Physiology of Vision

Almost 80% of our sensory responses from the environment is said to be perceived through the eyes. This processing of visual perception holds one-quarter of one's brain. The process of visual perception is a highly complicated process. It comprises three main sections –

- Optics of the eye
- Detection of photon and the first image processing in the retina
- Signal transmission and hence the processing of the visual cortex of the brain

Structure of the Eye

Although the eye is a small structure, it is the most complex organ of the human body. The eye is placed in a bony socket in the skull which extends only a small part outside that is visible. The eye wall comprises three layers – innermost, outermost and the middle layer.

Innermost layer –

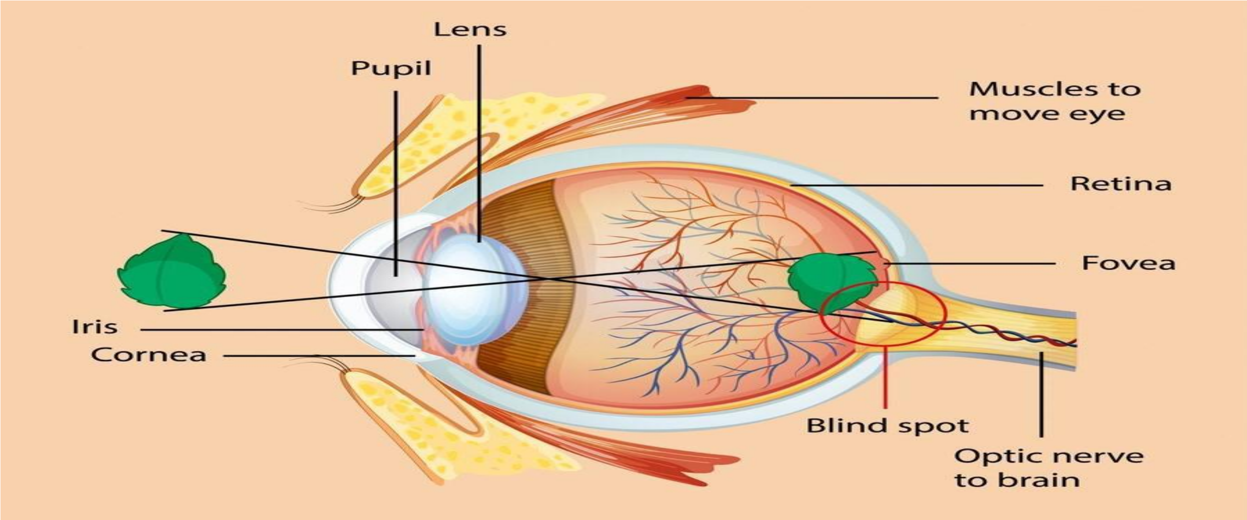
Here is the retina, it can be seen located directly behind the eyeball. The capillary found in the middle choroid nourishes the retina when available. It is the light sensitive part of the eye because it has many photoreceptors that are of two kinds (cones and rods). Rods are accountable for white and black visions and functional to see at night. Cones, on the other hand, account for different colour visions.

Middle layer –

It is the choroid comprising black pigmented cells, richly supplied with blood capillaries. This layer forms the ciliary body and iris.

Outermost layer –

It is also referred to as the sclera. It is a whitish tough layer comprising tissues which are connected together. This sclera functions to primarily protect and maintain the shape of the eyeball.



Different Parts of the Eye

The eye comprises several structures, take a look at the table for details of each structure.

Eye structure	**Description**
Cornea	It is a domed shaped structure shielding the eye against anything which can cause harm to the eye.
Lens	It is a very transparent layer, post the pupils takes in ambient light, then the lens focuses the light onto the retina.
Sclera	It forms the outermost part of the eye. It is white in appearance and is accountable to maintain the eyeball’s shape.
Retina	Located at the back of the eye. Its main role is in receiving light from the focus and passing it to electrical impulses before it reaches the brain.
Pupil	It is seen at the eye’s center. It is like a black dot having a tiny hole which enables light to pass.

