17/MHS01/302

NEUROHIOSTOLOGY

12TH APRIL 2020

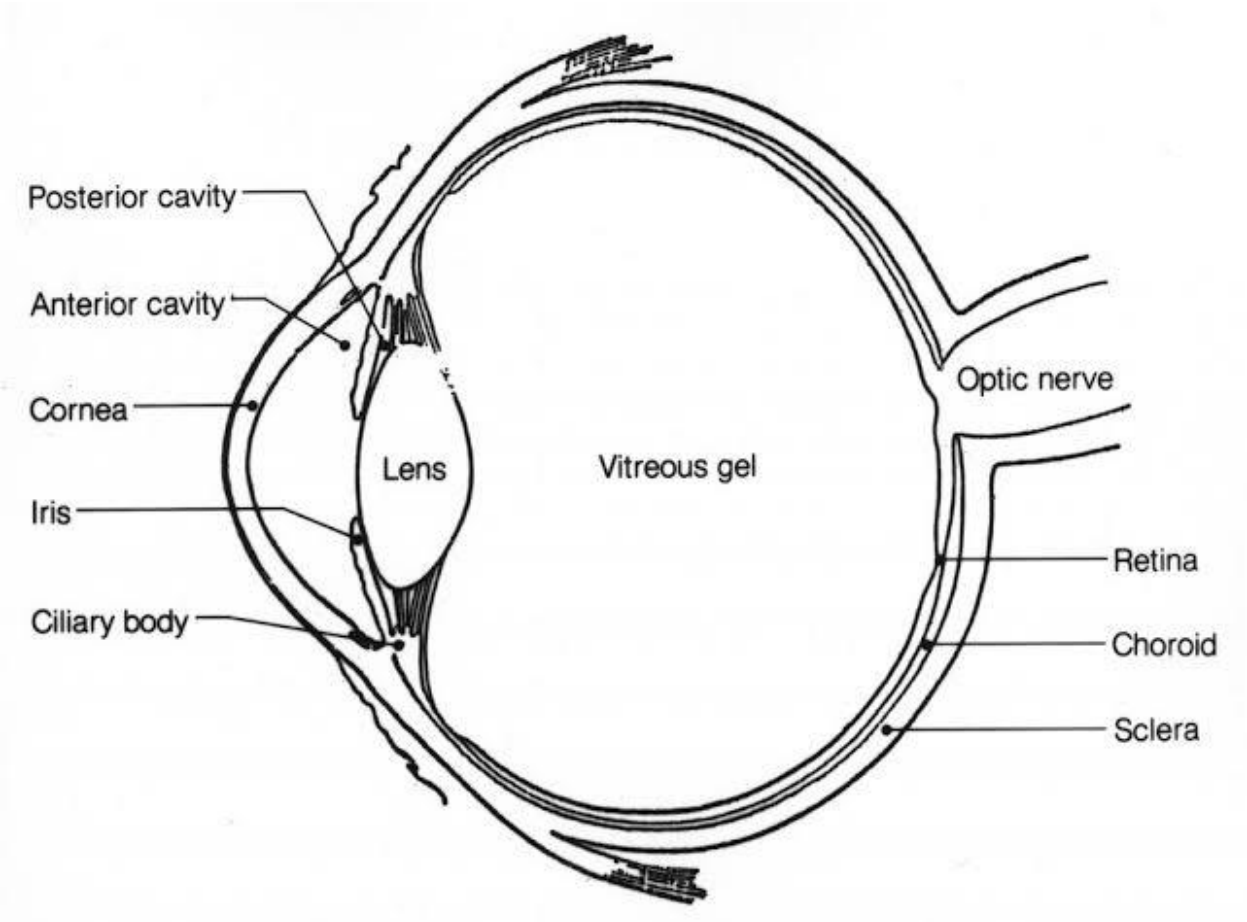
MEDICINE AND SURGERY

QUESTION 1

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

ANSWER

The eye constitutes the photoreceptor system. It is a complex and highly developed photosensitive organ that analyses the form, intensity and color of light reflected from objects, providing the sense of sight. The eyes are located in the protective areas of the skull, the orbits which also contains cushions of adipose tissue. Each eyeball includes a tough fibrous globe to maintain its shape, a system of transparent tissue that refracts light to focus an image, a layer of photosensitive cells and a system of neurons whose function is to collect, process and transmit visual information to the brain.



