EYE AND EAR

Eye

- The embryonic tissues which contribute to the formation of the eye include neural and surface ectoderm and neural crest-derived mesenchyme.
- The primordia which initiate ocular development can first be identified as a pair of shallow grooves on either side of the folding prosencephalon.
- These structures can be recognised towards the end of neurulation prior to the closure of the rostral neuropore.
- Formation of these grooves is induced by factors from adjacent pharyngeal endoderm and mesoderm.

- Following closure of the rostral neuropore, the grooves form diverticula, the optic vesicles, the cavities of which are initially continuous with the cavity of the forebrain.

- As the optic vesicles grow laterally towards the surface ectoderm, the neuroepithelium of the optic vesicles induces the surface ectoderm to proliferate and form the lens placodes.

- Following formation of the lens placodes, the lateral walls of the optic vesicles begin to flatten and become concave.

- This results in the conversion of the optic vesicles into double-walled optic cups.

- The inner and outer walls of each optic cup are initially separated by a space. The walls of the cup become apposed, resulting in the gradual disappearance of the intervening space.

- Narrowing of the stem of the optic vesicle leads to formation of the optic stalk. Because the invagination which shapes the optic cup occurs at the ventral margin of the vesicle, the rim of the optic cup is not continuous at its ventral aspect.

- This invagination results in the formation of a groove in the ventral rim of the cup which extends along the ventral surface of the optic stalk.

- This groove, referred to as the choroid fissure, provides access for the hyaloid blood vessels which supply the developing retina and lens.

- Associated with closure of the choroid fissure towards the end of the embryonic period, the hyaloid vessels become enclosed within the optic stalk and the rim of the optic cup becomes a continuous structure enclosing a rounded space, the primordium of the pupil.

- With the development of the optic cup, the lens placode invaginates into the rim of the optic vesicle and forms the lens vesicle.

- The lens vesicle subsequently loses contact with the surface ectoderm, is surrounded by mesenchymal tissue and becomes positioned at the opening of the optic cup.

Differentiation of the optic cup

- The retina is derived from the apposed walls of the optic cup. The outer wall of the optic cup forms the pigmented layer of the retina.
- It also contributes to the formation of the ciliary body and iris. Differentiation of the inner wall of the retina involves a series of developmental changes.
- Two distinct areas of differentiation develop in the inner layer of the retina.
- A narrow region close to the rim of the optic cup, the non-neural area of the retina, remains thin walled and subsequently contributes to the formation of the ciliary body and iris.

Differentiation of the optic cup

- The remainder, referred to as the neural area of the retina, develops in a manner analogous to the stages of neural tube differentiation.

- The neuroepithelial cells of the inner wall of the cup proliferate and differentiate giving rise to the specialised layers of the neural retina which include the light-sensitive rods and cones, the bipolar and ganglion cells and the supportive glial cells.

- As the optic vesicle invaginates and forms the optic cup, its light-sensitive photoreceptors are positioned adjacent to the pigmented retinal layer.

- The cellular layers constituting the inner wall of the optic cup are designated according to their positions relative to the outer wall.

- Accordingly, the cells of the inner wall which are immediately adjacent to the pigmented retinal layer are called the outer visual layer of the retina and the retinal layer most distant from the pigmented layer is referred to as the inner layer.

Lens

- Shortly after the formation of the lens vesicle, the epithelial cells located at the posterior wall begin to elongate and grow forwards towards the thinner anterior wall of the vesicle.

- During growth and elongation, these epithelial cells undergo profound transformation into transparent, elongated cells which contain large quantities of specialised proteins called crystallins.

- A unique feature of lens cell differentiation is that the cells, which initially contain normal cell organelles, undergo a special form of apoptosis which does not proceed to completion.

Lens

- The cell organelles gradually disappear, leaving living fibres with intact outer membranes, an inner cytoskeleton of proteins and transparent cytoplasm composed of crystallins.

- The mechanisms which prevent complete cellular destruction are currently not understood.

- Differentiation followed by transformation of the cells of the deep wall of the vesicle lead to formation of a rounded lens body or embryonic nucleus. Later, the primary lens fibres are augmented by a new population of secondary lens fibres.

Formation of the eyelids

- Towards the end of the embryonic period, two folds of ectoderm with mesodermal cores grow towards each other over the developing cornea.
- Subsequently, the edges of the ectodermal layers meet and become attached to each other by the epithelial lamina between them.
- Adhesion of the eyelids is a temporary union as they separate again before or shortly after birth.
- Separation of the eyelids occurs around the seventh month of gestation in humans, about the eighth day postnatally in pups and about the tenth day postnatally in kittens.

Muscles of the eye

- The extrinsic muscles of the eye develop from head somitomeres.

- The intrinsic muscles, the ciliary and pupillary muscles, develop from neural crest-derived mesenchyme.

Ear

- The ear, the special sensory organ of the body associated with hearing and equilibrium in vertebrates, has three distinct subdivisions referred to as the external, the middle and the inner ear.

- Each of these subdivisions has a separate embryological origin. The external ear, which directs sound towards the middle ear, is formed from the first pharyngeal cleft and its surrounding mesenchyme.

- This part of the ear consists of the auricle, the external auditory meatus and the outer lining of the tympanic membrane.

- The middle ear, which conducts and amplifies sound from the external to the inner ear, is derived from the first pharyngeal pouch and its surrounding mesenchyme.

Ear

- This segment of the ear is composed of the auditory tube, the tympanic cavity and its associated auditory ossicles.
- The inner ear, also referred to as the vestibulocochlear organ, includes the utricle, the semicircular ducts, the saccule and the cochlear duct.
- This subdivision of the ear develops from the otic placode.
- The vestibular apparatus is the sensory transducer for balance, while the cochlear apparatus contains auditory sensory receptors.
- Impulses detected by these organs are relayed to the brain by cranial nerve VIII.

Inner ear

- Bilateral ectodermal thickenings, the otic placodes, each of which develops in a position lateral to the rhombencephalon, give rise to the inner ears.
- The diverse membranous structures which develop from the otic placodes are collectively referred to as the membranous labyrinth of the inner ear.
- Invagination of the otic placode forms the otic pit, which, for a short time, retains its connection with surface ectoderm and then separates, forming the otic vesicle.
- The cavity of the otic vesicle fills with fluid, referred to as endolymph.

Middle ear

- The first pharyngeal pouch, which develops as an endodermal outgrowth of the foregut between the first and second pharyngeal arches, gives rise to the auditory tube and primitive tympanic cavity of the middle ear.

- The definitive tympanic cavity is formed from the dorsal blind end of the first pharyngeal pouch which grows towards the first pharyngeal cleft.

- The inner ectodermal wall of the first cleft and the endodermal wall of the tympanic cavity are separated by a layer of mesenchyme.

- This layer becomes attenuated, forming a thin connective tissue sheet between the outer ectodermal layer of the first pharyngeal cleft and the inner endodermal layer of the tympanic cavity.

External ear

- The auditory meatus of the external ear develops from the first pharyngeal cleft.
- Ectodermal cells at the blind end of the first pharyngeal cleft proliferate, forming a solid epithelial mass, the meatal plug.
- The plug, which persists for most of the foetal period, undergoes lysis in the perinatal period.

External ear

- Consequently, the ectoderm of the expanded auditory meatus becomes apposed to the endodermal wall of the tympanic cavity separated only by a thin layer of mesenchyme.
- Collectively, these three layers form the tympanic membrane.
- The cartilage of the external ear which surrounds the entrance of the external auditory meatus is derived from pharyngeal cleft mesenchyme.