

Basic structure of Eye-Ball

- Three coats/Layers

- Outermost

- Two component

- Sclera

- Protective

- Opaque

- Tough

- Posterior 5/6th

- Cornea

- Transparent

- Anterior 1/6th

- Middle/Uveal tract

- Nutritive

- Vascular

- Three components

- Choroid

- Ciliary body

- Iris

- Innermost/Retina

- Two components

- Photosensitive layer

- Two type of cells

- Rods

- Cones

- Terminates somewhere between coronal section and corneo-scleral junction

- Pigmented layer

- Absorbs light

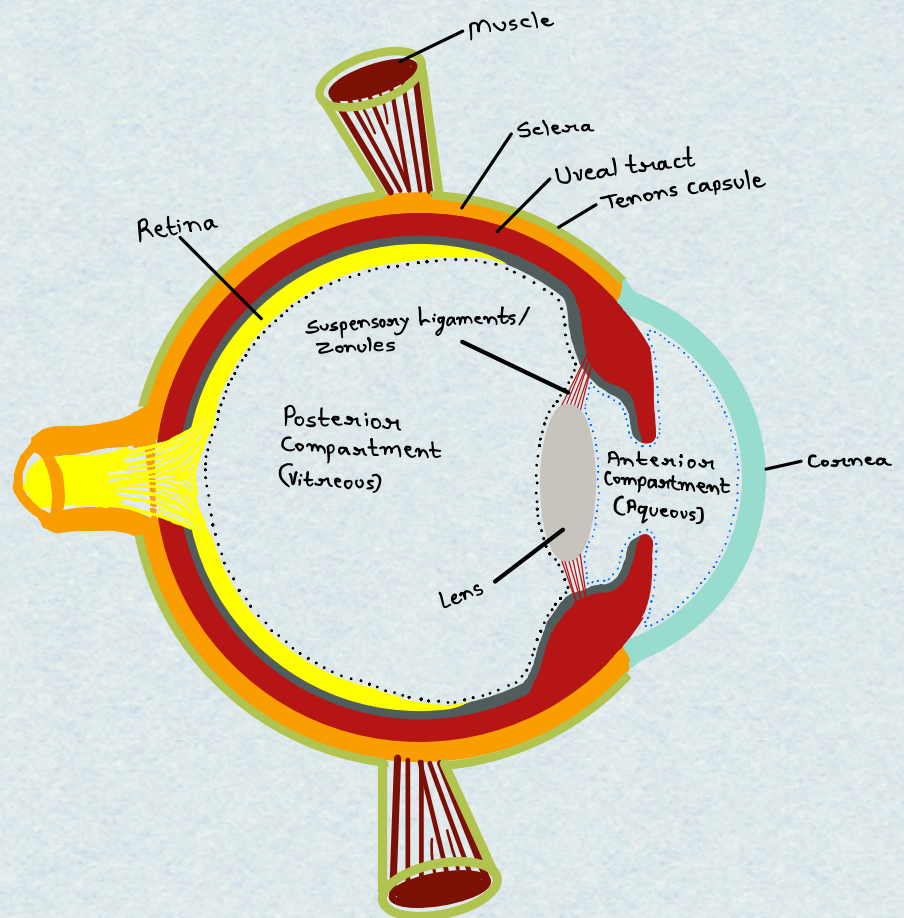
- Extends forward upto Iris

- Vitrous humour

- Aqueous humour

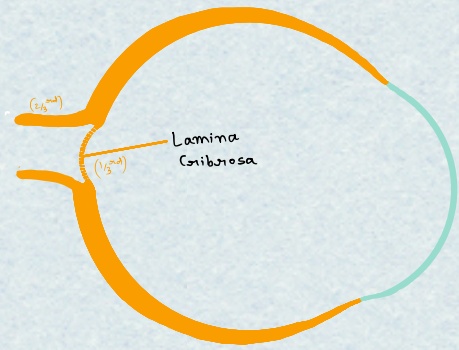
- Lens

- Zonules/Suspensory ligaments

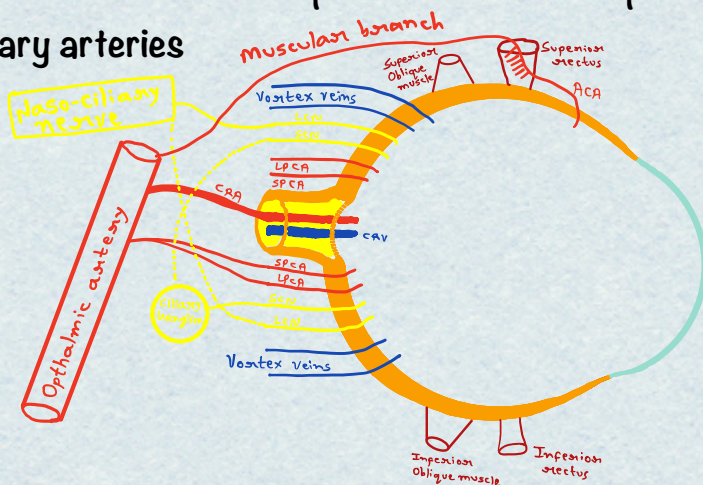
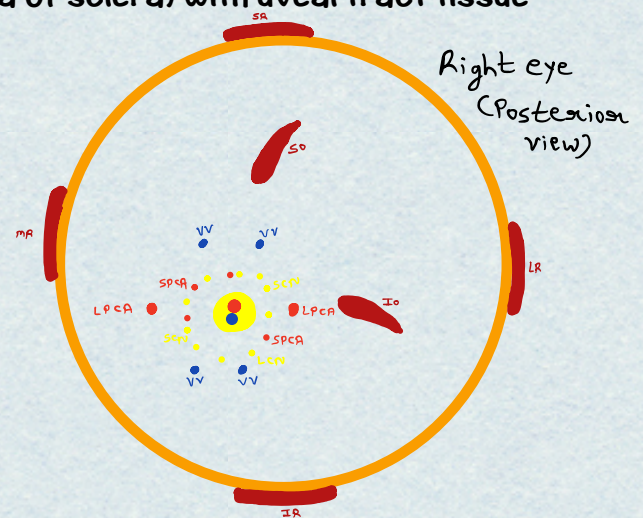


