

Eye embryology

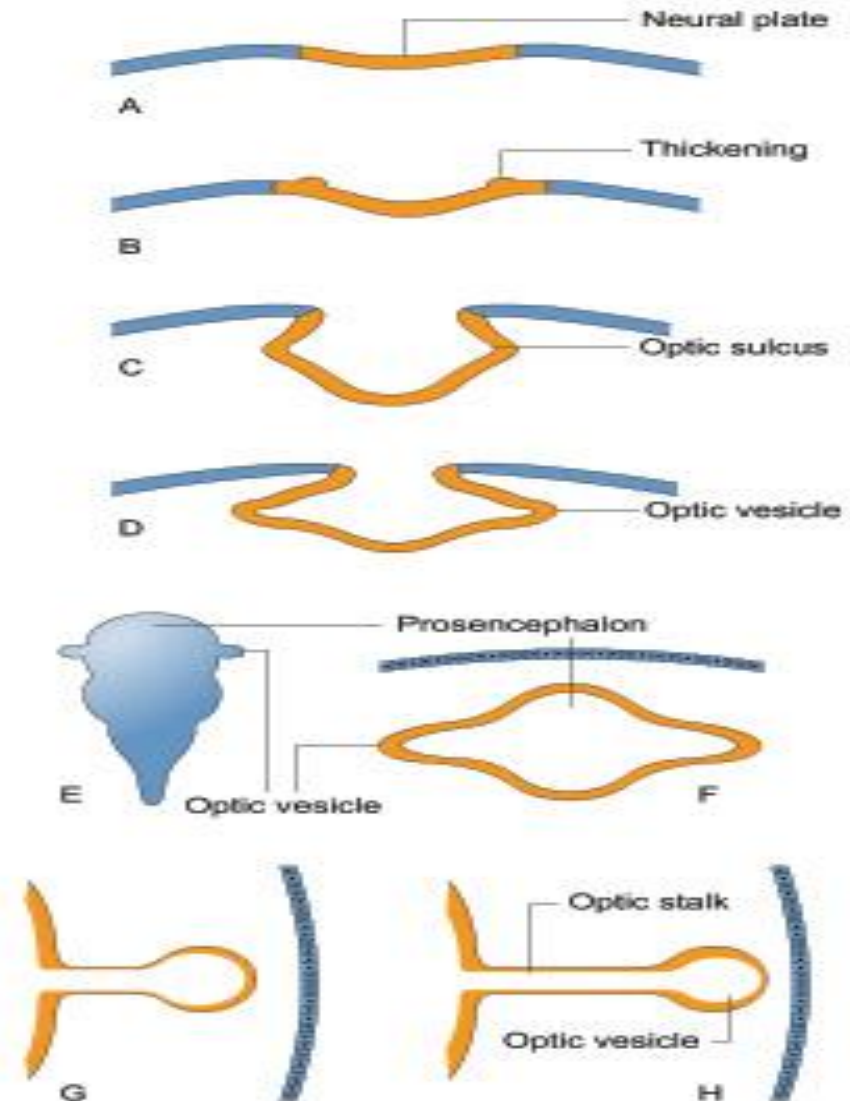
Sourav

Introduction

- The eyeball and its related structures are derived from the following primordia:
 1. *Optic vesicle, an outgrowth from prosencephalon (a neuroectodermal structure),*
 2. *Lens placode, a specialised area of surface ectoderm, and the surrounding surface ectoderm,*
 3. *Mesenchyme surrounding the optic vesicle*
 4. *Visceral mesoderm of maxillary process.*

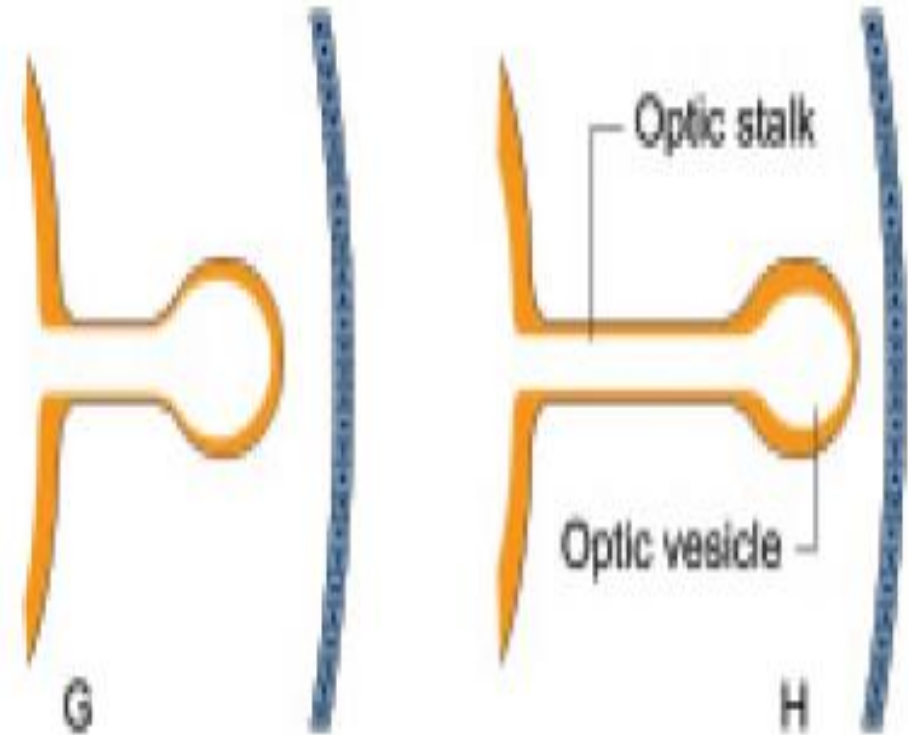
FORMATION OF OPTIC VESICLE AND OPTIC STALK

- The area of neural plate which forms the
- prosencephalon develops a linear thickened area on either side. which soon becomes depressed to form the optic sulcus.
- The neural plate gets converted into prosencephalic vesicle.



