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18/MHS01/383

MBBS

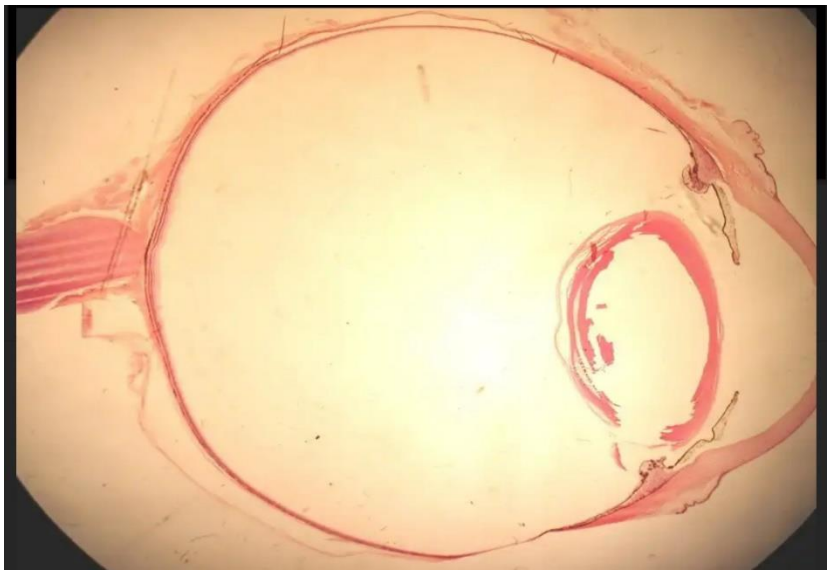
NEUROHISTOLOGY ASSIGNMENT

QUESTION 1

1. Write an essay on the histological importance of the eye in relation to their cellular functions.

ANSWER 1

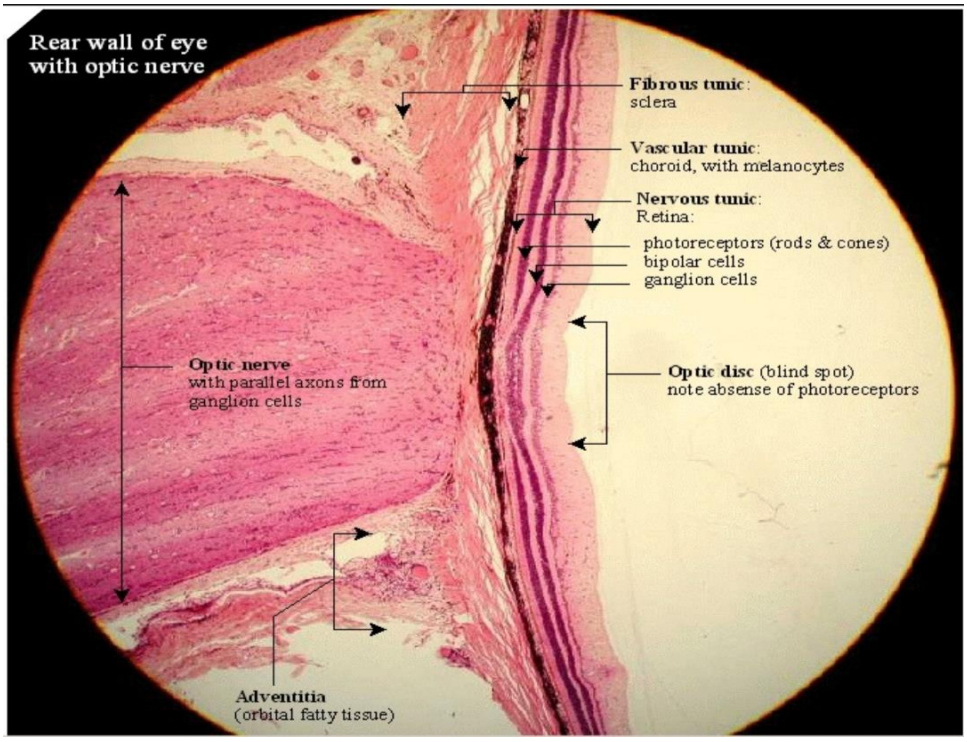
The eye is a complex and highly developed photosensitive organ that analyses the form, intensity and colour of light reflected from objects providing the sense of sight. The eyes are located in the protective areas of the skull, the orbits, which also contain cushions of adipose tissue.



Section through the eye optic nerve on the left.

