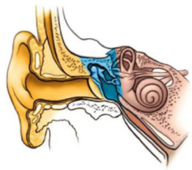
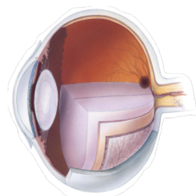
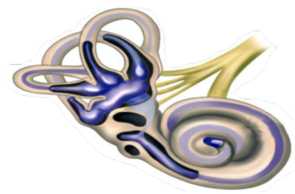




The Special Senses



- A sensation is the conscious or subconscious awareness of an internal or external stimulus
- Receptors for the special senses of smell, taste, vision, hearing, and equilibrium are anatomically distinct from one another and are concentrated in specific locations in the head
  - There are specific afferent pathways and translation sites in the brain for information assembled from these special senses

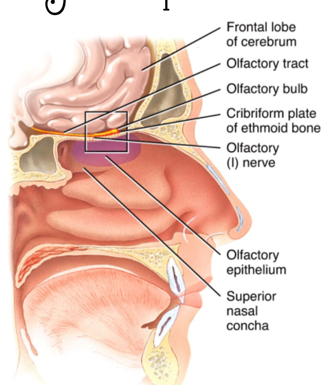
General Senses	**Special Senses**
– Somatic sensations (tactile, thermal, pain, and proprioceptive) and visceral sensations – Are scattered throughout the body – Are relatively simple structures	–Include smell, taste, vision, hearing and equilibrium –Are concentrated in specific locations in the head –Are anatomically distinct structures –Form complex neural pathways

Olfaction: The Sense of Smell

- Process of perceiving smells
  - Smell and taste are brought about through the interpretation of chemicals present in the environment
- Olfactory and gustatory (taste) impulses travel not only to the cerebral cortex, but also to the limbic system
  - We can have emotional responses and trigger strong memories to certain smells and tastes
  - Gustation and olfaction work together but olfaction is much stronger/more sensitive

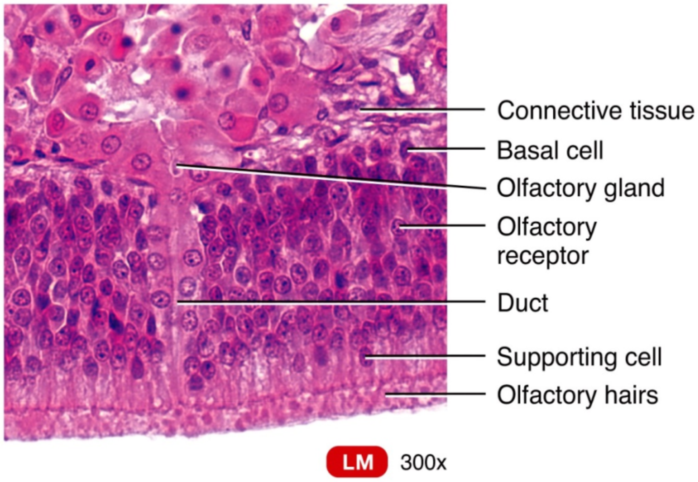
Anatomy of Olfactory Receptors

- The olfactory epithelium is located in the superior part of the nasal cavity covering the surface of the cribriform plate and extending along the superior nasal concha



(a) Sagittal view

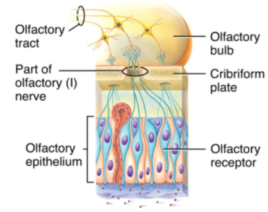
- The olfactory epithelium consists of 3 kinds of cells
  - The olfactory receptor is a bipolar neuron with cilia (called olfactory hairs)
  - There are 10-100 million of these receptors in the nose that respond to odorant molecules
  - Supporting cells provide support and nourishment
  - Basal cells are stem cells that replace olfactory receptors
  - Olfactory (Bowman's) Glands produce mucus that is carried of the surface of the epithelium by ducts
    - Moistens the epithelium and dissolves odorants for transduction



(c) Histology of olfactory epithelium

Physiology of Olfaction

- When an odorant binds to the receptor of an olfactory hair it initiates a cascade of intracellular events through a G-protein and a 2nd messenger
- production of cAMP --> opening of Na^+ channels --> inflow of Na^+ --> generator potentials

