



## Basic Anatomy & Physiology

[ **Color index:** **Important** | **Notes** | **Extra** ] [EDITING FILE](#)

### Objectives:

- Touch 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 & tear drainage system.

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**Resources:** Slides + Lecture Notes of ophthalmology + 434 / 435 team

# Embryology & Development

## ● Embryology of the eye

- This highly specialized sensory organ is derived from germ cell layers:

1. **Mesoderm:** give rise to **ciliary body and muscles** (vascular, muscular & supportive tissues)
2. **Ectoderm:** **ENDODERM** does not contribute in the eye embryology.
  - a. Neural ectoderm give rise to **retina and optic nerve** + epithelium of the iris and conjunctiva
  - b. Surface ectoderm give rise to the **epithelium of the cornea and lens**

### An interesting piece of information:

Part of the cornea, all of the lens (surface ectoderm invaginate to form the lens vesicle) and skin originate from the ectoderm, that is why:

\* Atopic dermatitis (eczema) is usually associated with cataract.

\* Very painful. Example: when you hit your eyes with the edge of the paper → corneal abrasion → pain.

**SAQ:** you might get a picture of corneal abrasion.

**Q1:** identify the picture: corneal abrasion **Q2:** What is the stain used? Fluorescein **Q3:** treatment: eye patch

\* Cornea and lens are the **only 2** parts in eye that can be changed surgically until now.

**Keratoplasty** for the cornea. **Pseudophakia:** replacing the lens with an artificial lens in cataract surgery.

الجلد القرنية والعدسة لهما نفس المنشأ، وهي الأجزاء التي يمكن تبديلها في العين (إِنَّ الَّذِينَ كَفَرُوا بِآيَاتِنَا سَوْفَ نُصَلِّيهِمْ نَارًا كَلِمًا تَضَجُّتْ جُلُودُهُمْ بَدَلْنَا هُمْ جُلُودًا غَيْرَهَا لِيَذُوقُوا الْعَذَابَ إِنَّ اللَّهَ كَانَ عَزِيزًا حَكِيمًا) (سورة النساء - آية 56) يقصد بالعذاب هنا "الألم"

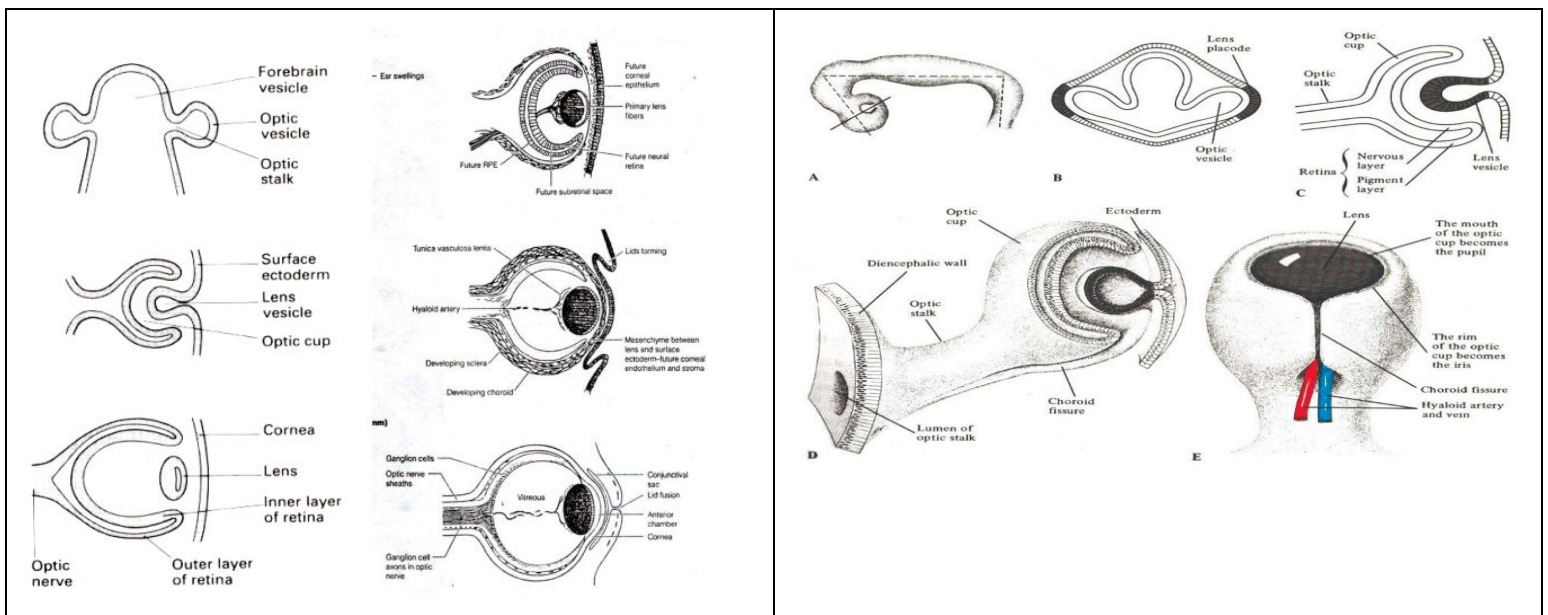
- The eye is essentially an outgrowth from the brain (neural ectoderm).

- Started as **optic vesicle** connected to the forebrain by **optic stalk**.

Invagination of both the optic vesicle to form optic cup and the optic stalk to form choroidal (or optic) fissure inferiorly.

Ectoderm → Neural tube → optic grooves → optic vesicle → optic cup & optic stalk

**Coloboma:** congenital malformation in the eye, that results from a defect in fusion in inferionasal part. any defect in any other place (superionaa, lateral temporal...) is NOT a congenital problem.



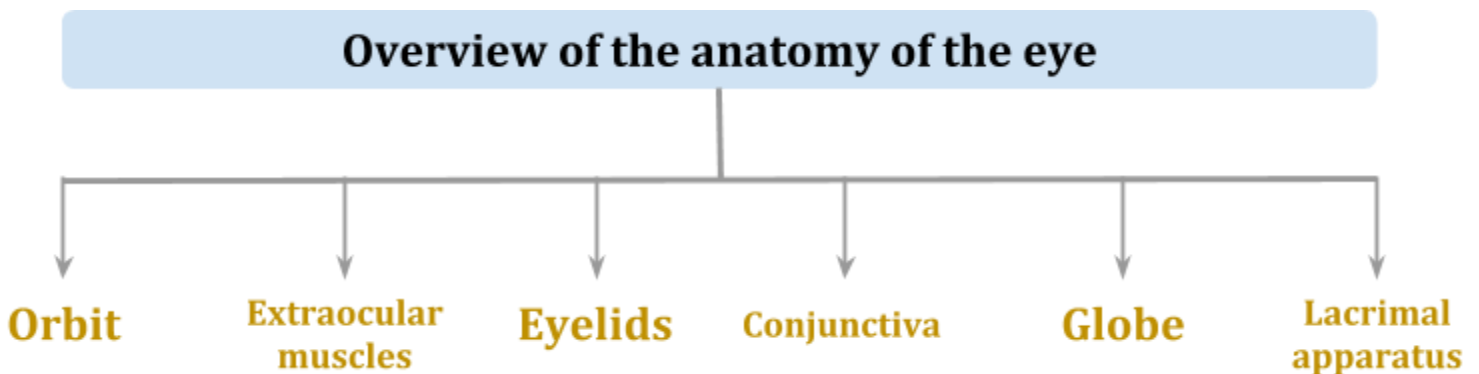
● **Development of the eye after birth**

- At birth, the eye is relatively large in relation to the rest of the body.
  - The iris has a bluish color due to little or no pigment on the anterior surface. Usually babies are born with light colored eyes, with age pigmentation darkens the eyes or it stays light like people with european descent.
  - During early infant life, the cornea & sclera can be stretched by raised IOP → enlargement of the eye.
- Difference between **infantile and childhood glaucoma** is noted by the size of the eye (very important to know)

	Congenital glaucoma	
	Infantile glaucoma	Childhood glaucoma
Patho-physiology	Non-working drainage system (non-functional trabecular meshwork) → high intraocular pressure (IOP)	
Age	Since birth - before 2 years	After 2 years
Elasticity	Present. Sclera and cornea can be stretched	Absent
Size of eye	Enlarged ( <b>buphthalmos</b> )	Same size. <u>NO</u> enlargement

- The eye reaches full size by the age of 8.
- Usually by age 2 the eye reaches its full size (adult globe) however, it is accepted up to age 8.
- The lens continues to enlarge throughout the life. The only part of the eye that continues to enlarge which explains **phacomorphic glaucoma**<sup>1</sup> or the acute glaucoma that occurs after 40 years.
- By age 40: (1) Lens capsule lose its elasticity (2) Refractive index increases (presbyopia)

