



Special Senses

The body's sensory receptors react to stimuli or changes occurring both within the body and in the external environment. When triggered, these receptors send nerve impulses along afferent pathways to the brain for interpretation, thus, allowing the body to assess and adjust to changing conditions so that homeostasis may be maintained.

The minute receptors of general sensation that react to touch—pressure, pain, temperature changes, and muscle tension—are widely distributed in the body. These are considered in Chapter 7. In contrast, receptors of the special senses—sight, hearing, equilibrium, smell, and taste—tend to be localized and in many cases are quite complex. The structure and function of the special sense organs are the subjects of the student activities in this chapter.

THE EYE AND VISION

1. Complete the following statements by inserting your responses in the answer blanks.

- _____ 1. Attached to the eyes are the (1) muscles that allow us to direct our eyes toward a moving object. The anterior aspect of each eye is protected by the (2), which have eyelashes projecting from their edges. Closely associated with the lashes are oil-secreting glands called (3) that help to lubricate the eyes. Inflammation of the mucosa lining the eyelids and covering the anterior part of the eyeball is called (4).

2. Trace the pathway that the secretion of the lacrimal glands takes from the surface of the eye by assigning a number to each structure. (Note that #1 will be *closest* to the lacrimal gland.)

- | | |
|-----------------------|----------------------------|
| _____ 1. Lacrimal sac | _____ 3. Nasolacrimal duct |
| _____ 2. Nasal cavity | _____ 4. Lacrimal canals |

3. Identify each of the eye muscles indicated by leader lines in Figure 8-1. Color code and color each muscle a different color. Then, in the blanks below, indicate the eye movement caused by each muscle.

- | | |
|---|---|
| <input type="radio"/> 1. Superior rectus _____ | <input type="radio"/> 4. Lateral rectus _____ |
| <input type="radio"/> 2. Inferior rectus _____ | <input type="radio"/> 5. Medial rectus _____ |
| <input type="radio"/> 3. Superior oblique _____ | <input type="radio"/> 6. Inferior oblique _____ |

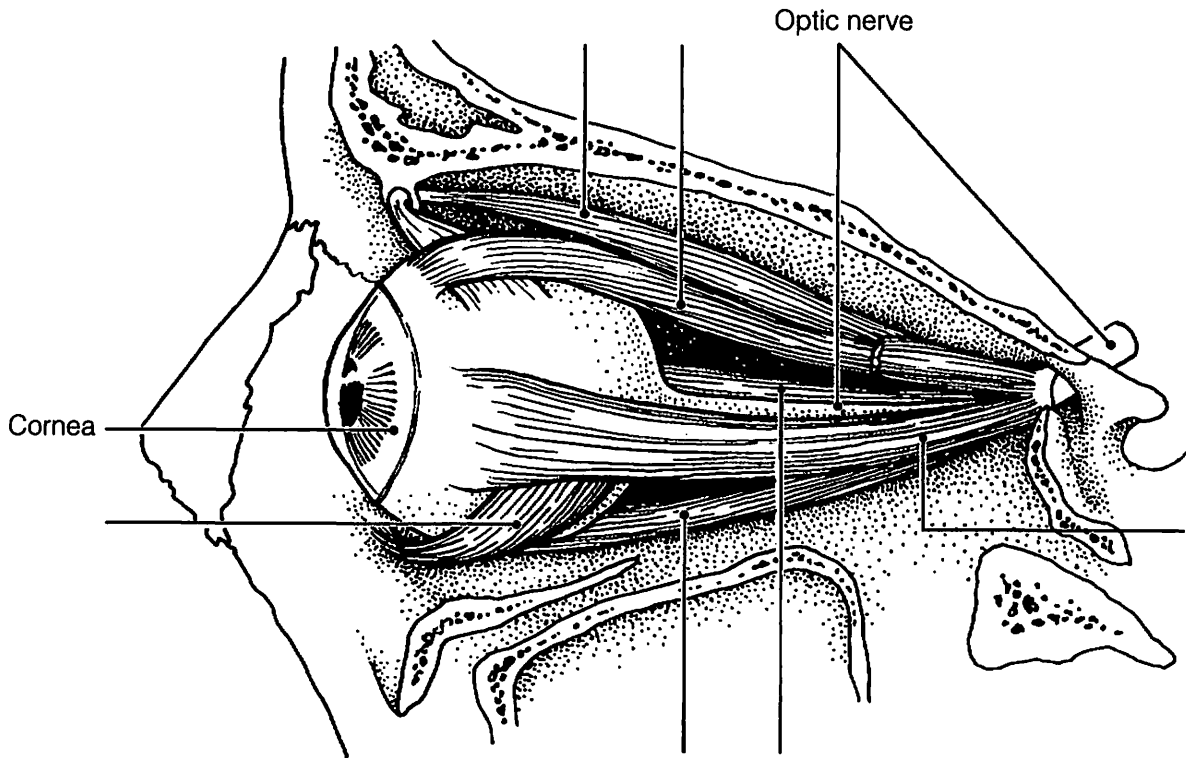


Figure 8-1

4. Three main accessory eye structures contribute to the formation of tears and/or aid in lubricating the eyeball. In the table, name each structure and then name its major secretory product. Indicate which of the secretions has antibacterial properties by circling that response.

