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**Course: Neurohistology**

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

The eye is a sense organ and it is used for the purpose of SEEING. It is a complex and highly developed photosensitive organ that permits an accurate analysis of the form, light intensity, and color reflected objects. It can also be seen as a series of overlapping layers of tissue. Each eye is composed of external and internal features.

External structures of the eye include the eyelashes, eyelids, muscles of the eye, accessory glands and conjunctiva.

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

1. The sclera and cornea make up the exterior layers.
2. The uvea: the vascular layer in the middle, subdivided into the iris, ciliary body and choroid.
3. The retina: constitutes he innermost layer and is made up of nervous tissue.

**EXTERNAL STRUCTURES**

* **Conjunctiva**: It 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.
* **Tear film**: The tear film consists of aqueous, mucous, and oily secretions.
* **Eyelid**: It is likewise known as the **cover of the eyes**; a mobile layer made up of skin and also muscular tissue and also covers the eyeball. It prevents foreign bodies from entering the inner eye and helps refresh and distribute the tear film by blinking.
* **Accessory glands**: Apocrine glands of Moll, Meibomian glands and Lacrimal glands
* **Eyelashes**: They are the hair-like structures located in the eye. They are finely sensitive to touch and warn the eye of possible debris and particles that may cause injury.
* **Muscles**: Orbicularis oculi, levator palpebrae superioris, superior tarsal muscle.

**INTERNAL STRUCTURES**

1. **Outermost layer: Sclera and cornea**
2. **The sclera (white of the eye)**: It is a dense connective tissue made up of mainly type 1 collagen fibres, oriented in different directions. The lack of parallel orientation of collagen fibres gives the sclera it’s 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 fibres. At the corneoscleral junction, also known as the **limbus**, the Tenon capsule contacts stroma of the conjunctiva.

1. **Cornea(transparent front layer of the eye)**: It consists of type 1 collagen fibres 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.**

* **The Corneal Epithelium**: It is **stratified non-keratinized squamous epithelium** consisting of 5/6 layers of cells. The basal part of the epithelium is numerous mitotic figures that are responsible for the cornea's remarkable regenerative capacity. This epithelial tissue is covered by protective layer of lipid and glycoprotein which is about 7m thick. The cornea has one of the richest sensory nerve supplies of the tissue.
* **The Bowman's Membrane**: consists of collagen fibres crossing at random. It possesses no cell. This membrane contributes greatly to the stability and strength of cornea.
* **The Stroma**: It is the **largest** of the cornea and it is formed of many layers of parallel collagen bundles that cross at approximately right angles to each other. The collagen fibrils within each lamella are parallel to each other and run the full width of the cornea. It is also known as **Substantia propria**.
* **The Descemet's Membrane**: It is a thick homogenous structure composed of fine collagenous filaments organized in a three-dimensional network.
* **The Corneal Endothelium**: is a **simple squamous epithelium**. These cells possess organelles for secretion that are characteristic cells engaged in active transport and protein synthesis and that may be related to the synthesis and maintenance of the Descemet's membrane.

The corneal epithelium and endothelium are responsible - for maintaining the transparency of the cornea. They both are capable for transporting sodium ions towards their apical surfaces.

**HISTOLOGICAL IMPORTANCE OF THE CORNEA**

The cornea serves a protective role and is responsible for the two-thirds of the refractive properties of the eye. It functions like a window that controls and focuses the entry of light into the eye.

1. **Middle layer: Uvea (iris, ciliary body, choroid)**
2. **Iris:** consists of one stromal layer with pigmented, fibrovascular tissue and two pigmented epithelial cells beneath the stroma. The sphincter pupillae and dilator pupillae muscles connect to the stroma. The pigmented layer of cell blocks rays of light and ensures that 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 humour in the anterior chamber into the venous canal of Schlemm (from here, fluid drains into episcleral veins.

**HISTOLOGICAL IMPORTANCE OF THE IRIS**

It is responsible for controlling the diameter and size of the pupil and thus the amount of light reaching the retina.

1. **Ciliary body:** The tissue that divides the posterior chamber and vitreous body.

* **Ciliary muscles**: These via the lens zonules, controls the structures of the lens which is vital for accommodation. Zonules are connective tissue fibres that connect the ciliary muscles and lens.
* **Ciliary epithelium**: It produces aqueous humour which fills the anterior compartment of eye.

