

Eye

◆ Eye Development

◆ Early Formation (Day 22)

- ~22nd day embryo → eyes appear as shallow optic grooves
 - Located on the sides of the forebrain
 - With neural tube closure: → Optic grooves evaginate → form optic vesicles (outpocketings of forebrain)
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◆ Optic Vesicle & Lens Formation

◆ Induction of Lens

- Optic vesicle contacts surface ectoderm → induces formation of lens placode
- Sequence:
 - Lens placode → invaginates → lens pit
 - Lens pit → forms lens vesicle

- By 5th week:
 - Lens vesicle separates from surface ectoderm
 - Lies within the mouth of optic cup
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◆ Optic Cup Formation

- Optic vesicle invaginates → forms double-walled optic cup
 - ◆ Layers:
 - Outer layer → future pigmented retina
 - Inner layer → future neural retina
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◆ Intraretinal Space

- Initially present between layers
 - Gradually disappears → layers come into apposition
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◆ Choroid Fissure

- Invagination extends inferiorly → forms choroid (optic) fissure
 - ◆ Function:
 - Allows entry of hyaloid artery into developing eye
 - ◆ Fate:
 - By 7th week → fissure margins fuse
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Clinical Correlation:

- Failure of fusion → coloboma (common viva question)
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◆ Optic Cup Opening

- Opening of optic cup → forms future pupil
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Summary

- Day 22 → optic grooves

- Optic vesicle → induces lens placode
 - Lens vesicle separates by week 5
 - Optic cup = double-layered
 - Choroid fissure:
 - Transmits hyaloid artery
 - Closes by week 7
 - Opening → pupil
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◆ Retina

◆ Origin

- Outer layer of optic cup → Pigmented layer of retina
 - Inner layer of optic cup → Neural retina
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◆ Neural Retina Differentiation

Posterior 4/5 — *Pars Optica Retinae* (visual part)

Differentiates into three layers:

1. Photoreceptor Layer

- Rods & cones

2. Mantle Layer → forms retinal cell layers:

- Outer nuclear layer
- Inner nuclear layer
- Ganglion cell layer

3. Fibrous Layer (Nerve Fiber Layer)

- Axons of ganglion cells converge → optic stalk
 - Optic stalk → optic nerve
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 Exam Tip:

- Light passes from inner → outer layers before reaching rods & cones
 - (i.e., photoreceptors are deepest)
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Anterior 1/5 — *Pars Ceca Retinae* (non-visual part)

- Thin, single-layered epithelium
- Gives rise to:

- Pars iridica retinae → posterior (inner) layer of iris
 - Pars ciliaris retinae → epithelium of ciliary body
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◆ Iris

◆ Components & Origin

1. Outer pigmented layer → from optic cup
 2. Inner non-pigmented layer → from optic cup
 3. Stroma (vascular connective tissue) → mesenchyme
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◆ Muscles of Iris

- Sphincter pupillae
- Dilator pupillae

👉 Origin: Neuroectoderm (optic cup)

🔑 Exam Pearl:

- Iris muscles are ectodermal in origin

- **!** Unlike most muscles (mesodermal) → frequently tested exception
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◆ Ciliary Body

◆ Development

- Pars ciliaris retinae → undergoes marked folding
- Covered externally by mesenchyme → forms ciliary muscle

◆ Connections

- Attached to lens via zonular fibers (suspensory ligament)

◆ Function

- Contraction/relaxation of ciliary muscle → changes lens curvature
→ Accommodation reflex
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◆ Lens Development

◆ Formation

- After lens vesicle formation:
 - Posterior wall cells → elongate anteriorly → primary lens fibers
 - By end of 7th week → lumen obliterated

◆ Growth

- Continuous addition of secondary lens fibers around central core (throughout life)
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🔑 Exam Tip:

- Lens keeps growing → becomes denser with age → leads to:
 - Presbyopia
 - Cataract
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◆ Choroid & Sclera

◆ Origin (End of 5th week)

- Surrounding mesenchyme differentiates into:

Layer	Structure	Analogy
Inner	Choroid (vascular, pigmented)	Pia mater
Outer	Sclera (tough fibrous)	Dura mater

- Sclera → continuous with dura of optic nerve

◆ Cornea & Anterior Chamber

◆ Formation

- Mesenchyme splits by vacuolization → forms anterior chamber

Layer	Derivative
Inner	Iridopupillary membrane
Outer	Substantia propria (corneal stroma)

◆ Cornea Composition

Layer	Origin
Outer epithelium	Surface ectoderm
Stroma (substantia propria)	Mesenchyme
Inner endothelium	Mesenchyme

◆ Additional Points

- Iridopupillary membrane → degenerates → clears anterior chamber
- Posterior chamber → between iris (anterior) & lens + ciliary body (posterior)

◆ Aqueous Humor Circulation

◆ Pathway

- Produced by ciliary processes → Posterior chamber → Through pupil → Anterior chamber → Drains via canal of Schlemm (scleral venous sinus)
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◆ Function

- Nourishes avascular structures:
 - Lens
 - Cornea
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🔑 Clinical Correlation:

- Glaucoma → blockage at canal of Schlemm → ↑ intraocular pressure → optic nerve damage
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◆ Vitreous Body

◆ Formation

- Mesenchyme enters optic cup via choroid fissure

Forms:

- Hyaloid vessels → supply lens & inner retina (fetal life)
 - Fibrous network between lens & retina
 - Interstitial gel → vitreous body
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◆ Later Changes

- Hyaloid vessels regress → leave hyaloid canal (Canal of Cloquet)
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🔑 Exam Tip:

- Persistence of hyaloid artery → congenital anomaly → visual defects
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◆ Optic Nerve Formation

◆ Early Connection

- Optic cup connected to brain via optic stalk
- Stalk contains choroid fissure → transmits hyaloid vessels

◆ Development

- Retina forms ganglion cells → axons grow into optic stalk
- By 7th week:
 - Choroid fissure closes
 - Optic stalk becomes a narrow channel

◆ Maturation

- Inner wall thickens due to nerve fibers
- Inner & outer walls fuse
- Inner cells → form neuroglia
- Optic stalk → transforms into optic nerve

◆ Blood Supply

- Hyaloid artery (proximal part) → becomes central artery of retina

◆ Coverings

Continuous with meninges:

Layer	Derived From
Pia	Choroid
Dura	Sclera

◆ Clinical Correlations

- Coloboma iridis → failure of choroid fissure closure
- Congenital cataract → defective lens fiber development
- Retinal detachment → persistence of intraretinal space
- Glaucoma → impaired aqueous drainage
- Persistent hyaloid artery → may cause visual impairment/blindness

🔑 Review

- Pars ciliaris → ciliary body
 - Lens → primary fibers (week 7) + lifelong secondary fibers
 - Choroid = vascular | Sclera = fibrous
 - Cornea = ectoderm + mesenchyme
 - Aqueous humor → drains via Schlemm canal
 - Vitreous → from mesenchyme + hyaloid system
 - Optic stalk → optic nerve
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◆ Clinical Correlations (Eye Abnormalities)

◆ Coloboma

- ◆ Cause
 - Failure of choroid fissure closure (→ 7th week)
- ◆ Most Common Type
 - Coloboma iridis → *keyhole-shaped pupil*

- ◆ Extent

- May involve:
 - Iris
 - Ciliary body
 - Retina
 - Choroid
 - Optic nerve
 - Can also affect eyelids
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- ◆ Persistent Iridopupillary Membrane

- ◆ Normal

- Membrane degenerates during anterior chamber formation

- ◆ Persistence

- Thin strands seen in front of lens
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- ◆ Congenital Cataract

- ◆ Definition

- Lens opacity
 - ◆ Causes
 - Genetic defects
 - Maternal rubella infection (critical: weeks 4-7)
 - ◆ Important Note
 - Infection after 7th week → lens spared → may cause:
 - Deafness (cochlear defects)
 - ◆ Prevention
 - MMR vaccination
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◆ Persistent Hyaloid Artery

- ◆ Normal
 - Regresses → leaves hyaloid canal (Canal of Cloquet)
- ◆ Persistence
 - Remains as:
 - Fibrous cord

- Cyst in vitreous
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- ◆ Microphthalmia

- ◆ Definition

- Abnormally small eye (~2/3 normal size)

- ◆ Associations

- Often with other ocular defects
 - Intrauterine infections:
 - CMV
 - Toxoplasmosis
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- ◆ Anophthalmia

- ◆ Definition

- Complete absence of eye
(*may have minimal residual tissue*)

- ◆ Associations

- Severe cranial abnormalities

◆ Congenital Aphakia

- ◆ Definition
 - Absence of lens
- ◆ Note
 - Very rare

◆ Aniridia

- ◆ Definition
 - Partial or complete absence of iris
- ◆ Cause
 - PAX6 mutation
- ◆ Associations
 - May be linked with:
 - Microphthalmia
 - Anophthalmia

◆ Cyclopia / Synophthalmia

◆ Spectrum

- Cyclopia → single eye
- Synophthalmia → partially fused eyes

◆ Cause

- Failure of midline development
 - Critical period: days 19-21 (or later)

◆ Associated Brain Defect

- Holoprosencephaly → fused cerebral hemispheres

◆ Risk Factors

- Alcohol
- Maternal diabetes
- SHH (Sonic Hedgehog) mutations
- Defective cholesterol metabolism (↓ SHH signaling)

Revision Table

Condition	Key Cause	Classic Feature
Coloboma	Failure of fissure closure	Keyhole pupil
Cataract	Rubella (4-7 weeks)	Lens opacity
Hyaloid persistence	Failure of regression	Vitreous cord
Microphthalmia	Infections	Small eye
Anophthalmia	Severe defect	No eye
Aphakia	Developmental failure	No lens
Aniridia	PAX6 mutation	No iris
Cyclopia	Midline defect	Single eye

High Yield Points

- 7th week → choroid fissure must close
 - Rubella (4-7 weeks) → cataract
 - SHH defect → cyclopia + holoprosencephaly
 - PAX6 → eye master gene (aniridia)
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-> The End <-