LAYERS OF THE EYE AND THEIR CELLULAR FUNCTIONS.

The structure of the mammalian eye has a lamina organization that can be divided into three main layers or *tunics* whose name reflects their basic function. These layers contain various cells which all function in this layers and this is referred to as their **cellular function.** The layers of the eye and the cellular functions include:

1. **FIBROUS LAYER**

   The fibrous tunic, also known as *tunica fibrosa oculi,* is the outer layer of the eye, consisting of;

   a. **SCLERA:** The fibrous external layer of the eyeball, the sclera, protects the more delicate internal structures and provides sites for muscle insertion. The sclera gives the eye most of its white color. It consist of tough, dense connective tissue filled with flat type I collagen bundles (protein collagen) to protect the inner components of the eye and maintain its shape. Posteriorly the sclera thickens to approximately 1mm and joins with the epineurium covering the optic nerve. A thinner inner region of the sclera, adjacent to the choroid, slightly less dense, with thinner collagen fibers, more fibroblasts, elastic fibers and melanocytes.

The sclera is made up of 3 divisions:

- Episclera; loose connective tissue, immediately beneath the conjunctiva
- Sclera proper; the dense white tissue that give the area its color
- Lamina fusca; the innermost zone, made up of elastic fibers.
- Endothelial layer.

Clinical significance: Yellowing of the sclera is a visual symptom of jaundice. In very rare but severe cases of kidney and liver failure, the sclera may turn black. In cases of osteogenesis imperfect, the sclera may appear to have a blue tint.

   b. **CORNEA:** The cornea is a colorless, transparent and completely avascular. The cornea consist of five layers;

      I. An external stratified squamous epithelium
      II. An anterior limiting membrane (Bowman's membrane, the basement membrane of the stratified epithelium)
      III. The stroma
      IV. Posterior limiting membrane (Descement's membrane, the basement membrane of the endothelium)
      V. An inner simple squamous endothelium.

The stratified surface epithelium is nonkeratinized, with five or six layers of cell, comprising about 10% of corneal thickness. Numerous mitotic figures are present in the basal layers, particularly the periphery of the cornea, reflecting the epithelium's high capacity for cell renewal and repair. The flattened surface cells have microvilli and folds protruding into a protective layer or tear film

of lipid, glycoprotein and water. As another protective adaptation, the corneal epithelium also has one of the richest sensory nerve supplies of any tissue. The basement membrane of this epithelium is very thick and contributes to the stability and strength of the cornea, helping to protect against infection of the underlying stroma.

The cornea of the eye is made up of 2 components

- Cellular component: includes; epithelial cells, keratocytes and endothelial cells
- Acellular component: includes; collagen and glycosaminoglycan.

Clinical significance:

1. **Corneal abrasion**: loss of the surface epithelial layer of the eye's cornea as a result of trauma to the surface of the eye.
2. **Corneal dystrophy**: a condition in which one or more parts of the cornea lose their normal clarity due to a buildup of cloudy material.
3. **Corneal neovascularization**: excessive ingrowth of blood vessels from the limbal vascular plexus into the cornea, caused by deprivation of oxygen from air.

2. VASCULAR LAYER

The vascular tunic, also known as *tunica vasculosa oculi* or the "uvea", is the middle vascularized layer which includes the **iris, cilliary body & choroid.**

a. **CHOROID:** The choroid is a highly vascular tunic, in the posterior two-thirds of the eye, with loose, well vascularized connective tissue rich in collagen, elastic fibers, fibroblasts, melanocytes, lymphocytes, mast cells and plasma cells. The choroid contains blood vessels that supply the retinal cells with oxygen and remove the waste products of respiration. The choroid gives the inner eye a dark color, which prevents disruptive reflections within the eye.

