

Chapter 15: The Special Senses

I. Olfaction

A. Olfactory Epithelium and Bulb

1. Structurally olfactory neurons are classified as _____
2. Axons of olfactory neurons pass through holes of the _____ to the _____
3. The olfactory tracts _____
4. What is an olfactory vesicle? _____
5. Where are olfactory hairs found? _____
6. Functionally odorants enter the nasal cavity:
 - a. Dissolve in _____
 - b. Bind to _____
 - c. Cilia of the olfactory neurons react by _____
7. How often is the olfactory epithelium lost? _____
8. What is the source of new olfactory neurons? _____

B. Neuronal Pathways for Olfaction

1. Axons from the olfactory neurons enter the _____
2. They synapse with _____ or _____
3. These cells pass olfactory information to the brain through _____ & synapse with _____
4. How is olfactory information modified before leaving the olfactory bulb?

5. Olfaction is the only major sensation that does not first go to _____
6. Where is the olfactory cortex located? _____
7. Functionally the lateral olfactory area _____
8. Functionally the medial olfactory area _____
9. The intermediate olfactory area has axons that extend to _____ where they synapse with _____
 - a. This is a major mechanism for _____

II. Taste

A. Papillae

1. In addition to papillae, taste buds are located on:
 - a. Other areas of _____
 - b. _____
 - c. Even _____
2. Vallate Papillae
 - a. How numerous are the vallate papillae? _____
 - b. Where are vallate papillae located? _____
 - c. Do they contain taste buds? _____
3. Fungiform Papillae
 - a. Where are fungiform papillae located? _____
 - b. Do they contain taste buds? _____
4. Foliate Papillae
 - a. Where are foliate papillae located? _____
 - b. Do they contain taste buds? _____
5. Filiform Papillae
 - a. How numerous are the filiform papillae? _____
 - b. Where are filiform papillae located? _____
 - c. Do they contain taste buds? _____

B. Histology of Taste Buds

1. What shape are taste buds? _____
2. One type of epithelial cell forms _____
3. Gustatory Cells
 - a. Specialized epithelial cells that are found in the _____
 - b. Live for about _____
 - c. What are gustatory hairs? _____
 - d. Gustatory hairs project through _____

C. Function of Taste

1. Tastants dissolve in _____ and enter the _____
2. Cause the gustatory cells to _____

3. The gustatory cells then release _____ that stimulate _____ in associated sensory neurons
4. A person tastes salt when _____ diffuse through channels and causes _____
5. Hydrogen ions of acids cause depolarization of gustatory cells in 1 of 3 ways:
 - a. _____
 - b. _____
 - c. _____
6. Sweet and bitter tastants bind to receptors and cause depolarization through _____
7. The new taste "umami" results when _____ bind to receptors and _____
8. The taste of food is also influenced by _____ & _____
9. Adaptation of taste may begin in _____ & be complete in _____
10. The wide variety of different tastes is the result of _____
11. Many of our sensations thought to be taste are actually _____

D. Neuronal Pathways for Taste

1. Which cranial nerve is responsible for taste from the following locations?
 - a. Anterior two-thirds of tongue _____
 - b. Posterior one-third of tongue, circumvallate papillae, & superior pharynx _____
 - c. Epiglottis _____
2. These nerves extend to the _____ of the medulla oblongata
3. Nerve fibers go from the nucleus to the _____
4. Neurons from the _____ go to the taste area of the cortex
 - a. Where is the taste area of the cortex located? _____