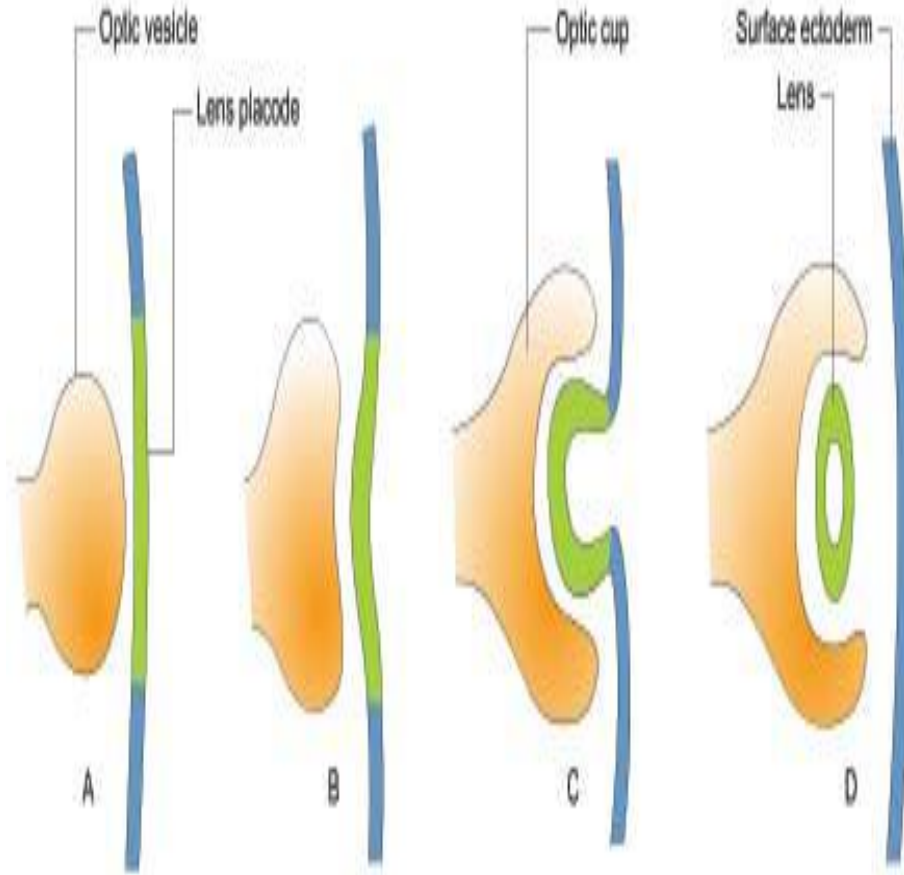
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- As the optic sulcus deepens, the walls of the prosencephalon overlying the sulcus bulge out to form the *optic vesicle*.
- *The proximal part* of the optic vesicle becomes constricted and elongated to form the *optic stalk*



FORMATION OF OPTIC CUP

- The optic vesicle is converted into a double-layered *optic cup*.
- The margins of optic cup grow over the upper and lateral sides of the lens to enclose it.
- such a growth does not take place over the inferior part of the lens.
- the walls of the cup show deficiency in this part.



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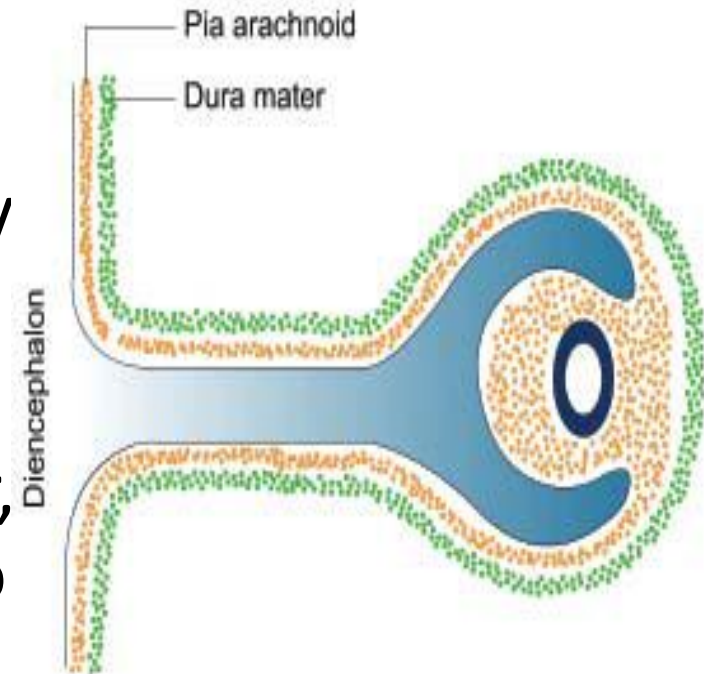
- This deficiency extends to some distance along the inferior surface of the optic stalk and is called the ***choroidal or fetal fissure***