Choroid	Forms the interphone between the sclera and the retina accountable for rendering nutrients to other portions of the eye.
Macula	Found in proximity to the retina. It aids the eye to focus on an object.
Conjunctiva	Conjunctiva gland is the part comprising mucus to moisten the eye. It aids in always keeping the eye moist. In the event of malfunction or failure of this gland, serious itching or pain can occur. It is also responsible to protect the cornea.
Iris	Colour of the eye is determined by this. This part imparts the eye with the colour. It surrounds the pupils by all sides. The iris shrinks and widens the pupils based on the light's intensity entering the eye. The iris widens the pupil if the light is low and vice versa.
Optic nerves	Bundle of nerves carrying impulses to the brain from the retina.
Anterior and posterior chambers	The front part in the interior of the eye section forms the anterior chamber and the back part forms the posterior chamber.

Physiology of Vision

Visual process is the series of actions that take place during visual perception. During the visual process, the image of an object seen by the eyes is focused on the retina, resulting in the production of visual perception of that object.

The physiological events which take place are as follows –

- Light's refraction which enters the eye
- Image focuses on the retina by accommodation of lens
- Image convergence
- Photochemical activity in the retina and the conversion into neural impulse
- To process in the brain and then perception

All the parts of the eye function together thus enabling us to see. At first light enters through the clear front layer of the eye, the cornea. Due to its structure (dome-shaped), it bends light to aid the eye in focusing.

Some part of this light passes the eye through the pupil opening. The coloured part of the eye, the iris, regulates how much light enters the pupil.

Light enters through the lens then when the lens functions with the cornea to focus light aptly on the retina. When light passes the retina, special cells referred to as photoreceptors convert light into electrical signals. These signals pass from the retina to the brain through the optic nerve. The brain then turns signals into images which we see.

Anatomy and Physiology of the Ear

What is the ear?
The ear is the organ of hearing and balance. The parts of the ear include:

- **External or outer ear**, consisting of:
    - **Pinna or auricle.** This is the outside part of the ear. **Pinna** is the outermost part, it has very fine hairs and glands. The glands secrete wax. It protects foreign organisms and dust from entering. The curved S-shaped tube about 2.5cm, its outer 1/3rd is elastic cartilage and its inner 2/3rd is bony in nature.
- ○
    - **External auditory canal or tube.** This is the tube that connects the outer ear to the inside or middle ear. **External auditory canal or meatus** is connected to pinna at the outer side and extends till tympanic membrane or eardrum. They also have wax glands.
- ○
- **Tympanic membrane (eardrum).** The tympanic membrane divides the external ear from the middle ear. **Tympanic membrane or eardrum** is made up of connective tissue. Skin covers the outer portion and from inside, it is covered by mucous membrane. The tympanic membrane separates the outer ear from the middle ear.

Outer ear Anatomy

Auricle is found closed to the side of the head and comprises of a fine plate of yellow elastic cartilage which is molded into distinct ridges, furrows and hollows forming an irregular shallow funnel. The concha is the deepest depression leading to the external auditory canal. The helix emerges from the base of the concha continuing as the rim of the upper part of the auricle. The antihelix in the inner ridge engirdles the concha and is separated by the scapha from the helix.

The external auditory canal is somewhat curved tube extending inwards from the base of the concha and blindly terminates at the tympanic membrane. In its exterior third, the wall of the canal comprises the cartilage and inner comprises the bone. The stretched passage is lined with skin covering the exterior surface of the tympanic membrane. Thin hair directed to the exterior and modified sweat glands producing earwax line the canal and prevent entry of foreign particles.

Pinna receives the sound in the form of vibration. The sound waves reach and vibrate the eardrum through the external auditory canal.

- **Middle ear (tympanic cavity)**, consisting of:
  - **Ossicles.** Three small bones that are connected and send the sound waves to the inner ear. The bones are called:
    - Malleus is a hammer-shaped bone, attached to the tympanic membrane.
    - Incus is an anvil-shaped bone, present between the malleus and stapes.
    - Stapes is the smallest bone of the body. It is stirrup-shaped and attached to the oval window of the cochlea.
  - **Eustachian tube.** A canal that links the middle ear with the back of the nose. The eustachian tube helps to equalize the pressure in the middle ear. Equalized pressure is needed for the correct transfer of sound waves. The eustachian tube is lined with mucous, just like the inside of the nose and throat.
    - The middle ear amplifies the sound waves and transmits to the inner ear.
    - The middle ear cavity is an air-filled, narrow space. The upper and lower chamber, the tympanum and epitympanum are as a result of a small constriction. The chambers are called atrium and attic. The space of the middle ear somewhat appears as a rectangular room having 4 walls, a roof and a floor. The lateral wall is formed by the tympanic membrane while the superior wall is a bone separating the cranial and middle ear cavity and the brain.
    - The inferior wall is a thin plate separating the middle ear cavity from the jugular vein and that of the carotid artery. The posterior wall somewhat separating the middle ear cavity from the mastoid antrum. In the anterior wall the eustachian tube opening can be found, connecting the middle ear to the nasopharynx. The inner wall separating the middle from the inner ear forms a section of the otic capsule of the inner ear.

