B.Sc PSYCHOLOGY

3rd SEM COMPLIMENTARY COURSE

UNIVERSITY OF CALICUT

PSG3C01- HUMAN PHYSIOLOGY

2019 ADMISSION

Prepared by

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COURSE CODE	**PSG3C01**
TITLE OF THE COURSE	**HUMAN PHYSIOLOGY III**
SEMESTER IN WHICH THE COURSE TO BE TAUGHT	**3RD**
NO. OF CREDITS	**3RD**
NO. OF CONTACT HOURS	**75 (5hrs/week)**

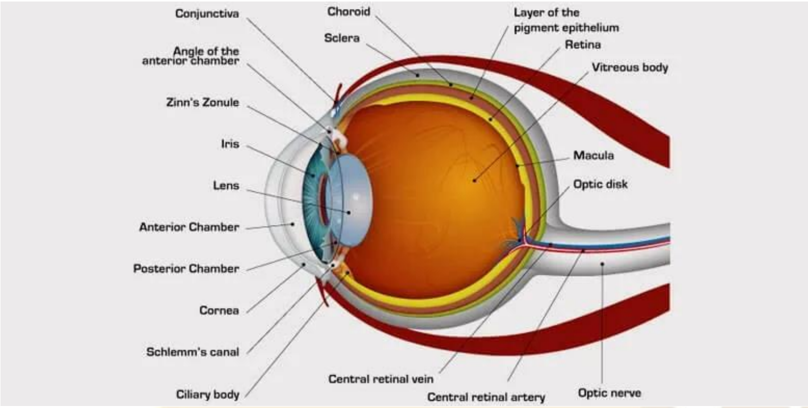
Objectives of the course:

- **This course Familiarizes the student of psychology with the sensory systems, pathways and perception of various senses. It also introduces the student to the endocrine system.**
- **Course Details**

MODULE NO.	NAME OF MODULE	MODULE HOURS
1	The visual system	18
2	Auditory system	16
3	Gustatory and olfactory system	16
4	Cutaneous senes	20
5	Endocrine system	20

MODULE 1: THE VISUAL SYSTEM

- **Structure of the human eye**



- Eye anatomy and physiology
- Eyes are spheroid shape organs fitted into the two orbitals of the skull. There are three major parts in each eye like- The sclera (fibrous layer) - Choroid layer – Retina
- **The sclera:** It makes up the outermost part of eye anatomy. It is made of a dense, strong fibrous wall consisting of the sclera that is 5/6th and the cornea that is anterior 1/6th of the eyeball.
- **The choroid layer:** This is the second layer forming the eyeball. It consists of a densely capillary rich layer, supplying blood to the eyeball. The choroid layer also acts as a black screen which prevents extra reflections inside the eyeball, so that we can get a perfect image.
- Parts are the iris, ciliary body and the ligaments.
- Iris: This is the extension of the choroid layer towards the anterior side of the eye. This iris is pigmented due to which there appears color in the eyes. The pigment is genetically determined and can be like black, brown, green, blue, etc

- **Lens:** The lens is a biconvex, transparent and elastic structure which can alter its shape. It helps to focus the objects based on their distance and concentrate the refracted light on to the retina. When it constricts, it becomes thicker and when it dilates, it becomes thin.
- **Retina:** This is the innermost layer of the eye made of nerve cells. This neural coat of the eye is an essential part of the eye. This retina is the only part of the eye that perceives the light and converts it into electrical energy. It consists of photosensitive cells, namely the rods and cones.
- The rods are light-sensitive and recognize the dark and bright light.
- The cones are color sensitive and recognize the colors.
- The light received from the lens is converted into a nerve impulse and carried backward as the optic nerve into the brain for further processing.
- The point at which the nerves from the retina converge is called the optic spot.
- The retinal chamber is filled with vitreous humor.
- **Accessory parts of the eye -** These are the parts which help in safety and smooth functioning of the eye. They are - The eyebrows - The eyelids and eyelashes - The lachrymal bodies
- **Segments and Chambers of Eyeball:** Eyeball is divided into two segments, the anterior one and the posterior one.
- **Anterior segment:** The segmentation inside the eye is based on the position of the lens. An anterior segment consists of a crystalline lens hanging from the ciliary body by zonules and all structures in front of it viz. iris, cornea, and two aqueous humor-filled spaces, i.e., anterior and posterior chambers.

- **Anterior Chamber:** The boundaries of the anterior chamber are anteriorly the back of the cornea and posteriorly the anterior surface of the iris and part of the ciliary body. It is 2.5mm deep in adults but varies in hypermetropes and myopes. It communities with the posterior chamber, located just behind it via pupil, i.e., opening through iris.
- **Posterior Chamber:** It is a small triangular structure located just behind the anterior chamber guarded by the posterior surface of the iris and parts of the ciliary body anteriorly and by the crystalline lens and its zonules posteriorly.
- **Posterior Segment:** It consists of all structures that are posterior to the lens, i.e., vitreous humor, retina, and choroid optic disc.
- **Extraocular Muscles:** Extraocular muscles are responsible for the continuous movement of the eyeball to increase the field of vision. They can be divided into two groups of muscles: **The Recti :** There are four recti muscles : Superior Rectus, Inferior Rectus, Medial Rectus, Lateral Rectus
- **The Oblique:** There are 2 oblique muscles : Superior Oblique, Inferior Oblique.
- **Physiology of Vision:** Physiology of Vision consists of three main mechanisms, they are: Initiation of vision, (**phototransduction**), which is a function of photoreceptors, i.e., Rods and cones. Processing and transmission of visual sensation which is a function of image processing cells of the retina and visual pathway. Visual perception is a function of the visual cortex and related areas of the cerebral cortex.
- **Layers of the retina:** Retina is the primary light perceiving the area of the eyeball covering the whole inner surface of the eyeball. They are: The inner limiting membrane (ILM);the nerve fiber layer (NFL); the ganglion cell layer (GCL); the inner plexiform layer (IPL); the inner nuclear layer (INL); the outer plexiform layer (OPL); the outer

nuclear layer (ONL); the outer limiting membrane (OLM); the photoreceptor layer (PL); The retinal pigmented epithelium (RPE) monolayer. All these layers have individual functions in the perception of light.

- **Phototransduction:** The rods and cones are the cells that are designed to cause chemical changes when light falls on it. They serve as sensory nerve ending for visual sensation. When the light falls on them, a cascade of visual reactions starts resulting in the generation of electrical changes. Rods contain a pigment called Rhodopsin or Visual Purple, while cones contain Iodopsin. Rods are responsible for dim light vision or monochromatic vision, while cones are responsible for color vision.
- **Photochemical changes:** The Photochemical changes include - Rhodopsin bleachin, Rhodopsin regeneration
- **Processing and Transmission of visual Impulse:** A receptor potential is developed in the photoreceptors, which is transmitted by electronic conduction, i.e., direct flow of current, not as an action potential, to other cells such as amacrine cells, horizontal cells, and ganglion cells. Now, these ganglion cells transmit electric impulses to an action potential to neurons of lateral geniculate bodies and later to the primary cortex.
- **Visual perception :** It consists of some thresholds, for example:
- **Light sense:** It refers to minimal brightness required to evoke a sensation of light, called light minimum. It should be measured after at least a dark adaptation for 20 to 30mins. The two types of visual adaptations are: Light adaptation, Dark adaptation
- Rods are more sensitive to low light vision, i.e., scotopic vision. Therefore rods are more used in dim light vision, whereas cones are more used in bright light vision, i.e., photopic

vision. The dark adaptation depends on the presence of vitamin A. So, deficiency of Vit A causes night blindness.

