

Lecture Outline: Sense, Sensation, and the Special Senses

I. Introduction to Senses

A. General vs. Special Senses

1. General Senses

- a. **Characteristics:** Not localized (spread out over the body), do not have a very complex or elaborate sense organ.
- b. **Examples:** Sense of vibration, temperature, itch, and touch (also called tactile sense). Touch is often mistakenly taught as a special sense.

2. Special Senses

- a. **Characteristics:** Highly localized (basically in the head), have a highly complex specialized organ for that sense.
- b. **The Five True Special Senses:**
 - (1) Taste (Gustation)
 - (2) Sight (Vision)
 - (3) Smell (Olfaction)
 - (4) Hearing (Audition)
 - (5) Balance

II. Vision

A. Associated Structures of the Eye

- 1. **Eyebrows:** Route sweat around the eye and are important signaling devices for facial expression.
- 2. **Eyelashes (Cilia):** Keep major specks of dirt and other foreign matter from entering the eye.
- 3. **Eyelids (Palpebrae):** Cover and protect the eye.
 - a. **Comissures/Canthus:** Edges where the superior and inferior

eyelids meet, known as lateral canthus and medial canthus.

B. Eyeball Structures

1. **Iris:** A muscular, pigmented ring that gives the eye its color and adjusts the diameter of the pupil.
2. **Pupil:** Not a structure itself, but the hole in the center of the iris through which light enters the eye. Its diameter is adjusted by the iris to control light intake.
3. **Cornea:** The amazingly transparent front surface of the eye, continuous with the sclera. It is the primary site of light refraction (bending of light rays for focusing) for terrestrial organisms due to the drastic change in density from air to the cornea.
4. **Sclera:** The tough, fibrous "white of the eye" that is continuous with the cornea. It is very difficult to puncture due to its toughness.
5. **Lacrimal Gland:** Located to the lateral side of each eye, it continuously produces tears (lacrimation).
 - a. **Tears Function:** Wash over the surface of the eye, cleaning it and containing antimicrobial agents to fight potential infections.
 - b. **Tear Drainage:** Tears drain at small spots at the medial canthus into lacrimal sacs and then into the nasal cavity, which is why your nose runs when you cry excessively.
6. **Conjunctiva:** A thin, one-cell-thick layer that directly covers the cornea and wraps around to cover the inner surface of each eyelid. Inflammation of this layer is called conjunctivitis.
7. **Orbits:** The bony eye sockets that house the eyeballs.
8. **Extrinsic Eye Muscles:** Six muscles per eyeball (not part of the eyeball itself) that move the eyeball in different directions.
 - a. **Rectus Muscles (Straight):** Superior, Inferior, Medial, and Lateral rectus muscles.
 - b. **Oblique Muscles (Diagonal):** Superior and Inferior oblique muscles, allowing for diagonal movement and slight twisting.
9. **Chambers of the Eyeball:** Divided by the lens and iris.
 - a. **Anterior Chamber:** Located between the inside of the cornea and

the front of the lens.

(1) Filled with **Aqueous Humor**: A very watery substance.

c. **Posterior Chamber**: The much larger chamber between the back of the lens and the back of the eyeball.

(1) Filled with **Vitreous Humor**: A gelatinous, glassy-appearing, and impressively transparent substance (in fresh eyes).

(2) **Maintains Retina Pressure**: Provides just enough pressure to keep the retina pressed against the back wall of the eyeball.

10. **Lens**: A tough, living, and transparent structure that performs the fine focusing of light rays to ensure sharp vision, adjusting based on object distance. It can become cloudy with age, leading to cataracts.

C. Layers of the Eyeball

1. **Superficial (Fibrous) Layer**: Composed of the sclera and cornea.

2. **Deepest (Innermost) Layer: Retina**: The light-sensitive layer of neural cells in direct contact with the vitreous humor.

a. **Photoreceptors**: Light-sensitive cells that make up part of the retina.