III. Visual System

A. Accessory Structures

1. Eyebrows
 - a. Protect the eyes by _____

- b. Help shade the eyes _____
2. Eyelids (Palpebrae)
- a. Protect the eyes from _____
- b. What is the palpebral fissure? _____
- c. What is a canthus? _____
- d. Where is the caruncle? _____
- e. What does the caruncle contain? _____
- f. What muscles are found in the eyelids?
1. _____
2. _____
- g. What is the function of the tarsal plate? _____
- h. Blinking helps lubricate the eye by _____
- i. What muscle closes the eyelids? _____
- j. What muscle elevates the upper lid? _____
- k. The eyelids also help regulate _____
- l. In reality a sty is an _____
- m. Where are the meibomian glands? _____
1. What do they do? _____
3. Conjunctiva
- a. What is the conjunctiva? _____
- b. Where is the palpebral conjunctiva located? _____
- c. Where is the bulbar conjunctiva located? _____
4. Lacrimal Apparatus
- a. Where is the lacrimal gland located? _____
- b. Which cranial nerve innervates the lacrimal gland? _____
1. Is this sympathetic or parasympathetic innervation? _____
- c. Functionally tears _____ and wash _____
- d. Tears are composed of mostly _____, with some _____, _____, and _____
1. What is the function of lysozyme? _____

- e. Excess tears that do not evaporate:
1. Drain at the medial canthus through an opening called _____
 2. The opening is located on _____
 3. The tears drain through the opening into small tubes called _____
 4. The small tubes open into _____
 5. The sac drains into the _____
 6. Finally the tears are emptied into _____
5. Extrinsic Eye Muscles
- a. How many extrinsic eye muscles are there? _____
 - b. Structurally a rectus muscle _____
 - b. Structurally an oblique muscle _____
 - c. Which cranial nerve innervates the superior oblique muscle? _____
 1. How does this nerve get its name? _____
 - d. Which cranial nerve innervates the lateral rectus muscle? _____
 1. How does this nerve get its name? _____
 - e. All other extrinsic eye muscles are innervated by _____
- B. Anatomy of the Eye
1. Fibrous Tunic
 - a. What is the sclera? _____
 1. The sclera is composed of _____
 2. Functionally the sclera:
 - a. Helps _____
 - b. Protects _____
 - c. Provides _____
 3. The visible part of the sclera is called _____
 - b. Anteriorly the sclera is continuous with the _____
 1. Describe the cornea: _____

 2. The connective tissue matrix of the cornea contains _____ fibers, _____ fibers, and _____

3. Why is the cornea transparent? _____

2. Vascular Tunic

- a. The vascular tunic contains most _____
- b. The vascular tunic contains a large number of _____ and appears _____ in color
- c. Where is the choroid? _____
 1. What does choroid mean? _____
- d. The ciliary body is continuous with the _____ and attached to the _____
 1. The ciliary body consists of:
 - a. Outer _____
 - b. Inner _____ attached to lens by _____
 2. The ciliary body contains _____ muscle called _____
 - a. The outer smooth muscle fibers are oriented _____
 - b. The central smooth muscle fibers are oriented _____
 - c. Ciliary muscle contraction _____ lens
 3. The ciliary processes are a complex of _____ & _____
 - a. What do the ciliary processes produce? _____
- e. The iris is the _____ part of the eye
 1. The iris is composed of _____ muscle surrounding the _____
 2. Light enters through the pupil and the iris _____ the amount of light by _____ of the pupil
 3. The sphincter pupillae is composed of _____
 - a. It is innervated by _____ from the _____
 - b. When the sphincter pupillae contracts the pupil _____
 4. The dilator pupillae is composed of _____
 - a. It is innervated by _____
 - b. When the dilator pupillae contracts the pupil is _____
- f. The term "intrinsic eye muscles" refers to:
 1. _____
 2. _____

3. _____

3. Retina

a. The innermost layer, the nervous tunic of the eye consists of:

1. Outer _____

a. Which is _____

2. Inner _____

a. Contains photoreceptors:

1. 120 million called _____

2. 6 or 7 million called _____

b. Landmarks of the retina:

1. What is the macula lutea? _____

2. What is the fovea centralis? _____

a. In terms of vision, what is special about the fovea centralis?