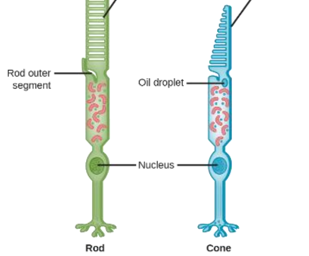
- Visual Pathways: shows the principal visual pathways from the two retinas to the visual cortex. The visual nerve signals leave the retinas through the optic nerves. At the optic chiasm, the optic nerve fibers from the nasal halves of the retinas cross to the opposite sides, where they join the fibers from the opposite temporal retinas to form the optic tracts. The fibers of each optic tract then synapse in the dorsal lateral geniculate nucleus of the thalamus, and from there, geniculocalcarine fibers pass by way of the optic radiation (also called the geniculocalcarine tract) to the primary visual cortex in the calcarine fissure area of the medial occipital lobe.
- Visual fibers also pass to several older areas of the brain: (1) from the optic tracts to the suprachiasmatic nucleus of the hypothalamus, presumably to control circadian rhythms that synchronize various physiologic changes of the body with night and day; (2) into the pretectal nuclei in the midbrain, to elicit reflex movements of the eyes to focus on objects of importance and to activate the pupillary light reflex; (3) into the superior colliculus, to control rapid directional movements of the two eyes; and (4) into the ventral lateral geniculate nucleus of the thalamus and surrounding basal regions of the brain, presumably to help control some of the body's behavioral functions. Thus, the visual pathways can be divided roughly into an old system to the midbrain and base of the forebrain and a new system for direct transmission of visual signals into the visual cortex located in the occipital lobes.
- In human beings, the new system is responsible for perception of virtually all aspects of visual form, colors, and other conscious vision. Conversely, in many primitive animals,

even visual form is detected by the older system, using the superior colliculus in the same manner that the visual cortex is used in mammals.

- Function of eye: The main function of the eye is to convert light into electrochemical impulses that the brain can interpret as visual images. The various parts of the eye perform different functions that contribute to this purpose.
- The eye is roughly analogous to a self-regulating, self-cleaning camera. The lens of the eye bends and refracts light, directing it toward the retina.
- The iris contracts or dilates to control the amount of light entering the eye.
- The cornea provides a clear shell that protects the eye without interfering with vision.
- The tear ducts and the eyelids work together to lubricate the eye and to wash away dust and other particles that might irritate or damage the eye.
- Visual coding: visual receptors and anatomy of the eye
- Visual receptors: rods Vs Cones, Photopigments and Color and blindness
- Rods Vs Cones: Rods- found in periphery, responds to faint light well; Cones- found in fovea, responds to bright light well. Ex. Looking at night sky, sometimes you can see a faint star in your periphery but not by directly looking at it. In the peripheral portions of the retina, the rods are 2 to 5 micrometers in diameter, whereas the cones are 5 to 8 micrometers in diameter; in the central part of the retina, in the fovea, there are rods, and the cones are slender and have a diameter of only 1.5 micrometers. the major functional segments of either a rod or a cone: (1) the outer segment, (2) the inner segment, (3) the nucleus, and (4) the synaptic body. The light-sensitive photochemical is found in the outer segment. In the case of the rods, this is rhodopsin; in the cones, it is one of three “color” photochemicals, usually called simply color pigments, that function almost exactly the

same as rhodopsin except for differences in spectral sensitivity. The outer segments of the rods and cone are large numbers of discs. Each of the discs is actually an infolded shelf of cell membrane. There are as many as 1000 discs in each rod or cone. Both rhodopsin and the color pigments are conjugated proteins. They are incorporated into the membranes of the discs in the form of transmembrane proteins. The concentrations of these photosensitive pigments in the discs are so great that the pigments themselves constitute about 40 per cent of the entire mass of the outer segment.

- The inner segment of the rod or cone contains the usual cytoplasm with cytoplasmic organelles. Particularly important are the mitochondria; as explained later, these mitochondria play the important role of providing energy for function of the photoreceptors.
- The synaptic body is the portion of the rod or cone that connects with subsequent neuronal cells, the horizontal and bipolar cells, that represent the next stages in the vision chain.
- Pigment Layer of the 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. This pigment performs the same function in the eye as the black coloring inside the bellows of a camera. Without it, light rays would be reflected in all directions within the eyeball and would cause diffuse lighting of the retina rather than the normal contrast between dark and light spots required for formation of precise images.



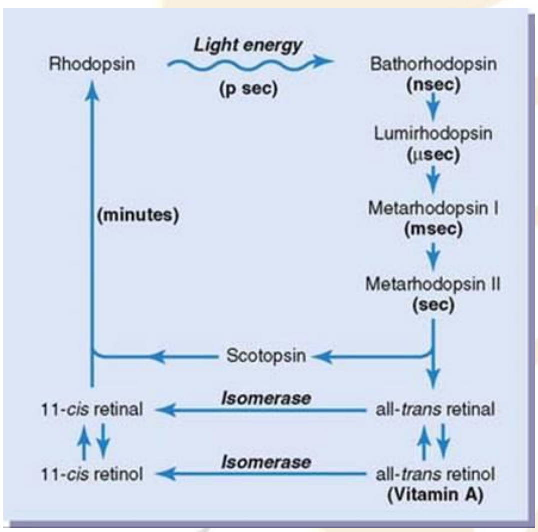
- Photopigments: are chemicals that release energy when struck by light(derivative of vitamin A). opsins modify these photopigments so that they react to diff wavelengths of light. The energy released then activates second messenger in the cell.
- Color and blindness: there are 3 main types of cones; red, blue,green. Blindness caused by deficiency in one of these (the red/green one), occurs more in males bc only have one X chromosome.
- The pigment layer also stores large quantities of vitamin A. This vitamin A is exchanged back and forth through the cell membranes of the outer segments of the rods and cones, which themselves are embedded in the pigment. We show later that vitamin A is an important precursor of the photosensitive chemicals of the rods and cones.
- Blood Supply of the Retina—The Central Retinal Artery and the Choroid. The nutrient blood supply for the internal layers of the retina is derived from the central retinal artery, which enters the eyeball through the center of the optic nerve and then divides to supply the entire inside retinal surface. Thus, the inner layers of the retina have their own blood supply independent of the other structures of the eye. However, the outermost layer of the retina is adherent to the choroid, which is also a highly vascular tissue lying between the retina and the sclera. The outer layers of the retina, especially the outer segments of the rods and cones, depend mainly on diffusion from the choroid blood vessels for their nutrition, especially for their oxygen.
- Retinal Detachment. The neural retina occasionally detaches from the pigment epithelium. In some instances, the cause of such detachment is injury to the eyeball that allows fluid or blood to collect between the neural retina and the pigment epithelium. Detachment is occasionally caused by contracture of fine collagenous fibrils in the

vitreous humor, which pull areas of the retina toward the interior of the globe. Partly because of diffusion across the detachment gap and partly because of the independent blood supply to the neural retina through the retinal artery, the detached retina can resist degeneration for days and can become functional again if it is surgically replaced in its normal relation with the pigment epithelium. If it is not replaced soon, however, the retina will be destroyed and will be unable to function even after surgical repair.

- Anatomy of the eye: Fovea and Periphery, order of occurrence, blind spot and the human eye.
- Fovea and Periphery: A tiny area specialized for acute, detailed vision as a result of the number of cones (which are perceptive to bright light). While the periphery of the eye is more sensitive to faint light as it consists of more rods.
- order of occurrence: Light enters the eye through an opening in the center of the iris called the pupil. Then, it is focused by the lens and cornea. Light is projected onto the retina, the rear surface of the eye, which is lined with visual receptors. The message goes from the back of the eye to bipolar cells, which then send their messages to ganglion cells. These are located in center of the eye.
- Blind spot: as a result of the anatomy of the eye, there is a blind spot at the optic nerve, which has no photoreceptors.
- chemistry of vision: Photochemistry of Vision
- Both rods and cones contain chemicals that decompose on exposure to light and, in the process, excite the nerve fibers leading from the eye. The light-sensitive chemical in the rods is called rhodopsin; the light sensitive chemicals in the cones, called cone pigments or color pigments, have compositions only slightly different from that of rhodopsin.