Accessory eye structures

Secretory product

1.	
2.	
3.	

5. Match the terms provided in Column B with the appropriate descriptions in Column A. Insert the correct letter response or corresponding term in the answer blanks.

Column A	Column B
_____ 1. Light bending	A. Accommodation
_____ 2. Ability to focus for close vision (under 20 feet)	B. Accommodation pupillary reflex
_____ 3. Normal vision	C. Astigmatism
_____ 4. Inability to focus well on close objects; farsightedness	D. Cataract
_____ 5. Reflex-constriction of pupils when they are exposed to bright light	E. Convergence
_____ 6. Clouding of the lens, resulting in loss of sight	F. Emmetropia
_____ 7. Nearsightedness	G. Glaucoma
_____ 8. Blurred vision, resulting from unequal curvatures of the lens or cornea	H. Hyperopia
_____ 9. Condition of increasing pressure inside the eye, resulting from blocked drainage of aqueous humor	I. Myopia
_____ 10. Medial movement of the eyes during focusing on close objects	J. Night blindness
_____ 11. Reflex constriction of the pupils when viewing close objects	K. Photopupillary reflex
_____ 12. Inability to see well in the dark; often a result of vitamin A deficiency	L. Refraction

6. The intrinsic eye muscles are under the control of which division of the nervous system? Circle the correct response.

1. Autonomic nervous system 2. Somatic nervous system

7. Complete the following statements by inserting your responses in the answer blanks.

- _____ 1. A (1) lens, like that of the eye, produces an image that is upside down and reversed from left to right. Such an image is called a (2) image. In farsightedness, the light is focused (3) the retina. The lens used to treat farsightedness is a (4) lens. In nearsightedness, the light is focused (5) the retina; it is corrected with a (6) lens.
- _____ 2. _____
- _____ 3. _____
- _____ 4. _____
- _____ 5. _____ 6. _____

8. Using key choices, identify the parts of the eye described in the following statements. Insert the correct term or letter response in the answer blanks.

Key Choices

- | | | |
|---|--|--|
| A. <input type="radio"/> Aqueous humor | F. <input type="radio"/> Fovea centralis | K. <input type="radio"/> Sclera |
| B. <input type="radio"/> Canal of Schlemm | G. <input type="radio"/> Iris | L. <input type="radio"/> Suspensory ligament |
| C. <input type="radio"/> Choroid coat | H. <input type="radio"/> Lens | M. <input type="radio"/> Vitreous humor |
| D. <input type="radio"/> Ciliary body | I. <input type="radio"/> Optic disk | |
| E. <input type="radio"/> Cornea | J. <input type="radio"/> Retina | |

- _____ 1. Attaches the lens to the ciliary body
- _____ 2. Fluid that provides nutrients to the lens and cornea
- _____ 3. The “white” of the eye
- _____ 4. Area of retina that lacks photoreceptors
- _____ 5. Contains muscle that controls the shape of the lens
- _____ 6. Nutritive (vascular) tunic of the eye
- _____ 7. Drains the aqueous humor of the eye
- _____ 8. Tunic, containing the rods and cones
- _____ 9. Gel-like substance that helps to reinforce the eyeball
- _____ 10. Heavily pigmented tunic that prevents light scattering within the eye
- _____ 11. _____ 12. Smooth muscle structures (intrinsic eye muscles)
- _____ 13. Area of acute or discriminatory vision
- _____ 14. _____ 15. Refractory media of the eye (#14–17)
- _____ 16. _____ 17.
- _____ 18. Anterionmost part of the sclera—your “window on the world”
- _____ 19. Pigmented “diaphragm” of the eye

9. Using the key choice terms given in Exercise 8, identify the structures indicated by leader lines on the diagram of the eye in Figure 8–2. Select different colors for all structures provided with a color-coding circle in Exercise 8, and then use them to color the coding circles and corresponding structures in the figure.