The structure of the choroid, is divided into 4 layers;

- Haller's layer- outermost layer of choroid consisting of larger blood vessels
- Sattler's layer- layer of medium diameter blood vessels
- Choriocapillaris- layer of capillaries
- Bruch's membrane.

b. **CILLIARY BODY:** The cilliary body is a part of the eye that includes the cilliary muscle, which controls the shape of the lens, and the cilliary epithelium, which produces the aqueous humor. The aqueous humor is produced in the non-pigmented portion of the cilliary body. The cilliary body is part of the uvea, the layer of tissue that delivers oxygen and nutrients to the eye tissues. The cilliary

body joins the *ora serrata* of the choroid to the root of the iris. The 3 main functions of the cilliary body include:

I. Accommodation
II. Aqueous humor production and resorption
III. Maintenance of the lens zonules for the purpose of anchoring the lens in place.

The zonular fibers collectively make up the suspensory ligament of the lens. These provide strong attachments between the cilliary muscle and the capsule of the lens.

c. **IRIS:** The iris is the most anterior extension of the uvea (middle layer) that partially covers the lens, leaving a round opening called the pupil. The iris is seen rather than the cornea when looking straight in one's eye due to the latter's transparency, the pupil is black because no light is reflected out of the interior eye. If an ophthalmoscope is used, one can see the fundus as well as vessels supplying additional blood flow to the retina especially those crossing the optic disk, the point where the optic nerve departs from the eyeballs.

LAYERS OF THE IRIS

1. **Stroma layer:** the stroma of the iris is a fibro vascular layer of tissue. The stroma connects to a sphincter muscle, which contracts the pupil in a circular motion and a set of dilator muscles, which pull the iris radially, to enlarge the pupil, pulling it in folds.
2. **Pigmented epithelium:** covers the back surface of the iris, and it is two cells thick.

3. NERVOUS LAYER

The nervous tunic also known as the *tunica nervosa oculi,* is the inner sensory layer which includes the retina.

RETINA: Contributing to vision, the retina contains the photosensitive rods and cone cells and associated neurons. To maximize vision and light absorption, the retina is a relatively smooth (but curved) layer. It has two points at which it is different;

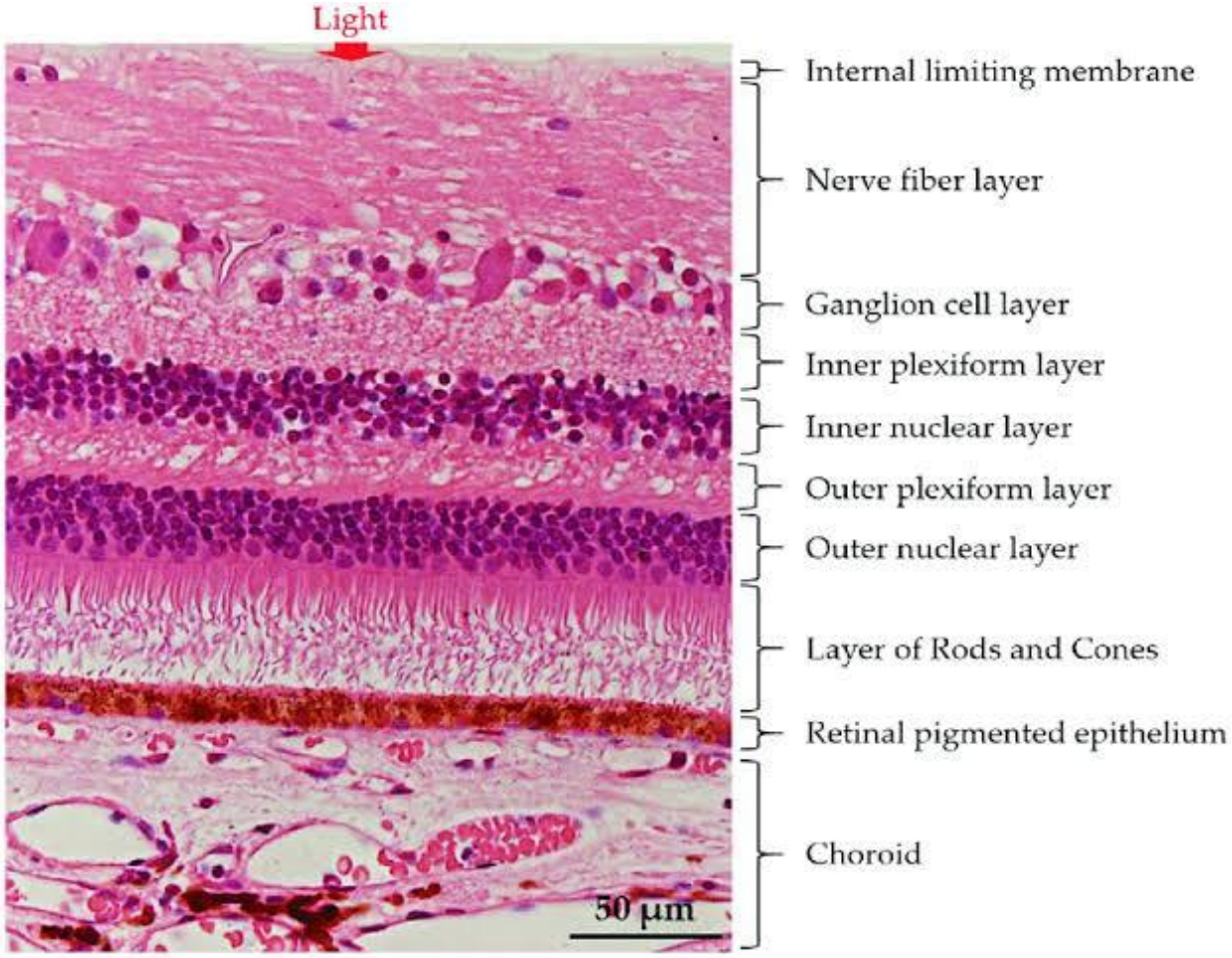
I. **Fovea:** The fovea is dip in the retina directly opposite the lens, which is densely packed with cone cells. It is largely responsible for color vision in humans and enables high acuity, such as is necessary in reading.