Optic cup and stalk

CHANGES IN THE ASSOCIATED MESENCHYME

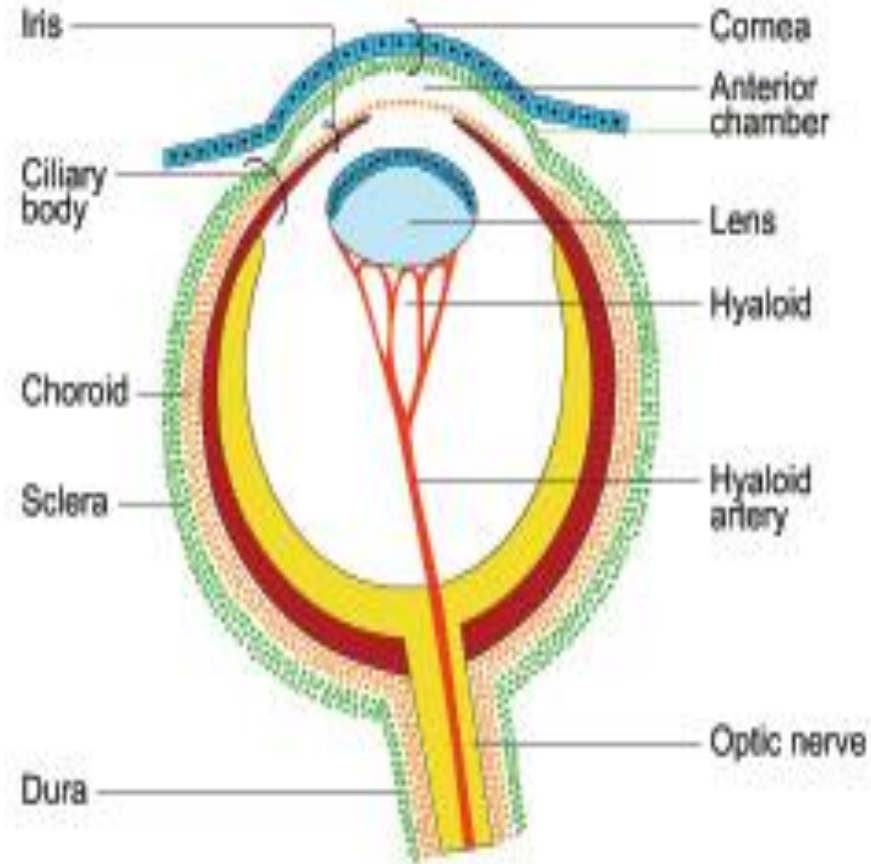
- The developing neural tube (from which central nervous system develops) is surrounded by mesenchyme, which subsequently condenses to form meninges.
- An extension of this mesenchyme also covers the optic vesicle. Later, this mesenchyme differentiates to form a superficial fibrous layer (corresponding to dura) and a deeper vascular layer (corresponding to pia-arachnoid)



Developing optic cup surrounded by mesenchyme

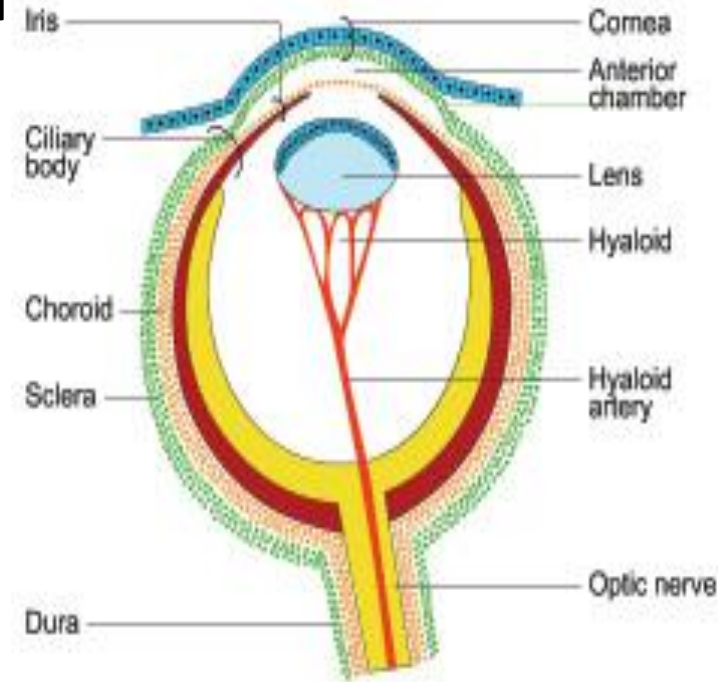
- With the formation of optic cup, part of the inner vascular layer of mesenchyme is carried into the cup through the choroidal fissure.
- With the closure of this fissure, the portion of mesenchyme which has made its way into the eye is cut off from the surrounding mesenchyme and gives rise to the hyaloid system of the vessels.

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Derivation of various structures of the eyeball.

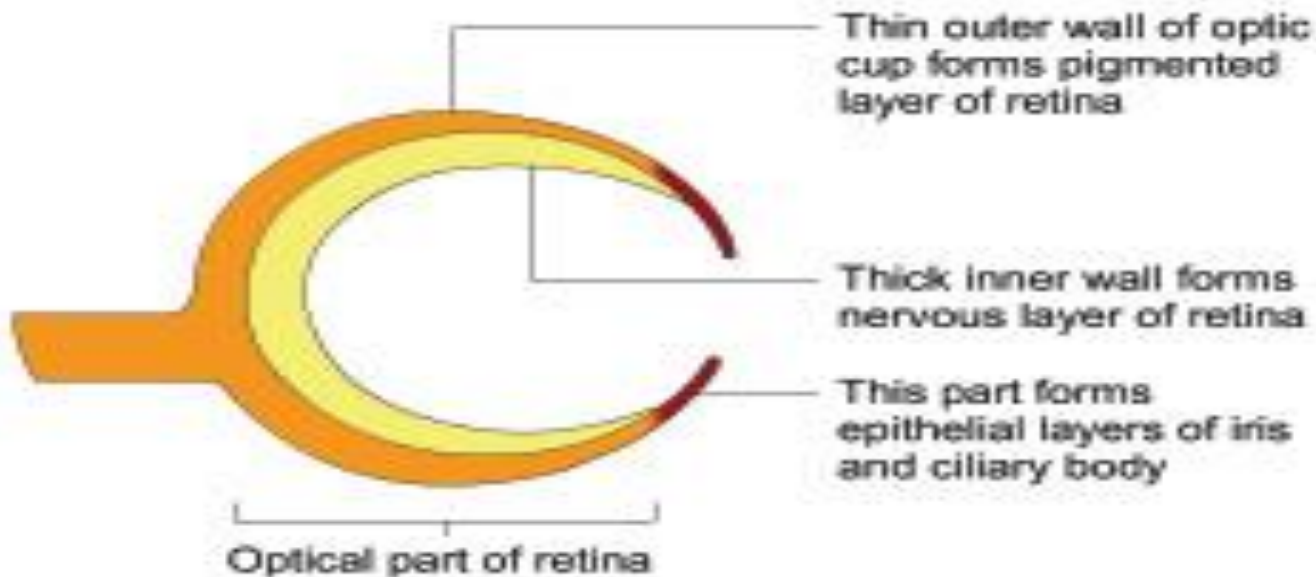
- The fibrous layer of mesenchyme surrounding the anterior part of optic cup forms the **cornea**.
- The corresponding vascular layer of mesenchyme becomes the **iridopupillary** membrane, which in the peripheral region attaches to the anterior part of the optic cup to form the **iris**.
- In the posterior part of optic cup the surrounding fibrous mesenchyme forms **sclera** and **extraocular muscles**, while the vascular layer forms the **choroid** and **ciliary body**.