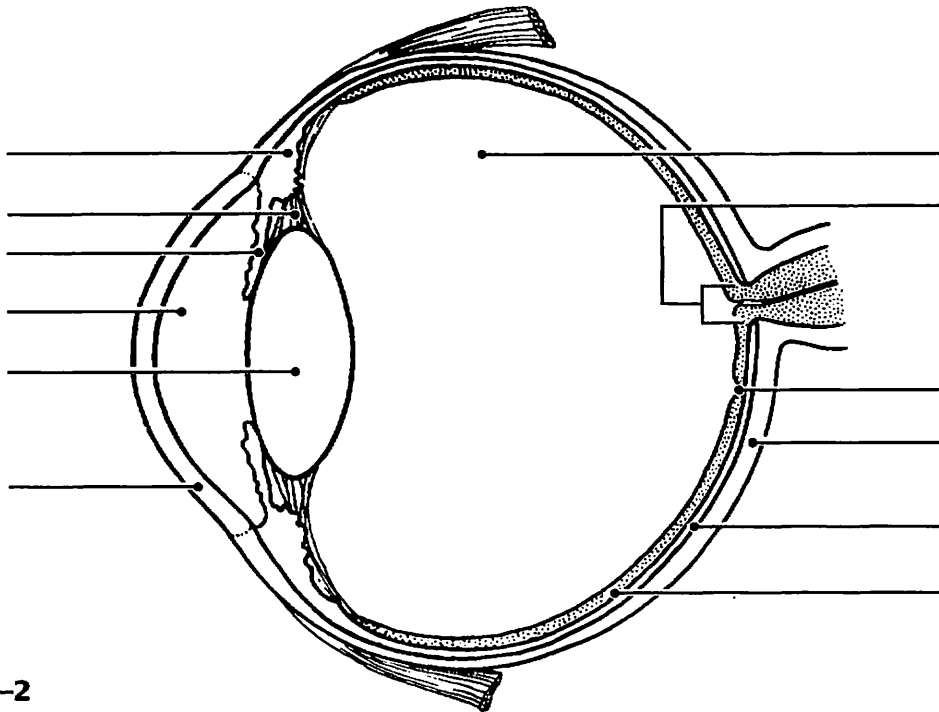
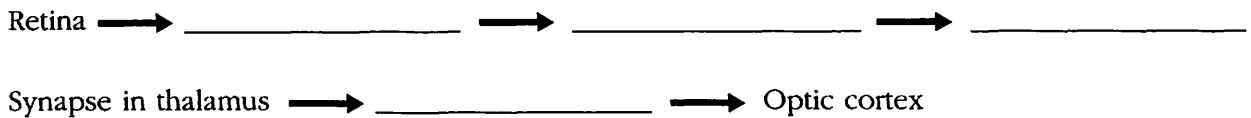


Figure 8-2

10. In the following table circle the correct word under the vertical headings that describes events occurring within the eye during close and distant vision.

Vision	Ciliary muscle		Lens convexity		Degree of light refraction	
1. Distant	Relaxed	Contracted	Increased	Decreased	Increased	Decreased
2. Close	Relaxed	Contracted	Increased	Decreased	Increased	Decreased

11. Name in sequence the neural elements of the visual pathway, beginning with the retina and ending with the optic cortex.



12. Complete the following statements by inserting your responses in the answer blanks.

- _____ 1. There are (1) varieties of cones. One type responds most vigorously to (2) light, another to (3) light, and still another to (4) light. The ability to see intermediate colors such as purple results from the fact that more than one cone type is being stimulated (5). Lack of all color receptors results in (6). Because this condition is sex linked, it occurs more commonly in (7). Black and white, or dim light, vision is a function of the (8).
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- _____ 6. _____ 7. _____ 8.

13. Circle the term that does not belong in each of the following groupings.

- | | | | |
|-----------------------|------------|----------------------|----------------|
| 1. Choroid | Sclera | Vitreous humor | Retina |
| 2. Ciliary body | Iris | Superior rectus | Choroid |
| 3. Pupil constriction | Far vision | Accommodation | Bright light |
| 4. Proprioceptors | Rods | Cones | Photoreceptors |
| 5. Ciliary body | Iris | Suspensory ligaments | Lens |

14. Complete the statements concerning rod photopigment and physiology by writing your responses in the answer blanks.

- _____ 1. The bent or kinked form of retinal is combined with a protein called (1) to form the visual pigment called (2). When
- _____ 2. light strikes the visual pigment, it straightens out and breaks down into its two components. This event is called (3)
- _____ 3. because the purple color of the visual pigment changes to (4) and finally becomes (5) as retinal is converted all the
- _____ 4. way back to vitamin (6).
- _____ 5.
- _____ 6.

THE EAR: HEARING AND BALANCE

15. Using key choices, select the terms that apply to the following descriptions. Place the correct letter in the answer blanks.

