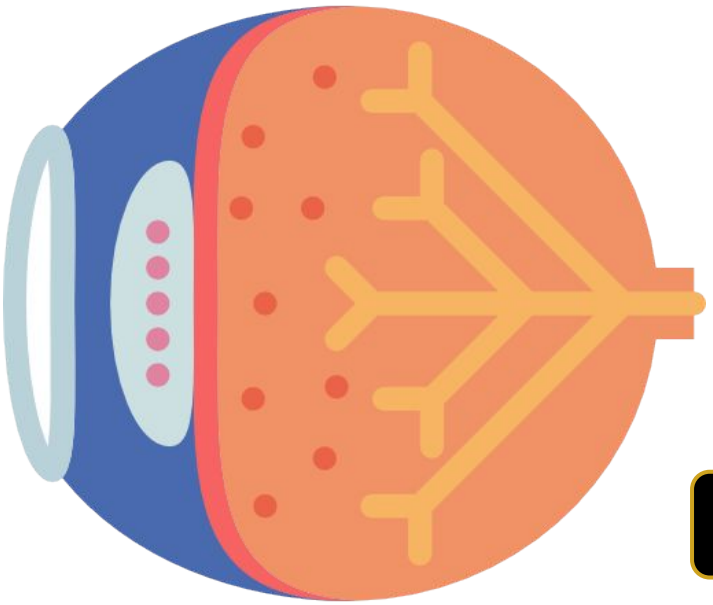
Lecture: 2



Editing file

Basic Anatomy and Physiology of the Eye

- Presented by Dr. Mohammed Al Shamrani/ Prof. Yasser Alfaky
- To describe the basic embryology and anatomy of the eye globe and orbital structures.
- To understand the anatomy and physiology of the extraocular muscles, eyelids and lacrimal system.
- To know the Anatomy and physiology of the visual pathway.
- To know the basic physiology of eye globe (e.g. phototransduction, intraocular pressure and accommodation).

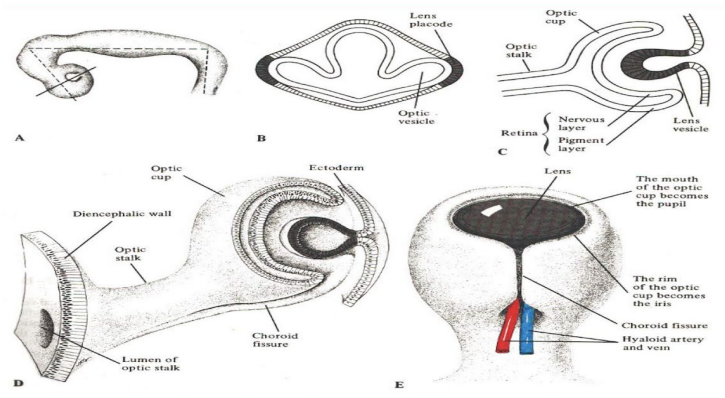
Important | Doctor's notes | Golden notes | Extra | Book

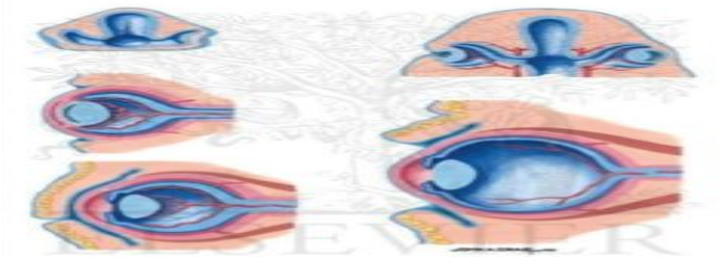
OPTHALMOLOGY TEAM

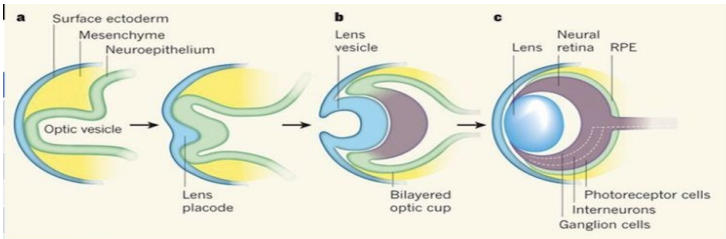
Embryology of the Eye

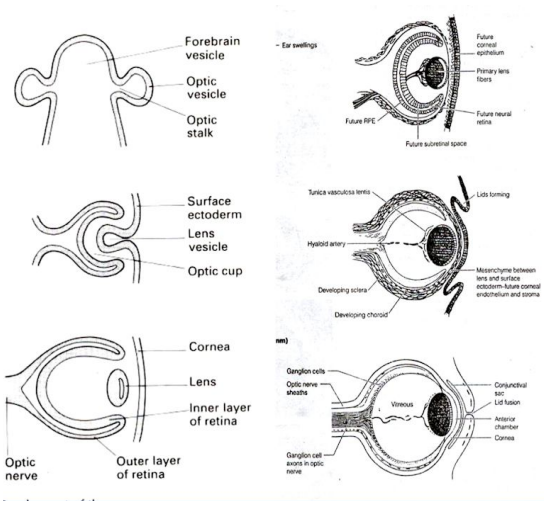
- Starts at about day 22 of gestation on the side of the forebrain.
- These groves grow and then invaginated to form optic vesicle and optic cup and its proximal part is connected to the forebrain by optic stalk. Part of the ectoderm from the lens.
- It becomes separated from surface ectoderm in day 33
- During development of the eye, all structures of the eye are vascular (important).
- At the end of embryogenesis, the lens, vitreous & cornea become avascular which ensures clarity of the media for the passage of light to be focused on the retina to be able to see.
- The blood vessels invading the eyes are coming from inferio-nasal aspect, and this is the last area that become completely fused. So, if we have defective fusion of this area, it will be evident after birth as defect on the sclera, choroid, iris and lens and that called coloboma.
- If the defect location is inferio-nasal this is a congenital anomaly. If it lateral, superior or superio-nasal this is not congenital anomaly, and you have to look for another etiology (It is important to know that the last fusion of the eye is inferio-nasal).
- Hyaloid vessels vascularize the cornea and lens and then at the end of embryogenesis it starts to regress (dissolve), they are no longer needed because of the clarity of the media.
- If the vessels do not disappear this is called persistent hyperplastic primary vitreous which results in absence of red reflex (also called dim red reflex, white red reflex, cat eye).
- Leukocoria = absence of red reflex in pediatrics.

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









ectodrem 1- lens 2- cornea (surface epithelium 3-conjunctiva
neuroectoderm 1-optic nerve 2- muscle of iris 3-retina

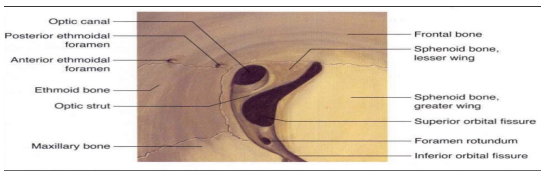
The Orbit

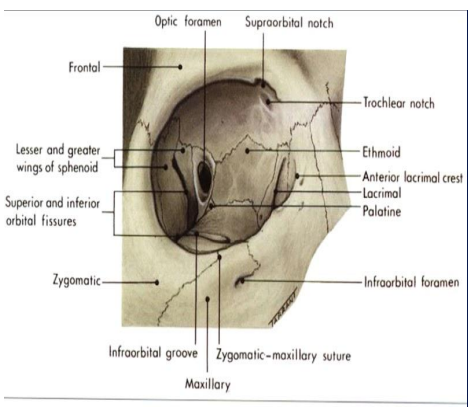
- As a socket, contains & protect the eye.
- It has the shape of a 4-sided pyramid, with its base in-front & its apex behind.
- Seven bones contribute the bony orbit. (frontal, zygomatic "temporal" , maxillary,sphenoid, ethmoid, palatine & lacrimal).
  - The zygomatic bone is the strongest as it is more prone to trauma
- The lateral aspect is the strongest wall of the orbit as well as the anterior aspect (rim).
  - If a pt presents w/ a fracture in the lateral orbital wall, he is most likely to have other fractured walls
- the lateral aspects (walls) are 45 degrees
- The smallest part is the orbital apex; therefore, any lesion in the apex is very dangerous because it presses on the vessels & nerves that pass through it.
- The weakest parts are the floor & the medial wall. Surrounded by nasal sinuses.
- The medial orbital wall (made of ethmoid bone) & ethmoid sinus are separated by a very thin straight bone called (lamina papyracea). Being thin makes it a very common source of infection; thus
  - The most common site of infection is the medial wall
    - A patient with sinusitis commonly presents with orbital cellulitis.
  - The medial orbital wall is the thinnest wall but not the weakest because it is a straight bone.
- The floor is slightly thicker but is weaker because it is curved. More risk to be fractured
    - The most common fracture of the orbital wall is the orbital floor (blowout fracture) due to blunt trauma & it causes high IOP.
    - The patient will complain of diplopia (vertical diplopia)
- From 435, MCQ: the infra-orbital nerve supplies the skin of the lower lid, so when you get a scenario saying a patient present with paresthesia of the lower lid, what nerve is affected? Infra-orbital nerve.
- Surrounded by nasal sinuses
- Important openings are:

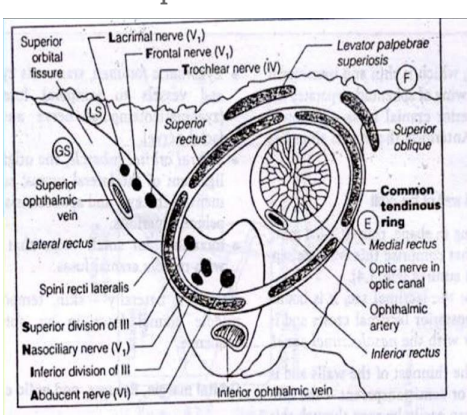
1. Optic foramen. Optic nerve and ophthalmic artery run through it
2. Superior orbital fissure. Between the lesser and greater wings of sphenoid
3. Inferior orbital fissure.