3. What is the optic disc? _____

a. What is formed here? _____

b. Why is it called the blind spot? _____

4. Compartments of the Eye

a. The Anterior Compartment

1. Is located in front of the _____

2. It is subdivided into two chambers:

a. The anterior chamber lies _____

b. The posterior chamber lies _____

1. The chambers are filled with _____

3. Functionally intraocular pressure:

a. Keeps the eye _____ &

b. Largely _____

4. Functionally aqueous humor also:

a. _____ light and

b. Provides _____ for structures such as _____

5. Aqueous humor is produced by _____ as a _____

6. Aqueous humor is drained by the _____
 7. Production and removal of aqueous humor at the same rate:
 - a. Circulates the _____
 - b. Maintains _____
 8. What is glaucoma? _____
- b. The Posterior Compartment
1. Is the _____ compartment behind the _____
 2. Surrounded almost completely by the _____
 3. What is vitreous humor? _____
 - a. The turnover of vitreous humor is _____
 4. Functionally the vitreous humor helps maintain _____ and is involved in _____ of light in the eye
5. Lens
- a. The lens is _____ and _____ with the greatest convexity (curvature) _____
 - b. Structurally the lens consists of:
 1. Layer of _____ on the anterior surface
 2. Posterior region of _____ called _____
 - a. These cells lose their _____ and accumulate _____ called _____
 3. Covered by a _____
 - c. The lens is suspended between _____
 1. Suspensory ligaments are connected from _____ to _____
- C. Functions of the Complete Eye
1. Light Refraction and Reflection
 - a. What is light refraction? _____
 - b. When is light refracted? _____
 - c. A concave lens causes light rays to _____
 - d. A convex lens causes light rays to _____
 - e. Causing light rays to converge is called _____
 - f. The point at which light rays cross is called the _____

- g. Where is the focused image formed? _____
- h. What is light reflection? _____
- i. Why is light reflection important to vision? _____
2. Focusing of Images on the Retina
- a. As light rays pass through the eye they are caused to converge by:
1. _____
 2. _____
 3. _____
 4. _____
- a. Which of these causes the greatest convergence? _____
- b. Fine adjustment in focusing is accomplished by _____
1. When the ciliary muscles are relaxed:
 - a. Suspensory ligaments maintain _____
 - b. Keeping the lens _____
 - c. Allowing for _____
 - d. This is the normal resting condition of the lens & is called _____
 2. When an object is closer than 20 feet, three events occur for focusing:
 - a. Accommodation of the Lens
 1. Ciliary muscles _____ due to _____ stimulation
 2. Pulls the choroid toward the lens to _____
 3. Allows the lens to _____ because of _____
 4. More spherical lens causes _____
 - b. Pupil Constriction
 1. The size of the pupil affects _____
 - a. Small pupil diameter results in _____
 - b. Large pupil diameter results in _____
 - c. Convergence of the Eyes
 1. Rotation of the eyes _____ to maintain a focused image on _____ of the retina
 2. This reflex stimulates the _____

D. Structure and Function of the Retina

1. List the three neuron layers of the sensory retina:
 - a. _____
 - b. _____
 - c. _____
2. The pigmented retina consists of _____
 - a. What is the purpose of the melanin? _____
3. Rods
 - a. Rods are _____ involved in _____ and are responsible for vision _____
 - b. Describe the structure of a rod _____

 - c. Where is rhodopsin found? _____
 1. Rhodopsin consists of a protein _____ bound to a pigment _____
4. Function of Rhodopsin
 - a. As light is absorbed by rod cells _____
 1. The shape change activates _____
 - a. Causes the closing of _____ resulting in _____
 - b. When not exposed to light:
 1. _____ channels are open and _____ into the cell
 2. This causes the photoreceptor to release _____
 3. Glutamate acts as an _____
 4. This causes the bipolar cell to _____
 - c. When exposed to light:
 1. The _____ channels _____ so fewer _____ enter the cell
 2. Therefore the amount of glutamate released _____
 3. This results in hyperpolarization of bipolar neurons _____
 4. Bipolar neurons depolarize sufficiently to release _____
 5. Stimulate ganglionic cells to _____
 - d. In bright light excess rhodopsin is _____

