Lecture 2

v1.01

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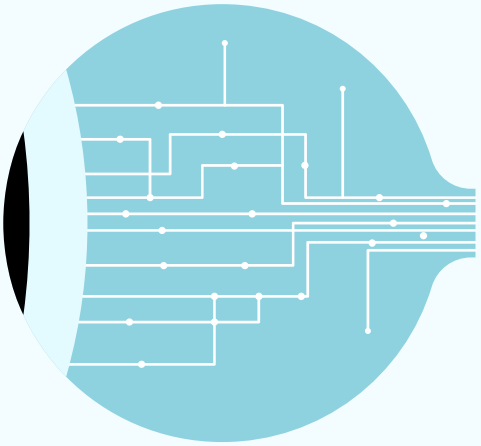

Basic anatomy and physiology of the eye

Presented by: Dr. Abdullah Almousa

Objectives of the course:

- Discuss **embryology** of the eye
- Explore anatomy of the **orbit**.
- Explore anatomy and physiology of **EOM**
- Explore anatomy of the **eyelid** and **conjunctiva**
- Explore anatomy of the **globe**
- Explore anatomy of the **visual pathway**.
- Understand the **physiology** of vision, accommodation, pupillary reflex and tear drainage

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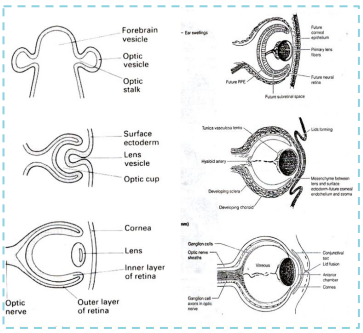
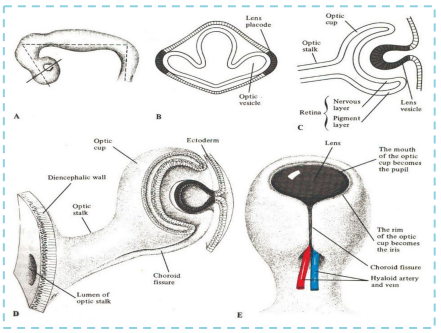
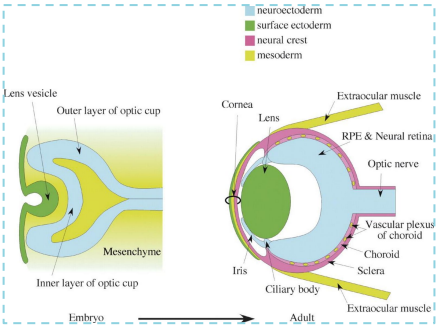
Embryology of the eye

- This highly specialized sensory organ is derived from neural ectoderm, mesoderm and surface ectoderm
- The eye is essentially an outgrowth from the **brain** (neural ectoderm).
- Start as the **Optic vesicle** connected to the forebrain by **Optic stalk**.







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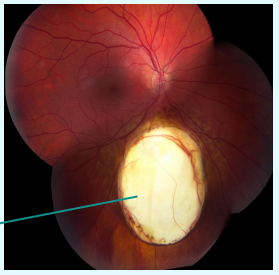
- During development of the eye, all structures of the eye are vascular (important).
- At the end of embryogenesis, **the lens**, **vitreous** & **cornea** become avascular which ensures clarity of the media for the passage of light to be focused on the retina to be able to see.
- Hyaloid vessels vascularize 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

Know the important parts (Lens, Retina, Vitreous, Cornea, Conjunctiva, Optic nerve) only and from where it is derived from (IMP FOR MCQs)
ectodrem:
1- lens
2- Base cornea (surface epithelium)
3- conjunctiva
neuroectoderm:
1- optic nerve
2- muscle of iris
3- retina
Mesoderm:
1-extraocular muscles
2-blood vessel

Embryology of the eye Cont.

Iris Coloboma:



- A **coloboma** (from the Greek: koloboma, meaning defect).
- **Iris colobomas** are located in the **inferonasal quadrant**.
- They are caused by failure of the **embryonic fissure (optic cup)** **to close** in the **5th** week of gestation, resulting in a "**keyhole-shaped**" pupil.
- They may be associated with colobomas of the ciliary body, choroid, retina, or optic nerve.
- **Related conditions:** CHARGE syndrome and Treacher Collins syndrome.

retinochoroidal coloboma
-can cause retinal detachment

Craniosynostosis:

- A premature closure of cranial sutures
- The orbit will be smaller and patient will present with bulging of the eye (proptosis).
- Abnormal closure of brain sutures the orbit bones fused together in early of life no expansion of orbit. clear exophthalmos cause small orbit, Later they have poor vision because of optic atrophy.
- They need surgery to avoid developing optic atrophy and complication
- eg: **Crouzon syndrome**

Development Of the Eye After Birth:

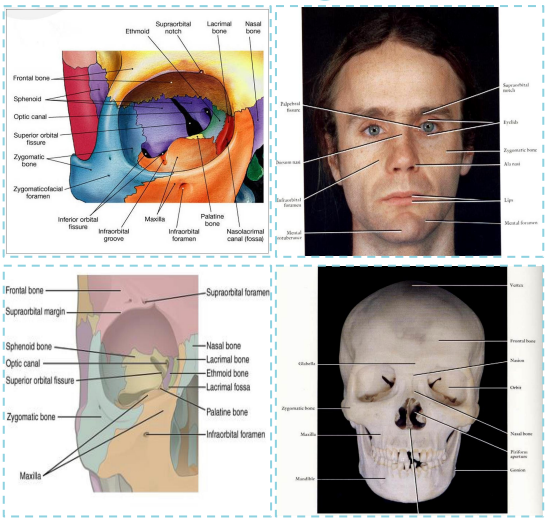
An abnormal IOP in the first 2 years can cause megalocornea

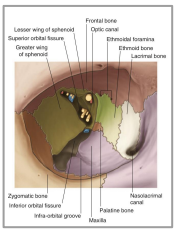
- At birth, the eye is relatively large in relation to the rest of the body.
- The eye reaches **full size by the age of 8 years**.
- During **early** infant life, the cornea & sclera can be **stretched by raised IOP** → enlargement of the eye.
- The **lens** continues to **enlarge throughout life**.
- The **iris** at birth has a bluish color due to **little or no pigment** on the anterior surface, then the pigment will increase with time until it becomes brownish.

Every beginning is difficult, but it gets easier from there on!

The Orbit

- The orbit surrounds the eye and provide protection.
- As a socket, contains & protect the eye, **seven** bones contribute the bony orbit (**frontal, zygomatic, maxillary, sphenoid, ethmoid, palatine & lacrimal**). **IMP to** know them, you may get asked about it. ★
- The optic canal is formed by sphenoid bone
- The **weakest** parts are the **floor** & the **medial wall**.
- Surrounded by nasal sinuses. (So if a patient have orbital cellulitis, he is more prone to develop sinusitis).
- Trauma is usually common in the temporal wall.
- The orbital wall have different thickness
- Fractures of the orbit are called “blow-out fracture”





Roof

- Formed by frontal bone

Lateral (temporal wall)

- Formed by zygomatic bone & greater wing of sphenoid.
- the **thickest** and **strongest.** (zygomatic bone) as it is more prone to trauma 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

Medial (Nasal wall)

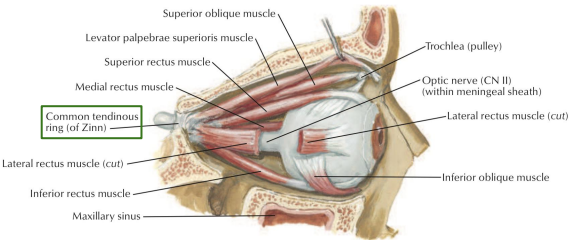
- Formed by part of frontal, ethmoidal, lacrimal bones & lesser wing of sphenoid bone.
- The **thinnest** wall
- ethmoid sinus are separated by a very thin straight bone called **lamina papyracea**. Being thin makes it a very common source of infection; thus:
  - The most common site of infection is the medial wall + the floor
  - A patient with sinusitis commonly presents with orbital cellulitis

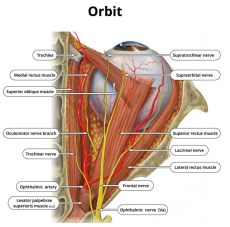
Floor (Inferior wall)

- Formed by zygomatic, maxillary & palatine bone.
- Slightly thicker than medial wall but it’s also very thin
- 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)

The Orbit Cont.