Each eye is composed of three concentric tunics or layers which include

- An external fibrous layer that consist of the sclera and cornea.
- A middle vascular layer also known as the uvea consisting of the choroid, ciliary body and the iris.
- An inner layer of nerve tissue, the retina which consist of an outer pigment epithelium and an inner retina proper.



Section showing rear wall of the eye with optic nerve.

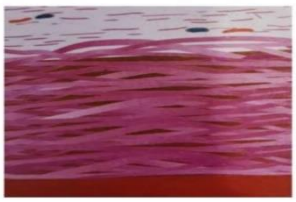
EXTERNAL FIBROUS LAYER

THE SCLERA

The opaque white posterior five-sixths of the external layer is the sclera. The clear averages 0.5mm in thickness, is relatively avascular and consists of tough dense connective tissue containing flat type I collagen bundles which intersect in various directions while remaining parallel to the surface of the organ, with a moderate amount of ground substance and scattered fibroblasts. Posteriorly the sclera thickens and joins with the epineurium of the optic nerve. A thin inner region of the sclera adjacent to the choroid is slightly less dense, with thinner collagen fibers, more fibroblasts, elastic fibres and melanocytes.

The sclera has three layers from external to internal which include the episclera, the external surface of the sclera, the sclera proper and the lamina fusca.

1. Episcleral tissue
2. Scleral proper
3. Lamina fusca



Histologically, the sclera is very important as it protects the more developed internal structures and provide form to the eye which is evident from its cellular features

THE CORNEA

The anterior one-sixth of the eye is the cornea which is colourless, transparent and completely avascular. The cornea consists of type I collagen fibres oriented in a uniform parallel direction to maintain transparency. It consists of five layers;

- Corneal epithelium: an external nonkeratinised stratified squamous epitheliumwith five or six cell layers comprising of about ten percent of the corneal thickness. It has a high capacity for cell renewal and repair.
- Bowman's membrane: this is a layer of subepithelial basement membrane protecting an underlying stroma. It is composed of collagen type I fibres, laminin and several other heparin sulphate glycosaminoglycans. It contributes greatly to the strength and stability of the cornea.
- Stroma: the largest layer of the cornea, the stroma has collagen fibres 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.
- Descemet's membrane: an acellular homogenous layer made up of fine type IV collagen that serves as a modified basement membrane of the corneal endothelium.
- Corneal endothelium: a one cell thick layer made up of simple squamous cells. Cells here do not regenerate and have pumps that maintain fluid balance and prevent swelling of the stroma.

Histologically, the cornea is very important as it acts as a structural barrier and protects the eye against infections. Along with the tear film, it provides a proper anterior refractive surface for the eye. It also contributes two-third of the refractive power of the eye. The cornea tends to repair itself quickly from minor abrasions, however deeper abrasions could cause the cornea to loose its transparency leading to visual impairment.

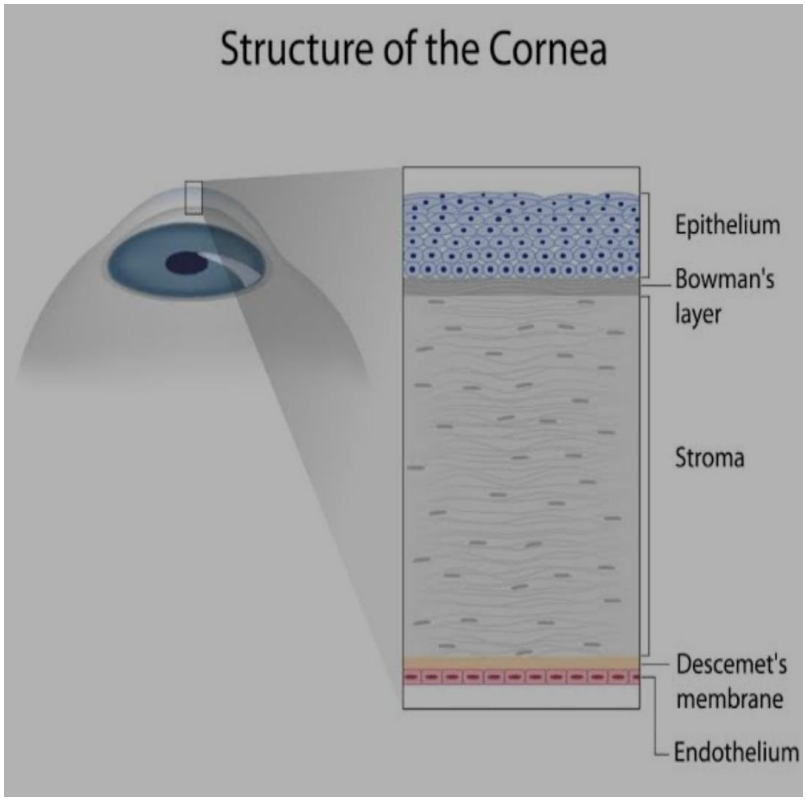


Diagram showing the five layers of the cornea

THE LIMBUS

This is also called the corneoscleral junction, it is an area of transition from the transparent collagen bundles of the cornea to the white opaque fibres of the sclera. It is highly vascularised consisting of a system of irregular endothelium lined channels called the trabecular network.