Derivation of various structures of the eyeball.

DEVELOPMENT OF VARIOUS OCULAR STRUCTURES

- Retina : Retina is developed from the two walls of the optic cup, namely:
- (a) nervous retina from the inner wall,
- (b) pigment epithelium from the outer wall



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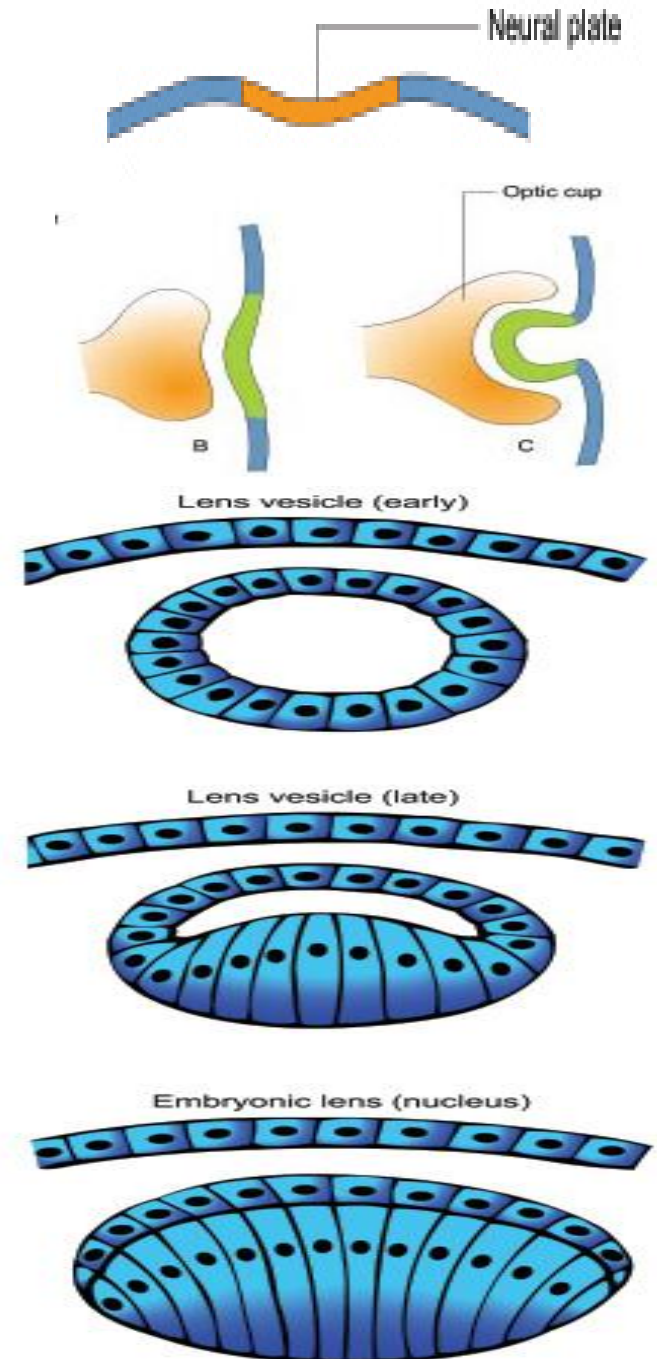
- **(A) Nervous retina:** The inner wall of the optic cup is a single-layered epithelium. It divides into several layers of cells which differentiate into the following **three layers**
- **Matrix cell layer.** Cells of this layer form the **rods and cones.**
- **Mantle layer.** Cells of this layer form the **bipolar cells, ganglion cells,** other neurons of retina and the supporting tissue.
- **Marginal layer.** This layer forms the **ganglion cells, axons** of which form the nerve fibre layer.

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- **(b) Outer pigment epithelial layer. Cells of the outer:**
- wall of the optic cup become pigmented. Its posterior part forms the **pigmented epithelium of retina** and the anterior part continues forward in **ciliary body and iris** as their anterior pigmented epithelium.