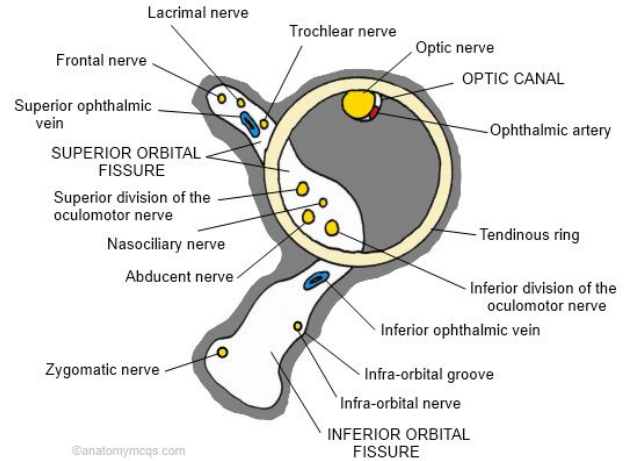
## Anatomy & Physiology



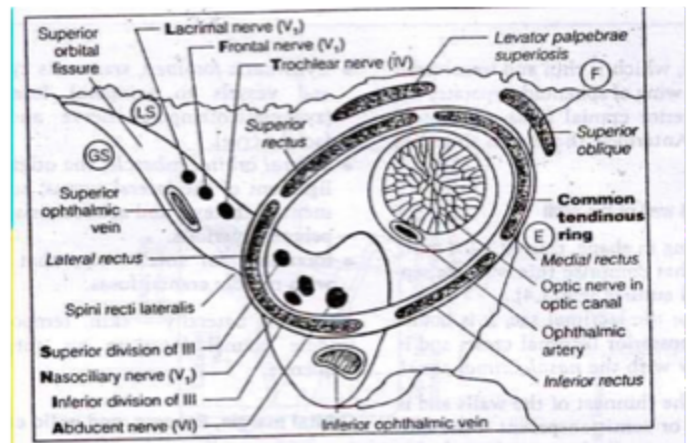
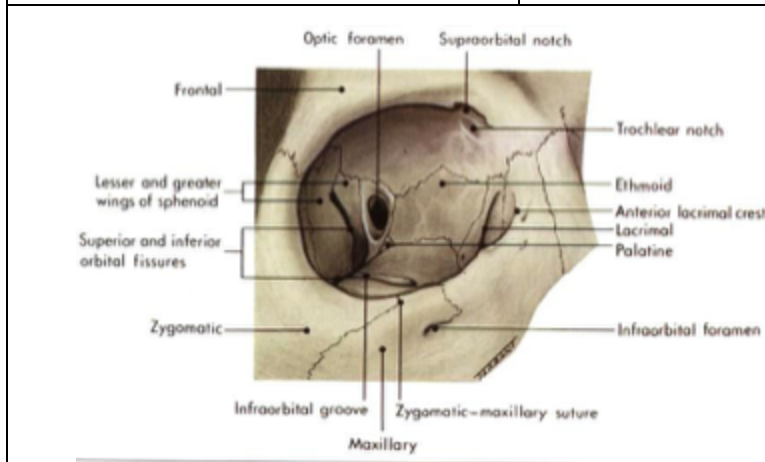
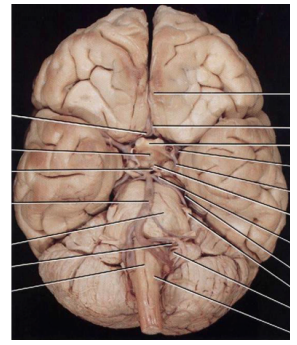
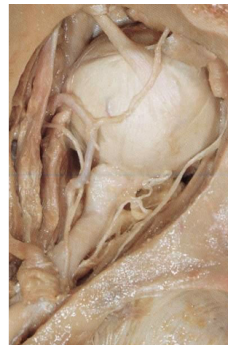
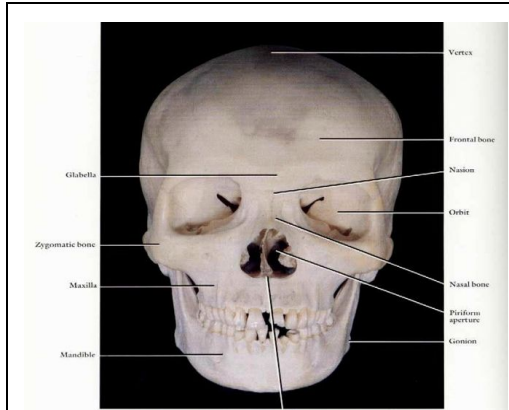
<sup>1</sup> term used for secondary angle-closure glaucoma due to lens intumescence. The increase in lens thickness from an advanced cataract, a rapidly intumescent lens, or a traumatic cataract can lead to **pupillary block** and angle closure.

# The Orbit

- A socket, contains & protect the eye.
- **Seven bones contribute the bony orbit:** frontal, zygomatic, maxillary, palatine, sphenoid, ethmoid, lacrimal.
- The weakest parts are the floor & the medial wall.
- Surrounded by nasal sinuses. **that is why if you have sinusitis you might have orbital cellulitis as well.**
- **Important openings are:** you have to know the structures running through all of them
  - Optic foramen (canal): **ex: optic nerve & vessels.**
  - Superior orbital fissure: **ex: nasociliary nerve & inferior division or third cranial nerve.**
  - Inferior orbital fissure:

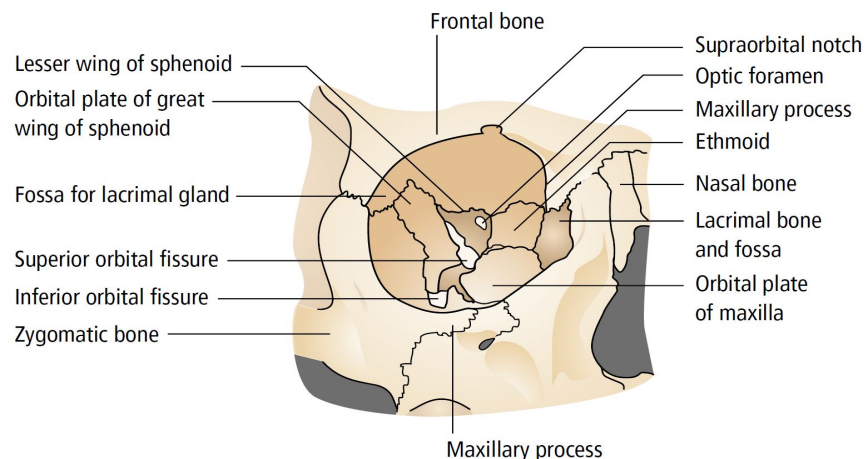


Optic foramen	Superior orbital fissure	Inferior orbital fissure
<ol style="list-style-type: none"> <li>Optic nerve.</li> <li>Ophthalmic artery.</li> <li>Central retinal vein.</li> </ol>	<p>ANY STRUCTURE NOT MENTIONED IN OTHER OPENINGS!</p> <p>III, IV, and VI cranial nerves, lacrimal nerve, frontal nerve, nasociliary nerve, orbital branch of middle meningeal artery, recurrent branch of lacrimal artery, superior orbital vein and superior ophthalmic vein.</p>	<ol style="list-style-type: none"> <li>Infraorbital nerve (part of maxillary nerve)</li> <li>Inferior ophthalmic vein.</li> <li>Infraorbital vein &amp; artery,</li> <li>Zygomatic nerve.</li> <li>Parasympathetic fibers to lacrimal gland</li> </ol>





- The eye lies within the bony orbit, which has the shape of a **four - sided pyramid**:
  - At **posterior apex**: optic canal; transmits optic nerve to the chiasm, tract & lateral geniculate body.
  - **Superior & inferior orbital fissures**: allow passage of blood vessels and cranial nerves which supply orbital structures.
  - The **lacrimal gland**: lies anteriorly in the superolateral aspect of the orbit.
  - On the **anterior medial** wall: lies the fossa for the lacrimal sac.
- Orbital margin is formed by the frontal, maxilla, and zygomatic bones.
- The **orbital cavity** is pyramidal, with its base in front and its apex (cone) behind.
  - **Roof**: formed by the orbital plate of the frontal bone, which separates the orbital cavity from the anterior cranial fossa and the frontal lobe of the cerebral hemisphere.
  - **Floor**: formed by the orbital plate of the maxilla, which separates the orbital cavity from the maxillary sinus. floor is the most easily part to get fractured (cause: blowout fracture) **"This is a common Q" Fracture of the floor is called orbital blowout fracture** and is due to blunt trauma which causes increased IOP and fracture of the orbital floor. This fracture causes impaction of inferior rectus muscle so the eye will be displaced inferiorly "defective elevation" and posteriorly "enophthalmos" and the inferior orbital nerve will be paralyzed. The patient will complain of diplopia "**vertical diplopia**". when u ask pt to look up and one of the eye did not move upward + hx of trauma think of blowout fracture.
  - **Medial wall**: formed from before backward by the frontal process of the maxilla, the lacrimal bone, the orbital plate of ethmoid (which separates the orbital cavity from the ethmoid sinuses), and the body of sphenoid. **The weakest parts are the floor (because it has many openings) & the medial wall. that is why when someone has sinusitis he will have orbital cellulitis.**
  - **Lateral wall**: formed by the zygomatic bone and the greater wing of sphenoid.
- **Other openings in the orbit**:
  - **Supraorbital notch**: Situated in the superior orbital margin, transmits the supraorbital nerve and blood vessels.
  - **Infraorbital groove and canal**: Situated in the orbital plate of the maxilla, the transmit the infraorbital nerve (a continuation of the maxillary nerve) and blood vessels.
  - **Nasolacrimal canal**: Located anteriorly in the medial wall; it communicates with the inferior meatus of the nose, and transmits the nasolacrimal duct.
- Nasal bone fracture is the most common facial fracture.
- Zygomatic bone is the strongest, because it's the most likely to get trauma.
- Ethmoid bone is very thin, so it is known as Lamina Papyracea **"thinnest part of the orbit"**. Patient with a **sinusitis** → invasion of the Infection from the ethmoidal sinus to the orbit results in **orbital cellulitis**, which is a serious complication.
- Both upper and lower divisions of oculomotor nerve (CN III) pass through Superior orbital fissure.
- **MCQs**: Infraorbital nerve: supplies the skin of the lower area of the lid. so when get senario says: **patient with paresthesia of the lower lid, what nerve is affected?** infraorbital nerve.