- Annulus of zinn (other names: common tendinous ring, annular tendon) is a fibrous band surrounds the optic nerve and gives origin to the for recti 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.



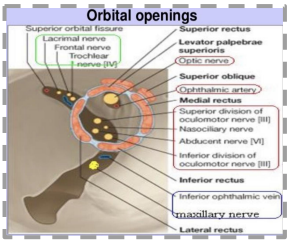


Orbital Foramina (important): ★

- These are important anatomical relations you should keep in mind, because if you have disease that affect the area can affect structures close to it
- You are supposed to know the openings of the orbit, and what structures go through them ★

Optic canal
Most IMP

1. Optic nerve
2. Ophthalmic artery



Superior orbital fissure

ANY STRUCTURE NOT MENTIONED IN OTHER OPENINGS

4 Structures pases inside annulus of zinn (intraconal):

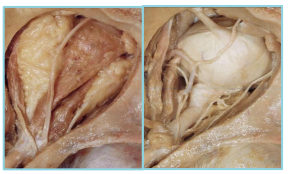
1. Oculomotor nerve III (Superior and Inferior branches)
2. Abducens nerve VI
3. Nasociliary nerve branch of V

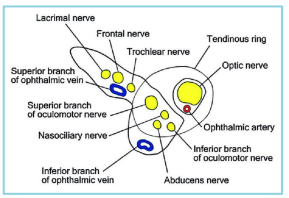
4 Structures pases above annulus of zinn (extraconal):

1. Frontal nerve branch of V
2. Lacrimal nerve branch of V
3. Trochlear nerve IV
4. Superior ophthalmic vein

Inferior orbital fissure

1. Inferior ophthalmic vein
2. Maxillary nerve branch of V
3. Infraorbital nerve.
4. Infraorbital vessels.





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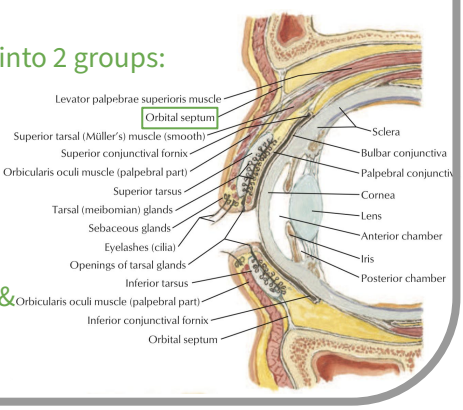
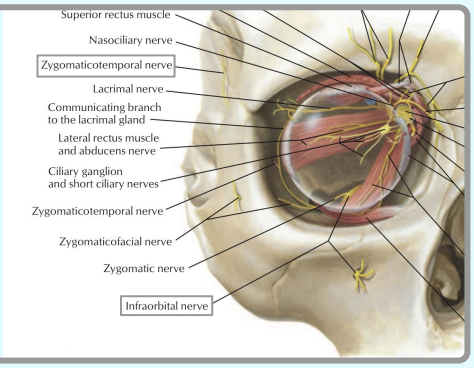
- All the extraocular muscles except the inferior oblique originate from a fibrous ring around the optic nerve (annulus of Zinn) at the orbital apex.
- If I mentioned something you don't know, say it passes through the superior orbital fissure.
- The bone is covered with periorbita (periosteum) which 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.



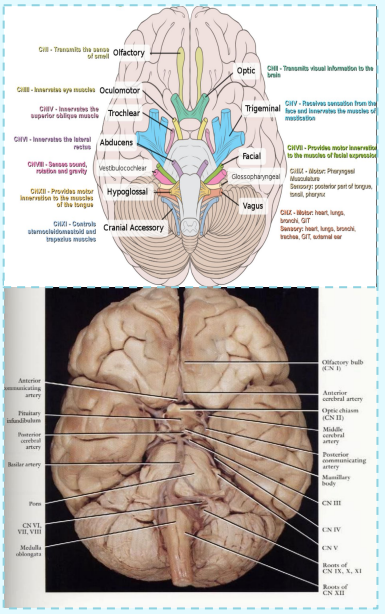
The Orbit Cont.

Infraorbital nerve:

- The infraorbital nerve is a purely sensory nerve derived from the second maxillary division of the trigeminal nerve
- Commonly injured in orbital floor fracture.
- when you get a scenario saying a patient present with paresthesia of the lower lid or cheeks, what nerve is affected? Infra-orbital nerve.
- if loss of sensation over the forehead, the Zygomaticotemporal is the affected

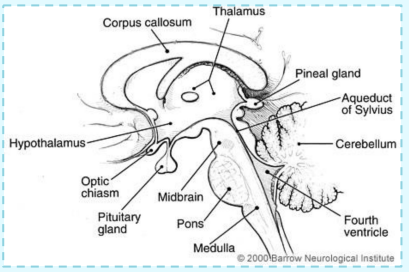


This image to simplify the functions of nerves:
Optic nerve: vision
Oculomotor nerve: eye movement (+eyelids)
Trochlear nerve: eye movement
Trigeminal nerve: providing sensations
Abducens nerve: lateral rectus
Facial nerve: providing orbicularis oculi muscle movements (closing the eye)
8th nerve: balance, nystagmus

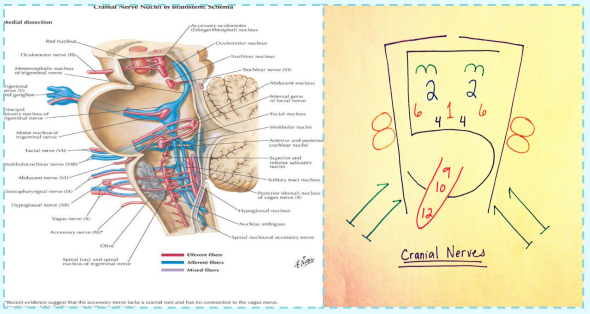


Important relationship between:

- **Pituitary adenoma** is very close to the optic chiasm, so it can compress the optic chiasm and cause **visual field loss & poor vision**
- Diseases affecting midbrain & pons will compress the cranial nerves adjacent to them.
- midbrain & cerebral aqueduct (if tumor to this area will affect midbrain & defect to 3rd nerve).



Origin of nuclei of cranial nerves (sensory, motor,autonomic)
We will not ask you about deep anatomy.



Extraocular Muscles

There are **six** extraocular muscles moving the eye: **Four recti: superior**, **inferior**, **medial** and **lateral recti**, and **two oblique: superior** and **inferior obliques**.

All these muscles are supplied by the third cranial nerve (Oculomotor n.) **except lateral rectus** (supplied by the Abducent n.) and **superior oblique**(responsible for reading action)(Trochlear n.).
The levator muscles are supplied by the oculomotor nerve

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All the extraocular muscles except the inferior oblique originate from a fibrous ring around the optic nerve (annulus of Zinn) at the orbital apex.
The levator muscles originate posteriorly adjacent to the superior rectus muscle

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

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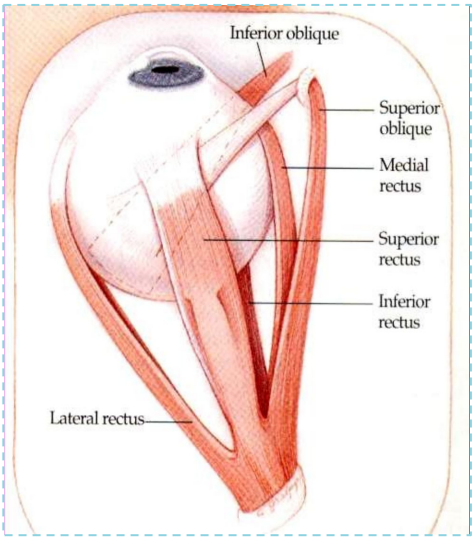
Both superior rectus & inferior oblique elevate the eye, so how to test each muscle separately?