- the photochemistry of rhodopsin, but the same principles can be applied to the cone pigments.
- Rhodopsin and Its Decomposition by Light Energy. The outer segment of the rod that projects into the pigment layer of the retina has a concentration of about 40 per cent of the light-sensitive pigment called rhodopsin, or visual purple. This substance is a combination of the protein scotopsin and the carotenoid pigment retinal (also called "retinene"). Furthermore, the retinal is a particular type called 11-cis retinal. This cis form of retinal is important because only this form can bind with scotopsin to synthesize rhodopsin.
- When light energy is absorbed by rhodopsin, the rhodopsin begins to decompose within a very small fraction of a second, as shown at the top of Figure 50–5. The cause of this is photoactivation of electrons in the retinal portion of the rhodopsin, which leads to instantaneous change of the cis form of retinal into an all-trans form that still has the same chemical structure as the cis form but has a different physical structure— a straight molecule rather than an angulated molecule. Because the three-dimensional orientation of the reactive sites of the all-trans retinal no longer fits with the orientation of the reactive sites on the protein scotopsin, the all-trans retinal begins to pull away from the scotopsin.
- The immediate product is bathorhodopsin, which is a partially split combination of the all-trans retinal and scotopsin. Bathorhodopsin is extremely unstable and decays in nanoseconds to lumirhodopsin. This then decays in microseconds to metarhodopsin I, then in about a millisecond to metarhodopsin II, and finally, much more slowly (in seconds), into the completely split products scotopsin and all-trans retinal.

- It is the metarhodopsin II, also called activated rhodopsin, that excites electrical changes in the rods, and the rods then transmit the visual image into the central nervous system in the form of optic nerve action potential, as we discuss later.
- Re-formation of Rhodopsin. The first stage in re-formation of rhodopsin, as shown in Figure 50–5, is to reconvert the all-trans retinal into 11-cis retinal. This process requires metabolic energy and is catalyzed by the enzyme retinal isomerase.
- Once the 11-cis retinal is formed, it automatically recombines with the scotopsin to re-form rhodopsin, which then remains stable until its decomposition is again triggered by absorption of light energy.

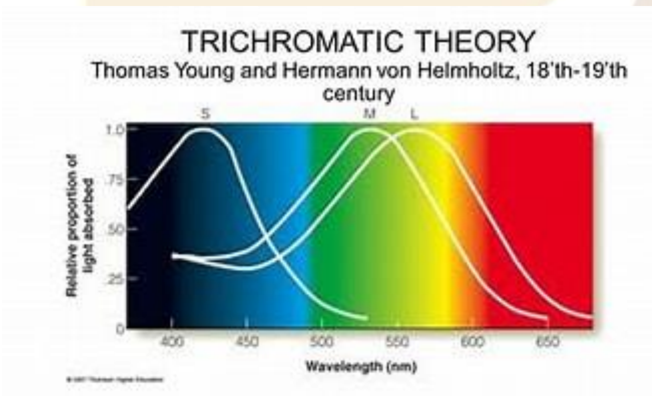


- Role of Vitamin A for Formation of Rhodopsin. Note in Figure that there is a second chemical route by which all-trans retinal can be converted into 11-cis retinal. This is by conversion of the all-trans retinal first into all-trans retinol, which is one form of vitamin A. Then the all-trans retinol is converted into 11-cis retinol under the influence of the enzyme isomerase.
- Finally, the 11-cis retinol is converted into 11-cis retinal, which combines with scotopsin to form new rhodopsin. Vitamin A is present both in the cytoplasm of the rods and in the

pigment layer of the retina. Therefore, vitamin A is normally always available to form new retinal when needed. Conversely, when there is excess retinal in the retina, it is converted back into vitamin A, thus reducing the amount of light-sensitive pigment in the retina. We shall see later that this interconversion between retinal and vitamin A is especially important in long-term adaptation of the retina to different light intensities.

- Night Blindness. Night blindness occurs in any person with severe vitamin A deficiency. The simple reason for this is that without vitamin A, the amounts of retinal and rhodopsin that can be formed are severely depressed. This condition is called night blindness because the amount of light available at night is too little to permit adequate vision in vitamin A–deficient persons. For night blindness to occur, a person usually must remain on a vitamin A–deficient diet for months, because large quantities of vitamin A are normally stored in the liver and can be made available to the eyes. Once night blindness develops, it can sometimes be reversed in less than 1 hour by intravenous injection of vitamin A.
- **Excitation of the Rod When Rhodopsin Is Activated by Light:** The Rod Receptor Potential Is Hyperpolarizing, Not Depolarizing. When the rod is exposed to light, the resulting receptor potential is different from the receptor potentials in almost all other sensory receptors. That is, excitation of the rod causes increased negativity of the intrarod membrane potential, which is a state of hyperpolarization, meaning that there is more negativity than normal inside the rod membrane. This is exactly opposite to the decreased negativity (the process of "depolarization") that occurs in almost all other sensory receptors.

- Coding of light and Dark: visual system is the use of microelectrodes to record the electrical activity of single neurons.
- Receptive field: that portion of the visual field in which the presentation of visual stimuli will produce an alteration in the firing rate of a particular neuron.
- **Theories of color vision:** trichromatic coding and Opponent -Process coding.
- **In 1802 Thomas Young**, a British physicist and Physician, Proposed that the eye detected different colors because it contained three types of receptors, each sensitive to single hue.
- **Young** referred to trichromatic theory,



- visual perception: the ability to interpret the surrounding environment using light in the visible spectrum reflected by the objects in the environment. A person can have problems with visual perceptual processing even if they have 20/20 vision. The resulting perception is also known as visual perception, eyesight, sight or vision. The gestalt laws of organization have guided the study of how people perceive visual components as organized patterns or wholes, instead of many different parts.
- Visual defects: visual system have different kinds of abnormalities.
- Myopia – often called nearsightedness, objects seen in sharp focus. It is caused by too much curvature of the cornea relative to the length of the eyeball. This causes the light

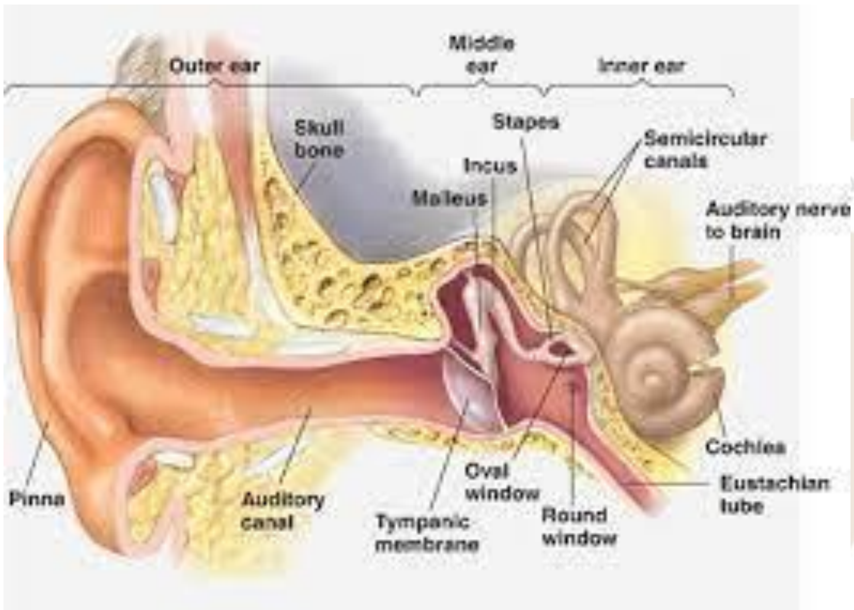
rays in the eye to be focused in front of the retina instead of on it. Myopia can be corrected by wearing glasses/contacts with **concave lenses.**

- Hypermetropia – often called farsightedness, people with it can see clearly far away, but not close up. It is caused by insufficient curvature of the cornea relative to the length of the eyeball. This can be corrected by wearing glasses/contacts that contain **convex lens.**
- Presbyopia – is an age-related condition that occurs as the lens loses its ability to change shape. This reduces the eye's ability to adjust for different distances, especially close up. To correct this defect, a person is prescribed **bifocal lens** that has both types of lenes- **convex and concave.**
- Astigmatism – The cornea is misshapen and does not properly focus the light entering the eye. Instead of hitting the retina in a focused point, the light is spread over two or more points. The result is blurry or stretched image. This condition can be corrected by using a special spherical cylindrical lens, that is placed in the out-of-focus axis.
- Cataract – is a clouding of the lens of the eye which leads to a decrease in vision. It develops slowly and can affect one or both eyes. These are most commonly due to aging but may also occur due to trauma or radiation exposure. Diagnosis is by an eye examination. Prevention includes wearing sunglasses, a wide brimmed hat, eating leafy vegetables and fruits and avoiding smoking.
- color blindness - also known as color vision deficiency. It is the decreased ability to see color or differences in color. Reading traffic signals, selecting ripe fruits etc becomes challenging.

