The anatomy of the eye and the physiology of the vision

Imagine a camera that is composed with 2 million working parts, and stored up to 24 million images around you throughout life span. This incredible amazing camera is our eyes. The human eyes are one of the most interesting medical field that are being studied, as well as one of the most complex organs that has many features. The eyes are the organs of sight and one of our special senses. Vision is our one of our dominant sense: 70% of all the sensory receptors in the body are in the eyes, and almost half of the cerebral cortex is involved in some aspect of the visual processing. Only the anterior one sixth of the eye is visible.

The accessory structures of the eye include the eyebrows, eyelid, conjuctiva, lacrimal apparatus, and extrinsic eye muscles. The eyebrows are short, coarse hair over the supraoribital. In the deep area to the skin of the eyebrow are parts of the orbicularis oculi and corrugator muscles. Contraction of the orbicularis muscles depresses the eyebrow, and the corrugator muscles moves the eyebrow medially (Marieb 2004). Each eye is set within a recession in the skull known as the orbit and is covered by the protective fold of the eyelid, or palpebrae. (Wingerd, 2011).

The eyelids are separated by the palperbral fissure and meet at the lateral and medial canthi. In the medial canthus the lacrimal caruncle, which is a flashy elevation, is found. It contains whitish, oily secretion that will usually collect in the medial canthus during sleep (Martini 2009). Eyelids are thin, skin covered folds supported internally by connective tissue sheets called Tarasl plates. The Tarsal plates also attach the orbicularis oculi and levator palperbrae superioris muscles that run within the eyelid. The muscles that

encircle the eye are Orbicularis oculi muscles, and when they contracts, the eye closes.

Out of the two eyelids, the larger upper one is much more mobile, because of the levator palpebrae superioris muscle; this muscle raises the eyelid to open the eye. The eyelid muscles are activated reflexively to cause the eye to blink every 3-7 second, and the reason is to protect the eye from foreign objects, as well as to prevent drying of the eye, because each time we blink accessory structures secretions (oil, mucus, and saline solution) are spread across the eyeball surface (Marieb, 2004). In addition to the eye accessory structures, we find in free margin of each eyelid the eyelashes.

The follicles of the eyelash hairs are richly innervated by nerve endings, which are hair follicles receptors, and anything that touches the eyelashes, even puff of air, will result in a reflex blinking. There are several types of glands that are associated with the eyelid. The Tarsal, or Meibomian, glands are embedded in the tarsal plates; their ducts open at the eyelid edge just posterior to the eyelashes. As a result, these sebaceous glands produce an oily secretion that lubricates the eyelid and the eye and prevents the eyelid from sticking together.

Most sebaceous and modified sweat glands called ciliary glands lie between the hair follicles. (Marieb 2004). Since the eyes are very important it must be protected. Therefore, the eye receives additional protection from a thin sheet of cells that covers the anterior surface of the eye and the inner surface of the eyelid, this protection thin sheet is known as conjunctiva, means to bind together. The conjunctiva is kept moistened by watery

secretion from the large lacrimal glands, which secrete tears. It covers only the iris and the pupil, not the cornea.

The ocular conjunctiva is very thin, and blood vessels are visible beneath it. Conjunctival sac is where contact lenses lies; also eye medications are applied to its inferior recess. It major function is to produce mucus that prevents the eyes from drying out. (Martini 2009) Next accessory structure of the eye is the lacrimal Apparatus, which produces, distributes, and removes tears. Each eye consists of lacrimal gland with associated ducts, paired lacrimal canaliculi, a lacrimal sac and a nasolacrimal duct (Martini 2009).

Blinking spreads tears downward and across the eyeball to the medical commissure, where the enter the paried lacrimal canaliculi (canals) via two tiny openings called lacrimal puncta, visible as tiny red dots on the medial margin of each eyelid. From the lacrimal canals, the tears drain into the lacrimal sac and then into the nasolacrimal duct, which empties into the nasal cavity at the inferior nasal meatus. In addition, lacrimal fluid (tears) contains mucus, antibodies, and lysozyme, an enzyme that destroys bacteria.

Thus, it cleanses and protects the eye surface as it moistens and lubricates it. Marieb 2004). Lastly accessory structure of the eye is extrinsic eye muscles. They originate from the bony orbit and insert into the outer surface of the eyeball. These muscles allow the eye movement and help to maintain the shape of the eyeball and hold it in the orbit. There are four rectus muscles that originate from the annular ring, superior, inferior, lateral, and

medial. The function of the oblique muscles is to move the eye in the vertical plane when the eyeball is already turned medially by the rectus muscle.

