

Chapter 20

Special Senses (Eye)

20.1. General Structural Observations

The eye is a spherical structure located within the orbit of the skull. The eye is held in place in the orbit by ligaments. The orbit is lined by the periosteum. There are six Extrinsic Ocular Muscles for each eye which afford the eye a wide degree of mobility. These extrinsic muscles are skeletal muscles. The orbit also contains the Lacrimal Glands. The lacrimal gland is a serous gland which produces the lubricant for the eye. The orbit has nerves, blood vessels, lymph vessels, and a cushioning pad of adipose tissue.

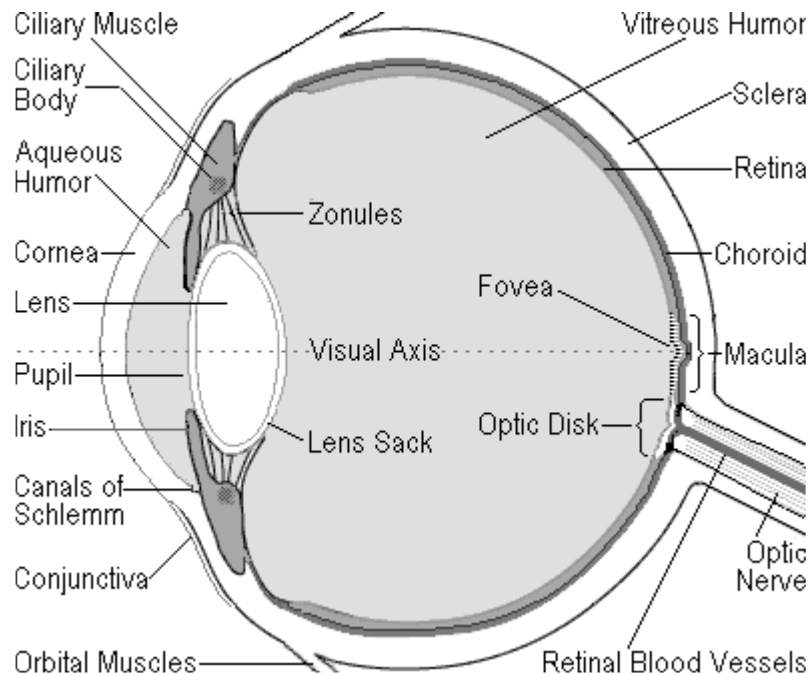


Fig.20.1. The structure of the Eye

b) The eye has a number of accessory structures such as the eyelashes, eyebrows, and palpebrae. The eyeball itself is light proof except for the anterior portion which is the transparent Cornea. Light will pass through the cornea, through the pupil, and be focused by the lens on to the retina. The anterior portion of the eye is covered by a superficial structure called the Conjunctiva. The conjunctiva is an epithelial tissue which covers the outer coat of the eye at it's exposed portions. The conjunctiva is reflected back off of the eye and forward.

a) The Ocular/Bulbar Conjunctiva covers the exposed portions of the eye, except for the cornea.

b) The Palpebral Conjunctiva covers the inner aspect of the eyelid. The conjunctiva is a transparent, stratified squamous epithelium.

The eyeball contains two cavities:

1) Anterior Cavity - the cavity located between the cornea and the iris. It is divided

into two portions. [1] Anterior Chamber is located between the cornea and the lens. [2] Posterior Chamber is located between the lens and the iris. The anterior cavity contains an viscous fluid called Aqueous Humor. Aqueous humor is a plasma filtrate produced by the capillaries of the ciliary body. It is drained by a series of venous sinuses called the Canal of Schlemm. The canal of Schlemm is drained by the ciliary vein.

2) Posterior Cavity - the cavity located posterior to the iris. It is also called the Vitreous Body. The posterior cavity forms the bulk of the eye's inner space. The posterior cavity contains the Vitreous Humor. Vitreous humor is a transparent, jelly-like connective tissue made up of a very few collagen fibrils embedded in a matrix of hyaluronic acid. Vitreous humor serves a number of purposes: {a} It refracts light. {b} It pads/cushions the retina. {c} It protects the retina. {d} It helps the eyeball to maintain its shape under conformational stress from the extrinsic ocular muscles.

The lens of the eye serves to focus light on to the retina. It is of epithelial origin. The lens is biconcave in shape so as to better focus incoming light. The lens is composed of three parts:

[a] Capsule - a tough, elastic basement membrane of the lens epithelium. It forms the outer layer and envelopes the entire retina.

[b] Anterior Epithelium - is the epithelial component of the lens and will produce the innermost portion, the lens substance. Immediately below the capsule the epithelium is a low cuboidal but cell height increases as you move deeper into the lens and eventually becomes columnar towards the equator.

[c] Lens Substance - is mostly composed of fibers, called Lens Fibers, produced by the anterior epithelium. These fibers are flexible and allow for accommodation. The eyeball has three tunics: (1) Tunica fibrosa or the corneoscleral layer (2) Tunica vasculosa or the uvea, (3) Tunica interna or the nervous tunic.

20.2. The Tunica Fibrosa

The tunica fibrosa is the tough outer tunic of the eye. It is composed of the sclera, cornea, and an intermediate zone between the two called the limbus.

20.2.1. The Sclera

The sclera forms the bulk of the fibrous tunic covering the posterior four fifths of the eye. It is a dense, regular fibrous connective tissue. It has many bundles of collagen fibers running along the long axis of the eye. The exposed anterior portion is covered by the bulbar conjunctiva. The sclera has two basic functions: It serves as the point of insertion for the extrinsic ocular muscles. It helps the eye to maintain its rigid shape.