II. **Optic disc** : Sometimes referred to as anatomical blind spot, is a point on the retina where the optic nerve pierces the retina to connect to the nerve cells on its inside. No photosensitive cells exist at this point, it is thus blind. Continuous with the retina are the cilliary epithelium and the posterior epithelium of the iris.

In addition to the rods and cones a small portion of the ganglion cells in the retina are themselves photosensitive through a pigment ***melanopsin.***

RODS AND CONES OF THE RETINA

This are the two types of photoreceptor cells in the retina. The rods are responsible for vision at low levels (scotopic vision). They do not mediate color vision, and have a low spatial acuity, WHILE cones are active at higher light levels (photopic vision), are capable of color vision and are responsible for high spatial acuity. The light levels, where both are operational, is called “mesopic”.



QUESTION 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.

ANSWER

RETINA: The retina, is the innermost, light-sensitive layer of the eye. The neural retina consists of several layers of neurons interconnected by synapses, and is supported, by an outer layer of pigmented epithelial cells.

LAYERS OF THE RETINA

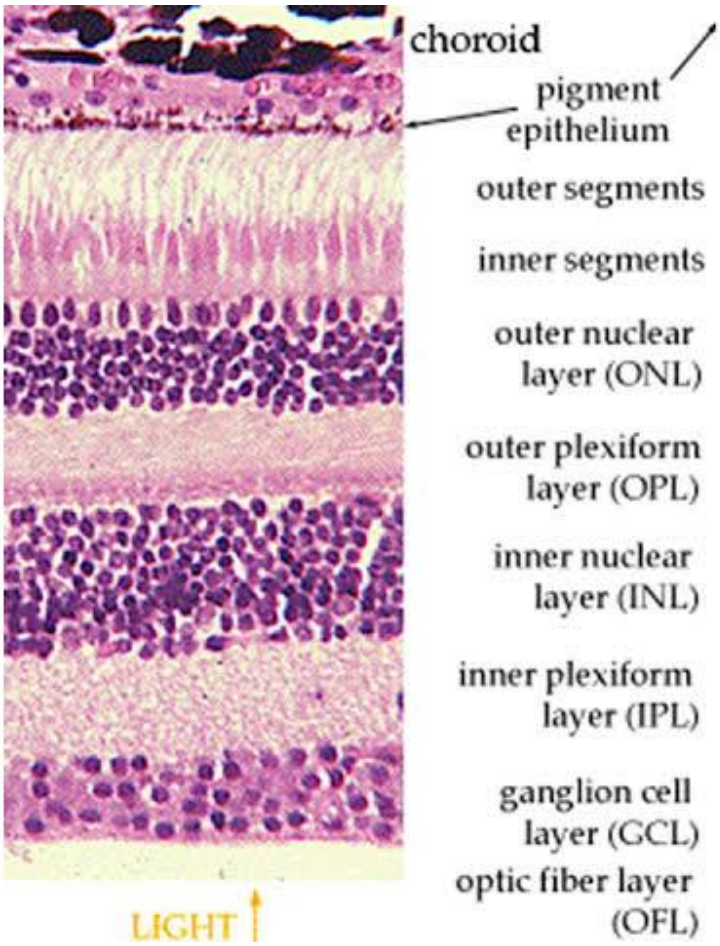
There are 3 main layers of the retina. They include:

1. **Outer nuclear layer:** This is one of the layers of the retina, the light detecting portion of the eye. The outer nuclear layer, contains several strata of oval nuclear bodies. They are of two kinds, rod and cone granules.
2. **Inner nuclear layer:** The inner nuclear layer of the retina consists of the cell bodies of horizontal cells, bipolar cells, amacrine cells, interplexiform neurons, Muller cells, and sometimes displaced ganglion cells. The retinal vasculature of the deep capillary network, is located in the inner nuclear layer.
3. **Ganglion cell layer**: This is a layer of the retina that consists of retinal ganglion cells and displaced amacrine cells. The cells are somewhat flask shaped; the rounded internal surface of each resting on the stratum opticum, and sending off an axon which is prolonged into it. The ganglion cells vary much in size, and the dendrites, of the smaller ones as a rule, arborize in the inner plexiform layer as soon as they enter it; while those of the larger cells ramify close to the inner nuclear layer.

OTHER LAYERS OF THE RETINA INCLUDE:

1. **Inner limiting membrane**: A thin layer of Muller glial cells (retinal glial cells) and basement membrane which separates the vitreous from the retina.
2. **Nerve fiber layer**: This layer contains axons of retinal ganglion cells and the astrocytes which support them. Collectively, these axons constitute the optic nerve. In the region where this nerve is found, there are no photoreceptors hence this region is referred to as the blind spot.
3. **Inner plexiform layer:** This layer contains the axons of amacrine, bipolar, glial and the dendrites of retinal ganglion cells. Amacrine cells are cells that connect bipolar cells with ganglion cells. The axons relay information to the cell bodies in the inner nuclear layer.
4. **Outer plexiform layer:** This layer contains the synaptic processes of rods and cones cells.

5. **<u>Outer limiting membrane</u>:** Rods and cones consists of synaptic terminal, cell body, inner segment and outer segment. The outer limiting membrane is a layer of Muller glial cells that separates the cell bodies from the inner segment of the rods and cones.
6. **<u>Photoreceptive (Bacillary) layer</u>:** This layer contains the inner and outer segments of the rods and cones. The inner and outer segments are connected to each other by cilium. The inner segment contains the abundant mitochondria while the outer segment contains the light absorbing materials.
7. **<u>Retinal pigmented epithelium</u>**: This is the most external layer of the retina. It is made up of a layer of simple cuboidal epithelial cells. This layer is closest to the choroid plexus and it provides nourishment and supportive functions to the neural retina. The melanin pigment in this layer prevents the reflection of light and this is very important for clear vision.