Structure of sclera

- Whitish from outside and slightly brownish from inside
- Irregularly arranged collagen fibres (Opaque)
- Interspersed elastic fibres
- Collagen fibres vary in thickness
- Considered as a continuation of duramater
- Inner to the sclera proper there is suprachoroidal lamina/Lamina fusca (Connective Tissue)
- Outer to the sclera proper there is episclera (Connective Tissue)
- Outer to the episclera there is fascia/Tenons capsule
- Episclera is highly vascular under the bulbar conjunctiva (Role in episcleritis)
- Provides site of attachment for extraocular muscles
- Thinnest part- Site of muscle attachment
- Thickest part- Near optic nerve
- Weakest part- Lamina cribrosa (Physiological cupping)

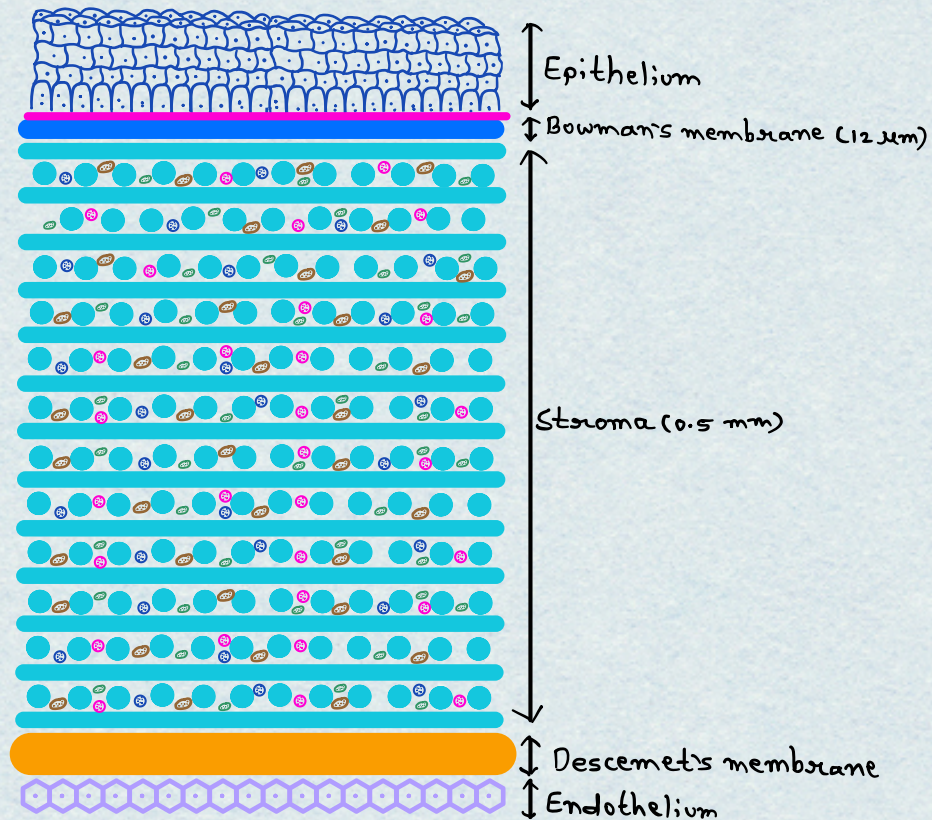


- Staphyloma
 - Bulging/Ballooning out of outermost layer (Ectasia of sclera) with uveal tract tissue
- Scleral spur- Provides site of attachment for ciliaris
- Canal of Schlemm/Sinus venosus sclerae
- Structures piercing sclera
 - Fibres of optic nerve
 - Short ciliary nerves (From ciliary ganglion)
 - Long ciliary nerves (From Naso-Ciliary nerve)
 - Short posterior ciliary arteries (10-20)
 - Long posterior ciliary arteries (2)
 - Vortex veins (4)- Drains into superior and inferior ophthalmic veins
 - Anterior ciliary arteries