(1) **Rods**: Much easier to activate, important in very dim lighting situations, but do not provide color information (vision in shades of gray).

(2) **Cones**: Require more light to activate, come in three varieties (red, green, blue sensitive), and provide information about color and object shape.

d. **Light Pathway Through Retina**: Light must first pass through layers of other cells before reaching the photoreceptors.

Information then flows from:

(1) Rods and Cones

(2) Bipolar Cells

(3) Ganglion Cells (whose axons form the optic nerve)

h. **Pigmented Layer**: A layer within the retina that absorbs light that

does not hit a rod or cone, preventing reflection and confusion.

(1) **Tapetum Lucidum:** A special reflective pigmented layer found in some animals (e.g., cows), reflecting light to give photoreceptors a second chance, enhancing vision in low light (causes "eye shine").

j. **Optic Disc (Blind Spot):** The area at the back of the eye where all the axons from the ganglion cells converge to leave the eyeball as the optic nerve. There are no photoreceptors in this area, resulting in a "blind spot" where light cannot be sensed. The brain astonishingly "fills in" this missing visual information.

k. **Macula:** A spot on the retina with a high concentration of photoreceptors.

(1) Outer zone of macula has a high concentration of rods.

(2) **Fovea Centralis:** The central part of the macula with an especially high concentration of cones, providing very good resolution and color information, especially when looking directly at an object.

3. **Intermediate Layer: Choroid:** A collection of blood vessels that provides a rich blood supply to parts of the eye, although not directly to structures like the cornea or lens to maintain their transparency.

D. Properties of Light

1. **Electromagnetic Energy:** Light is a type of energy that occurs in waves, with both electrical and magnetic components.

2. **Wavelength:** The distance from one part of a wave to the next corresponding part. Wavelength determines the perceived color of visible light.

3. **Visible Spectrum:** Humans can only see a tiny fraction of the electromagnetic spectrum, roughly wavelengths from 400 to 700 nanometers (from violet to red). Other animals can see beyond this range (e.g., insects see ultraviolet).

4. **Color Perception:** Different types of cones respond best to different ranges of wavelengths within the visible spectrum (blue, green, red). Any color other than pure red, green, or blue is perceived as a mixture

activating multiple cone types. White light contains all wavelengths.

III. Audition and Balance (Ear)

A. **Ear as a Dual Special Sense Organ:** Responsible for both hearing (audition) and balance.

B. Outer Ear (External Ear)

1. **Pinna (Auricle):** The visible, funnel-shaped outer flap that collects sound waves.
2. **External Acoustic Meatus (Auditory Canal):** A tunnel that directs sound waves inward.
3. **Tympanic Membrane (Eardrum):** A membrane barrier that marks the boundary between the outer ear and the middle ear. Sound pressure waves cause it to vibrate.

C. Middle Ear: An air-filled chamber.

1. **Auditory Ossicles (Smallest Bones in the Body):** Three tiny bones that transmit and amplify vibrations from the eardrum to the inner ear.
 - a. **Malleus (Hammer):** Connected to the tympanic membrane.
 - b. **Incus (Anvil):** Connects the malleus and stapes.
 - c. **Stapes (Stirrup):** The flat part (foot) is connected to the oval window of the vestibule.
 - d. **Function: Amplification Device:** The ossicles increase the pressure of sound waves. The oval window has an area about 1/20th the size of the eardrum, meaning the same force applied over a much smaller area increases the pressure by approximately 20 times. This amplified pressure is crucial for moving the liquid in the inner ear, which is much denser than air.

D. **Inner Ear:** This sensitive structure (cochlea, vestibule, and semicircular canals) is entirely encased in bone, preventing bulging when pressure waves are transmitted.

1. **Vestibulocochlear Nerve:** A cranial nerve with two parts:
 - a. **Vestibular Tributary:** Carries information for balance.
 - b. **Cochlear Tributary:** Carries information for audition (hearing).
2. **Structures and Functions:**

a. **Cochlea ("Snail-shaped")**: The organ of audition (hearing).