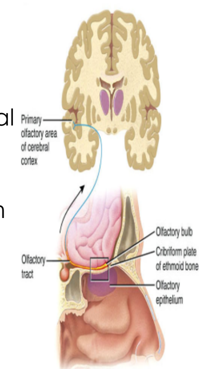


Odor Thresholds & Adaptation

- The olfactory apparatus can detect about 10,000 different odors, often in concentrations as low as 1/25 billionth of a milligram per milliliter of air
- Adaptation (decreasing sensitivity) occurs rapidly
  - Adapt by about 50% after the first second of stimulation, but adapt slowly after that
  - Complete insensitivity occurs about a minute after exposure

The Olfactory Pathway

- Once generated, nerve impulses travel through the two olfactory nerves --> olfactory bulbs --> olfactory tract --> primary olfactory area in the temporal lobe of the cortex
  - Olfaction is the only sensory system that has direct cortical projections without first going through relay stations in the thalamus



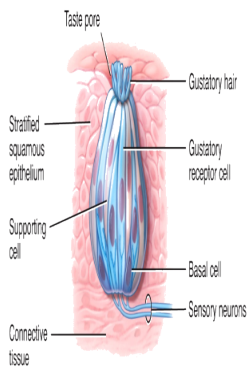
- Olfactory supporting cells and glands are innervated by the facial (VII) nerve, a component of which provides parasympathetic motor innervation to lacrimal glands and the mucous membranes in the nasal cavity
  - This is why certain odors will make our nose run and cause us to produce tears

Gustation: The Sense of Taste

- Only five primary tastes can be distinguished: sour, sweet, bitter, salty, and umami ("meaty" or "savory")
  - Umami is believed to arise from taste receptors that are stimulated by monosodium glutamate (MSG), a substance naturally present in many foods and added to others as a flavor enhancer
  - All other flavors, such as chocolate, pepper, and coffee, are combinations of the five primary tastes, plus accompanying olfactory and tactile (touch) sensations

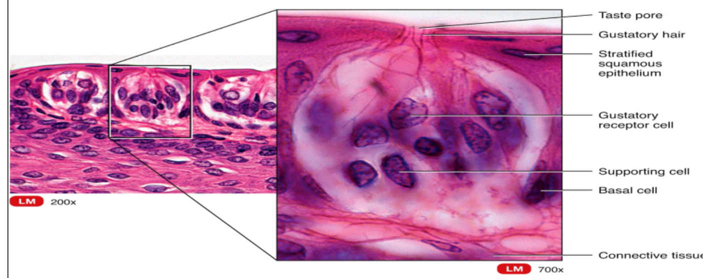
Anatomy of Taste Buds & Papillae

- We have nearly 10,000 taste buds located on the tongue, soft palate, pharynx, and larynx
  - Each taste bud is composed of about 50 gustatory receptor cells, surrounded by a number of supporting cells
  - Basal cells located near the CT base multiply and differentiate, first to become the supporting cells around the bud, then the gustatory receptorcells inside the taste bud



(c) Structure of a taste bud

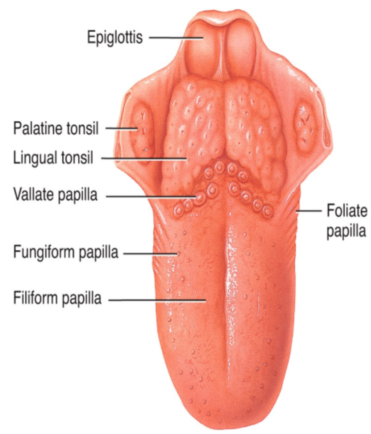
- A single, long microvillus, called a gustatory hair, projects from each receptor cell to the surface through the taste pore
- Each gustatory receptor cell has a lifespan of about 10 days



(d) Histology of a taste bud from a vallate papilla

- Taste buds are found in 3 different types of papillae (elevations on the tongue which provide a rough texture)
  - About 12 very large vallate papillae form a row at the back of the tongue (each houses 100–300 taste buds)
  - Fungiform papillae are mushroom-shaped and are scattered over the entire surface of the tongue (containing about 5 taste buds each)
  - Foliate papillae are located in small trenches on the lateral margins of the tongue, but most of their taste buds degenerate in early childhood

- In addition, the entire surface of the tongue has filiform papillae that contain tactile receptors but no taste buds
  - They increase friction between the tongue and food, making it easier to move food in the oral cavity



