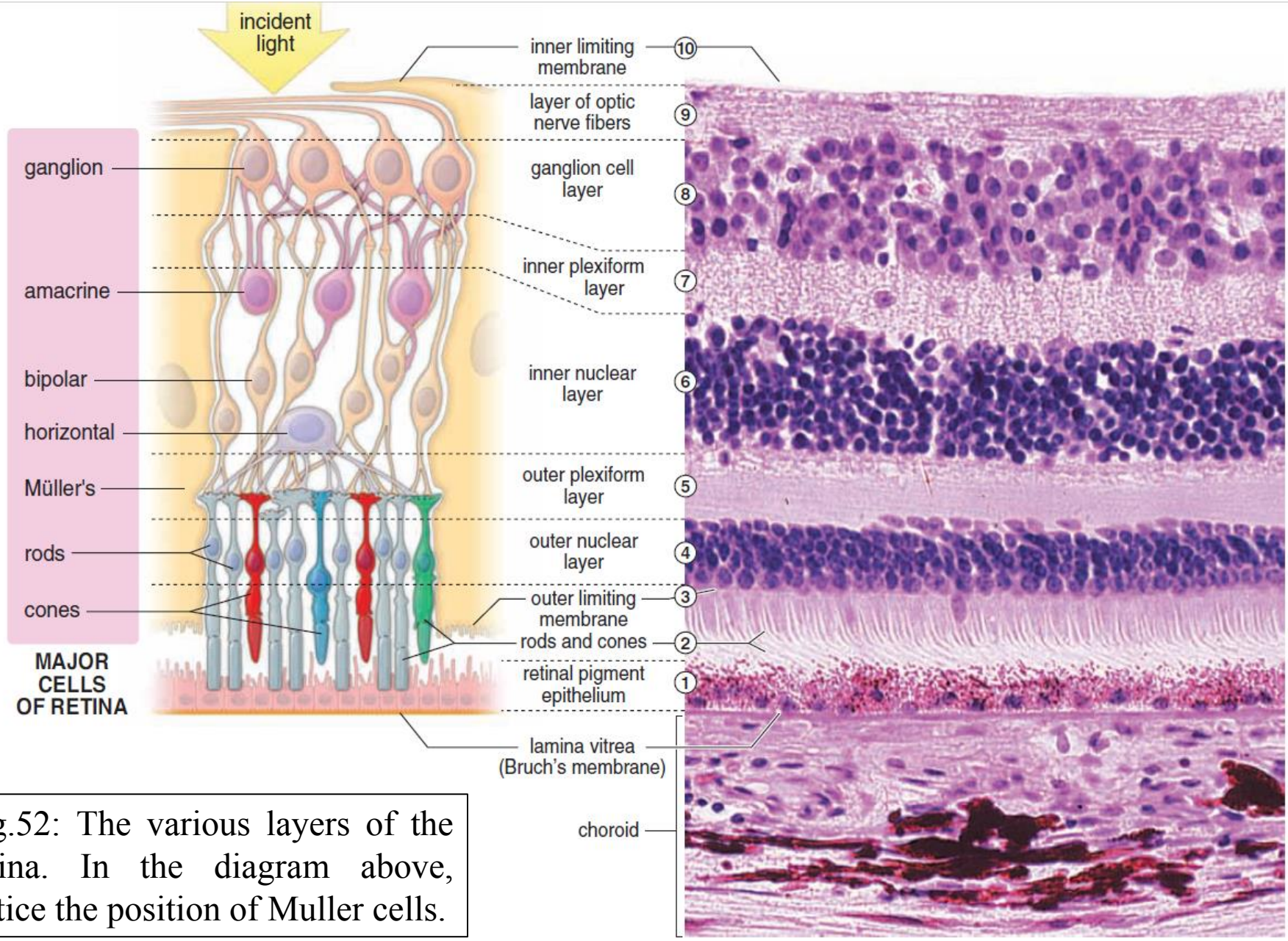
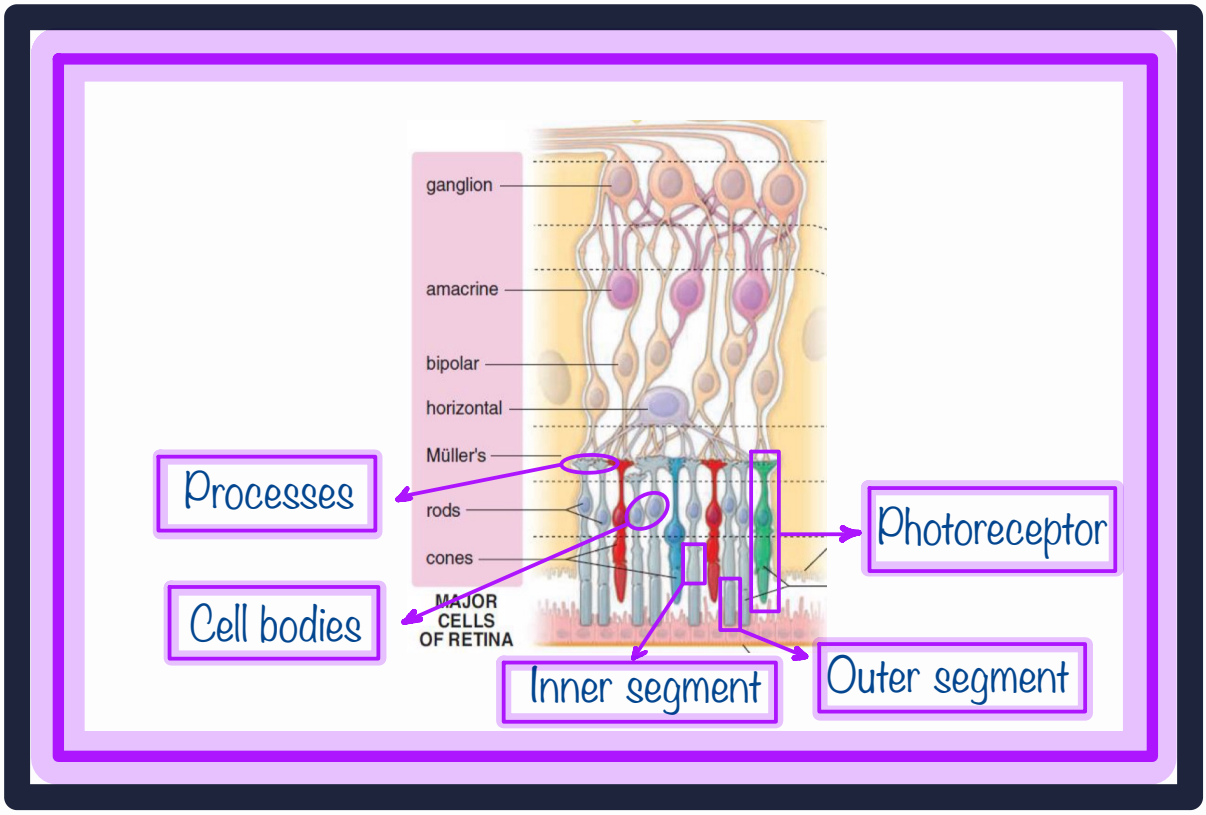