The superior oblique muscles runs along the medial wall of the orbit, and when contracts it rolls the eye downwards and laterally, then makes a right angle turn and passes through a fibrocartilaginous loop perched from the frontal bone known as the trochlea, which insert in the superior lateral surface of the eye. The inferior oblique muscle rotates the eye up and laterally. It originates from the medial orbit surface and runs laterally, and insert on the inferolateral eye surface. These muscles are among the most precisely and rapidly controlled skeletal muscles in the entire body.

This reflects their high axon to muscles-fiber ratio: the motor units of these muscles contain only 8 to 12 muscles cells and in some cases as few as 2 or 3. (Marieb 2004). Furthermore, the eye itself is best known as the eyeball. In adults, the eye is sphere has a diameter of about 2. 5 cm (1 inch). The eyeball most anterior point is the anterior pole; its most posterior point is known us posterior pole. The eyeball is composed of three coats (or tunics), the fibrous, vascular, and sensory tunics. The internal cavity is filled with fluid known as humors that helps maintain its shape.

Next, the lenses are adjustable focusing apparatus of the eye. The lens stands vertically and divides the eye into anterior and posterior cavities. (Martini 2009). The fibrous tunic is composed of dense avasuclar connective tissue, and is made of two regions: the sclera and the cornea. The sclera is what best known as “ the white of the eye”, is posterior portion and the bulk of the fibrous tunic. It protects and shapes the eyeball and provides a strong

attachment site for the extrinsic eye muscles. On the posterior side, the sclera is pierced by the optic nerve, and it continuous with the dura mater of the brain.

However, the cornea is anterior and transparent. The crystal clear cornea forms a window that lets light enter the eye. The external sheet of the cornea is covered by stratified squamous epithelium and merges with the ocular conjunctiva at the sclera cornea junction. (Marieb 2004). Here is where stem cells located, so in case of damage (scratch) of the cornea the stem cells can easily repair it. (Martini 2009). The internal cornea is lined by endothelium, composed of simple squamous epithelium. Its cells have active sodium pumps that maintain the clarity of the cornea by keeping the water of the cornea low.

Most of the nerves ending in the cornea are pain receptors. In case the cornea was touched, blinking and tearing occurs reflexively. In addition, the cornea is the most exposed region of the eye it; therefore, it can easily be damaged from dust, and slivers. However, luckily its capacity for regeneration and repair is extraordinary. The cornea is avascular (doesn’t have its own blood supplies) therefore, it is easily transplanted from one person to another with little or no possibility of rejection. (Marieb 2004). However, one of the tunics (coats) that own its own blood supplies is the vascular tunic, also called the uvea.

It consists of the choroid, ciliary body, and iris. Since the choroid is highly vascular it provides oxygen and nutrients to other tunics that are avascular. It has melanocytes to make the dark membrane. This dark membrane

absorbs light and by doing so it prevents it from scattering and reflecting within the eye (reflecting within the eye can cause visual confusion). On the anterior of the choroid becomes the ciliary body, which is thickened ring of tissue that encircles the lens. (Martini 2009). The ciliary body is primarily composed with smooth muscles called ciliary muscles; this muscles helps to maintain the shape of the lens.

Near the lens there is a fold called ciliary processes that contain capillaries that secret fluid that fills the cavity of the eyeball. In addition, the suspensory ligaments attach to the lens to hold is vertically in the eye. Next, the iris is the colored region of the eye. It lies between the cornea, lens, and continuous with the ciliary body. The iris has a round central opening called the pupil which allowed light to enter the eye. Iris is made from two smooth muscles layers with elastic fibers. These two muscles allow the iris to act as diaphragm to control the pupil size.

In distance vision and dim light, the radial muscles contract and the pupil dilate, by doing so it allows extra light to enter the eye. This process is controlled by the parasympathetic fibers. On the contrary, in close up vision and strong light, the circular muscles contract the pupil, so less light can enter the eye, and this process is controlled by the sympathetic fibers. In some cases, the changes in pupil size can be cause by emotional reactions to what the eye is seeing. When the iris contains many pigments the eye color appears brown or black.

