Objectives:

✔️ describe normal development of the eye from the lens vesicle, optic cup, and adjacent mesenchyme

✔️ name the more common abnormalities of the eye

Optic Cup and Lens Vesicle

— The developing eye appears in the 22-day embryo as a pair of shallow grooves on the sides of the forebrain. With closure of the neural tube, these grooves form outpocketings of the forebrain, the optic vesicles.

— These vesicles subsequently come in contact with the surface ectoderm and induce changes in the ectoderm necessary for lens formation.

— Shortly thereafter the optic vesicle begins to invaginate and forms the double-walled optic cup.

— Invagination is not restricted to the central portion of the cup but also involves a part of the inferior surface that forms the choroid fissure.

— Formation of this fissure allows the hyaloid artery to reach the inner chamber of the eye.

— During the seventh week,
  1. the lips of the choroid fissure fuse, and
  2. the mouth of the optic cup becomes a round opening, the future pupil.

— The inner and outer layers of this cup are initially separated by a lumen, the intraretinal space (B). But soon this lumen disappears, and the two layers appose each other.

— During these events, cells of the surface ectoderm, initially in contact with the optic vesicle, begin to elongate and form the lens placode. This placode subsequently invaginates and develops into the lens vesicle.

— During the fifth week, the lens vesicle loses contact with the surface ectoderm and lies in the mouth of the optic cup.

— The outer layer of the optic cup, which is characterized by small pigment granules, is known as the pigmented layer of the retina.

— Development of the inner (neural) layer of the optic cup is more complicated.

✔️ Pars optica retinæ

✔️ pars ceca retinæ

— Pars optica retinæ

— The posterior four-fifths of the neural layer
  1. photoreceptive layer
  2. the mantle layer
  3. ganglion cell layer
  4. fibrous layer

— On the surface is a fibrous layer that contains axons of nerve cells of the deeper layers.

— Nerve fibers in this zone converge toward the optic stalk, which develops into the optic nerve.

— Hence, light impulses pass through most layers of the retina before they reach the rods and cones.
The pars ceca retinae

✓ pars iridica retinae
✓ pars ciliaris retinae

— The pars ceca retinae
— It is the anterior fifth of the inner layer. It remains one cell layer thick.
— It later divides into
1. the pars iridica retinae, which forms the inner layer of the iris, and
2. the pars ciliaris retinae, which participates in formation of the ciliary body.
— The region between the optic cup and the overlying surface epithelium
— is filled with loose mesenchyme.
— The sphincter and dilator pupillae muscles form in this tissue and they develop from the underlying ectoderm of the optic cup.

The iris
— In the adult, is formed by
1. the pigment-containing external layer,
2. the unpigmented internal layer of the optic cup, and
3. a layer of richly vascularized connective tissue that contains the pupillary muscles
— The pars ciliaris retinae
— is easily recognized by its marked folding and externally it is covered by a layer of mesenchyme that forms the ciliary muscle;
— on the inside it is connected to the lens by a network of elastic fibers, the suspensory ligament or zonula
— Contraction of the ciliary muscle changes tension in the ligament and controls curvature of the lens.

Lens
— Shortly after formation of the lens vesicle. cells of the posterior wall
1. begin to elongate anteriorly and
2. form long fibers that gradually fill the lumen of the vesicle
— By the end of the seventh week, these primary lens fibers reach the anterior wall of the lens vesicle.
— Growth of the lens is not finished at this stage since new (secondary) lens fibers are continuously added to the central core.