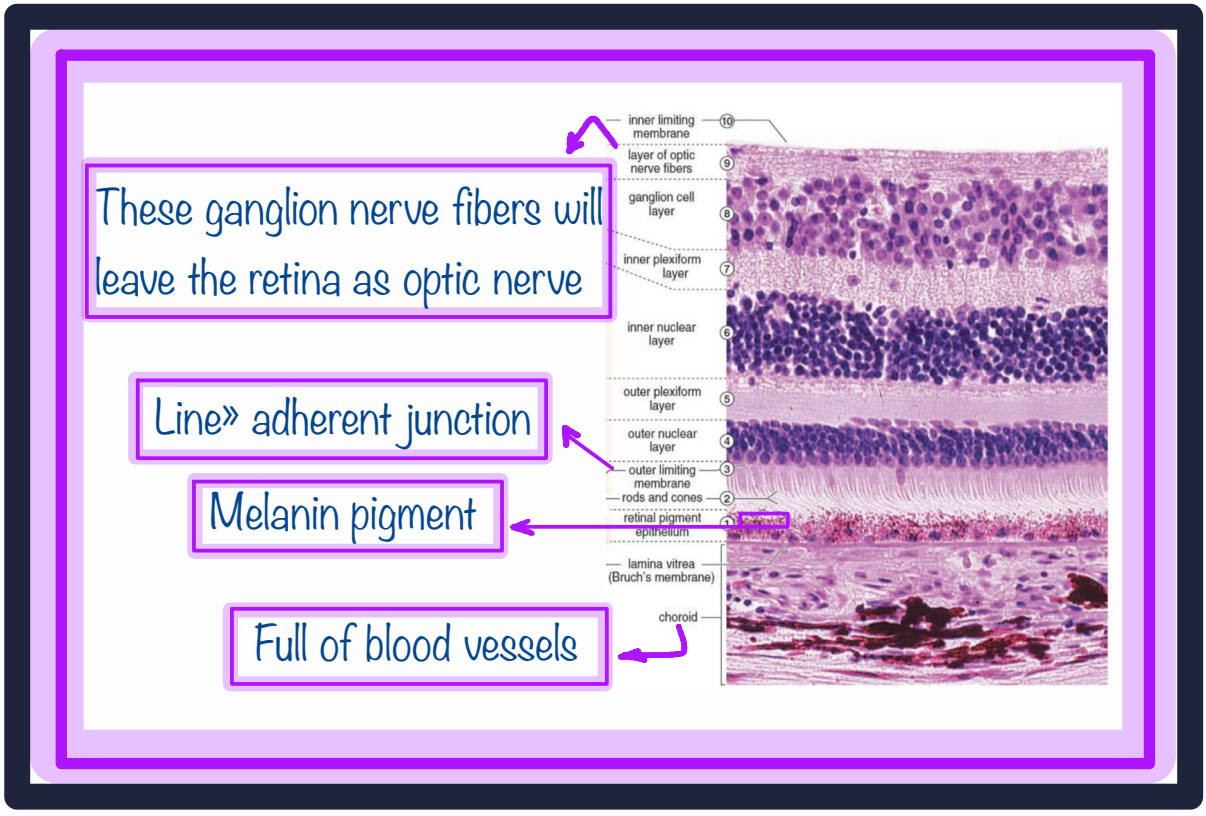