MIDDLE VASCULAR LAYER OR UVEA

THE CHORIOD

The choroid is a highly vascular tunic in the posterior two-thirds of the eye, with loose, well vascularized connective tissue rich in collagen and elastic fibres, fibroblasts, melanocytes, macrophages, lymphocytes and mast cells. The abundant melanocytes give the layer its characteristic black colour and blocks light from entering the eye except through the pupil.

The outer part of the choroid bound to the sclera is the suprachoroidal lamina while the inner region is called the choriocapillary lamina. A thin sheet known as the Bruch’s membrane seperates the choriocapillary lamina from the retina.

Histologically the choroid is very important as it provides nourishment to the outer layers of the retina through its rich vascular network. It is part of the uveal tract.

THE CILIARY BODY

This consists of the ciliary epithelium and ciliary muscle. The ciliary muscle via the lens zonules, controls the structure of the lens which is vital for accommodation. The ciliary epithelium which is a double layer of low columnar epithelial cellsproduces aqeous humor which fills the anmterior compartment of the eye.

Histologically the ciliary body is very important as the contraction and relaxation of its smooth muscle fibres changes the tension of the zonular fibres or suspension ligaments of the lens allowing it to change shape in a process known as accommodation. The ciliary epithelium covers numerous ciliary processes extending from the ciliary body. There is also a complex vasculatue that can't be seen. Fluid from these vessels is processed and transported by the epithelial cells to the posterior chamber as aqueous humor. The epithelial cells constitute the blood-aqueous barrier.

THE IRIS

The iris is the most anterior extension of the middle layer that partially covers the lens, leaving a round open space called the pupil. The anterior surface of the iris is not covered by epithelium but consists of an irregular discontinuous layer of fibroblasts and melanocytes. Deeper in the iris the stroma is more loose connective tissue with microvasculature. The posterior surface of the iris is smooth with a double layered epithelium.

The sphincter pupillae and dilator pupillae muscles connect to the stroma. The angle formed by the iris and cornea contains connective tissue with endothelial channels called trabecular network, which drain aqueous humor in the anterior chamber to the canal of Schlemm. From here fluid drains into the episcleral veins.

Histologically the iris is very important as the contraction and relaxation of the muscle fibres in the sphincter and dilator pupillae help to constrict and dilate the pupils in response to sympathetic or parasympathetic stimulation.

INNER NERVOUS LAYER

THE LENS

The lens is a transparent biconvex structure immediately behind the iris, used to focus light on the retina. The lens is covered by a thick homogenous capsule rich in proteoglycans and type IV collagen. Subcapsular lens epithelium consist of a single layer of cuboidal epithelial cells and is present only on the anterior surface of the lens. Lens fibres are highly elongated and appear thin, flattened structures. The fibres are densely packed together forming a perfectly transparent tissue highly specialized for light refraction.

Histologically the lens is very important as it helps to refract light to be focused on the retina. The flexibility allows the lens to be easily manipulated by the ciliary muscles.

THE VITREOUS BODY

The vitreous body occupies thre vitreous chamber behind the lens. It is composed of transparent connective tissue containing mostly 99% water (vitreous humor), bound to hyaluronate and a small amount of collagen. This gel like connective tissue is contained within the vitreous membrane clomposed of type IV collagen fibres.