Therefore, iris with small amount of pigments will result in iris colored blue, gray, or green. Most babies' eyes have a lighter colored iris since their iris

pigment is not yet fully developed. (Marieb 2004). In addition, the neural tunic or as we best know it as the retina is very delicate; it contains neurons called photoreceptors and glia. It receives blood from two sorces: outer 1/3 from the vascular tunic, and inner 2/3 from central artery and vein that run in the center of the optic nerve. The neural tunic is composed of two un-fused layers: the outer layer, called the pigmented layer, and the inner layer called the neural layer.

The outer layer is a single cell thick lining, absorbs light and prevent scatter, store vitamin A, and they also act as phagocytes, which mean they are able to remove any dead, or damage photoreceptors. The second layer is the inner layer, called the neural layer, which extents posterior to the margin of the cilliary body. This junction is known as the ora serrata retinae. It has three major neurons that go from posterior to anterior: the photoreceptors, bipolar cells, and ganglion cells, where the action potential is generated. Furthermore, the axons make a right angled turn and leave the posterior eye as the optic nerve.

The retina has other also have other neurons: the horizontal and amacrine cells, which play roll in visual processing. Also contains, the optic disc, where optic nerves leave the eye, best known as “ the blind spot”, because it lacks photoreceptors. The optic disc is weak because the sclera doesn’t cover it. Although we have a “ blind spot” in our eye, we don’t notice these gaps in our vision, and that is due to the brain that uses a sophisticated process called filling in to deal with the absence of the input. There are about ? of a million photoreceptors in the eye.

The photoreceptors contain 2 types: rods and cones. Unlink the cones, the rods are more sensitive to light, but don’t provide sharp images or color vision like the cones. Rods are our dim-light vision receptors. In contrast, cones are our bright light vision receptors, and provide high insight color vision. The macula lutea, has primarily cones and it lateral to the blind spot. In the macula lutea there is a pit in the center called, fovea centrails, is our detailed color vision and has only cones. (Marieb 2004). Internal chambers and fluids, divide the eye into anterior and posterior cavities.

The posterior segment (or cavity) is filled with clear gel called vitreous humor, which is able to transmit light, support the posterior aspect of the eye, hold the neural retina against the pigmented layer, and supply to intraocular pressure, helping to offset the pulling force of the extrinsic eye muscles. The vitreous humor forms in the embryo and lasts for a lifetime. However, the anterior segment is subdivided by iris into anterior and posterior chambers. This cavity is filled with aqueous humor, a clear liquid that is alike composition to blood plasma.

Normally, the aqueous humor is produced and drained at the same time; it maintain a constant intraocular pressure of approximately 16 mm Hg, this pressure helps to support the eyeball internally. It takes away metabolic wastes. Lastly, it provides nutrients and oxygen to the lens and cornea. If something blocks the canal of Schlemm, fluid backs up like a clogged sink, which will increase the pressure. In case of too much pressure it can cause blindness, condition called glaucoma. It’s very hard to detect it once it’s happening, since this condition is slow and painless that people cannot notice the problem until damage has been done.

Lenses are biconvex, transparent and flexible that can change. In the elastic capsule they are avascular. The lens has 2 region lens epithelium that has cuboidal cells, and lens fibers, which is a protein that are tightly hold together to make the lens. Our eye is constantly creates fibrous cells, therefore, with in time the lens becomes denser and less flexible. With aging the lens cannot receive the same amount nutrients it used to when the lens was younger. Therefore, these fibrous cells will form cloudy areas in the eye, and this is called cataract. 99% of the human population will have cataract as they age.

The treatment is to remove the lens and transplant an artificial lens (Marieb, 2004). However, a recent study shows that that the most effective method to remove dense cataract is OZil Torsional Ultrasound with Intelligent Phacoemulsification (IP); this study with the OZil Phaco tip it doesn't repel nuclear material. " Therefore, the surgeon does not need to set vacuum and fluid flow to neutralize this repulsive force. The ability to reduce the total volume of fluid in the eye increases the protection of the endothelium. Furthermore, using lower vacuum settings prevents postocclusion surge.

Because surgeons can use lower settings with OZil Torsional phacoemulsification, the anterior chamber remains stable". Finally, the physiology of the eye, light travels in straight line. However, just like sound, light can reflect, or bounce, off a surface. Refraction of light ray occurs when it meets a different medium at the oblique angle. When light hits the curve at the angle it is refracted. The images we see are formed by a convex lens, called the real images. Essentially, everything we see is upside down and

revered from left to right; however, the brain interprets it. Our eyes are best adapted for focusing for distant vision.