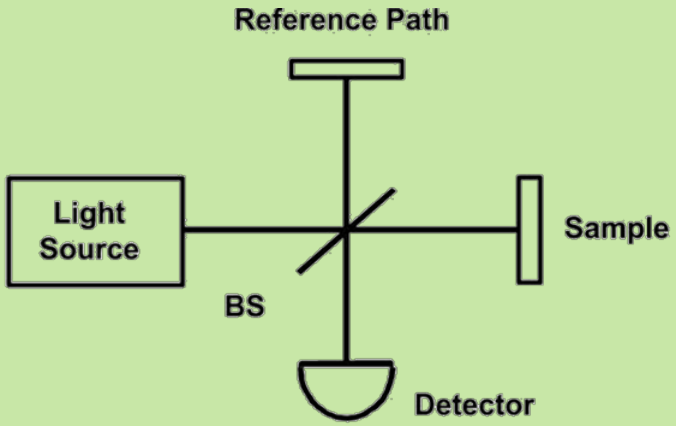
Fig.52: The various layers of the retina. In the diagram above, notice the position of Muller cells.





Optical Coherence Tomography (OCT)

- OCT is a non-invasive imaging techniques that renders an in-vivo cross-sectional view of layered structures like the retina.
- Light from a source is directed onto a beam splitter and one of the beams is incident onto the sample to be imaged, while the second beam travels a reference path with a variable path length and time delay.