Structure of cornea

- Surface area is 7% of total surface area of eye ball
- Surface area is 1.1 square centimeter
- Avascular
- Thickness at center- 0.52 mm
- Thickness at periphery- 0.7 mm
- Anterior diameter
 - Horizontal- 11.7 mm
 - Vertical- 11 mm
- Posterior diameter- 11.5 mm
- Anterior radii of curvature- 7.8 mm
- Posterior radii of curvature- 6.5 mm
- Functions
 - Transmission of light
 - Refraction of light
 - Structural integrity of eye ball
 - Protection



- Five layers
 - Epithelium
 - Non keratinised stratified squamous epithelium
 - 5-6 layered
 - Superficial layers are made up of flattened cells
 - Basal layer is made up of columnar cells
 - Whole epithelial cells are regenerated within 6-7 days
 - Stem cells are present at limbus/margin
 - Micro villi present at superficial flattened cells and holds the water to keep it wet
 - Ferritin granules in nucleus of epithelial cells protects their DNA from UV damage
 - Fuses with conjunctival cells at limbus
 - Bowman's membrane/ Anterior lamina
 - Acellular dense connective tissue layer
 - Collagen fibrils and ground substance
 - Homogenous
 - Amorphous
 - Doesn't regenerate

- Abruptly disappear at limbus
- Stroma
 - Dense connective tissue layer
 - Lamellae of collagen fibrils
 - Cells
 - Keratocytes
 - Histiocytes
 - Macrophages
 - Leucocytes
 - Collagen fibrils in a lamellae are parallel to each other at equidistance
 - Collagen fibrils in a lamellae are perpendicular to collagen fibrils of adjacent lamellae
 - Thickness of collagen fibril is less than wavelength of light
 - Corneal stroma is kept in slightly DEHYDRATED state
 - Fuses with sclera at limbus(Regular arrangement of fibrils become irregular)
- Descemet's membrane/Posterior lamina
 - Collagen and elastic fibrils
 - It can regenerate
 - Acellular
 - Forms trabecular meshwork at limbus by its extensions
- Endothelium
 - Single layer of cells
 - Provide nutrition to cornea
 - Keeps cornea dehydrated
 - Sodium/Potassium ATPases are present
 - Regeneration doesn't occur
 - Continues as covering of trabecular meshwork

Structure of retina

- Anterior termination of retina is called ora serrata (Wavy margin)

- Ocular fundus

- Part of the retina which could be seen through ophthalmoscope

- Macula lutea

- Central retina

- Sharpest acuity

- Infero-lateral to the optic disc

- Yellowish in colour

- Central depressed part is called fovea centralis

- Avascular

- 5-6 mm diameter

- Depends on chorio-capillary diffusion for nutrition

- Diffused margins

- Optic disc

- Present medial to macula lutea

- Optic disc can be differentiated from macula lutea by observing retinal blood vessels passing through optic disc

- Blind spot

- 1.5 mm diameter

- Depression is called physiological cupping

- Sharp margins

- Cells and layers

- Retinal detachment is retinal dissection in which photosensitive layer of retina is detached from pigmented layer of retina

- Layers

- Retinal pigmented epithelium

- Melanosomes are present

- Absorbs light and prevent internal reflection of light

- Provides nutrition to outer neural layer of retina

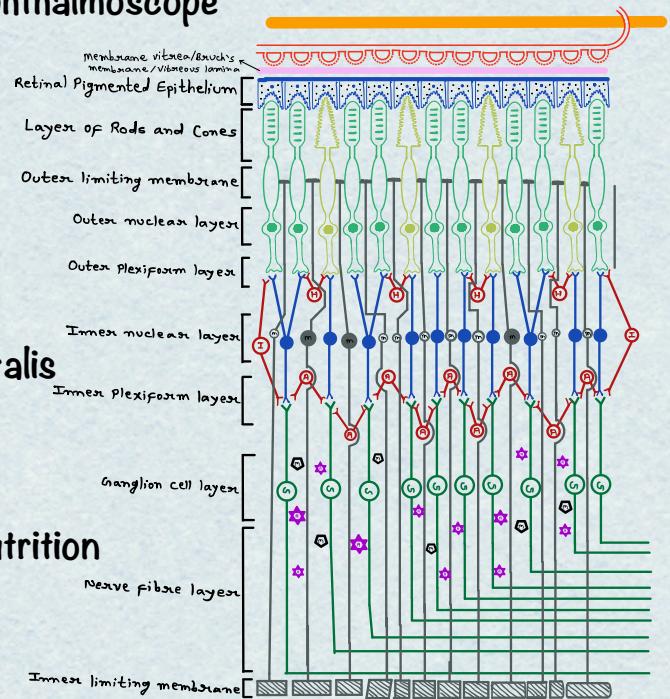
- Capillary loops provide nutrition by diffusion