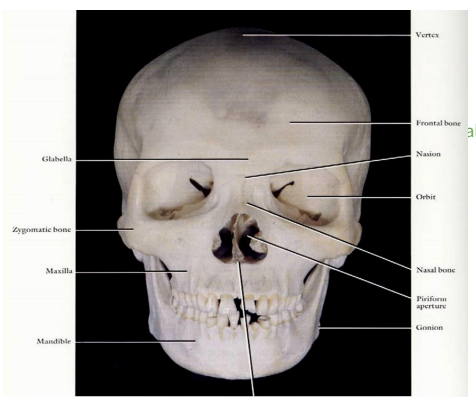
Openings in the orbit (Important)

Optic foramen Most precious	Superior orbital fissure	Inferior orbital fissure
1. Optic nerve 2. Ophthalmic artery.	ANY STRUCTURE NOT MENTIONED IN OTHER OPENINGS. 1. III, IV, and VI cranial nerves. 2. Lacrimal nerve. 3. Naso-ciliary nerve 4. Superior ophthalmic vein 5. Inferior ophthalmic vein.	1. Infraorbital nerve. 2. Infraorbital vessels.





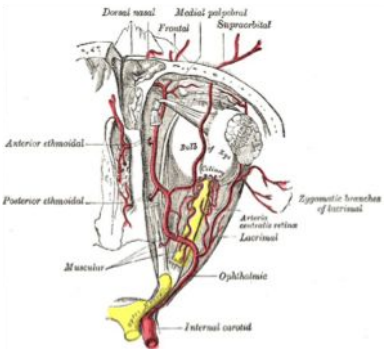




The Orbit Cont.

- If I mentioned something you don't know, say it passes through the superior orbital fissure.
- The bone is covered with periorbita (periosteum) which is loosely adherent to the orbital walls. Thus, it can accumulate pus, sub-periosteal abscess or hemorrhage.
- The orbital septum prevents bulging of the globe. The periorbita is very resistant to infection; therefore, we divide the infections into 2 groups:
    - Anterior to the orbital septum (pre-septum).
        - Any infection that develops anterior to the orbital septum can be treated as outpatient by either oral or systemic antibiotics.
    - Posterior to the septum (orbital).
        - Any infection behind the orbital septum is very dangerous as it can easily get access to the cavernous sinus through the ophthalmic vein & induce cavernous sinus thrombosis which is fatal
        - Orbital cellulitis should be treated aggressively as in-patient.
- Annulus of zinn (other names: common tendinous ring, annular tendon) is a fibrous band surrounds the optic nerve and gives origin to the extraocular muscles (lateral, medial, superior, inferior recti muscles
- Extraocular muscles pass in angulated way except the medial rectus which comes straight & the lateral rectus which comes exactly bisecting the globe . That's why medial and lateral recti can do only one movement.
    - ADduction for the medical recti
    - ABduction for the lateral recti.

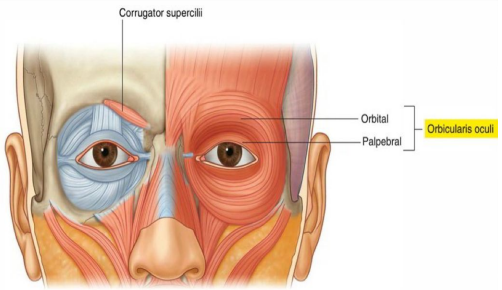
- Craniosynostosis: eg Crouzon syndrome
    - **a birth defect in which the bones in a baby's skull join together too early**.
- Orbital dimensions:
    - Orbital volume: 30cm3
    - Entrance height: 35mm
    - Entrance width: 40mm
    - Medial wall length: 45m
- The eyeball takes up about one-fifth of the orbital volume.
- The remaining is taken up by the extraocular muscles, fascia, fat, blood vessels, nerves and the lacrimal gland.



The Eyelids

- The eyelids can 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 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 lids are:
  - Closed by orbicularis oculi muscle (innervated by facial n.)
  - The orbicularis oculi muscle is composed of three parts: the orbital part, the palpebral part, and the lacrimal part. The palpebral part composed of pre-septal & pretarsal.
  - We have three types of closures:
    - Involuntary closure, by pretarsal part of orbicularis.
    - Voluntary closure, by pre-septal part of orbicularis.
    - Forceful closure, by orbital part.
  - Contraction of the peripheral fibers of the orbicularis muscle results in a protective forced
  - The lacrimal part of orbicularis is responsible for suctioning the tears (when eye closes this muscle contracts and the lacrimal sac will expand. As a result, there will be negative pressure inside which sucks the tear, so this is how the tears are drained from the eye).
- The lids are opened with Levator palpebrae muscle (innervated by oculomotor n. Superior division), Muller's muscle (sympathetic supply) & Lower lid retractors.
- The sympathetic supply will be affected in pts w/ Horner syndrome in which they have miosis, partial ptosis, anhidrosis & enophthalmos (Mnemonic: MAPLE).

- The difference between ptosis due to parasympathetic & sympathetic injury is that:
- In third nerve palsy (para-sympathetic injury) ptosis occurs due to levator palpebrae muscle paralysis & is associated with lateral deviation of the eye; while, in sympathetic nerve injury the Muller's muscle will be paralyzed & patient will have ptosis as in Horner's syndrome.
- Tarsus is a thick fibrous tissue that acts as a skeleton to the lid.
- Meibomian gland produces meibum, an oily substance that prevents evaporation of the eye's tear film



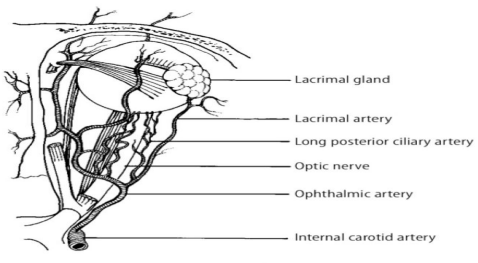
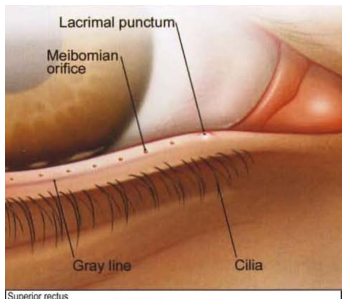
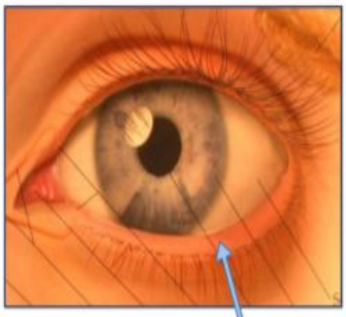
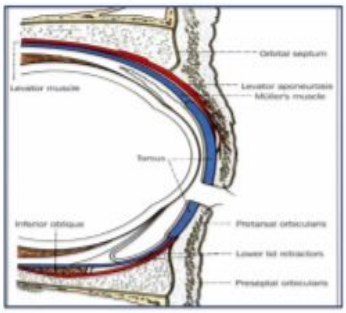
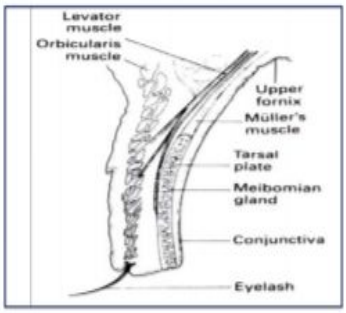


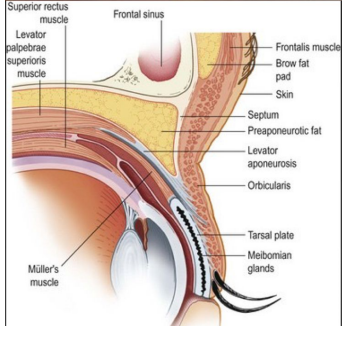
Figure 2.5. Blood supply of the eye.





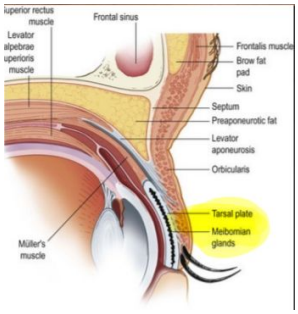






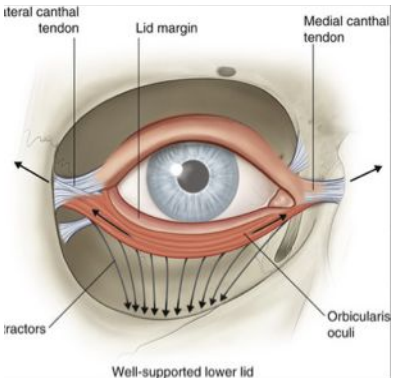
The Eyelids Cont.

