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Medicine and Surgery

ANA 305 : Histology of Special Senses and Neurohistology

Special Senses Assignment

**QUESTION 1**

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

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. They are protected within the orbits of the skull which also contain adipose cushions, each eyeball consists externally of a tough, fibrous globe that maintains its overall shape. Internally the eye contains transparent tissues that refract light to focus the image, a layer of photosensitive cells, and a system of neurons that collect, process, and transmit visual information to the brain.

Each eye ball is composed of three layers:

* A tough external fibrous layer consisting of the sclera and the transparent cornea.
* A middle vascular layer that includes the choroid, ciliary body, and iris
* An inner sensory layer, this includes, the lens, vitreous and retina.

**The External layer**

**Sclera**

The sclera is a fibrous, external layer of the eyeball that protects the more delicate internal structures and provides sites for muscle insertion, it makes up the white posterior five-sixths of the external layer with the remaining anterior one-fifth being the cornea, it encloses most of the eyeball. The sclera averages 0.5 mm in thickness and consists mainly of dense connective tissue, with flat bundles of type I collagen intersecting in various directions, these intersections give it it’s white appearance, however, the collagen of the sclera and cornea are continuous , microvasculature is present near the outer surface. Tendons of the extraocular muscles which move the eyes insert into the anterior region of the sclera. Posteriorly the sclera thickens to approximately 1 mm and joins with the epineurium covering the optic nerve. The four layers of the sclera from external to internal are episclera, stroma, lamina fusca, endothelium.

**Histological importance of the sclera**

The sclera supports the eye shape and protects the delicate internal structures of the eye, it is also acts as a site of attachment for the extrinsic muscles of the eye.

**Cornea**

In contrast to the sclera, the anterior one-sixth of the eye, the cornea, is transparent and completely avascular, this transparency is as a result of the parallel arrangement of the type I collagen fibers

A section of the cornea shows five distinct layers:

* An external stratified squamous epithelium. It is a fast growing, regenerating multicellular layer which interacts directly with the tear film.
* An anterior limiting membrane (Bowman’s membrane), which is the basement membrane of the external stratified epithelium. This layer also serves protecting the underlying stroma. It is composed of type 1 collagen, laminin, and several other heparan sulfate proteoglycans.
* A thick stroma also called substantia propria. 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.
* A posterior limiting membrane (Descemet’s membrane), which is an acellular layer basement membrane of the endothelium made of type IV collagen
* An inner simple squamous 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. When corneal endothelial cells are lost, neighboring cells stretch to attempt to compensate these losses.

**Histological importance of the cornea**

The cornea protects the anterior portion of the eye and refracts incoming light into the light

**Middle layer**

**Choroid**

Located in the posterior two-thirds of the eye, the choroid consists of loose, well-vascularized connective tissue and contains numerous melanocytes. These form a characteristic black layer in the choroid and prevent light from entering the eye except through the pupil. Two layers make up the choroid, these include:

* The inner choroido-capillary lamina has a rich microvasculature important for nutrition of the outer retinal layers.
* Bruch’s membrane, a thin extracellular sheet, is composed of collagen and elastic fibers surrounding the adjacent microvasculature and basal lamina of the retina’s pigmented layer.

**Histological importance of the choroid**

The choroid layer helps supply nourishment to the retina layer, it also contains pigments that absorb light. It is also has a significance in age-related macular degeneration, where an accumulation of lipid deposits prevents diffusion of nutrients to the retina.