- Layer of rods and cones

- Rods

- Rhodopsin

- Spherule



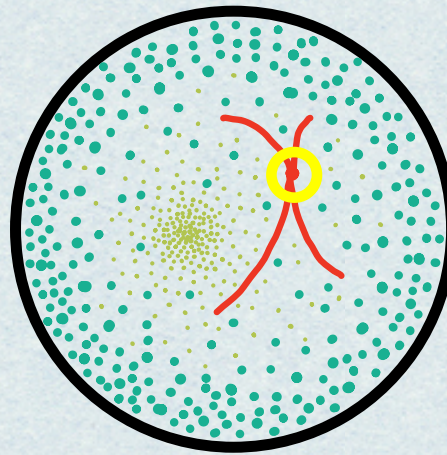
- Scotopic vision

- Cones

- Pedicles

- Photopic vision

- Outer limiting membrane
- Outer nuclear layer
- Outer plexiform layer
- Inner nuclear layer
- Inner plexiform layer
- Ganglion cell layer
- Nerve fibre layer
- Inner limiting membrane



- Few important points

- Outer five layers are supplied by choroecapillaries

- Functions of retinal pigmented epithelium

- Blood retinal barrier
 - Absorbs extra light
 - Regeneration of bleached visual pigment
 - Turn over of outer segment of rods and cones
 - Releases growth factors
 - Releases immunosuppressive substances

- Differences between rods and cones

- Rods

- 120 million
 - Black and white vision
 - Rhodopsin
 - More sensitive to light

- Cones

- 6.5 million
 - Colour vision
 - Iodopsin
 - Less sensitive to light
 - Macula lutea
 - Sharp acuity
 - Fovea centralis

- Sharpest acuity
- Light directly hits the cones
- Classical IO layers are absent
- Choreocapillaries are the only source of blood supply
- One cone- One bipolar- One ganglion cell
- Photoreceptor cells and bipolar cells are able to generate graded potential but ganglion cells are able to produce action potential
- Some of the ganglion cells are able to sense the light and send signals to hypothalamus to control circadian rhythm
- Nerve fibres of retina are not myelinated but they become myelinated in optic nerve

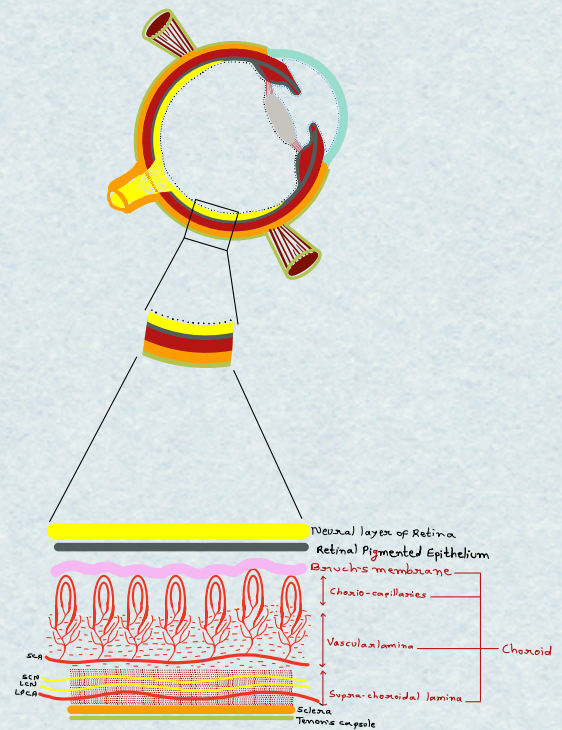
Uveal tract

• Choroid

- Fuses with ciliary body at ora serrata
- Highly vascular
- Pigmented
- Supra-choroidal lamina
 - Delicate connective tissue
 - Present between choroid proper and sclera
 - Structures passing through it
 - Long ciliary nerves
 - Short ciliary nerves
 - Long posterior ciliary arteries
- Choroid is mainly supplied by short posterior ciliary artery
- Vascular lamina
 - Outer part of choroid
 - Vascular part
- Arteriolar branches of short posterior ciliary are present in most of the choroid posteriorly
- Anterior most part is supplied by branches of anterior ciliary arteries and long posterior ciliary arteries
- Arteriolar branches of ciliary arteries become progressively smaller as they reach to inner choroid and form wide caliber capillaries like sinusoids and known as chorio-capillaries
- As age increases, extra cellular deposits become the part of Bruch's membrane and contribute to retinal degeneration

• Ciliary body

- Posterior 2/3rd of eyeball is called posterior segment/compartment which includes the structures behind the lens
- Anterior 1/3rd of eyeball is called anterior segment/compartment which includes the rest of anterior structures
- Ciliary processes are present at inner anterior 1/3rd surface of ciliary body
- Inner surface
 - Pars plana
 - Pars plicata
 - Covered by double epithelium



- Retinal pigment epithelium
- Epithelium made up of continuation of neural layer from ora serrata

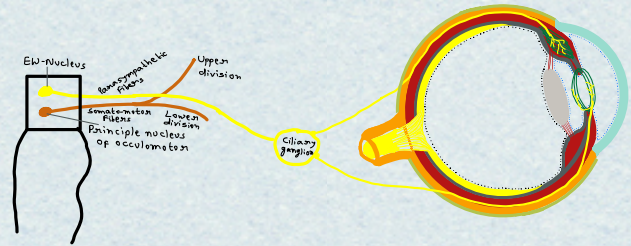
○ Black box effect due to heavily pigmented layers of eye