- Nyktelopia – also called night-blindness, is a condition making it difficult or impossible to see in relatively low light. It may exist from birth or be caused by injury or malnutrition (vit A deficiency).

Module 2 Auditory System

- Anatomy of the auditory system.



Ear consists of 3 parts,

1. **External ear – formed into 2 parts:- a) Auricle or pinna , b) external auditory meatus.**
2. **Middle ear- 3 structures:- 1. Auditory ossicles, 2. Auditory muscles, 3. Eustachian tube.**
3. **Internal ear – it contains the sense organs of hearing and equilibrium.**

- External ear consists of 2 parts:

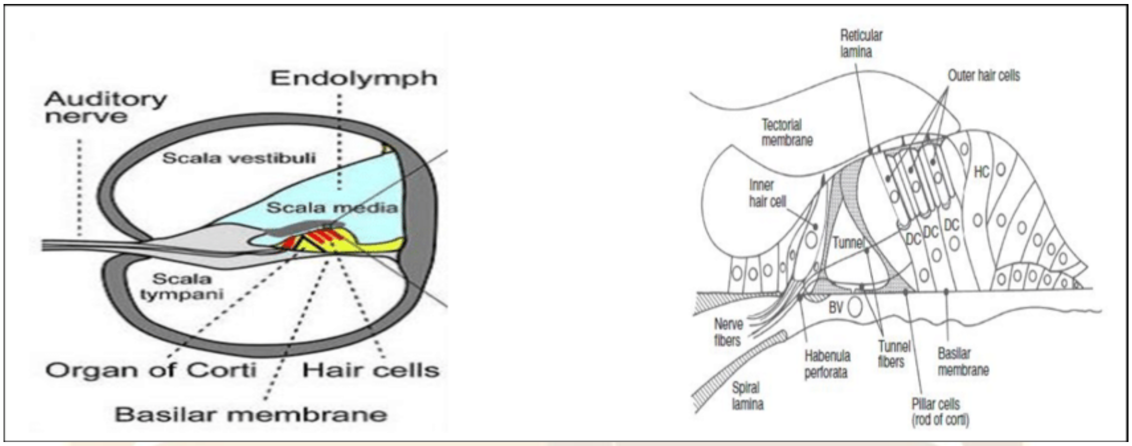
  - Auricle or pinna: auricle, also called pinna, in human anatomy, the visible portion of the external ear, and the point of difference between the human ear and that of other mammals. The auricle in humans is almost rudimentary and generally immobile and lies close to the side of the head. It is composed of a thin plate of yellow elastic cartilage covered by a tight-fitting skin. The external ear cartilage is molded into shape and has well-defined hollows, furrows, and ridges that form an irregular shallow funnel. The deepest depression in the auricle, called the concha, leads to the external auditory canal or meatus. The one portion of the auricle that has no cartilage is the lobule—the fleshy lower part of the auricle. The auricle has several small basic muscles that connect it to the skull and scalp. Generally nonfunctional in human beings, they are capable of limited movement in some people.

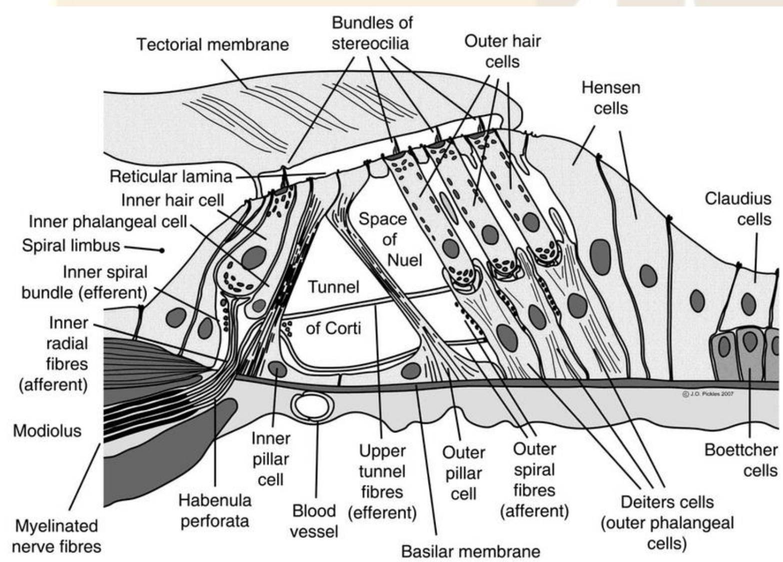
- **external auditory canal**, also called external auditory meatus, or external acoustic meatus, passageway that leads from the outside of the head to the tympanic membrane, or eardrum membrane, of each ear. The structure of the external auditory canal is the same in all mammals. In appearance it is a slightly curved tube that extends inward from the floor of the auricle, or protruding portion of the outer ear, and ends blindly at the eardrum membrane, which separates it from the middle ear. The outside third of the canal wall consists of cartilage, and the inner two-thirds of the wall are made of bone. The canal is nearly 1 inch (2.5 cm) in length and is lined with skin that extends to cover the tympanic membrane. Tiny hairs directed outward and modified sweat glands that produce cerumen (earwax) help to discourage insects from entering the ear.
- **Middle ear:** or tympanic cavity is a small, narrow, irregular, laterally compressed chamber, situated within the temporal bone. It is also known as tympanum. It is separated from external auditory meatus by tympanic membrane. It consists following structures like auditory ossicles, auditory muscles and eustachian tube
- The tympanic membrane is also called the eardrum. It separates the outer ear from the middle ear. When sound waves reach the tympanic membrane, they cause it to vibrate. The vibrations are then transferred to the tiny bones in the middle ear. The middle ear bones then transfer the vibrating signals to the inner ear. The drum membrane has three layers: the outer layer, continuous with the skin on the external canal; the inner layer,

continuous with the mucous membrane lining the middle ear; and, between the two, a layer of radial and circular fibres that give the membrane its tension and stiffness. The membrane is well supplied with blood vessels, and its sensory nerve fibres make it extremely sensitive to pain.

- Auditory ossicles: The auditory ossicles (malleus, incus, and stapes) play a key role in this function. The malleus connects to the tympanic membrane transferring auditory oscillations to the incus and then the stapes. The stapes connects to the oval window allowing for mechanical energy to be transferred to the fluid-filled inner ear.
- Auditory muscles: These two muscles are the tensor tympani (Eustachian) muscle and stapedius muscle. The tensor tympani muscle lies inside a bony canal superior to the pharyngotympanic (Eustachian) tube, and passes posteriorly to insert onto the handle of the malleus. When it contracts, it pulls the handle of the malleus medially which tenses the tympanic membrane. Because the tympanic membrane is tense, it is not able to vibrate as much and the amplitude of oscillations is reduced. This is done in response to loud noises to protect the structures of the internal ear.
- The eustachian tube extends from the middle ear to the upper part of the throat behind the nose. Also known as the auditory tube, it helps keep the middle ear healthy by equalizing pressure, clearing secretions, and protecting it from pathogens that might otherwise cause infections. The eustachian tube consists of bone, cartilage, and fibrous tissue. The hollow tube is lined with cilia, hair-like projections that sweep mucus away from the middle ear toward the nasopharynx. The eustachian tube has three roles in keeping the middle ear healthy. Keeps air pressure equal on both sides of the eardrum. Drains secretions from the middle ear. Protects the middle ear from bacteria and viruses.

