

Unit 8: The Special Senses

I. The Senses

A. General senses of touch

1. Temperature
2. Pressure
3. Pain

B. Special senses

1. Smell
2. Taste
3. Sight
4. Hearing
5. Equilibrium

II. The Eye and Vision

A. 70% of all sensory receptors are in the eyes

B. Each eye has over a million nerve fibers

C. Protection for the eye

1. Most of the eye is enclosed in a bony orbit
2. A cushion of fat surrounds most of the eye

D. Accessory Structures of the Eye

1. Eyelids and eyelashes

- a. Tarsal glands lubricate the eye
- b. Ciliary glands are located between the eyelashes

2. Conjunctiva

- a. Membrane that lines the eyelids
- b. Connects to the surface of the eye
- c. Secretes mucus to lubricate the eye

3. Lacrimal apparatus

- a. Lacrimal gland—produces lacrimal fluid
- b. Lacrimal canals—drain lacrimal fluid from eyes
- c. Lacrimal sac—provides passage of lacrimal fluid towards nasal cavity
- d. Nasolacrimal duct—empties lacrimal fluid into the nasal cavity
- e. Function of the lacrimal apparatus
 - (1) Protects, moistens, and lubricates the eye
 - (2) Empties into the nasal cavity

- f. Properties of lacrimal fluid
 - (1) Dilute salt solution (tears)
 - (2) Contains antibodies and lysozyme
- 4. Extrinsic eye muscles
 - a. Six muscles attach to the outer surface of the eye
 - b. Produce eye movements
- E. Structure of the Eye
 - 1. Layers forming the wall of the eyeball
 - a. Fibrous layer
 - (1) Outside layer
 - (2) Sclera
 - (a) White connective tissue layer
 - (b) Seen anteriorly as the "white of the eye"
 - (3) Cornea
 - (a) Transparent, central anterior portion
 - (b) Allows for light to pass through
 - (4) Repairs itself easily
 - (5) The only human tissue that can be transplanted without fear of rejection
 - b. Vascular layer
 - (1) Middle layer
 - (2) Choroid is a blood-rich nutritive layer in the posterior of the eye
 - (3) Pigment prevents light from scattering
 - (4) Modified anteriorly into two structures
 - (a) Ciliary body—smooth muscle attached to lens
 - (b) Iris—regulates amount of light entering eye
 - i. Pigmented layer that gives eye color
 - ii. Pupil—rounded opening in the iris
 - c. Sensory layer
 - (1) Inside layer
 - (2) Retina contains two layers
 - (a) Outer pigmented layer
 - (b) Inner neural layer
 - i. Signals pass from photoreceptors via a two-neuron chain
 - A. Bipolar neurons
 - B. Ganglion cells

- ii. Contains receptor cells (photoreceptors)
 - A. Rods
 - B. Cones
- iii. Signals leave the retina toward the brain through the optic nerve
- iv. Optic disc (blind spot) is where the optic nerve leaves the eyeball
 - A. Cannot see images focused on the optic disc
- v. Neurons of the retina and vision
 - A. Rods
 - 1. Most are found towards the edges of the retina
 - 2. Allow dim light vision and peripheral vision
 - 3. All perception is in gray tones
 - B. Cones
 - 1. Allow for detailed color vision
 - 2. Densest in the center of the retina
 - 3. Fovea centralis—area of the retina with only cones
 - 4. No photoreceptor cells are at the optic disc, or blind spot
 - 5. Cone sensitivity
 - a. Three types of cones
 - b. Different cones are sensitive to different wavelengths
 - c. Color blindness is the result of the lack of one cone type

2. Lens

- a. Biconvex crystal-like structure
- b. Held in place by a suspensory ligament attached to the ciliary body
- c. Cataracts result when the lens becomes hard and opaque with age
 - (1) Vision becomes hazy and distorted
 - (2) Eventually causes blindness in affected eye