○ Stroma

▸ Major arterial circle is contributed by

- Anterior ciliary arteries
- Posterior ciliary arteries

▸ Small vascular loops are present in ciliary processes which provides sinusoidal capillaries and helps in aqueous humour production



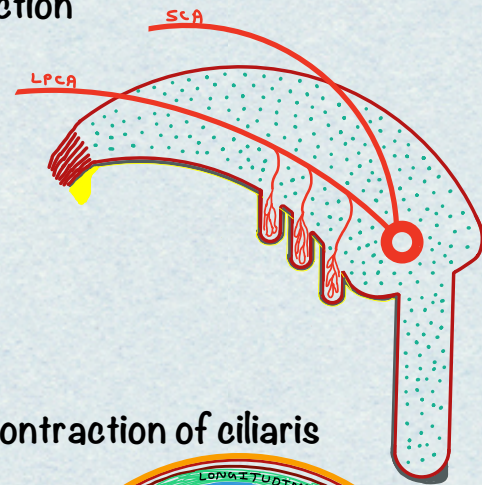
○ Ciliaris muscle

▸ 3 directional arrangement of fibres

- Longitudinal
- Circular
- Radial

▸ Attached on scleral spur which is a fixed end

▸ Scleral spur moves slightly backward due to contraction of ciliaris

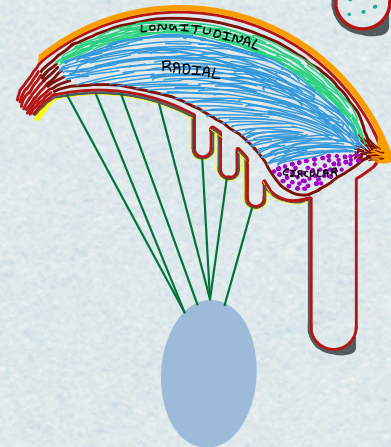


○ functions

▸ Accommodation of lens

▸ Attachment for suspensory ligaments

▸ Production of aqueous humour



• Iris

○ Double epithelium is present

○ Neural layer is heavily pigmented behind the iris

○ Pigmented epithelial cells which are present behind the iris have myofillaments

○ These myofillaments extends into posterior part of iris to make a network and it is called dilator pupili

○ Anteriorly extended part of these epithelium at pupillary margin is called pupillary ruff

○ Anterior part of iris does not have epithelium or endothelium and made of network of fibrocytes with embedded melanocytes

○ Anterior surface of iris is continued peripherally with trabecular meshwork

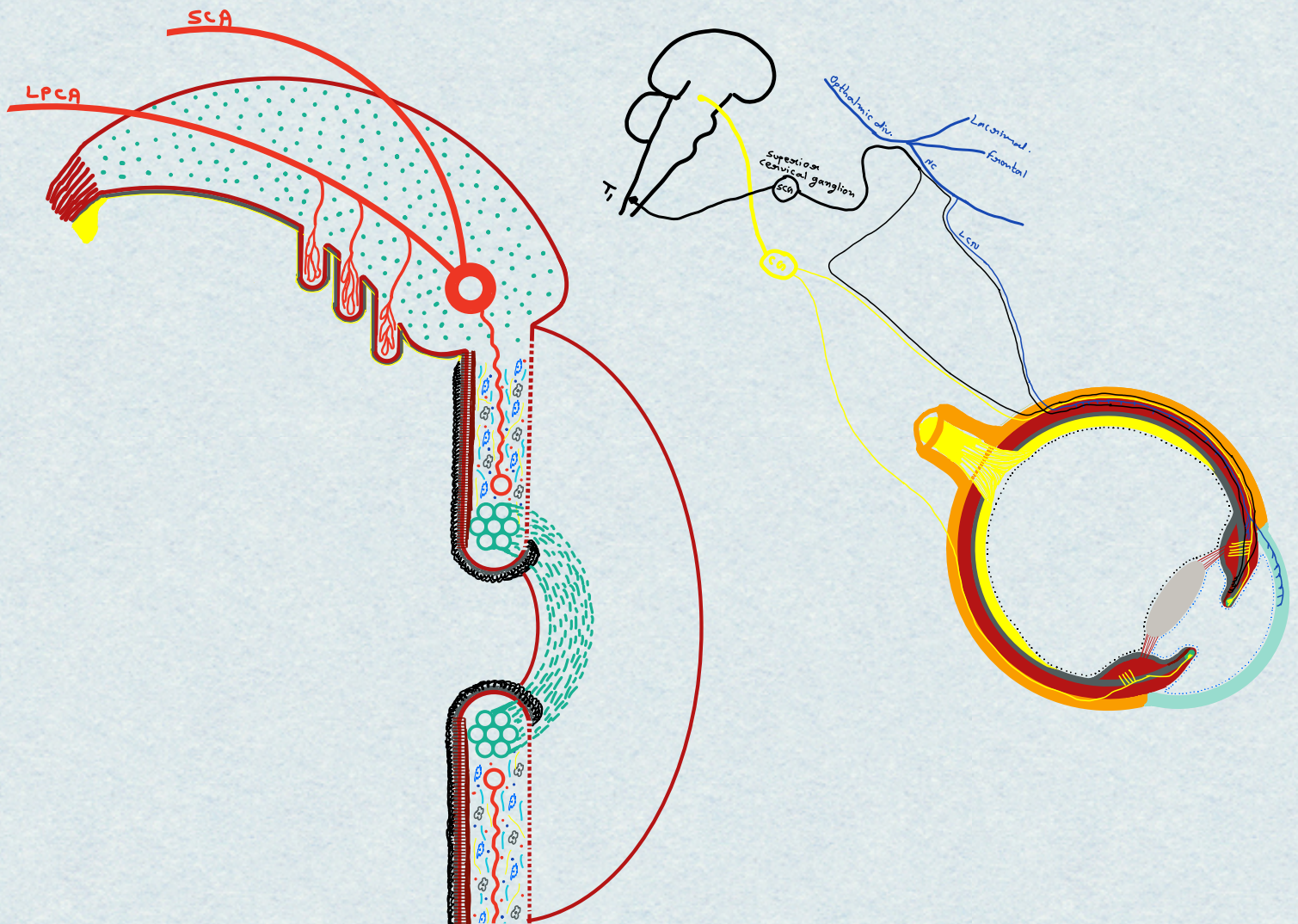
○ Anterior surface of iris contains small channels which allow aqueous humour movement from anterior chamber to stroma of iris and stroma of iris to anterior chamber