# Extraocular muscles

- There are **6 muscles** responsible for the **movement of the eye**:
  - **Four recti**: superior, inferior, medial (the largest), and lateral.
  - **Two oblique muscles**: superior and inferior.

## You need to know the origin & insertion of each muscle

Muscle	Origin	Insertion	Nerve supply	Action
<b>Superior rectus</b>	Superior part of common tendinous ring of zinn	Superior & anterior aspect of the sclera	Oculomotor (CN III)	<b>Primary: elevation</b> Secondary: adduction <b>Tertiary: incycloduction (intorsion)</b>
<b>Inferior rectus</b>	Inferior part of common tendinous ring of zinn	Inferior & anterior aspect of the sclera	Oculomotor (CN III)	<b>Primary: depression</b> Secondary: adduction <b>Tertiary: excycloduction (extortion)</b>
<b>Medial rectus</b>	Medial part of common tendinous ring of zinn	Anterio-medial aspect of the sclera	Oculomotor (CN III)	<b>Primary: medial rotation or adduction</b>
<b>Lateral rectus</b>	Lateral part of common tendinous ring of zinn	Anterio-lateral aspect of the sclera	Abducens (CN VI)	<b>Primary: lateral rotation or abduction</b>
<b>Superior oblique</b>	Body of the sphenoid bone	Sclera - posterior to the superior rectus	Trochlear (CN IV)	<b>Primary: depression</b> Secondary: abduction <b>Tertiary: incycloduction (intorsion)</b>
<b>Inferior oblique</b>	Anterior aspect of the orbital floor.	Sclera - posterior to the lateral rectus	Oculomotor (CN III)	<b>Primary: elevation</b> Secondary: abduction <b>Tertiary: excycloduction (extortion)</b>

- Intorsion & extorsion are micromovements of the eye (not visible)

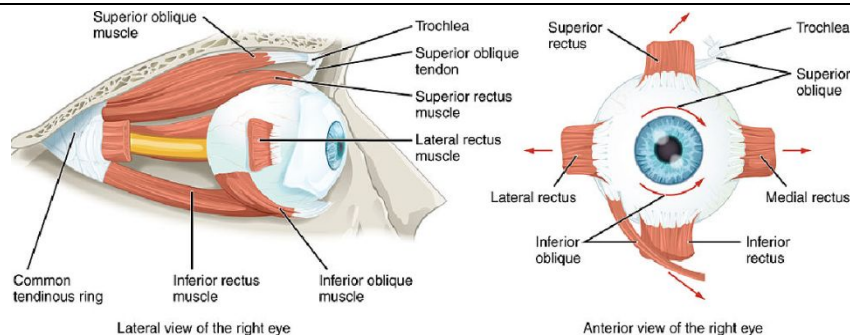
- **All are supplied by Oculomotor nerve (III), except:**

- Superior oblique → Trochlear nerve (CN IV)
- Lateral rectus → Abducens nerve (CN VI)

- **Hence for clinical testing:**

Muscle	Superior oblique	Inferior oblique	Superior rectus	Inferior rectus
<b>Direction to look</b>	Down & in	Up & in	Up & out	Down & out

Movement of obliques are the opposite. **[O: Oblique = I: In], [R: Rectus = O: Out]**



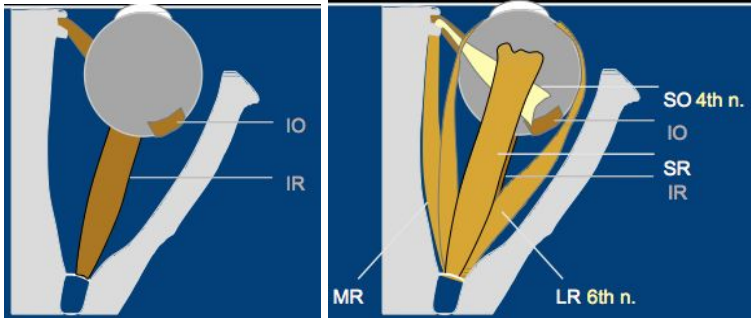
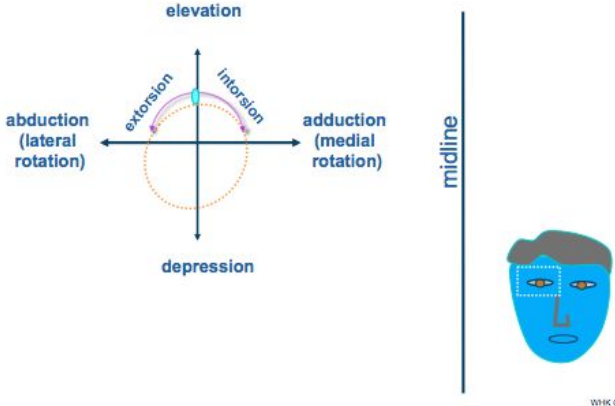
Note that there is a **difference** between **normal function & clinical testing!** Helpful [link](#)

**Normal function:** (1) SO: down & out (2) IO: up & out (3) SR: up & in (4) IR: down & in.

**Clinical testing:** (1) SO: down & in (2) IO: up & in (3) SR: up & out (4) IR: down & out.

**SR & IO:** both elevate the eye **IR & SO:** both depress the eye | we need to eliminate one to test the other

**Why?** for example SR vs IO: up & out. Orienting the visual gaze axis perpendicular to the inferior oblique muscle fiber direction to trap the IO so SR is the only muscle that is mediating elevation. Likewise with the other muscles. [**testing pure muscle action**]

Attachments of eye muscles	Action of eye muscles
	

### Extra from 435 team

#### - Notes:

1. Superior oblique is the most superior muscle in the orbit.
2. Medial recti are strong muscles that keeps the eye in its normal position. During sleep, the eye tends to move laterally due to the relaxation of the medial recti. It's important that during preoperative assessment of a patient with strabismus. Check the angle of deviation before injecting anesthetic drugs; the eyes changes angles during sleep.
3. **Abducens nerve** is the only nerve passing through the **cavernous sinus** (around internal carotid), other nerves pass in the wall of cavernous (not through it). A trauma at this structure will cause: **medial squint**.

#### - Attachment of the Recti Muscles to the Eye:

- The **recti** are attached **in front** of the equator<sup>2</sup>, unlike the obliques which are attached behind the equator.
- All muscles are originated from behind the eye, except inferior oblique (anatomically and physiologically), and superior oblique(physiologically only)<sup>3</sup>

- Patient with a 3rd nerve palsy, how can you rule out 4th nerve palsy? **Important OSCE question**

**The clinical manifestations of 3rd nerve palsy:** Ptosis + all muscles are paralyzed except the LR, so the eye will be abducted and little down + The patient can not look downward because the IR is paralyzed.

- To know if the 4th nerve is intact or not, ask the patient to look downward and if the 4th nerve is intact, then the eye will be in intorsion due to the action of SO.

<sup>2</sup> equator: the largest diameter of the eyeball.

<sup>3</sup> SO: is originated from behind the eye (anatomically), BUT the function of the muscle is like its originated from anterior because of the rounded tendon.

# The Eyelids

- There are upper & lower eyelids.
- They provide a protective covering for the eye. fish don't have eyelids because the water acts as a covering.
- The lids are:

- o **Closed by:** *orbicularis oculi*, supplied by facial nerve (CN VII)
- o **Opened by: IMPORTANT: difference between ptosis due to parasympathetic & sympathetic injury!**
  - *levator palpebrae superioris*, supplied by oculomotor nerve (CN III) **parasympathetic supply.**

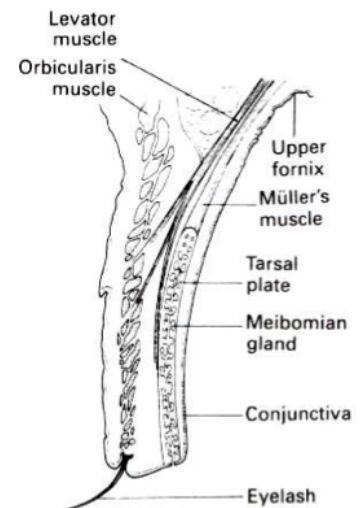
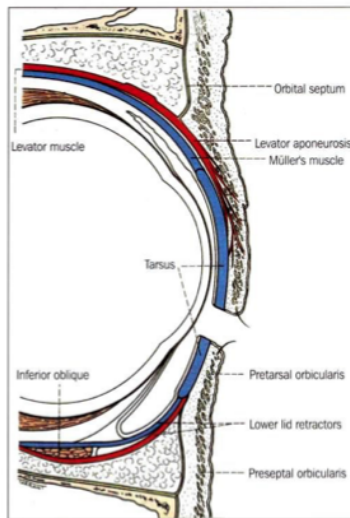
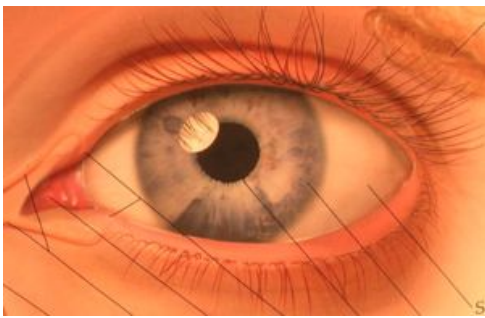
Ptosis occur with third nerve palsy due to levator palpebrae muscles paralysis.