Histologically the vitreous body is important as it provides physical support holding the retina in place next to the choroid

THE RETINA

The retina, the inner layer of the eye is the nervous tissue where photons of light convert to neurochemical energy via action potentials. The retina contains two major layers, the inner neural layer contains neurons and photoreceptors while the outer pigmented layer is an epithelium lying on the Brusch's membrane. This pigmented cuboidal epithelium also lines the ciliary body and posterior iris. The diverse functions of the cells in the retinal pigmented epithelium include

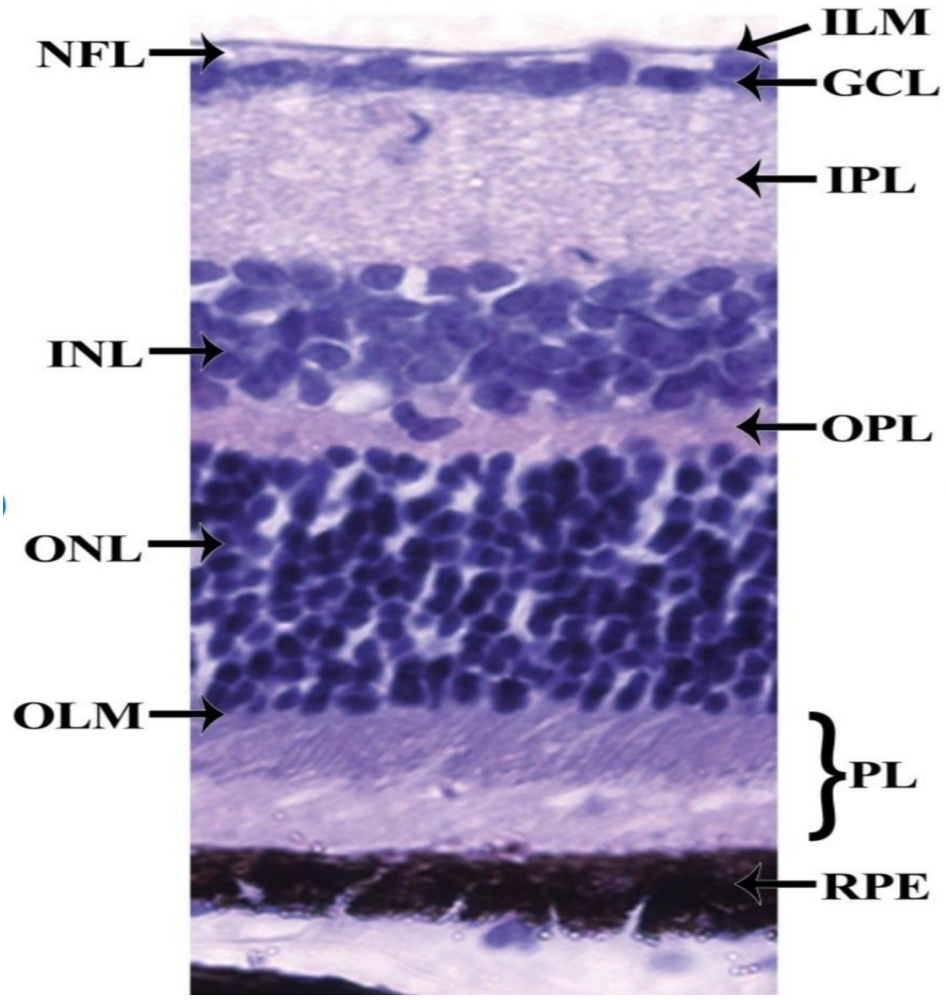
- Serve as an important part of the blood-retina barrier.
- Absorb light passing through the retina to prevent its reflection
- Phagocytes shed components from the adjacent rods and cones
- Remove free radicals and
- Isomerize and regenerate the retinoids used as chromophores by the rod and cones.

QUESTION 2

1. Corona virus can penetrate through the eye and implicate the immune system, briefly discuss the layers of the retina for information penetration.

ANSWER

Histologically The retina can be divided into 10 layers including (1) the inner limiting membrane (ILM); (2) the nerve fiber layer (NFL); (3) the ganglion cell layer (GCL); (4) the inner plexiform layer (IPL); (5) the inner nuclear layer (INL); (6) the outer plexiform layer (OPL); (7) the outer nuclear layer (ONL); (8) the outer limiting membrane (OLM); (9) the photoreceptor layer (PL), and (10) the retinal pigmented epithelium (RPE) monolayer.



1. Inner limiting membrane – basement membrane elaborated by Müller cells.

2. Nerve fibre layer – axons of the ganglion cell bodies (note that a thin layer of Müller cell footplates exists between this layer and the inner limiting membrane).

3. Ganglion cell layer – contains nuclei of ganglion cells, the axons of which become the optic nerve fibres, and some displaced amacrine cells.

4. Inner plexiform layer – contains the synapse between the bipolar cell axons and the dendrites of the ganglion and amacrine cells.

5. Inner nuclear layer – contains the nuclei and surrounding cell bodies (perikarya) of the amacrine cells, bipolar cells, and horizontal cells.

