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**Course Code:** ANA 305.

**Question:**

1. Write an essay on the histological importance of the eye in relation to their cellular functions.
2. Corona virus can penetrate the body through the eye and implicate the immune system, briefly discuss the layers of the retina for information penetration.

**Question 1:**

The eye is a complex and highly developed photosensitive organ that permits an accurate analysis of the form, light intensity, and color reflected from objects.

The eye is made up of both external and internal structures.

* The external structures of the eye include the eyelashes, eyelids, muscles, accessory glands, and conjunctiva.
* The internal structures of the eye consist of three layers of tissue arranges concentrically: an external layer (made up of the sclera and the cornea), a middle layer called the vascular layer (made up of the iris, ciliary body and choroid; collectively called the Uvea), and an inner layer of nerve tissue, the retina (consisting of an outer pigment epithelium and an inner retina proper)

**External Structures of the Eye:**

1. **Conjunctiva:** lines the inner part of the eyelids
2. **Tear Film:** consists of aqueous, mucus, and oily secretions.
3. **Accessory Glands:** include the apocrine glands of Moll, meibomian glands, lacrimal glands.
4. **Muscles:** the muscles of the eye include the orbicularis oculi, levator palpebrae superioris, superior tarsal muscle.
5. **Eyelids:** The eyelids are a mobile layer made up of skin and also muscular tissue, and they cover the eyeballs.

**Internal Structures of the Eye:**

The innermost structures of the eye are organized in the three layers as follows:

1. **External Layer: Sclera and Cornea:**
2. **The Sclera:**

The sclera is also called “**the white of the eye**”. The sclera is made up of dense connective tissue consisting of mainly type I 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 sclera is made up of 4 layers. From external to internal, they are the episcleral, the stroma, the lamina fusca, and the endothelium. The external surface of the sclera, the episcleral is connected by a loose system of thin collagen fibers to a dense layer of connective tissue called the Tenon’s capsule. The Tenon’s capsule comes in contact with the loose conjunctival stroma at the corneoscleral junction, also known as the limbus.

1. **The Cornea:**

This is the transparent front layer of the eye. It is colorless and transparent. The cornea consists of type I collagen fibers oriented in a uniform parallel direction to maintain transparency. A transverse section of the cornea shows that it consists of 5 layers:

1. **Corneal epithelium:** made up of non-keratinized, stratified squamous epithelium. This layer is a fast growing, regenerating multicellular layer (5 or 6 layers) which interacts directly with the tear film.
2. **Bowman’s membrane:** also known as the “**anterior basement membrane**”. It is a layer of subepithelial basement membrane protecting the underlying stroma. It is composed of type I collagen, laminin, and several other heparan sulfate proteoglycans.
3. **Stroma:** This is the largest layer of the cornea and can be called the “**substantia propria of the cornea**”. It 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 cancelled by destructive interference, and the spacing of less than 200nm allows for transparency.
4. **Descemet’s membrane:** also known as the “**posterior basement membrane**”. It is an acellular layer made up of type IV collagen that serves as a modified basement membrane of the corneal endothelium.
5. **Corneal endothelium:** it 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.
6. **Middle Layer: Uvea (Iris, Ciliary Body, Choroid):**
7. **Iris:**

The iris controls the amount of light that enters through the pupil and divides the anterior chamber from the posterior chamber. The anterior chamber is the space between the cornea and the iris while the posterior chamber is the space between the posterior surface of the iris and the anterior surface of the lens. Both of these chambers contain aqueous humor, which is a watery fluid produced by the ciliary body.

The iris consists of a stromal layer with pigmented, fibrovascular tissue and 2 pigmented epithelial cells beneath the stroma. On the side of the iris facing the anterior chamber is the connective tissue of the “**irideal stroma**”. This stroma consists of a loose connective tissue containing fibroblasts and a variable number of melanocytes. At the pupillary margin of the iris is a band of circularly arranged smooth muscle known as the “**constrictor pupillae muscle**” and **its contraction causes the pupil to constrict**.

The portion of the iris facing the posterior chamber consists of 2 prominent cell layers. The most obvious is the “**posterior pigmented epithelium**”. The pigment serves to block the light so that only light passing through the pupil is focused through the lens onto the retina. Just above this epithelium is a “**slightly less pigmented anterior epithelium**” which actually consists of myoepithelial cells that are specialized such that they project their contractile portions in a radial manner so that they **cause the pupils to dilate when they contract**. This muscular portion of the anterior pigmented epithelium constitutes the “**dilator pupillae muscle**”.

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 the episcleral veins.

1. **Ciliary Body:**

This is the tissue that divides the posterior chamber and the vitreous body. It consists of the ciliary muscle and 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.