(1) Contains **Mechanoreceptors**: Sensory receptors that fire when mechanically deformed (bent, squeezed, or stretched).

(2) It is a coiled, tapering tube with three fluid-filled chambers: Scala Vestibuli, Scala Tympani, and the central chamber known as the **Organ of Corti**.

(3) **Organ of Corti**: Houses the sensory hair cells (mechanoreceptors) that sit on the pliable **Basilar Membrane** (floor) and are covered by the stiffer **Tectorial Membrane** (roof). When pressure waves cause the basilar membrane to move sufficiently, the hair cells are jammed into the tectorial membrane, creating action potentials.

(4) **Frequency and Pitch Perception**: The tapering width of the basilar membrane means different parts have different resonant frequencies. A sound wave of a specific frequency will cause only one particular part of the basilar membrane to vibrate strongly, jamming its hair cells into the tectorial membrane and sending information to the brain that is interpreted as a specific pitch. Higher notes are sensed at narrower parts of the membrane (corresponding to higher frequencies).

f. **Vestibule**: Houses receptors for **static balance** (balance when the head is in a changed but stationary position). A slab of gel-like material slides with head tilts, bending hair cells and sending signals to the brain.

g. **Semicircular Canals**: Three canals that are mutually orthogonal (at right angles to each other), housing receptors for **dynamic balance** (balance while moving). Swirling fluid inside these canals (caused by head movement) deforms hair cells within a cone-shaped structure called the cupula, providing the brain with information about the direction and combination of head movements (X, Y, Z axes).

IV. Olfaction (Smell)

A. **Organ:** The nose, specifically a region of the inner moist lining called the **nasal epithelium**.

B. **Receptors: Chemoreceptors**, which respond to the presence of specific chemicals.

1. Chemicals capable of activating these receptors are called **odorants**.
2. Olfactory receptor cells have hair-like structures (stereocilia) that maximize surface area.
3. When an odorant binds to a receptor protein on these hair cells, the protein changes shape, opening ion channels and creating an action potential that is sent to the brain.
4. Humans have roughly 50 kinds of olfactory receptors, but their various combinations allow for the discernment of thousands of different individual odor sensations.

C. **Connection to the Brain:** The hair cell endings need to be accessible to air, but the brain is inside the cranium. Axons from these cells pass through holes in the **cribriform plate** of the **ethmoid bone** to connect to the main **olfactory nerves** (cranial nerves) that send information to the brain.

V. **Gustation (Taste)**

A. **Organ:** The mouth, primarily the tongue, but also sparsely distributed in the cheeks.

B. **Receptors:** Also **chemoreceptors**, which respond to specific chemicals called **tastants**.

1. Taste and smell are separate senses but are often experienced together. Eliminating the smell component (e.g., by covering the nose or having a cold) reduces the overall perceived "taste" sensation, even though the taste sensation itself remains.

C. **Structures of the Tongue**

1. **Papillae (Pilli):** The visible bumps on the tongue, which house much smaller taste buds.
2. **Taste Buds:** Much smaller than papillae, taste buds are located within the papillae and contain sensory cells called **gustatory hairs** (hair-like

structures that maximize surface area for receptors). Saliva helps dissolve tastants so they can bind to these receptors.

D. **Basic Tastes (Five):** Humans can perceive five fundamental tastes, each with its own kind of receptors.

1. Sour (or Acid)

2. Salty

3. Sweet

4. Bitter

5. **Umami (Savory):** A Japanese word meaning roughly "deliciousness," specifically referring to savory taste found in meat and mushrooms.

This fifth taste was discovered relatively recently and its receptors specifically respond to glutamate (e.g., in MSG).

E. **Regional Sensitivity on Tongue:** While all five tastes can be sensed on any part of the tongue, certain regions have a higher concentration of specific taste receptors, leading to stronger sensations in those areas (e.g., salty region).

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