(a) Dorsum of tongue showing location of papillae

Physiology of Gustation

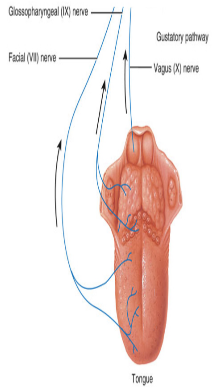
- Tastants are chemicals that stimulate gustatory receptor cells
  – When dissolved in saliva, it can make contact with the plasma membrane of the gustatory hairs, which are the sites of taste transduction
- Receptor potentials for different tastants
- Different tastes arise from the activation of different groups of taste neurons

Taste Thresholds & Adaptation

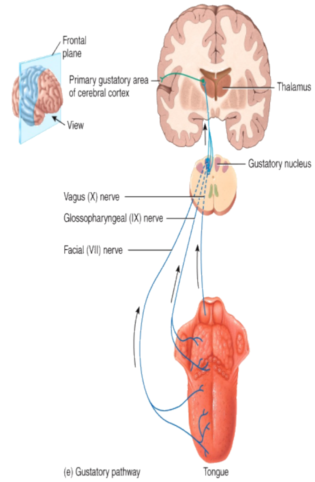
- The threshold for taste varies for each of the primary tastes
  - We are most sensitive to bitter substances, such as quinine
  - Because poisonous substances are often bitter, this high sensitivity may have a protective function
  - The threshold for sour substances is somewhat higher, followed by salty and sweet substances
- Complete adaptation to a specific taste can occur in 1–5 minutes of continuous stimulation

The Gustatory Pathway

- Three cranial nerves contain axons of the first-order gustatory neurons that innervate the taste buds
  - The facial (VII) nerve serves taste buds in the anterior 2/3 of the tongue
  - The glossopharyngeal (IX) nerve serves taste buds in the posterior 1/3 of the tongue
  - The vagus (X) nerve serves taste buds in the throat and epiglottis

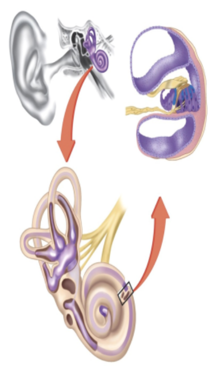


- Nerve impulses propagate along these cranial nerves to the gustatory nucleus in the medulla oblongata
- From there, axons carrying taste signals project to the hypothalamus, limbic system, and thalamus
  - Arrive at the primary gustatory area at the base of the somatosensory cortex in the parietal lobe



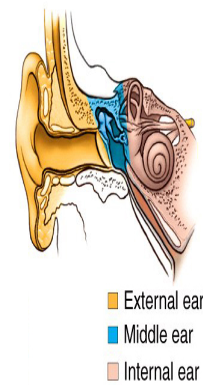
Hearing & Equilibrium

- Audition, the process of hearing, is accomplished by the organs of the ear
- The ear is an engineering marvel because its sensory receptors can transduce sound vibrations with amplitudes as small as the diameter of an atom of gold into electrical signals 1000 times faster than the eye can respond to light
  - The ear also contains receptors for equilibrium

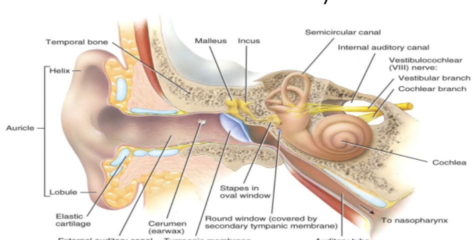


Anatomy of the Ear

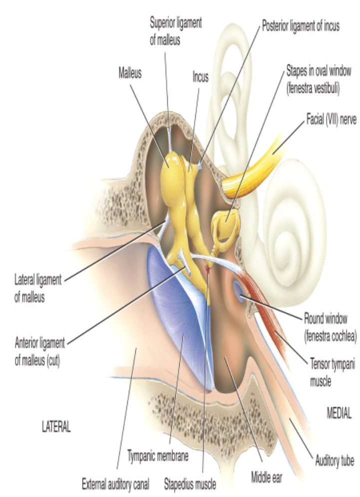
- The ear has 3 principle regions
  - The external ear, which uses air to collect and channel sound waves
  - The middle ear, which uses a bony system to amplify sound vibrations
  - The internal ear, which generates action potentials to transmit sound and balance information to the brain