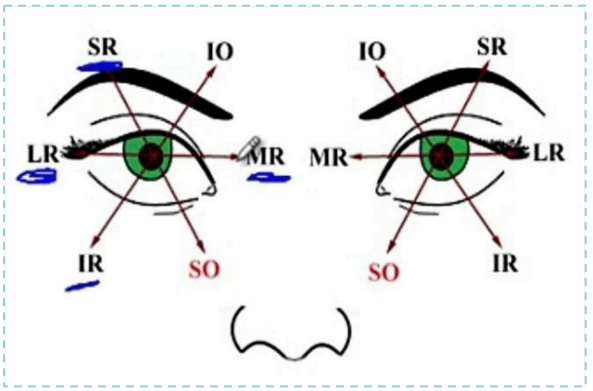
- For superior rectus, let patient look laterally then up.
- For inferior oblique, let patient look medially then up.
- Same concept for inferior rectus & superior oblique.
  - Recti muscles on each corner but the oblique different superior on position because of tendon insertion come to trochlear bone. When the muscle contract the eye move (in,down) عصله قراءه
  - Inferior oblique comes beneath of eye and if contract the eye move (in,up)

General roles to help you memorize:

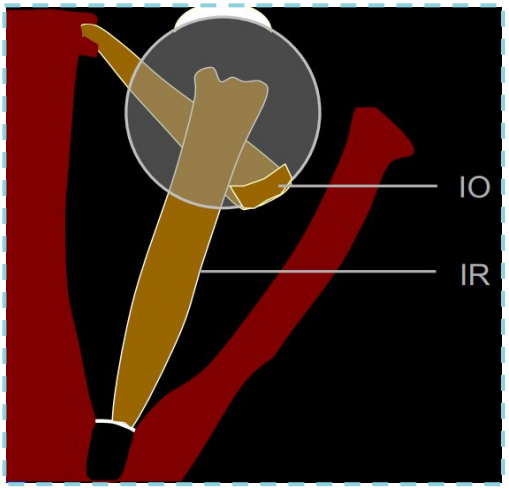
- All recti are adductors EXCEPT lateral rectus which is abductor
- All obliques are abductors. So, three muscles are adductors & three are abductors.
- All superiors are intortors (intorsion).
- All inferior are extortors.

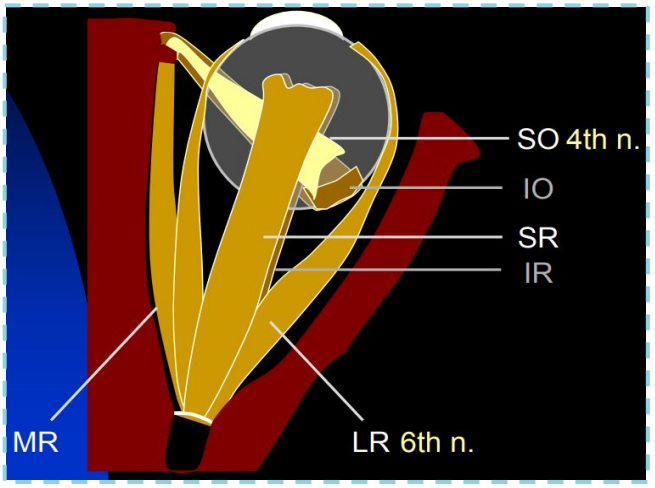
Why we have intorsion & extortion movements? For compensatory movement with our head.
Tricky thing in MCQs: Superior oblique depresses the eye ON adduction (so the adductor here is another muscle). Be sure to differentiate between ON & AND



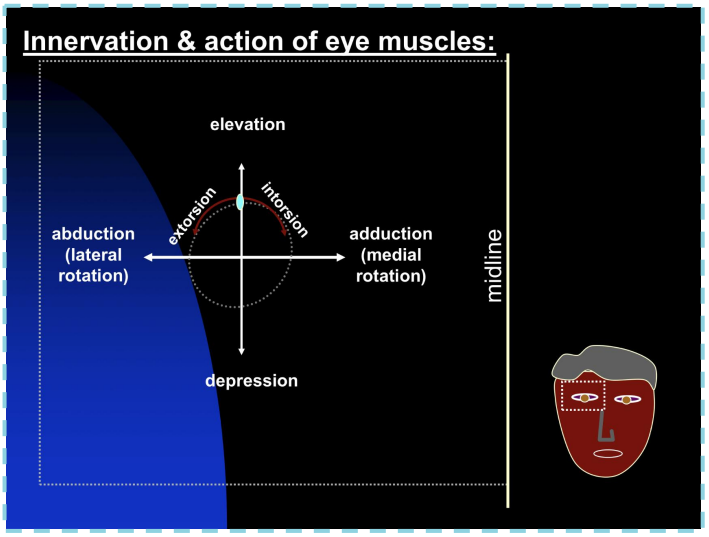


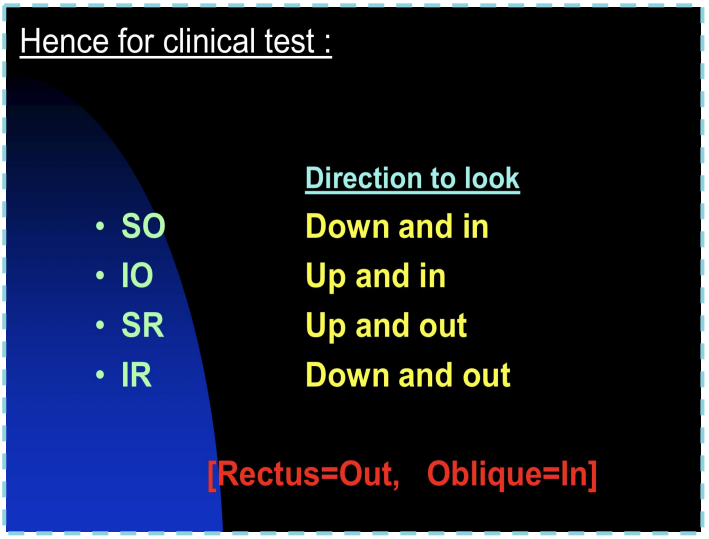
Attachment of eye muscles:





Innervation & action of eye muscles:





- Primary actions of eye muscles:
  - Elevation, depression, adduction, and abduction.
- Secondary actions of eye muscles:
  - Intorsion, and extortion (Circular movement, they will move if you rotate your head).

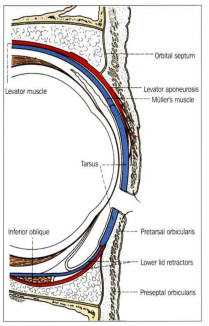
Extraocular muscles function

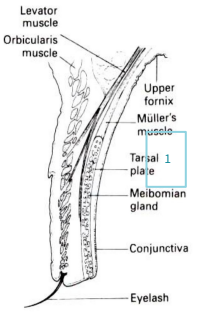
Muscle	Primary	Secondary	Tertiary
Medial rectus	Adduction		
Lateral rectus	Abduction		
Inferior rectus	Depression	Excyclotorsion	Adduction
Superior rectus	Elevation	Incyclotorsion	Adduction
Inferior oblique	Excyclotorsion	Elevation	Abduction
Superior oblique	Incyclotorsion	Depression	Abduction

Extra

The Eyelids

- They provide a protective covering for the eye.(distribute tear film)
- The lids are **closed** by Orbicularis oculi muscle (Facial n.) and **opened** with Levator palpebrae muscle (Oculomotor n.), Muller's muscle (Sympathetic supply) assist in the opening of eyelids & Lower lid retractors.
- In case of Horner syndrome, Muller's muscle is not functioning that's why the patient will have ptosis.





1- it's cartilaginous part gives attachment to Muller's and Lower lid retractors muscles

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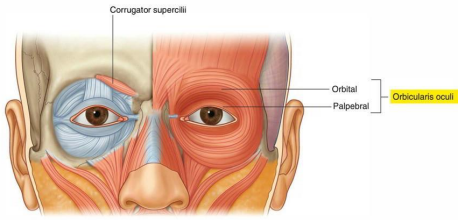
The lids are:

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).