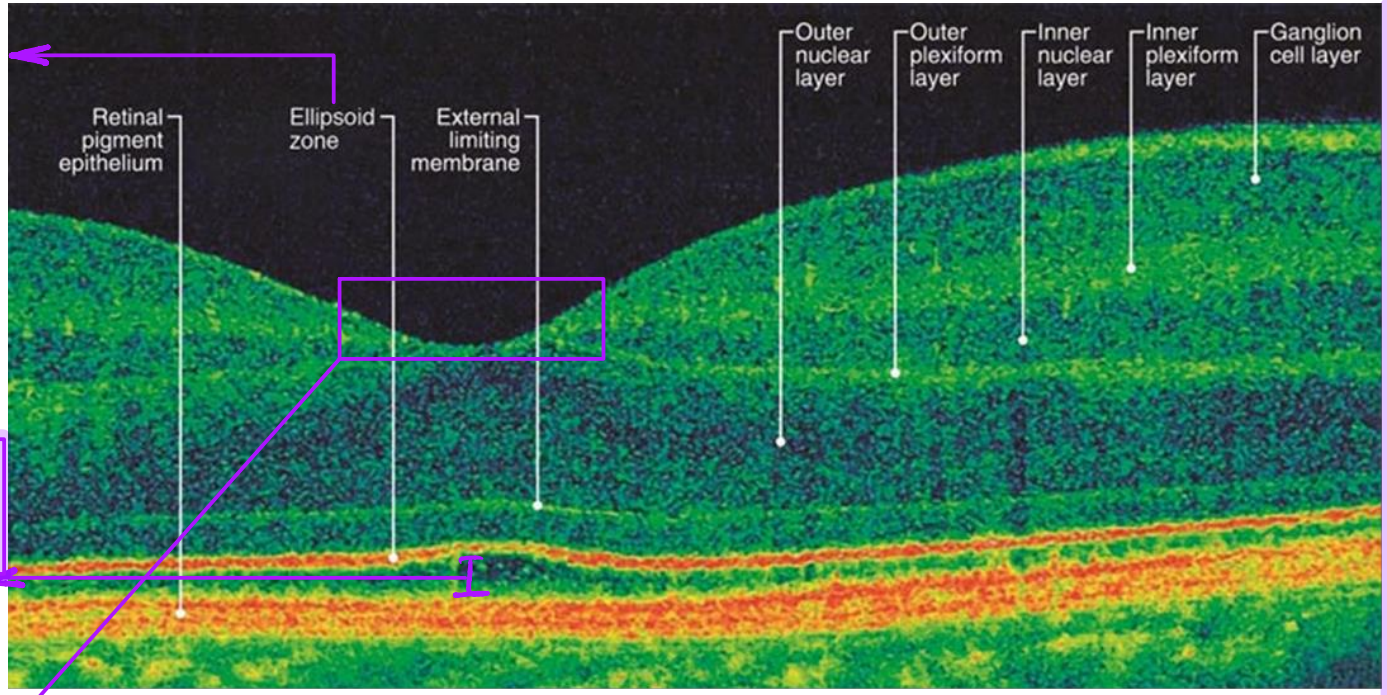


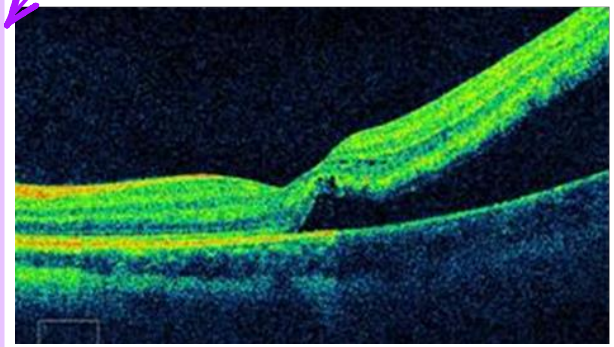
- The backscattered light from the sample is interfered with reflected light from the reference and detected with a photodetector. If coherence occurs, this means that the distance traveled by the light reflected from the sample is the same as the distance of the reference path.