**HISTOLOGICAL IMPORTANCE OF CILIARY BODY**

It is important for the functions of accommodation, aqueous humour production and resorption. It also functions in the maintenance of the lens zonules for the purpose of anchoring the lens in place.

1. **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.

**HISTOLOGICAL IMPORTANCE OF CHOROID**

It is important in providing nourishment to the outer layers of the retina through blood vessels.

1. **Innermost layer: Lens, Vitreous, Retina:**
2. **Lens:** It separates the aqueous and vitreous chambers. It consists of 3 parts which are: 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 the older lens cells towards the middle.

**HISTOLOGICAL IMPORTANCE OF LENS**

By changing its shape, it changes the focal distance of the eye. In other words, it focuses the light rays that pass through it (and onto the retina) in order to create clear images of objects that are positioned at various distances.

1. **Vitreous**: This is a jelly-like space made of type II collagen separating the retina and the lens.

**HISTOLOGICAL IMPORTANCE OF VITREOUS**

It performs a vital role in protecting the eye. Most importantly, it helps to hold its spherical shape. Along with maintaining the eye shape, it helps to absorb shock to the eye and keep the retina properly connected to the back of the eye. The light passes through the vitreous on its way to the retina.

1. **Retina:**

This is the nervous tissue of the eye where photons of light convert to neurochemical energy via energy potentials. Moreover, the retina is divided into 10 distinct layers from innermost to outermost, they are: the inner limiting membrane, the optic nerve fiber layer, the ganglion cell layer, the inner plexiform layer, the inner nuclear layer, the outer plexiform layer, the outer nuclear layer, the external limiting membrane, the rod and cone layer, the retinal pigment epithelium.

**HISTOLOGICAL IMPORTANCE OF RETINA**:

The retina receives light that the lens has focused and convert the light into neural signals and sends these signals on to the brain for visual recognition membrane.

**QUESTION 2. Corona Virus can penetrate the body through eye and implicate the immune system, briefly explain the layers of the retina for information penetration.**

The retina has 10 distinct layers which are arranged from the innermost to the outermost. They are:

1. The inner limiting membrane
2. The optic nerve fibre layer
3. The ganglion cell layer
4. The inner plexiform layer
5. The inner nuclear layer
6. The outer plexiform layer
7. The outer nuclear layer
8. The external limiting membrane
9. The rod and cone layer
10. The retinal pigment epithelium
    1. **Inner limiting membrane:** The ILM is the retina's inner surface bordering the vitreous humor and thereby forming a diffusion barrier between the neural retina and vitreous humor. The ILM contains laterally contacting Muller cell synaptic boutons and other basement membrane parts.
    2. **Optic nerve fiber layer:** The nerve fiber layer is the second innermost layer of the retina from the vitreous. Patients with retinitis pigmentosa may have a measurable degree of retinal nerve fibre layer thinning.
    3. **Ganglion cell layer:** This layer contains the retinal ganglion cells (RGCs) and displaced amacrine cells. As a rule of thumb, smaller RGCs dendrites arborize in the inner plexiform layer while larger RGCs dendrites arborize in other layers.
    4. **The inner plexiform layer:** This layer contains the **axodendritic synapses** between the axons of bipolar cells and dendrites of the ganglions. The processes of the amacrine cells are located in this layer.
    5. **The inner nuclear layer:** This contains the cell bodies of the bipolar cells, amacrine cells, horizontal cells and nuclei of the Muller cells.
    6. **The outer plexiform layer:** This layer contains the axodendritic synapses between the axons of photoreceptor cells and dendrites of bipolar and horizontal cells. It displays the **synaptic** **ribbons** within the rods and cones cells at synaptic sites.
    7. **The outer nuclear layer:** The layer consists primarily of nuclei of rods and cones.
    8. **The external limiting membrane:** It is not a true membrane but an area where **zonulae** **adherens** (belt desmosomes) are located between the photoreceptor cells and the retinal glial cells (Muller cells). It also contains the microvilli that projects from the Muller cells.
    9. **The rods and cones layer:** This 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.
    10. **The retinal pigment epithelium:** This is a single layer of cuboidal epithelial cells firmly attached to the **Bruch** **membrane**. This is the layer 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. The retinal pigment epithelial cells esterify Vitamin A (used in the formation of visual pigment by rods and cones) and they phagocytize the shed tips of the outer segment of rods and cones.