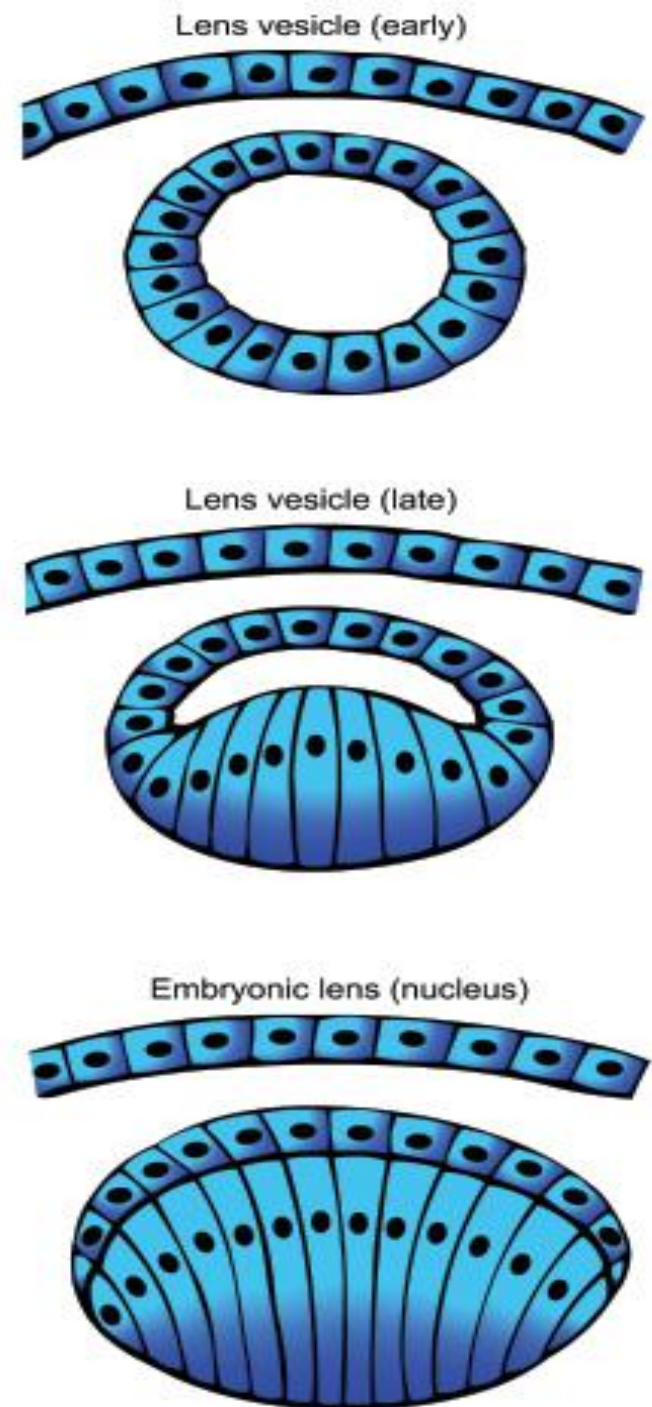
Crystalline lens

- The crystalline lens is developed from the surface ectoderm.
- *Lens placode*, thickened area of surface ectoderm from which lens develops, is identifiable by 27 days of gestation. It invaginates the sinus below the surface of ectoderm to form a lens vesicle, which consists of a single layer of cells covered by a basal lamina.



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- ***Primary lens fibres.*** The cells of posterior wall of lens vesicle elongate rapidly to form the primary lens fibres which obliterate the cavity of lens vesicle. The primary lens fibres are formed upto 3rd month of gestation and are preserved as the compact core of lens, **known as *embryonic nucleus***

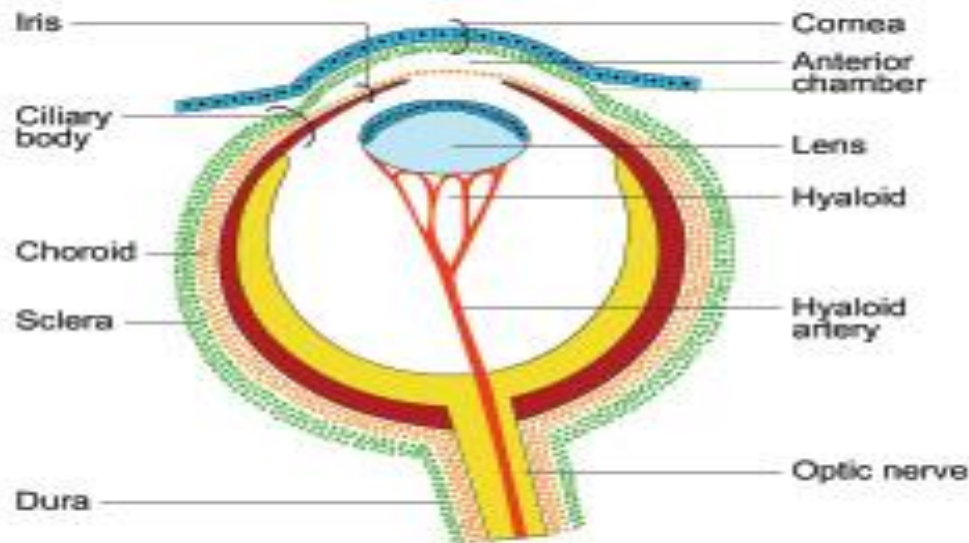


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- ***Secondary lens fibres*** are formed from equatorial cells of anterior epithelium which remain active through out life.
- Depending upon the period of development, the secondary lens fibres are...
- ***Fetal nucleus*** (3rd to 8th month),
- ***Infantile nucleus*** (last weeks of fetal life to puberty),
- ***Adult nucleus*** after puberty
- ***Cortex*** (superficial lens fibres of adult lens)
- ***Lens capsule*** is a true basement membrane produced by the lens epithelium on its external aspect.

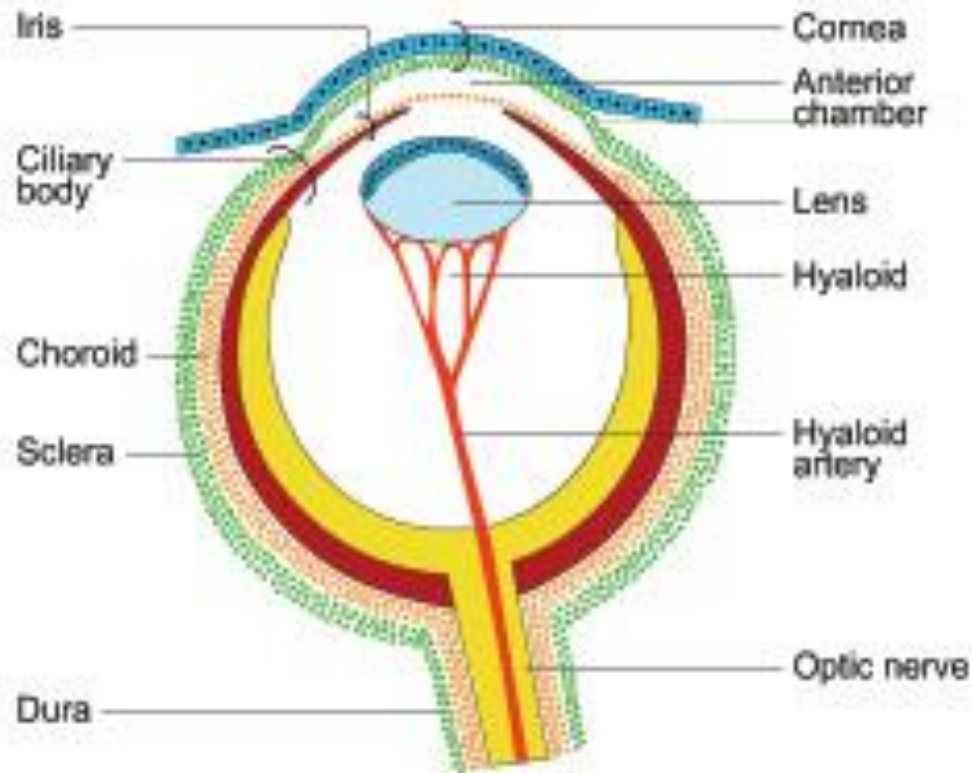
Cornea

- **1. *Epithelium*** is formed from the surface ectoderm.
- **2. *Other layers***. endothelium, Descemet's membrane, stroma and Bowman's layer are derived from the fibrous layer of mesenchyme lying anterior to the optic cup



