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 QUESTIONS.

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 eyes and implicate the immune system, briefly discuss the layers of the retina for information penetration.

 ANSWERS.

1. The eyes are highly developed photosensitive organs for analyzing the form, intensity and color of light reflected from objects and providing the sense of sight. The eyes are protected within the orbits of the skull which also contain adipose cushions. Each eyeball is like a camera. It has a lens which produces images of objects that we look at. The image falls on alight sensitive membrane called the retina, cells in the retina convert light images into nervous impulses that pass through the optic nerve and other visual pathways to reach visual areas in the cerebral cortex, it is in the cortex that vision is actually perceived.

 The eye is made up of two structures; External structures and Internal structures.

* EXTERNAL STRUCTURES: The external structures of the eyes include the eyelashes, eyelids, muscles, accessory glands and conjunctiva.

 -EYELIDS: The eyelids are pliable structures containing skin, muscle and conjunctiva that protects the eyes. The skin is loose and elastic, lacks fat, and has only very small hair follicles and fine hair, except at the distal edge, where large follicles with eyelashes are present. Beneath the skin are striated fascicles of the orbicularis oculi and levator palpebrae muscles. The skeleton of the eyelid is formed by a mass of fibrous tissue called the tarsus or tarsal plate. The eyelids help to protect the eyes from excessive sunlight and injury.

 and keeps the cornea moist by spreading lacrimal fluid.

* EYELASHES: These are hairs that grow from the margins of the eyelids.
* MUSCLES: Orbicularis oculi, levator palpebrae superioris, superior tarsal muscle.
* ACCESSOR. Y GLANDS: There are numerous glands present in the eyes; Sebaceous glands, Tarsal glands, Lacrimal glands, Glands of Moll, Glands of Zeis, Glands of Wolfring.
* CONJUCTIVA: The conjunctiva is a thin, transparent that covers the inner surface of each eyelid (palpebral conjunctiva) and the anterior part of the sclera (ocular conjunctiva). At the free margin of the eyelid the palpebral conjunctiva becomes continuous with skin, and at the margin of the cornea, the ocular conjunctiva becomes continuous with the anterior epithelium of the cornea. It forms a conjunctival sac when the eyelids are closed. The conjunctiva consists of an epithelial lining that rests on the connective tissue. Over the eyelids this connective tissue is highly vascular and contains much lymphoid tissue.it is much less vascular over the sclera. The epithelium consists of a stratified columnar epithelium, with numerous goblet cells, supported by a thin lamina propria of loose vascular connective tissue. The epithelium lining the palpebral conjunctiva is typically two layered. There is a superficial layer of columnar cells, and a deep layer of flattened cells. At the conjunctival fornix and over the sclera, the epithelium is three layered there being an additional layer of polygonal cells between the two layers mentioned above. The three layered epithelium changes to two layers at the sclerocorneal junction.
* INTERNAL STRUCTURES: The internal structures of the eye are organized in three layers;
* An External fibrous layer made up of the sclera and the cornea.
* A Middle vascular layer made up of the Choroid, Ciliary body and Iris.
* An Internal sensory layer made up of the Retina.

Not part of these layers but part of the internal structure is the; Lens, Aqueous Humor and Vitreous chamber.