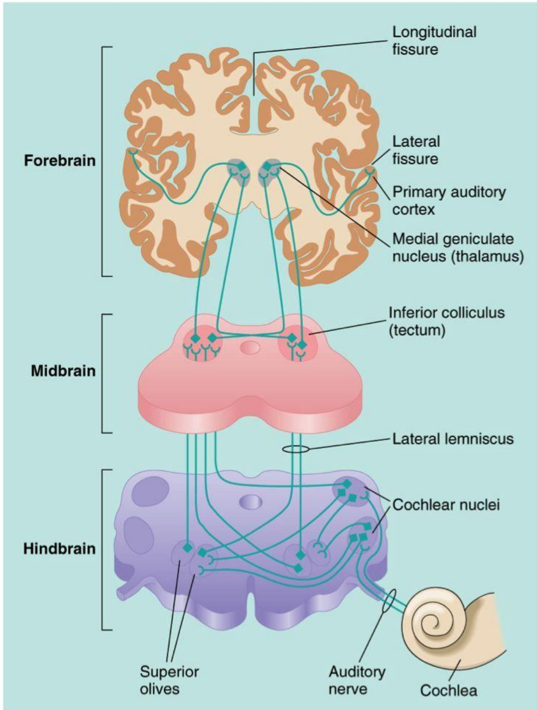
- Internal ear: Inner ear, also called labyrinth of the ear, part of the ear that contains organs of the senses of hearing and equilibrium. The bony labyrinth, a cavity in the temporal bone, is divided into three sections: the vestibule, the semicircular canals, and the cochlea.
- The cochlea is a hollow, spiral-shaped bone found in the inner ear that plays a key role in the sense of hearing and participates in the process of auditory transduction. Sound waves are transduced into electrical impulses that the brain can interpret as individual frequencies of sound. The spiral shape of the cochlea allows for differing frequencies to stimulate specific areas along the spiral. This results in a tonotopic map that enables people to perceive various frequencies of sound. Specific areas along the cochlea are stimulated by vibrations carried within a fluid known as endolymph found in the cochlear duct. The vibrations are then converted to electrical impulses in the cochlear duct through mechanical stimulation of hair cells within a special structure known as the organ of Corti. These nerve impulses are carried by the vestibulocochlear nerve from the cochlea to the brain for interpretation.
- The cochlea is filled with fluid (perilymph and endolymph) and is divided into three chambers called the scala vestibuli, scala media, and the scala tympani. Two of these fluid-filled chambers sense pressure changes (caused by sound) while the third chamber contains the organ of Corti, the cochlear duct and the basilar membrane.

- 

- Organ of corti
- 

- The organ of Corti is a specialized sensory epithelium that allows for the transduction of sound vibrations into neural signals. The organ of Corti itself is located on the basilar membrane. The organ of Corti rests on the basilar membrane and contains two types of hair cells: inner hair cells and outer hair cells.
- Structure of the organ of Corti. Each outer hair cell is supported by a phalangeal cell of Deiters, or supporting cell, which holds the base of the hair cell in a cup-shaped depression. From each Deiters' cell a projection extends upward to the stiff membrane, the reticular lamina, that covers the organ of Corti.

- Italian anatomist Alfonso Giacomo Gaspare Corti (1822–1876) discovered the organ of Corti in 1851. The structure evolved from the basilar papilla and is crucial for mechano-transduction in mammals. Cross-section through the spiral organ of Corti at greater magnification, showing position of the hair cells on the basement membrane.
- Auditory pathways: The auditory pathway conveys the special sense of hearing. Information travels from the receptors in the organ of Corti of the inner ear (cochlear hair cells) to the central nervous system, carried by the vestibulocochlear nerve (CN VIII). This pathway ultimately reaches the primary auditory cortex for conscious perception. First-order neuron: "a first order neuron is in the somatosensory system.". Neuron (neurone) second-order neuron. Neural axis. Spinal root. Motor neuron pool. Unipolar neuron. First-order neurons conduct impulses from receptors of the skin and from proprioceptors (receptors located in a join, muscle or tendon) to the spinal cord or brain stem, where they synapse with second-order neurons. First-order neuron's cell bodes reside in gangion (dorsal root or cranial). The axon of the 1st order neuron will synapse with the 2nd order neuron at the level of the brain stem, which commonly decussate (crosses over) to the opposite side. In turn, the axon of the 2nd order neuron will descend along the spinal cord tracts where it will synapse with the 3rd order neuron. Second order neurons- The neurons of the dorsal and ventral cochlear nuclei in the medulla oblongata form the second order neurons of auditory pathway. The axons of the second order neurons pass through a complex pathway, which runs in four different directions. Ascending & Descending tracts of spinal cord. The 3rd order neuron is located in the ventral horn of the spinal cord, which will exit with the spinal nerve to supply the muscle.

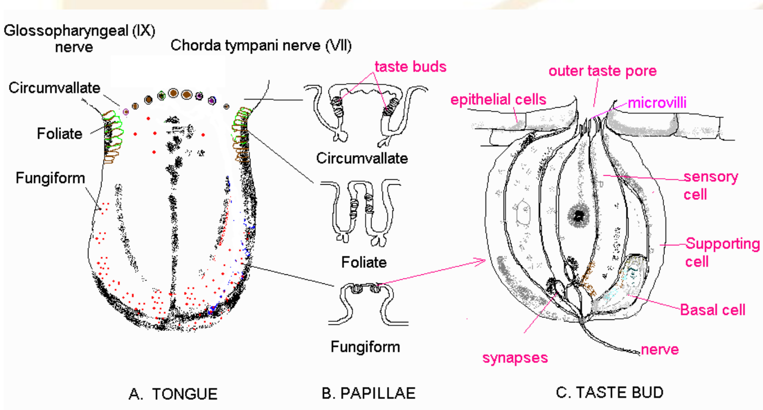
- 

- Auditory perception: Auditory perception refers to the ability of the brain to interpret and create a clear impression of sounds. Good auditory skills enable children to distinguish between different pitches, volumes, rhythms and sources of sounds and words, which has amongst others, significant benefits for learning reading. Transduction of Sound Vibrating objects, such as vocal cords, create sound waves or pressure waves in the air. When these pressure waves reach the ear, the ear transduces this mechanical stimulus (pressure wave) into a nerve impulse (electrical signal) that the brain perceives as sound.
- Hearing abnormalities: Conductive hearing loss is caused by impairment in air transmission of sound waves to the inner ear. The impairment of function is due to pathology at the level of the external auditory canal, the tympanic membrane, or the ossicular chain, resulting in inefficient conversion of sound waves from air to the fluid medium of the endolymph in the membranous labyrinth. A rare cause of conductive

hearing loss is the “third mobile window” of the inner ear, which is attributed to a dehiscent superior semicircular canal or an enlarged vestibular aqueduct.

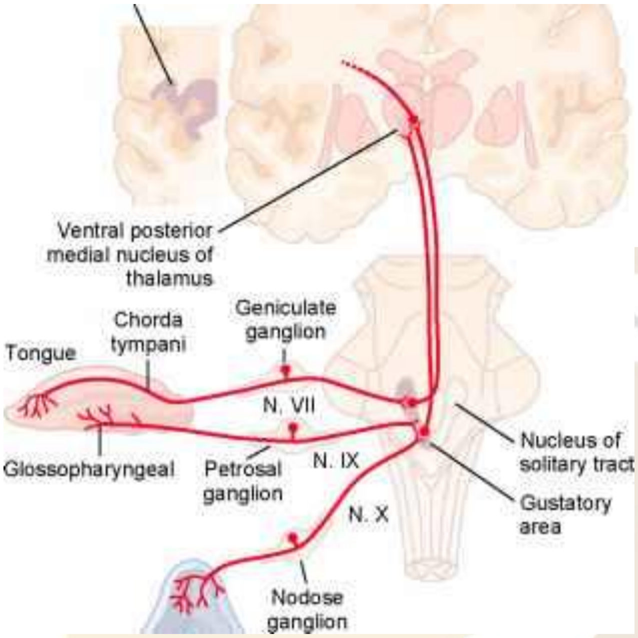
- Sensorineural hearing loss (SNHL) is caused by damage to these special cells, or to the nerve fibers in the inner ear. Sometimes, the hearing loss is caused by damage to the nerve that carries the signals to the brain. Sensorineural deafness that is present at birth (congenital) is most often due to: Genetic syndromes.
- Statorecepectors: a specialized sensory nerve ending that reacts to changes in the position of the body in space. In lower invertebrates, statoreceptors are located in statocysts, which are vesicles of equilibrium. In humans and other vertebrates, the function of statoreceptors is performed by the vestibular apparatus and the organs of sight, the éxteroceptors of the skin, and the proprioceptors of the muscles, tendons, joints, and ligaments.

