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**MATRIC NO:** 17/MHS01/165

**DEPARTMENT:** MBBS

**LEVEL:** 300L

**NEUROHISTOLOGY ASSIGNMENT**

**ANSWERS**

**NUMBER 1:**

The internal structures of the eye consist of three layers of tissue arranged concentrically:

The sclera and cornea make up the exterior layers.

The uvea is the vascular layer in the middle, subdivided into the iris, ciliary body, and choroid.

The retina constitutes the innermost layer and is made up of nervous tissue.

Internal Structures of the Eye": The innermost structures of the eye are organized in the three layers as follows

(A)- "Outermost Layer: Sclera and Cornea":

1. "The sclera (white of the eye)" [2]:

The sclera is dense connective tissue made of mainly type 1 collagen fibers, oriented in different directions. The lack of parallel orientation of collagen fibers gives the sclera its white appearance, as opposed to the transparent nature of the cornea. However, the collagen of the sclera and cornea are continuous.

The four layers of the sclera from external to internal are episclera, stroma, lamina fusca, endothelium.

The episclera is the external surface of the sclera. It is connected to the Tenon capsule by thin collagen fibers. At the corneoscleral junction, also known as the limbus, the Tenon capsule contacts stroma of the conjunctiva.

2. "Cornea (transparent front layer of the eye)":

Consists of type I collagen fibers oriented in a uniform parallel direction to maintain transparency

Consists of five layers: epithelium (non-keratinized, stratified squamous epithelium), Bowman layer, stroma (also called substantia propria), Descemet's membrane, corneal endothelium.

Corneal epithelium: fast growing, regenerating multicellular layer which interacts directly with the tear film.

Bowman layer: This is a layer of subepithelial basement membrane protecting the underlying stroma. It is composed of type 1 collagen, laminin, and several other heparan sulfate proteoglycans.

Stroma: The largest layer of the cornea, the stroma has collagen fibers arranged in a regular pattern. Keratocytes maintain the integrity of this layer. The function of this layer is to maintain transparency, which occurs by the regular arrangement, and lattice structure of the fibrils, whereby scatter from individual fibrils gets canceled by destructive interference, and the spacing of less than 200 nm allows for transparency.

Descemet's membrane: an acellular layer made of type IV collagen that serves as a modified basement membrane of the corneal endothelium

Corneal endothelium: a one cell thick layer made of either simple squamous or cuboidal cells. Cells in this region do not regenerate and have pumps that maintain fluid balance and prevent swelling of the stroma. When corneal endothelial cells are lost, neighboring cells stretch to attempt to compensate these losses.

(B)- "Middle Layer: Uvea (Iris, Ciliary Body, Choroid)":

#### 1. "Iris":

Consists of (1) stromal layer with pigmented, fibrovascular tissue and (2) pigmented epithelial cells beneath the stroma

The sphincter pupillae and dilator pupillae muscles connect to the stroma

The pigmented layer of cells blocks rays of light and ensures that light must move through the pupil to reach the retina

The angle formed by the iris and cornea contains connective tissue with endothelial channels called the trabecular meshwork, which drains aqueous humor in the anterior chamber into the venous canal of Schlemm[8]. From here, fluid drains into episcleral veins.

#### 2. "Ciliary Body": The tissue that divides the posterior chamber and vitreous body

Consists of the ciliary muscle and the ciliary epithelium

The ciliary muscle, via the lens zonules, controls the structure of the lens, which is vital for accommodation. Zonules are connective tissue fibers that connect the ciliary muscle and lens.

The ciliary epithelium produces aqueous humor which fills the anterior compartment of the eye.

### 3. "Choroid":

Consists of a dense network of blood vessels supplying nourishment to structures of the eye, housed in loose connective tissue.

The choriocapillary layer is located in the innermost part of the choroid and supplies the retina

The Bruch membrane is an extracellular matrix layer situated between the retina and choroid and has significance in age-related macular degeneration, where an accumulation of lipid deposits prevent diffusion of nutrients to the retina.

### (C)- "Innermost layer: Lens, Vitreous, Retina":

#### 1. Lens: separates the aqueous and vitreous chambers[9]

Consists of an outer capsule, a middle layer called cortex, and an inner layer called the nucleus.

The capsule is the basement membrane of the lens epithelium which lies below

New lens cells differentiate from the lens epithelium and are incorporated peripherally, pushing older lens cells towards the middle.

#### 2. Vitreous: a jelly-like space made of type II collagen separating the retina and the lens

#### 3. Retina: nervous tissue of the eye where photons of light convert to neurochemical energy via action potentials

Moreover, the retina itself is divided into various layers as follows :

Retinal pigment epithelium: made of cuboidal cells containing melanin which absorbs light. These cells also establish a blood-retina barrier through tight junctions.

"Rod and cone cells": the layer of cells with photoreceptors and glial cells. Rods are located peripherally and are more sensitive to light and motion than cones. Cones have higher visual acuity and specificity for color vision.

The function of the cornea is to let light rays enter the eye and converge the light rays.

The iris is the pigmented tissue lying behind the cornea that gives color to the eye and controls the amount of light entering the eye by varying the size of the papillary opening.

The lens is the natural lens of the eye (crystalline lens). Transparent, biconvex intraocular tissue that helps bring rays of light to focus on the retina.

The retina is the light sensitive nerve tissue in the eye that converts images from the eye's optical system into electrical impulses that are sent along the optic nerve to the brain, to interpret as vision.