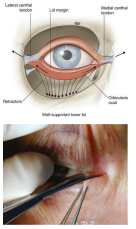
Opened

- with Levator palpebrae muscle (innervated by oculomotor n. Superior division), Muller's muscle (sympathetic supply) & Lower lid retractors.
- muller muscle connect the inferior part of levator to facial plate
- 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.
- ptosis may be due to a myogenic, neurogenic, aponeurotic, mechanical or traumatic cause.



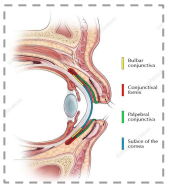
Orbital compartment syndrome:

- If the pressure inside the orbit increased for any reason the eyelid will become tense, in case of trauma if there's bleeding inside the orbit the blood will press the eyeball against eyelids, if you don't interfere early patient will lose his vision, because high pressure will affect the blood supply.
- It's treated by releasing the pressure by lateral canthotomy (cutting the lateral canthus) or cantholysis.

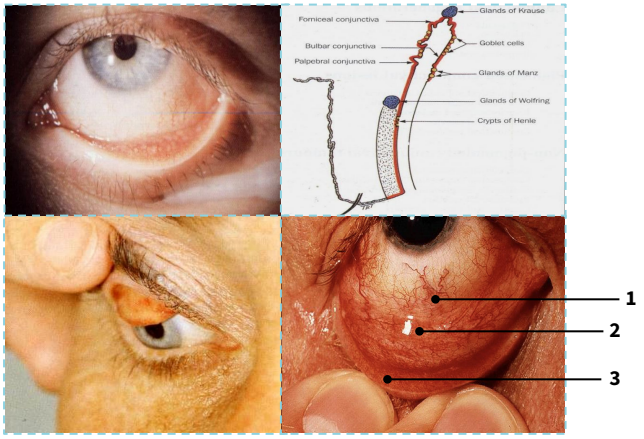


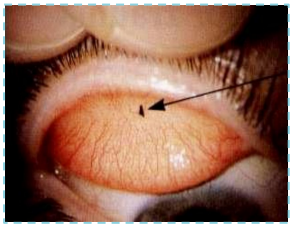
Conjunctiva

- Three parts:
  1. **Bulbar** conjunctiva.(eye Globe)
  2. **Palpebral** conjunctiva.(eyelid)
  3. **Forniceal** conjunctiva.(fornix)



- The stroma (no adenoid tissues until 3 months after
- birth).
- Follicles & Papillae.
- Injection and chemosis.

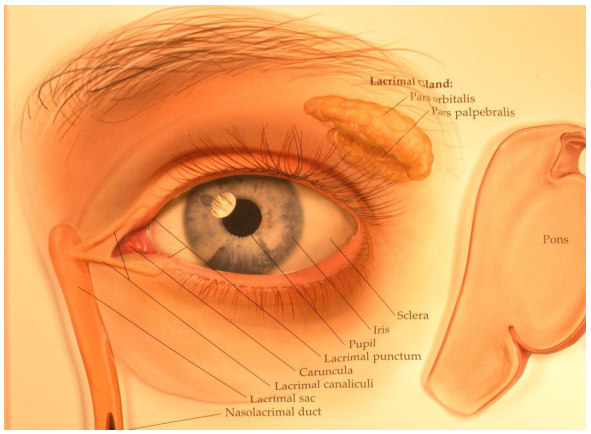


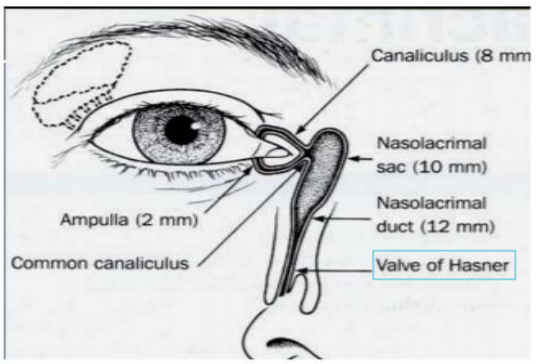


Very common for foreign bodies to get stuck in this location

The Lacrimal Apparatus

- Lacrimal gland secretes tears into the upper fornix of the conjunctival sac which are spread over the surface of the cornea as a tear film by blinking of the lids.
- Tears accumulate at the inner canthus and drain into the lacrimal sac via the puncta & canaliculi.
- The sac is continuous inferiorly with the nasolacrimal duct which opens into the nasal cavity just beneath the inferior turbinate.



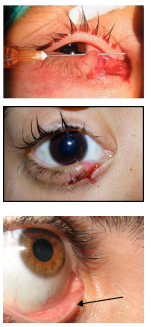


- Sometimes the valve of hasner is closed in the first few months of life and will cause tear stagnation lead to bacterial overgrowth and recurrent conjunctivitis, usually if we do finger massage for about 1 week the valve will be open

The Lacrimal Apparatus Cont.

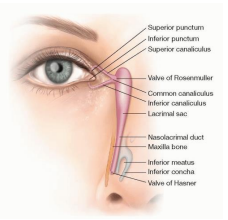
Canalicular laceration: (439 Slides)

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



Congenital nasolacrimal duct obstruction (CNLDO): (439 Slides)

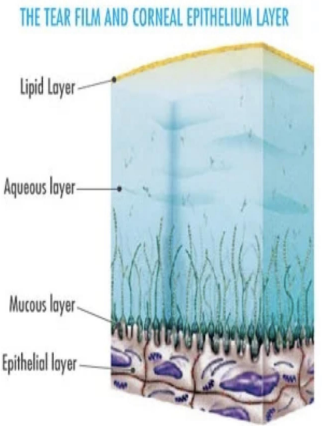
- is a **common condition causing excessive tearing or mucoid discharge from the eyes**, due to blockage of the nasolacrimal duct system.
- Failure of the distal part of the nasolacrimal duct to fully canalize at birth is the usual cause of a watering, sticky eye in an infant.
- Nasolacrimal duct obstruction affects as many as 20% children aged <1 year worldwide and is often resolved without surgery
- it can be acquired due to tumors or burns causing strictures
- 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 or canaliculi)
- Management
  - If closed by bony part: nothing to do.
  - If closed by membranous part: observe for 1 year > goes spontaneously, if persists > syringe & probing



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.This layer is affected by sjogren syndrome
- The outer lipid layer is secreted by the meibomian glands. The most?
- Schirmer test is used to determine whether the eye produces enough tears to keep it moist.



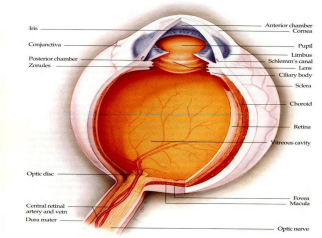
The eye (Globe)

- Two spheres with different radii:
  - Cornea, window of the eye.
  - Sclera, opaque shell.
- The eye measures approximately 24 mm in all its main diameters.
  - (Each 1mm increase in eye length will increase the myopia by 3 diopters).

- The anterior 1/6 of the fibrous layer of the eye is formed by the cornea.
- The posterior 5/6 are formed by the sclera and lamina cribrosa.
- The junction of cornea and sclera is as the limbus.
- Cornea: one of the most sensitive tissues of the body, as it is densely innervated with sensory nerve fibres via the ophthalmic division of the **trigeminal nerve**

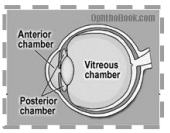
The Coats of The Eye:

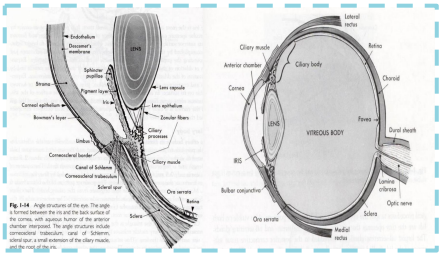
- **Three layers:**
  - **The outer:** inelastic coat, transparent cornea, and opaque sclera.
  - **The middle, vascular coat, The Uvea:** choroid, ciliary body, and iris.
  - **The inner:** The Retina, extends forwards to within 6 mm of the limbus.



