

Embryology, anatomy and physiology of the eye



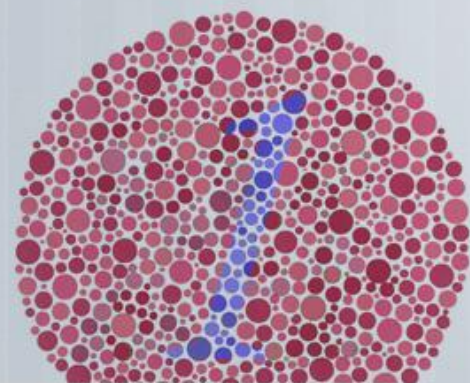
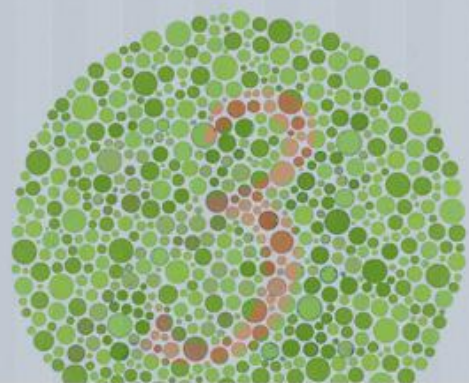
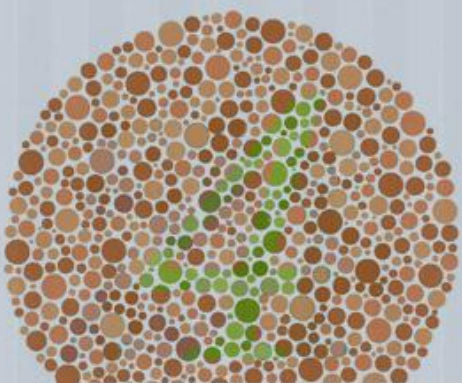
431
Teams
medical students

Ophthalmology Team

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Big thanks to 429 team



From slides Doctor's Notes Team's Notes From the book Important

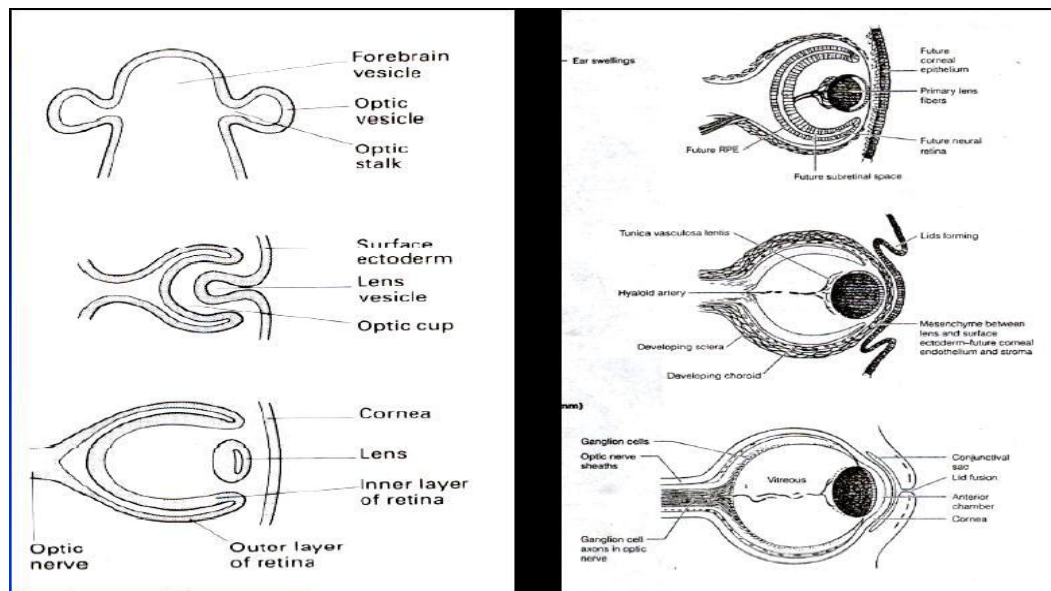
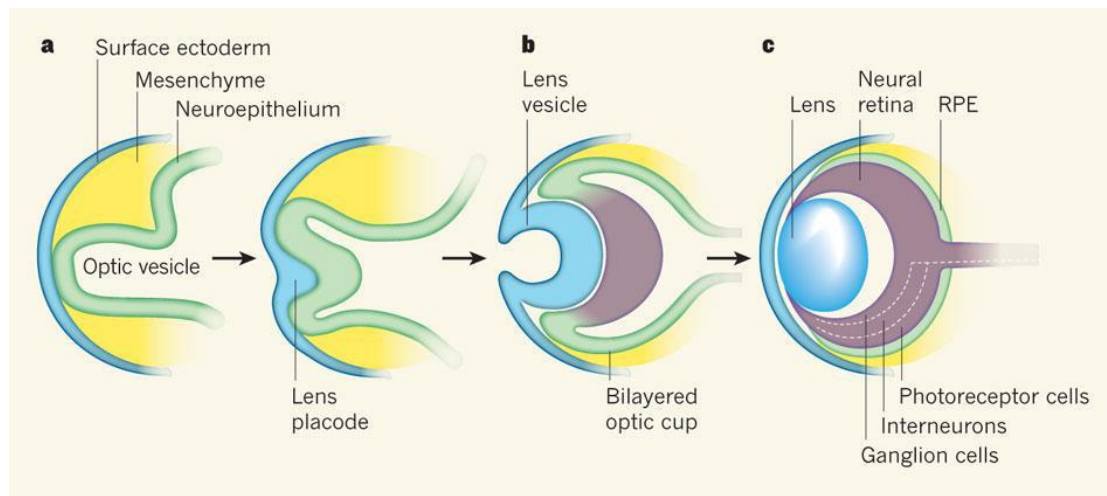
Embryology:

Early eye development results from a series of inductive signals. This highly specialized sensory organ is derived from:

A) Neural ectoderm: differentiates into the retina, the posterior layer of the iris, and the optic nerve.

B) Mesoderm: between the neuroectoderm and surface endoderm gives rise to the fibrous and vascular coat of the eye.

C) Surface ectoderm: forms the lens of the eye and corneal epithelium



The eye is essentially an outer growth from the brain (neural ectoderm).

On both sides of the brain, lateral bud develop and elongate forming the optic vesicle which is connected to the forebrain by **optic stalk**.

Then the surface ectoderm starts to develop, forcing and separating the vesicle into two layers by invagination. "These two layers will form the retina later on"

Also, Surface ectoderm invaginate to form the lens vesicle. At embryonic life, Cornea and lens are **vascular** to supply generation cells.

With time, these vessels will disappear from the cornea and lens to give clear cornea and lens to give clear image. "These vessels supply the developing eye from the inferonasal aspect"

After disappearance there will be complete fusion to form the globular structure of the eye. "So any defect in fusion is called coloboma"

Coloboma: any defect in the structures of the eye such as iris, retina or choroid.
"Should be inferonasal in location"

After birth:

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.

The lens continues to enlarge throughout the life.

The iris has a bluish color due to little or no pigment on the anterior surface.

During early infant life, the cornea & sclera can be stretched by raised IOP.

If the child has congenital glaucoma; the eye will be bigger in size, unlike in adults which the eye will remain in the same size.

The orbit:

Below the eyebrow we will find the orbital rim.

In superiolateral aspect of the orbit there is a depression called **lacrimal gland fossa** and behind it there is the **lacrimal gland**. "Which is responsible for the production of tear"

The lateral rim of the orbit is formed by the zygomatic bone.

In the medial aspect there is a bony crest which is called anterior lacrimal crest and behind it there is the lacrimal sac.

The orbit is like a socket, contains and protects the eye.

The weakest part is the floor "because its curvature", the medial wall is thin and the lateral wall is the strongest.