The inner ear anatomy consists of the following parts –

Inner ear is the part of the ear containing the structures of the senses of equilibrium and hearing. A cavity in the temporal bone – the bony labyrinth is split into 3 sections – the semicircular canals, vestibule, and the cochlea.

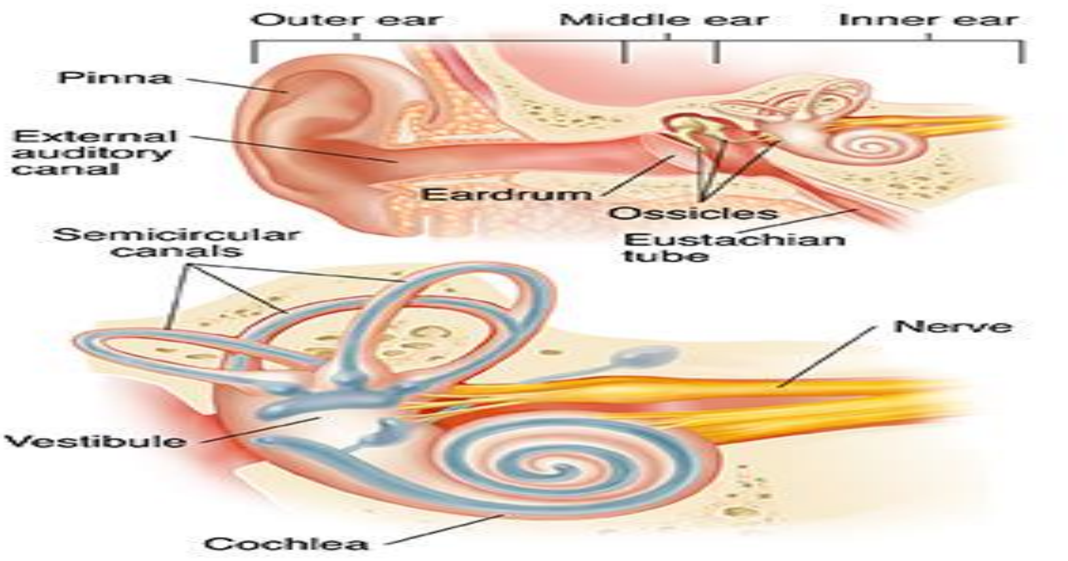
- The inner ear is called the **labyrinth**. It is composed of a group of interconnected canals and sacs.
- The membranous labyrinth is present inside the bony labyrinth and surrounded by a fluid known as **perilymph.**
- The **endolymph** is filled within the membranous labyrinth.
- Auditory receptors are located in the cochlea and vestibular apparatus maintains the body balance.

- **Cochlea.** This contains the nerves for hearing. The Cochlea is a coiled portion of the membranous labyrinth, which looks like a snail.
- The cochlea is made up of three canals, upper vestibular canal or scala vestibuli, middle cochlear duct or scala media and the lower tympanic canal or scala tympani, which are separated by thin membranes.
- The scala vestibuli is filled with the perilymph and terminates at the oval window.
- The scala tympani is also filled with the perilymph and ends at the opening in the middle ear, i.e. round window.
- The **Reissner's membrane** separates scala media and scala vestibuli.
- The scala media is filled with endolymph and contains the auditory organ, **the organ of Corti.**
- Each organ of Corti contains ~18000 hair cells. Hair cells are present in the **basilar membrane**, which separates scala media from scala tympani.
- **Stereocilia** project from the hair cells and extend till the cochlear duct. There is another membrane called the tectorial membrane present above hair cells.
- Hair cells present in the cochlea detect pressure waves, there are sensory receptors (afferent nerves) present at the base of hair cells that send signals to the brain.

