HUMAN ANATOMY AND PHYSIOLOGY 1(BP101T)

UNIT: 4 SPECIAL SENSES

CLASS: 5

TOPIC: STRUCTURE AND FUNCTIONS OF EYE AND ITS DISORDERS

INTRODUCTION

The body has an innate ability to sense change in its internal and external environment, which enables it to maintain a state of homeostasis and continued survival. Special sense organs are characterised by large and complex organs, each with a unique function. Sensory organs have special receptors that allow us to smell, taste, see, hear and maintain equilibrium or balance. Information conveyed from these receptors to the central nervous system is used to help to maintain homeostasis.

OPHTHALMOLOGY: It is the branch of science that deals with the study of eyes and their disorders.

EYE: Vision is extremely important for human survival. More than half of the sensory receptors are located in the eyes. The eye is situated in the orbital cavity and is supplied by optic nerves. It is spherical in shape and about 2.5 cm in diameter. The eye is located in bony socket called as orbit. The space between the eye and the orbital cavity is occupied by adipose tissue. The bony walls of the orbit help to protect the eye from injury.

Accessory Structures of the Eye: ✓ Eyelids ✓ Eyelashes ✓ Eyebrows ✓Lacrimal apparatus ✓ Extrinsic eye muscles

EYELIDS: The eyelids are two movable folds of tissue situated above and below the front of each eye. On their free edges there are short, curved hairs called as eyelashes.

Various layers of tissue forming the eyelids are: ✓ A thin covering of skin ✓ A thin sheet of subcutaneous connective tissue (loose areolar tissue) ✓ Two muscles: The orbicularis oculi and the levator palpebrae superioris ✓ A thin sheet of dense connective tissue - Tarsal plate ✓ Lining of conjunctiva

FUNCTIONS: The eyelids and eyelashes protect the eye from injury. The eyelids protect the front surface of eyes from excessive wind, small particles in the air and from minor mechanical injury. Blinking at about 3-7 seconds intervals spreads tears and oily secretions over the cornea, preventing injury to eye."

CONJUNCTIVA: It is a thin transparent membrane that lines the eyelids and the front of the eyeball. The corneal conjunctiva consists of avascular stratified epithelium i.e. epithelium without blood vessels. When the eyelids are closed, the conjunctiva becomes a closed sac. It protects the delicate cornea and the front of eye.

EYEBROWS: Numerous hairs (eyebrows) projects obliquely from the surface of the skin. They protect the eyeball from sweat, dust and other foreign bodies.

LACRIMAL APPARATUS: It consists of: ✓ 1 Lacrimal gland and its ducts ✓ 2 Lacrimal canaliculi ✓ 1 Lacrimal sac ✓ 1 Nasolacrimal duct The lacrimal apparatus is a structure that produces and drains lacrimal fluid (tears). It has size and shape of an almond. It secrets lacrimal fluid which drains into 6-12 excretory lacrimal ducts that empty tears onto the surface of conjunctiva of the upper lid. The fluid protects, clean, lubricates and moistens the eyeball.

Extrinsic eye muscles: Six extrinsic muscles move the eye together. ✓ Superior rectus ✓ Inferior rectus ✓Lateral rectus ✓ Medial rectus ✓ Superior oblique Inferior oblique.

Anatomy of the Eyeball: The adult eyeball measures about 2.5 cm in diameter. Only the anterior 1/6th is exposed, the rest is protected in bony socket of the orbit. The wall of eyeball consists of three layers.

- Fibrous tunic
- Vascular tunic
- Retina

1.FIBROUS TUNIC: It is the superior layer of eyeball. It consists of anterior cornea and posterior sclera. The cornea is transparent coat that covered the coloured iris. Because it is curved, the cornea helps to focus the light onto the retina. The cornea is about 0.5 to 1 mm thick and consists mainly of the following structure:

- Corneal epithelium
- Substantia propia
- Corneal endothelium

  The sclera: The white of the eye is a layer of dense connective tissue made up of collagen fibres and fibroblasts The sclera covers the entire eyeball except the cornea. It gives shapes to the eyeball, makes it more rigid and protects its inner parts. At the junction of sclera and cornea is an opening known as canal of schlemm. A fluid called aqueous humour drains into the sinus.

2.VASCULAR TUNIC: The vascular tunic/uvea is the middle layer of eyeball. It is composed of three parts.

- Choroid
- Ciliary body
- Iris

Highly vascularized choroid is the posterior portion of the vascular tunic lines most of the internal surface of the sclera. Its numerous blood vessels provide nutrients to the posterior surface of retina. The choroid also contains melanocytes that produce the pigment melanin which appear dark brown in colour. In the anterior portion of the vascular tunic, the choroid becomes the ciliary body. Like the choroid the ciliary body appears dark brown in colour because it contains melanin producing melanocytes. In addition ciliary body contains ciliary body processes and ciliary muscles. The coloured portion of eyeball has a flattened donut shape. It is suspended between the cornea and lens and is attached to its outer margin to the ciliary processes. It consists of melanocytes, circular and radial smooth muscle fibres. The amount of melanin in the iris determines the eye colour.

