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LEVEL: 300L

DEPARTMENT: MEDICINE AND SURGERY

NEUROHISTOLOGY ASSIGNMENT

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

Answer: The eye has often been called “the window to the soul”, but is anatomically viewed as a series of overlapping tissue.

Externally, its structures are: eyelashes, lids, muscles, accessory glands and conjunctiva. Internally, it has three layers of tissue that are arranged concentrically:

1. The sclera and the cornea that form its exterior layers.
2. The uvea in the middles that is the vascular layer, and is subdivided into the iris, ciliary body and choroid.
3. The retina that makes up the most inner layer, and is comprised of nervous tissue.

All these will be histologically considered and further divided.

THE EXTERIOR LAYERS

1. Conjuctiva

* The conjunctiva lines the inner part of the eyelids.
* The tarsal plate lies beneath the conjunctiva and contains meibomian glands, which secrete an oily substance to decrease the evaporation of the tear film.

2. Tearfilm*:* The tear film consists of aqueous, mucus, and oily secretions.

3. Accessory glands*:* Apocrine glands of Moll, meibomian glands, lacrimal glands.

4. Muscles*:*Orbicularis oculi, levator palpebrae superioris, superior tarsal muscle.

5. Eyelid*:* The eyelid, likewise known as the cover of the eye, a mobile layer made up of skin and also muscular tissue and also covers the eyeball.

THE INTERIOR LAYERS

 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)

* 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. From here, fluid drains into episcleral veins.

2. CiliaryBody*:* 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 prevents diffusion of nutrients to the retina.

C. Innermost layer: Lens, Vitreous, Retina.

1. Lens: separates the aqueous and vitreous chambers

* 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

2. Briefly discuss the layers of the retina for information penetration.

 Answer: The retina is the innermost layer of the eye that is responsible for visual processing; that turns light energy from photons into three dimensional images. It is located in the posterior portion of the eyeball (except for the area of the optic nerve), and is the only extension of the brain that can be seen from the outside world naturally.

 The retina is made up of six different cell types that are dispersed into ten layers, each one playing a specific role in creating and transmitting vision. These ten layers are made up of distinct neurons that are interconnected by synapses.

 The layers of the retina from the most anterior to the most posterior are as follows:

1. Inner limiting membrane
2. Nerve fiber layer
3. Ganglion cell layer
4. Inner plexiform layer
5. Inner nuclear layer
6. Outer plexiform layer
7. Outer nuclear layer
8. External limiting membrane
9. The layer of rods and cones
10. Retinal Pigment Epithelium (RPE)
11. Inner limiting membrane: it is the retina’s inner surface bordering the vitreous humor, thereby forming a diffusion barrier between the two. It contains laterally contacting Muller cell synaptic boutons and other basement membrane parts.
12. Nerve fiber layer: it’s the second layer after the vitreous humor and the innermost layer of the fundus. It consists of axons in the ganglion cells en route to the CNS. Its thickest near the porous opticus and is formed by the converging of all the retinal ganglion cell axons as they enter the optic nerve.
13. Ganglion cell layer: this layer contains the retinal ganglion cells and displaced amacrine cells, Muller cell bodies and astroglial cells. They are separated from each other by glial processes of Muller cells, and are generally a cell thick except near the macula and the temporal side of the optic disc.
14. Inner plexiform layer: it is also called inner synaptic layer. it’s an area comprised of dense reticulum of fibrils formed by interlace dendrites of retinal ganglion cells and cells of the inner nuclear layer. The smaller RCGs dendrites arborize here. This layer is responsible for initiating the process of motion detection, changes in brightness and recognition of contrast and hue.
15. Inner nuclear layer: this is the layer of the retina that contains the nuclei and cell bodies of bipolar cells, horizontal cells and amacrine cells. It also contains Muller cells nuclei, and sometimes, displaced ganglions. Its main function is to receive input from the inner plexiform layer and project it to the outer plexiform layer. Hemorrhages that happen here look round in shape, and are often called dot or blot haemorrhages.
16. Outer plexiform layer: also called the outer synaptic layer, it has synaptic connections between photoreceptor cells, horizontal cells and bipolar neurons. The projections of rods and cones end in the rod spherules and cone pedicles respectively. These in turn make synapses with dendrites of midget bipolar cells in the Fibers of Henle. It is thought to be a membrane known as the **middle limiting membrane**, which demarcates the extent of the retinal vasculature. It prevents the spread of retina; exudates into the outer retinal layers.
17. Outer nuclear layer: it contains the nuclei and cell bodies of the photoreceptor cells (rods and cones), and varies in width. Its thickest in the fovea where it contains about 10 layers of cone nuclei.
18. External limiting membrane: it is not a true membrane. It’s just comprised of adherent junctions between Muller’s cells and photoreceptors, separating the inner segment portions of the photoreceptors from their cell nuclei. These junctions can resist the entrance of some large molecules, hereby creating a barrier.
19. Photoreceptor layer (rods and cones): it contains the inner and outer segments of photoreceptors; rods and cones. Cones are active in well-lit illumination and identify color. Rods are more active in dim illumination and register light intensity.
20. Retinal pigment epithelium: it sits immediately on Bruch’s membrane and consists a single layer of hexagonal cells. These are densely pigmented in the macula area. The RPE are supportive cells and have macrophage function with little cell division occurring in the layer. They have gap junctions.

All these layers are made up of six different cell types. These are:

1. Rods: these cells have been traced back to approximately 500million years ago, when a piscine ancestor evolved rods to aid the cones that were already present. It has been assumed that this change was to allow organisms have better survival in low-light settings.

Rods make up approximately 95% of photoreceptors in human retina’s and register low light levels, so form black and white vision; scotopic vision. They have slow speed of response and only function at night.

1. Cones: the human retina has about 6-7million cones, and thehy make up only 5%of the photoreceptors. However, only about 100,000cones are used for visual acuity. Cones respond to wavelengths of light. They are concentrated in the macula, and specialize in detecting red light (64%), green light (32%) or blue light (2%).
2. Retinal Ganglion Cells: they are the retinas main output neuron. They are also a third class of photoreceptors that transmit both image-forming and non-image forming information, that contributes to the ciracardian rhythm, regulating release of melatonin and regulating pupil size.
3. Amacrine cells: They are the ultimate utility cells of the retina. They are intermediate neurons that release the inhibitory transmitter, GABA or glycine. They can be both inhibitory or excitatory due to their gap junctions. They are very diverse in function.
4. Bipolar cells: they are 2nd order long projection neurons, named after their axons 180-degree orientation. They receive visual inputs from rods and cones and project their axons on retinal ganglion cells.
5. Horizontal cells: they are involved in regulating information transfer between bipolar cells and photoreceptors. They also help the eyes adjust to bright and low light conditions.