**Ciliary Body**

The ciliary body is an anterior expansion of the uvea that encircles the lens, it lies posterior to the limbus. Like the choroid, most of the ciliary body rests on the sclera. Important structures associated with the ciliary body include the following:

* The Ciliary muscle, which makes up most of the ciliary body’s stroma and consists of three groups of smooth muscle fibers. Contraction of these muscles affects the shape of the lens and is important in visual accommodation.
* Ciliary processes, which are a radially arranged series of about 75 ridges extending from the inner highly vascular region of the ciliary body. These provide a large surface area covered by a double layer of low columnar epithelial cells, the ciliary epithelium. The epithelial cells directly covering the stroma contain much melanin and correspond to the anterior projection of the pigmented retina epithelium. The surface layer of cells lacks melanin and is contiguous with the sensory layer of the retina.
* The ciliary zonule is a system of many radially oriented fibers composed largely of fibrillin-1 and 2 produced by the nonpigmented epithelial cells on the ciliary processes. The fibers extend from grooves between the ciliary processes and attach to the surface of the lens, holding that structure in place.

**Histological importance of the ciliary body**

The ciliary body holds suspensory ligaments that attach to the lens and change lens shape for far and near vision. The ciliary epithelium produces aqueous humor which fills the anterior compartment of the eye.

**Iris**

The iris is the most anterior extension of the middle uveal layer which covers part of the lens, leaving a round central pupil. The anterior surface of the iris is exposed to aqueous humor in the anterior chamber and consists of a dense layer of fibroblasts and melanocytes with interdigitating processes and is unusual for its lack of an epithelial covering. Deeper in the iris, the stroma consists of loose connective tissue with melanocytes and sparse microvasculature. The posterior surface of the iris has a two-layered epithelium continuous with that covering the ciliary processes, but very heavily filled with melanin. The highly pigmented posterior epithelium of the iris blocks all light from entering the eye except that passing through the pupil. Myoepithelial cells form a partially pigmented epithelial layer and extend contractile processes radially as the very thin dilator pupillae muscle. Smooth muscle fibers form a circular bundle near the pupil as the sphincter pupillae muscle. The dilator and sphincter muscles of the iris have sympathetic and parasympathetic innervation, respectively, for enlarging and constricting the pupil.

**Histological importance of the iris**

The iris controls pupil dimeter and thus the amount of light entering the eye. 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.

**Internal layer**

**Lens**

The lens is a transparent biconvex structure suspended immediately behind the iris and is held in place by fiber called ciliary zonule, which focuses light on the retina. Derived from an invagination of the embryonic surface ectoderm, the lens is a unique avascular tissue and is highly elastic, a property that normally decreases with age. The lens has three principal components:

* A thick, homogeneous lens capsule composed of proteoglycans and type IV collagen surrounds the lens and provides the place of attachment for the fibers of the ciliary zonule. This layer originates as the basement membrane of the embryonic lens vesicle.
* A subcapsular lens epithelium consists of a single layer of cuboidal cells present only on the anterior surface of the lens. The epithelial cells attach basally to the surrounding lens capsule and their apical surfaces bind to the internal lens fibers. At the posterior edge of this epithelium, near the equator of the lens, the epithelial cells divide to provide new cells that differentiate as lens fibers. This process allows for growth of the lens and continues at a slow, decreasing rate near the equator of the lens throughout adult life.
* Lens fibers, these are highly elongated, terminally differentiated cells that appear as thin, flattened structures. Developing from cells in the lens epithelium, lens fibers typically become 7 to 10 mm long, with cross-section dimensions of about 2 by 8 μm. The cytoplasm becomes filled with a group of proteins called crystallins, and the organelles and nuclei undergo autophagy. Lens fibers are packed tightly together and form a perfectly transparent tissue highly specialized for light refraction.

**Histological significance of the lens**

The lens helps to refract light to be focused on the retina, the flexibility allows of the lens allows it to be easily manipulated by the ciliary muscles by changing its curvature to help focus the image.

**Vitreous body**

The vitreous body occupies the large vitreous chamber behind the lens. It consists of transparent, gel-like connective tissue that is 99% water (vitreous humor), with collagen fibrils and hyaluronate, contained within an external lamina called the vitreous membrane. The only cells in the vitreous body are a small mesenchymal population near the membrane called hyalocytes, which synthesize the hyaluronate and collagen, and a few macrophages.