- **Vestibule.** This contains receptors for balance.
  - Vestibule of the ear maintains the equilibrium and is present above the cochlea. It is present in the membranous labyrinth. It has two sac-like chambers called saccule and utricle and three semicircular canals.
  - **Saccule and utricle** have macula, which is a projecting ridge.
  - **Macula** has hair cells, which are sensory. Stereocilia protrude out from the hair cells.
  - Stereocilia are covered by ampullary cupula, which is gelatinous and otoliths are embedded in it.
  - **Otoliths** are calcium ear stones, which press stereocilia against gravity and play an important role in spatial orientation.

- Each semicircular canal is filled with endolymph and present at the right angle to each other and connects to the utricle. The base of canals is swollen and known as the **ampulla.**
- **Crista ampullaris** is present in each of the ampulla and responsible for sensing angular rotation. It has hair cells.
- There are no otoliths present in cristae like maculae of saccule and utricle and stereocilia of hair cells are stimulated by the movement of endolymph in the canals.

- **Semicircular canals.** This contains receptors for balance.
- The three semicircular canals of the bony labyrinth are delegated as per its position – posterior, horizontal, superior. The posterior and superior canals are in diagonal vertical planes intersecting at right angles. Each canal has the ampulla opening into the vestibule. Ampullae or superior and horizontal canals are found above the oval window however, the ampulla of the posterior canal leads to the opposite side of the vestibule. The vestibular aqueduct is near the mouth opening into the cranial cavity. The vestibule completes the circle for every semicircular canal.



Physiology of Ear

Ears perform two main functions, hearing and equilibrium maintenance.

- The organ of Corti (Cochlea) is responsible for hearing function.
- Maculae (Saccule and Utricle) are responsible for static equilibrium.
- Cristae (semicircular canals) are responsible for dynamic equilibrium.

Mechanism of Hearing

1. The pinna receives the sound waves and it reaches the tympanic membrane through the meatus.
2. The eardrum vibrates and these vibrations get transmitted to the three ossicles present in the middle ear.
3. Malleus, incus and stapes amplify the sound waves.
4. These vibrations then reach the perilymph (scala vestibuli) through the oval window.
5. Then the pressure waves get transferred to the endolymph of scala media and reach basilar membrane and then to perilymph of scala tympani. This movement of fluid is facilitated by the round window present at the end of scala tympani.
6. The basilar membrane movement causes rubbing of stereocilia against the tectorial membrane.
7. Stereocilia are bent resulting in the opening of ion channels in the plasma membrane of hair cells. Glutamate, a neurotransmitter, is released due to Ca^{++} ion movement inside the cell.
8. These neurotransmitters bind to the receptors of afferent neurons, which synapse with hair cells causing depolarisation of neurons. A nerve impulse is generated and transmitted to the auditory cortex of the brain through the auditory nerve (cranial nerve VIII).
9. The brain analyses the impulses and we hear the sound. The brain not only recognises the sound but also judges the direction, loudness and pitch of the sound.

Mechanism of Maintaining Equilibrium

We all know that hearing ability is due to ears. Other than hearing, ears are also responsible for maintaining equilibrium.

The vestibular apparatus is the main organ for maintaining equilibrium.

Static equilibrium is maintained by macula of saccule and utricle. Otoliths press against stereocilia due to gravitational pull and stimulate the initiation of a nerve impulse. When the head is tilted or moves in a straight line with increasing speed, otoliths press on stereocilia of different cells. The brain interprets the nerve impulses resulting in the awareness of body position with respect to ground, irrespective of the head position.

Utricle responds to the vertical movement and Saccule responds to the sideways movement of the head.

Dynamic equilibrium is detected by cristae of semicircular canals.

integumentary system

sThe integumentary system is the largest organ of the body that forms a physical barrier between the external environment and the internal environment that it serves to protect and maintain. The integumentary system includes the epidermis, dermis, hypodermis, associated glands, hair, and nails. In addition to its barrier function, this system performs many intricate functions such as body temperature regulation, cell fluid maintenance, synthesis of Vitamin D, and detection of stimuli. The various components of this system work in conjunction to carry out these functions—for example, body temperature regulation occurs through thermoreceptors that lead to the adjustment of peripheral blood flow, degree of perspiration, and body hair.