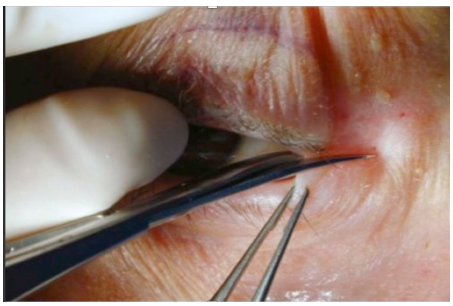
ptosis may be due to a myogenic, neurogenic, aponeurotic, mechanical or traumatic cause.

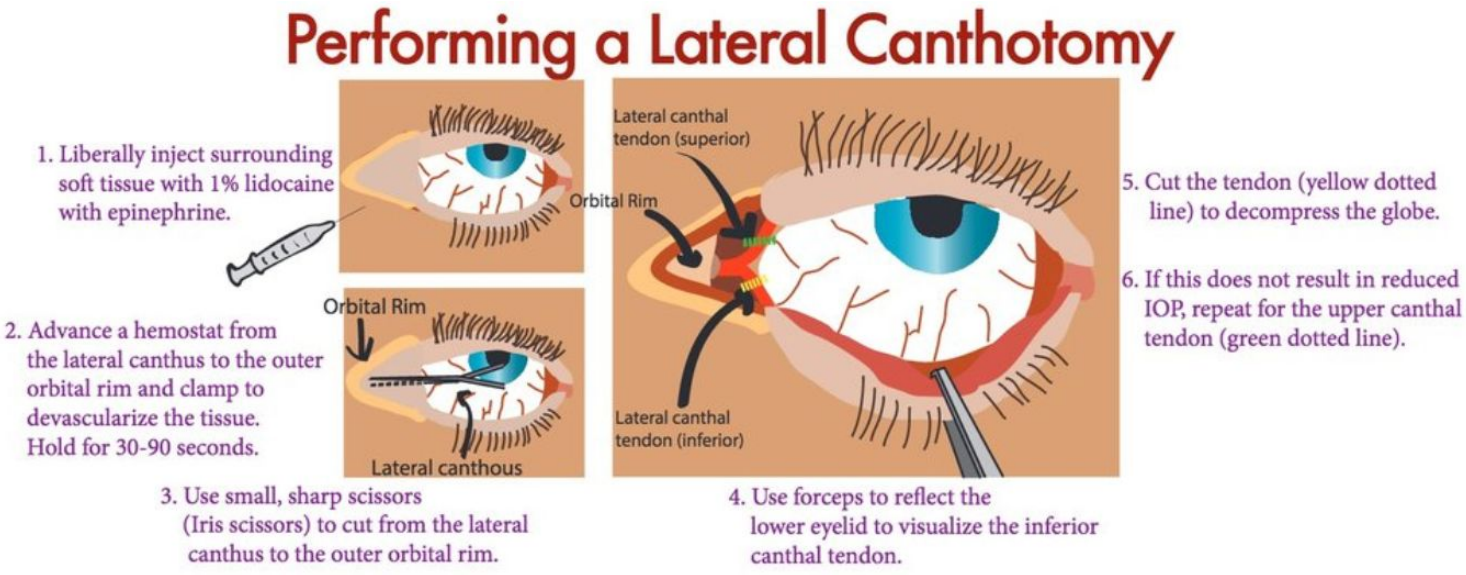


muller muscle connect the inferior part of levator to facial plate

Lateral canthotomy should be performed as **acute management** for **orbital compartment syndrome**, which presents with increased intraocular pressure (IOP) and impaired extraocular motility. Typically, this syndrome occurs within the context of recent orbital trauma or eye surgery. Indications for immediate canthotomy include sudden vision loss or relative afferent pupillary defect in the setting of **retrobulbar hemorrhage** with proptosis and **IOP greater than 40 mm Hg**.

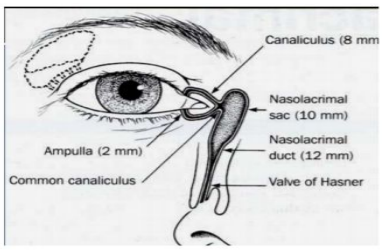


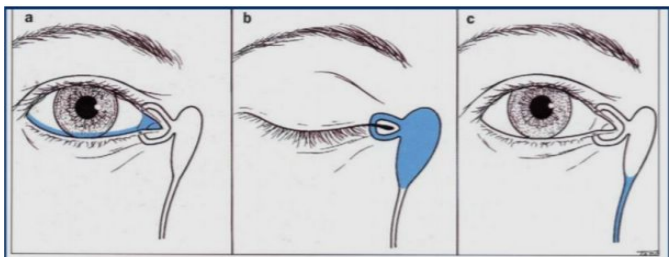


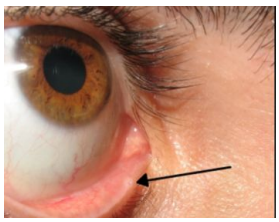


Lacrimal Apparatus

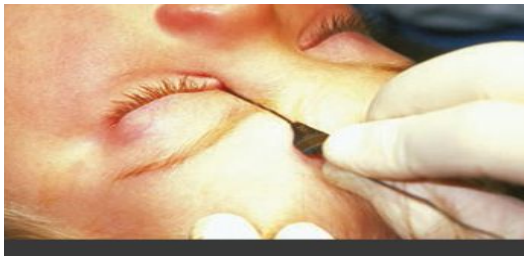
- The major lacrimal gland occupies the superior temporal anterior portion of the orbit. It has ducts that open into the palpebral conjunctiva.
- Tears collect at the medial part of the palpebral fissure and pass through the puncta and the canaliculi into the lacrimal sac, which terminates in the nasolacrimal duct inferiorly.
- The nasolacrimal duct opens into the inferior meatus of the nose.
- Tear production & secretion (it works by reflex tearing).
- Tears drain from superior & inferior puncta to upper & lower canaliculi >> lacrimal sac >> nasolacrimal duct which opens into inferior meatus.
    - Failure of the distal part of the nasolacrimal duct to fully canalize at birth is the usual cause of a watering, sticky eye in an infant.
- Valve of hasner prevents nasal secretion from going up. Valve of hasner is located at the lower end of the nasolacrimal duct (at the meatus). If well developed, it prevents air from being blown back from the nose into the lacrimal sac.
- Inflammation of the lacrimal gland : dacryoadenitis . Inflammation of the lacrimal cyst: dacryocystitis.
- Fluorescein test is done for pediatrics & adults
- We put fluorescein stain in the eye.
- Normally it goes away after 15 mins, but if it doesn't it indicates obstruction But not specific where (maybe in duct , canaliculi
- From 436 (A), you need to memorize the lengths
    - Babies born with teary eyes have a problem with the nasolacrimal duct (blocked).
    - If closed by bony part: nothing to do.
      Closed by membranous part: observe for 1 year > goes spontaneously> persists > syringe & probing







- canalicular laceration
- Canalicular trauma refers to **sudden physical injury that results in damage to the lacrimal drainage system of the eye**.

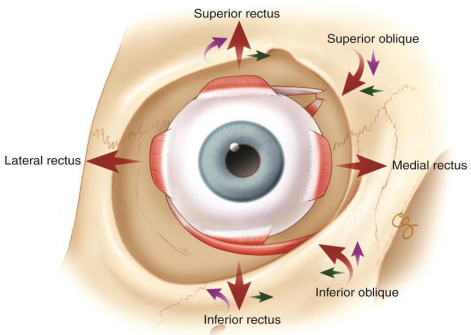


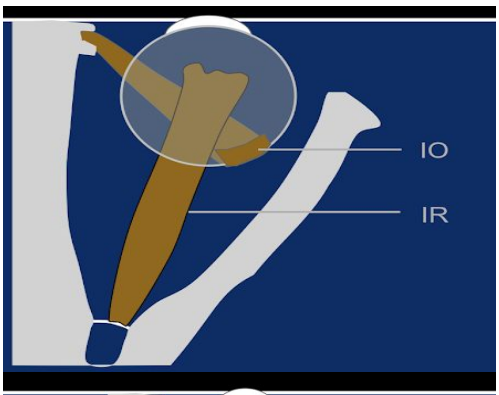
Congenital nasolacrimal duct obstruction (CNLDO) is a **common condition causing excessive tearing or mucoid discharge from the eyes**, due to blockage of the nasolacrimal duct system. Nasolacrimal duct obstruction affects as many as 20% children aged <1 year worldwide and is often resolved without surgery

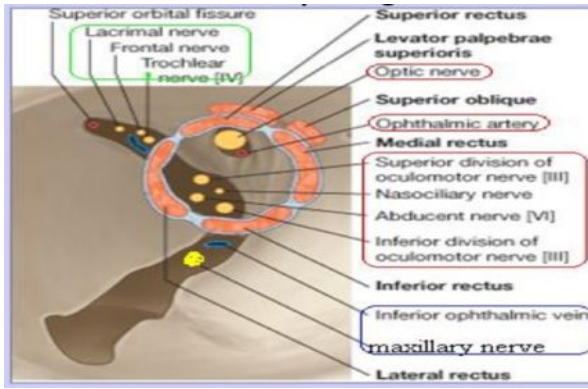
Extraocular Muscles

- 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).
  - The levator muscles are also supplied by the oculomotor
- 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