Ciliary Body. The circumferential tissue (a ring of tissue between the end of the choroids and the beginning of the iris) inside the eye composed of the ciliary muscle (involved in lens accommodation and control of intraocular pressure and thus the shape of the lens)

Choroid: The vascular (major blood vessel), central layer of the eye lying between the retina and sclera. Its function is to provide nourishment to the outer layers of the retina through blood vessels.

The sclera provides protection and form.

## **NUMBER 2:**

. Retina

The retina, the innermost tunic of the eye, develops with

two fundamental sublayers from the inner and outer layers of

embryonic optic cup ,

■ The outer pigmented layer is a simple cuboidal

epithelium attached to Bruch's membrane and the

choroido-capillary lamina of the choroid .

This heavily pigmented layer forms the other part of the

dual epithelium covering the ciliary body and posterior

iris.

■ The inner retinal region, the neural layer, is thick and

stratified with various neurons and photoreceptors.

Although its neural structure and visual function extend

anterior only as far as the ora serrata, this

layer continues as part of the dual cuboidal epithelium

that covers the surface of the ciliary body and posterior

iris.

### 1)Retina Pigmented Epithelium

The pigmented epithelial layer consists of cuboidal or low

columnar cells with basal nuclei and surrounds the neural

layer of the retina. The cells have well-developed junctional

complexes, gap junctions, and numerous invaginations of

the basal membranes associated with mitochondria. The

apical ends of the cells extend processes and sheath-like

projections that surround the tips of the photoreceptors.

Melanin granules are numerous in these extensions and in

the apical cytoplasm. This cellular region

also contains numerous phagocytic vacuoles and secondary lysosomes, peroxisomes, and abundant smooth ER

(SER) specialized for retinal (vitamin A) isomerization.

The diverse functions of the retinal pigmented epithelium

include the following:

- The pigmented layer absorbs scattered light that

passes through the neural layer, supplementing the

choroid in this regard.

- With many tight junctions, cells of the pigmented epithelium form an important part of the protective bloodretina barrier isolating retina photoreceptors from the

highly vascular choroid and regulating ion transport

between these compartments.

- The cells play key roles in the visual cycle of retinal

regeneration, having enzyme systems that isomerize all-trans-retinal released from photoreceptors and

produce 11-cis-retinal that is then transferred back to the

photoreceptors.

- Phagocytosis of shed components from the adjacent

photoreceptors and degradation of this material occurs

in these epithelial cells.

- Cells of pigmented epithelium remove free radicals

by various protective antioxidant activities and support

the neural retina by secretion of ATP, various polypeptide growth factors, and immunomodulatory factors.

## 2) Neural Retina

True to its embryonic origin, the neural retina functions as

an outpost of the CNS with glia and several interconnected

neuronal subtypes in well-organized strata. Nine distinct layers comprise the neural retina, described here with their functional significance.

Three major layers contain the nuclei of the interconnected neurons (Figures 23–14b and 23–15):

■ Near the pigmented epithelium, 3) the outer nuclear layer

(ONL) contains cell bodies of photoreceptors (the rod

and cone cells). These cells, like the pigmented epithelial

cells, receive O<sub>2</sub>

and nutrients by diffusion from the choroidocapillary lamina of the choroid.

4) The inner nuclear layer (INL) contains the nuclei of

various neurons, notably the bipolar cells, amacrine cells,

and horizontal cells, all of which make specific connections with other neurons and integrate signals from rods

and cones over a wide area of the retina.

■ Near the vitreous, 5) the ganglionic layer (GL) has neurons

(ganglion cells) with much longer axons. These axons

make up the nerve fiber layer (NFL) and converge to

form the optic nerve which leaves the eye and passes

to the brain. The GL is thickest near the central, macular



region of the retina, but it thins peripherally to only one layer of cells (Figure 23–6).

Between the three layers with cell nuclei are two fibrous or

“plexiform” regions containing only axons and dendrites connected by synapses (Figure 23–15):

■ 6) The outer plexiform layer (OPL) includes axons of the

photoreceptors and dendrites of association neurons in

the INL.

■ 7) The inner plexiform layer (IPL) consists of axons and

dendrites connecting neurons of the INL with the ganglion cells

The rod and cone cells, named for the shape of their outer

segments, are polarized neurons with their photosensitive

portions aligned in the retina’s 10) rod and cone layer (RCL) and

their axons in the OPL.

All neurons of the retina are supported metabolically by

elongated, regularly arranged glial cells called Müller cells.

With their perikarya in the INL, Müller cells extend processes

that span the entire thickness of the neural retina.

From these major Müller cell processes smaller lateral extensions ramify in each layer and ensheath virtually all the neuronal processes, cell bodies, and blood vessels. Müller cells are

critical for retinal function, providing neurotrophic substances,

removing waste products, regulating ion and water homeostasis, regulating blood flow, and maintaining a blood-inner retina

barrier. Müller cells also organize two boundaries that appear as

very thin retinal “layers”:

■ 8)The outer limiting layer (OLL) is a poorly stained but

well-defined series of adherent junctions (zonula adherentes) between the photoreceptors and Müller cells

■ 9)The inner limiting membrane (ILM) consists of terminal expansions of Müller cell processes that cover the

collagenous membrane of the vitreous body and form

the inner surface of the retina.

All these layers of the retina can be seen by routine light

microscopy. It is important to note that light must pass through all the layers of the

neural retina before reaching the layer of rods and cones.

Branches of the central retinal artery and vein

run mainly within the nerve fiber and GLs, surrounded by perivascular feet of Müller cells and astrocytes which are located

there. In some retina regions capillaries extend as deeply as the INL. A few scattered microglial cells occur throughout the

neural retina.