Module 3 Gustatory and Olfactory system

- Anatomy of taste buds and its function: taste buds are a small organ located primarily on the tongue. The adult human tongue contains between 2,000 and 8,000 taste buds, each of which are made up of 50 to 150 taste receptor cells. Taste receptor cells are responsible for reporting the sense of taste to the brain. Taste buds exist primarily in the small bumps on your tongue, called papillae. They also are present in other parts of the mouth, like the palate and throat. There are four types of papillae:
- Filiform: The most common, covering the tough surface of the tongue, and do not contain taste buds
- Fungiform: Located near the front of the tongue
- Circumvallate: Located near the back of the tongue
- Foliate: Located on the sides of the tongue
- Structure of taste buds:
- 

- primary sensations of taste: Currently five sub-modalities (tastes) are recognized, including sweet, salty, bitter, sour, and umami (savory taste or the taste of protein). Umami is the most recent taste sensation described, gaining acceptance in the 1980s.

- **taste thresholds and intensity discrimination:** In low concentration of taste substance, each taste bud gives response to one primary taste stimulus. The afferent nerve fiber from the taste buds carry impulses of one taste sensation.
- **Threshold for taste sensation:** sweet taste sugar: 1 in 200 dilution; salt taste: 1 in 400dilution ; sour taste: 1 in 15,000dilution; bitter taste: 1 in 2,000,000 dilution.
- **Taste preferences and control of the diet:** this simply means that an animal will choose certain types of food in preferences to others, and the animal automatically uses this to help control the type of diet it eats. The phenomenon of taste preference almost certainly results from some mechanism located in the central nervous system and not from a mechanism in the taste receptors themselves, although it is true that the receptors often become sensitized in favour of a needed nutrient.
- **Taste pathways:** Anatomy of taste pathway (diagram) When the taste buds from the anterior two-thirds of the tongue and soft palate are stimulated, the special visceral afferent fibers of the facial nerve (CN VII) receive that information and leave the oral cavity together with the lingual nerve. Taste buds are formed by groupings of taste receptor cells. Receptor cells protrude into the central pore of the taste bud. Chemical changes within sensory cells, from the taste molecules binding onto the taste receptors, will result in neural impulses that transfer to the brain through other nerves. Where these neural impulses transfer to will depend on where the receptor is located, such as the posterior two thirds of the tongue. Taste information is transmitted to the medulla, thalamus, limbic system, and to the gustatory cortex, which is tucked underneath the overlap between the frontal and temporal lobes.
- **transmission of signals into the central nervous system.**



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- Taste impulses from the anterior two thirds of the tongue pass first into the lingual nerve, then through the chorda tympani into the facial nerve, and finally into the tractus solitarius in the brain stem. Taste sensations from the circumvallate papillae on the back of the tongue and from other posterior regions of the mouth and throat are transmitted through the glossopharyngeal nerve also into the tractus solitarius, but at a slightly more posterior level. Finally, a few taste signals are transmitted into the tractus solitarius from the base of the tongue and other parts of the pharyngeal region by way of the vagus nerve.
- Organization of the olfactory membrane: The olfactory system is the most thoroughly studied component of the chemosensory triad and processes information about the identity, concentration, and quality of a wide range of chemical stimuli. These stimuli, called odorants, interact with olfactory receptor neurons in an epithelial sheet, the olfactory epithelium, that lines the interior of the nose. The axons arising from the receptor cells project directly to neurons in the olfactory bulb, which projects in turn to the pyriform cortex in the temporal lobe.

- sense of smell and stimulation of the olfactory cells: The Nasal Epithelium is a specialized epithelial tissue inside the nasal cavity that is involved in smell. In most vertebrates, the olfactory bulb is the most forward part of the brain.
- In humans, however, the olfactory bulb is on the bottom side of the brain. There are tens of millions of olfactory receptor cells, but only about 2000 glomeruli.
- Glomeruli receive input from between 5000 and 10,000 olfactory receptor cells but output onto only 10 to 25 mitral cells
- The glomerulus (plural glomeruli) in olfaction is a structure in the olfactory bulb. Each odor activates a different pattern of glomeruli.
- Mitral cells are neurons that are part of the olfactory system
- The following items can hurt or eliminate a person's ability to smell or detect odors:
- Medical Conditions: Head trauma, stroke, subdural hematoma, tumors, hemorrhage, infections, seizures and nerve damage, Parkinson's and Alzheimer's diseases
- Physical Changes: Stuffy nose, colds, allergies, mouth breathing, dentures
- Aging and Genetics:Bone deformities, cleft palate, loss of receptors
- Toxic Damage: Acids, solvents, insecticides, chemicals
- Categorizing smell: Now, researchers have used mathematics to describe odors systematically and simplify them into 10 categories: fragrant, woody/resinous, fruity (non-citrus), chemical, minty/peppermint, sweet, popcorn, lemon, pungent and decayed.
- transmission of smell signals into the central nervous system: The olfactory portions of the brain were among the first brain structures developed in primitive animals, and much of the remainder of the brain developed around these olfactory beginnings. In fact, part

of the brain that originally subserved olfaction later evolved into the basal brain structures that control emotions and other aspects of human behavior.

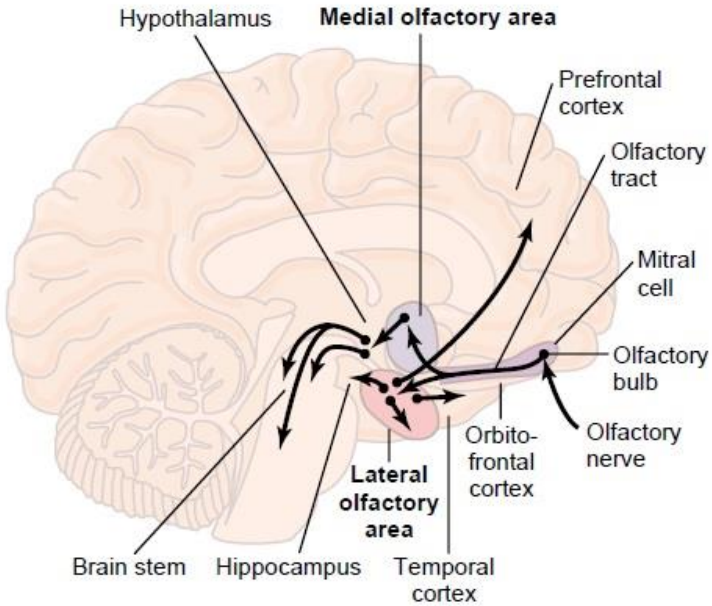

Figure 53–4

Neural connections of the olfactory system.

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Module 4 Cutaneous senses (Somatic sensations)

- The somatic (general) senses collect information about cutaneous sensations **(tactile sensations on the surface of the skin)** and proprioceptive sensations.
- Classification - the mechanoreceptive somatic senses (tactile and position): The somatic senses can be classified into three physiologic types: (1) the mechanoreceptive somatic senses, which include both tactile and position sensations that are stimulated by mechanical displacement of some tissue of the body; (2) the thermo-receptive senses, which detect heat and cold; and (3) the pain sense, which is activated by any factor that damages the tissues
- Detection and transmission of tactile sensations - tactile receptors, detection of vibration, tickling and itch: Although touch, pressure, and vibration are frequently classified as separate sensations, they are all detected by the same types of receptors. There are three principal differences among them: (1) touch sensation generally results from stimulation of tactile receptors in the skin or in tissues immediately beneath the skin; (2) pressure sensation generally results from deformation of deeper tissues; and (3) vibration sensation results from rapidly repetitive sensory signals, but some of the same types of receptors as those for touch and pressure are used.
- **Tactile Receptors.** There are at least six entirely different types of tactile recep-tors, but many more similar to these also exist.
- Free nerve endings, Meissner's corpuscle, fingertips, movement of any hair on the body, deeper layers of the skin, pacinian corpuscles.