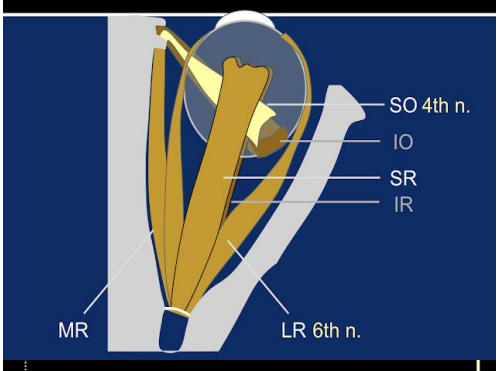
- Both superior rectus & inferior oblique elevate the eye, so how to test each muscle separately?
  - For superior rectus, let patient look laterally then up.
  - For inferior oblique, let patient look medially then up.
  - Same concept for inferior rectus & superior oblique.
- General roles to help you memorize:
  - All recti are adductors EXCEPT lateral rectus which is abductor
  - All obliques are abductors. - So, three muscles are adductors & three are abductors.
  - All superiors are intortors (intorsion).
  - All inferior are extortors.
- Why we have intorsion & extortion movements? For compensatory movement with our head.
- Tricky thing in MCQs:
  - Superior oblique depresses the eye ON adduction (so the adductor here is another muscle). Be sure to differentiate between ON & AND

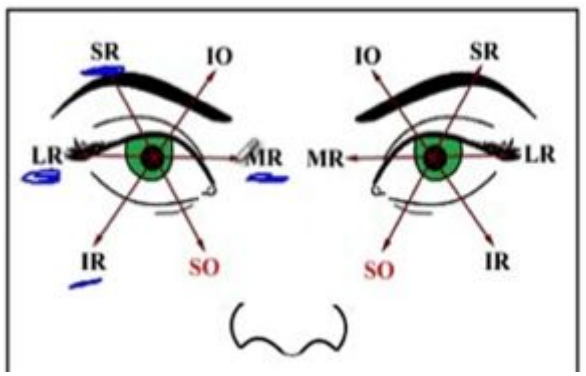


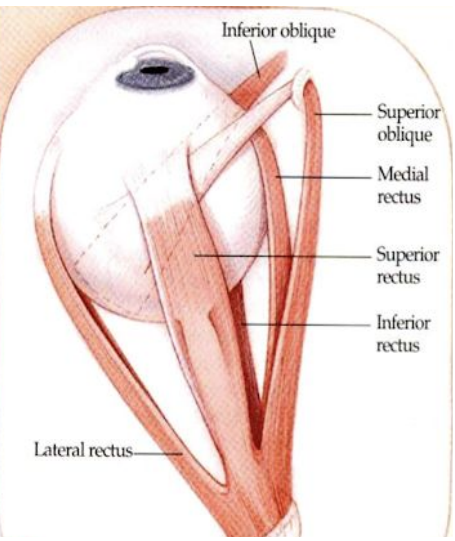


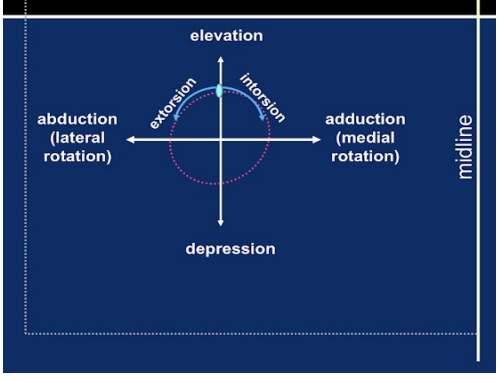


Muscle	Primary	Secondary	Tertiary
Medial rectus	Adduction		
Lateral rectus	Abduction		
Inferior rectus	Depression	Excyclotorsion	Adduction
Superior rectus	Elevation	Incyclotorsion	Adduction
Inferior oblique	Excyclotorsion	Elevation	Abduction
Superior oblique	Incyclotorsion	Depression	Abduction

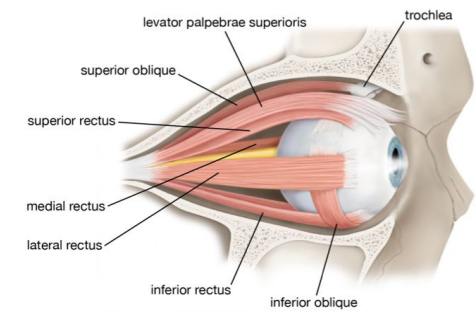






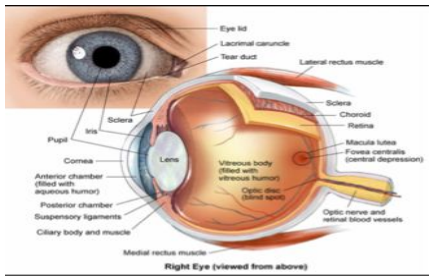


Muscles of the right eye



The Globe

The eye has three layers:



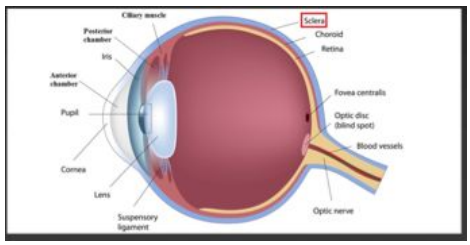
1) Outer fibrous layer:
   - cornea
   - sclera
   - lamina cribrosa.
2) Middle vascular layer ("uveal tract"):
   - iris
   - ciliary body – consisting of the pars plicata and pars plana
   - choroid
3) Inner nervous layer:
   - pigment epithelium of the retina
   - retinal photoreceptors
   - retinal neurons.

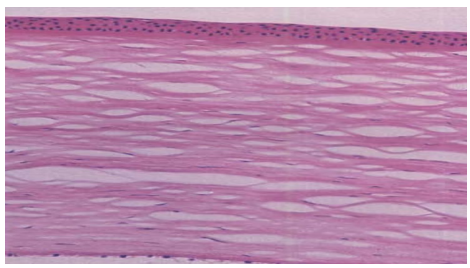
-2/3 of the refractive power of the eye is from the cornea while 1/3 is from the lens.

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.

The cornea has five layers antero-posteriorly:





1. Epithelium and its basement membrane nonkeratinized stratified squamous epithelium.
2. Bowman's layer – homogeneous sheet of modified stroma.
3. Stroma – forms 90% of total corneal thickness. Consists of lamellae of collagen, cells (Keratocytes) 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.

It has 5 layers

Layer (anterior to posterior)		condition
Epithelium	➢ continuation of the bulbar conjunctiva ➢ ectodermal origin	Abrasion. Treatment by covering the eye for 24hrs and defect will heal without scarring. Never use topical anesthesia in this case.
Bowman's membrane	clear **acellular** layer	Abrasion. Risk of scarring
Stroma	contains collagen fibrils that accounts for around 90% thickness	
Descemet's membrane		Disturbance of this layer is common in congenital glaucoma. Management is surgical via keratoplasty
Endothelium	Single layer	It end in the angle, we have to know if it's open or closed which is about schwalbe's line , trabecular meshwork , scleral spur , ciliary body and iris if all structures are seen that mean **open angle glaucoma while if all structures closed that mean closed angle.**

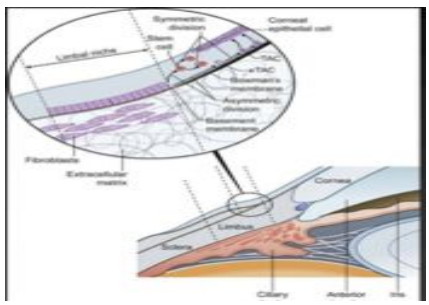
The Globe Cont.

Characteristics of the cornea:

- Clear, What structure maintains clarity? 1-because of arrangement of collagen fibers / 2-avascular /3- endothelium is forming a bulge that prevent fluid from accumulate inside bulge
- Avascular: supplied from tearfilm and aqueous.
- rich in sensory neurons. (Painful)
- Main refractive surface of the eye.

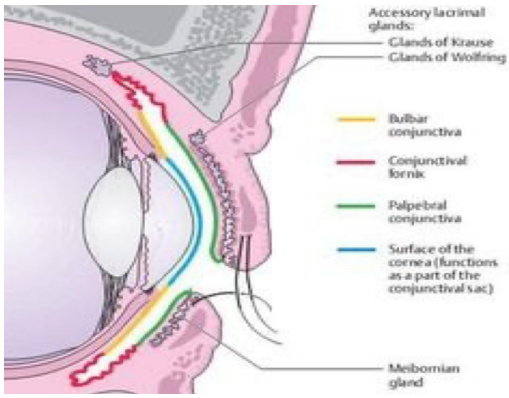
Limbus

- The junction between the cornea and sclera
- Area of corneal epithelial stem cells
- Stem cell deficiency: eg chemical burns
- Loss or malfunction of stem cells does not permit maintenance or regeneration of the corneal epithelial mass but leads to conjunctivalization of the corneal surface.



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 (Covers the sclera) and fornix.

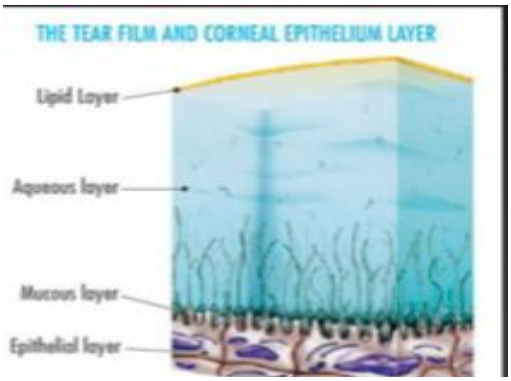


Tear film

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.