20.2.2. The Cornea

The cornea is an avascular, transparent window forming the anterior one fifth of the eyeball. The cornea is continuous with the sclera. The cornea has five layers: The outermost layer is a layer of stratified squamous, nonkeratinized, epithelium. Deep to that is Bowman's Membrane. Bowman's membrane is an acellular, densely packed layer of fine collagen fibrils. The third layer is called the Stroma and represents 90% of the thickness of the cornea. It is composed of several layers of collagen fibrils embedded in a ground substance. The ground substance will contain chondroitin sulfate and keratin sulfate. The fourth layer is called Descemet's Membrane. Descemet's membrane is an acellular collagenous layer having a small elastic fiber component. The fifth and innermost layer is called an Endothelium although it is composed of a simple cuboidal

epithelium.

20.2.3. The Limbus

The limbus represents the zone of transition between the sclera and cornea.

20.3. The Tunica Vasculosa or Uvea

The uvea is the middle tunic. The vascular tunic has three continuous structures: the choroid, the ciliary body, and the iris. These structures function both to exclude light and to form a nutrient layer housing blood vessels.

20.3.1. The Choroid

The choroid is an extremely vascular deeply pigmented layer lining the posterior eye (beneath the sclera) from the optic disc to the ora serrata. The choroid is made up of two components.

a] **Pigmented Epithelium** - a simple cuboidal epithelium having heavily pigmented cells. These cells are immediately abutting, and even slightly interdigitate with, the photoreceptor cells of the tunica interna. They protect the photoreceptor cells from excessive exposure to light. The pigmented epithelial cells sit on a basement membrane called Bruch's Membrane.

b] **Choroid Proper** - a heavily vascularized loose connective tissue rich in pigment cells called Melanophores.

20.3.1. The Ciliary Body

The ciliary body is an intermediary structure between the choroid and iris. It is composed of epithelium, connective tissue, and smooth muscle. The epithelium, called Ciliary Epithelium, is a cuboidal epithelium. It has two portions: the Pars Plicata and the Pars Plana. The Ciliary Connective Tissue is a highly vascular loose connective tissue. The capillaries produce the aqueous humor. The smooth muscle component makes up the Ciliary Muscles. The ciliary muscles are three layers of smooth muscle that allow for accommodation. They are attached to the lens by means of the Suspensory Ligaments.

20.3.2. The Iris

The iris is the most anterior portion of the uvea. The iris is a pigmented disc of loose connective tissue covered anteriorly by epithelium. The epithelium is stratified being composed of two layers of cuboidal cells. The iris also contains a central opening called the Pupil that allows light to pass to the lens. The iris will contain two sets of smooth muscle that will control the size of the pupil and so control the amount of light entering the eye.

1] Dilator Pupillae is a radially arranged smooth muscle under sympathetic control.

2] Constrictor Pupillae is a circularly arranged smooth muscle under parasympathetic control.

20.4. The Tunica Interna or Tunica Nervosa

The tunica nervosa is the nervous component of the eye, the Retina. It develops as an outgrowth of the brain. The retina lines the choroid and terminates anteriorly at the ora serrata. The retina is a three layered structure:

20.4.1. The Photoreceptor Layer - is the outermost layer and is in contact with the choroid. It consists primarily of two cell types designed to respond photic stimuli.

The two cell types are:

a} Cones - conical shaped cells which need high levels of light to respond. They allow for color vision.

b} Rods - rod shaped cells which need only low levels of light to respond. They allow for black and white vision as well as vision in dim light conditions. The photoreceptor has three basic portions:

i} The Outer Segment is the portion facing the pigmented epithelium. It contains the photopigments. The photopigment is held in hundreds of membranous discs running the length of the outer segment. These discs develop from the cell membrane. The outer segment is conical in cones and rod-like in rods.

ii} The Connecting Stalks are narrow structures attaching the outer segment to the inner segment.

iii} The Inner Segment/Cell Body is the portion furthest from the choroid. It has an axonal process that extends to the next cell layer.

c} Topography - The topography of the retina has two prominent features:

1] Macula Lutea (the "yellow spot") is a circular, yellowish region on the retina. It contains the Fovea/Area Centralis at its center. The fovea is a pit containing only cones. It is the main region for vision.

2] Optic Disc (the "blind spot") is an area lacking photoreceptors where the optic nerve is exiting the retina.

20.4.2. The Bipolar Cell Layer

The bipolar cell layer consists of three primary cell types: Bipolar Cells, Horizontal Cells, and Muellarian Cells. The bipolar cell layer is designed to support the photoreceptors and to conduct the impulse towards the brain. Bipolar cells connect with the axon-like process of the photoreceptor cells. The connection between rods and bipolar cells and between cones and bipolar cells show two patterns: {a} low convergence (typically 1:1) for cones and bipolar cells, {b} and high convergence (15:1 for example) for rods and bipolar cells.

20.4.3. The Ganglion cell Layer

The ganglion cell layer is the innermost layer and is in contact with the vitreous humor. The ganglion cell layer has the lowest cell population (the photoreceptor layer has the highest) due to convergence. Usually several bipolar cells will synapse with one ganglion cell. The axons of the ganglion cells exit the eye at the optic disc and form the optic nerve.