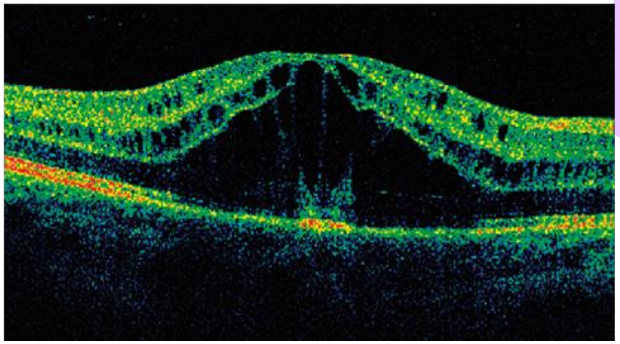
Part of inner segment of photo receptor, has a lot of mitochondria

Outer segment of photoreceptor

Depression » fovea centralis of macula Nuclie around it for cones بعيد عنها برجع rods لل nuclie and cones

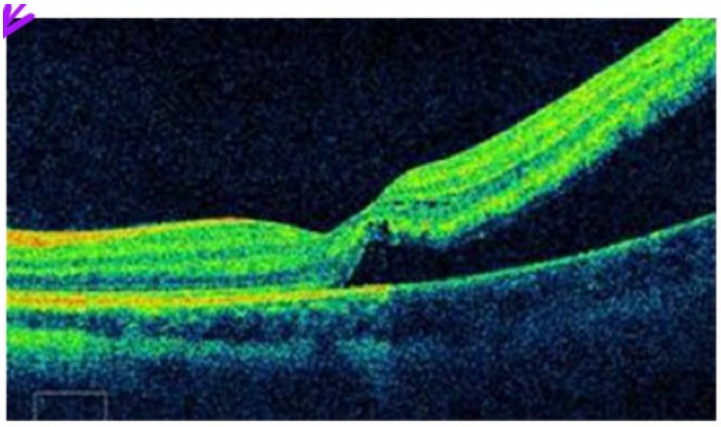




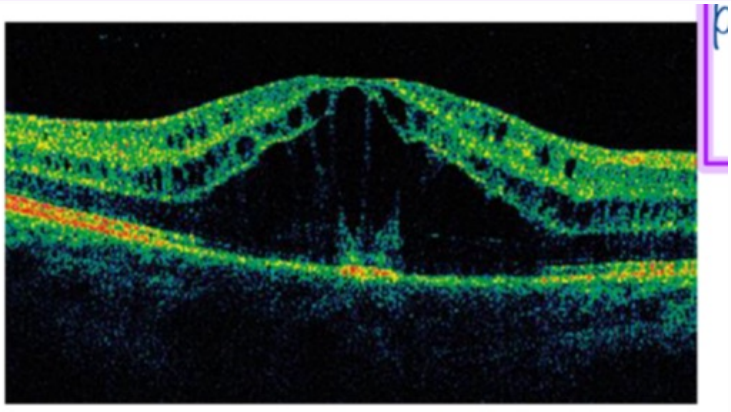


اللون البرتقالي منطقة فيها pigment او mitochondria .. اللون الازرق يعني منطقة فيها nuclei كتير .. اللون الاخضر منطقة فيها processes كتير

Fig.53: OCT of the retina at the macula. Top image, normal retina (ellipsoid zone is the part of the inner segment of rods and cones close to the outer segment). Bottom left, retinal detachment. Bottom right, macular degeneration.



Retina is completely separated from eyeball forming this space » disease called retinal detachment



Complete destruction in the macula (the space in the image) » disease called macular degeneration

Inside the eyeball

a. Anterior and Posterior chambers:

- The anterior chamber is the space between the cornea and the iris. The posterior chamber is the space between the iris and the lens.
- The anterior and posterior chambers are continuous with each other through the pupil. These two chambers together are called the ***anterior cavity***.
- They are filled with a clear fluid called the ***aqueous humor***. This fluid supplies nutrients to the avascular cornea and lens, removes wastes, and maintains shape of eye.