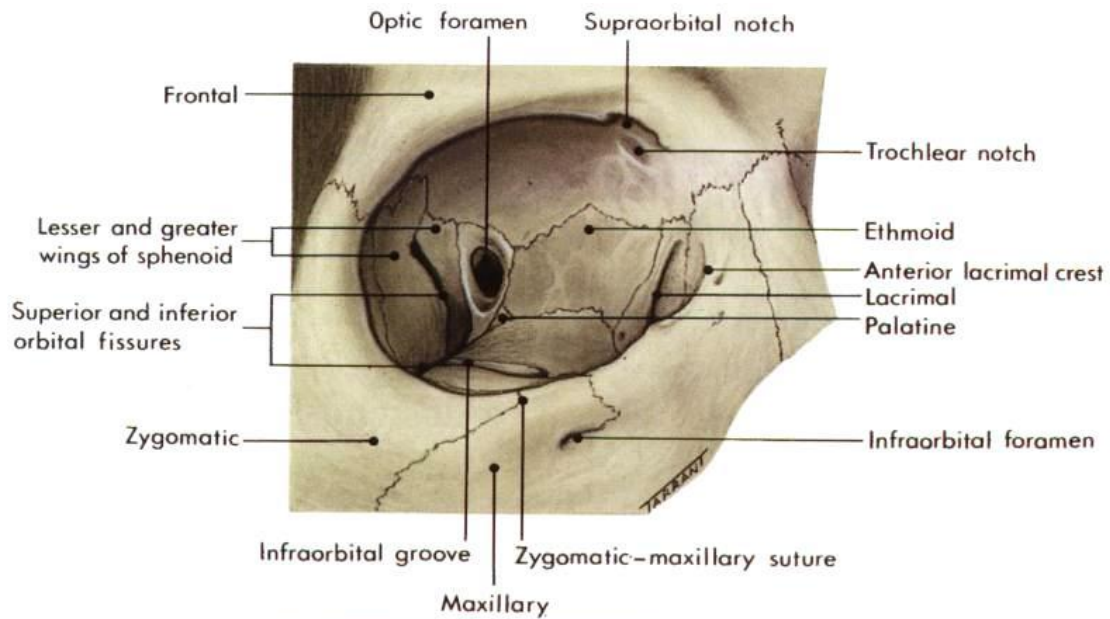
Seven bones contribute the bony orbit.*

Surrounded by nasal sinuses.

The medial wall is very thin so that the infection can spread very easy. "Sinusitis can be complicated to orbital cellulitis through the ethmoidal sinus"

*Anterior part of the orbit is formed by 3 bones: Zygomatic, frontal and maxillary bone.

Posterior part is formed by 4 bones: Lacrimal, sphenoidal, ethmoidal and palatine bone.



The openings of the orbit:

The optic foramen contains two important structures:

- 1- The optic nerve.
- 2- The ophthalmic artery.

The inferior orbital fissure:

- 1- Infraorbital nerve
- 2- The inferior division of the ophthalmic vein. "it may pass through the superior fissure; it is anatomical variation"

The superior orbital fissure: "ALL THE OTHER STRUCTURES PASSES THROUGH THIS FISSURE":

- 1- Trochlear nerve.
- 2- Abducent nerve.
- 3- Oculomotor nerve.
- 4- frontal nerve.
- 5- lacrimal nerve.
- 6- Nasociliary nerve.
- 7- Branch of the ophthalmic division of trigeminal artery.
- 8- Superior ophthalmic vein.

Extraocular muscles:

Muscle	Action	Nerve supply
Superior rectus	Elevation and adduction	Oculomotor “3”
Inferior rectus	Depression and adduction	Oculomotor “3”
Medial rectus	Adduction	Oculomotor “3”
Lateral rectus	Abduction	Abducent “6”
Superior oblique	Depression, abduction and intorsion	Trochlear “4”
Inferior oblique	Elevation, abduction and extorsion	Oculomotor “3”

The eyelid:

They provide a protective covering for the eye, and spread of the pericornial tear film.

The lids are closed by: Orbicularis oculi muscle (Facial n.)

and opened by:

- 1- Levator palpebrae muscle, innervated by Oculomotor nerve
- 2- Muller’s muscle(superior tarsal muscle), innervated by Sympathetic fibers.
- 3- Lower lid retractors.

Conjunctiva:

Three parts:

1. Bulbar conjunctiva. “Covers the sclera”
2. Palpebral conjunctiva. “Related to the eyelid”
3. Forniceal conjunctiva “The connection between bulbar and palpebral”

The conjunctiva contains the accessory lacrimal gland which is responsible for the basal lacrimal secretion.

The stroma (no adenoid tissues until the age of 3 months).

Some diseases characterized by follicle formation which is the aggregation of lymphoid tissue.

Other diseases characterized by papillae formation which is proliferation of the epithelium of the conjunctiva.

Injected conjunctiva: red conjunctiva “infection”.

Chemosis: edematous conjunctiva.

Limbus: Where the conjunctiva ends and the cornea starts.

Orbital septum:

Prevent the eye from bulging out when leaning forward.

Very strong barrier against the spread of infections.

Infection behind the septum is called orbital cellulitis “it may cause cavernous sinus thrombosis because the venous drainage is through the ophthalmic vein which ends in the cavernous sinus”.

Infection anterior to the septum is called preseptal cellulitis “Not very dangerous”

Lacrimal apparatus:

Lacrimal gland secret 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 medial canthus “lacus lacrimalis” 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 “in the inferior meatus”.

The role of orbicularis oculi “facial nerve” in tear drainage:

Horner's muscle is a part of orbicularis muscle that attached to the lacrimal wall of the lacrimal sac.

