

SENSES

- Ability to perceive stimuli

Sensation/Perception – conscious awareness of stimuli received

GENERAL SENSES

- Have receptors distributed over the body
 - Senses for touch, pressure, pain, temp., vibration, itch, proprioception
1. **Somatic Senses** – provide sensory info about the body and the environment
 2. **Visceral Senses** – provide info about various internal organs (pain & pressure)

Transduction – a receptor absorbs energy from stimulus

Sensory Receptors – sensory nerve endings capable of responding to stimuli by developing action potentials

1. **Mechanoreceptors** – mechanical stimuli
2. **Chemoreceptors** – chemicals (odor molecules)
3. **Photoreceptors** – light
4. **Thermoreceptors** – temperature changes
5. **Nociceptors** – sensation of pain
6. **Free nerve endings** – simplest and most common receptors
 - **Cold receptors** – decreasing temp.; stop responding at below 12°C
 - **Warm receptors** – increasing temp.; stop responding above 47°C
7. **Touch receptors** – structurally more complex; enclosed by capsules
8. **Merkel disks** – light touch and superficial pressure
9. **Hair follicle receptors** – light touch
10. **Meissner corpuscles** – fine, discriminative touch; localizing tactile sensations
11. **Ruffini corpuscles** – continuous pressure in skin
12. **Pacinian corpuscles** – deepest receptors; deep pressure, vibration, position

Pain

- Unpleasant perceptual and emotional experiences
1. **Superficial Pain** – localized; rapidly conducted action potentials

2. **Deep/Visceral Pain** – diffuse; action potentials are propagated more slowly

Local anesthesia – injected near a sensory receptor/nerve resulting in reduced pain

General anesthesia – loss of consciousness is produced; affects reticular formation

Gate control theory – inhibits action potentials carried to the brain by the spinothalamic tract

Referred Pain

- Originate in a region of the body that is not the source of the pain stimulus
- Clinically useful in diagnosing the actual cause of the painful stimulus
- Occurs bcos the sensory neurons (from the superficial area) to which the pain is referred, and the neurons (from the deeper, visceral area) where the pain stimulation originates, **converge onto the same ascending neurons** in the spinal cord; thus the **brain can't distinguish**

SPECIAL SENSES

- Localized to specific parts of the body
- Smell, taste, sight, hearing, balance

OLFACTION

- Sense of **smell**
- Occurs in response to airborne molecules

Odorants – airborne molecules

Olfactory neurons – bipolar neurons

Olfactory epithelium – lines the superior part of the nasal cavity

Neuronal Pathways for Olfaction

- Axons of the **olfactory neurons** form the **olfactory nerves**, which enter the **olfactory bulb**. **Olfactory tracts** carry action potentials from the olfactory bulbs to the **olfactory cortex of the brain**.

Olfactory bulb – where olfactory neurons synapse with interneurons

Olfactory tracts – relays action potentials to the brain

Olfactory cortex – where each olfactory tract terminates

Adaptation – feedback + temporary decreased sensitivity

TASTE

Taste buds – detect taste stimuli

Papillae – enlargements on the surfaced of the tongue

Taste cells – 40 specialized epithelial cells

Taste hairs – hair-like processes

Taste pore – tiny opening in the surrounding stratified epithelium

Taste sensations

1. Sour
2. Salty
3. Bitter
4. Sweet
5. Umami (savory)

Neuronal Pathways for Taste

1. **Facial Nerve (7)** – transmits taste sensations from the anterior of the tongue
2. **Glossopharyngeal nerve (9)** – carries taste sensations from the posterior of the tongue
3. **Vagus nerve (10)** – carries some taste sensations from the root of the tongue
4. **Gustatory portion of the brainstem nuclei**
5. **Thalamus**
6. **Taste area (Insula)**

VISION

Orbits – bony cavities where the eyes are housed

Accessory Structures of the Eye

- Protect, lubricate, and move the eye

Eyebrows – protect the eyes by preventing perspiration from running down

Eyelids – protect the eyes from foreign objects

- ❖ **Blinking** – occurs about 20 times/min.; keeps the eyes lubricated

Conjunctiva – thin, transparent mucous membrane covering the inner surface of the eyelids; lubricate the surface of the eye

- ❖ **Conjunctivitis** – inflammation of the conjunctiva

Lacrimal Apparatus

- ❖ **Lacrimal gland** – produces tears
 - **Lacrimal canaliculi** – small ducts where excess tears are collected
 - **Lacrimal duct** – enlargement of nasolacrimal duct
- ❖ **Nasolacrimal duct** – opens into the nasal cavity