Key Choices

- | | | | |
|------------------|----------------------------|------------------------|----------------------|
| A. Anvil (incus) | E. External auditory canal | I. Pinna | M. Tympanic membrane |
| B. Auditory tube | F. Hammer (malleus) | J. Round window | N. Vestibule |
| C. Cochlea | G. Oval window | K. Semicircular canals | |
| D. Endolymph | H. Perilymph | L. Stirrup (stapes) | |

- _____ 1. _____ 2. _____ 3. Structures composing the outer ear
- _____ 4. _____ 5. _____ 6. Structures composing the bony or osseous labyrinth
- _____ 7. _____ 8. _____ 9. Collectively called the ossicles
- _____ 10. _____ 11. Ear structures not involved with hearing

- ___ 12. Allows pressure in the middle ear to be equalized with the atmospheric pressure
- ___ 13. Vibrates as sound waves hit it; transmits the vibrations to the ossicles
- ___ 14. Contains the organ of Corti
- ___ 15. Connects the nasopharynx and the middle ear
- ___ 16. ___ 17. Contain receptors for the sense of equilibrium
- ___ 18. Transmits the vibrations from the stirrup to the fluid in the inner ear
- ___ 19. Fluid that bathes the sensory receptors of the inner ear
- ___ 20. Fluid contained within the osseous labyrinth, which bathes the membranous labyrinth

16. Figure 8–3 is a diagram of the ear. Use anatomical terms (as needed) from key choices in Exercise 15 to correctly identify all structures in the figure provided with leader lines. Color all external ear structures yellow; color the ossicles red; color the equilibrium areas of the inner ear green; and color the inner ear structures involved with hearing blue.

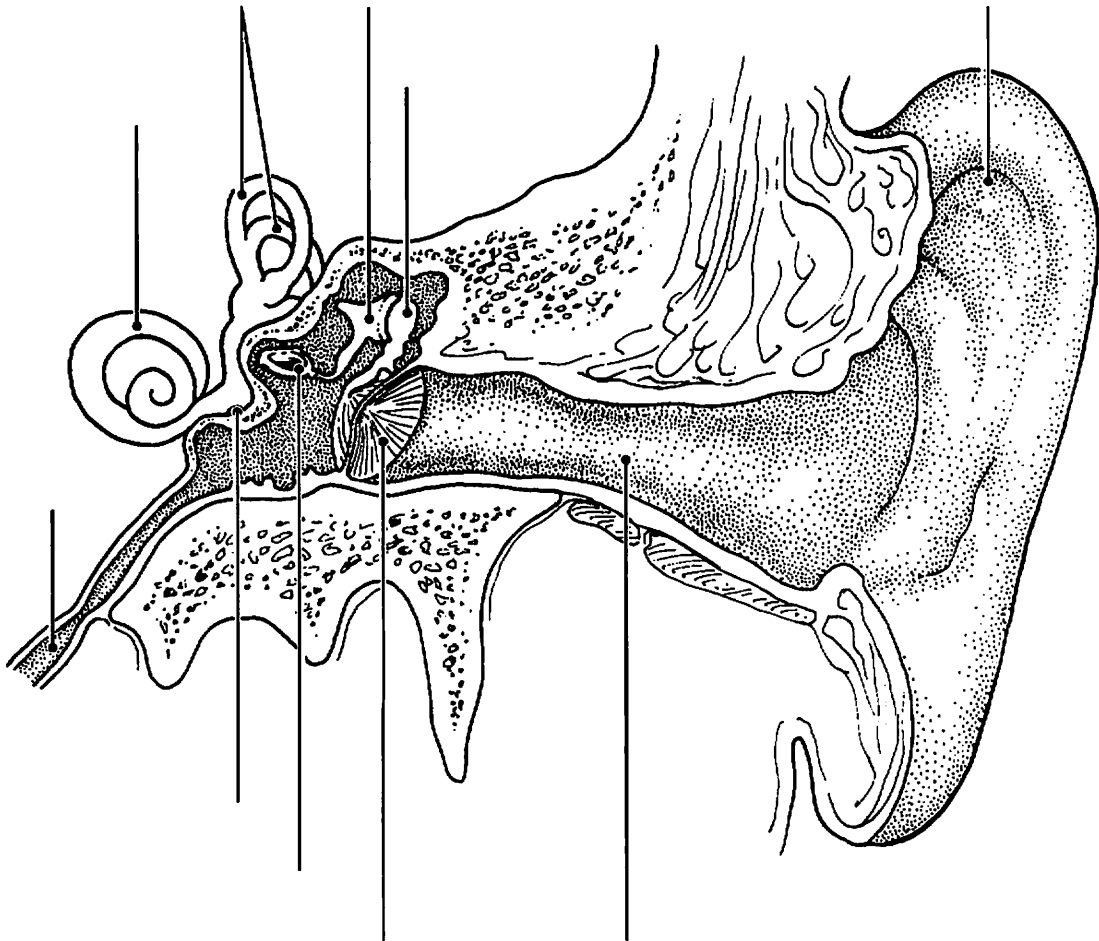


Figure 8–3

19. Complete the following statements on the functioning of the static and dynamic equilibrium receptors by inserting the letter or term from the key choices in the answer blanks.

