EYE

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It is a complex and highly developed photosensitive organ. It is located in a protective boney structure in the skull; the orbit.

Each eye is composed of three concentric layers:

1-External layer: the fibrous coat; Sclera, and Cornea.

2-Middle layer: the vascular or uveal tract or tunica vasculosa; Choroid, Ciliary body and Iris.

3-Inner layer: the nervous coat; Retina.
The eye contains three compartments:

**Anterior chamber:** located between the cornea, and the iris and lens.

**Posterior chamber:** located between the iris, ciliary processes, zonular attachments, and the lens.

**Vitreous space:** located behind the lens, and zonular attachments. It is surrounded by the retina.

Anterior and posterior chambers contain protein poor fluid; the **aqueous humor**, while the vitreous space contains gelatinous substance; **vitreous body**.
THE EXTERNAL LAYER

Sclera

It is the opaque white posterior 5/6 of the external layer of the eye, forming a segment of sphere of 22 mm in diameter. It consists of tough dense connective tissue, mainly of flat collagen bundles that run in various directions, with moderate amount of ground substance, and few fibroblasts. The external surface of the sclera is called episclera, which consists of loose thin collagen fibers.
Episclera is surrounded by dense C.T layer called **Tenon's capsule.** Between the capsule and sclera is **Tenon's space,** which allows the rotating movement of the eye ball in all directions. At the point of exit of the optic nerve the sclera is reduced and form a fenestrated **lamina cribrosa**. This area is a weak point in the wall of eye ball, and any increase in the intra ocular pressure (glaucoma) will cause bulging of sclera outside.
Cornea

It represents the colorless, transparent, anterior 1/6 of the eye ball. It consists of five layers:

1- **Epithelial layer**: stratified seq. non keratinized epith. of 5-6 cell layers. These cells have great power of regeneration, with a turn over time of 7 days. The surface cells show microvilli that protrude into a space filled by the pre corneal tear film; a protective layer of lipid and glycoprotein.

2- **Bowman's membrane**: thick, homogenous layer of 7-12 um thickness, consists of collagen fibers that run in different directions, with no cells. It is important in stability and strength of the cornea.
3- **Stroma**: formed by many layers of parallel collagen bundles that cross at right angles to each other. Between these fibers are the fibroblasts with their flat cytoplasmic extension. Both cells and fibers are immersed in amorphous glycoprotein substance. Stroma is avascular.

4- **Descemet's membrane**: thick, homogenous layer, of 5-10 um thickness, composed of fine collagen filaments, arranged in 3 dimensional network.

5- **Endothelium**: simple seq. epith., specialized for active transport and protein synthesis, to maintain Descemets membrane.
Limbus:
It is the corneo-scleral junction, where transition from the transparent collagen fibers of cornea to the white, opaque fibers of the sclera. It is highly vascularized. At the limbus, in the stromal layer, there are an irregular endothelial lined channels in a form of trabecular meshwork, merge to form the **Canal of Schlem**, which drains fluid from anterior chamber of the eye. It communicates externally with the venous system.
THE MIDDLE LAYER
CHOROID
Highly vascularised coat, consists of blood vessels, loose connective tissue rich in fibroblasts, macrophage, lymphocytes, masts cells, collagen and elastic fibers. It is rich in melanocytes, which give it the black color.
The choroid consists of three layers:

1- **Suprachoroidal membrane**: it is the superficial layer, consists of loose C.T., which binds the choroid to the sclera. It is rich in melanocytes.

2- **Choriocapillary layer**: the intermediate layer, highly vascular, contains large blood vessels, and extensive capillary network which is important for the nutrition of retina. Between blood vessels, there is C.T., and pigment cells.

