Chapter 7

Audition, the Body Senses, and the Chemical Senses
Chapter 7

Auditory System
The Stimulus

- Sound is produced by objects that vibrate and set molecules of air into motion.
- Sound travels approximately 700 miles per hour.
- Humans are sensitive to vibrations between 30 and 20,000 times per second.
- Vibrations of air are perceived as sounds
The Stimulus

- **Pitch:**
  - A perceptual dimension of sound; corresponds to the fundamental frequency of the stimulus.

- **Hertz:**
  - Cycles per second

- **Loudness:**
  - A perceptual dimension of sound; corresponds to the intensity of the stimulus.

- **Timbre:**
  - A perceptual dimension of sound; corresponds to the complexity of the stimulus.
<table>
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<th>Physical Dimension</th>
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- loud
- soft
- low
- high
- simple
- complex
Audition
Anatomy of the Ear

- Pinna:
  - The external ear that we can see; collects sound from the environment.

- Tympanic membrane:
  - The eardrum; vibrates when stimulated by sound waves.

- Ossicles:
  - The bones of the middle ear.
Audition

Anatomy of the Ear

The ossicles of the middle ear

- **Malleus:**
  - The “hammer”, the first of the three ossicles; attached to the tympanic membrane.

- **Incus:**
  - The “anvil”; located between the malleus and the stapes.

- **Stapes:**
  - The “stirrup”, the third ossicle; attached to the oval window of the cochlea.
Audition

Anatomy of the Ear

- Cochlea:
  - The snail-shaped, fluid-filled, bony structure of the inner ear; contains the basilar membrane and the auditory receptor hair cells.

- Oval Window:
  - An opening in the bone of the cochlea that reveals a membrane against which the baseplate of the stapes presses, transmitting sound vibrations into the fluid-filled cochlea.
Audition

Anatomy of the Ear

The cochlea contains three spiral chambers:

- Scala vestibuli:
  - Contains the round window.

- Scala media:
  - Contains the organ of Corti.

- Scala tympani:
  - Contains the oval window.
Audition

Anatomy of the Ear

- Organ of Corti:
  - The sensory organ on the basilar membrane that contains the auditory hair cell; considered the receptive organ of the auditory system.

- Hair cell:
  - The sensory receptive cell of the auditory apparatus.

- Deiter cell:
  - A supporting cell found in the organ of Corti; sustains the auditory hair cells.
Audition

Anatomy of the Ear

- Basilar membrane:
  - A membrane in the cochlea of the inner ear; contains the organ of Corti.

- Tectorial membrane:
  - A membrane located above the basilar membrane; serves as a shelf against which the cilia of the auditory hair cells move.

- Round window:
  - An opening in the bone of the cochlea that permits vibrations to be transmitted, via the oval window, into the fluid of the cochlea.
Audition

- Auditory Hair Cells and the Transduction of Auditory Information
  - Cilium:
    - A hair-like appendage of a cell involved in movement or transducing sensory information; found on the receptors in the auditory and vestibular system.
  - Tip link:
    - An elastic filament that attaches the tip of one cilium to the side of the adjacent cilium.
  - Insertional plaque:
    - The point of attachment of a tip link to a cilium.
Audition

The Auditory Pathway

- **Cochlear nerve:**
  - A branch of the eighth cranial nerve; the branch of the auditory nerve that transmits auditory information from the cochlea to the brain.

- **Olivocochlear bundle:**
  - A bundle of efferent axons that travel from the olivary complex of the medulla to the auditory hair cells on the cochlea.

- **Cochlear nucleus:**
  - One of a group of nuclei in the medulla that receive auditory information from the cochlea.
Audition

The Auditory Pathway

- Superior ovlivary complex:
  - A group of nuclei in the medulla; involved with auditory functions, including localization of the sound source.

- Lateral lemniscus:
  - A band of fibers running rostrally through the medulla and pons; carries fibers of the auditory system.
Audition

The Central Auditory System

- **Tonotopic representation:**
  - A topographical organized mapping of different frequencies of sound that are represented in a particular region of the brain.

- **Belt region:**
  - The first level of auditory association cortex; surrounds the primary auditory cortex.

- **Parabelt region:**
  - The second level of auditory association cortex; surrounds the belt region.
Audition

Perception of Pitch

- Place code:
  - The system by which information about different frequencies is coded by different locations on the basilar membrane.

- Cochlear implant:
  - An electrical device surgically implanted in the inner ear that can enable a deaf person to hear.
Audition

Perception Loudness

- Subjects can detect a sound that vibrates the eardrum less than the diameter of a hydrogen atom.

- The softest sounds we can detect move the tip of the hair cells between 1 and 100 picometers (trillionths of a meter).

- Rate code:
  - The system by which information about different frequencies is coded by the rate of firing of neurons in the auditory system.
Audition

Perception of Timbre

- **Fundamental frequency:**
  - The lowest, and usually most intense, frequency of a complex sound; most often perceived as the sound’s basic pitch.

- **Overtone:**
  - The frequency of complex tones that occurs at multiples of the fundamental frequency.
Audition

Perception Spatial Location

- Humans can determine the location of a sound because auditory neurons respond selectively to different arrival times of the sound waves at the left and right ears.

- Phase difference:
  - The difference in arrival times of sound waves at each of the eardrums.
The Vestibular System

Anatomy of the Vestibular Apparatus

- **Vestibular sac:**
  - One of a set of two receptor organs in each inner ear that detects changes in the tilt of the head.