Patient came to the ER with ptosis (third nerve palsy) and the eye is out because of the lateral rectus, how can you test if the third nerve palsy is with/without fourth nerve palsy? ask the patient to look down. If fourth nerve is intact → intorsion. If not → unable to do intorsion **[that is at resident's level you'll not be asked about it]**

- **Muller's muscle, sympathetic innervation injury** → paralysis of Muller's muscle → ptosis like with horner syndrome. Mnemonic: **MAPLE** + sometimes heterochromia

(**M:** miosis (small pupil), **A:** anhidrosis (dry skin), **P:** ptosis, **L:** loss of ciliospinal reflex<sup>4</sup>, **E:** enophthalmos)

- **Lower lid retractors**



Extra from 435 team

- Tarsus is the skeleton of the eyelid.
- Contraction of the peripheral fibres of the orbicularis muscle results in a protective, forced eye closure, while that of the inner, palpebral muscle results in the blink.
- It spreads the tears, and keeps ocular surface wet all the time.
- Orbital septum is a strong fibrous tissue, that serves to separate some eye structures from other structures, and it's an important barrier against infection.<sup>5</sup>
- It has special meibomian glands (modified sebaceous glands) which secrete oily material that retards tear and makes it stay longer in front of the cornea. divided into:
  - o Anterior lamella: Skin and orbicularis (fibrosis of this leads to ectropion).
  - o Posterior lamella: Tarsus and levator and conjunctival (fibrosis leads to entropion).
- Eyelashes are important as a protective to the eye (because the hair which is directed outward gives the orbicularis more time to close). the area where eyelashes get out is called lid margin.
- Inflammation of lid margin is called Blepharitis.
- With entropion, upper eyelashes will be directed inward, and may damage cornea with time, with ectropion, lower eyelashes will be directed away from the eye, and this will lead to tearing and eye will become dry.

<sup>4</sup> The ciliospinal reflex (pupillary-skin reflex) consists of dilation of the ipsilateral pupil in response to pain applied to the neck, face, and upper trunk.

<sup>5</sup> infection anterior to orbital septum (preseptal cellulitis), behind septum (orbital cellulitis, very dangerous).

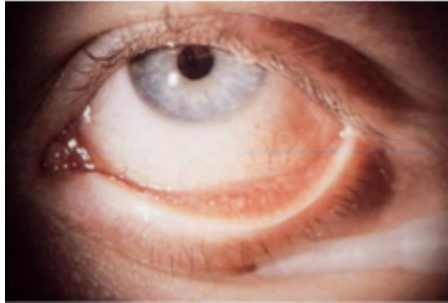


# Conjunctiva

## - Three parts:

1. **Bulbar conjunctiva** part that is covering the sclera (sclera is the white visible part)
2. **Palpebral conjunctiva** behind the eyelid
3. **Forniceal conjunctiva** at the fonix inside the eye “في الآخر”

- Limbus. | - The stroma: **adenoid** layer and **fibrous** layer (no adenoid tissues until 3 months after birth)<sup>6</sup>.
- Follicles & Papillae. | - Injection & chemosis.



### You can see:

- the three parts of the conjunctiva: Bulbar, palpebral & forniceal.

### - Accessory lacrimal glands:

Goblet cells, Glands of Krause, Glands of Manz, Glands of Wolfring  
They are called the:

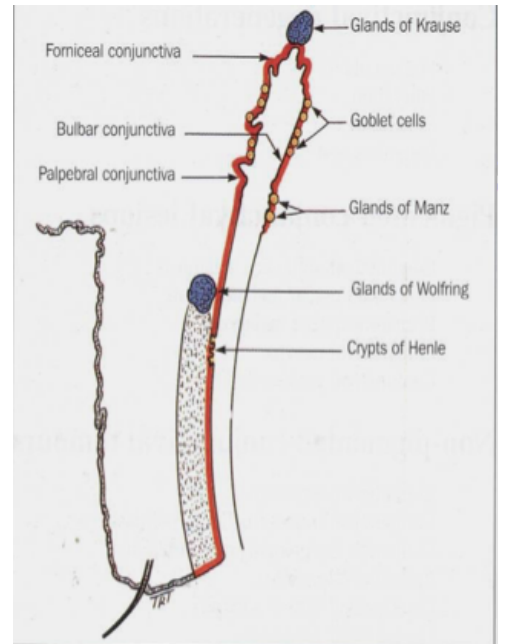
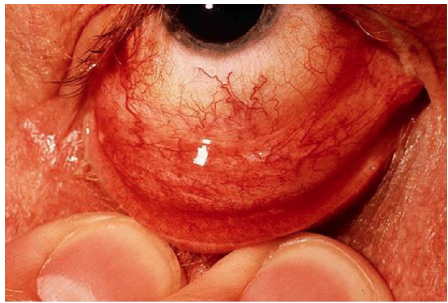
Sensory lacrimal glands → normal secretions (tears)

Lacrimal glands → reflex secretions like crying or happiness tears.

### Tears ≠ lacrimal glands

**Trachoma** is an infectious disease. It used to be endemic in Saudi but now is eradicated. You can see the scarring of old trachomas in some patients.

No tear film → severe dry eye



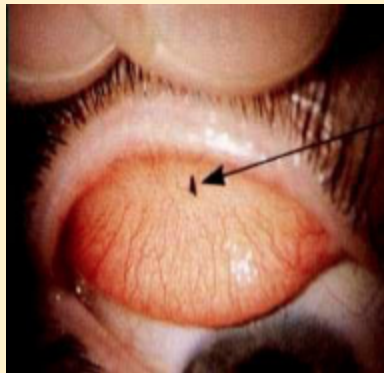
### SAQ:

#### Q1: Identify the picture?

Foreign body in palpebral conjunctiva.

#### Q2: treatment?

Foreign body removal & topical antibiotics



### SAQ:

#### Q1: Identify the picture?

Scars in palpebral conjunctiva due to old trachoma.

#### Q2: treatment?

Lubrication

Most previous batches

didn't know how to answer this question



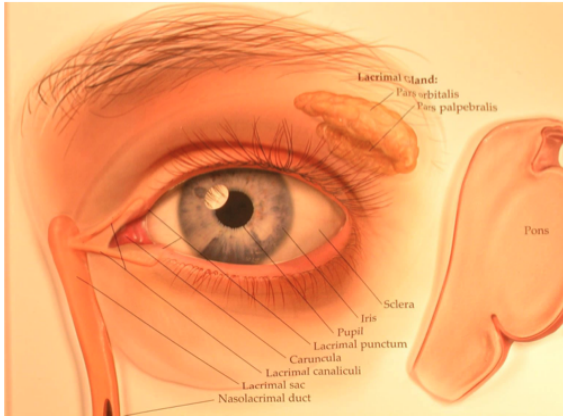
## Extra from 435 team

- It is the transparent membrane covering the sclera, it's the outer cover of the eye, normally it has vessels and sometimes they are prominent, but if there are no vessels or redness, then the patient might be anemic.
- In a case of vernal keratoconjunctivitis, the bulbar conjunctiva may have tranta's spots. “discrete whitish raised dots along the limbus”
- Forniceal conjunctiva: it has a structure called Cul-de-sac, which serves as a reservoir for tears and drugs.
- Injection : is peripheral hyperemia of the anterior ciliary vessels which produces a deep red or rose color of the corneal stroma. Causes of ciliary injection: keratitis, Uveitis, Acute glaucoma.
- Chemosis : It is a swelling of the conjunctiva due to abnormally permeable capillaries

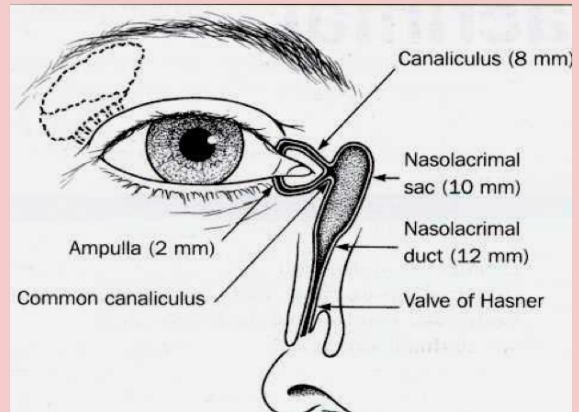
<sup>6</sup> inflammation of adenoid is called (Follicular Conjunctivitis), and inflammation of fibrous layer is called (Papillary Conjunctivitis)

# The Lacrimal Apparatus

- Lacrimal gland has two parts: bulbar & palpebral. It connects with the eye by a duct. Works by reflex tearing.
- Tear secretion & drainage. if there is secretion with no drainage = persistent tearing
- Layers of precorneal tear film.
- Fluorescein test, done to adults & pediatrics: we put a stain (fluorescein) in the eye → goes away after 15 min  
If it does not go down → indicative of nasolacrimal duct obstruction.