Choroid, Sclera, and Cornea
— At the end of the fifth week, the eye primordium is completely surrounded by loose mesenchyme.
— This tissue soon differentiates into
1. an inner layer comparable with the pia mater of the brain; it later forms a highly vascularized pigmented layer known as the choroid
2. an outer layer comparable with the dura mater; develops into the sclera and is continuous with the dura mater around the optic nerve
— Differentiation of mesenchymal layers overlying the anterior aspect of the eye is different
— The anterior chamber forms through vacuolization and splits the mesenchyme into
1. an inner layer in front of the lens and iris, the iridopupillary membrane, and
2. an outer layer continuous with the sclera, the substantia propria of the cornea
— The anterior chamber itself is lined by flattened mesenchymal cells.
— Hence, the cornea is formed by
— (a) an epithelial layer derived from the surface ectoderm,
— (b) the substantia propria or Stroma, which is continuous with the sclera, and
— (c) an epithelial layer, which borders the anterior chamber.
— The **iridopupillary membrane** in front of the lens disappears completely, providing communication between the anterior and posterior eye chambers.

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**Vitreous Body**

— Mesenchyme not only surrounds the eye primordium from the outside but also invades the inside of the optic cup by way of the choroid fissure. Here it forms

1. **the hyaloid vessels**, which during intrauterine life supply the lens and form the vascular layer on the inner surface of the retina
2. a delicate network of fibers between the lens and retina.

— The **interstitial spaces** of this network later fill with a transparent gelatinous substance, forming the vitreous body.

— The **hyaloid vessels** in this region are obliterated and disappear during fetal life, leaving behind the hyaloid canal.

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**Optic Nerve**

— The optic cup is connected to the brain by the optic stalk, which has a groove, the choroid fissure, on its ventral surface. In this groove are the hyaloid vessels.

— The **nerve fibers of the retina** returning to the brain lie among cells of the inner wall of the stalk.

— During the seventh week, the choroid fissure closes, and a narrow tunnel forms inside the optic stalk.

— As a result of the continuously increasing number of nerve fibers, the inner wall of the stalk grows, and the inside and outside walls of the stalk fuse. Cells of the inner layer provide a network of neuroglia that support the optic nerve fibers.

— The optic stalk is thus transformed into the optic nerve. Its center contains a portion of the hyaloid artery, later called the central artery of the retina. On the outside, a continuation of the choroid and sclera, the pia arachnoid and dura layer of the nerve, respectively, surround the optic nerve.

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**Clinical Correlates**

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**Coloboma**

— may occur if the choroid fissure fails to close. Normally, this fissure closes during the seventh week of development. When it does not, a cleft persists.

— Although such a cleft is usually in the iris only—**coloboma iridis**—it may extend into the ciliary body, the retina, the choroid, and the optic nerve.

— Coloboma is a common eye abnormality frequently associated with other eye defects.

— Colobomas (clefts) of the eyelids may also occur.

— The iridopupillary membrane may persist instead of being resorbed during formation of the anterior chamber.

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**Congenital cataracts**

— the lens becomes opaque during intrauterine life. This anomaly is usually genetically determined. Many children of mothers who have had **German measles (rubella) between the fourth and seventh weeks of pregnancy** have cataracts.

— If the mother is infected **after the seventh week of pregnancy**, the lens escapes damage, but the child may be deaf as a result of abnormalities of the cochlea.

**The hyaloid artery may persist to form a cord or cyst.**

— Normally, the distal portion of this vessel degenerates, leaving the proximal part to form the central artery of the retina.

— **Congenital aphakia** (absence of the lens) and **aniridia** (absence of the iris) are rare anomalies of microphthalmia; the eye is too small; the eyeball may be only two-thirds of its normal volume.

— Usually associated with other ocular abnormalities, microphthalmia frequently results from intrauterine infections such as cytomegalovirus and toxoplasmosis.
Anophthalmia
— is absence of the eye. In some cases, histological analysis reveals some ocular tissue.
— The defect is usually accompanied by severe cranial abnormalities.
— Cyclopia & synophthalmia
— Cyclopia single eye and synophthalmia fusion of the eyes
— comprise a spectrum of defects in which the eyes are partially or completely fused
— The defects are due to a loss of midline tissue that may occur
1. as early as days 19 to 21 of gestation or
2. at later stages when facial development is initiated.