FUNCTION OF THE CELLS IN THE RETINA

The cells of the retina function in various purposes, and this cells, make up the layers of the retina. They include:

1. **Photoreceptors (rods and cones)**: The detection of light begins at the deepest cell layer in the retina, the photoreceptors, located in the outer nuclear layer. Rods are very light sensitive and are responsible for dim-light vision. Cones, on the other hand, are not very light sensitive but are specific to a particular wavelength of light. This cones are responsible for high acuity color vision.
2. **Bipolar cells**: Photoreceptors use neurotransmitters, glutamate, to communicate at the synapse with bipolar cells within the outer plexiform layer. At the inner plexiform layer, bipolar cells are responsible for transmitting an impulse to the retinal ganglion cells.
3. **Retinal ganglion cells**: these are the final receivers and transmitters of the initial stimulus. They send the information they receive down their axons, which eventually form the optic nerve and project to higher brain centers
4. **Amacrine cells**: amacrine cells modulate the excitation of the retinal ganglion cells, through contact with ganglion cell dendrites or bipolar cell axon terminal bulbs, using the neurotransmitter GABA and glycine.
5. **Horizontal cells**: these cells function to modulate the communication between photoreceptors and bipolar cells. Bipolar cells contact the ganglion and amacrine cells at the inner plexiform layer.
6. **Muller cells**: these are cells of glial origin and are essential for proper retinal function. They contact almost every cell type in the retina, spanning the entire width from the photoreceptors to the inner retina. They serve to recycle neurotransmitters, prevent glutamate toxicity and regulate nutrient homeostasis in the retina.

MEANS BY WHICH INFORMATION PENETRATION IN THE RETINA OCCURS

Photoreception: Photoreception is the mechanism of light detection by the eye through photoreceptive cells- rods and cones that lead to vision. The photoreceptive cells span through ***the outer plexiform, outer nuclear and photoreceptive layers***. The part of the photoreceptive cells that detect light is the outer segment. The light rays in the form of light stimuli passes through the layers of the retina to reach the outer segment of the rods and cones in the photoreceptive layer. These cells convert the light stimulus into electrical nerve impulse (action potential). They send the impulses to their synaptic ends in the outer plexiform layer.

Photo transduction: Rods and cones consist of synaptic terminal, cell body, inner segment and outer segment. The inner segment contains abundant mitochondria while the outer segment

contains the light absorbing materials. The outer segments are modified cilia that contain disks filled with opsins (protein molecules that absorb photons). In rods the opsins are called rhodopsin (opsins + retinal) while in cones they are called photopsin (different types of opsins + retinal). **Photo transduction** is the cascade of changes in the rods and cones triggered when light hits and activates chromosphere (retinal). This process is similar in both rods and cones.

Using rods for example, in the dark, rhodopsin is not active and cation channels are open by cyclic guanosine monophosphate (cGMP) allowing influx of cations which keeps the cell depolarized and leads to the release of the neurotransmitter; glutamate. When light is present, rhodopsin absorbs a photon of light. Retinal changes from 11-cis-retinal (original form) to all-trans retinal. This causes a conformational change in opsin, which in turn activates transducin. Transducin activates cGMP phosphodiesterase which breaks down cGMP. Reduction in the number of cGMP results in closure of the cation channels which in turn leads to hyperpolarization of the rods and reduction in the release of glutamate. Less glutamate in the synaptic cleft excites a set of bipolar neurons and the action potential stimulated in these bipolar neurons, is transmitted to the brain for interpretation. After activating transducin, all-trans-retinal dissociate from opsin and are transported to the pigmented epithelium where they are converted to 11-cis-retinal and transported back to the rods (this mechanism is known as **bleaching**). When the light is removed, Arrestin binds to rhodopsin and preventing it from activating transducin. This stops the cascade and soon cGMP level rises and opens up the cation channel thus returning the rods back to their depolarized state.

Transmission to Bipolar Cells: This process involves ***the inner nuclear layer and the inner plexiform layer***. The bipolar neurons found in these layers form synapses with the synaptic processes of the rods and cones in the outer plexiform layer. The electrical impulses generated are transferred through these synapses to the bipolar neurons. The impulses travel to the axons of the bipolar neurons and are transmitted to the ganglion cells.

Transmission to the Ganglion Cells: This process involves ***the ganglion cell and nerve fiber layers*** of the retina. The retinal ganglion cells are found in these layers and they form synapses with the bipolar neurons. Impulses from the bipolar neurons are transmitted to them.

Transmission along the Optic Nerve: The axonal fibers of the ganglion cells form the optic nerve which transmits the nerve impulse to the brain for interpretation. There are no photoreceptors present in the region of the retina where ganglion axon fibers feed into the optic nerve.