Contraction of orbicularis > closure of the eyelid.

Contraction of horner's muscle > distention of lacrimal sac > -ve pressure > suck the tear from lake lacrimalis.

Relaxation of orbicularis > open eye

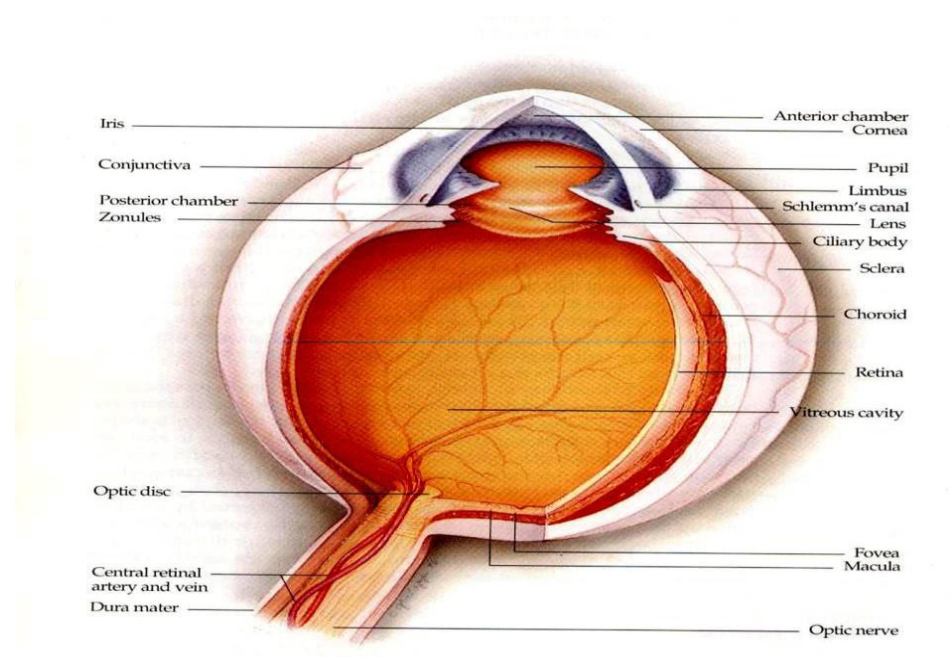
Relaxation of Horner's muscles > +ve pressure in the sac > push the tear to the nose.

Main lacrimal gland:
Reflex tearing.
Accessory lacrimal gland: Basal secretion of the tear.

Composition of tears: “From lecture notes”

- 1- Mucin gel layer produced by the conjunctival goblet cells, in contact with the ocular surface;
- 2- An aqueous layer produced by the lacrimal gland;
- 3- A surface oil layer produced by the meibomian glands and delivered to the lid margins.

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.

It has three layers:

1. **The outer:** inelastic coat, transparent cornea and opaque sclera.
2. **The middle:** vascular coat, The Uvea: choroid “posterior”, ciliary body “middle” and iris “anterior”. “The iris contain heavily pigmented melanin cells”
3. **The inner:** The Retina, extends forwards to within 6 mm of the limbus.

Anterior chamber: between cornea and iris.

Posterior chamber: between iris and lens.

Vitreous cavity: behind the lens.

We should have a well inflated globe to have a clear image. “That’s why we should have a fixed intraocular pressure”

High IOP: Glaucoma

Low IOP: Hypotony

Cornea, lens and vitreous are avascular structures.

Triad of glaucoma:

- 1- High IOP.
- 2- High cup-disk ratio.
- 3- Decrease visual field.

The aqueous fluid “which is produced by the ciliary body” give a continuous supply to these structures.

The lens:

The crystalline lens is the only structure continuously growing throughout the life.

Located between the posterior chamber and the vitreous cavity, separates the anterior and posterior segments of the eye.

It's a sac of gelatinous proteins surrounded by a basement membrane (the capsule) created by the lens epithelial cells.

The lens grows by elongation and transformation of the epithelial cells into lens fibers.

Zonular fibers suspend the lens from the ciliary body and enable the ciliary muscle to focus the lens by changing the its shape (accommodation).

Cornea has the main refraction power but the lens has a changeable refraction.

The refractive power of the lens changes with aging.

During childhood and early adulthood > soft lens

With aging > decrease elasticity > decrease accommodation.

Accommodation power in children= 14 diopter(1\14).

Accommodation power by the age of 40 is 1 diopter.