3- **Bruch's membrane**: (lamina vitrea): the inner most layer, consists of thin hyaline membrane, of 1-4 um thick, composed of central elastic fibers, covered on both sides by collagen fibers, and the basal lamina of choriocapillary layer on one side, and the basal lamina of the pigment epith. Of the retina on the other side.
CILIARY BODY
It is the anterior expansion of the choroid at the level of the lens, at the inner surface of the anterior portion of the sclera. In transverse section, ciliary body forms a triangle. One face is in contact with the vitreous, the other with the sclera, and the third with the lens and posterior chamber of the eye.
Histologically, it consists of loose C.T. rich in elastic fibers, blood vessels, and melanocytes. Within this tissue, there are the ciliary muscles, which are composed of two bundles of smooth muscle fibers that inserted on the sclera anteriorly, and on different regions of the ciliary body posteriorly. These muscles are important in visual accommodation. The surface of ciliary body that faces the vitreous., posterior chamber, and lens is covered by the anterior extension of the retina. In this region, the retina consists only of two cell layers; the pigment epith. of the retina (simple columnar rich in melanin), and the non pigment epith. of the retina (simple columnar sensory epith.).
CILIARY PROCESSES

Ridge like extensions of the ciliary body, consist of a loose C.T. core, with numerous fenestrated capillaries. From the ciliary processes emerge the zonule fibers, that insert into the capsule of the lens and anchor it in place. Ciliary processes are covered by the same double epith. layer of the ciliary body, where the apical ends of these cells meet head to head, and joined together by desmosomes and tight junctions. The non pigment epith. has basal foldings and interdigitations characteristic of ion transport. These cells actively transport certain constituents of plasma into the posterior chamber, forming the aqueous humor.
This fluid flows toward the lens and passes between it and the iris, reaching the anterior chamber of the eye, then to the angle between the cornea and basal part of the iris. Then it penetrates the tissue of the limbus in a series of labyrinthine spaces, finally reaching the Canal of Schlem, which communicates with the venous system of the sclera. Any impediment (blockage) to the drainage of aqueous humor caused by an obstruction in the outflow channels results in an increase of the intraocular pressure, causing glaucoma.
IRIS

It is an extension of the choroid, which partially covers the lens, leaving a round opening in the center called **the pupil**.

**Histology:**

1-Anterior surface: is covered by simple seq.epith. which is continuous with the posterior covering of the cornea.

2-Middle layer: of fine C.T, which is highly vascular and rich in pigment cells.
Posterior surface: is covered by the double epithelium layer which is continuous with that of the ciliary body and processes (derived from retina). It contains melanin pigment. The outer cell layer contains the myofilaments of the dilator pupillae muscle. The iris also contains another smooth muscle-bundles, which are concentric with the pupillary margins, forming the sphincter pupillae muscle.
The melanocytes of the stroma of the iris are responsible for the color of the eye. If the layer is thin with little pigment, the light reflected from black pigment epithelium present in the posterior surface of the iris will be blue. When pigment increase, the iris will give greenish-blue shades, finally brown. Albinos has no pigment in their iris, so it will appear pink due to the reflection of blood vessels of the iris.
THE INNER LAYER

Retina

It lines the eye ball, ending at the margin of the pupil, where the inner surface faces the vitreous, while the outer one faces the choroid. Its nervous element extends only as far as the posterior limit of the ciliary body (ora serata). The extension forward
being entirely non nervous. In living eye, the retina appears red in color by ophthalmoscope, due to reflection from blood vessels in the choroid. The retina consists of the following layers:

**1-pigment epithelial layer:** consists of columnar cells with basal nuclei. The basal portion adheres firmly to Bruch's membrane. The basal cell membrane has many invaginations, with numerous mitochondria, suggesting an ion transport activity. Cell apex has abundant extensions to the next layer. The cytoplasm is rich in S.E.R., melanin granules, at the apical cytoplasm, with microvilli.
2-Photoreceptor layer of Rods and Cones: the name is according to their shape, with their long axis is perpendicular to the plane of the retina. Rod cells are more in number than cones, and they are found more at the periphery of the retina, and they are important for peripheral vision, and vision at low light intensity. Cone cells are specialized for color vision, and fine details. This layer can be divided into an outer segment, inner segment, nuclear region, and a synaptic region.
Rod cell is thin, elongated (50x3um), composed of two portions; an external photosensitive rod shaped portion that composed of 600-1000 flattened membranous disks. These disks appear as parallel lamellae of 2um diameter, and not continuous with the plasma membrane, and they are oriented at right angles to the long axis of the cell. They contain the photopigment Rhodopsin, or visual purple. The inner segment is separated from the outer one by a constriction or neck, below which there is a basal body and a cilium arise and pass to the outer segment. The inner segment is rich in glycogen and mitochondria, for the production of energy necessary for the visual process. Rod cells are extremely sensitive to light.
Cone cell is elongated (60x1.5 um), its structure is similar to that of Rod cell, except for its conical shape, and the structure of its outer segment, where the membranous disks arise as an invaginations of the plasma membrane. These disks contain the photopigment iodopsin.

