

Development of the eye

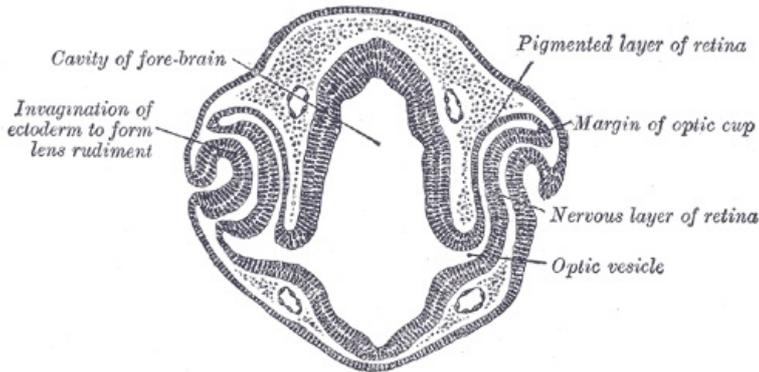
Tissues that contribute to eye development: **neural ectoderm, surface ectoderm and mesoderm with contribution of neural crest cells.**

OPTIC CUP AND LENS VESICLE

Outset of the process: 22nd day of development;

Steps:

1. Appearance of grooves of either side of developing forebrain;
2. The grooves undergo a transformation into **optic vesicles** with closure of anterior neuropore;
3. The optic vesicles become in contact with surface ectoderm;
4. Formation of **lens placode**, which is a thickening of surface ectoderm in contact with the optic vesicles;
5. Invagination of optic vesicles gives rise to the optic cups:
 - Double walled;
 - Inner and outer layers are separated by a provisory **intraretinal space** or **optic cup cavity**; this space disappears and is not present in the newborn eyes, thus, the two layers, the pigmented and neural retina appose each other; however this space can be reopened as a pathological condition called the **retinal detachment**;
 - Presence of choroid fissure in inferior surface - entrance for **hyaloid vessels** into the eye chamber; the distal portions of the hyaloid vessels degenerate but the proximal portions become the **central retinal vessels**;
6. Invagination of **lens placode**, which gives rise to the **lens vesicle**, in the mouth of the optic cup;
7. Fusion of choroid fissure lips around 7th week provides a closure for the anterior round opening which represents the future **pupil**.



RETINA, IRIS AND CILIARY BODY

The human retina is sub divided into a **inner neural** retina and an **outer pigmented** layer;

Outer / Pigmented retina:

- Cells in this layer contain pigment granules;
- Cells in this layer do not differentiate into neurons during normal embryogenesis but in postnatal life some of these cells maintain stem cell properties and can differentiate into multiple cell types;

Inner/ Neural Retina: It is important to mention that the neural/ inner retina can be subdivided by **ora serrata** into:

- **Optica retinae:** posterior four-fifths; lines posterior portion of eyeball and contains photoreceptors;
 - **Photoreceptive layer:** cells bordering the intraretinal space that differentiate into rods and cones;
 - **Mantle layer:** gives rise to neurons and supporting cells, including the outer nuclear layer, inner nuclear layer, and ganglion cell layer;
 - **Fibrous layer:** on the surface; contains axons of nerve cells of the deeper layers; nerve fibers converge into optic stalk - future **optic nerve**;
- **Caeca retinae:** anterior one-fifth; free of photoreceptors and can be subdivided into:
 - **Pars iridicae:** covering posterior aspect of iris;
 - **Adult iris:**
 - Pigment-containing external layer;
 - Unpigmented internal layer of the optic cup;
 - Richly vascularized connective tissue;
 - **Sphincter pupillae:** from loose mesenchyme that fills region between the optic cup and the overlying surface epithelium;
 - **Dilator pupillae:** differentiation from outer pigmented epithelium;
 - **Pars ciliaris:** covering ciliary body;
 - Outside: layer of mesenchyme that forms the **ciliary muscle**;
 - Inside: connected to lens by a network of elastic fibers: **suspensory ligament or zonula**;
 - Contraction of the ciliary muscle changes tension in the ligament and controls curvature of the lens.

LENS

1. Appearance of **lens placode** - from surface ectoderm;
2. Formation of **lens vesicle** - after invagination together with optic cup;
3. Elongation of posterior wall cells that form long fibers that gradually fill the lumen of the vesicle;
4. Primary lens fibers reach anterior wall of vesicle;
5. New/ secondary lens fibers are continuously added to central core.