The most significant role of the lipid layer is in retarding evaporation of tears from the ocular surface. The aqueous/mucin layer forms the bulk of the tears.



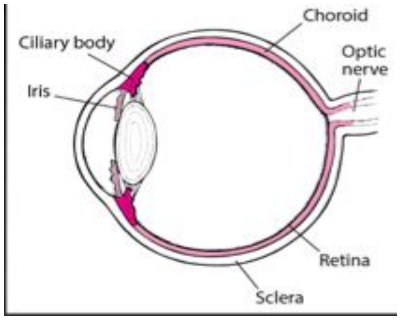
Sclera

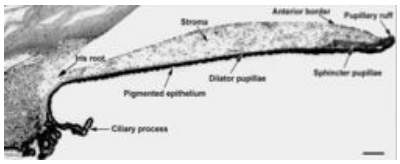
- The sclera consists of irregular lamellae of collagen fibers.
- Posteriorly, the external two thirds of the sclera become continuous with the dural sheath of the optic nerve.
- The inner one-third becomes the lamina cribrosa
- The episcleral is a layer of loose connective tissue deep to the conjunctiva, overlying the sclera.
- it's not clear and vascular
- The sclera is thickest posteriorly(become thinner as you go anterior) and thinnest beneath the insertions of the recti muscles. (first area of sclera)

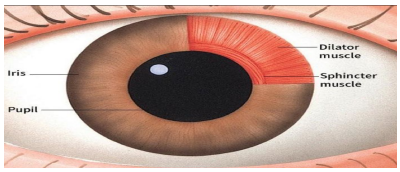
The Globe Cont.

Middle Layer

- The middle layer is highly vascular, called uveal 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.







Iris

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

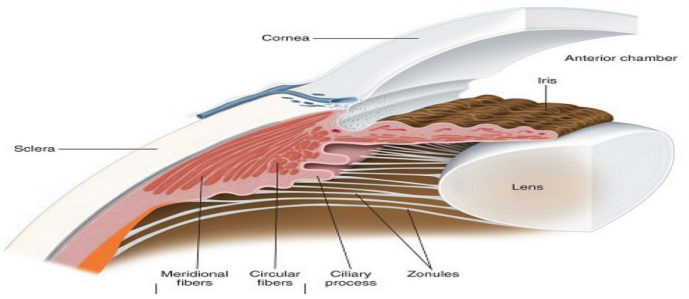
Ciliary body

- 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.

The inner side is divided into two zones:

- the pars plicata forms the anterior 2 mm and is covered by ciliary processes
- 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.

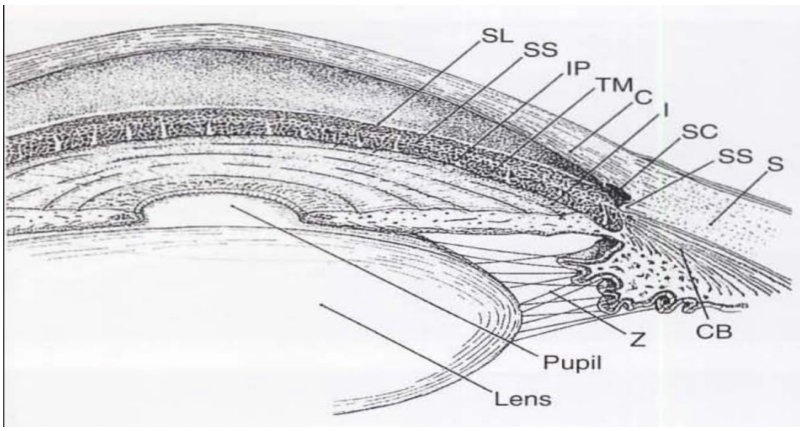
circular fibers has role in accommodation when it contracts it lead to relaxation of zonules and it becomes more thin and it can complete light mode

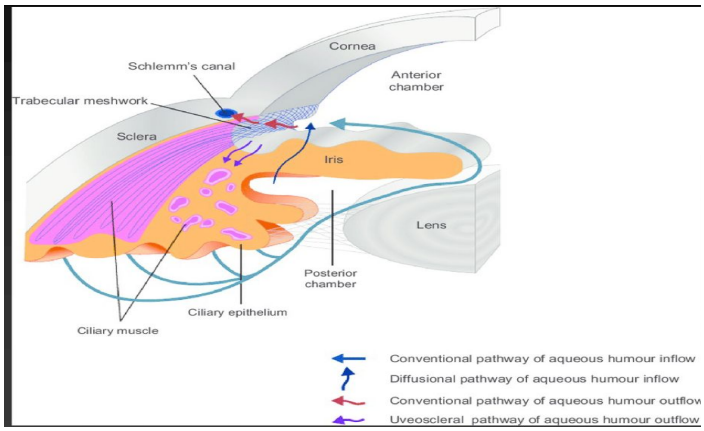


The Globe Cont.

Intraocular Pressure

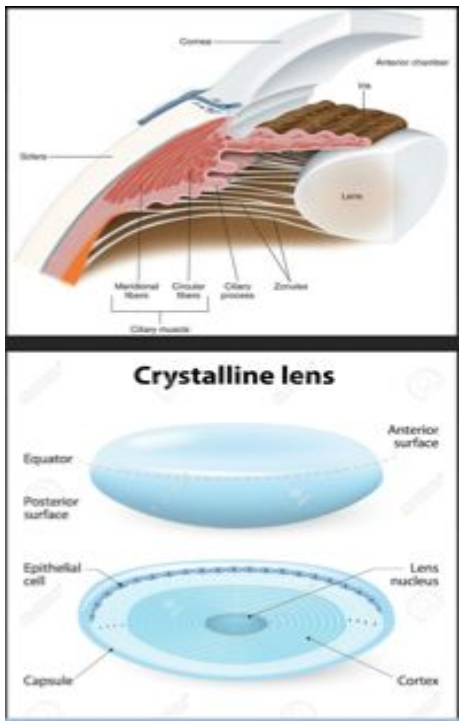
- The pressure within the eye is maintained at a steady level by continuous formation & drainage of aqueous.
- Aqueous is secreted by the ciliary epithelium → posterior chamber → anterior chamber (through the pupil) → drained through the anterior chamber angle.
- The intraocular pressure (IOP) is normally 10 – 21 mmHg; increased IOP called Glaucoma (glaucoma is a triad of high IOP enough to induce optic n. damage manifested by visual field defect).
- The most important is to know the baseline. If someone's IOP baseline is 12 and now is 20, this is considered high & should be investigated.
- If the IOP is increased and there is no damage to the nerve we call it Ocular hypertension, but if the IOP is normal and there is damage to the nerve we call it Normal tension glaucoma.
- High IOP almost always due to an obstruction of aqueous outflow
- low IOP always due to decrease production of aqueous fluid





Crystalline lens

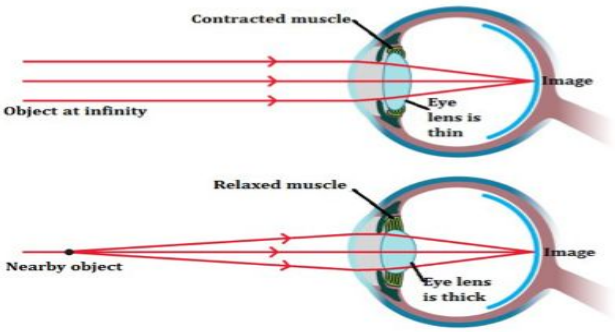
- Transparent avascular part, helps to focus the light on the retina.
- The only part of body that continue its enlargement thorough life.
- Suspended by the zonules.
- Changes in its structure leads to cataract.
- The crystalline lens is the only structure continuously growing throughout the life
- The power of the eye around 60 Dioptres.
- 1/3 from the lens and it has changeable power (accommodation)
- 2/3 from the cornea, this is why refractive surgery mainly directed towards the Cornea .

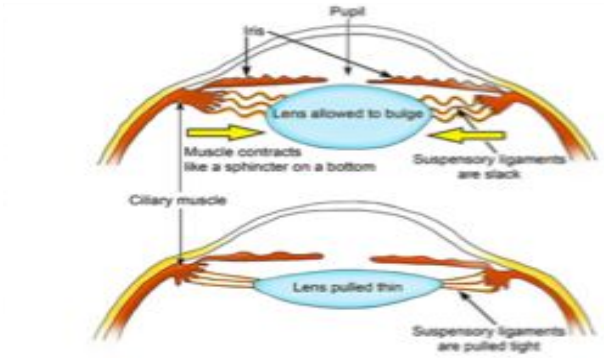


The Globe Cont.