Go to:

Organ Systems Involved

Components of the Integumentary System

Skin: The skin is made up of two layers—the superficial epidermis and the deeper dermis.

The epidermis is the tough outer layer that acts as the first line of defense against the external environment. It is composed of stratified squamous epithelial cells that further break down into four to five layers. From superficial to deep, the primary layers are the stratum corneum, stratum granulosum, stratum spinosum, and stratum basale. In the palms and soles, where the skin is thicker, there is an additional layer of skin between the stratum corneum and stratum granulosum called the stratum lucidum. The epidermis regenerates from stem cells located in the basal layer that grow up towards the corneum. The epidermis itself is devoid of blood supply and derives its nutrition from the underlying dermis.

The dermis is the underlying connective tissue framework that supports the epidermis. It further subdivides into two layers—the superficial papillary dermis and the deep reticular layer. The papillary layer forms finger-like projections into the epidermis, known as dermal papillae, and consists of highly vascularized, loose connective tissue. The reticular layer has dense connective tissue that forms a strong network.[1] The dermis as a whole contains blood and lymph vessels, nerves, sweat glands, hair follicles, and various other structures embedded within the connective tissue.

Hypodermis: The hypodermis lies between the dermis and underlying organs. It is commonly referred to as subcutaneous tissue and is composed of loose areolar tissue and adipose tissue. This layer provides additional cushion and insulation through its fat storage function and connects the skin to underlying structures such as muscle.

Hair: Hair is derived from the epidermis but grows its roots deep into the dermis. Its structure divides into the externally visible hair shaft and the hair follicle within the skin. The hair follicle has an intricate structure that contains the hair bulb that actively divides to extend the hair shaft vertically.[2] Hair generally categorizes into hormone-dependent, thicker terminal hairs in regions such as the axilla, pubic areas, scalp, chest, etc., and androgen-independent vellus hairs that cover the rest of the areas.[2] Hair growth has multiple phases called anagen (growth phase), catagen (nonproliferative phase), and telogen (resting phase) that cycles depending on hormones and nutrients.[3] Hair covers the majority of the body with the few exceptions of the palms, soles, lips, and portions of external genitalia. Hair serves as mechanical protection for the skin, increases sensory function, and aids in regulating body temperature. Arrector pili muscles located in the dermis attach to hair follicles, helping the shaft to stand and trap air close to the epidermis for temperature control.

Nails: Nails form as layers of keratin and appear at the dorsal tips of the fingers and toes.[4] The nail growth begins at the nail matrix that creates new cells and pushes old cells out distally. The visible portion of the nail is the nail plate covering the nail bed, where it adheres to the finger. Nails function to protect the fingers and toes while increasing the precision of movements and enhancing sensation.

Associated Glands: There are four types of exocrine glands within human skin—sudoriferous, sebaceous, ceruminous, and mammary glands.

Sudoriferous glands, also known as sweat glands, are further divided into eccrine and apocrine glands. Eccrine glands are distributed throughout the body and primarily produce serous fluid to regulate body temperature.[5] Apocrine glands are present in the axilla and pubic area and produce milky protein-rich sweat.[5] These glands are responsible for odor as bacteria break down the secreted organic substances.

Sebaceous glands are part of the pilosebaceous unit, including the hair, hair follicle, and arrector pili muscle.[6] It secretes an oily substance called sebum, a mixture of lipids that forms a thin film on the skin. This layer adds a protective layer, prevents fluid loss, and also plays an antimicrobial role.[7][8]

Go to:

Function

Physical protection: Given that the integumentary is the covering of the human body, its most apparent function is physical protection. The skin itself is a tightly knit network of cells, with each layer contributing to its strength. The epidermis has an outermost layer created by layers of dead keratin that can withstand wear and tear of the outer environment, while the dermis provides the epidermis with blood supply and has nerves that bring danger to attention amongst other functions. The hypodermis provides physical cushioning to any mechanical trauma through adipose storage, and the glands secrete protective films throughout the body. The nails protect the digits, which are prone to repeated trauma by creating a hard covering, and hairs throughout the body filter harmful particles from entering the eyes, ears, nose, etc.