Extrinsic Eye Muscles – 6 skeletal muscles that accomplish movement of each eyeball

- ❖ **Rectus muscles**
 - **Superior rectus** – rolls eye upwards
 - **Inferior rectus** – rolls eye downward
 - **Lateral rectus** – turns eye outward

- **Medial rectus** – turns eye inward

- ❖ **Oblique muscles** – two muscles to the long axis; superior and inferior

- **Superior oblique** – rotates counterclockwise

- **Inferior oblique** – rotates clockwise

Anatomy of the Eye

Eyeball – hollow, fluid-filled sphere

Tunics – 3 layered wall of the eye

- ❖ **Fibrous tunic** – sclera + cornea

- **Sclera** – firm, white, outer connective tissue; maintains the shape of the eye

- **Cornea** – transparent, permits light to enter; refracts the entering light; ‘window of the eye’

- ❖ **Vascular tunic** – contains most of the blood vessels of the eye

- **Choroid** – thin structure that consists of melanin containing pigment cells (causing black appearance); absorbs light so that it is not reflected inside

- **Ciliary body** – responsible for accommodation; near objects = CM contracts + lens become rounder; far objects = CM relaxes + lens become ovoid

- **Ciliary muscles** – smooth muscles

- **Suspensory ligaments** – attached the perimeter of the lens

- **Lens** – flexible, biconvex, transparent disc

- **Cataract** – opacity of lens

- **Iris** – colored part of the eye; regulates diameter of the pupil

- **Pupil** – controls the amt. of light entering the eyes

- **Parasympathetic** – light intensity increases; pupillary constriction

- **Sympathetic** – light intensity decreases; pupillary dilation

- ❖ **Nervous tunic** – innermost tunic

- **Retina** – covers the posterior 5/6 of the eye

- **Pigmented retina** – keeps light from reflecting back into the eye

- **Sensory retina** – contains **rods & cones** (photoreceptors) which respond to light

- a. **Rods** – can function in very dim light; doesn't provide color vision

- **Rhodopsin** – photosensitive pigment; breaks down into:

- **Opsin** – colorless protein

- **Retinal** – yellow pigment

- **Night blindness** – difficulty seeing in dim light; caused by vit. A deficiency
- b. **Cones** – require more light; provide color vision
 - **Red, Blue, Green** – major types of color sensitive opsin
 - **Color blindness** – caused by lack of three cone types
 - **Partial color blindness** – lack of one cone type
 - **Retinal detachment** – separation of sensory retina from the pigmented retina

Regions of the Retina

1. **Macula lutea** – small, yellow spot near the center of the posterior retina
 - **Fovea centralis** – region of sharpest vision; where light is most focused
2. **Optic disc** – white spot through which a no. of blood vessels enter the eye;
 - **Blind spot of the eye** – contains no photoreceptor cells and doesn't respond to light

Chambers of the Eye

- ❖ **Anterior chamber**
- Posterior chamber**
 - Bet. the cornea and lens
 - **Aqueous humor** – watery fluid; helps maintain pressure within the eye, refracts light, provides nutrients
 - **Glaucoma** – increase in the intraocular pressure due to blockage of AH flow
- ❖ **Vitreous chamber**
 - Posterior to the lens
 - Vitreous humor – transparent, jelly-like substance; helps maintain pressure within the eye, holds the lens and retina in place; does not circulate

Functions of the Eye

1. **Light Refraction**
 - **Focal point** – crossing point
 - **Focusing** – causes light to converge
2. **Focusing Images on the Retina**
 - **Accommodation** – causes greater refraction of light; enables the eye to focus on images

Neuronal Pathways for Vision

- Light passes through **cornea**, through the **aqueous humor**, through the **lens**, through the **vitreous humor**, image forms on photoreceptors in **retina**, breakdown of **rhodopsin**, signals **bipolar cells**.
- Axons pass through the **optic nerves** to the **optic chiasm**, where some cross. Axons from the **nasal retina** cross, and those from the **temporal retina** do not.

- **Optic tracts** from the chiasm lead to the thalamus.
- **Optic radiations** extend from the thalamus to the **visual cortex** in the **occipital lobe**.