3-External limiting membrane: consists of lateral processes of the glial cells (Muller's cells). The fibers of these cells contact the bases of Rod and Cone cells, and form a series of desmosomal junctions which appear as dense line by L.M.
4-External nuclear layer: consists of nuclei of Rods and cones.

5-External plexiform layer: where the synapses between fibers of Rods and Cones, and the dendrites of bipolar neurons, and horizontal cells.

6-Internal nuclear layer: consists of nuclei of bipolar cells, which are of two types:

Diffuse bipolar neuron: has synapse with two or more photoreceptors.

Monosynaptic neuron: synapse with only one cone cell and one ganglion cell.
This layer contains also nuclei of horizontal cells, Amacrine cells, and Muller cells.

7-Internal plexiform layer: where the synapses between the bipolar neurons and ganglion cells, and amacrine cells.

8-Ganglion cell layer: It consists of single row of typical nerve cells, with large euchromatic nucleus. Their axons will form the optic nerve, which exits from, the retina at the blind spot, which is devoid of receptors.

9-Nerve fiber layer: consists of the' axons of ganglion cells(optic nerve).

10-Internal limiting membrane: represents a basal lamina upon which the radial glial fibers ramify.
Muller cells: they contain abundant microfilaments, and glycogen in their cytoplasm. Their processes bind together the neural cells of the retina and extend from the inner to the outer limiting membranes.

Horizontal cells: of unknown function, found in contact with different photoreceptors. May act to integrate stimuli.

Amacrine cells: of unknown function, found in contact with ganglion cells.

Macula: a yellow pigmented area, of 1.5mm diameter, rich in ganglion cells and bipolar cells, with less number of Rod cells.

Fovea: contains only Cone cells, and the retina is thin this area. Both macula and fovea are modified for acuteness of vision.
CONJUNCTIVA

Transparent, thin mucous membrane that covers the anterior part of the eye (bulbar conj.), and extends up to the cornea and the internal surface of the eye lid (palpebral conj.) It consists of stratified columnar epith. with goblet cells, of 4-5 cell thickness. Bellow this is a lamina propria of loose C.T.
VITREOUS BODY

Occupies the bulk of the posterior part of the eye ball, behind the lens. It appears as a transparent gel. consists of water (99%), a small amount of collagen, and heavily hydrated hyaluronic acid molecules. It has few cells.
LENS
A biconvex structure characterized by great elasticity which is lost with age. It consists of three components:

1- Lens capsule: thick, homogenous, reflectile, carbohydrate rich capsule. It consists of collagen, and glycoprotein.

Sub capsular epith.: single layer of cuboidal epith. at the anterior surface of the lens. These cells are responsible for the formation of lens fibers, where they have many interdigitations.

Lens libers: elongated, thin, flattened, highly differentiated cells, that derived
from cells of lens sub capsular cells. These fibers loose their nuclei, and filled with a group of protein called crystalline. Lens is held in place by a radially oriented group of fibers, the zonule, that insert on one side on the lens capsule, and on the other on the ciliary body. Zonule fibers are elastic, and are important in the process of accommodation.
EYE LIDS

Movable folds of tissue that protect the eye. They are covered by loose and elastic skin. There are three types of glands in the lid:

1- **Meibomian gland**: lone, sebaceous glands in the tarsal plate. They produce sebaceous substance forming an oily layer on the surface of the tear film, preventing rapid evaporation of the normal tear layer.

2- **Glands of Zeis**: smaller, modified sebaceous glands connected with the follicles of eye lashes.

3- **Swat gland of Moll**: unbranched sinuoseous tubules that empty their secretion into the follicles of the eye lashes.
LACRIMAL APPARATUS

Lacrimal glands: tear secreting glands, located in the anterior superior temporal portion of the orbit. They are tubuloalveolar glands whose ducts are connected to the glands of the superior conjunctival fornix. The acinus is lined by simple columnar epith., of the serous type.