Immunity: The skin is the body's first line of defense as it acts as the physical barrier that prevents direct entry of pathogens. Cells are connected through junction proteins with reinforcement by keratin filaments.[9]

Antimicrobial peptides (AMPs) and lipids on the skin also act as a biomolecular barrier that disrupts bacterial membranes. AMPs, such as defensins and cathelicidins, are produced by various cells in the skin, such as dendritic cells, macrophages, glands, etc., and are activated by proteolytic cleavage with stimulation. Lipids, such as sphingomyelin and glucosylceramides, are stored in lamellar bodies found in the stratum corneum and display antimicrobial activity.[9]

An additional aspect of the skin's immunity lies in the resident immune cells. Both myeloid and lymphoid cells are present in the skin, and some, such as the Langerhans cells or dermal dendritic cells, possess the capability to travel to the periphery and activate the greater immune system.[9]

Wound healing: When our body undergoes trauma with a resulting injury, the integumentary system orchestrates the wound healing process through hemostasis, inflammation, proliferation, and remodeling.[9]

Hemostasis occurs through tissue factor located in subendothelial spaces of the skin, which triggers the coagulation cascade to form a fibrin clot.

In the following inflammatory phase, immune cells such as neutrophils and monocytes will infiltrate the injury site to attack pathogens and clear out debris.

The proliferative phase involves the multiplication of resident cells such as keratinocytes and fibroblasts that contribute to the formation of granulation tissue. Through a matrix of immune cells and the eventual formation of a collagen network by fibroblasts and myofibroblasts, the new extracellular matrix forms.[9]

The final remodeling phase consists of apoptosis as cells are no longer needed and excess structures are broken down in efforts to restore the original architecture. Macrophages secrete matrix metalloproteases that remove excess collagen, and remaining immature collagen matures to finalize the extracellular matrix.[9]

Vitamin D synthesis: The primary sources of vitamin D are sun exposure and oral intake. With ultraviolet sunlight exposure, 7-dehydrocholesterol converts to vitamin D3 (cholecalciferol) in the skin. Cholecalciferol is then hydroxylated in the liver, then kidney into its active metabolite form, 1,25-dihydroxy vitamin D (calcitriol).[10] This metabolite ultimately leads to increased calcium absorption in the gut and is crucial for bone health.

Regulation of body temperature: The skin has a large surface area that is highly vascularized, which allows it to conserve and release heat through vasoconstriction and vasodilation, respectively. When body temperatures rise, blood vessels dilate to increase blood flow and maximize the dissipation of heat.[11] In conjunction with this method, the evaporation of sweat secreted by the skin allows for greater heat loss. The hair on the body also affects the regulation of body temperature as erect hair can trap a layer of heat close to the skin. Various inputs from central and skin thermoreceptors provide fine-tuning for this thermoregulatory system.

Sensation: Skin innervation is by various sensory nerve endings that discriminate pain, temperature, touch, and vibration. Mediation of innocuous touch in glabrous skin by four types of mechanoreceptors—Meissner corpuscle, Pacinian corpuscle, Ruffini endings, and Merkel cells.[12] Meissner corpuscles can detect movement across the skin, Pacinian corpuscles detect high-frequency vibration, Ruffini endings detect stretch, and Merkel cells aid in spatial imaging. In hairy skin, tactile stimuli are picked up by three types of hair follicles and their associated longitudinal and circumferential lanceolate endings.[12] Noxious stimuli in both glabrous and hairy skin are detectable by free nerve endings located in the epidermis.[12] Each type of receptor and nerve fiber varies in its adaptive and conductive speeds, leading to a wide range of signals that can be integrated to create an understanding of the external environment and help the body to react appropriately.

The olfactory system is responsible for our sense of smell. This sense, also known as olfaction, is one of our five main senses and involves the detection and identification of molecules in the air.

Once detected by sensory organs, nerve signals are sent to the brain where the signals are processed. Our sense of smell is closely linked our sense of taste as both rely on the perception of molecules. It is our sense of smell that allows us to detect the flavors in the foods we eat. Olfaction is one of our most powerful senses. Our sense of smell can ignite memories as well as influence our mood and behavior.