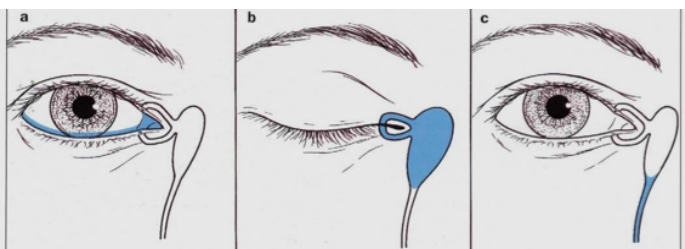


**“هذه الصورة تحفظونها صم”**  
**You need to know the length** Ampulla (2 mm), canaliculus (8 mm), common sac (10 mm), nasolacrimal duct (12 mm): bony part & soft part, valve of hasner → inferior meatus of the nose.



Babies born with teary eyes have a problem with the nasolacrimal duct (blocked)

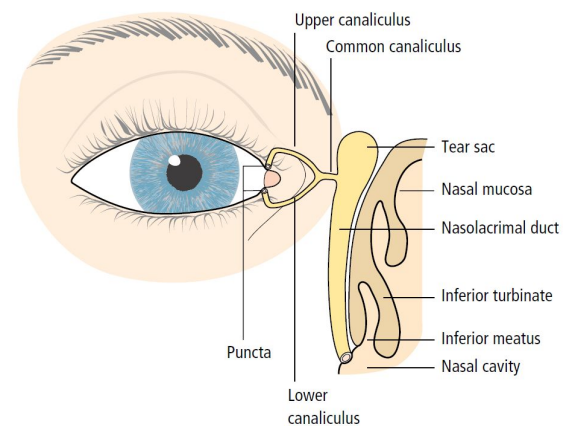
- \* Closed by bony part → nothing to do
- \* Closed by membranous part → observe for 1 year → goes spontaneously → persists → syringe & probing “تسريب”



**Fluorescein test**

Extra from 435 team

- Duct opens in superior conjunctival fornices.
- Tears drain into the upper and lower puncta and then into the lacrimal sac via the upper and lower canaliculi (Figure). They form a common canaliculus before entering the lacrimal sac. The nasolacrimal duct passes from the sac to the nose.
- 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 and canaliculi. (tears do not stay)
- the sac is continuous inferiorly with nasolacrimal duct which opens into the nasal cavity just beneath the inferior turbinate.
- The cascade : punctum (the start of the drainage system) > canaliculi > nasolacrimal sac > nasolacrimal duct > Inferior meatus (valve of Hasner is at the meatus).
- For the lacrimal gland, normally it's not palpable.
- The canaliculi connect the punctum to the nasolacrimal sac, not the duct.
- Blinking help tear drainage into the system by creating negative pressure.
- Infection of the lacrimal gland is called (Adenitis), and of lacrimal sac (Dacryocystitis).
- Running eye and nose means intact nasolacrimal duct.
- Tear film. 3 layers consists of: Mucin gel layer, Aqueous layer (produced by lacrimal gland), Oil layer: Meibomian glands.



# Eye (globe)

## - Two spheres with different radii:

- Cornea (transparent), window of the eye.
- Sclera (white), opaque shell.

- Cornea is stronger than sclera.

- Sclera is opened in most ruptured globe (open globe) cases in the ER due to blunt trauma. Why? Special arrangement of vertical & horizontal collagen → transparency of the cornea. Corneal injury → becomes white due to scarring (like sclera). Scleral fibers are interwoven → white & opaque.

- **The eye measures approximately 24 mm in all its main diameters.**

## - Three layers:

- **The outer** (outer protective layer): inelastic coat, transparent **cornea** and opaque **sclera**.
- **The middle:** (vascular nourishment layer) coat, **The Uvea:** choroid, ciliary body and iris.
- **The inner** (neurosensory): The **retina**, extends forwards to within 6 mm of the limbus & **optic nerve**

- If there is no vascular tissue the eye will atrophy because all secretions are coming from the ciliary body.

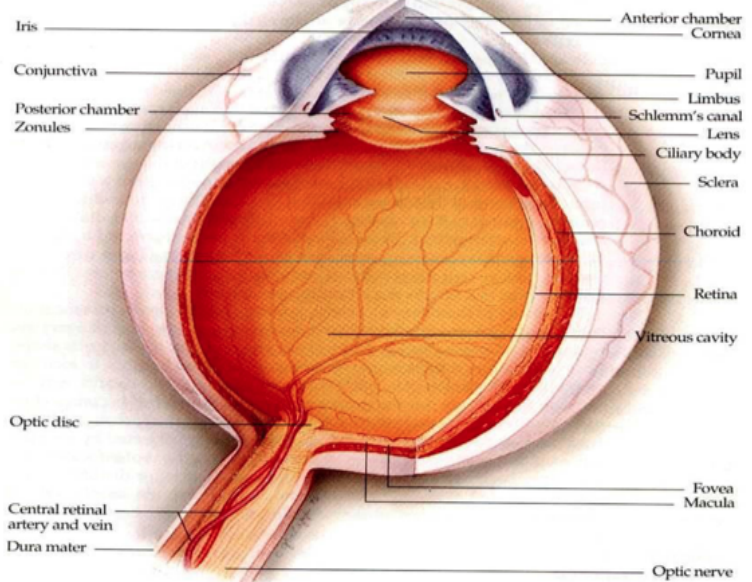
### SAQ:

You might get a picture pointing to a structure.

So, it is very important to know all the structures.

Examples:

- a. Lens.
- b. Vitreous cavity.
- c. Fovea.
- d. Optic nerve.
- e. Iris.



### Extra from 435 team

- Eye consist of globe (eyeball, extraocular muscles) and adnexa (lacrimal gland and sac).

#### - Coats of the Eye:

**1. Fibrous coat:** Made up of a posterior opaque part, the sclera, and an anterior transparent part, the cornea. Both are formed of collagenous fibers with different arrangement. Lamina cribrosa is the area of the sclera that is pierced by the nerve fibers of the optic nerve. Cornea is in contact posteriorly with the aqueous humor.

**functions are: protection and vision**

**2. Vascular pigmented coat :** Consists from behind forward, of the choroid, the ciliary body “ **mainly**”, and the iris. The choroid is composed of an outer pigmented layer and an inner, highly vascular layer. The ciliary body is continuous posteriorly with the choroid, and anteriorly, it lies behind the peripheral margin of the iris. It is composed of the ciliary ring, the ciliary processes, and the ciliary muscles. “**The ciliary body has pigmented and non-pigmented epithelium, the non-pigmented one secretes the aqueous**”

if ciliary body affected (uveitis) will cause atrophy of the eye.

**3. Inner layer:** composed of the optic nerve and the retina. The retina extends forward to within 6 mm of the limbus.



# Eye Chambers

## - Three optically clear spaces:

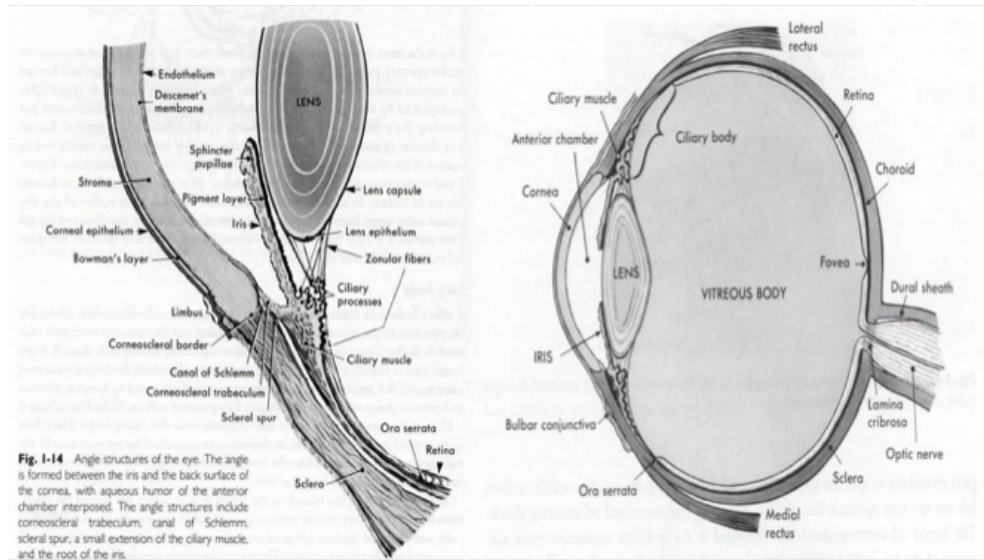
- **Anterior chamber:** in front of the iris (between the cornea and the iris)
- **Posterior chamber:** immediately behind the iris. (between the iris and zonule fibers)

These two chambers which communicate through the pupil are filled with clear aqueous humour السائل المائي

- **Aqueous humour:** (1) secretion: non-pigmented ciliary epithelium. (2) pathway: posterior chamber → pupil → anterior chamber (3) drainage: at the angle → canal of schlemm → trabecular meshwork.