- e. In a dark room _____
5. Cones
- Cones require _____ to function
 - At night objects appear gray because _____
 - Describe the structure of a cone _____
 - What is the visual pigment present in cones? _____
 - This consists of _____ and a photopigment _____
 - List the three major types of color sensitive opsin:
 - _____
 - _____
 - _____
 - Iodopsin functions like rhodopsin except _____
 - Color is interpreted in the _____ as combinations of sensory input from the various _____ stimulated
6. Inner Layers of the Retina
- What cells do rods and cones synapse with? _____
 - What cells synapse with ganglion cells? _____
 - Axons from the ganglion cells converge at the _____
 - The point where the axons converge forms the _____
 - How many rods connect to one bipolar cell? _____
 - How many cones connect to one bipolar cell? _____
 - Therefore which photoreceptor provides the sharpest vision? _____
- E. Neuronal Pathways for Vision
- Which retinal nerve fibers cross at the optic chiasma? _____
 - Most of the ganglionic axons terminate in _____
 - Some axons terminate in _____
 - What are "optic radiations"? _____
 - Where is the visual cortex in the cerebrum? _____
 - Describe a "visual field" _____
 - The _____ part of the visual field projects to the _____ retina
 - What is binocular vision? _____
 - Explain depth perception? _____

IV. Hearing and Balance

A. Auditory Structures and Their Functions

1. External Ear

- a. Describe the auricle _____
 1. The auricle is composed of _____
- b. Functionally the auricle _____
- c. The external auditory canal contains _____ & _____
 1. What is cerumen commonly called? _____
- d. Functionally hairs and cerumen _____
- e. Describe the tympanic membrane _____
- f. Specify the composition of each layer of the tympanic membrane:
 1. Inner layer is _____
 2. Middle layer is _____
 3. Outer layer is _____
- g. Sound waves cause the tympanic membrane to _____

2. Middle Ear

- a. The middle ear is an _____ cavity
- b. It is separated on the medial side from the inner ear by the _____ and _____
- c. Two openings provide _____
 1. One passage opens into the _____
 2. The auditory or eustachian tube opens into _____
 - a. Functionally this tube _____
 - b. This is important because a distorted tympanic membrane _____ its vibrations and makes hearing _____
- d. The middle ear contains three auditory ossicles:
 1. _____ meaning hammer
 2. _____ meaning anvil
 3. _____ meaning stirrup
- e. Which ossicle attaches to the tympanic membrane? _____
- f. Which ossicle attaches to the oval window? _____

- g. What is the function of the annular ligament? _____
3. Inner Ear
- a. The bony labyrinth consists of _____ & _____
1. It is lined with _____
- b. The membranous labyrinth is _____
- c. The membranous labyrinth is filled with _____
- d. The space between the membranous and bony labyrinth is filled with _____
- e. List the three parts of the inner ear:
1. _____
2. _____
3. _____
- f. Which part(s) are involved in balance? _____
- g. Which part(s) are involved in hearing? _____
- h. List the three parts of the cochlea:
1. _____
2. _____
3. _____
- i. What is the helicotrema? _____
- j. Which cochlear chamber extends from the oval window to the helicotrema? _____
- k. Which cochlear chamber extends from the helicotrema to the round window? _____
- l. What fluid fills the scala vestibuli and scala tympani? _____
- m. What membrane borders the scala vestibuli? _____
- n. What membrane borders the scala tympani? _____
- o. Where is the cochlear duct? _____
- p. What fluid fills the cochlear duct? _____
- q. The basilar membrane near the oval window is _____ & _____
1. Responds to _____ vibrations
- r. The basilar membrane near the helicotrema is _____ & _____

1. Responds to _____ vibrations
- s. Hair cells and supporting epithelial cells form the _____
- t. The hair cells have _____ at their apical ends
- u. The hair cells are arranged in _____ extending the _____
- v. The tips of the hairs are embedded in _____ called _____
- w. The basilar regions of a hair cell are covered _____
- x. Afferent fibers of these neurons form the _____
- y. This nerve joins with the _____ to form _____

B. Auditory Function

1. External Ear

- a. The auricle _____ sound waves and funnels them through the _____ to the _____
- b. The brain uses the time interval between sound reaching both ears to _____

2. Middle Ear

- a. When sound waves strike the tympanic membrane they cause it to _____
- b. In turn this causes vibration of the _____ and the _____
- c. The auditory ossicles are important in the transmission of sound waves to the oval window because the vibrations are _____
- d. What is the function of the sound attenuation reflex? _____