1. **Choroid:**

The choroid consists of a dense network of blood vessels supplying nourishment to the structures of the eye, housed in loose connective tissue. It consists of 3 distinct layers. Closest to the sclera is a layer of pigmented melanocytes. Next is an extensive capillary bed of the “**Choriocapillary layer**” (which supplies the retina), followed by the “**Bruch’s membrane**”, an extracellular matrix layer situated between the retina and choroid.

1. **Inner Layer: Lens, Vitreous, Retina:**
2. **Lens:**

The lens separates the aqueous and vitreous chambers. It consists of an outer capsule, a middle layer called the cortex and an inner layer called the nucleus.

The lens capsule is the basement membrane of the underlying lens epithelium which consists of a layer of epithelial cells that are more squamous toward the anterior apex of the lens and become taller as you move posteriorly towards the lens equator. New lens cells differentiate from the lens epithelium at the lens equator and are incorporated peripherally, pushing older lens cells towards the middle.

1. **Vitreous:**

This is a jelly-like space made of type II collagen, separating the retina from the lens. It contains the gelatinous vitreous body.

1. **Retina:**

The retina is the nervous tissue of the eye where photons of light convert to neurochemical energy via action potentials.

**Function:**

The layers of the eye perform distinct functions which coalesce to create a unified, perpetual experience. The essential role of the external eye structures is to protect the delicate tissue of the internal eye.

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 is performed by the lens which is functionally adjustable by the action of the zonular fibers and ciliary muscles.

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 helps to support the retina.

**Question 2:**

The retina is the light-sensitive tissue that lines the inside of the eye. The retina functions in a manner similar to the film in a camera. The optical elements within the eye focus an image onto the retina, which initiates a series of chemical and electrical events within the retina. Nerve fibers within the retina then send electrical signals to the brain, which then interprets these signals as visual images.

The retina consists of millions of cells packed together in a tightly knit network spread over the surface of the back of the eye. These cells can be divided into 3 basic cell types namely:

* Photoreceptor cells, which consist principally of cones and rods. Each human retina contains approximately 120 million rods and 6 million cone photoreceptors.
* Neuronal cells, which include bipolar cells, ganglion cells, horizontal cells and amacrine cells.
* Glial cells, which include Muller cells, astrocytes and microglial cells.

**Anatomic Layers of the Retina:**

  The vertebrate retina has 10 distinct layers. From the closest to the farthest from the vitreous body, they are:

1. The inner limiting membrane
2. The nerve fiber layer
3. The ganglion cells layer
4. The inner plexiform layer
5. The inner nuclear layer
6. The outer plexiform layer
7. The outer nuclear layer
8. The outer limiting membrane
9. The rod and cone layer
10. The pigment epithelium
11. **The Inner Limiting Membrane:**

This is the boundary between the retina and the vitreous body. It is formed by astrocytes and the footplates of Muller cells together with a basal lamina.

1. **The Nerve Fiber Layer:**

The nerve fiber layer is the layer of optic nerve fibers consisting of ganglion cell axon fibers, which course towards the optic nerve head.

1. **The Ganglion Cells Layer:**

This layer contains the nuclei of ganglion cells whose axons become the optic nerve fibers for messages. There are also some displaced amacrine cells within this layer. Additionally, this layer contains the non-rod and non-cone photoreceptors, the photosensitive ganglion cells, which are important for reflexive responses to bright daylight.

1. **The Inner Plexiform Layer:**

The inner plexiform layer contains the synapses between dendrites of ganglion cells and amacrine cells and the axons of bipolar cells.

1. **The Inner Nuclear Layer:**

It contains the nuclei of horizontal, bipolar and amacrine cells. This layer is thicker in the central area of the retina compared to the peripheral retina because of a greater density of cone-connecting second-order neurons (cone bipolar cells) and smaller and more closely spaced horizontal cells and amacrine cells concerned with the cone pathways. Nuclei of the supporting Muller cells are also present in this layer.

1. **The Outer Plexiform Layer:**

It is also known as “The Outer Synaptic Layer”. The outer plexiform layer contains the rod and cone axons (projections of rods and cones ending in the rod spherule and cone pedicle), horizontal cell dendrites, and bipolar cells dendrites. Synapses among these structures occur within this layer. In the macular region, this layer is termed the fiber layer of Henle.

1. **The Outer Nuclear Layer:**

It consists of the cell bodies of the retinal rods and cones. In the peripheral retina, the rod cell bodies outnumber the cone cell bodies, and vice versa for the central retina.

1. **The Outer Limiting Membrane:**

It is also called “The External Limiting Membrane” and is the layer that separates the inner segment portions of the photoreceptors from their cell nuclei.

1. **The Rod and Cone Layer:**

This layer is also known as the “Bacillary Layer” and contains the inner segments of the rod and cone photoreceptor cells.

1. **The Pigment Epithelium:**

The pigment epithelium is the most external layer of the retina. It leans on the choroidal layer of the eye. It contains a single layer of cuboidal-supporting cells for the neural portion of the retina. These supporting cells contain melanin, which absorbs light and decreases light scatter within the eye.