○ Diameter of pupil ranges between 2 mm to 8 mm in a normal person

○ Constrictor pupili is located towards pupillary margin

○ Stroma of iris contains

- Fibrocytes
 - Melanocytes
 - Collagen
 - Blood vessels
 - Minor arterial circle supplied by major arterial circle is present near pupillary margin
 - Nerves
- Stroma of iris, dilator pupili muscle and constrictor pupili muscle are derived from neural crest cells
 - Colour of iris is determined by the absorption and reflection of light by anterior border surface of iris and melanocytes of stroma of iris
 -



Aqueous humor (Production, circulation and drainage)

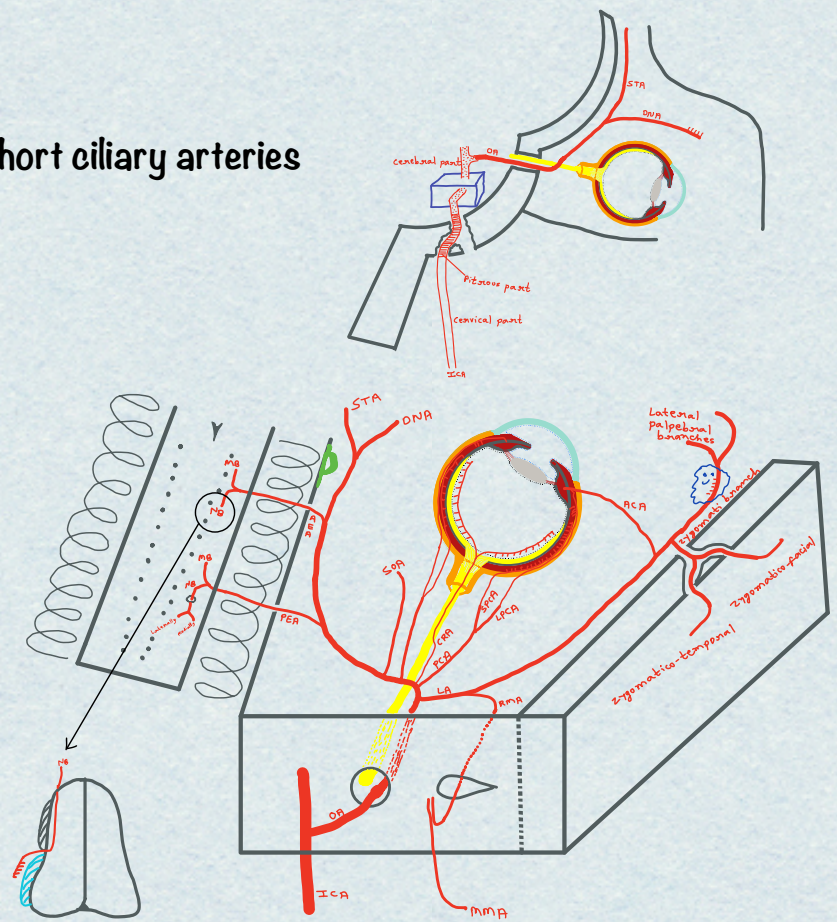
- Provides nutrition to avascular structures
 - Lens
 - Cornea
- Elongated fibrils of proteoglycan molecules are present in vitreous humor
- Clear transparent fluid
- 0.3ml of aqueous humor is present in an eye at a time
- Rate of production and drainage of aqueous humor is 2.5 micro liter per minute
- Aqueous humor contains
 - Sodium ions
 - Chloride ions
 - Bicarbonate ions
 - Water
 - Glucose
 - Amino acids
 - Ascorbic acid (Antioxidant)
- Sodium is actively secreted by ciliary process epithelial cells through sodium-potassium ATPases
- Anions follow sodium from epithelial cells
- Water follows osmotic gradient generated by ions in aqueous humor
- Components of iridocorneal angle
 - Iris
 - Ciliary body
 - Sclera
 - Cornea
- Endothelial cells of Schlemm's canal show similarity with lymphatics than veins
- Drainage
 - Trabecular meshwork
 - Uveoscleral pathway
- Trabecular meshwork
 - Contain channels of connective tissue
 - Drains aqueous humor into Schlemm's canal
 - 90% of total drainage
 - Offer resistance to the drainage of aqueous humor that contributes normal IOP
 - Normal IOP ranges 10-20 mm of Hg