- **Glaucoma:** closed-angle glaucoma (if closed), open-angle glaucoma (open but non-functional)

- **Vitreous cavity:** filled by gel-like structure, The Vitreous. السائل الزجاجي



## - The Intraocular pressure (IOP)

- The pressure within the eye is maintained at a steady level by continuous formation & drainage of aqueous.
- **The intraocular pressure, (IOP), is normally 10 - 21 mmHg; increased IOP called Glaucoma.**  
If IOP becomes high it might lead to glaucoma & optic nerve atrophy.
- High IOP almost always due to an obstruction of aqueous outflow.

Extra from 435 team

- It should be always clear, abnormal blood collection in it is known as hyphema and it is mainly due to trauma.
- Collection of pus in the anterior chamber is known as **hypopyon**.

- **Glaucoma happens because of problem in absorption not because of increase secretion.**

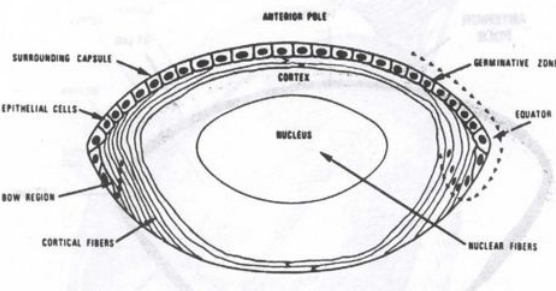
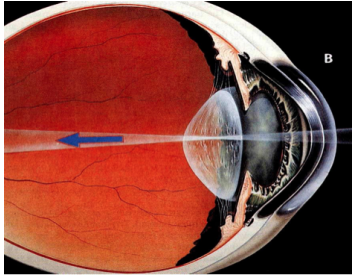
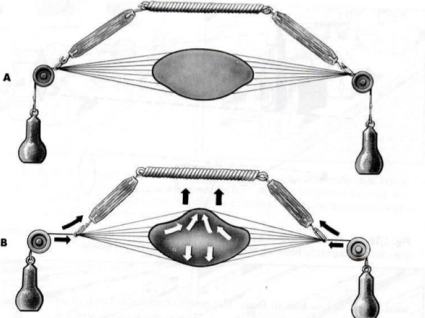
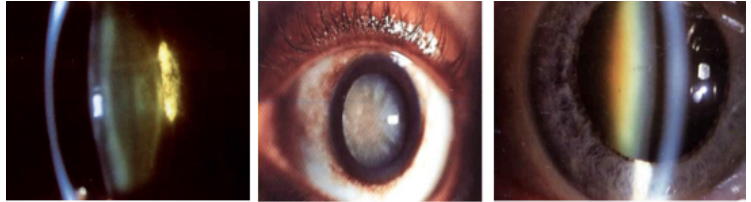
- **434 notes:**

- the aqueous is secreted with the help of **carbonic anhydrase enzyme**. Drainage: **Trabecular meshwork into the schlemm's canal (85%)**, and the other 15% got drained through the uveoscleral outflow (absorbed by the iris and the ciliary body to the suprachoroidal space).
- If the patient has a predisposing factor of glaucoma (e.g. hyperopia) and the pupil remained mid-dilated for a long period, the iris will adhere to the lens, and this will cause pupillary block, which in turn leads to accumulation of the aqueous in the posterior chamber and hence raising of IOP leading to the development of acute glaucoma. **The initial treatment of acute glaucoma is carbonic anhydrase enzyme inhibitors** to reduce the volume of accumulated aqueous like: Acetazolamide "Diamox" and Sulfonamide. These drugs act mainly on the trabecular pathway. Prostaglandins found to be active on the other pathway and has cosmetic side effects, it elongates and thickens eyelashes. **The initial intervention is long term treatment is clear lens extraction or laser iridotomy.**
- Anterior segment is anything in front of the lens including anterior chamber, cornea, iris, and lens itself. Posterior segment is anything behind the lens including vitreous, retina and optic nerve. When the patient complains of decreased vision but has normal anterior and posterior segments, then he might have **amblyopia "lazy eye"**.



# The Lens

- The crystalline lens is the only structure continuously growing throughout the life.
- **Structures:** capsule (anterior & posterior), epithelium and lens fibers, nucleus and cortex (in between)
- Children have embryonic nucleus (soft), adults have hard nucleus.
- Zonules or suspensory ligament (about 70,000) attaches the nucleus to the ciliary body on each sides. Which is important in accommodation (contract or relax depending if you're looking near or far away). After 40 years, the elasticity of the zonules diminishes (no contraction) → inability to see what is near.
- **Disease of the lens:**
  - o Cataract.
  - o Congenital anomalies and effect of systemic diseases.

Structures of the lens	Changeable refractive media
	 <p>Light passes: cornea → anterior chamber → lens → retina</p>
Zonules contraction & relaxation	Cataract
 <p><b>A:</b> contraction of zonules → far vision  <b>B:</b> relaxation of zonules → bulging of lens → near vision</p>	 <p><b>There are 3 types of cataract:</b>  <b>A: Nuclear</b> cataract  <b>B: Cortical</b> cataract  <b>C: Posterior subcapsular</b> cataract. Occurs with steroid use or trauma (in both pediatric &amp; adult patients)</p>

## Extra from 435 team

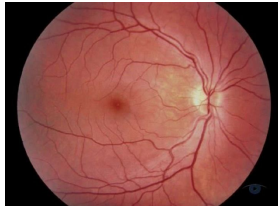
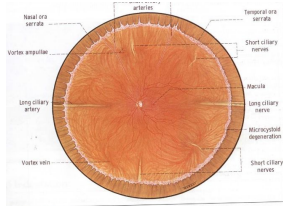
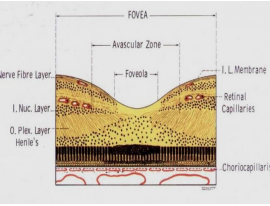

- It is a transparent, biconvex structure enclosed in a transparent capsule. It is situated behind the iris and in front of the vitreous body and is encircled by the ciliary processes. **(It's a changeable refractive media).**
- The lens consists of an **elastic capsule**, which envelops the structure; a **cuboidal epithelium**, which is confined to the anterior surface of the lens; and **lens fibers**, which are formed from the cuboidal epithelium at the equator of the lens.
- It is mainly ectodermal in origin, so it is very sensitive to pain.
- **Attack of high pressure cause destruction of the epithelium under anterior capsule cause opacity.**


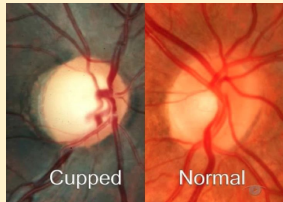
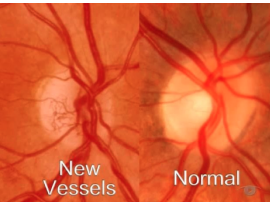


### - 434 Notes :

- o **Important question:** Post kidney transplant patient **on steroids** came complaining of decreased vision, what is the possible cause? The answer depends on the IOP, if it is normal, then he might have posterior subcapsular cataract. If his IOP is elevated, then he might have glaucoma.
- o Two approaches of cataract surgery: **phacoemulsification** and standard extracapsular cataract extraction (ECCE).

# Retina & Vitreous

- **Optic nerve head, macula, fovea, retinal background, ora serrata & retinal vasculature.**
- **Remember:** there are two parts of the retina without blood vessels: macula (fovea) & ora serrata. That is why most ophthalmic surgical procedures are done there (**pars plana**) ex. vitrectomy.
- **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.
- Vitreous attachment. | - Retinal detachment. | - Effect of systemic diseases.