* EXTERNAL FIBROUS LAYER:
1. SCLERA: The sclera is the white of the eye. It is a 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 the 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. The sclera helps to protect the internal structures within the eye, it resists the intraocular pressure and maintains the shape of the eye, its smooth external surface allows eye movements to take place with ease, it also provides attachment to the tendons of the extraocular muscles that moves the eyeball at its anterior region.
2. CORNEA: This forms the anterior one-sixth of the eyeball. It is convex forward. It is colorless and avascular but has a very rich nerve supply. The cornea is made up of five layers; Corneal epithelium, Bowman’s membrane, Corneal stroma, Descemet’s membrane & Endothelium.
3. CORNEAL EPITHELIUM: This is the outer most layer. It makes up 10% of the corneal thickness, it is non keratinized stratified squamous epithelium. The cells in the deepest layer of the epithelium are columnar; in the middle layers they are polygonal; and in the superficial layers they are flattened. The cells are arranged with great regularity. The cells on the superficial surface shows projections either in the form of microvilli or folds of plasma membrane. These folds are believed to play an important role in retaining a film of fluid over the surface of the cornea. The he corneal epithelium regenerates rapidly after damage.
4. BOWMAN’S MEMBRANE: The corneal epithelium rests on the anterior limiting lamina (also called Bowman’s membrane). With light microscope, this lamina appears to be structure less, but with EM it is seen to be made of fine collagen fibrils embedded in matrix. It gives great stability and strength to the cornea.
5. CORNEAL STROMA: Most of the thickness of the cornea is formed by the substantia propria or corneal stroma. It is made up of type 1 collagen fibers embedded in a ground substance containing sulphated glycosaminoglycans. They are arranged with great regularity and form lamellae. The fibers within one lamellus are parallel to one another, but the fibers in the adjoining lamellae run in different directions forming obtuse angles with each other. The transparency of the cornea is due to regular arrangement of fibers, and because of the fact that the fibers and ground substance have the same refractive index. Fibroblasts are present in this layer. They appear to be flattened in vertical sections through the cornea, but are seen to be star-shaped on surface view. They are also called keratocytes or corneal corpuscles.
6. DESCEMET’S MEMBRANE: This is an acellular layer made of type IV collagen that serves as a modified basement membrane of the corneal endothelium.
7. CORNEAL ENDOTHELIUM: This is a one-cell thick layer made up of either simple squamous or cuboidal cells. Cells in this region do not regenerate, they are adapted for transport of ions and possess numerous mitochondria. They are united to neighboring cells by desmosomes and by occluding junctions. They help to maintain fluid balance in the cornea, thus ensuring its transparency, and prevents swelling of the stroma. When the corneal endothelial cells are lost, neighboring cells stretch to attempt to compensate these losses.

- MIDDLE VASCULAR LAYER OR UVEA.

a) 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 supplies the retina. The Bruch membrane is an extracellular matrix layer situated between the retina and the choroid and has significance in age-related macular degeneration, where an accumulation of lipid deposits prevent diffusion of nutrients to the retina.

b) CILIARY BODY: The ciliary body represents an anterior continuation of the choroid. It is a ring-like structure continuous with the periphery of the iris. It is connected to the lens by the suspensory ligament. The ciliary body is made up of vascular, connective tissue and muscle. The muscle compartment constitutes the ciliaris muscle. The ciliaris muscle is responsible for producing alterations in the convexity of the lens (through the suspensory ligament) enabling the eye to see objects at varying distances from it. In other words, the ciliaris, is responsible for accommodation. The inner surface of the ciliary body is lined by a double layered epithelium. The outer cell layer is pigmented, whereas the inner cell layer is non-pigmented. The cells of the inner layer secrete aqueous humor. The anterior part of the ciliary processes.

c) IRIS: The iris is the most anterior part of the vascular layer of the eyeball. It forms a diaphragm placed immediately in front of the lens. At its periphery it is continuous with the ciliary body. In its center, there is an aperture the **pupil**. The pupil regulates the amount of light passing into the eye. The iris is composed of a stroma of connective tissue containing numerous pigment cells, and in which are embedded blood vessels and smooth muscle. Some smooth muscle fibers are arranged circularly around the pupil and constrict it. They form the **sphincter pupillae**. Other fibers run radially and form the **dilator pupillae**. The posterior surface of the iris is lined by a double layer of epithelium continuous with that over the ciliary body. This epithelium represents a forward continuation of the retina. The cells of this epithelium are deeply pigmented.

- INTERNAL/ SENSORY LAYER:

 RETINA: This is the nervous tissue of the eye. It is the inner coat of the eyeball and lines the posterior three-fourth surface. It also contains photoreceptors which are essential for vision. The retina has a specialized area where vision is most acute, called as fovea centralis or macula. This area contains only cones which are essentially bare. The retina also has a blind spot, the optic disc where the optic nerve leaves the eye and there are no photoreceptors. The retina is divided into various layers;