Key Choices

- | | | |
|---------------------|-------------------|------------------------|
| A. Angular/rotatory | E. Gravity | I. Semicircular canals |
| B. Cupula | F. Perilymph | J. Static |
| C. Dynamic | G. Proprioception | K. Utricle |
| D. Endolymph | H. Saccule | L. Vision |

- _____ 1. The receptors for (1) equilibrium are found in the crista
ampullaris of the (2). These receptors respond to changes
_____ 2. in (3) motion. When motion begins, the (4) fluid lags
behind and the (5) is bent, which excites the hair cells.
_____ 3. When the motion stops suddenly, the fluid flows in the oppo-
site direction and again stimulates the hair cells. The receptors
_____ 4. for (6) equilibrium are found in the maculae of the (7)
and (8). These receptors report the position of the head in
_____ 5. space. Tiny stones found in a gel overlying the hair cells roll
in response to the pull of (9). As they roll, the gel moves
_____ 6. and tugs on the hair cells, exciting them. Besides the equilib-
rium receptors of the inner ear, the senses of (10) and
_____ 7. (11) are also important in helping to maintain equilibrium.
_____ 8.
_____ 9.
_____ 10.
_____ 11.

20. Indicate whether the following conditions relate to conduction deafness (*C*) or sensorineural (central) deafness (*S*). Place the correct letter choice in each answer blank.

- _____ 1. Can result from the fusion of the ossicles
_____ 2. Can result from damage to the cochlear nerve
_____ 3. Sound is heard in one ear but not in the other, during both bone
and air conduction
_____ 4. Often improved by a hearing aid
_____ 5. Can result from otitis media
_____ 6. Can result from excessive earwax or a perforated eardrum
_____ 7. Can result from a blood clot in the auditory cortex of the brain

21. List three things about which a person with equilibrium problems might complain. Place your responses in the answer blanks.

_____ , _____ , and _____

22. Circle the term that does not belong in each of the following groupings.

1. Hammer Anvil Pinna Stirrup
2. Tectorial membrane Crista ampullaris Semicircular canals Cupula
3. Gravity Angular motion Sound waves Rotation
4. Utricle Saccule Auditory tube Vestibule
5. Vestibular nerve Optic nerve Cochlear nerve Vestibulocochlear nerve

CHEMICAL SENSES: SMELL AND TASTE

23. Complete the following statements by inserting your responses in the answer blanks.

- _____ 1. Three cranial nerves involved in transmitting impulses for the sense of taste are the (1), (2), and (3). Impulses for
- _____ 2. the sense of smell are transmitted by the (4) nerve. The
- _____ 3. receptors for smell are located in the (5) of the nasal pas-
- _____ 4. sages; the act of (6) increases the sensation, because it
- _____ 5. brings more air into contact with the receptors. The receptors
- _____ 6. for taste are found in clusterlike areas called (7), most of
- _____ 7. which are located on the sides of (8) or (9) papillae.
- _____ 8. The four basic taste sensations are (10), (11), (12), and
- _____ 9. (13). The most protective receptors are thought to be those
- _____ 10. that respond to (14) substances. When nasal passages are
- _____ 11. congested, the sense of taste is decreased. This indicates that
- _____ 12. much of what is considered taste actually depends on the
- _____ 13. sense of (15). It is impossible to taste substances with a
- _____ 14. (16) tongue, because foods must be dissolved (or in
- _____ 15. solution) to excite the taste receptors. The sense of smell is
- _____ 16. closely tied to the emotional centers of the brain (limbic
- _____ 17. region), and many odors bring back (17).

24. On Figure 8-5A, label the two types of tongue papillae containing taste buds. On Figure 8-5B, color the taste buds green. On Figure 8-5C, color the gustatory cells red, the supporting cells blue, and the cranial nerve fibers yellow. Add appropriate labels to the leader lines provided to identify the *taste pore* and *microvilli* of the gustatory cells.