Accommodation

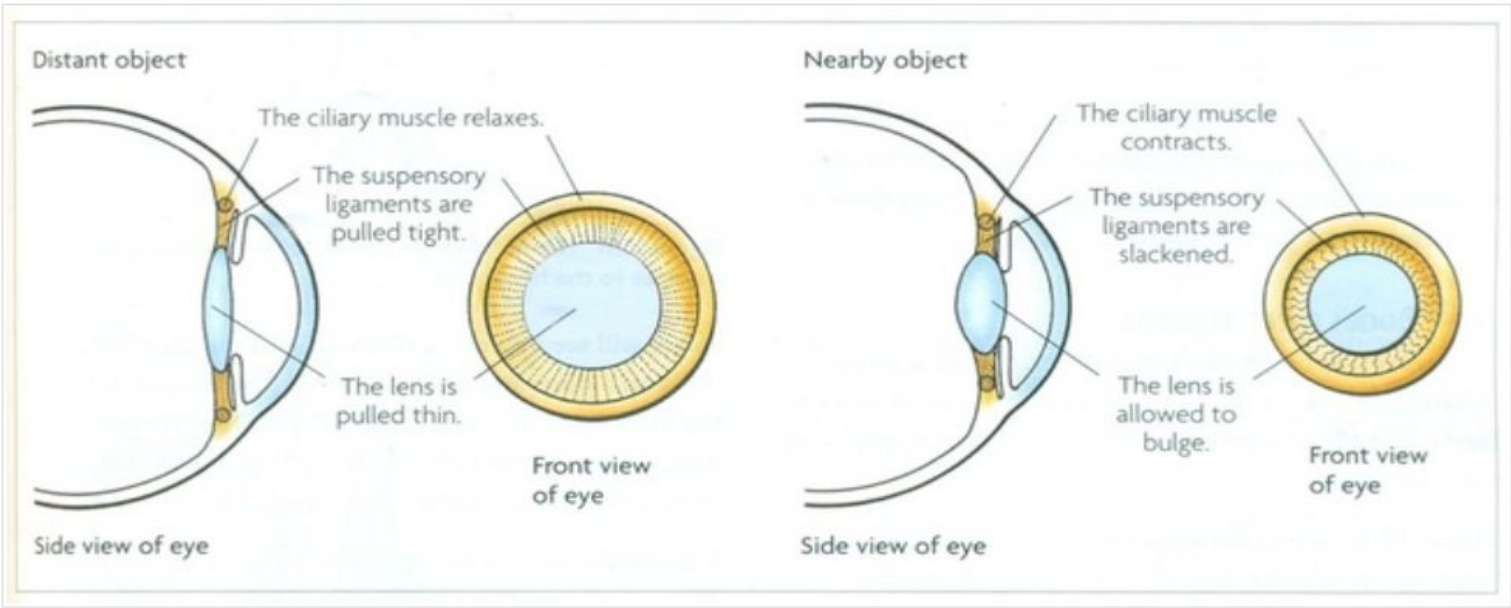
- What happens during accommodation?





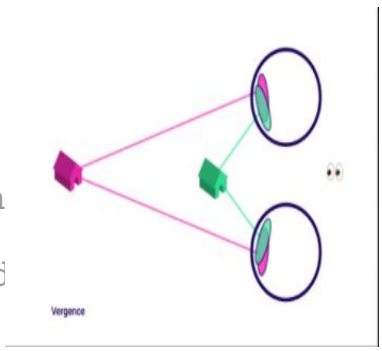
During far vision, the ciliary bodies relax, the zonule stretch, and **the lens flattens**. During near accommodation, the ciliary bodies contract (i.e., shorten), which relaxes the zonule and rounds the lens (i.e., thickens it). This brings the near object into focus.

- **Other elements of accommodation:**
  - Miosis



Distance objects
The ciliary muscles relax, giving them a larger diameter. This pulls on the suspensory ligaments which, in turn, pull on the lens. This makes the lens thinner (less convex). As the ciliary muscles are relaxed, there is no strain on the eye.

Near objects
The ciliary muscles contract, giving them a smaller diameter. This removes th tension on the suspensory ligaments which , in turn, stop pulling on the lens. The lens becomes thicker (more convex). As the ciliary muscles are contracted there is strain on the eye, which can cause a headache if a near object (book, microscope, computer screen etc.) is viewed for too long.

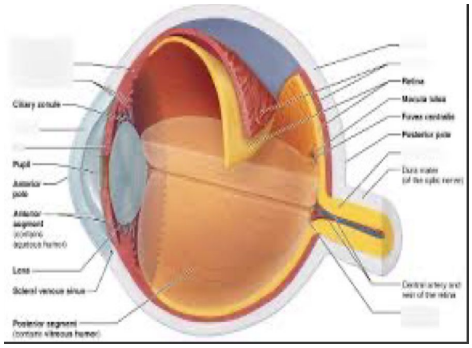


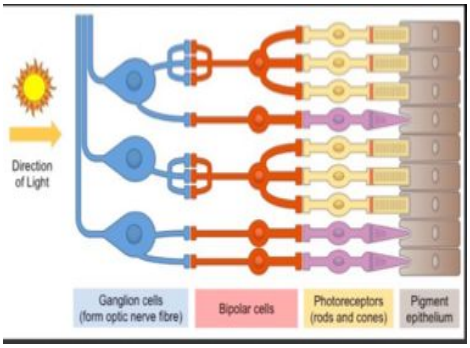
  - Convergence
    By medial rectus muscle

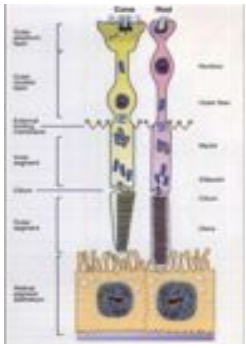
What is the relationship between accommodation and horizontal strabismus?

- patient with Farsightedness (hyperopia) will try to accommodate more to see near objects, they will start to converge their eyes more lead to accommodate Esotropia.

The Globe Cont.



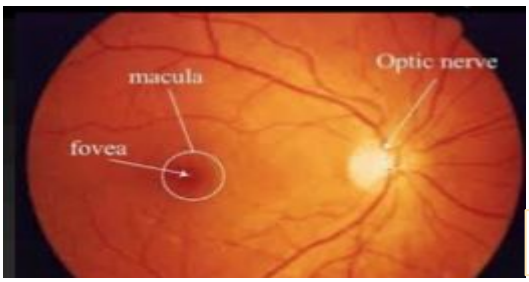




Inner Layer

The retina:

- outer pigment epithelium
- an inner sensory part
- rods night vision
- cons day vision
- 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.
- Normal fundus photograph by indirect opthalmoscopy (with indirect we can see a wide field while with direct we can see the optic nerve only)



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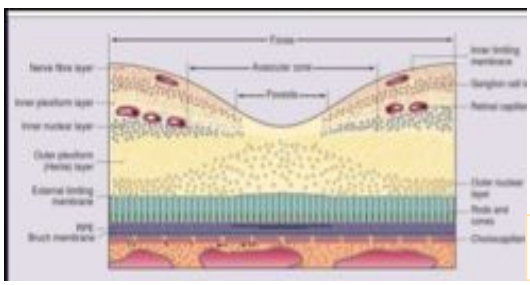


2

- More info regarding pic 1 & 2

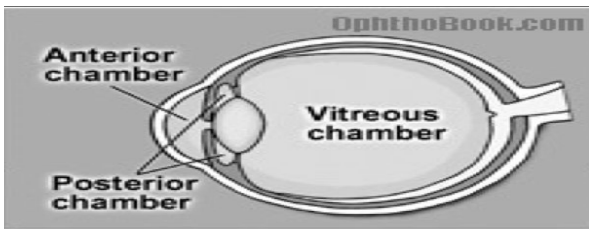
1) Optic nerve head: (from which the blood vessels is coming)
    - The first thing we look at is the optic nerve. It has a lot of diseases that you have to comment in the OSCE and determine any abnormality.
    - You can identify the optic nerve head clearly, but you cannot draw it with a pencil.
    - We call the central pale part the optic cup. It does not have any nerve fiber layer, and the normal disc to cup ratio is almost 0.3 (1/3). This is important because if we have any edema or any compression it won't be affected directly it gives time for the edema not to strangulate the optic nerve.

2) Macula and Fovea centralis:
- Fovea centralis is responsible for the highest visual acuity.
    - It has very condensed photoreceptors and no blood vessels (avascular). So, it takes its blood supply from the choroid behind it. Because if it has blood vessels, it will obstruct the passage of the light.
    - It is also sloppy, so the light will hit directly on the photoreceptors. You will see the sloping part as a ring in the fundus when you look at a normal fovea.
    - Since this part is thinner it will look darker, because it is highlighting the underlying choroid melanin pigment.

3) Artery. 4) Vein.
    - The artery is brighter and thinner than the vein, always the artery crosses over the vein.
- what area are avascular in eye 1-central cornea 2-lens 3- fovea centralis 4-vitreous

Chambers of The Eye

- Three optically clear spaces:
  - The anterior chamber, in front of the iris.
  - The posterior chamber, immediately behind the iris.
    - These two chambers which communicate through the pupil are filled with clear aqueous humor.
  - The vitreous cavity: filled by gel-like structure, the vitreous.
- The lens and cornea are avascular, so they obtain oxygen & nutrients from surrounding fluids (aqueous humor).
- Aqueous humor is produced by the epithelium of the ciliary body.
  - The ciliary body has pigmented & non-pigmented epithelium; the aqueous humor is secreted from the non-pigmented.
- It is secreted into the posterior chamber, from which it flows through the pupil to enter the anterior chamber, then it is drained into the canal of Schlemm through the trabecular meshwork and finally the episcleral venous pressure.
- Aqueous humor production is continuous & is not pressure gradient. So, if IOP is raised its production will not stop.
- Inflammation of the ciliary body (uveitis) causes atrophy of the eye.
- Abnormal blood collection in the anterior chamber is known as hyphema & is mainly due to trauma.
- Pus collection in the anterior chamber is known as hypopyon.