Olfactory System Structures

Our sense of smell is a complex process that depends on sensory organs, nerves, and the brain. Structures of the olfactory system include:

- **Nose**: opening containing nasal passages that allows outside air to flow into the nasal cavity. Also a component of the respiratory system, it humidifies, filters, and warms the air inside the nose.
- **Nasal cavity**: cavity divided by the nasal septum into left and right passages. It is lined with mucosa.
- **Olfactory epithelium**: specialized type of epithelial tissue in nasal cavities that contains olfactory nerve cells and receptor nerve cells. These cells send impulses to the olfactory bulb.
- **Cribriform plate**: a porous extension of the ethmoid bone, which separates the nasal cavity from the brain. Olfactory nerve fibers extend through the holes in the cribriform to reach the olfactory bulbs.

- **Olfactory nerve:** nerve (first cranial nerve) involved in olfaction. Olfactory nerve fibers extend from the mucous membrane, through the cribriform plate, to the olfactory bulbs.
- **Olfactory bulbs:** bulb-shaped structures in the forebrain where olfactory nerves end and the olfactory tract begins.
- **Olfactory tract**: band of nerve fibers that extend from each olfactory bulb to the olfactory cortex of the brain.
- **Olfactory cortex:** area of the cerebral cortex that processes information about odors and receives nerve signals from the olfactory bulbs.

Our Sense of Smell

Our sense of smell works by the detection of odors. Olfactory epithelium located in the nose contains millions of chemical receptors that detect odors. When we sniff, chemicals in the air are dissolved in mucus. Odor receptor neurons in olfactory epithelium detect these odors and send the signals on to the olfactory bulbs. These signals are then sent along olfactory tracts to the olfactory cortex of the brain through sensory transduction.

The olfactory cortex is vital for the processing and perception of odor. It is located in the temporal lobe of the brain, which is involved in organizing sensory input. The olfactory cortex is also a component of the limbic system. This system is involved in the processing of our emotions, survival instincts, and memory formation.

The olfactory cortex has connections with other limbic system structures such as the amygdala, hippocampus, and hypothalamus. The amygdala is involved in forming emotional responses (particularly fear responses) and memories, the hippocampus indexes and stores memories, and the hypothalamus regulates emotional responses. It is the limbic system that connects senses, such as odors, to our memories and emotions.

Sense of Smell and Emotions

The connection between our sense of smell and emotions is unlike that of the other senses because olfactory system nerves connect directly to brain structures of the limbic system. Odors can trigger both positive and negative emotions as aromas are associated with specific memories.

Additionally, studies have demonstrated that the emotional expressions of others can influence our olfactory sense. This is due to activity of an area of the brain known as the piriform cortex which is activated prior to odor sensation.

The piriform cortex processes visual information and creates an expectation that a particular fragrance will smell pleasant or unpleasant. Therefore, when we see a person with a disgusted facial expression before sensing an odor, there is an expectation that the odor is unpleasant. This expectation influences how we perceive the odor.

Odor Pathways

Odors are detected through two pathways. The first is the orthonasal pathway which involves odors that are sniffed in through the nose. The second is the retronasal pathway which is a pathway that connects the top of the throat to the nasal cavity. In the orthonasal pathway, odors that enter the nasal passages and are detected by chemical receptors in the nose.

The retronasal pathway involves aromas that are contained within the foods we eat. As we chew food, odors are released that travel through the retronasal pathway connecting the throat to the nasal cavity. Once in the nasal cavity, these chemicals are detected by olfactory receptor cells in the nose.

Should the retronasal pathway become blocked, the aromas in foods we eat cannot reach odor detecting cells in the nose. As such, the flavors in the food cannot be detected. This often happens when a person has a cold or sinus infection.

Taste Buds

Taste buds are cells on your tongue that allow you to perceive tastes, including sweet, salty, sour, bitter and umami. Taste buds regenerate approximately every 10 days, which means injured taste buds usually repair on their own.

Taste buds are tiny sensory organs that allow you to experience taste. They're located inside the tiny bumps covering your tongue called papillae. Taste buds let you know what you're eating and drinking and whether it tastes "good" or "bad." This information makes eating pleasurable, which helps keep your body nourished. Your taste buds also alert you when something isn't safe to consume, like spoiled milk or rotten meat.