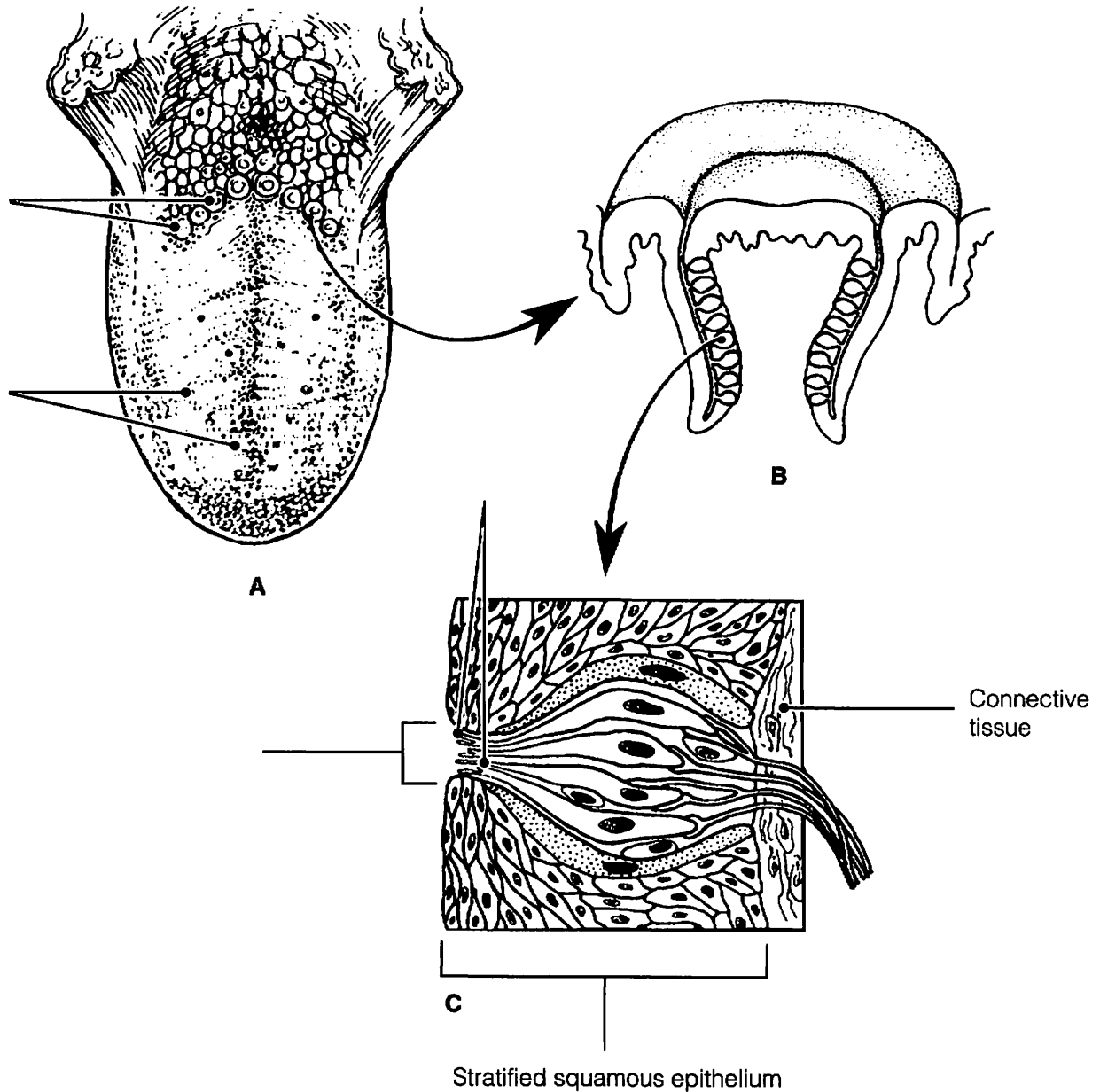


Figure 8-5

25. Figure 8–6 illustrates the site of the olfactory epithelium in the nasal cavity (part A is an enlarged view of the olfactory receptor area). Select different colors to identify the structures listed below and use them to color the coding circles and corresponding structures in the illustration. Then add a label and leader line to identify the olfactory “hairs” and add arrows to indicate the direction of impulse transmission.

- | | |
|--|--|
| <input type="radio"/> Olfactory neurons (receptor cells) | <input type="radio"/> Olfactory bulb |
| <input type="radio"/> Supporting cells | <input type="radio"/> Cribriform plate of the ethmoid bone |
| <input type="radio"/> Fibers of the olfactory tract | <input type="radio"/> Olfactory nerve filaments |