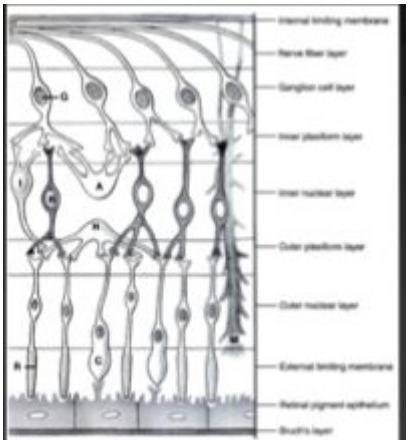


The Choroid

- The choroid is formed of arterioles, venules and a dense, fenestrated capillary network.
- It has a remarkably high blood flow.
- Contain high amount of melanin pigment.

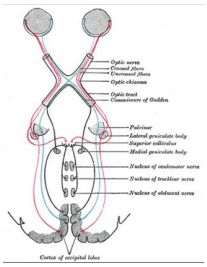
Optic Nerve

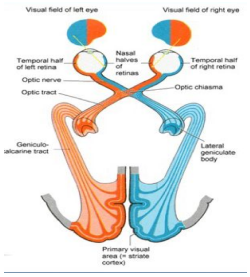
- contains around 1.2 million nerve fibers, which are axons of the retinal ganglion cells.
- 1 mm in the globe.
- 25 mm in the orbit.
- 9 mm in the optic canal.
- 16 mm in the cranial space



Visual pathway

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

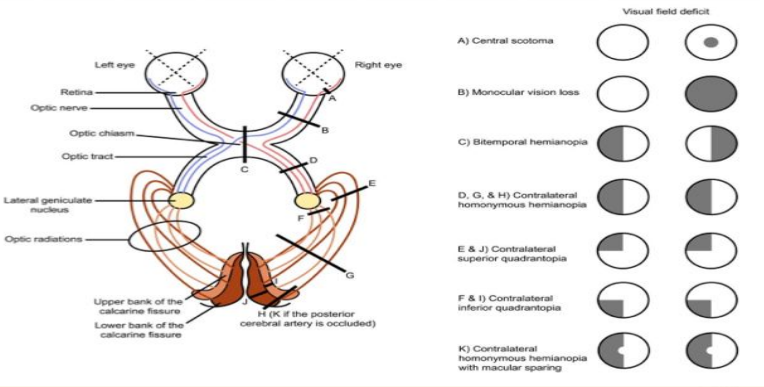




- Visual pathway three neurons:
  1. Bipolar cell lies within the retina.
  2. Ganglion cell, synapse in lateral geniculate body.
  3. Third neuron terminates in visual cortex.

- Why do we have decussation?
  - We have decussation so the right or left visual field from both eyes are processed in one visual cortex (the integrity of the image).
  - For example, the left visual field from both eyes get processed in the right visual cortex only, not right & left cortex.

IMP



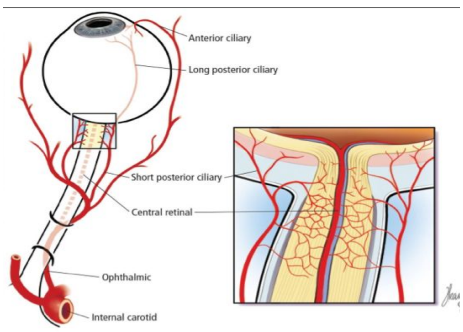
Process of Vision

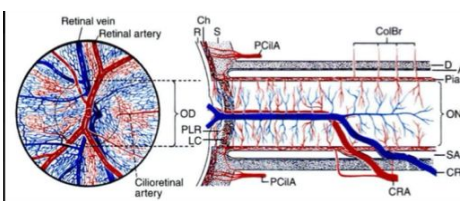
- The retina:
  - It is divided into retinal pigment epithelium (outermost) & neurosensory retina (innermost).
  - The neurosensory retina consists of the photoreceptors (rods and cones), the bipolar nerve layer (and horizontal nerve cells) and the ganglion cell layer, whose axons give rise to the innermost, nerve fiber layer.
    - These nerve fibers converge to the optic nerve head, where they form the optic nerve
- The retina has 10 layers: (1) the inner limiting membrane (2) the nerve fiber layer (3) the ganglion cell layer (4) the inner plexiform layer (5) the inner nuclear layer (6) the outer plexiform layer (7) the outer nuclear layer (8) the outer limiting membrane (9) the photoreceptor layer and (10) the retinal pigmented epithelium.

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, (supply retina)
- The anterior ciliary arteries (supply ciliary body and iris)
- The posterior ciliary arteries. (supply sclera)
- 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 which leave the eyeball from posterior four quadrants of the globe





Female doctor notes

Embryology of the eye

- The eye is only part of the body that internal structures can be seen with the naked eye.
- This highly specialized sensory organ is derived from:
  - Neural ectoderm.
  - Surface ectoderm.
  - Mesoderm.
  - Endoderm is not related to eye development.
- The eye is essentially an outgrowth from the brain (neural ectoderm)
- Started as **Optic vesicle** connected to the forebrain by **Optic stalk**.
  - Looking at the budding of the eyes, it starts as a cup that buds and narrows moving anteriorly with time.
  - The optic vesicle will stimulate the surface ectoderm to invaginate which will stimulate the cup to be depressed and form claves, after that the surface ectoderm will separate which forms the primitive lens and the two layers will form the neurosensory part of the retina. we have a potential space between these two layers which will lead to retinal detachment is created.
  - One step of development stimulates the next step, so if there is maldevelopment in one of the steps, the next will be affected.
- ALL structures of the developing eye are highly vascularized, but later in development some of these structures will avascular and clear to allow passage of light, they are: cornea, lens, and vitreous.
- The blood vessels invaginate the eyes are coming from inferio-nasal aspect, so the globe is not a continuous structure at development. And this is the last area that become completely fused. So, if we have defective fusion of this area, it will be evident after birth as defect on the sclera, choroid, iris and lens and that called coloboma. Other sites indicate trauma to the eye but they are not congenital.
- If the vessels do not disappear this is called persistent hyperplastic primary vitreous which results in absence of red reflex (also called dim red reflex, white red reflex, cat eye).
- Leukocoria = absence of red reflex in pediatrics.

Development of the eye after birth

- At birth, the eye is relatively large in relation to the rest of the body.
- Refraction depends on:
  - Curvature of refractive surface : cornea or lens
  - Axial length : the distance between the screen and the lens (size of eye)
    - HYPEROPIA: If power is fixed and the screen is moving anteriorly, the image will focus behind the screen
    - MYOPIA: If power is fixed and the screen is moving posteriorly, the image will focus in front of the screen
    - So, bc children have smaller eyes, having hyperopia up to 1.5 diopter is normal.
- The iris has a bluish color due to little or no pigment on the anterior surface.
- During early infant life, the cornea & sclera can be stretched by raised IOP › enlargement of the eye.
- The eye reaches full size by the age of 8 years.
- The lens continues to enlarge throughout the life. That is why we need reading glasses as we get older due to the added fibers so we need added power to see clearly, bc the harder the lens gets the less power it has.
- High pressure IOP> eyes expand, giving us congenital glaucoma, which will give myopia.

The orbit

- Bony cage protecting the eye Seven bones contribute the bony orbit.
  - Single bone: ethmoid, sphenoid, frontal.
  - Paired bones: palatine, maxillary, lacrimal, zygomatic.
- As a socket, contains & protect the eye.
- Seven bones contribute the bony orbit.
- The weakest parts are the floor & the medial wall.
- Surrounded by nasal sinuses.
- Important openings are: (exam question)
  - Optic foramen.Most important: optic nerve & ophthalmic artery.
  - Superior orbital fissure. Oculomotor, trochlear, abducens, lacrimal, naso- ciliary and frontal nerves. superior and inferior ophthalmic veins.
  - Inferior orbital fissure. Infraorbital bundle: nerve (from maxillary division of trigeminal), vein, artery.
  - If I mentioned something you don't know, say it passes through the superior orbital fissure.
  - all extra ocular muscles come from the apex of orbit (annulus of zinn). except inferior oblique (coming from anterior)
- Regarding the orbit, which wall is the most likely to have trauma? The lateral wall and that is why it is the strongest.
- The medial wall is the thinnest, increasing the risk of orbital cellulitis due to sinus infection (in pediatric age group)
- The inferior wall (maxillary sinus dome) the weakest is most likely to be blowout fracture due to its dome shape and irregularities.
- Sinuses : surrounding the eye (frontal, ethmoid, sphenoid, maxillary), frontal is not yet developed in pediatric age group.