- Sensory pathways for transmitting somatic signals into the central nervous system: Almost all sensory information from the somatic segments of the body enters the spinal cord through the dorsal roots of the spinal nerves. However, from the entry point into the cord and then to the brain, the sensory signals are carried through one of two alter-native sensory pathways: (1) the dorsal column–medial lemniscal system or (2) the anterolateral system. These two systems come back together partially at the level of the thalamus.

- somatosensory cortex: The somatosensory cortex lies on a ridge of the cerebral cortex called the **postcentral gyrus**
- position senses: The position senses are frequently also called proprioceptive senses. They can be divided into two subtypes: (1) static position sense, which means conscious perception of the orientation of the different parts of the body with respect to one another, and (2) rate of movement sense, also called kinesthesia or dynamic proprioception.
- Position Sensory Receptors. Knowledge of position, both static and dynamic, depends on knowing the degrees of angulation of all joints in all planes and their rates of change.
- Thermal sensations: Thermal sensation has a large influence on thermal comfort, which is an important parameter for building performance. Understanding of thermal sensation may benefit from incorporating the physiology of thermal reception. The main issue is that humans do not sense temperature directly; the information is coded into neural discharge rates.
- thermal receptors, their excitation and transmission of thermal signals: Thermal gradations are discriminated by at least three types of sensory receptors: cold receptors, warmth receptors, and pain receptors. The pain recep-tors are stimulated only by extreme degrees of heat or cold and, therefore, are responsible, along with the cold and warmth .
  - the effects of different temperatures on the responses of four types of nerve fibers: (1) a pain fiber stimulated by cold, (2) a cold fiber, (3) a warmth fiber, and (4) a pain fiber stimulated by heat., for “freezing cold” and “burning hot” sensations.

- Pain : The sensation of pain involves communication between your nerves, spinal cord, and brain. There are different types of pain, depending on the underlying cause. We all feel pain in different ways, so you may find it difficult to describe the type of pain you're feeling to others
- Purpose: Pain is a universal experience that serves the vital function of triggering avoidance. The pain sensation is a necessary part of being human. Pain sensation is a fact of life. Even the primitive amoeba takes avoiding action in the face of adverse events
- Types: pain can be either acute or chronic
- Acute pain: the pain is generally intense and short-lived. Different types are;
- somatic pain -a person feels this superficial pain on the skin or the soft tissues just below the skin.
- **Visceral pain:** This pain originates in the internal organs and the linings of cavities in the body
- **Referred pain:** A person experiences visceral pain at a location other than the source of tissue damage. For example, people often experience shoulder pain during a heart attack.
- **Chronic pain:** pain lasts far longer than acute pain, and often no cure.
- pain receptors: Pain receptors, also called **nociceptors**, are a group of sensory neurons with specialized nerve endings widely distributed in the skin, deep tissues (including the muscles and joints), and most of visceral organs.
- pain suppressive system: This pain suppression system is organized at three levels of the neuraxis: midbrain, medulla, and spinal cord. Activation of neurons in the midbrain periaqueductal gray matter (by electrical stimulation, opiates, and possibly psychological factors) excites neurons of the rostral medulla, some of which contain serotonin. Pain Suppression Analgesia System in the Brain and Spinal Cord. The serotonin causes local

cord neurons to secrete enkephalin as well. The enkephalin is believed to cause both presynaptic and postsynaptic inhibition of incoming type C and type AS pain fibers where they synapse in the dorsal horns.

- pain sensation: The sensation of pain is a result of pH alterations secondary to tissue demise and bacterial degradation, edema, and subsequent tissue hypoxemia caused by vasoconstriction or pressure on vital capillaries from swelling at the site of injury (Simon et al., 2018).

Module 5 Endocrine system

- Introduction to endocrinology: Endocrinology is the understanding of hormone secretion, hormone action, and principles of feedback control
- The endocrine system is evaluated primarily by measuring hormone concentrations
- Principles of endocrinology Functions of hormones and their regulation Chemical signalling - endocrine, paracrine, autocrine and intracrine mechanisms Chemical classification of hormones and their synthesis Hormone synthesis Transport of hormones in the circulation and their half-lives. The term endocrine was coined by Starling
- an overview of the importance of endocrine glands: The endocrine system has important parts to play in the human body. This system consists of glands that can be observed throughout the human body, from the head all the way down towards the genital region of the body. The purpose of these glands that are part of the endocrine system is to produce a large variety of hormones.
- Hormones play a vital role in various activities in the body including growth and development. They also support the nervous system. Endocrine glands in animals are the hypothalamus, the pituitary gland, the pineal gland, the thyroid, the parathyroid, the thymus, the pancreas, the adrenal gland and the gonads.
- These hormones are produced in our body through nine primary glands and these glands, along with other organs that provide auxiliary functions make up the endocrine system. Let us have a detailed look at the endocrine system notes and explore the major endocrine glands in the human body.
- Numerous involuntary physiological activities are under the control of the endocrine system. It consists of glands which release hormones. Endocrine glands are also called

ductless glands. Hormones play a vital role in various activities in the body including growth and development.

- Mode of action of hormones and influence on growth and behavior: A Hormone is a tiny chemical messenger, travelling along with the bloodstream. It exists to maintain internal balance or in other words, keeps the human body in a state of homeostasis.
- This is an extremely rudimentary definition of hormones, as in reality there are numerous hormones that perform an immense number of functions for various purposes. Starting with receptors, they are specific for every hormone. Their sensitivity and responsiveness are dependent on both, the number of receptors and its affinity. Also, the site of the receptor might be: Present in or on the surface of the cell membrane. g. protein or peptide hormones and catecholamines.

In the cytoplasm. E.g. steroid hormones; Or

In the cell nucleus. E.g. thyroxine.

- Furthermore, hormones can be divided into groups on the basis of their chemical nature:

Peptide, polypeptide, protein hormones.

Steroid s

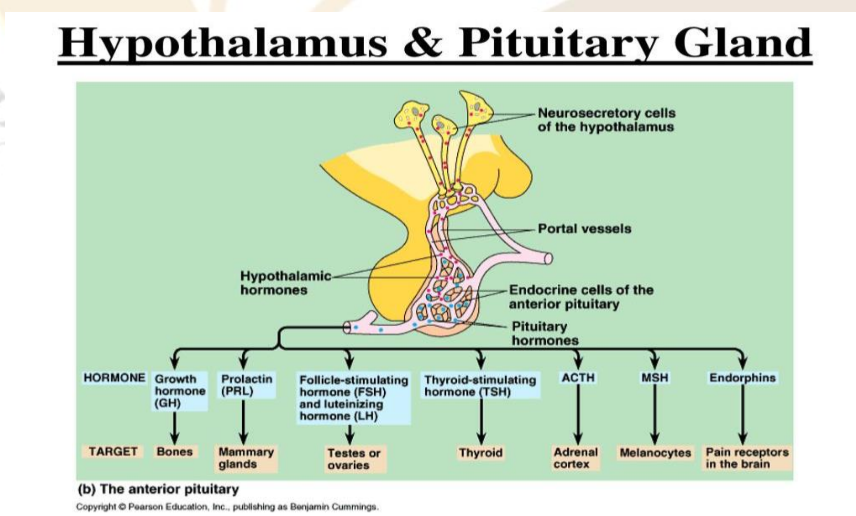
Iodothyronines (thyroid hormone).

Amino acid derivatives.

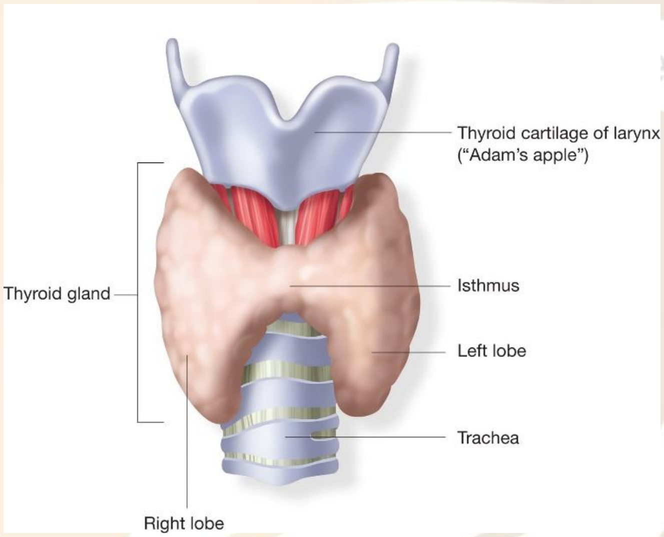
- The hormones that interact with membrane-bound receptors generally don't enter target cells, rather generate second messengers that proceed to regulate cellular metabolism.
- On the other hand, hormones which interact with intracellular receptors mostly regulate gene expression or chromosome function by the interaction of hormone receptor complex

with the genome. The sum total of all the biochemical actions results in physiological and developmental effects.