1. RETINA PIGMENT EPITHELIUM: The pigmented epithelium consists of low columnar cells with basal nuclei. The cells have well-developed junctional complexes, gap junctions, and numerous invaginations of the basal membranes associated with mitochondria. The apical ends of the cells extend processes and sheath-like projections that surround the tips of the photoreceptors. Melanin granules are numerous in the extensions and apical cytoplasm. This cellular region also contains numerous phagocytic vacuoles and secondary lysosomes, peroxisomes, and abundant smooth ER, with specialized regions in these cells for isomerization of all-trans-retinal (derived from vitamin A) and its transport to the photoreceptors. The diverse functions of the cells in the retinal pigmented epithelium are; they serve as an important part of the blood-retina barrier, they help to absorb light passing through the retina to prevent its reflection, they also phagocytose shed components from the adjacent rods and cones, remove free radicals, and isomerize and regenerate the retinoids used as chromophores by the rods and cones.
2. LAYER OF RODS AND CONES: The 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. The rods and cones, named for the shape of their outer segments, are polarized neurons. At one pole is a single photosensitive dendrite and at the other are synapses with cells of the bipolar layer. The rod and cone cells can be divided into outer and inner segments, a nuclear region, and a synaptic region. The outer segments are modified primary cilia and contain stacks of membranous saccules shaped as flattened disks. The photosensitive pigments of the retina are located in the membranes of these saccules. Both rod cells and cone cells pass through a thin layer, the outer limiting layer, which consists of a series of junctional complexes between the photoreceptors and the organizing glial cells of the retina called Müller cells
3. ROD CELLS: The human retina has approximately 120 million rod cells. They are extremely sensitive to light, responding to a single photon, and allow some vision even with light low levels, such as at dusk or nighttime. Rod cells are thin, elongated cells (50 m x 3 m), composed of two distinct segments. The outer segment is photosensitive; the inner segment contains the metabolic machinery for the cell's biosynthetic and energy-producing processes. The outer rod-shaped segment consists mainly of 600–1000 flattened membranous discs stacked like coins and surrounded by the plasma membrane. Between this outer segment and the cell's inner segment is a constriction, the connecting stalk, which is a modified cilium arising from a basal body. The inner segment is rich in glycogen and mitochondria near the base of this cilium. Abundant polyribosomes located inside the mitochondrial region produce proteins that are transported to the outer segment, where they are incorporated into the membranous discs. These proteins include the visual pigment rhodopsin which is bleached by light and initiates the visual stimulus.
4. CONE CELLS: The human retina has 6 or 7 million cone cells, which are less sensitive to low light than rod cells and are specialized for color vision in bright light. Three functional types of cone cells, not distinguishable morphologically, contain variations of the visual pigment iodopsin with maximal sensitivities in the red, blue, or green regions of the visible spectrum, which enables these cells to detect those colors in reflected light. Cone cells are also elongated, with outer and inner segments, a modified cilium connecting stalk, and an accumulation of mitochondria and polyribosomes. The outer segments of cones differ from those of rods in their shorter, more conical form and in the structure of their stacked membranous disks, which in cones remain as continuous invaginations of the plasma membrane along one side. Also, newly synthesized membrane proteins are distributed uniformly throughout the outer segment of cones and although iodopsin turns over, the discs are shed much less frequently than in rods.
5. OUTER LIMITING MEMBRANE: This is a layer of Muller cells and rod/cone junctions which serves to separate the photosensitive regions of the retina from the areas that transmit the electrical signals.
6. OUTER NUCLEAR LAYER: This layer consists of nuclei of rod and cone cells. This layer is darkly stained.
7. OUTER PLEXIFORM LAYER: This layer contains synaptic processes of rod and cone cells with bipolar neurons and horizontal cells. This layer stains lightly.
8. INNER NUCLEAR LAYER: This layer contains the cell body of glial, amacrine, bipolar, and horizontal cells
9. INNER PLEXIFORM LAYER: This layer relays information from cells of the inner nuclear layer. Thus, this layer has axons of amacrine, bipolar, and glial cells and dendrites of retinal ganglion cells.
10. GANGLION CELL LAYER: This layer contains nuclei of retinal ganglion cells.
11. NERVE FIBER LAYER: This layer contains axons of retinal ganglion cells and the astroglia which support them. Collectively, these axons constitute the optic nerve.
12. INTERNAL LIMITING MEMBRANE: A thin layer of Muller glial cells and basement membrane which demarcates the vitreous anteriorly from the retina posteriorly.

- 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.

- VIRTREOUS BODY: The vitreous body occupies the 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 composed of type IV collagen and other proteins of external laminae. The only cells in the vitreous body are a few macrophages and a small population of cells near the membrane called hyalocytes, which synthesize the hyaluronate and collagen.

 OVERALL FUNCTIONS OF THE EYES.

The layers of the eye perform distinct functions which coalesce to create a unified, perceptual experience. The essential role of the external eye structures is to protect the delicate tissue of the internal eye. The eyelid prevents foreign bodies from entering the inner eye and helps refresh and distribute the tear film by blinking. Eyelashes are finely sensitive to touch and warn the eye of possible debris and particles that may cause injury.

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.

1. CHALAZION: A sterile lump often in the upper eyelid caused by obstruction of the Meibomian oil glands.

2.CONJUCTIVITIS: Inflammation of the transparent conjunctiva that may be caused by bacterial or viral infections, allergies, or exposure to certain chemicals.