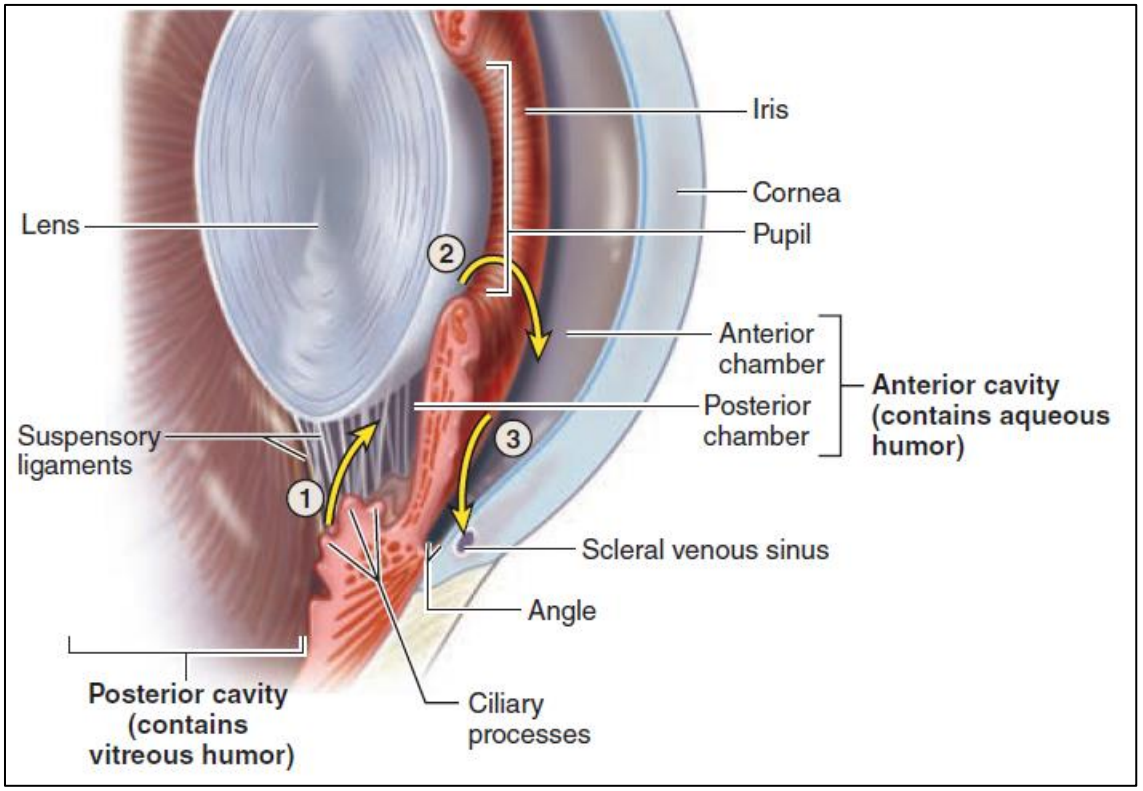
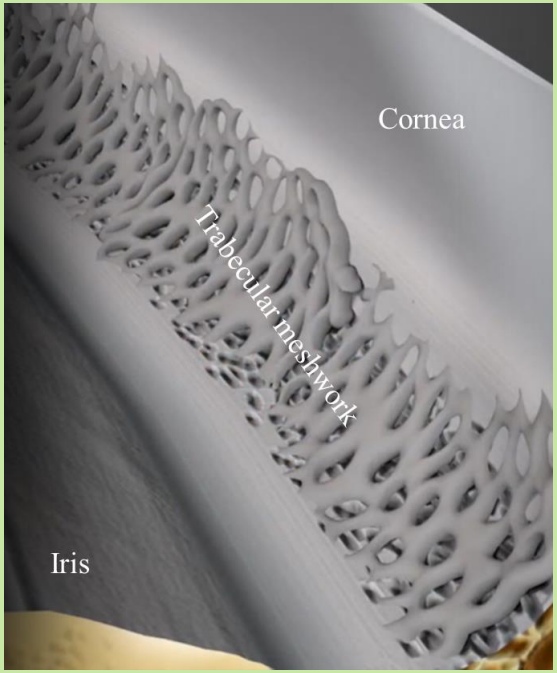


Fig.54: Anterior and posterior chambers.

Glaucoma

- The aqueous humor is a fluid present inside a closed space (the anterior cavity); therefor, a pressure is formed in this space called '***the intraocular pressure***'.
- The aqueous humor is produced by the ciliary processes and circulates in the posterior chamber. After passing through the pupil, it enters and circulates in the anterior chamber. At the angle between the iris and the cornea, the humor passes through a ***trabecular meshwork*** to enter the scleral venous sinus to return to the systemic venous circulation.