Limbus is the zone between the cornea and sclera
(site of incision in cataract surgery)

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** humor.
  - The vitreous cavity: behind the lens, filled by gel-like structure.
- 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 aqueous humor is secreted from the non-pigmented cilliary body.
- 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 eye (Globe) Cont.

439 slides

Characteristics of the cornea:

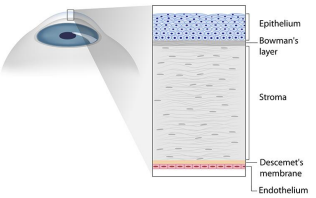
- Clear, What structure maintains clarity?
  1- because of arrangement of collagen fibers, when the stroma get injured the arrangement will disturb and forms scar then it will be opaque
  2- avascularity 3- endothelium is forming a bulge that prevent fluid from accumulate inside bulge
- Avascular: supplied from tearfilm and aqueous.
- rich in sensory neurons. (Painful)
- Main refractive surface of the eye. 2/3 of the refractive power of the eye is from the cornea while 1/3 is from the lens.

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.

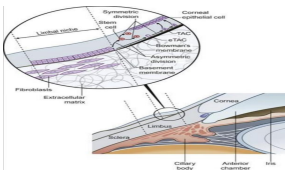
A B C D E

- **A**nterior epithelium
- **B**owman's layer
- **C**entral stroma
- **D**escemet's membrane
- **E**ndothelium



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.
- One example of diseases causes limbal stem cell deficiency (LSCD) is aniridia (absence of the iris).

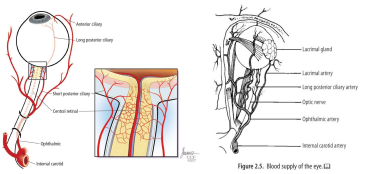


Blood supply:

Arterial supply

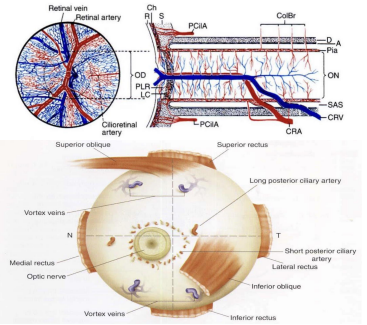
The blood supply of the globe is derived from the ophthalmic artery, which is a branch of the internal carotid artery:

- The central retinal artery supply retina
- The anterior ciliary arteries supply ciliary body and iris
- The posterior ciliary arteries supply sclera



Venous supply

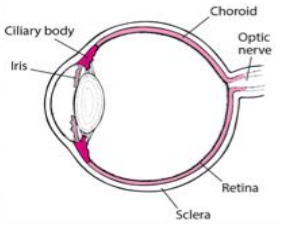
- The central retinal artery branches are accompanied by equivalent veins into central retinal vein.
- The choroid, ciliary body and iris are drained by approximately four vortex veins which leave the eyeball from posterior four quadrants of the globe



The eye (Globe) Cont.

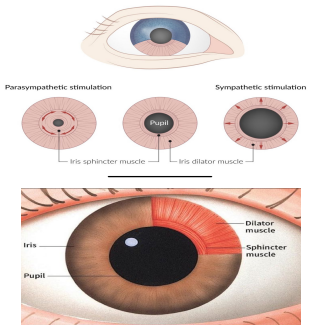
439 slides

- 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 (circular) constricts the pupil. (lead to miosis) (parasympathomemtics, 3rd cranial nerve)
- Contraction of the dilator pupillae muscle (radial) dilates the pupil (sympathetic, superior cervical ganglion)
- Important to know: When you have horner's syndrome there will be interruption of the sympathetic fibers that's why they have non-dilating pupils (miosis).



Choroid

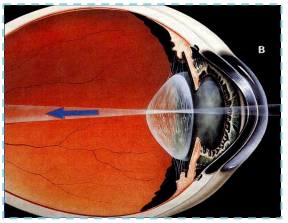
- The choroid is formed of arterioles, venules and a dense, fenestrated capillary network.
- It has a remarkably high blood flow.
- Contain high amount of melanin pigment.

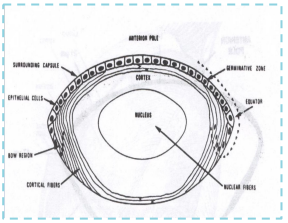
The Rock himself came to stop you, and he says: "You deserve a break!!"

The Globe Cont.

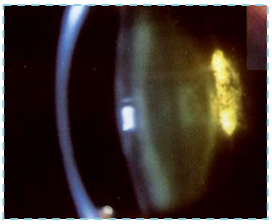
The lens:

- The crystalline lens is the only structure **continuously growing throughout the life**
- Changeable refractive media (helps in accommodation)
- After 40 presbyopia might happen and will cause lack of accommodation and the patient can't see near objects clearly
- It has three main parts: Capsule, epithelium and lens fibers
- Congenital anomalies and effect of systemic diseases.
- Changes in its structure leads to **cataract**.
- Suspended by the zonules.
- Transparent avascular part, helps to focus the light on the retina

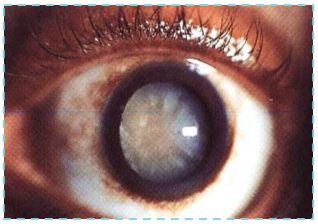




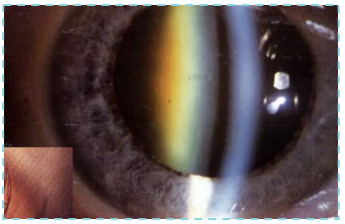
Nucleus Sclerosis: cataract that comes with age



Subcapsular Cataract



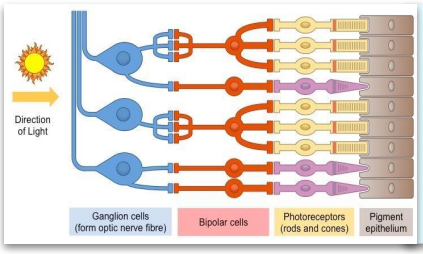
Cortical Cataract



Nuclear sclerotic cataract (most common type)

The retina:

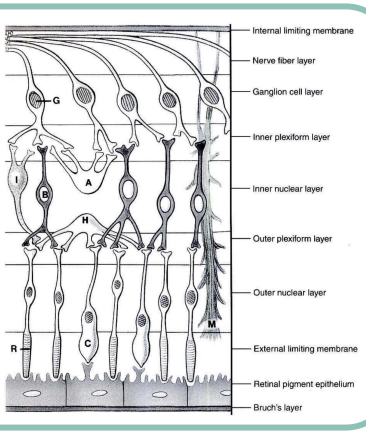
- Retina is an anterior extension of the brain.
- Made up from:
  - outer pigment epithelium
  - an inner sensory part which has two parts:
    1. photoreceptors: rods, cons
    2. bipolar cells: connect photoreceptors to inner layer

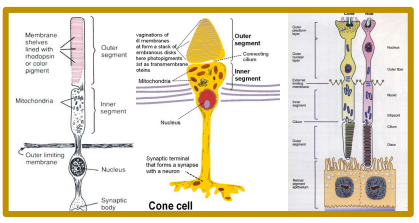


- The light passes through cornea > lens > vitreous and reaches retina
- stimulates photoreceptors then depolarization travels to bipolar cells
- ganglion cells takes the message from bipolar cells then transmit it through axons of ganglion cells which form the optic nerve

In
New
Generation
It
Is
Only
Ophthalmologist
Examining
Patient's
Retina

- Inner limiting membrane
- Nerve fiber layer (NFL)
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane
- Photoreceptors
- Retinal pigmented epithelium



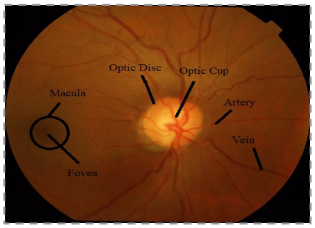


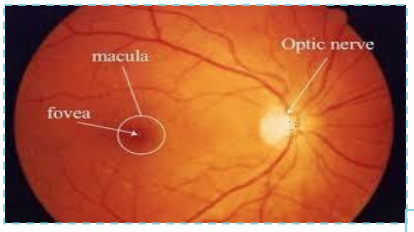
Hi nerd, this is useless histology information just in case they ask us Closest to the visual field (and farthest from the brain) is the axon terminal, which releases a neurotransmitter called glutamate to bipolar cells. Farther back is the cell body, which contains the cell's organelles. Farther back still is the inner segment, a specialized part of the cell full of mitochondria. The chief function of the inner segment is to provide ATP (energy) for the sodium-potassium pump. Finally, closest to the brain (and farthest from the field of view) is the outer segment, the part of the photoreceptor that absorbs light. Outer segments are actually modified cilia that contain disks filled with opsin, the molecule that absorbs photons, as well as voltage-gated sodium channels.