3. Inner Ear

- a. As the stapes vibrates the oval window:
 1. It produces _____ in the perilymph of _____
 2. These are transmitted through the thin _____
 3. Producing simultaneous waves in the _____
 4. Vibration of the _____ causes distortion of the _____

5. This distortion causes waves in the _____
 6. Ultimately causing vibration of the _____
- b. Vibration of the round window acts as a _____
 - c. Distortion of which membrane is most important to hearing? _____
 - d. Depolarization of the hair cells occurs when _____
 - e. What determines which part of the basilar membrane will be distorted?

 - f. The superior olivary nucleus in the medulla analyzes nerve impulses from the cochlea to determine area of _____
 1. Based on this it sends nerve impulses to the cochlea inhibiting

 2. This process localizes _____
 - g. Action potentials from:
 1. The base of the basilar membrane are interpreted as _____
 2. The apex of the basilar membrane are interpreted as _____
- C. Neuronal Pathways for Hearing
1. Neurons from the cochlear ganglion synapse in _____
 2. These neurons synapse in or pass through the _____
 3. Neurons terminating in this nucleus may:
 - a. Synapse with neurons returning to the cochlea for _____
 - b. Project to cranial nerves for _____ reflex
 - c. Join _____
 4. Ascending neurons from the superior olivary nucleus travel in _____
 5. All ascending fibers synapse in the _____ and from there project to _____ of the _____
 6. Where is the auditory portion of the cerebral cortex? _____
 7. The superior colliculus is involved in _____
- D. Balance
1. The static labyrinth consists of the _____ & _____
 2. The static labyrinth is primarily involved in _____
 3. The kinetic labyrinth is associated with _____

4. The kinetic labyrinth is involved in evaluating _____
5. How big is the macula?
6. What direction is the macula oriented?
 - a. In the utricle _____
 - b. In the saccule _____
7. Structurally a macula is composed of columnar _____ & _____
8. Hair cells have numerous microvilli called _____
9. Hair cells have one cilium called a _____
10. The hair cells are embedded in _____
11. Otoliths are composed of _____ & _____
12. The gelatinous mass moves in response to _____
13. Depolarization of hair cells results from _____
14. Hyperpolarization of hair cells results from _____
15. As the head is moved and the gelatinous mass moves the pattern of intensity _____
16. This information can be interpreted in the brain as _____
17. In response the body _____
18. The kinetic labyrinth consists of _____
 - a. One in the _____ plane
 - b. One in the _____ plane
 - c. One in the _____ plane
19. The expanded portion of each semicircular canal is called an _____
20. The sensory structure inside the ampulla is called _____
21. What is a cupula? _____
22. What is embedded in the cupula? _____
23. Why does the cupula not respond to gravity? _____
24. The cupula is a float that is displaced by _____
25. Endolymph movements move the cupula which _____ hairs & _____
26. This system detects _____ rather

E. Neuronal Pathways for Balance

1. Neurons from the hair cells converge to form the _____
2. Where do these sensory fibers terminate? _____
3. From here the axons run to _____
4. In addition to the inner ear, the vestibular nucleus also receives input from:
 - a. _____
 - b. _____

V. Effects of Aging on the Special Senses

- A. How much olfaction loss occurs with aging? _____
- B. Gustation _____ as people age because _____ &

- C. The lens loses flexibility because _____
 1. There is a reduction and eventual loss in the ability to _____
- D. List age related visual problems from most common to less common:
 1. _____
 2. _____
 3. _____
 4. _____
- E. What happens to the number of cones as we age? _____
 1. This causes a _____ & _____
- F. What happens to the number of hair cells in the cochlea? _____
 1. Since this doesn't happen equally in both ears older people may have trouble

- G. What happens to the number of hair cells in the saccule, utricle, and ampullae?

- H. What happens to the number of otoliths? _____
- I. Therefore elderly people experience a decreased sensitivity to:
 1. _____
 2. _____

3. _____
 - a. This causes elderly people to experience:
 1. _____
 2. _____