✓High concentration: Brown/Black eye colour

✓ Moderate concentration: Green eye colour

✓Low concentration: Blur eye colour

The principal function of the iris is to regulate the amount of light entering the eyeball through the pupil, the hole in the centre of the iris. When bright light stimulates the eye, parasympathetic fibres of oculomotor nerves (III) stimulates the circular muscles (sphincter papillae) of the iris to contract causing decrease in the size of the pupil (Constriction). In dim light, sympathetic neurones stimulates the radial muscles (dilator papillae) of the iris to contract causing increase in the size of the pupil (Dilation).

3.RETINA: The third and inner coat of the eyeball is the retina. It is extremely thin and transparent. The optic disc is the site where the optic (II) nerve exits the eyeball.

It consists of:

- Central retinal artery
- Central retinal vein The retina consists of a pigmented layer and neural layer. The pigmented layer is a sheet of melanin-containing epithelial cells. The melanin in the pigmented layer of retina also helps to absorb stray light rays. The neural layer is a multi-layered outgrowth of the brain. It consists of three layers:
- The photoreceptor layer
- Bipolar cell layer
- Ganglion cell layer

LENS: The lens is present behind the pupil and iris within the cavity of the eyeball. A crystalline protein, arranged like the layers of an onion, make up the lenses transparent and lacks blood vessels. The lens helps to focus images on the retina to facilitate clear vision.

INFERIOR OF THE EYEBALL: The lens divides the interior of the eyeball into two cavities:

✓ The anterior cavity

✓ The vitreous chamber The anterior cavity consists of two chambers:

✓Anterior chamber: It lies between the iris and in front of the lens.

✓ Posterior chamber: It lies behind the iris and in front of the lens. Both the chambers of the anterior cavity are filled with aqueous humour - a watery fluid that nourishes the lens and cornea. Normally, aqueous humour is completely replaced about every 90 minutes. The second and larger cavity of the eyeball

is the vitreous chamber which lies between the lens and the retina. It is never replace throughout the life. This substance contributes the intraocular pressure and helps in preventing eyeball from collapsing. The pressure in the eye, called intraocular pressure, is produced mainly by the aqueous humour and partly by the vitreous body It is normally about 16 mm Hg. The intraocular pressure maintains the shape of the eyeball and prevents it from collapsing.

PHYSIOLOGY OF VISION: The rods and cones are two types of photoreceptors that helps in transducing light rays into the receptor potential. The retina of each eye contains about 6 millions of cones and 120 millions of rods. Rods: These help in viewing grey shades in dim light and are responsible for absorbing shapes and movements. Cones: They provide colour vision in bright light. The cones cannot functions in dim light. The rods and cones are named because of their shapes. The rods and cones are differentiated into two parts:

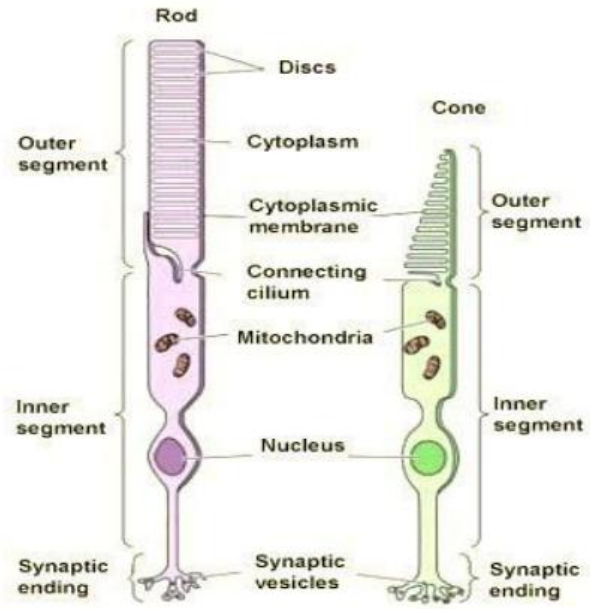
- Outer segment
- Inner segment

The outer segments of cones are cone shaped whereas those of rods are rod shaped. The outer segment of rods as well as cones contains invaginated membranes called as discs. The first step in visual transduction in absorption of light by a photo pigments. These pigments are coloured protein that undergoes structural changes when they absorb light, in the outer segment of photoreceptor. The pigment present in the rods is rhodopsin and the cones is iodopsin. Both rhodopsin as well as iodopsin contains retinal (derivatives of vitamin-A). All photo pigments associated with vision contains two parts: ✓ A glycoprotein known as opsin. ✓ Derivative of vitamin - A known as retinal. Good vision depends on adequate dietary intake of carotene-rich vegetables

such as carrots, spinach, broccoli and yellow squash or foods that contains vitamin-A such as liver. Retinal is light absorbing part of all visual photo pigments. In human retina there are four different opsins, three in the cones and one in the rods (rhodopsin).