The extraocular muscles

- If we first open the eye the first muscle we will see is the levator (eyelids) then superior oblique
- 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 Abducent (6) nerve) and superior oblique (Trochlear (4) nerve).
  - The levator muscles and intraocular muscles (accumudation) are also supplied by the oculomotor
- All the extraocular muscles except the inferior oblique originate from a fibrous ring around the optic nerve (annulus of Zinn) at the orbital apex.
- Optic chiasm is usually in front or superior to the pituitary, so pituitary mass can affect vision.
- Abducens is the only nerve within the cavernous sinus and the first to be affected by a carotid cavernous fistula or aneurysm. It supplies the lateral rectus, so when it is affected it will give us inward deviation.
- The optic nerve, the ophthalmic blood vessels and the nerves to the extraocular muscles (except fourth nerve) are contained within the muscle cone
- If the anatomical axis of the muscle is the same as the axis of the globe it will have one action.
- Both superior rectus & inferior oblique elevate the eye, so how to test each muscle separately?
  - For superior rectus, let patient look laterally then up.
  - For inferior oblique, let patient look medially then up.
  - Same concept for inferior rectus & superior oblique.
- General roles to help you memorize:
  - All recti are adductors EXCEPT lateral rectus which is abductor
  - All obliques are abductors. - So, three muscles are adductors & three are abductors.
  - All superiors are intortors (intorsion).
  - All inferior are extortors.
- The equator is the longest diameter of any bone (here we are talking about the orbit)
  - All recti are attached anterior to the equator. So, contraction of the superior will induce elevation and contraction of the inferior will induce depression.
  - All obliques are attached posterior to the equator. So, contraction of the superior will induce depression and contraction of the inferior will induce elevation.
- Why we have intorsion & extortion movements? For compensatory movement with our head.
- Eye is important in 6 cranial nerves: optic (vision),
- Tricky thing in MCQs: Superior oblique depresses the eye ON adduction (so the adductor here is another muscle). Be sure to differentiate between ON & AND
- Hence for clinical test

	Direction to look
• SO	• Down and in
• IO	• Up and in
• SR	• Up and out
• IR	• Down and out

[R=0, O=I]

The Eyelids

- They provide a protective covering for the eye.and spread precorneal tear film (which is the source of supply to cornea).
- The lids are: closed by Orbicularis oculi muscle (Facial n.) opened with Levator palpebrae muscle (Oculomotor n.), Muller's muscle (Sympathetic supply) & Lower lid retractors.
- Orbital septum (from periosteum) protects the eye from sagging out due to gravity, protects the fat from protruding, and protects from infection.

The Conjunctiva

- Three parts
  - Bulbar conjunctiva over sclera
  - Palpebral conjunctiva lining the eyelid
  - Forniceal conjunctiva the junction
- Limbus (imp surgical landmark)
- The stroma (no adenoid tissues until 3 months after birth)
- Follicles and papillae
- Injection (red eye, inflam of conjunctiva) and chemosis

Lacrimal Apparatus

- Physiology
  - Tear secretion.tear goes from lateral to medial on eye closure > orbicularis subtracts leading to lacrimal duct exoansuon.
  - Layers of precorneal tear film.
  - Drainage of tear.
  - Lacrimal gland has two parts: 1- orbital part: hidden, not palpable) 2-palpebral part

THE EYE (GLOBE)

- Two spheres with different radi:
  - Cornea, window of the eye.
  - Sclera, opaque shell.
- The eye measures approximately 24 mm in all its main diameters.

The Coats of The Eye

- **Three layers:**
  - **The outer:** inelastic coat, transparent cornea and opaque sclera.
  - **The middle, vascular coat, The Uvea:** choroid, ciliary body and iris.
  - **The inner:** The Retina, extends forwards to within 6 mm of the limbus.

The Chambers of The Eye

- **Three optically clear spaces:**
  - The anterior chamber, in front of the iris
  - The posterior chamber, immediately behind the iris.
  - These two chambers which communicate through the pupil are filled with clear aqueous humour.
  - The vitreous cavity: filled by gel-like structure, The Vitreous.
  - Open Vs. closed angle glaucoma, difference in management medical Vs. surgical.

The Intraocular Pressure IOP

- The pressure within the eye is maintained at a steady level by continuous formation & drainage of aqueous. (Production doesn't depend on pressure)
- Aqueous is secreted by the ciliary epithelium › posterior chamber › anterior chamber (through the pupil) -> drained through the anterior chamber angle.
- The intraocular pressure, (IOP), is normally 10 - 21 mmHg; increased IOP called Glaucoma.
- High IP almost always due to an obstruction of aqueous outflow. Production is fixed

The lens

- The crystalline lens is the only structure continuously growing throughout the life.
- Capsule, epithelium and lens fibers.
- Cataract.
- Congenital anomalies and effect of systemic diseases.

Retina and Vitreous

- Optic nerve head, macula, fovea(avascular to focus photons without scattering increasing VA) , retinal background, Ora serrata, and retinal vasculature.
- Vitreous attachment.
- Retinal detachment.
- Effect of systemic diseases.
- The artery is brighter and thinner than the vein, always the artery crosses over the vein.

PROCESS OF VISION

- Function of the eye:
- Receive the image and change it into language that the brain can understand
- The retina:
  - It is divided into retinal pigment epithelium & neurosensory retina.
  - Photoreceptors contains visual pigment (11-cis-retinal) that changes into Rhodopsin upon light stimulation

Visual pathway

- Three neurons

1. Bipolar cell, lies within the retina.
2. Ganglion cell, synapse in lateral geniculate body.
3. Third neuron terminates in Visual cortex.

Summary

The Orbit

- Seven bones contribute the bony orbit. (frontal, zygomatic "temporal" , maxillary,sphenoid, ethmoid, palatine & lacrimal).
- The weakest parts are the floor & the medial wall. Surrounded by nasal sinuses.
- Important openings are:
  1. Optic foramen
  2. Superior orbital fissure.
  3. Inferior orbital fissure.

The globe

- The eye has three layers:

1) Outer fibrous layer:

- cornea
- sclera
- lamina cribrosa.

Middle vascular layer ("uveal tract"):

- iris
- ciliary body – consisting of the pars plicata and pars plana
- choroid

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 limbu

Middle layer

- The middle layer is highly vascular, called uveal 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.

Inner layer

The retina:

- outer pigment epithelium
- an inner sensory part
- rods night vision
- cons day vision
- ighest 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.

Chambers of the Eye

The **anterior chamber behind the cornea**. The posterior chamber sits behind the iris and in front of the lens, while the vitreous chamber fills the majority of the eye behind the iris.

Visual pathway

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

Summary

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, (supply retina)
- The anterior ciliary arteries (supply ciliary body and iris)
- The posterior ciliary arteries. (supply sclera

Extraocular muscle

- 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)

Lecture Quiz

1- Regarding anatomy of the orbit, which statement is false:
- A- The thinnest wall is the medial wall.
- B- The weakest wall is the floor.
- C- The ophthalmic artery passes through optic canal.
- D- The superior division of oculomotor nerve passes through the superior orbital fissure.
- E- The inferior division of oculomotor nerve passes through the inferior orbital fissure.

2- Regarding extra-ocular muscles, which statement is false:
- A- All are supplied with oculomotor nerve except the lateral rectus.
- B- The superior rectus elevates the eye on abduction.
- C- The inferior rectus depresses the eye on abduction.
- D- Superior oblique depresses the eye on adduction.
- E- Inferior oblique elevates the eye on adduction.

3- Which muscle doesn't take origin from the orbital apex?
- A- Inferior oblique
- B- inferior rectus
- C- Superior oblique
- D- Levator palpebrae superioris

4- Photoreceptors, all are true EXCEPT:
- A- Visual acuity is partly of function of rod
- B- Color vision is the function of the cons
- C- Night function is the function of the rod
- D- Optic nerve contains about one million fibers
- E- Optic nerve has no receptors

5- Chambers of the eye are
- A- anterior chamber
- B- posterior chamber
- C- non the above
- D- a&b

6- tennis ball player had a trauma to the orbit complaining of enophthalmos and inability to elevate the eye. What is the most likely diagnosis?
A- Fracture to the medial side
B- Orbital floor fracture
C- 3rd nerve palsy
D- 6th nerve palsy

1-E 2-A 3-A 4-A 5-D 6-B

OPTHALMOLOGY TEAM

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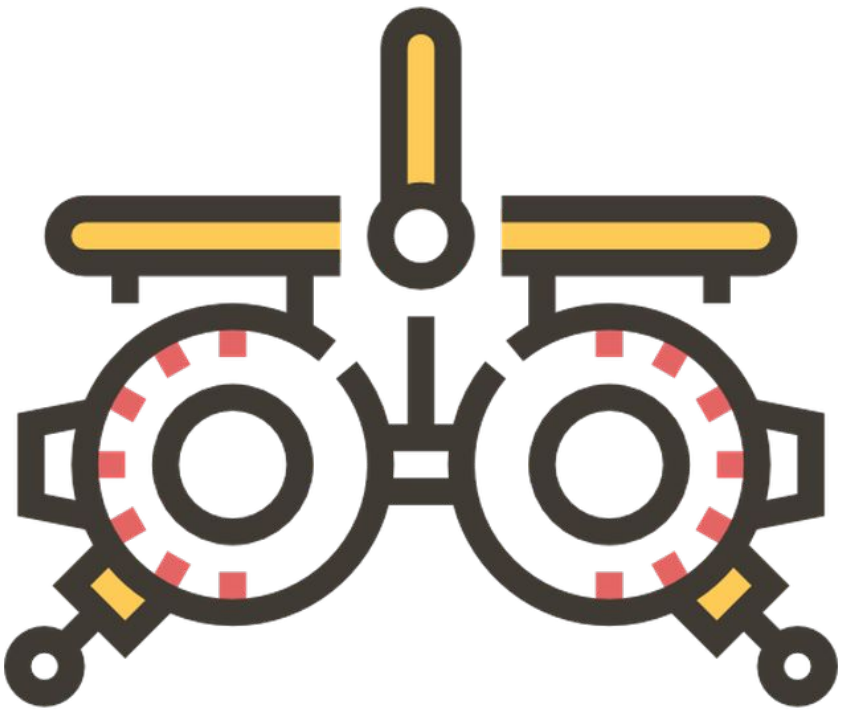

To your Lord is the ultimate knowledge of it

The Noble Quran: 79:44