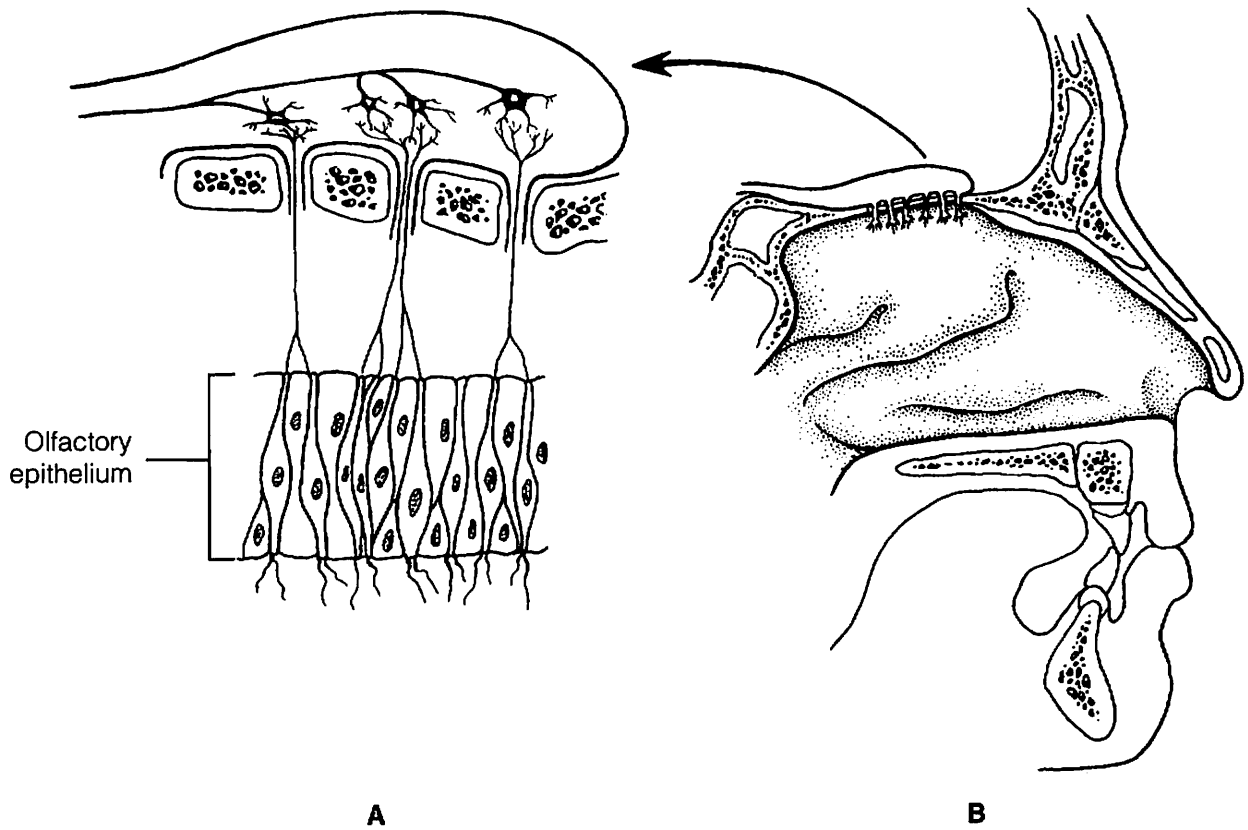


Figure 8–6

26. Circle the term that does not belong in each of the following groupings.

- | | | | | |
|-----------------------|------------------|------------------------|---------------------|-------------|
| 1. Sweet | Musky | Sour | Bitter | Salty |
| 2. Bipolar neuron | Epithelial cell | Olfactory receptor | Ciliated | |
| 3. Gustatory cell | Taste pore | Papillae | Neuron | |
| 4. Vagus nerve | Facial nerve | Glossopharyngeal nerve | Olfactory nerve | |
| 5. Olfactory receptor | High sensitivity | Variety of stimuli | Four receptor types | |
| 6. Sugars | Sweet | Saccharine | Metal ions | Amino acids |

DEVELOPMENTAL ASPECTS OF THE SPECIAL SENSES

27. Complete the following statements by inserting your responses in the answer blanks.

- | | | |
|-------|----|--|
| _____ | 1. | The special sense organs are actually part of the <u>(1)</u> and are formed very early in the embryo. Maternal infections, particularly <u>(2)</u> , may cause both deafness and <u>(3)</u> in the developing child. Of the special senses, the sense of <u>(4)</u> |
| _____ | 2. | requires the most learning or takes longest to mature. All infants are <u>(5)</u> , but generally by school age emmetropic vision has been established. Beginning sometime after the age of 40, the eye lenses start to become less <u>(6)</u> and cannot bend properly to refract the light. As a result, a condition of farsightedness, called <u>(7)</u> , begins to occur. <u>(8)</u> , a condition in which the lens becomes hazy or discolored, is a frequent cause of blindness. In old age, a gradual hearing loss, called <u>(9)</u> , occurs. A declining efficiency of the chemical senses is also common in the elderly. |
| _____ | 3. | |
| _____ | 4. | |
| _____ | 5. | |
| _____ | 6. | |
| _____ | 7. | |
| _____ | 8. | |
| _____ | 9. | |



INCREDIBLE JOURNEY

A Visualization Exercise for the Special Senses

You . . . see a discontinuous sea of glistening, white rock slabs . . .

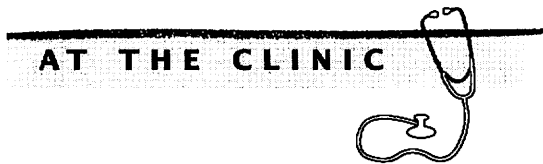
28. Where necessary, complete statements by inserting the missing words in the answer blanks.