The Globe Cont.

Retina Inner layer:

- Highest density of cons is in the fovea and decrease rapidly outside the fovea. However the total number of cons outside the fovea is more than that in the fovea.
- Fovea has no rods.
- If patient has a disease in the fovea, when you examine him cons are still working, because there's cons in other parts of the retina
- Normal fundus photograph by indirect ophthalmoscopy (with indirect we can see a wide field while with direct we can see the optic nerve only)





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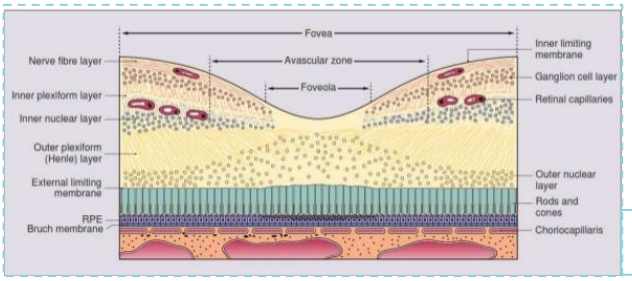
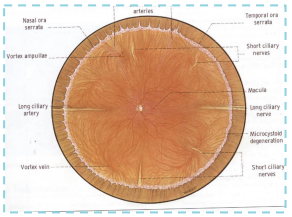


2

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 on 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 Cup to Disc ratio is almost 0.3 (1/3).
- Significance: in chronic glaucoma, the fibers surrounding the optic nerve becomes thinner, and the axons die. The cup itself dilates, **increasing the ratio**

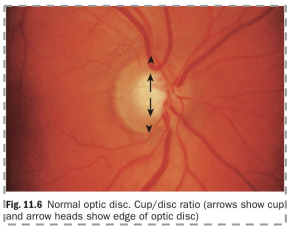


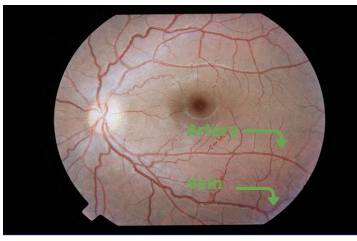
Fig. 11.6 Normal optic disc. Cup/disc ratio (arrows show cup and arrow heads show edge of optic disc)

2) Macula and Fovea centralis:

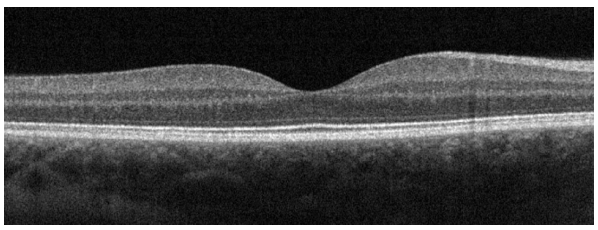
- Fovea centralis is responsible for the highest visual acuity.
- It has very condensed photoreceptors and no blood vessels (avascular). So, it takes its blood supply from the choroid behind it. Because if it has blood vessels, it will obstruct the passage of the light.
- It is also sloppy, so the light 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.
- The retina end in the ora serrata just before the pupil
- Fovea:only cons no rods

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



Artery is brighter and crosses vein

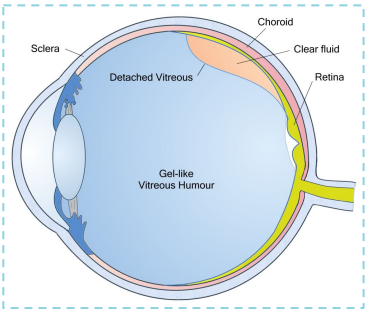


Optical coherence tomography (OCT)

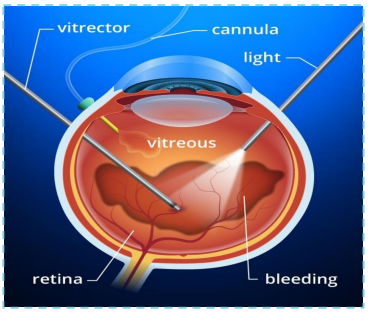
- A modality of imaging for the eye
- we send a light to the retina and recorded when it came back
- can show the retinal layers
- used to diagnose pathologies involve the choroid, retinal pigment epithelium and photoreceptors

The Globe Cont.

Retina and Vitreous:

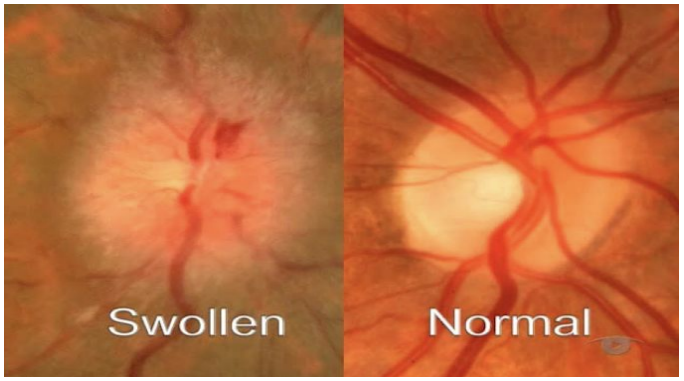


- **Vitreous attachments:**
  - Optic nerve head, macula, Ora serrata, and retinal vasculature
- **Retinal detachment:**
  - due to vitreous detachment
- **Effect of systemic diseases on the retina:**
  - eg: Diabetic or HTN retinopathy

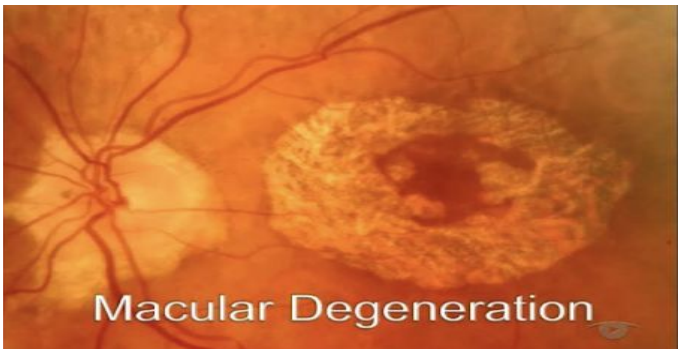


Sharp demarcation due to optic atrophy

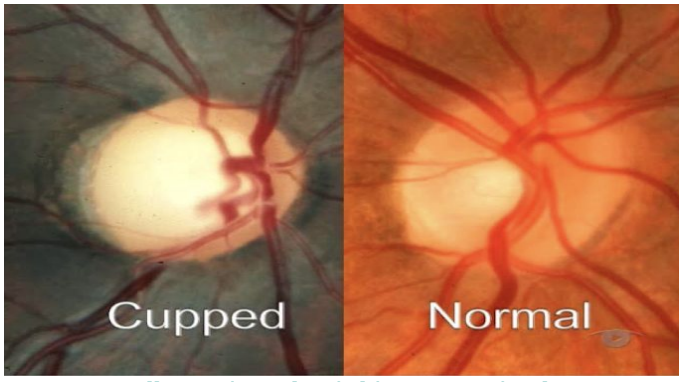
Diabetic neuropathy (neovascularization)