CHOROID & SCLERA

Loose mesenchyme around eye primordium differentiates into:

- **Choroid:** highly vascularized pigmented layer; inner layer; comparable with the pia mater of the brain;
- **Sclera:** outer layer comparable with the dura mater; outer layer; continuous with the dura mater around the optic nerve;

CORNEA

3 layers:

1. **Outer epithelium** from the surface ectoderm;
2. **Substantia propria/ stroma:** continuous with the sclera;
3. **Inner epithelial:** borders the anterior chamber.

Anterior chamber:

- Vacuolization;
- Lined by flattened mesenchymal cells.
- Splits mesenchyme into:
 - Inner/ **Iridopupillary membrane:** outer layer continuous with sclera;
 - This membrane disappears completely;
 - Its permanence is called **Persistent pupillary membrane (PPM);**
 - Outer/**Substantia propria of the cornea;**

Posterior chamber

- Between the iris anteriorly and the lens and ciliary body posteriorly;

Posterior & Anterior chambers:

- Communication between chambers occurs other through the pupil;
- Filled with **aqueous humor:**
 - Produced by ciliary process of the ciliary body;
 - Provides nutrients for the avascular cornea and lens;
 - From the anterior chamber, it passes through the **scleral venous sinus/ canal of Schlemm** at the iridocorneal angle where it is resorbed into the bloodstream;
 - Blockage of the flow of fluid at the canal of Schlemm is one cause of **glaucoma.**

VITREOUS BODY

Components:

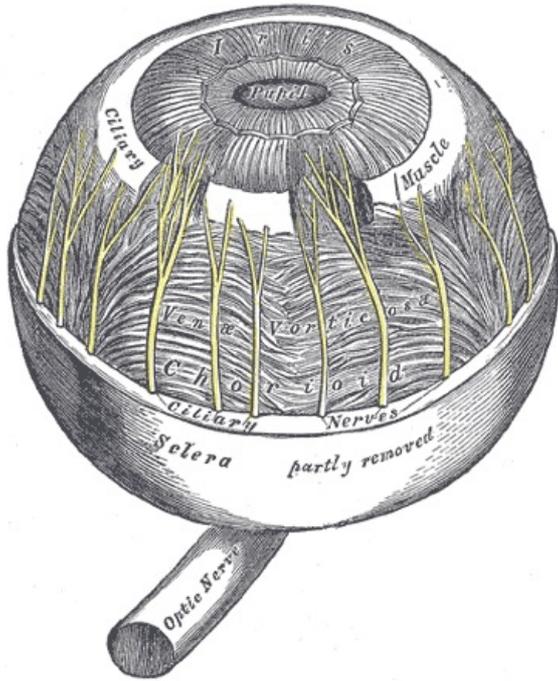
- Mesenchyme (invades optic cup through choroid fissure) gives rise to:
 - Hyaloid vessels, which during intrauterine life:
 - Supply lens;
 - Form the vascular layer on the inner surface of the retina;
 - Network of fibers between the lens and retina;
- Transparent gelatinous substance (interstitial spaces)

Disappearance of hyaloid vessels: **Hyaloid canal** remains throughout life; this canal can also be called **Cloquet's canal** or **Stilling's canal.**

OPTIC NERVE

- Until seventh week: choroid fissure in the optic stalk serves as passage for hyaloid vessels and nerve fibers from retina;
- Around seventh week: closure of choroid fissure;
- Increase of number of nerve fibers;
- Growth of inner wall of the stalk;
- Fusion of inside and outside walls;
- Cells of the inner layer provide a network of neuroglia that support the optic nerve fibers;
- Optic stalk undergoes transformation into optic nerve;

- At the eyeball, the dura fuses with the sclera while the arachnoid and pia mater merge with the choroid;
- Connective tissue septa, which arise from the pia mater, separate the fibre bundles in the optic nerve.



SOURCES

Langman's Medical Embryology, Jan Langman, T.W. Sadler, ISBN-10: 0781743109

Histology: A Text and Atlas, Sixth Edition, Michael Ross & Wojciech Pawlina, Lippincott, Williams & Wilkins

Gray's anatomy, Susan Standring, PhD, DSc, Elsevier