- **Semicircular canal:**
  - One of the three ring-like structures of the vestibular apparatus that detect changes in head rotation.

- **Utricle:**
  - One of the vestibular sacs.

- **Saccule:**
  - One of the vestibular sacs.
Vestibular System

Anatomy of the Vestibular Apparatus

- Ampulla:
  - An enlargement in a semicircular canal; contains the cupula and crista.

- Cupula:
  - A gelatinous mass found in the ampulla of the semicircular canals; moves in response to the flow of the fluid in the canals.
The Vesibular System
The Receptor Cells

- Hair cells:
  - Similar to the hair cells found in the cochlea; method of transduction is also similar to hair cells of the cochlea
The Vestibular System

The Vestibular Pathway

- Vestibular ganglion:
  - A nodule on the vestibular nerve that contains the cell bodies of the bipolar neurons that convey vestibular information to the brain.
Chapter 7

Somatosenses
Somatosenses

The stimuli

- The cutaneous senses respond to several different types of stimuli: pressure, vibration, heating, cooling, and events that cause tissue damage (and hence pain).

- Some receptors report changes in muscle length to the brain; providing our sense of kinesthesia.

- Additional receptors provide information about the internal organs such as the linings of muscles and the gastrointestinal system.
Somatosenses

Anatomy of the Skin and its Receptive Organs

- **Cutaneous sense:**
  - One of the somatosenses; includes sensitivity to stimuli that involve the skin.

- **Kinesthesia:**
  - Perception of the body’s own movements.

- **Organic sense:**
  - A sense modality that arises from receptors located within the inner organs of the body.
Somatosenses

Anatomy of the Skin and its Receptive Organs

- Meissner’s corpuscles:
  - The touch-sensitive end organs located in the papillae, small elevations of the dermis that project up into the epidermis.

- Merkel’s disk:
  - The touch-sensitive end organs found at the base of the epidermis, adjacent to sweat ducts.
Somatosenses

Perception of Cutaneous Stimulation

Touch

- Glabrous skin:
  - Skin that does not contain hair; found on the palms and soles of the feet.

- Ruffini corpuscle:
  - A vibration-sensitive organ located in hairy skin.

- Pacinian corpuscles:
  - A specialized, encapsulated somatosensory nerve ending that detects mechanical stimuli, especially vibrations.
Chapter 7

Gustation
Gustation is related to eating and is our first chemical sense.

This sense modality helps us to determine the nature of things we put in our mouths.

The tongue, palate, pharynx, and larynx contain about 10,000 sensory receptor taste buds.

There are only four qualities of taste: bitterness, sourness, sweetness, and saltiness.
Gustation

Anatomy of the Taste Buds and Gustatory Cells

- **Saltiness:**
  - The receptor for saltiness appears to be a simple sodium channel.

- **Sourness:**
  - The receptors for sourness appear to respond to the hydrogen ions in acidic solutions.
Gustation

Anatomy of the Taste Buds and Gustatory Cells

- **Bitterness:**
  - The typical stimulus for bitterness is a plant alkaloid such as quinine.

- **Sweetness:**
  - The typical stimulus for sweetness is a sugar such as glucose or fructose.

- **Gustducin:**
  - A G-protein that plays a vital role in the transduction of sweetness and bitterness.
Sodium ions enter ion channel, depolarize membrane.

Hydrogen ion binds with receptor, closes potassium channel. Potassium ions cannot leave cell; membrane depolarizes.

Bitter substance binds with receptor, activates gustducin, which activates phosphodiesterase, destroying cyclic AMP.

Sweet substance binds with receptor, activates gustducin, which activates an enzyme, producing cyclic AMP.

Potassium ion

Taste receptor

Destruction of cyclic AMP closes potassium channels, depolarizes membrane.

Potassium channel

Cyclic AMP causes calcium channels to open, which causes release of neurotransmitter.

(a) Salty

(b) Sour

(c) Bitter

(d) Sweet
Gustation

The Gustatory Pathway:

- **Chorda Tympani:**
  - A branch of the facial nerve that passes beneath the eardrum; conveys taste information from the anterior part of the tongue and controls the secretion of some salivary glands.

- **Nucleus of the solitary tract:**
  - A nucleus of the medulla that receives information from visceral organs and from the gustatory system.
Chapter 7

Olfaction
Olfaction

The Stimulus

- Olfaction is the second chemical sense.
- For humans, olfaction is the most enigmatic of the modalities.
- The stimulus for odor (known as odorants) consists of volatile substances having a molecular weight in the range of approximately 15 to 300.
- Almost all odorous compounds are lipid soluble and of organic origin.
Olfaction

Anatomy of the Olfactory Apparatus

- Olfactory epithelium:
  - The epithelial tissue of the nasal sinus that covers the cribiform plate; contains the cilia of the olfactory receptors.

- Olfactory bulb:
  - The protrusion at the end of the olfactory tract; receives information from the olfactory receptors.
Olfaction

Anatomy of the Olfactory Apparatus

- Mitral cell:
  - A neuron located in the olfactory bulb that receives information from olfactory receptors; axons of mitral cells bring information to the rest of the brain.

- Olfactory glomerculus:
  - A bundle of dendrites of mitral cells and associated terminal buttons of the axons of olfactory receptors.