			
<p><b>Normal retina:</b></p> <ul style="list-style-type: none"> <li>* Optic nerve</li> <li>* Macula (fovea)</li> </ul>	<ul style="list-style-type: none"> <li>* Retinal artery &amp; vein.</li> <li>* Optic disc.</li> </ul>	<p>Macula → fovea → avascular zone → Foveola (sharp vision 20/20 with color)</p>	<p>Normal optic disc has small cup (0.3 to 0.4 cup-to-disc C/D ratio). Optic cup: pale area in central fovea <b>pic</b></p>

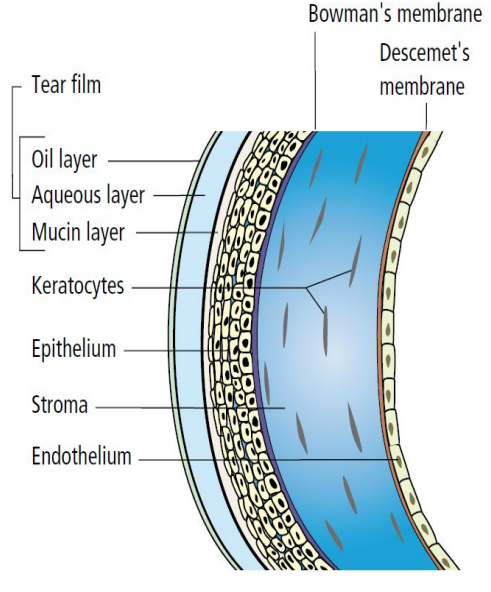
				
<p><b>SAQ:</b> Disc edema. If bilateral = papilledema (can be due to intracranial or brain tumor)</p>	<p><b>SAQ:</b> If C/D ratio is more than the range = large or physiologic or pathological (glaucoma) cup. How to diagnose glaucoma? Measure IOP (ocular tonometry) &amp; visual field.</p>	<p>New vessels (mostly opticociliary shunt vessels) due to sella turcica meningioma <b>OR</b> central vein occlusion <b>OR</b> diabetic retinopathy.</p>	<p><b>SAQ: very important</b> Retinitis pigmentosa: Pigmented clumps + pale optic disc</p>	<p>Age-related macular degeneration</p>

## Extra from 435 team

- The retina consists of an outer pigmented layer and an inner nervous layer. Its **outer** surface is in contact with the choroid and its inner surface is in contact with the vitreous body.
- At the center of the posterior part of the retina is an oval, yellowish area, the **macula lutea**, which is the area of the retina for the most distinct vision. It has a central depression, the **fovea centralis**.
- The optic nerve leaves the retina about 3 mm to the **medial** side of the macula lutea by the optic disc. **The optic disc** is slightly depressed at its center, where it is pierced by the **central retinal artery**. At the optic disc, is a complete absence of rods and cones, so that the optic disk is insensitive to light and is referred to as the **"blind spot"**.
- Photoreceptors contains visual pigment [large protein (opsin) attached to retinal (**vitamin A aldehyde**)]
- Light splits the opsin from the retinal with initiation of a graded electrical potential → Transmitted through the visual pathway to be processed in the visual cortex (occipital lobe) → vision sense.
- **Macula:** an area of the eye near the center of the retina where visual perception **is most acute**.
- **Fovea:** The fovea is the region in the center back of the eye that is responsible for acute (central) vision. **The fovea has a high density of cones. (while periphery of retina has higher density of rods).**
- Rods is used for night vision and cones for day vision
- **Vitreous humor:** It is a gel-like substance occupied the space behind the lens and in front of the retina at the back of the eye, it comprises a large portion of the eyeball. It consists of water, collagen, salt and sugar. It maintains the shape of the eye, and it is a clear solution to the light can easily pass through it.

# Cornea

<i>It has 5 layers</i>		
	Layer (anterior to posterior)	condition
Epithelium	<ul style="list-style-type: none"> <li>&gt; continuation of the bulbar conjunctiva</li> <li>&gt; ectodermal origin</li> </ul>	Abrasion. Treatment by covering the eye for 24hrs and defect will heal <b>without scarring</b> . Never use topical anesthesia in this case.
Bowman's membrane	clear <b>acellular</b> layer	Abrasion. Risk of <b>scarring</b>
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 <b>keratoplasty</b>
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 <b>open angle glaucoma</b> while if all structures closed that mean <b>closed angle</b> .



**You should know all 5 histological layers of the cornea.**

## Extra from 435 team

- The cornea is 500-530 micron(0.5mm) in thickness. It consists of **five layers: epithelium, bowman's layer** "called anterior limiting membrane", **corneal stroma, descemet's layer** "called posterior limiting membrane", **and corneal endothelium**.
- It protects the internal ocular structures. Together with the lens, it refracts and focuses light onto the retina.
- Nutrition of the cornea is supplied almost entirely by the aqueous humour.
- It is transparent because: **it is avascular and it has regularly arranged collagen fibers.**
- The epithelium is from surface ectodermal origin, thus it is very sensitive and also it **can regenerate** after being injured.
- **The thickness of the cornea affects the IOP reading.** After Lasik, the cornea becomes weak and a false low reading of IOP could occur, so the diagnosis of glaucoma might be missed. **One possible risk of Lasik is keratoconus**, which is central thinning and plugging of the cornea. This might end with corneal scarring and keratoplasty "corneal transplantation"
- The patient with keratoconus when he looks down, his lower eyelid becomes V shaped because of the plugging, and this is called **Munson's sign. "important"** **(Keratoconus is a strong contraindication of Lasik.)** So, When bowman's membrane gets injured, it will heal with a scar "opacity".



### - SAQ:

- Corneal abrasion usually does not cause scars unless the bowman's layer or the stroma are injured.
- The descemet's membrane is a very strong membrane, but in case of congenital glaucoma, it will be stretched and the aqueous will invade the cornea, which will disturb corneal fibers arrangement and cause corneal edema. If congenital glaucoma doesn't get corrected early, the condition will worsen and end up with corneal scarring and keratoplasty might be needed. **So the treatment of congenital glaucoma is surgical. Important Q:** When the patient got blunt trauma in the eye, which one is more susceptible to injury, cornea or sclera? **The answer is sclera**
- Actually, both Cornea and sclera are made up of collagen fibers but they differ in the arrangement. The corneal fibers are arranged in vertical and horizontal planes, making it more clear and 100 times stronger than sclera. The fibers of the sclera are arranged in haphazard fashion, which make them weaker and more opaque.

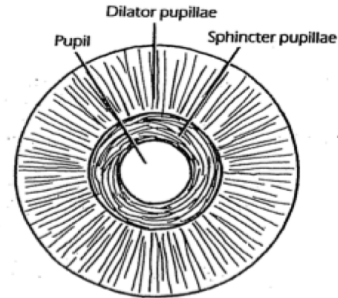
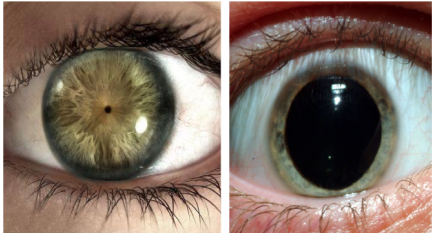


# Iris & Pupil

- The iris has two muscles:

- **Dilator pupillae:** dilation of pupil (mydriasis) supplied by **sympathetic fibers**
- **Sphincter pupillae:** constriction of pupil (miosis), supplied by **parasympathetic fibers** from the oculomotor nerve. **Predominant.**

Difference between two pupils (small & large) is called: **Anisocoria.**



Extra from 435 team

- The iris is a thin, contractile, pigmented diaphragm attached peripherally to the anterior part of the ciliary body.
- It forms the pupil at its centre, the aperture of which can be varied by the circular sphincter and radial dilator muscles to control the amount of light entering the eye.

- **434 notes:**

- In patients with 3rd nerve palsy and spared pupil like in diabetes, or in patients with semi dilated\fully dilated pupil and 3rd nerve palsy, what is the recommended investigation?
- The answer is **MRA "magnetic resonance angiography"** because the most common cause of surgical 3rd nerve palsy is aneurysm, which can be detected using MRA.

# Ciliary Body

Extra from 435 team

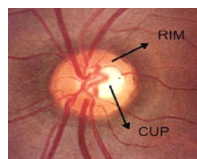
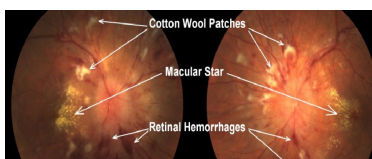
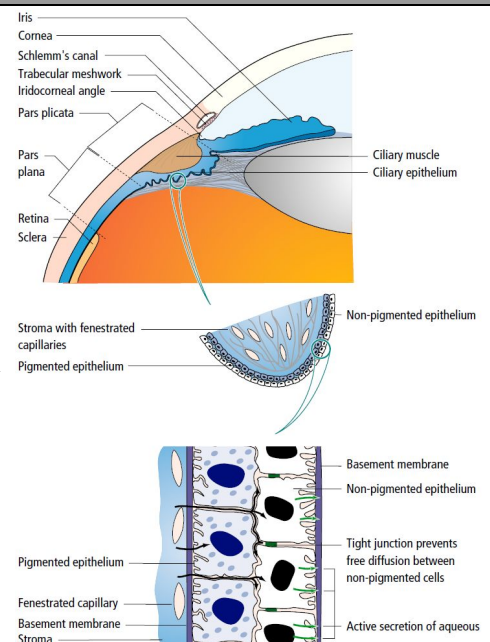
- The structure of the ciliary body is triangular in cross-section, and it encircles the inside of the eye behind the colored iris. It connects posteriorly with the choroid and anteriorly with the iris.

- The ciliary body is subdivided into three parts:

- The ciliary muscle (responsible for changes in lens thickness and curvature during **accommodation**)
- The ciliary processes at the front ( pars plicata ):They are responsible for the secretion of **aqueous humour**.
- The pars plana at the rear. Pars plicata has the ciliary processes, and the zonular lens fibers from the crystalline lens pass deep into the valleys between them.

- **434 notes:**

- In fundus examination, you should comment on: **the optic disc, the retinal vessels, and the macula.**
- Patient with chronic visual loss + the fundus is not seen = **do B-scan ultrasound. "Gold standard"**





# Optic Nerve

Extra from 435 team

- Optic nerve > optic disc > rim and cup (when increased is sign of glaucoma, or could be physiological and we differentiate two types by measuring IOP and visual field)

- contains around 1.2 million nerve fibers, which are axons of the retinal ganglion cells.