The retina:

The retina has nine distinct layers: “The doctor did not mention them in details”

- 1. The internal limiting membrane:** is the inner basement membrane
- 2. The nerve fiber layer:** contains unmyelinated ganglion cell axons that then form the optic nerve and finally synapse with nuclei of cells in the lateral geniculate body.
- 3. The ganglion cell layer:** is composed of a single layer of ganglion cells, except in macula, where it's multilayered.
- 4. The inner plexiform layer:** contains the synapses between the bipolar cell and ganglion cell or amacrine cell.
- 5. The inner nuclear layer:** contains the cell bodies of the bipolar, amacrine, horizontal, and muller cells.
- 6. The outer plexiform layer:** contains the synapses between photoreceptors and the bipolar cells
- 7. The outer nuclear layer:** is composed of the photoreceptor cell nuclei.
- 8. The external limiting membrane**
- 9. The photoreceptor layer:** contains the rods and cones (120 million rods and 6 million cones)

When we see the fundus we should comment on the optic head, the macula and the vessels

Macula is responsible for central vision.

The vein is thicker than the artery.

The artery always crosses over the vein.

The photoreceptors change the photo power to electrical potential.

Cons: in the central.

Rods: in the periphery

Cup or cupping: the pale area in the optic disk. Normally, its ,3

Optic nerve head cupping progression



Physiology of the eye:

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 dioptres.

The cornea is the major refracting element of the eye with a power of approximately 40 dioptres. If the curvature is greater in one meridian than the other → Astigmatism.

The refractive power of the lens is about 17 dioptres at rest. Accommodation able to change.

The power of the lens markedly depends on age.

Emmetropia: Optically normal eye in which rays of light from a distant object are focused on the retina without accommodation.

Myopia: Light focused on front of the retina, corrected by concave lens.

Hypermetropia (hyperopia): Light focused behind the retina, corrected by convex lens.

The 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.

High IOP almost always due to an obstruction of aqueous outflow.

Vision:

The central retina contains yellow pigment, Xanthophyll, the so called macula lutea (yellow spot).

It is divided into retinal pigment epithelium & neurosensory retina.

Photoreceptors contains visual pigment which consists of a 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.

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.

Regarding embryology and development of the eye all are FALSE except:

- 1- The eye is derived from mesoderm, endoderm and surface ectoderm.
- 2- The eye coloboma should be superiotemporal in location.
- 3- The eye reaches full size at puberty.
- 4- The lens continues to enlarge throughout the life.
- 5- During early infant life the cornea and sclera cannot be stretched by increase IOP.

Answer:

4

Regarding the orbit, all are TRUE except:

- 1- The thinnest wall of the orbit is the medial wall.
- 2- The weakest wall is the floor.
- 3- The ophthalmic artery passes through the optic canal.
- 4- The superior division of the oculomotor nerve passes through the superior orbital fissure.
- 5- The inferior division of the oculomotor nerve passes through the inferior orbital fissure.

Answer:

5

Regarding the eyelid and conjunctiva, all are TRUE except:

- 1- The lids are closed by orbicularis oculi muscle supplied by facial nerve.
- 2- The lids are open by levator palpebrae superioris muscle supplied by oculomotor nerve and muller's muscle by parasympathetic supply.
- 3- The tarsus is the skeleton of the eyelid.
- 4- The orbital septum is a strong barrier against infection.
- 5- The conjunctiva has three parts: bulbar, palpebral and fornical conjunctiva.

Answer:

2

Regarding the lacrimal apparatus all are FALSE except:

- 1- Lacrimal gland is located in the inferonasal aspect of the orbit.
- 2- Lacrimal gland is the only source of tears.
- 3- The tears are spread over the surface of the cornea as a tear film by blinking of the lids.
- 4- Tears drain into the lacrimal sac via a punctum and the nasolacrimal duct.
- 5- The facial nerve has no role in tear drain.

Answer: 3

Summary:

- 1- Coloboma has to be inferonasal in location.
- 2- The floor of the orbit is the weakest part.
- 3- The lateral part of the orbit is the strongest.
- 4- The optic canal contains the most important structures: The optic nerve and the ophthalmic artery.
- 5- The orbital septum is strong against infection.
- 6- The connection between the bulbar and the palpebral parts of the conjunctiva is called the fornix.
- 7- Infection behind the orbital septum called orbital cellulitis, and can cause cavernous sinus thrombosis.
- 8- The facial nerve has a role in tear drainage.
- 9- Normal IOP is from 10 to 21.
- 10- Triad of glaucoma: Decrease visual field, increase IOP and increase cup-disk ratio.