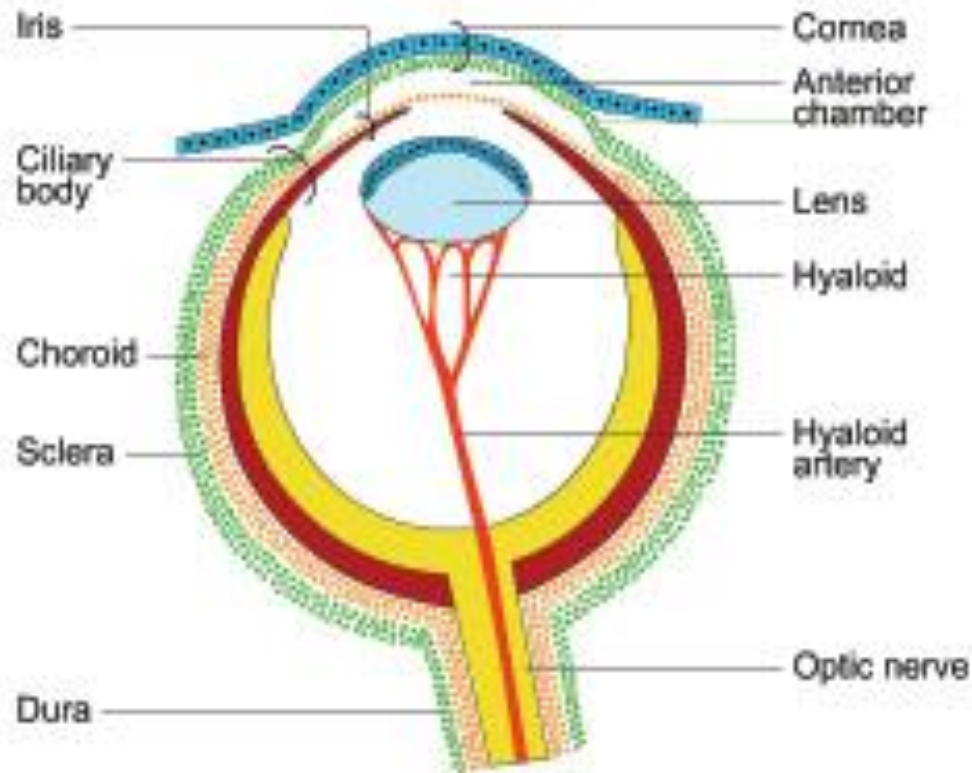
Sclera

- Sclera is developed from the fibrous layer of
- mesenchyme surrounding the optic cup



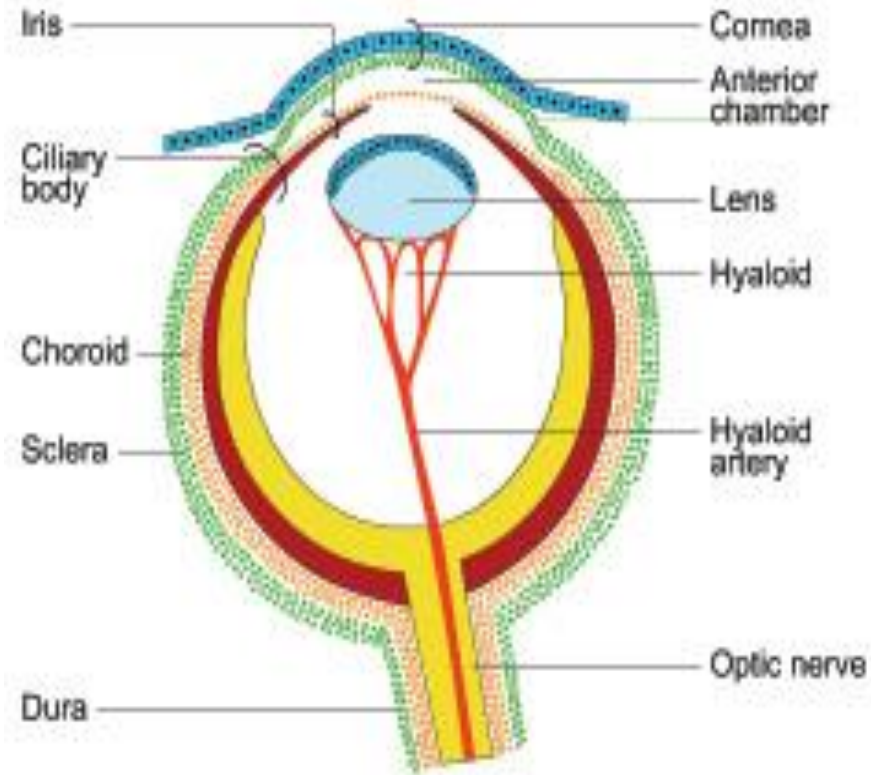
Choroid

- It is derived from the inner vascular layer of
- mesenchyme that surrounds the optic cup



Ciliary body

- The two layers of *epithelium of ciliary body* develop from the anterior part of the two layers of optic cup (neuroectodermal).
- *Stroma of ciliary body, ciliary muscle and blood vessels* are developed from the vascular layer of mesenchyme surrounding the optic cup