- the length of optic nerve in these structures: **important to know**

- o 1 mm in the globe.
- o 25 mm in the orbit.
- o 9 mm in the optic canal.
- o 16 mm in the cranial space

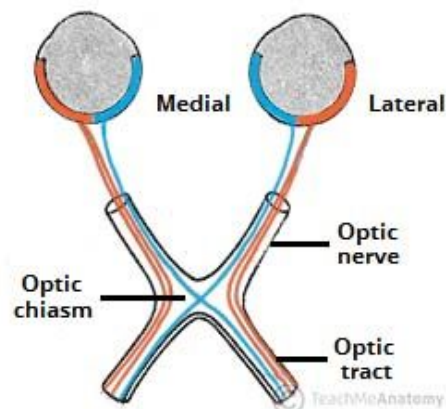
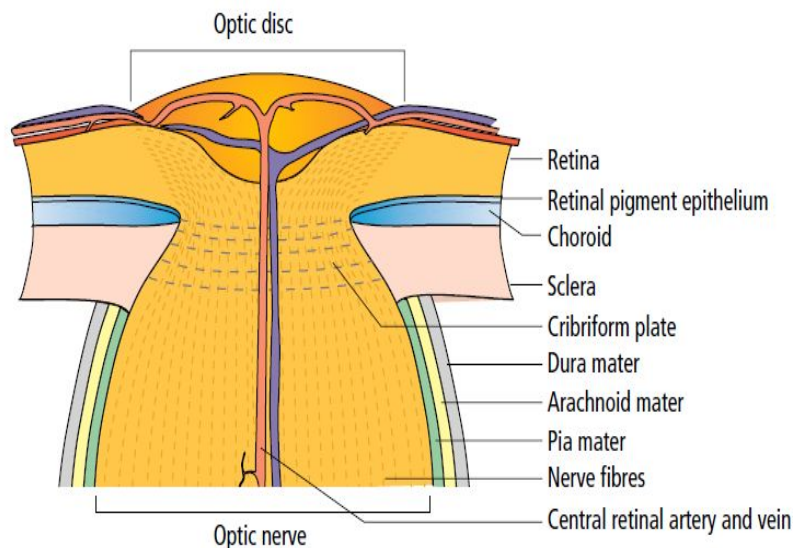
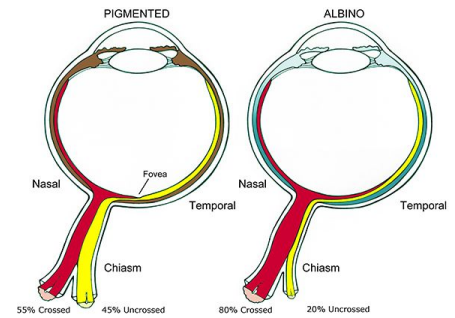
- **Partial decussation occurs and about 53%** of the fibers cross to form the optic tracts (if pt have carotid lesion will develop binasal hemianopia).

- **The optic nerve** leaves the retina about 3 mm to the medial side of the macula lutea by the optic disc. The optic disc is slightly depressed at its center, where it is pierced by the central retinal artery. At the optic disc, is a complete absence of rods and cons, so that the optic disk is insensitive to light and is referred to as the "blind spot".

- **Optic disc:** the terminal part of the optic nerve where ganglion cells fibers leaves the eye.

- **Optic cup:** a central depression within the optic disc.

- The normally cup-disk ratio is **3/10 (0.3)** Measurement is crucial to diagnose certain diseases like glaucoma.



# Optics of the Eye

Extra from 435 team

- The eye is like a camera. Light must have a clearly pathway to be clearly focused on the sensory receptors of the retina, i.e., Clear cornea, anterior chamber, lens and vitreous cavity.
- **The Refractive power of the eye is about 58 -62 diopters.**
- **The cornea is the major refracting element of the eye with a power of approximately 40 diopters.** If the curvature is greater in one meridian than the other → Astigmatism.
- **The refractive power of the lens is about 17-21 diopters at rest. Accommodation can change the power of the lens markedly depending on the age.**

## - 434 notes:

- Young kids have a strong accommodation up to 30 diopters as their lenses has 70.000 zonule fibers.
- When ciliary body contracts → relaxation of the zonules → plugging of the lens and thus increased depth of focus and you will be able to see near objects.
- When ciliary body relaxes → contraction of the zonules → thinning of the lens, so you will be able to see far objects clearly.
- **Important:** \*With increased age, usually from 40s, people experience a problem with near vision "Presbyopia", why?

**Because of:** (1) Loss of elasticity of the lens (2) Increased refractive index of the lens due to nuclear sclerosis.

- **Presbyopia is treated with convex lens.**
- **Hyperopia "farsightedness"** → treated with convex lens.
- **Myopia "nearsightedness"** → treated with concave lens.
- Patient with big eyes ">25 mm in diameter" the image will be reflected in front of the retina leading to myopia, to correct it we give the patient a concave lens, thus causes a diversion of light rays.
- Patient with small eyes "<21 mm in diameter" the image will be reflected behind the retina leading to hyperopia, to correct it we give the patient a convex lens that causes a conversion of light rays.

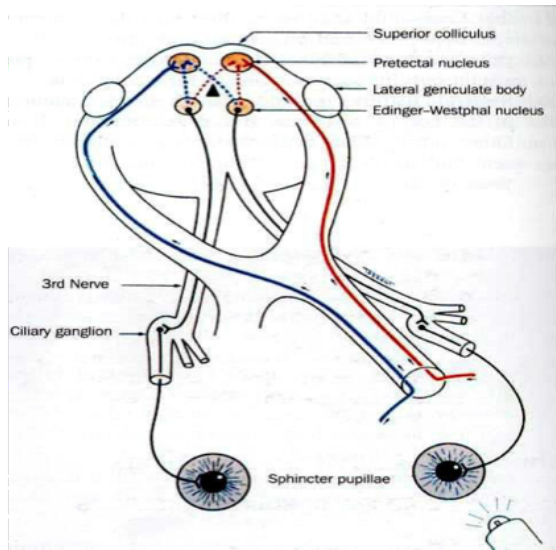
## Vision / Visual Pathway

- **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 (vitamin A aldehyde: 11-cis-retinal) that changes into Rhodopsin (chemical) upon light stimulation (electrical stimulation)
- **Visual Pathway: THREE order neurons:**
  1. **Bipolar cell:** lies within the retina. from photoreceptors to retinal ganglion cell.
  2. **Ganglion cell:** from retinal ganglion cell to synapse in lateral geniculate body
  3. **Third neuron:** from lateral geniculate body and terminates in visual cortex.

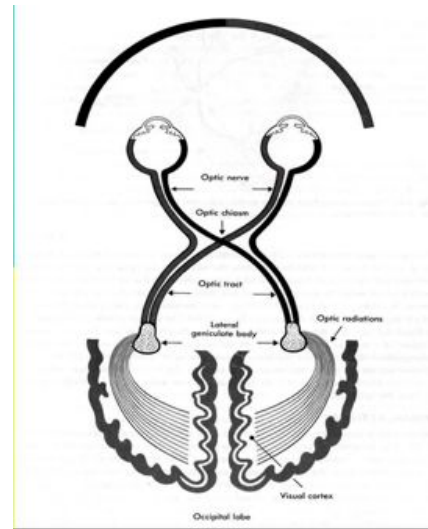
Extra from 435 team

- The central retina contains yellow pigment, Xanthophyll, the so called macula lutea ( yellow spot).
- Light splits the opsin from the retinal with initiation of a graded electrical potential → Transmitted through the visual pathway to be processed in the visual cortex (occipital lobe) → vision sense.

## Pupillary light reflex by CN III



## Visual pathway



# Summary

Question	Answer
The socket that contains the eye is called .....	<b>ORBIT</b>
The orbit is formed by ..... Bones.	<b>Seven</b>
The optic nerve pass through .....	<b>Optic foramen or canal</b>
The eye has ..... Extraocular muscles, ..... Recti and ..... obliques.	<b>Six , 4 , 2</b>
All extraocular muscles are supplied by ..... except ..... & .....	<b>Oculomotor nerve, SO4, LR6.</b>
When we test a patient 4th nerve we should ask him to look .....	<b>Down and in.</b>
The space that lies behind the cornea & in front of the iris called .....	<b>Anterior chamber</b>
The fluid that fills the chambers of the eye called .....	<b>Aqueous humors.</b>
The cavity that lies behind the lens called .....	<b>Vitreous cavity</b>
The main refractive structure in the eye is .....	<b>the cornea.</b>
The second refractive structure in the that can change its power .....	<b>the lens</b>
The structure that determines the color of the eye is .....	<b>the iris</b>
when the lens get opacified this condition called .....	<b>cataract</b>
The central part of the retina is called .....	<b>the macula.</b>
The central part of the macula is called .....	<b>fovea</b>
The central part of the fovea is called	<b>foveola</b>
The optic nerve lies in ..... part of the retina.	<b>nasal</b>
The percentage of the decussating fibers is .....	<b>53%</b>