- There is a balance between the rate of production and removal of the aqueous humor. Any problem that leads to accumulation of this humor will lead to increased intraocular pressure; and this is a serious condition known as '*Glaucoma*'.

b. The lens:

- A transparent, biconvex elastic disc suspended between the iris and the vitreous body by the suspensory ligament.
- The convexity of the lens can be changed by the action of the ciliary muscle. This changes the refractive ability of the lens to accommodate for the visualization of objects at various distances.
- Histology of the lens:

1. *Lens capsule*: a thickened basal lamina. Site of attachment of the zonular fibers
2. *Lens epithelium*: a single layer of cuboidal cells present only on the anterior surface of the lens. The epithelial cells divide to form new cells, which differentiate as lens fibers.
3. *Lens fibers*: highly elongated, terminally differentiated cells that appear as thin, flattened structures. The cytoplasm is filled with proteins called crystallins, and the organelles and nuclei disappear.

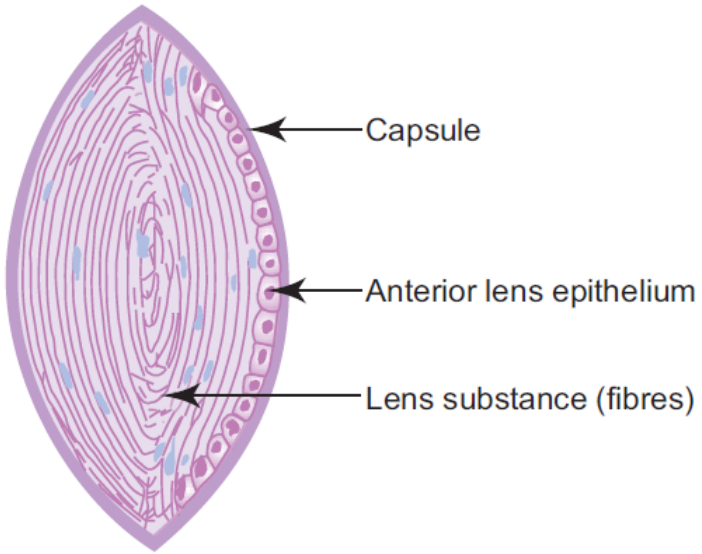


Fig.55: Diagram showing the various layers of the lens. Note the limit of the lens epithelium.

Presbyopia is the loss of elasticity of the lens with old age leading to decrease its ability to accommodate.

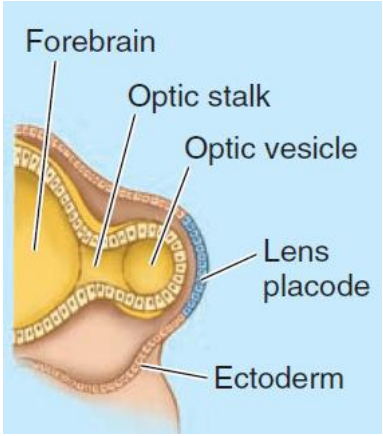
The denaturation of the crystallins proteins will decrease the transparency of the lens. When areas of the lens become opaque or cloudy and vision is impaired, this is called ***cataract***.

c. The vitreous chamber (posterior cavity):

- Located posterior to the lens.
- It's filled with a transparent gelatinous substance called the vitreous body, which is important to keep the retina and lens in place.
- A channel, called the ***hyaloid canal***, passes through the body. It represents the position of the ***hyaloid artery*** which nourished the eye during its development. This artery disappears later only, leaving an empty canal.

Development of the eye

- During the 4th week of development, an outgrowth from the lateral wall of the developing forebrain appears (neuroectoderm). As this ***optic vesicle*** reaches the surface ectoderm, it will induce it to form the ***lens placode***.
- The attachment of the optic vesicle to the forebrain elongates and narrows to form the ***optic stalk***. The vesicle, itself, will invaginate to form the double-layered ***optic cup***.
- The lens placode will invaginate to form the ***lens vesicle***. This will separate from the surface ectoderm to lie within the indentation of the optic cup. The lens vesicle will form the lens.