Once focusing on far object our lens shape doesn’t change. For a normal, or emmetropic, eye the far point is 6m (20 feet). However, focusing for close vision demands the eye to make active adjustments; to restore focus three process must happen simultaneously: constriction of the pupils, accommodation of the lens, and convergence of the eyeballs. This signal reflex response appears to be blurring of the retina image. (Marieb, 2004) Visual problems related to refraction can result from hyper-refractive (over converging) or hyporefrective (underconverging) lens and/or form structural abnormalities of the eyeball.

Myopia, or nearsighted, occurs when the corneal curvature is too steep or axial length of the eye is too long, light is focus short on the retina. Therefore, result in near objects seen clearly and distant object seen blurred. The use of concave lens that depart the light before it enters the eye or surgical procedure known as radial keratotomy, are often the treatment options. As we have the nearsighted vision problem, we also have the farsighted vision problem known as hyperopia. This occurs when the corneal curvature is too flat or axial length of the eye is too short, causes images to focus behind retina.

Thus, near objects appear blurry. The treatment, convex lenses are needed to converge the light more strongly for close vision. (Wingerd, 2011). Unequal curvatures in different parts of the lens (or cornea) lead to blurry image as well, this is known as astigmatism. To fix this problem special

cylindrically ground lenses, and/or laser procedures. (Marieb, 2004). Phototrnasduction are found in the outer cavity. It’s a process of converting light energy into a graded receptor potential. Next, both rods and cones have an outer segment or receptor region joined to an inner segment.

Rods are found in the inner segment (cavity) and it connects to the cell body by an outer fiber. They have single kind of pigment and because of that it absorb different wavelength, where cones have each 1 of 3 pigments. Cones are also found in the inner segment (cavity); thus, connects directly to the cell body. Most cones are one to one. The outer segments of both have the visual pigments or photopigament in discs which are in-folding. These photopigments change shape as they absorb light. Furthermore, the discs are sperated in rods and continuous in cones.

The light absorbing molecule is called the retinal, and it combines proteins called opsins. Overall, there are 4 types of visual pigments; depending on type opsins is bound, retinal absorbs different wavelengths of visible spectrum. Next, the retinal has a bent, or kinked shaper called the 11-cis isomer, and 11-trans isomer. (Marieb, 2004). In stimulation of the photoreceptors the excitation of rods is taking place, here we find purple pigment called rhodopsin, molecules arranged as a single layer in the membranes of each discs in the rods’ outer segment. It maximally absorbs green light.

In stimulation of the photoreceptors we also find excitation of cones, their activation is similar to rohdospin; however, unlike in the rods, in the cones the activation is much higher. If one cones or more are damaged it can lead

to color blindness (also can be inherited). (Marieb, 2004) Light transduction in photoreceptors, in dark, cyclic GMP bind to cation channels in outer segment keeping them open. Ca+ channels are open at the photoreceptor synaptic terminals, which will lead to constant release of the neurotransmitter (glutamate) to bipolar cells. The rhodopsin is very sensitive.

Therefore, as long as the light is low intensity, relatively a little portion of rhodopsin is being bleached and the retina continues to respond to light stimuli. The visual pathway to the brain is by optic nerve and it’s an X-shaped optic chiasma (cross). The process occurs as follows: the optic tracts sweep posterior around the hypothalamus and send most of their axons to synapse with neurons in the lateral geniculate body. In addition, the interior capsule forms optic radiation to fibers in the cerebral white matter, which leads to the primarily visual cortex in occipital lobes.

Some other axons send braches to the midbrain. The fiber end in the superior colliculi. However, some axons go to the suprachiasmatic nucleus of the hypothalamus, which functions as the “ timer” to set out daily biorhythms. (Marieb, 2004) In conclusion, the anatomy of the eye and the physiology of vision are very complex subjects; however, this research provided all the information about the accessory structure of the eye as well as its anatomy, followed by its physiology.

In addition, there are many disorders and disease involved in the eye. Nevertheless, the two most common once are glaucoma, and cataract which were discussed above. Nowadays, with the newer, faster technology almost all the disorders and disease found within the eye has a treatment to it. In

case of disorders the eyes have many avascular parts; therefore, it can be transplanted very easily without any side defects.