What tastes can taste buds detect?

Taste buds detect five basic tastes, including:

1. **Sweet**: Sweet foods mostly contain some form of sugar (sucrose, glucose, fructose and lactose). They include foods like honey, fruit and ice cream.
2. **Salty**: Salty foods contain table salt (sodium chloride) or mineral salts, like magnesium or potassium. Think of foods like pretzels, chips and movie theater popcorn.

3. **Bitter**: Bitter foods may contain ingredients like caffeine or compounds from plants, among others. Bitter is a complex taste regarding whether your taste buds recognize it as "good" or "bad." For example, some people like bitter foods, like coffee and dark chocolate, while others don't.
4. **Sour**: Sour foods, like citrus fruits and vinegar, often contain some form of acid (acetic acid, citric acid, lactic acid).
5. **Umami**: Umami is a savory, rich or meaty flavor. Many foods that your taste buds register as umami contain a substance called glutamate. Umami foods include tomatoes, asparagus, fish, mushrooms and soy.

Your taste buds experience these tastes in various combinations, making your experience of food and drink all the more complex. For example, taste buds may register a food as mostly sweet but also salty and umami. Or, a drink may taste mostly bitter but also sweet.

Taste buds work with the olfactory receptors in your nose to allow you to experience flavor. When you chew food, your teeth and the saliva in your mouth work together to break it down. This breakdown releases chemicals from the food that flow to your taste buds. These chemical signals also travel up your nasal passages to receptors in your nose. Together, these signals from your nose and mouth allow you to experience flavor. Think of, for instance, how holding your nose doesn't prevent you from tasting something, but it can change the flavor or dampen its intensity.

Other cells in your mouth and throat contain receptors that register how hot or cold a food or drink is. "Hot" includes temperature and spice. "Cold" includes temperature and certain flavor sensations, like mint or eucalyptus.

Multiple sensitive cells work together to shape your experience of eating and drinking.

The average adult has anywhere from 2,000 to 10,000 taste buds. We lose taste buds as we age, which means that children have more taste buds than adults. Sizes and numbers of taste buds vary from person to person.

These differences mean that, although everyone detects the same five tastes, perceptions and experiences of these tastes vary.

Taste buds come in different sizes. On average, they have a diameter of about one-thirtieth of a millimeter and a length of one-sixteenth of a millimeter. Taste buds primarily cover your tongue. To a lesser extent, you also have taste buds on the roof of your mouth and in your throat. The taste buds on your tongue are housed inside visible bumps called papillae. There are three types of papillae that contain taste buds:

- **Fungiform:** Located on the sides and tip of your tongue. They contain approximately 1,600 taste buds.

- **Circumvallate:** Located on the back of your tongue. They contain approximately 250 taste buds.
- **Foliate:** Located on the back portion of your tongue, on each side. There are about 20 of these papillae, and they contain several hundred taste buds each.

It's a common misconception that your tongue contains taste zones, or specific regions devoted to just one taste. Instead, taste buds that detect sweet, salty, bitter, sour and umami are scattered throughout your tongue. Some parts of your tongue are a bit more sensitive to certain tastes.

structure of a taste bud?

A taste bud is a collection of cells grouped inside the bumps on your tongue called papillae. A taste bud includes:

- **Taste receptor cells**: Each taste bud has between 50 to 150 taste receptor cells. These cells contain receptors that extend upward inside the taste pore. These extensions are taste hairs called microvilli. The microvilli come into contact with the chemicals in the food and drink you consume. Taste receptor cells connect to nerves that transmit taste signals to your brain. Your brain registers the chemical that came into contact with the receptor as sweet, salty, etc.
- **Basal cells**: These cells are stem cells that eventually become taste receptor cells. Your body replaces taste receptor cells approximately every 10 days.
- **Supporting cells (sustentacular cells)**: These cells are scattered throughout your taste buds alongside taste receptor cells. Although they're in your taste buds, they can't detect taste.

How often do taste buds change?

Basal cells develop into new taste receptor cells every week or two (10 days on average). Our taste buds decrease as we age, which means that your perception of taste changes at different stages of life. The foods you love as an adult may differ from those you love as a child. Similarly, taste perception changes as you transition through adulthood.