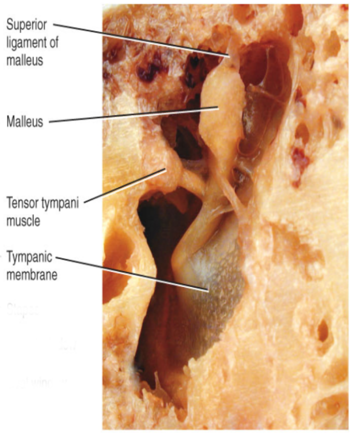
- The anatomy of the external ear includes
  - The auricle (pinna), a flap of elastic cartilage covered by skin and containing ceruminous glands
  - A curved 1" long external auditory canal situated in the temporal bone leading from the meatus to the tympanic membrane (TM – or ear drum) which separates the outer ear from the cavity of the middle ear



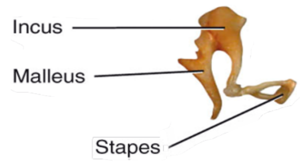
- The middle ear is an air-filled cavity in the temporal bone
  - It is lined with epithelium and contains 3 auditory ossicles (bones)
  - The stapes (stirrup)
  - The incus (anvil)
  - The handle of the malleus (hammer) attaches to the TM



- Two small skeletal muscles (the tensor tympani and stapedius) attach to the ossicle and dampen vibrations to prevent damage from sudden, loud sounds



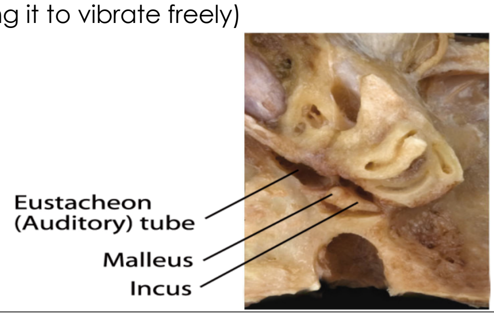
Right middle ear viewed from posterosuperior with incus and stapes removed



Auditory ossicles

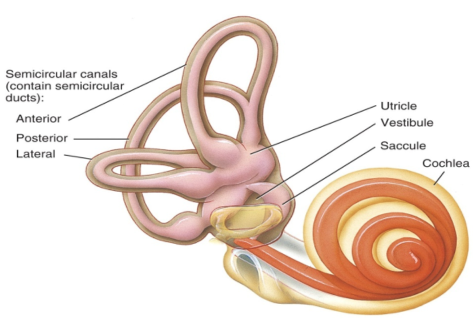
Cast of internal ear (right) compared to a dime for size

- The Eustachian (auditory) tube connects the middle ear with the nasopharynx (upper portion of the throat)
  - It consists of bone and hyaline cartilage and is normally passively collapsed
  - It opens to equalize pressures on each side of the TM(allowing it to vibrate freely)

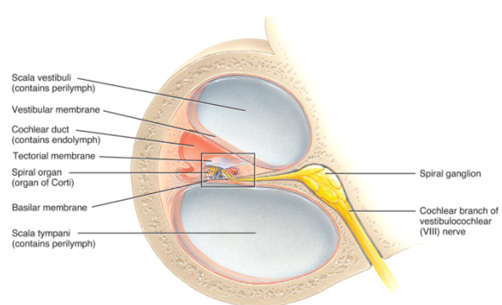


- The internal ear (inner ear) is also called the labyrinth because of its complicated series of canals
  - Structurally, it consists of two main divisions: an outer bony labyrinth that encloses an inner membranous labyrinth
    - The bony labyrinth is sculpted out of the petrous part of the temporal bone, and divided into three areas: (1) the semicircular canals, (2) the vestibule, and (3) the cochlea

- The vestibule is the middle part of the bony labyrinth
  - The membranous labyrinth in the vestibule consists of two sacs called the utricle and the saccule
- The three semicircular canalsare above the vestibule, each ending in a swollen enlargement called the ampulla (for dynamic equilibrium)



- The snail shaped cochlea contains the hearing apparatus
  - Two types of fluid (perilymph and endolymph) fill its 3 different internal channels: The scala vestibuli, scala tympani, and cochlear duct



(c) Section through one turn of the cochlea

- Perilymph transmits the vibrations coming from the stapes in the oval window up and around the scala vestibuli, and then back down and around the scala tympani – causing the endolymph in the cochlear duct to vibrate
- Pressure waves in the endolymph cause the basilar membrane of the cochlear duct to vibrate, moving the hair cells of the spiral organ of Corti against an overhanging flexible gelatinous membrane called the tectorial membrane

- Note how the sound waves between the number 1 and number 2 in this diagram are shown impacting different parts of membranous labyrinth
- This is a representation of sounds waves of different frequencies being transduced at the segment of the basilar membrane that is “tuned” for a particular pitch