Papilledema hyperemic optic disc with ill defined borders



Seen in retinitis pigmentosa (العشى الليلي),myopia



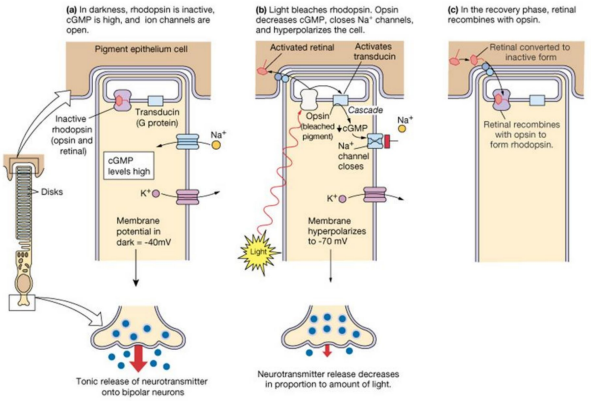
Normally cup is 0.3 but is bigger, seen in glaucoma

Can be an effect of some medications or old age
Pale fundus dark spots caused by hereditary disease

Physiology of the Eye

Vision:

- **Function of the eye:** receive the image and change it into language that the brain can understand.
- **The retina:**
  - To function you need:
    - Retinal pigment epithelium.
    - Neurosensory retina.
  - Photoreceptors contains visual pigment (11-cis-retinal) that changes into (all trans retinal) upon light stimulation.
- The visual cycle is the biological conversion of a **photon** into an electrical signal in the **retina**.



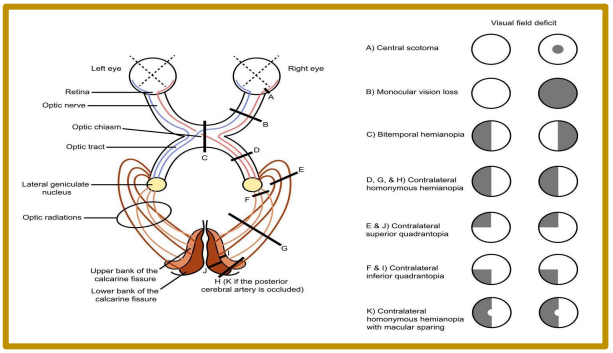
The details are not important

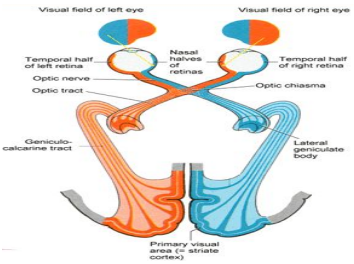
Visual Pathway:

Helpful for memorization

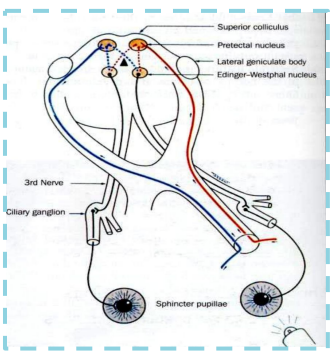
- The optic nerve is the axons of the ganglion cell (inner layer of retina)
- The axons of the temporal retina will run in the same side
- The axons of the nasal retina will cross to the opposite side
- then synapse in lateral geniculate body (thalamus)
- then loop into optic tract and and terminate in the visual cortex
- Action potential Na influx and k outflux retinal pigment hyperpolarization revert back when the light is up to photorector to bipolar cells to ganglion cell all the way of retina (optic nerve to optic tract till synap with lateral geniculate body and terminate in visual cortex)
- 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.





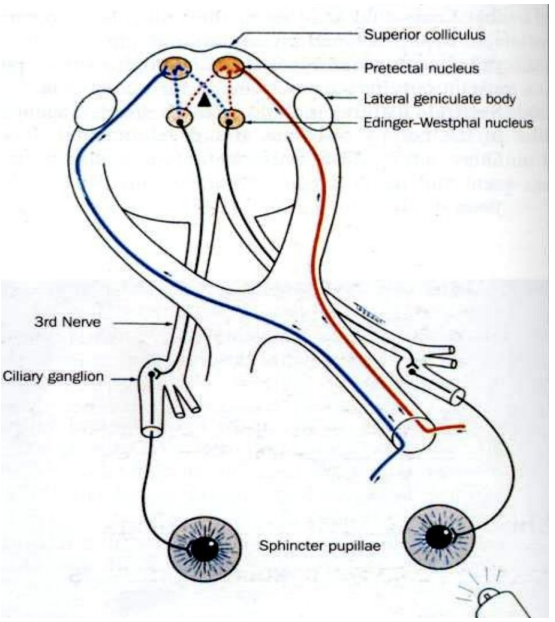
The nasal fibers transmit light from temporal field and vice versa



Physiology of the Eye Cont.

Pupil light reflex:

- Light reflex stimulate one eye to optic nerve pupil fibers exit to lateral geniculate nucleus go to superior colliculus and edinger-westphal nucleus (these nucleuses of third nerve) so bilateral represented. That's why we get direct & consensual response

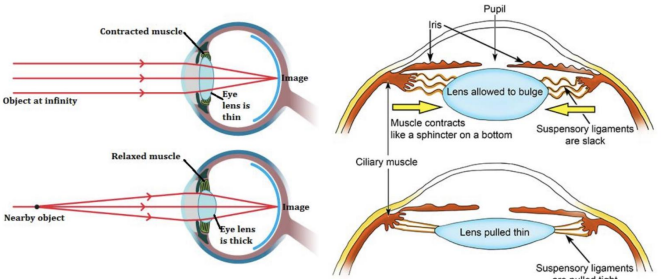


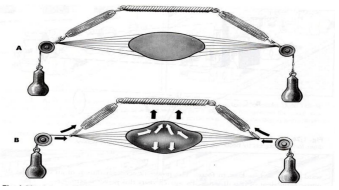
Accommodation + Miosis + Convergence together are called "Near Reflex"

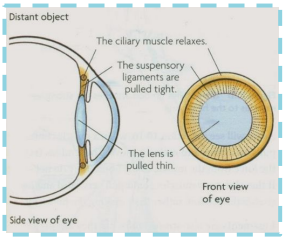
Accommodation:

- Accommodation is a process of focusing the light on the retina, the lens plays the main role
- What happens during accommodation?

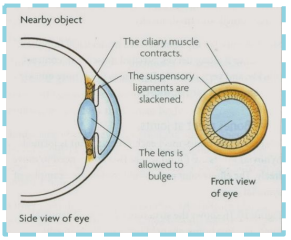
1. During far vision, the ciliary bodies relax, the zonule stretch, and **the lens flattens**. During near accommodation, the ciliary bodies contract (i.e., shorten), which relaxes the zonule and rounds the lens (i.e., thickens it). This brings the near object into focus.







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.



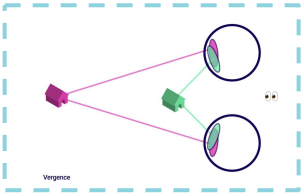
Near objects:
The ciliary muscles contract, giving them a smaller diameter. This removes the tension on the suspensory ligaments which , in turn, stop pulling on the lens. The lens becomes thicker (more convex). As the ciliary muscles are contracted, there is strain on the eye, which can cause a headache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

- **Other elements of accommodation:**

2. Miosis: constriction of sphincter of the iris (circular muscle), pupil will become smaller, helps to look to near things

3. 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.

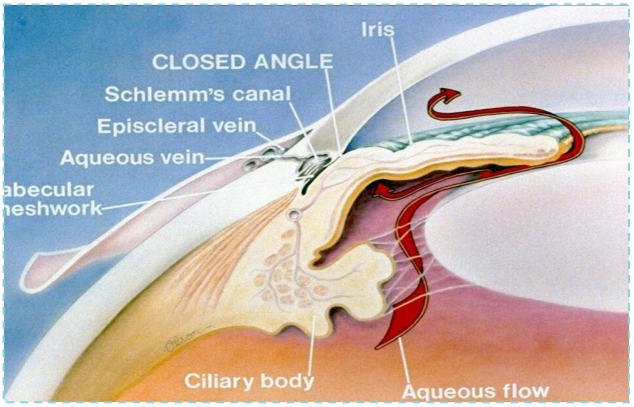
Physiology of the Eye Cont.