- Drainage system
 - Iridocorneal angle-Trabecular meshwork-Schlemm's canal-Collector channels-Aqueous veins-Episcleral veins
- Phagocytic cells are present in trabecular meshwork which help in removing particulate matter to avoid the blockage
- Pericanalicular interstitium is rich in phagocytic cells
- Uveoscleral pathway
 - 10-15% of total drainage
 - Drainage system
 - Ciliary body-Choroid-Suprachoroidal space-Sclera- Scleral venous plexus-Episcleral veins

Ophthalmic artery (Origin, course and branches)

- It is a branch of cerebral part of the internal carotid artery
- It originates medial to the anterior clinoid process from internal carotid artery after emerging out from roof of cavernous sinus
- It enters in orbit from optic canal and inferomedial to the optic nerve
- After entering in orbit it takes sharp turn above optic nerve towards medial wall of orbit
- It divides in two branches near trochlea
 - Dorsal nasal artery
 - Supra trochlear artery
- Central retinal artery originates from ophthalmic artery when ophthalmic artery is just below to the optic nerve after entering in orbit
- Central retinal artery pierce the duramater and enters in the substance of the optic nerve 1.2 cm behind the eye ball accompanied by central retinal vein
- Central retinal artery divides in two branches at optic cup
 - Superior branches
 - Inferior branches
 - Each branch further divides in nasal and temporal branches
- Central retinal artery supplies inner half of retina
- Lacrimal artery originate from ophthalmic artery as soon as it enters in orbit
 - Lacrimal artery runs laterally along the superior border of lateral rectus
 - Terminal branches of lacrimal artery are palpebral branches which anastomoses with medial palpebral branches and forms superior arcade and inferior arcade
 - Lacrimal artery passes through lacrimal glands
 - Recurrent meningeal artery is the branch of lacrimal artery which passes through superior orbital fissure and anastomoses with middle meningeal artery of external carotid arterial system
 - Muscular branches of lacrimal artery gives origin to anterior ciliary arteries
 - It gives branches to lacrimal glands
 - Zygomatic branch is originated from lacrimal artery which pierces the lateral wall of orbit and gives two branches which anastomoses with superficial branches of external carotid arterial system
 - Zygomatico-temporal branch from zygomatico-temporal foramen
 - Zygomatico-facial from zygomatico-facial foramen

- It goes along lacrimal nerve
- Supraorbital branch
- Muscular branches which gives origin to short ciliary arteries
- Muscular branches originate from
 - Lacrimal arteries
 - Directly from ophthalmic artery
 - Supraorbital artery
- Posterior ciliary arteries
 - Long
 - Short
- Posterior ethmoidal artery
 - Supplies ethmoidal air sinus system
 - Two branches
 - Meningeal branch
 - Nasal branches
 - Medially- septum of the nose
 - Laterally- lateral wall of the nose- Anastomoses with sphenoid-palatine artery which is a part of external carotid arterial system
- Anterior ethmoidal artery
 - Two branches
 - Meningeal branch
 - Nasal branch
 - As come down, they emerge out below nasal bone and above nasal cartilage to supply external lower part of nose
- Medial palpebral branches



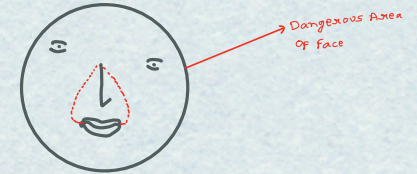
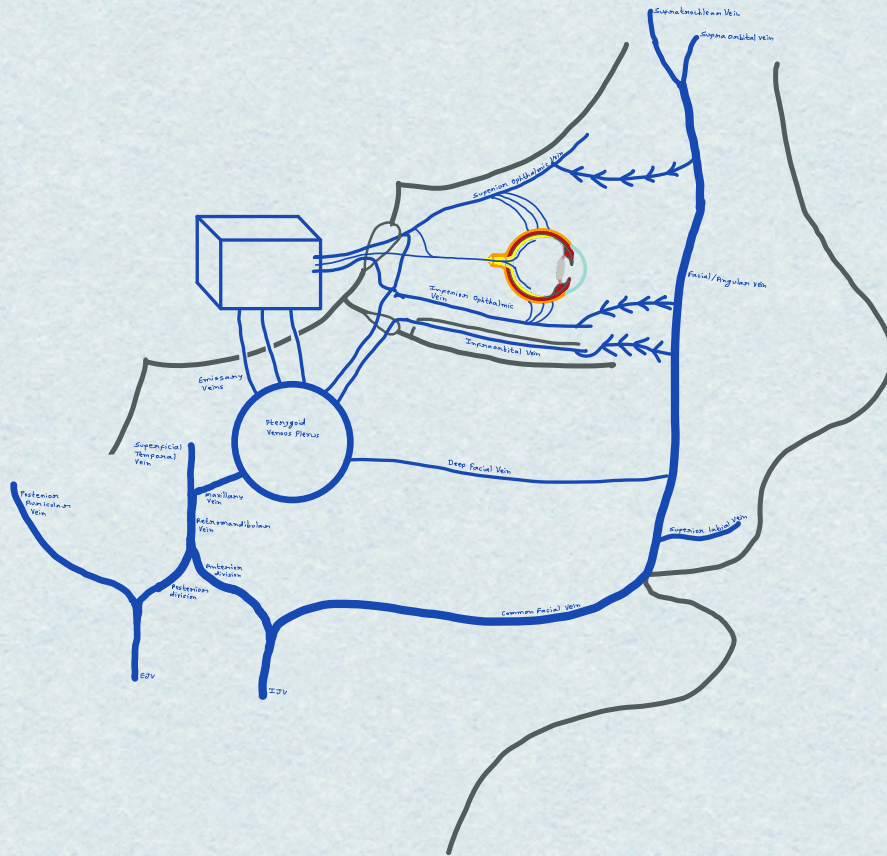
Blood supply to eye ball