3. Two Segments, or Chambers, of the Eye

- a. Anterior (aqueous) segment

- (1) Anterior to the lens
- (2) Contains aqueous humor
 - (a) Watery fluid found between lens and cornea
 - (b) Similar to blood plasma
 - (c) Helps maintain intraocular pressure
 - (d) Provides nutrients for the lens and cornea
 - (e) Reabsorbed into venous blood through the scleral venous sinus, or canal of Schlemm
- b. Posterior (vitreous) segment
 - (1) Posterior to the lens
 - (2) Contains vitreous humor
 - (a) Gel-like substance posterior to the lens
 - (b) Prevents the eye from collapsing
 - (c) Helps maintain intraocular pressure
- F. Pathway of Light Through the Eye
 - 1. Light must be focused to a point on the retina for optimal vision
 - 2. The eye is set for distance vision (over 20 feet away)
 - 3. Accommodation—the lens must change shape to focus on closer objects (less than 20 feet away)
 - 4. Image formed on the retina is a real image
 - a. Real images are
 - (1) Reversed from left to right
 - (2) Upside down
 - (3) Smaller than the object
 - 5. Optic chiasma
 - a. Location where the optic nerves cross
 - b. Fibers from the medial side of each eye cross over to the opposite side of the brain
 - 6. Optic tracts
 - a. Contain fibers from the lateral side of the eye on the same side and the medial side of the opposite eye
- g. Eye Reflexes
 - 1. Internal muscles are controlled by the autonomic nervous system

- a. Bright light causes pupils to constrict through action of radial, circular, and ciliary muscles
 - b. Viewing close objects causes accommodation
 - 2. External muscles control eye movement to follow objects
 - a. Viewing close objects causes convergence (eyes moving medially)
- h. Eye Disorders

- 1. Emmetropia—eye focuses images correctly on the retina
 - 2. Myopia (nearsighted)
 - a. Distant objects appear blurry
 - b. Light from those objects fails to reach the retina and are focused in front of it
 - c. Results from an eyeball that is too long
 - 3. Hyperopia (farsighted)
 - a. Near objects are blurry while distant objects are clear
 - b. Distant objects are focused behind the retina
 - c. Results from an eyeball that is too short or from a “lazy lens”
 - 4. Astigmatism
 - a. Images are blurry
 - b. Results from light focusing as lines, not points, on the retina due to unequal curvatures of the cornea or lens
 - 5. Night blindness—inhibited rod function that hinders the ability to see at night
 - 6. Color blindness—genetic conditions that result in the inability to see certain colors
 - a. Due to the lack of one type of cone (partial color blindness)
 - 7. Cataracts—when lens becomes hard and opaque, our vision becomes hazy and distorted
 - 8. Glaucoma—can cause blindness due to increasing pressure within the eye
 - 9. Hemianopia—loss of the same side of the visual field of both eyes; results from damage to the visual cortex on one side only
- iii. The Ear
- A. Houses two senses

1. Hearing
2. Equilibrium (balance)
- B. Receptors are mechanoreceptors
- c. Different organs house receptors for each sense
- D. Anatomy of the Ear
 1. The ear is divided into three areas
 - a. External (outer) ear
 - b. Middle ear (tympanic cavity)
 - c. Inner ear (bony labyrinth)
- E. The External Ear
 1. Involved in hearing only
 2. Structures of the external ear
 - a. Auricle (pinna)
 - b. External acoustic meatus (auditory canal)
 - (1) Narrow chamber in the temporal bone
 - (2) Lined with skin and ceruminous (wax) glands
 - (3) Ends at the tympanic membrane
- F. The Middle Ear (Tympanic Cavity)
 1. Air-filled cavity within the temporal bone
 2. Only involved in the sense of hearing
 3. Two tubes are associated with the inner ear
 - a. The opening from the auditory canal is covered by the tympanic membrane
 - b. The auditory tube connecting the middle ear with the throat
 - (1) Allows for equalizing pressure during yawning or swallowing
 - (2) This tube is otherwise collapsed
 4. Three bones (ossicles) span the cavity
 - a. Malleus (hammer)
 - b. Incus (anvil)
 - c. Stapes (stirrup)
 - d. Function
 - (1) Vibrations from eardrum move the malleus à anvil à stirrup à inner ear
- g. Inner Ear or Bony Labyrinth