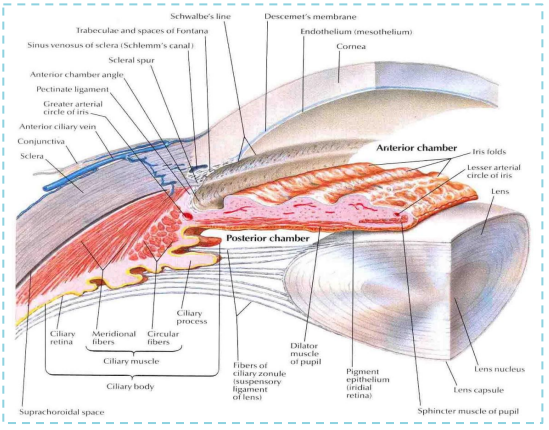
Accommodation cont.

The lens has suspensory ligament. When we see near this ligament relax so the lens become more thicker. If contract suspensory ligament the lens stretched and you can see distance. This contraction and relaxation happen because of ciliary muscle longitudinal fiber when contract the muscle come closer to eye and lens relax and bulge. When you want see distance the muscle relax and the lens pulled. As we said the children have very strong accommodation. So we give them Cycloplegia medication to paralyze ciliary muscle and relax the lens will stretch out and we can check refractive error and give them glasses. The distance image convergence to muccula while near image more closer more divergence we need more lens power to focus the light in same spot of the retina. We need lens more thicker during accommodation.The pupil constricted called miosis and this happen during accommodation with convergence.

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



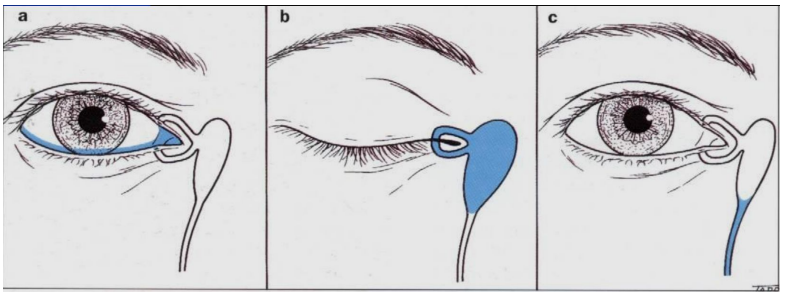


Angle is important because the fluid move from posterior chamber to anterior. Sometimes the pupil close this angle so the fluid accumulate and this called closed angle glaucoma
If pupil large compress the posterior chamber this called open glaucoma. tx : remove the lens and replace with artificial lens or laser peripheral iridotomy.

Physiology of the Eye Cont.

Lacrimal Apparatus:

- a) Tear secretion
- b) Layers of precorneal tear film
- c) Drainage of tear



This image demonstrate the role of the eyelids in drainage the tears, the eyelids act like a pump machine, when the eye is open, the tears can be seen in the down periphery of the eye, once the eye is closed, the eyelid is pushing the tear to the lacrimal sac, and opening the eyelid again is pushing the tear fluid to the nasolacrimal duct all the way to the inferior turbinate

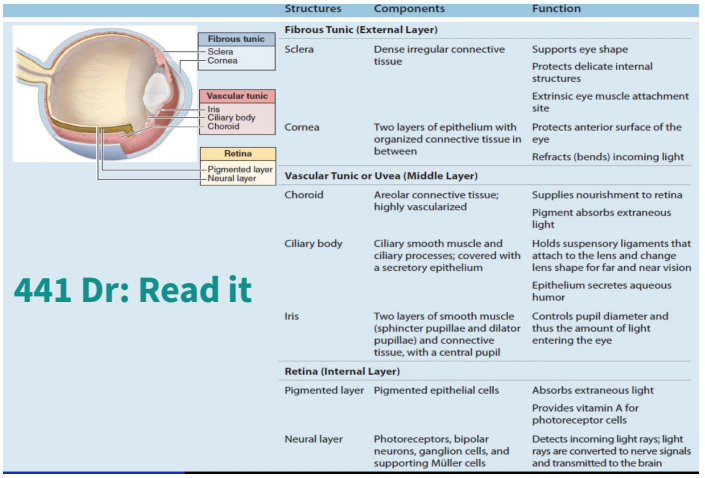
438 Slides & Notes

If you wanna have a look on 438 Slides & Notes click on the barcode

Summary

Overview of extraocular muscles

Muscle	Function (Ocular movements)	Origin	Insertion	Innervation
Superior rectus muscle	• **Elevation**, adduction, and **intorsion** (the inward, rotational movement of the eye) of the eyeball	• Common tendinous ring	• Upper globe	• Oculomotor nerve (CN III)
Inferior rectus muscle	• **Depression**, extorsion, and adduction of the eyeball		• Lower globe	
Medial rectus muscle	• **Adduction** of the eyeball		• Medial globe	
Lateral rectus muscle	• **Abduction** of the eyeball		• Lateral globe	• Abducens nerve (CN VI)
Superior oblique muscle	• **Intorsion**, depression, and abduction of the eyeball [2]	• Above the optic canal, on the body of sphenoid bone (and common tendinous ring) • Travels through trochlea of superior oblique	• Upper posterior globe	• Trochlear nerve (CN IV)
Inferior oblique muscle	• Elevation, abduction, and **extorsion** (the outward, rotational movement of the eye) of the eyeball	• Lateral to the lacrimal groove • On the floor of the orbit	• Lower posterior globe	• Oculomotor nerve (CN III)



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

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.

Summary

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

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

Q1- 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.

Q2- 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.

Q3- Which muscle doesn't take origin from the orbital apex?

A- Inferior oblique
B- inferior rectus
C- Superior oblique
D- Levator palpebrae superioris

Q4- 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

Q5- Chambers of the eye are

A- anterior chamber
B- posterior chamber
C- non the above
D- a&b

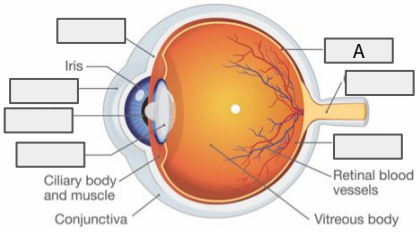
Q6- tennis ball player had a trauma to the orbit complaining of enophthalmos and inability to elevate the eye. What is the most likely diagnosis?

A- Fracture to the medial side
B- Orbital floor fracture
C- 3rd nerve palsy
D- 6th nerve palsy

Answers: Q1: E | Q2: A | Q3: A | Q4: A | Q5: D | Q6: B

Short Answer Questions

Case 1

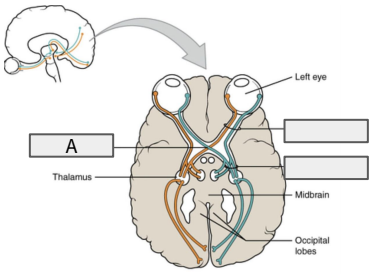


A: Identity the structure (A) ?

B: What is the embryological origin of structure labelled in the previous question ?

C: Mention other structure with same embryological origin ?

Case 2



A: Identity the structure (A) ?

B: Name the visual defect in case of damage in area mentioned in the previous question?

Answers:

Case 1
A: Retina
B: Neuroectoderm
C: Optic nerve, muscles of the iris

Case 2
A: Optic chiasm
B: Bitemporal hemianopia

This work was originally done by **438 and 439 Ophthalmology Team**

Edited by 441 Ophthalmology Team

Team leaders:

Abdullah Aldayel **Ibrahim Aljurayyan** **Sultan Alosaimi**

Members:

Abdulaziz Annab **Abdullah Aldayel**

Note Takers:

Hamad Alshaalan **Abdulaziz Alabdulrahman**
Ibrahim Aljurayyan **Abdullah Aldayel**
Sultan Alosimi