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MATRICULATON NUMBER: 17/MHS01/036

COURSE: HISTOLOGY OF SPECIAL SENSES AND NEUROHISTOLOGY

COURSE CODE: ANA 305

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

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.

A) Outermost Layer: Sclera and Cornea

1) The Sclera (white of the eye)

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 ae continuous. The four layers of the sclera from external to internal are episclera, stroma, lamina fusca, and 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)

This consists of type 1 collagen fibers oriented in a uniform parallel direction to maintain transparency.it consists of five layers: Epithelium (non-keratinized, stratified squamous epithelium), Bowman layer, stroma (also called substantia propria), Descemet’s membrane, corneal endothelium.

1. Corneal epithelium: it is a fast growing, regenerating multicellular layer which interacts directly with the tear film.
2. 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 heparin sulfate proteoglycans.
3. Stroma: this is 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 get cancelled by destructive interference, and the spacing of less than 200nm allows for transparency.
4. Descemet’s membrane: this is an acellular layer made of type IV collagen that serves as a modified basement membrane of the corneal endothelium.
5. Corneal endothelium: this is 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

This 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. From here, fluid drains into episcleral veins.

2) Ciliary body

This is the tissue that divides the posterior chamber and vitreous body. It 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

This 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 it 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 prevents diffusion of nutrients to the retina.

C) Innermost Layer: Lens, Vitreous, Retina

1) Lens: this separates the aqueous and vitreous chambers. It 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: this is a jelly-like space made of type II collagen separating the retina and the lens.

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

The Internal parts of the eye have primarily structural and visual functions. The cornea serves a protective role and is responsible for two-thirds of the refractive properties of the eye. The remaining one-third of refraction is performed by the lens, which is functionally adjustable through the action of the zonular fibers and ciliary muscles. At the end of the visual process, as rays of light bend through the cornea and lens, photon energy is converted to neurochemical action potentials by cells of the retina, which then send these impulses to the brain, via the optic nerve. The Uvea of the eye is a crucial mediator of nutrition and gas exchange, as blood vessels course through the ciliary body and iris, while the choriocapillaris in the posterior eye help support the retina. This abundant blood supply is implicated in Uveitis; as inflammatory mediators enter the eye through this vascular network.

Clinical Significance

* Glaucoma: This refers to optic nerve damage related to increase intraocular pressure. Drainage of aqueous humor through the trabecular meshwork is often implicated.
* Age-related macular degeneration: This is a progressive eye disease causing damage to the macula or central portion of the retina. Accumulation of drusen, or lipid-laden deposits in Bruch’s membrane of the retina, is associated with disease severity.
* Fuchs Dystrophy: This is a disease of the corneal endothelium, that causes accumulation of excess edema in the corneal stroma. Progression of the disease often causes blisters in the eye, also referred to as bullous keratopathy.

2. Coronavirus can penetrate the body through eye and implicate the immune system, briefly discuss the layers of retina for information penetration.

The retina is a thin layer of neural tissue that lines the back of the eye. It is part of the central nervous system displaced into the eye during development. In addition to the light-sensitive photoreceptor cells (rods and cones), the retina contains five basic classes of neurons and one principal type of glial cell, the Müller cell. The neurons are organized into three cellular (nuclear) layers which are separated by two synaptic (plexiform) layers.

The vertebrate retina has ten distinct layers. From closest to farthest from vitreous body (vitreous humor) are:

1. Inner Limiting Membrane: this is the basement membrane elaborated by Müller cells.
2. Nerve Fiber Layer: the axons of the ganglion cell bodies are present in this layer. Also, a thin layer of Müller cell footplates exists between this layer and the inner limiting membrane.
3. Ganglion cell layer: this contains nuclei of ganglion cells, the axons of which become the optic nerve fibers, and some displaced amacrine cells.
4. Inner Plexiform Layer: this contains the synapse between the bipolar cell axons and the dendrites of the ganglion and amacrine cells.
5. Inner Nuclear Layer: this contains the nuclei and surrounding cell bodies (perikarya) of the amacrine cells, bipolar cells, and horizontal cells.
6. Outer Plexiform Layer: this contains 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: this contains cell bodies of rods and cones.
8. External Limiting Membrane: this is the layer that separates the inner segment portions of the photoreceptors from their cell nuclei. It separates the photosensitive regions of the retina from the areas that transmit the electrical signals.
9. Inner segment/Outer Segment Layer: these contain the inner segments and outer segments of rods and cones. The outer segments contain a highly specialized light-sensing apparatus.
10. Retinal Pigment Epithelium: this is a single layer of cuboidal cells. 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 through the globe of the eyeball; this is very important for clear vision.

These layers can be grouped into four main processing stages. At each synaptic stage there are also laterally connecting horizontal and amacrine cells. Virtually all of the junctions (synapses) between the retinal neurons are made in the two synaptic layers, and all visual information also passes across at least two synapses, one in the outer plexiform layer and another in the inner plexiform, before it leaves the eye through the optic nerve. The four main processing stages are:

1. Photoreception
2. Transmission to bipolar cells
3. Transmission to ganglion cells
4. Transmission along the optic nerve

The following is what happens when we are in a dark environment:

* Photoreception: in the dark, the photoreceptor cells become depolarized which activates the photoreceptor cells. The activated photoreceptor cells in turn activates the bipolar cells.
* Transmission to Bipolar Cells: bipolar cells, by nature, are inhibitory cells. Therefore, by default, if the bipolar cells get activated, they inhibit the ganglion cells. The bipolar cells get activated when they receive the neurotransmitter, Glutamate, that is released by depolarized photoreceptor cells. The bipolar cells receive the released neurotransmitter at the synapse between the bipolar cells and the photoreceptor cells that is present at the outer plexiform layer of the retina.
* Transmission to Ganglion cells: when the bipolar cells get activated, they inhibit the ganglion cells.
* Transmission along the Optic nerve: part of the optic nerve is comprised of the axons of the ganglion cells in the retina. So when the ganglion cells are inhibited, the optic nerve perceives no light.

The following happens when we are in an environment that has light:

* Photoreception: when there is light the photoreceptor cells (rods and cones) become hyperpolarized and therefore, it is inhibited. Hence, the inhibited photoreceptor cells are unable to activate the bipolar cells.
* Transmission to Bipolar cells: as the photoreceptor cells are hyperpolarized and inhibited, no glutamate would be released and so the bipolar cells remain inhibited.
* Transmission to Ganglion cells: if the bipolar cells are inhibited, they cannot inhibit the ganglion cells. So by default, the ganglion cells become activated.
* Transmission along the Optic nerve: the activated ganglion cells transmit signals to the optic nerve which allow you to perceive the presence of light.

Clinical Significance

* Retinal detachment: this occurs when the outer pigment epithelial layer separates from the inner neurosensory layer consisting of rods and cones; this is a vision-threatening condition as the neurosensory layer is unable to receive nutrients from the underlying choriocapillaris and retinal pigment epithelium.