1. Includes sense organs for hearing and balance
 2. Filled with perilymph
 3. A maze of bony chambers within the temporal bone
 - a. Cochlea
 - b. Vestibule
 - c. Semicircular canals
4. Organs of Equilibrium
 - a. Equilibrium receptors of the inner ear are called the vestibular apparatus
 - b. Vestibular apparatus has two functional parts
 - (1) Static equilibrium
 - (a) Maculae—receptors in the vestibule
 - i. Report on the position of the head
 - ii. Send information via the vestibular nerve
 - iii. Anatomy of the maculae
 - A. Hair cells are embedded in the otolithic membrane
 - B. Otoliths (tiny stones) float in a gel around the hair cells
 - c. Movements cause otoliths to bend the hair cells
 - (2) Dynamic equilibrium
 - (a) Crista ampullaris—receptors in the semicircular canals
 - i. Tuft of hair cells
 - ii. Cupula (gelatinous cap) covers the hair cells
 - iii. Action of angular head movements
 - A. The cupula stimulates the hair cells
 - B. An impulse is sent via the vestibular nerve to the cerebellum
 5. Organs of Hearing
 - a. Organ of Corti
 - (1) Located within the cochlea
 - (2) Receptors = hair cells on the basilar membrane
 - (3) Gel-like tectorial membrane is capable of bending hair cells
 - (4) Cochlear nerve attached to hair cells transmits nerve impulses to auditory cortex on temporal lobe

b. Mechanism of Hearing

- (1) Vibrations from sound waves move tectorial membrane
- (2) Hair cells are bent by the membrane
- (3) An action potential starts in the cochlear nerve
- (4) Continued stimulation can lead to adaptation

iv. Olfaction—The Sense of Smell

A. Olfactory receptors are in the roof of the nasal cavity

1. Neurons with long cilia
2. Chemicals must be dissolved in mucus for detection
3. Impulses are transmitted via the olfactory nerve
4. Interpretation of smells is made in the cortex
5. Olfactory Epithelium

v. The Sense of Taste

A. Taste buds house the receptor organs

B. Location of taste buds

1. Most are on the tongue
2. Soft palate
3. Cheeks

c. Taste Buds

1. The Tongue and Taste

a. The tongue is covered with projections called papillae

- (1) Filiform papillae—sharp with no taste buds
- (2) Fungiform papillae—rounded with taste buds
- (3) Circumvallate papillae—large papillae with taste buds

b. Taste buds are found on the sides of papillae

2. Structure of Taste Buds

a. Gustatory cells are the receptors

- (1) Have gustatory hairs (long microvilli)
- (2) Hairs are stimulated by chemicals dissolved in saliva

b. Impulses are carried to the gustatory complex by several cranial nerves because taste buds are found in different areas

- (1) Facial nerve
- (2) Glossopharyngeal nerve
- (3) Vagus nerve

- 3. Taste Sensations
 - a. Sweet receptors (sugars)
 - (1) Saccharine
 - (2) Some amino acids
 - b. Sour receptors
 - (1) Acids
 - c. Bitter receptors
 - (1) Alkaloids
 - d. Salty receptors
 - (1) Metal ions
 - e. Umami
 - (1) "beefy"
 - (2) amino acid glutamate
- vi. Chemical Senses: Taste and Smell
 - A. Both senses use chemoreceptors
 - 1. Stimulated by chemicals in solution
 - 2. Taste has four types of receptors
 - 3. Smell can differentiate a large range of chemicals
 - 4. Both senses complement each other and respond to many of the same stimuli
- vii. Developmental Aspects of the Special Senses
 - A. Formed early in embryonic development
 - B. Eyes are outgrowths of the brain
 - C. All special senses are functional at birth
 - D. Eye problems
 - 1. Strabismus—"crossed eyes" results from unequal pulls by the external eye muscles in babies
 - 2. Ophthalmia neonatorum—conjunctivitis resulting from mother having gonorrhea. Baby's eyelids are swollen and pus is produced
 - 3. Presbyopia—"old vision" results from decreasing lens elasticity that accompanies aging
 - E. Ear problems
 - 1. Presbycusis—type of sensorineural deafness
 - 2. Otosclerosis—ear ossicles fuse