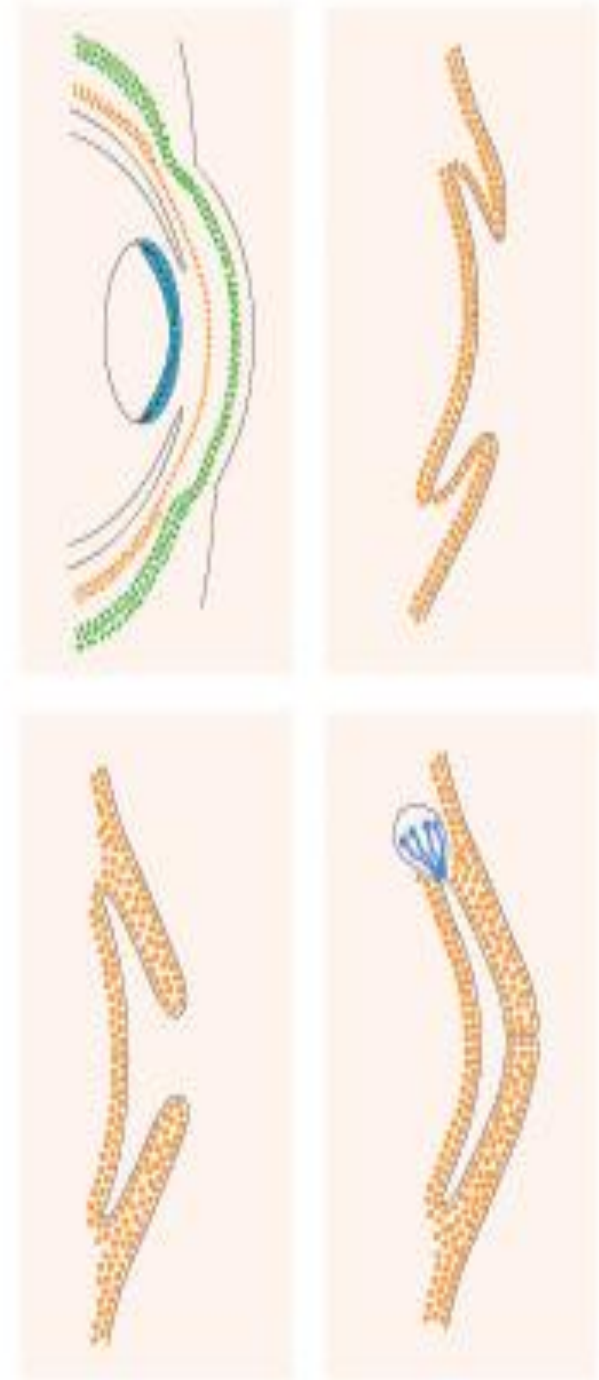


Vitreous

1. **Primary or primitive** vitreous is mesenchymal in origin and is a vascular structure having the hyaloid system of vessels.
2. **Secondary or definitive or vitreous proper** is secreted by neuroectoderm of optic cup. This is an avascular structure. When this vitreous fills the cavity, primitive vitreous with hyaloid vessels is pushed anteriorly and ultimately disappears.
3. **Tertiary vitreous is developed** from neuroectoderm in the ciliary region and is represented by the ciliary zonules.

Eyelids

- Eyelids are formed by reduplication of surface ectoderm above and below the cornea.
- The folds enlarge and their margins meet and fuse with each other.
- The lids cut off a space called the **conjunctival sac**.
- The folds thus formed contain some mesoderm which would form the **muscles of the lid and the tarsal plate**.
- The lids separate after the seventh month of intra-uterine life.

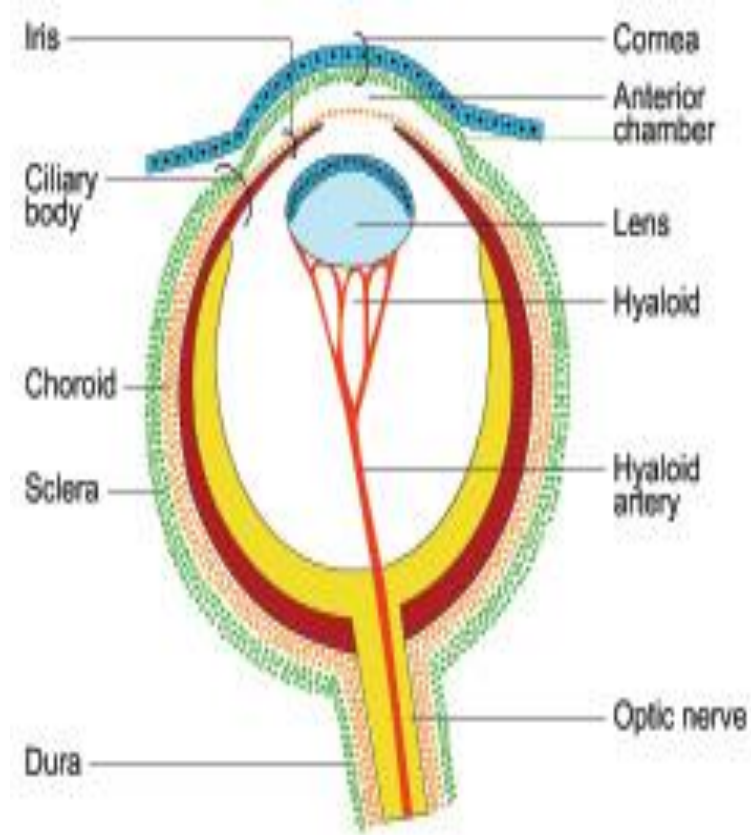


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- *Tarsal glands are formed by ingrowth of a regular row of solid columns of ectodermal cells from the lid margins.*
- *Cilia develop as epithelial buds from lid margins.*

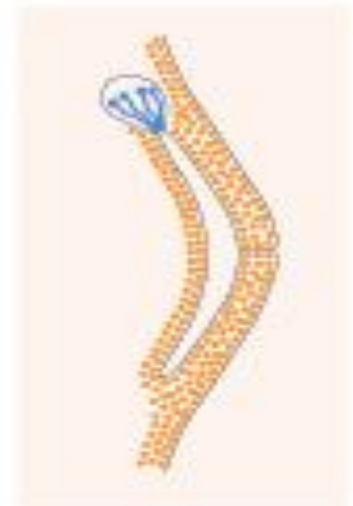
Iris

- Both layers of *epithelium* are derived from the marginal region of optic cup (neuroectodermal)
- *Sphincter and dilator pupillae muscles* are derived from the anterior epithelium (neuroectodermal).
- *Stroma and blood vessels* of the iris develop from the vascular mesenchyme present anterior to the optic cup.