- _____ 1. Your present journey will take you through your host's inner ear to observe and document what you have learned about
- _____ 2. how hearing and equilibrium receptors work.
- _____ 3. This is a very tightly planned excursion. Your host has been instructed to move his head at specific intervals and will be
- _____ 4. exposed to various sounds so that you can make certain observations. For this journey you are miniaturized and
- _____ 5. injected into the bony cavity of the inner ear, the (1), and are to make your way through its various chambers in a
- _____ 6. limited amount of time.
- _____ 7. Your first observation is that you are in a warm sea of (2) in the vestibule. To your right are two large sacs, the (3)
- _____ 8. and (4). You swim over to one of these membranous sacs, cut a small semicircular opening in the wall, and wiggle
- _____ 9. through. Since you are able to see very little in the dim light, you set out to explore this area more fully. As you try to
- _____ 10. move, however, you find that your feet are embedded in a thick, gluelike substance. The best you can manage is slow-
- _____ 11. motion movements through this (5).
- _____ 12. It is now time for your host's first scheduled head movement. Suddenly your world tips sharply sideways. You hear a roar (rather like an avalanche) and look up to see a discontinuous sea of glistening, white rock slabs sliding toward you. You protect yourself from these (6) by ducking down between the hair cells that are bending vigorously with the motion of the rocks. Now that you have seen and can document the operation of a (7), a sense organ of (8) equilibrium, you quickly back out through the hole you made.

Keeping in mind the schedule and the fact that it is nearly time for your host to be exposed to tuning forks, you swim quickly to the right, where you see what looks like the opening of a cave with tall seaweed waving gently in the current. Abruptly, as you enter the cave, you find that you are no longer in control of your movements, but instead are swept along in a smooth undulating pattern through the winding passageway of the cave, which you now know is the cavity of the (9). As you move up and down with the waves you see hair cells of the (10), the sense organ for (11), being vigorously disturbed below you. Flattening yourself against the chamber wall to prevent being carried further by the waves, you wait for the stimulus to stop. Meanwhile you are delighted by the electrical activity of the hair cells below you. As they depolarize to send impulses along the (12), the landscape appears to be alive with fireflies.

- _____ 13. Now that you have witnessed the events for this particular sense receptor, you swim back through the vestibule toward
- _____ 14. your final observation area at the other end of the bony chambers. You recognize that your host is being stimulated again because of the change in fluid currents, but since you
- _____ 15. are not close to any of the sensory receptors, you are not sure just what the stimulus is. Then, just before you, three
- _____ 16. dark openings appear, the (13). You swim into the middle opening and see a strange structure that looks like the brush

end of an artist's paintbrush; you swim upward and establish yourself on the soft brushy top portion. This must be the (14) of the (15), the sensory receptor for (16) equilibrium. As you rock back and forth in the gentle currents, a sudden wave of fluid hits you. Clinging to the hairs as the fluid thunders past you, you realize that there will soon be another such wave in the opposite direction. You decide that you have seen enough of the special senses and head back for the vestibule to leave your host once again.



- 29.** An infant girl with strabismus is brought to the clinic. Tests show that she can control both eyes independently. What therapy will be tried before surgery?
- 30.** A man in his early 60s comes to the clinic complaining of fuzzy vision. An eye examination reveals clouding of his lenses. What is his problem and what factors might have contributed to it?
- 31.** Albinism is a condition in which melanin pigment is not made. How do you think vision is affected by albinism?
- 32.** A man claiming to have difficulty seeing at night seeks help at the clinic. What is the technical name for this disorder? What dietary supplement will be recommended? If the condition has progressed too far, what retinal structures will be degenerated?

- 33.** A child is brought to the speech therapist because she does not pronounce high-pitched sounds (like “s”). If it is determined that the spiral organ of Corti is the source of the problem, which region of the organ would be defective? Is this conduction or sensorineural deafness?
- 34.** Little Biff’s uncle tells the physician that 3-year-old Biff has frequent earaches and that a neighbor claims that Biff needs to have “ear tubes” put in. Upon questioning, the uncle reveals that Biff is taking swimming lessons and he can’t remember the last time the boy had a sore throat. Does Biff have otitis media or otitis externa? Does he need ear tubes? Explain your reasoning.
- 35.** Harry fell off a tall ladder and fractured the anterior cranial fossa of his skull. On arrival at the hospital, a watery, blood-tinged fluid was dripping from his right nostril. Several days later, Harry complained that he could no longer smell. What nerve was damaged in his fall?
- 36.** Brian is brought to the clinic by his parents, who noticed that his right eye does not rotate laterally very well. The doctor explains that the nerve serving the lateral rectus muscle is not functioning properly. What nerve is he referring to?
- 37.** When Mrs. Martinez visits her ophthalmologist, she complains of pain in her right eye. The intraocular pressure of that eye is found to be abnormally elevated. What is the name of Mrs. Martinez’s probable condition? What causes it? What might be the outcome if the problem is not corrected?