- There is no lymphatics inside the eye ball
- Central retinal arterial system supplies inner half of retina
- Capillary branches of central retinal artery forms Blood Retinal Barrier
- Short posterior ciliary arteries form circle of Zinn around the head of optic nerve
- Each muscular branch of superior, inferior and medial rectus muscle gives two branches of anterior ciliary artery and lateral rectus gives one branch of anterior ciliary artery to major arterial circle of ciliary body
- Central retinal vein
- Vortex veins
- Episcleral veins drain either in vortex veins or in anterior ciliary veins

Orbital veins and clinical correlates

- Superior ophthalmic vein
 - Drains into cavernous sinus
 - It starts behind the upper lid to medial side
 - Multiple tributaries which corresponds to branches of ophthalmic artery
- Inferior ophthalmic vein
 - May drain into
 - Superior ophthalmic vein
 - Cavernous sinus
 - Pterygoid plexus
- Infraorbital vein
 - Drain into pterygoid venous plexus
- Pterygoid venous plexus is the venous network around the lateral pterygoid muscle in infratemporal fossa between temporalis muscle and lateral pterygoid muscle and also between medial pterygoid and lateral pterygoid
 - Pterygoid venous plexus is connected with cavernous sinus through multiple emissary veins
 - These emissary veins pass through
 - Sphenoidal foramen
 - Foramen ovals
 - Cartilage of foramen lacerum
 - These emissary veins don't have any valves so the blood can move in either direction

- Corresponding veins of branches of maxillary artery drains into pterygoid venous plexus
- Pterygoid venous plexus drains into maxillary vein
- Maxillary vein joins superficial temporal vein and form Retromandibular vein



Ophthalmic nerve

- Division of trigeminal nerve
- Gives origin to
 - Nash-ciliary nerve
 - Frontal
 - Lacrimal nerve
- Travels through lateral wall of cavernous sinus after origin from trigeminal ganglion
- All the branches of ophthalmic nerve enters in orbit through superior orbital fissure
- Lacrimal branch
 - Moves laterally in orbit
 - Supplies
 - Lacrimal gland
 - Upper lateral part of the upper eyelid and underlying conjunctiva
 - parasympathetic fibres from pterygopalatine ganglion also supplies lacrimal gland which move along zygomatico-temporal branch of zygomatic nerve which is branch of man nerve
- frontal branch
 - Moves upward and anterior in orbit between roof of orbit and levator palpebrae superioris
 - Divides into two branches
 - Supratrochlear branch
 - Lateral
 - Supplies skin of forehead laterally
 - Supraorbital branch
 - Medial
 - Supplies
 - Skin of forehead medially
 - Frontal sinus mucosa
 - Supplies the skin upto vertex
- Naso-ciliary
 - Turns medially above the optic nerve
 - Divides in following branches near trochlea
 - Anterior ethmoidal branch
 - Enters in anterior ethmoidal canal through anterior ethmoidal foramen and appears in anterior cranial fossa just above the cribriform plate and move through a slit and enters in nose and finally divides into two branches

- Medial nasal branches
- Lateral nasal branches
- One of its branch passes through a groove under the nasal bone and comes out on termination of nasal bone between nasal bone and nasal cartilage and known as external nasal nerve which is a continuation of anterior ethmoidal nerve
- Supplies
 - Middle and anterior ethmoidal air sinuses with underlying mucosa
 - Little bit meninges
 - Nasal mucosa
- Posterior ethmoidal branch
 - Supplies
 - Posterior ethmoidal air sinuses with underlying mucosa
 - Sphenoid sinus
- Infratrochlear branch
 - Supplies
 - Medial most part of the upper eyelid and underlying conjunctiva
 - Lacrimal sac
 - Lacrimal caruncle
- Sensory root of the ciliary ganglion