Optic nerve – leaves the eye and exits the orbit

Optic chiasm – where two optic nerves connect

Optic tracts – the route of the ganglionic axons

Optic radiations – formed by neurons from the thalamus

Visual cortex – where vision is perceived

Visual field – image seen by each eye

HEARING & BALANCE

Anatomy and Function of the Ear

1. **External Ear** – outer part we see
 - a. **Auricle** – fleshy part; collects sound waves & directs them toward the EAC
 - b. **External auditory canal** – passageway that leads to the eardrum
 - c. **Ceruminous glands** – lines the auditory canal
 - **Cerumen/earwax** – modified sebum; protects the lining of the canal
 - d. **Tympanic membrane/Eardrum** – thin membrane that separates the external from the middle ear; sound waves causes it to vibrate
2. **Middle Ear** – air filled chamber
 - a. **Oval and Round window** – connects the middle to the inner
 - b. **Auditory Ossicles** – amplify vibrations
 - i. **Malleus (hammer)** – medial surface of the tympanic m.
 - ii. **Incus (anvil)** – connects malleus to stapes
 - iii. **Stapes** – its base is seated in the oval window
 - c. **Auditory/Eustachian tube** – enables pressure to be equalized
3. **Inner Ear** – fluid filled chamber; for sound waves, balance, equilibrium
 - a. **Bony labyrinth** – interconnecting tunnels and chambers
 - i. **Cochlea** – hearing
 - ii. **Vestibule** – balance
 - iii. **Semicircular canal** – balance
 - b. **Membranous labyrinth** – smaller set of membranous tunnels and chambers
 - **Endolymph** – clear fluid
 - c. **Perilymph** – fluid bet. membranous and bony labyrinths

Cochlea

- Contains receptors for hearing
- Snail shell shape

Spiral lamina – threads of the screw (base)

Scala vestibuli – extends from the oval window to the apex of the cochlea

Scala tympani – extends in parallel with the scala v. from the apex

Vestibular membrane – wall of the ML that lines the scala vestibuli

Basilar membrane – wall of the ML that lines the scala tympani

Cochlear duct – space bet. the VM and the BM; filled with endolymph

Spiral organ/Organ of Corti – specialized structure; contains hair cells

Hair cells – specialized sensory cells; contain microvilli

Tectorial membrane – acellular gelatinous shelf

Cochlear/Spiral ganglion – contains cell bodies of hair cells

Cochlear nerve – formed by axons of sensory neurons

Vestibulocochlear nerve (CN 8) – formed by cochlear nerve + vestibular nerve

Glutamate – neurotransmitter for hearing

Hearing

Higher pitches – causes max. distortion of the BM

Sound volume – function of sound wave amplitude

Conduction deafness – results from mechanical deficiencies

Sensorineural hearing loss – caused by deficiencies in the spiral organ/nerves

Neuronal Pathways for Hearing

- Soundwaves enter **external auditory meatus**, causing the **tympanic membrane** to vibrate.
- **Malleus, incus, stapes** amplify the vibrations, causing the **oval window** to vibrate.
- Vibrations are conducted through **perilymph**, and transmitted to the **endolymph**, causing the basilar membrane to vibrate.
- Hair cells in the **organ of Corti** are stimulated.
- From the **vestibulocochlear nerve**, action potentials travel to the **cochlear nucleus** and on to the **cerebral cortex**.

Cochlear nucleus – where the cochlear nerve sends axons

Inferior colliculus – where neurons in the cochlear nucleus project to the other areas of the brainstem

Balance

Static equilibrium – vestibule; evaluating the position of head relative to gravity

Dynamic equilibrium – semi-circular canals; evaluating changes in the direction and rate of head movements

Vestibule

- ❖ **Utricle**
- ❖ **Sacculle**

Maculae – specialized patches of epithelium

Otolithic membrane – gelatinous mass

Otoliths – gravity detectors composed of protein and calcium carbonate

Semicircular canals – involved in dynamic equilibrium; enables a person to detect movements in any direction

- ❖ **Ampulla** – expanded base of each SC
- ❖ **Crista ampullaris** – specialized epithelium formed within each ampulla
- ❖ **Cupula** – curved, gelatinous mass contained in each crista

Motion sickness – caused by continuous stimulation of the SC; characterized by nausea & weakness

Neuronal Pathways for Balance

- Axons in the **vestibular portion** of the **vestibulocochlear nerve** project to the **vestibular nucleus** and on to the **cerebral cortex**.

Vestibulocochlear nerve (8) – project to the vestibular nucleus in the brainstem

Balance – a complex sensation involving sensory input

Effects of Aging on the Senses

Presbyopia – lenses' ability to change shape initially declines and is eventually lost

Presbycusis – age-related sensorineural hearing loss