Lacrimal canalicule: drain the lacrimal secretion throw lacrimal puncta, which are round opening of 0.5mm diameter on the medial aspect of both upper and lower lid margins. It is lined by thick stratified seq. epith. Lacrimal sac: the dilated portion of the lacrimal drainage, lies in the boney lacrimal fossa.
Cornea. The anterior structure of the eye, the cornea has five layers. (a): The micrograph shows the external stratified squamous epithelium (E), which is nonkeratinized and five or six cells thick. It is densely supplied with sensory free nerve endings that trigger the blinking reflex and its surface is covered with a tear film produced by glands in the eyelids and superior orbit. The stroma (S) comprises approximately 90% of the cornea’s thickness, consisting of some 60 layers of long type I collagen fibers arranged in a precise orthogonal array and alternating with flattened cells called keratocytes. The stroma is lined internally by endothelium (EN). X100. H&E. (b): The corneal epithelium rests firmly on the thick homogeneous Bowman’s membrane (arrow). The stroma is completely avascular and nutrients reach the keratocytes and epithelial cells by diffusion from the surrounding limbus and aqueous humor behind the cornea. X400. H&E. (c): The posterior surface of the cornea is covered by simple squamous epithelium (endothelium) that rests on another thick, strong layer of collagen and other extracellular material called Descemet’s membrane (arrow). Na/K ATPase of the endothelial cells is responsible for pumping Na+ and drawing water out of the cornea, maintaining its proper state of hydration. In this state the cornea is perfectly transparent and with its curvature is a major refractive structure of the eye. X400. H&E.
Sclera, choroid, and retina. This section of the wall of an eye shows the dense connective tissue of the sclera (S) and the loose, vascular connective tissue of the choroid (C). Melanocytes are prominent in the choroid, especially in its outer region, the suprachoroidal lamina (SCL). The choroid’s inner region, the choroidocapillary lamina (CCL), has a rich microvasculature which helps provide O2 and nutrients to the adjacent retina. Between the choroid and the retina is a thin layer of extracellular material known as Bruch’s layer (B). The outer layer of the retina is the pigmented layer (P) of cuboidal epithelium containing melanin. Adjacent to this are the packed photoreceptor components of the rods and cones (R&C), the cell bodies of which make up the outer nuclear layer (ONL). Junctional complexes between these cells are aligned and can be seen as a thin line called the outer limiting layer (OLL). Axons of the rods and cones extend into the outer plexiform layer (OPL) forming synapses there with dendrites of the neurons in the inner nuclear layer (INL). These neurons send axons into the inner plexiform layer (IPL), where they synapse with dendrites of cells in the ganglionic layer (GL). Axons from these cells fill most of the nerve fiber layer (NFL) which is separated by the inner limiting layer (ILL) from the gelatin—like connective tissue of the vitreous body (VB). X200. H&E.
External plexiform layer. Synapses with bipolar cells.

Metabolic region. Protein and phospholipid synthesis plus ATP production.

Photosensitive region. Generation of the receptor potential.
Eyelid. (a): The eyelid is a pliable tissue with skin (S) covering its external surface and smooth conjunctiva (C) lining its inner surface. At the outer rim of the eyelid are a series of large hair follicles (F) for the eyelashes. Associated with these hair follicles are small sebaceous glands and modified apocrine sweat glands. Internally eyelids contain fascicles of striated muscle (M) comprising the orbicularis oculi muscle and closer to the conjunctiva a thick plate of fibroelastic connective tissue called the tarsus (T). This tarsal plate provides structural support for the eyelid and surrounds a series of large sebaceous glands, the tarsal glands (TG) (aka Meibomian glands), with acini secreting into long central ducts (D) that empty at the free edge of the eyelids. X12.5. H&E. (b): At higher magnification, only the inner aspect of the eyelid is seen and it shows that the conjunctiva is a mucous membrane consisting of a stratified columnar epithelium with small cells resembling goblet cells and resting on a thin lamina propria (LP). Large cells undergoing typical holocrine secretion are shown in the tarsal gland acini (TG), and the fibrous connective tissue in the tarsus (T) surrounding the acini. Sebum from these glands is added to the tear film and helps lubricate the ocular surface. X200. H&E.