Activation of Photo-pigments: Photo-pigments respond to light in the following process:

(1) In darkness, retinal has a bent shape, called cis-retinal, which fits tightly into the opsin portion of the photopigment when cis-retinal absorbs a photon of light; it straightens out to a shape called trans-retinal.

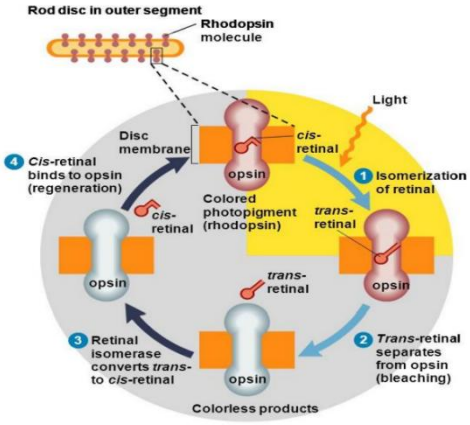


Rod cell and Cone cell

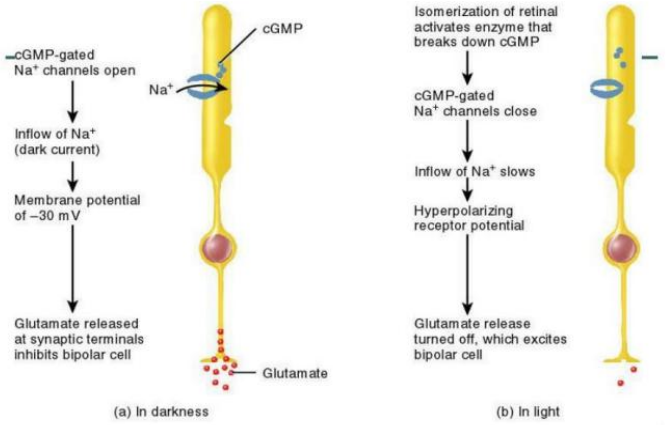
(2) This cis-to-trans conversion called as isomerisation and is the first step in visual transduction.

(3) An enzyme called as retinal isomerase converts trans-retinal back to cis-retinal.

(4) The cis-retinal then binds to opsin, reforming a functional photopigment. This process of resynthesis of photopigment called as regeneration. The inner segment of rods and cones contains mitochondria, which provides energy. The discs of the rods are constantly regenerated whereas this does not occur in cones.



Activation of photo-pigments



Operation of photoreceptor in darkness and light

LIGHT AND DARK ADAPTATION: When the person emerges from dark surroundings (a tunnel) into the sunshine, light adaptation occurs. Our visual system adjusts in seconds to the brighter environment by decreasing its sensitivity. When the person enters a darkened room such as a theatre, visual system undergoes dark adaptation by increasing sensitivity. As the light level increases more and more photo pigment is bleached. While light is bleaching, more photopigment molecules however, others are being regenerated. Release of Neurotransmitter by Photoreceptors: Operation of Rod Photoreceptor in Darkness: In darkness, the cyclic GMP levels of photoreceptors are high. This level of GMP opens the ligand gated sodium ions channels. Inflow of Nations through the channel in the photoreceptor takes place called as dark current which partially depolarizes the photoreceptor. As a result, in darkness the membrane potential of a photoreceptor is -30 mV which is much closer to -70 mV. This partial depolarization during darkness triggers release of neurotransmitter at the synaptic terminals. The neurotransmitter is the amino acid glutamate or glutamic acid, This glutamate inhibits the bipolar cells that synapse with rods.Operation of Rod Photoreceptor in Light: When light strikes on retina the cis-retinal undergoes isomerisation to trans-retinal, enzyme transduction get activated which activates phosphodiesterase which breaks down cyclic GMP and leads to decrease in cyclic GMP levels which in turn is responsible for closing of sodium channels. So, inflows of Na+ ions in photoreceptor get decreases. The

membrane potential becomes more negative -70 mV (hyperpolarizing receptor potential). This sequence of events produces a hyperpolarizing receptor potential that decreases the release of neurotransmitter glutamate. Thus, light excites bipolar cells that synapse with rods by turning off the release of inhibition of neurotransmitter. The excited bipolar cells subsequently stimulate the ganglion cells to form action potentials in their axons.