- Major endocrine glands - their location, structure, hormones produced and its role
    - Hypothalamus: Hypothalamus is a minute region, almost the size of an almond, present at the centre of the human brain, near the pituitary gland. three main regions- anterior, middle and posterior. It plays a vital role in the production of hormones. Maintaining the hypothalamus health is very important. Its improper functioning causes several disorders.
    - Pituitary: The pituitary is an endocrine (hormone-producing) gland that sits just beneath the base of the brain, behind the bridge of the nose. It is very small , the size of a pea. The pituitary gland is called the 'master gland' as the hormones it produces control so many different processes in the body. It senses the body's needs and sends signals to different organs and glands throughout the body to regulate their function and maintain an appropriate environment.



    - Thyroid: A gland that makes and stores hormones that help regulate the heart rate, blood pressure, body temperature, and the rate at which food is converted into energy. Thyroid hormones are essential for the function of every cell in the body. The thyroid gland, in particular, controls just about every cell in the human body. It secretes hormones calcitonin, T4 thyroxine, or tetraiodothyronine and T3 triiodothyronine into the bloodstream.



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- Adrenal: A small gland that makes steroid hormones, adrenaline, and noradrenaline. These hormones help control heart rate, blood pressure, and other important body functions. There are two adrenal glands, one on top of each kidney. Also called suprarenal gland. The adrenal glands are located in the posterior abdomen, between the superomedial kidney and the diaphragm. They are retroperitoneal, with parietal peritoneum covering their anterior surface only. The right gland is pyramidal in shape, contrasting with the semi-lunar shape of the left gland. They control many important functions, including:

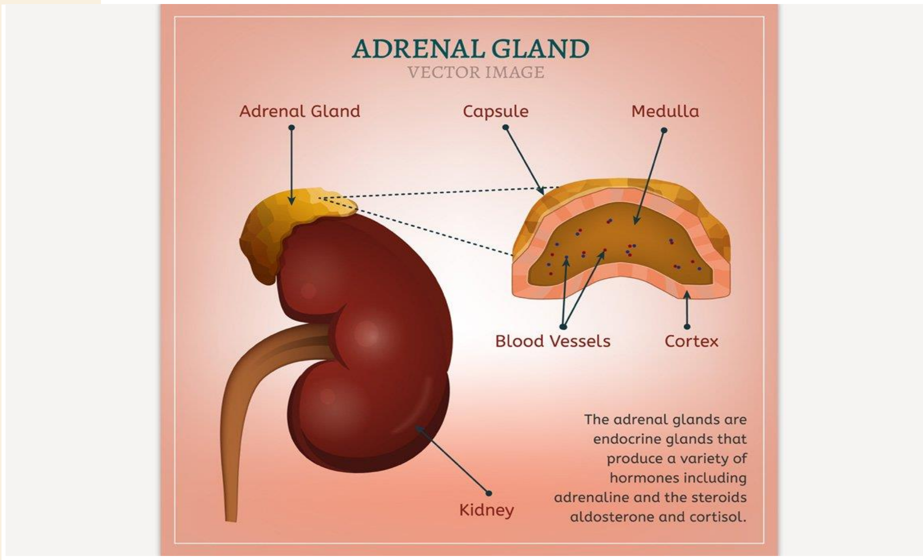
    1. Metabolism
    2. Blood sugar levels
    3. BP
    4. Salt and water balance

5. Pregnancy

6. Sexual development before and during puberty

7. Stress response

8. Balance of sex hormones, including estrogen and testosterone.



- Gonads: Primary reproductive gland that produces reproductive cells (gametes). In males the gonads are called testes; the gonads in females are called ovaries. (see ovary testis). Sex glands develop in a pair of longitudinal ridges located alongside the mesentery, the anchoring fold of membrane to the gut. To make haploid cells in humans, a gonad facilitates a special type of cell division known as meiosis. During meiosis, a diploid cell's DNA is doubled, creating 92 chromosomes, which are then split into 4 cells. Each cell is unique and contains 23 unpaired chromosomes.
- Thymus: An organ that is part of the lymphatic system, in which T lymphocytes grow and multiply. The thymus is in the chest behind the breastbone. Thymus, pyramid-shaped lymphoid organ that, in humans, is immediately beneath the breastbone at the level of the heart. The organ is called thymus because its shape resembles that of a thyme

leaf. The thymus functions chiefly to develop T lymphocytes. Once mature, these cells leave the thymus and are transported via blood vessels to the lymph nodes and spleen.

- pineal body: The pineal gland (or pineal body) is a small, pine-cone shaped organ that lies within the roof of the third ventricle, deep within the brain. Autopsy studies have shown that the average size of the pineal gland is similar to that of a grain of rice. The ventricles are fluid-filled spaces, and the third ventricle extends from the large lateral ventricles to the narrow cerebral aqueduct, passing between the two halves of the part of the brain called the diencephalon. It is located within an area called the epithalamus, just behind the thalamus and above the cerebellum, resting at the back of the brain, near the brain stem. There is a small fluid-filled pineal recess that projects into the stalk of the pineal body, allowing for the hormones it produces to more easily be diffused throughout the brain.
- Placenta: Placenta refers to the temporary vascular organ found in mammals, which attaches the fetus to the uterus of the mother during pregnancy. The placenta is the passage that unites the fetus to the mother. The placenta facilitates the exchange of nutrients and oxygen to the fetus. The placenta is a structure that forms a strong bond between the fetus and the mother. A number of finger-like projections known as chorionic villi grow into uterine tissue from the chorion's outer surface. These villi pierce the mother's uterine wall and create the placenta. The placenta is a connective tissue that connects the fetal membrane to the inner uterine wall. As a result, the placenta is regarded as both embryonic as well as maternal. The developing embryo absorbs oxygen and nutrients from the mother via the placenta while eliminating carbon dioxide and nitrogenous waste. The placenta serves as a lifeline between the mother and the

fetus, ensuring that the fetus receives the nutrients it requires from the mother's body in order to survive. At the same time, it works as a barrier, protecting the fetus from several maternal infections.

Go for further reading;

- Guyton & Hall, Textbook of Medical Physiology 12 Edn., Saunders.
- Dr.Sumodan P.K,(2020);*complementary course for human physiology Part-II*; Calicut University central co-operative stores Ltd.
- Visual Perception - an overview | ScienceDirect Topics
- https://www.ncbi.nlm.nih.gov/books/NBK532311/#:~:text=The%20auditory%20system%20processes%20how,nuclei%2C%20and%20auditory%20cortex
- https://www.verywellhealth.com/what-is-the-eustachian-tube-1192115
- https://www.ncbi.nlm.nih.gov/books/NBK531483/#:~:text=The%20cochlea%20is%20a%20hollow,as%20individual%20frequencies%20of%20sound
- Cochlea: Anatomy, Function, and Treatment (verywellhealth.com)
- Anatomy, Head and Neck, Ear Organ of Corti - StatPearls - NCBI Bookshelf (nih.gov)
- Perfect Explanation of the Trichromatic Theory of Color Vision - Art Hearty
- Taste Pathways – Introduction to Sensation and Perception (umn.edu)
- Transmission of Taste Signals into the Central Nervous System - Medical Physiology (euroformhealthcare.biz)
- The Organization of the Olfactory System - Neuroscience - NCBI Bookshelf (nih.gov)

Transmission of Smell Signals into the Central Nervous System (brainkart.com)

- Classification Of Somatic Senses - Medical Physiology (euroformhealthcare.biz)
- Detection and Transmission of Tactile Sensations (brainkart.com)