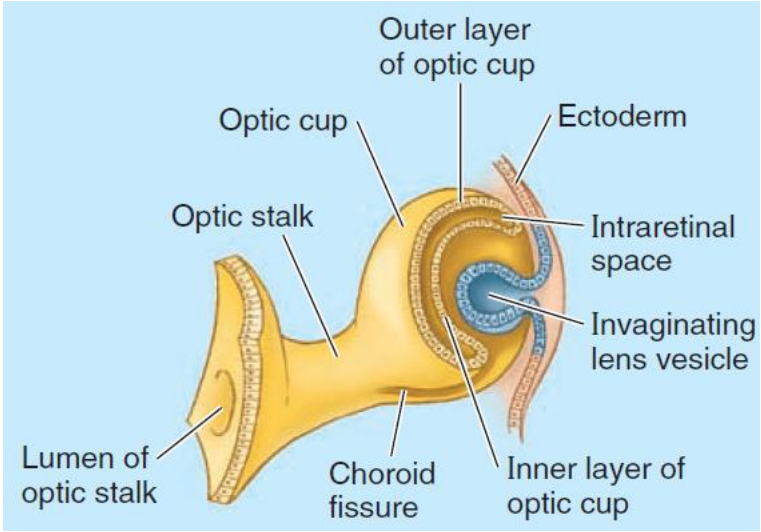


Fig.56: Early development of the eye.

- A groove appears in the optic cup and stalk. Through it pass the hyaloid artery (branch of the ophthalmic). The outer layer of the optic cup will form the retinal pigment layer; whereas, the inner layer will form the neural layer of the retina.
- More and more axons of the ganglionic cells of the retina will pass through the stalk, eventually closing its lumen. The groove will close and the hyaloid artery will run in a canal in the center of the stalk, which has, now, been converted into the optic nerve.
- The hyaloid artery beyond the optic disc will disappear. Its proximal part (running through the optic nerve) is now the central artery of the retina.
- Other parts of the eye will form from ectoderm and mesoderm.

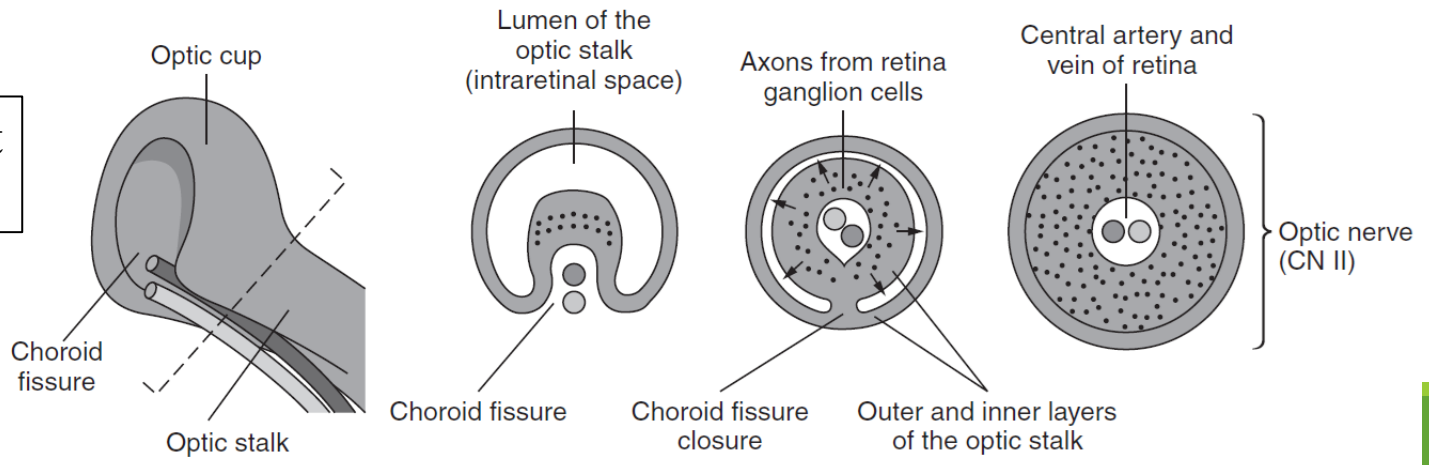


Fig.57: Development of the optic nerve.


Thank You