3. CATARACT: A sclerotic nuclear cataract is the most common and is due to opacification in the central nucleus of the lens. Cortical cataracts are due to opacifications in the cortex and have a distinct wedge-shaped appearance. Posterior sub capsular cataracts arise from behind the sac-like structure of the lens.

4.GLAUCOMA: Refers to optic nerve damage related to increased intraocular pressure. Drainage of aqueous humor through the trabecular meshwork is often implicated.

5.AGE-RELATED MACULAR DEGENERATION: 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.

6.FUSCH DYSTROPHY: 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.

7.FLOATERS: The sensation of floaters is due to changes that occur in the jelly-like vitreous layer of the eye.

8.RETINAL DETACHMENT: It 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.

2.Much remains unknown about the novel coronavirus, including whether it truly can be transmitted through your eyes. But it’s likely that it can be. The American Academy of Ophthalmology (AAO) says the virus is thought to spread mostly by person-to-person contact through respiratory droplets produced when an infected person coughs or sneezes. The World Health Organization (WHO) says it also can be transmitted through droplets of saliva or mucus from the nose. Infected droplets (or infected mucus) can end up in an uninfected person’s mouth or nose and potentially travel to the lungs, according to the U.S. Centers for Disease Control and Prevention (CDC). The AAO notes that these droplets might enter through your eyes, too. Mucous membranes throughout the body are the most susceptible areas for virus transmission. The novel coronavirus, which causes a respiratory disease called COVID-19, also might be spread if someone touches an object or surface (such as a doorknob or countertop) where the virus is present, and then touches their mouth, nose or eyes, according to the ophthalmology group. When it comes to transmission through the eyes, the American Optometric Association (AOA) indicates the coronavirus might enter your body through the conjunctiva and then spread throughout your body through blood vessels within the conjunctiva. The conjunctiva is the clear, thin membrane that covers part of the front of the eye as well as the inner part of the eyelids. Some evidence suggests conjunctivitis, which most of us know as pink eye, could be a symptom of COVID-19. However, this is said to be rare, with pink eye developing in an estimated 1% to 3% of people with coronavirus.

PENETRATION OF INFORMATION THROUGH THE LAYERS OF THE RETINA.

The retina is the innermost, light-sensitive layer of tissue of the eye. The optics of the eye create a focused two-dimensional image of the visual world on the retina, which translates that image into electrical neural impulses to the brain to create visual perception. The retina serves a function analogous to that of the film or image sensor in a camera.

The neural retina consists of several layers of neurons interconnected by synapses, and is supported by an outer layer of pigmented epithelial cells. The primary light-sensing cells in the retina are the photoreceptor cells, which are of two types: rods and cones. Rods function mainly in dim light and provide black-and-white vision. Cones function in well-lit conditions and are responsible for the perception of color, as well as high-acuity vision used for tasks such as reading. A third type of light-sensing cell, the photosensitive ganglion cell, is important for entrainment of circadian rhythms and reflexive responses such as the pupillary light reflex.

Light striking the retina initiates a cascade of chemical and electrical events that ultimately trigger nerve impulses that are sent to various visual centers of the brain through the fibers of the optic nerve. Neural signals from the rods and cones undergo processing by other neurons, whose output takes the form of action potentials in retinal ganglion cells whose axons form the optic nerve. Several important features of visual perception can be traced to the retinal encoding and processing of light. Light must pass through the overlying layers to reach the photoreceptor cells, which are of two types, rods and cones, that are differentiated structurally by their distinctive shapes and functionally by their sensitivity to different kinds of light. Rods predominate in nocturnal animals and are most sensitive to reduced light intensities; in humans they provide night vision and aid in visual orientation. Cones are more prominent in humans and those animals that are active during the day and provide detailed vision (as for reading) and color perception. In general, the more cones per unit area of retina, the finer the detail that can be discriminated by that area. Rods are fairly well distributed over the entire retina, but cones tend to concentrate at two sites: the fovea centralis, a pit at the rear of the retina, which contains no rods and has the densest concentration of cones in the eye, and the surrounding macula lutea, a circular patch of yellow-pigmented tissue about 5 to 6 mm (0.2 to 0.24 inch) in diameter.

When light enters the eye, it passes through the cornea and the lens and is refracted, focusing an image onto the retina. Light-sensitive molecules in the rods and cones react to specific wavelengths of light and trigger nerve impulses. Complex interconnections (synapses) between and within retinal cell layers assemble these impulses into a coherent pattern, which in turn is carried through the optic nerve to the visual centers of the brain, where they are further organized and interpreted.