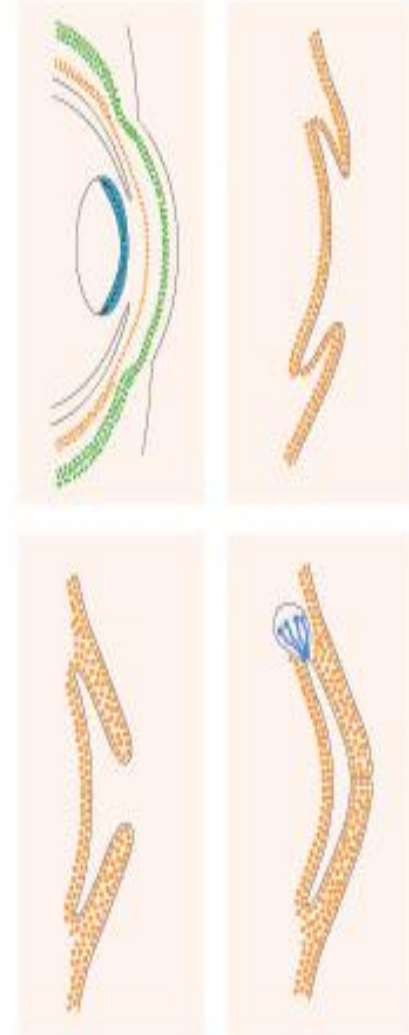
Conjunctiva

- **Conjunctiva** develops from the ectoderm lining the lids and covering the globe .
- **Conjunctival glands** develop as growth of the basal cells of upper conjunctival fornix. Fewer glands develop from the lower fornix.



The lacrimal apparatus

- **Lacrimal gland** is formed from about 8 cuneiform epithelial buds which grow by the end of 2nd month of fetal life from the superolateral side of the conjunctival sac.
- **Lacrimal sac, nasolacrimal duct and canaliculi.** These structures develop from the ectoderm of nasolacrimal furrow.
- It extends from the medial angle of eye to the region of developing mouth.



Extraocular muscles

- All the extraocular muscles develop in a closely associated manner by mesodermally derived mesenchymal condensation.

STRUCTURES DERIVED FROM THE EMBRYONIC LAYERS

1. Surface ectoderm

- The crystalline lens
- Epithelium of the cornea
- Epithelium of the conjunctiva
- Lacrimal gland
- Epithelium of eyelids and its derivatives viz., cilia, tarsal glands and conjunctival glands.
- Epithelium lining the lacrimal apparatus.

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2. Neural ectoderm

- Retina with its pigment epithelium
- Epithelial layers of ciliary body
- Epithelial layers of iris
- Sphincter and dilator pupillae muscles
- Optic nerve
- Melanocytes
- Secondary vitreous
- Ciliary zonules

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- **3. Associated paraxial mesenchyme**
- Blood vessels of choroid, iris, ciliary vessels, central retinal artery, other vessels.
- Primary vitreous
- Substantia propria, Descemet's membrane and endothelium of cornea.
- The sclera
- Stroma of iris
- Ciliary muscle

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- Sheaths of optic nerve
- Extraocular muscles
- Fat, ligaments and other connective tissue structures of the orbit
- Upper and medial walls of the orbit
- Connective tissue of the upper eyelid

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4. Visceral mesoderm of maxillary process below the eye

- Lower and lateral walls of orbit
- Connective tissue of the lower eyelid

<i>Stage of growth</i>	<i>Development</i>
2.6 mm (3 weeks)	Optic pits appear on either side of cephalic end of forebrain.
3.5 mm (4 weeks)	Primary optic vesicle invaginates.
5.5 to 6 mm	Development of embryonic fissure
10 mm (6 weeks)	Retinal layers differentiate, lens vesicle formed.
20 mm (9 weeks)	Sclera, cornea and extraocular muscles differentiate.

<i>Stage of growth</i>	<i>Development</i>
25 mm (10 weeks)	Lumen of optic nerve obliterated.
50 mm (3 months)	Optic tracts completed, pars ciliaris retina grows forwards, pars iridica retina grows forward.
60 mm (4 months)	Hyaloid vessels atrophy, iris sphincter is formed.
230-265 mm (8th month)	Fetal nucleus of lens is complete, all layers of retina nearly developed, macula starts differentiation.
265-300 mm (9th month)	Except macula, retina is fully developed, infantile nucleus of lens begins to appear, pupillary membrane and hyaloid vessels disappear.

Eye at birth

- *Anteroposterior diameter of the eyeball* is about 16.5 mm (70% of adult size which is attained by 7-8 years).
- *Corneal diameter* is about 10 mm. Adult size (11.7 mm) is attained by 2 years of age
- *Anterior chamber* is shallow and angle is narrow.
- *Lens* is spherical at birth. Infantile nucleus is present

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- **Retina.** Apart from macular area the retina is fully differentiated. Macula differentiates 4-6 months after birth.
- Newborn is usually **hypermetropic** by +2 to +3 D.
- Orbit is more **divergent** (50°) as compared to adult
- Lacrimal gland is still underdeveloped and **tears are not secreted.**

Postnatal period

- **Fixation** starts developing in first month and is completed in 6 months.
- **Macula** is fully developed by 4-6 months.
- **Fusional reflexes, stereopsis and accommodation** is well developed by 4-6 months.
- **Cornea** attains normal adult diameter by 2 years of age.
- **Lens** grows throughout life.

- Thank you