**Histological importance of the Vitreous body**

it provides physical support, holding the retina in place.

**Retina**

The retina, the innermost tunic of the eye, develops with two fundamental sublayers from the inner and outer layers of embryonic optic cup.

The outer pigmented layer is a simple cuboidal epithelium attached to Bruch’s membrane and the choroidocapillary lamina of the choroid. This heavily pigmented layer forms the other part of the dual epithelium covering the ciliary body and posterior iris.

The inner retinal region, the neural layer, is thick and stratified with various neurons and photoreceptors. its neural structure and visual function extend anterior only as far as the ora serrata , this layer continues as part of the dual cuboidal epithelium that covers the surface of the ciliary body and posterioriris.

**Histological importance of the retina**

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

**Question 2**

**Corona virus can penetrate the body through the eye and implicate the immune system, briefly discuss the layers of retina for information penetration.**

The retina is the sensory membrane that lines the inner surface of the back of the eyeball. It's composed of several layers, including one that contains specialized cells called photoreceptors.

There are two types of photoreceptor cells in the human eye — rods and cones.

Rod photoreceptors detect motion, provide black-and-white vision and function well in low light. Cones are responsible for central vision and color vision and perform best in medium and bright light.

Rods are located throughout the retina; cones are concentrated in a small central area of the retina called the macula. At the center of the macula is a small depression called the fovea. The fovea contains only cone photoreceptors and is the point in the retina responsible for maximum visual acuity and color vision.

Six major cell types form the various layers within the human retina:

* Photoreceptors (rods and cones): form the outer nuclear layer and synapse with bipolar cells at the outer plexiform layer, Rods deal predominantly with peripheral and night vision, Cones deal mainly with central vision
* Bipolar cells - make up the inner nuclear layer : Synapse with amacrine cells and ganglion cells at the inner plexiform layer
* Amacrine cells : Inhibitory cells which interact with bipolar cells and retinal ganglion cells
* Retinal ganglion cells - form the ganglion cell layer (innermost layer, furthest from the photoreceptors) : Axons tract towards the back of the eye and form the optic nerve
* Horizontal cells : Assist in operations such as contrast enhancement and preservation of spatial information.
* Muller cells: glial cells which support metabolism and homeostasis of the retina

The retina has ten distinct layers. From closest to farthest from the vitreous body:

* Inner limiting membrane: basement membrane elaborated by Müller cells.
* Nerve fibre layer: axons of the ganglion cell bodies, note that a thin layer of Müller cell footplates exists between this layer and the inner limiting membrane.
* Ganglion cell layer: contains nuclei of ganglion cells, the axons of which become the optic nerve fibres, and some displaced amacrine cells.
* Inner plexiform layer: contains the synapse between the bipolar cell axons and the dendrites of the ganglion and amacrine cells.
* Inner nuclear layer: contains the nuclei and surrounding cell bodies (perikarya) of the amacrine cells, bipolar cells, and horizontal cells.
* Outer plexiform layer: projections of rods and cones ending in the rod spherule and cone pedicle, respectively. These make synapses with dendrites of bipolar cells and horizontal cells. In the macular region, this is known as the Fiber layer of Henle.
* Outer nuclear layer: cell bodies of rods and cones.
* External limiting membrane: layer that separates the inner segment portions of the photoreceptors from their cell nuclei.
* Inner segment / outer segment layer: inner segments and outer segments of rods and cones. The outer segments contain a highly specialized light-sensing apparatus.
* Retinal pigment epithelium: single layer of cuboidal epithelial cells. This layer is 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.

These layers can be grouped into 4 main processing stages:

* Photoreception
* Transmission to bipolar cell
* Transmission to ganglion cells, which also contain photoreceptors, the photosensitive ganglion cells
* Transmission along the optic nerve. At each synaptic stage there are also laterally connecting horizontal and amacrine cells.