6. Outer plexiform layer – projections of rods and cones ending in the rod spherule and cone pedicle, respectively. These make synapses with dendrites of bipolar cells and horizontal cells. In the macular region, this is known as the *Fiber layer of Henle*.

7. Outer nuclear layer – cell bodies of rods and cones.

8. External limiting membrane – layer that separates the inner segment portions of the photoreceptors from their cell nuclei.

9. Inner segment / outer segment layer – inner segments and outer segments of rods and cones. The outer segments contain a highly specialized light-sensing apparatus.

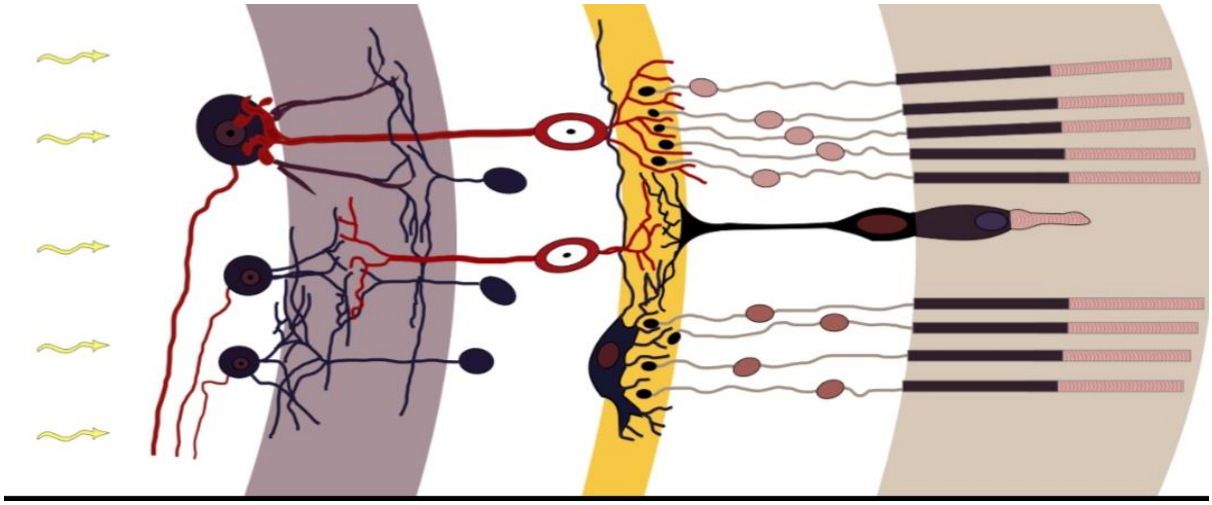
10. Retinal pigment epithelium – single layer of cuboidal epithelial cells (with extrusions not shown in diagram). This layer is closest to the choroid, and provides nourishment and supportive functions to the neural retina, The black pigment melanin in the pigment layer prevents light reflection throughout the globe of the eyeball; this is extremely important for clear vision.

Information transmission through the retina

These layers can be grouped into 4 main processing stages: photoreception; transmission to bipolar cells; transmission to ganglion cells, which also contain photoreceptors, the photosensitive ganglion cells; and transmission along the

optic nerve. At each synaptic stage there are also laterally connecting horizontal and amacrine cells.

The optic nerve is a central tract of many axons of ganglion cells connecting primarily to the lateral geniculate body, a visual relay station in the diencephalon (the rear of the forebrain). It also projects to the superior colliculus, the suprachiasmatic nucleus, and the nucleus of the optic tract. It passes through the other layers, creating the optic disc.



Mechanism of activity of bipolar neurons

Bipolar cells receive inputs from a set of photoreceptor cells that define the bipolar cell's **receptive field**. **The neurotransmitter released from all photoreceptor cells is glutamate**. Because glutamate release is *decreased* upon exposure to light, a bipolar cell that responds to glutamate by excitation will be excited when the light is off. These are called **off-center bipolar cells** because they **are active when the light is off** in the center of their receptive field

Some bipolar cells respond to glutamate by hyperpolarization, or inhibition. In the dark, the photoreceptors maximally release glutamate and these bipolar cells are maximally hyperpolarized. In the light, the photoreceptors are hyperpolarized and they release less glutamate. These bipolar cells are called **on-center bipolar cells** because they **are active when the light is on**.

REFERENCE

1. JUNQEIRA'S BASIC HISTOLOGY TEXT & ATLAS
2. RESEARCH GATE
3. WIKIPEDIA.