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

   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
      ______ 2. Nasal cavity
      ______ 3. Nasolacrimal duct
      ______ 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.

○ 1. Superior rectus
○ 2. Inferior rectus
○ 3. Superior oblique
○ 4. Lateral rectus
○ 5. Medial rectus
○ 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.

<table>
<thead>
<tr>
<th>Accessory eye structures</th>
<th>Secretory product</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
</tbody>
</table>
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.

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

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.
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. Aqueous humor  
B. Canal of Schlemm  
C. Choroid coat  
D. Ciliary body  
E. Ciliary zonule  
F. Cornea  
G. Fovea centralis  
H. Iris  
I. Lens  
J. Optic disk  
K. Retina  
L. Sclera  
M. Vitreous humor

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. Area of acute or discriminatory vision  
12. Smooth muscle structures (intrinsic eye muscles)  
13. Refractory media of the eye (#14-17)  
14. Anteriormost part of the sclera—your “window on the world”  
15. 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.
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.

<table>
<thead>
<tr>
<th>Vision</th>
<th>Ciliary muscle</th>
<th>Lens convexity</th>
<th>Degree of light refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Distant</td>
<td>Relaxed</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td></td>
<td>Contracted</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>2. Close</td>
<td>Relaxed</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td></td>
<td>Contracted</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
</tbody>
</table>

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

Retina → _______ → _______ → _______ → Optic cortex

Synapse in thalamus → _______ → _______ → 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)_.
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 light strikes the visual pigment, it straightens out and breaks down into its two components. This event is called (3). Because the purple color of the visual pigment changes to (4) and finally becomes (5) as retinal is converted all the way back to vitamin (6).

__________________________  2.

__________________________  3.

__________________________  4.

__________________________  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 acoustic meatus  I. Pinna  M. Tympanic membrane
B. Auditory (pharyngotympanic) 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.
17. Sound waves hitting the eardrum set it into vibration. Trace the pathway through which vibrations and fluid currents travel to finally stimulate the hair cells in the organ of Corti. Name the appropriate ear structures in their correct sequence and insert your responses in the answer blanks.

Eardrum → → → → Oval window → → → → Hair cells

18. Figure 8–4 is a view of the structures of the membranous labyrinth. Correctly identify the following major areas of the labyrinth on the figure: membranous semicircular canals, saccule and utricle, and the cochlear duct. Next, correctly identify each of the receptor types shown in enlarged views (organ of Corti, crista ampullaris, and macula). Finally, using terms from the key choices below, identify all receptor structures provided with leader lines. (Some of these terms may need to be used more than once.)

**Figure 8–4**

**Key Choices**
A. Basilar membrane  E. Hair cells
B. Cochlear nerve  F. Otoliths
C. Cupula  G. Tectorial membrane
D. Gel  H. Vestibular nerve
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  
B. Cupula  
C. Dynamic  
D. Endolymph  
E. Gravity  
F. Perilymph  
G. Proprioception  
H. Saccule  
I. Semicircular canals  
J. Static  
K. Utricle  
L. Vision

1. The receptors for ___(1)___ equilibrium are found in the crista ampullaris of the ___(2)__. These receptors respond to changes in ___(3)___ motion. When motion begins, the ___(4)___ fluid lags behind and the ___(5)___ is bent, which excites the hair cells.

2. When the motion stops suddenly, the fluid flows in the opposite direction and again stimulates the hair cells. The receptors for ___(6)___ equilibrium are found in the maculae of the ___(7)___ and ___(8)__. These receptors report the position of the head in 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 and tugs on the hair cells, exciting them. Besides the equilibrium receptors of the inner ear, the senses of ___(10)___ and ___(11)___ are also important in helping to maintain equilibrium.

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 the sense of smell are transmitted by the (4) nerve. The receptors for smell are located in the (5) of the nasal passages; the act of (6) increases the sensation, because it brings more air into contact with the receptors. The receptors for taste are found in clusterlike areas called (7), most of which are located on the sides of (8) or (9) papillae.

2. The five basic taste sensations are (10), (11), (12), (13), and (14). The most protective receptors are thought to be those that respond to (15) substances. When nasal passages are congested, the sense of taste is decreased. This indicates that much of what is considered taste actually depends on the sense of (16). It is impossible to taste substances with a (17) tongue, because foods must be dissolved (or in solution) to excite the taste receptors. The sense of smell is closely tied to the emotional centers of the brain (limbic region), and many odors bring back (18).

3. 

4. 

5. 

6. 

7. 

8. 

9. 

10. 

11. 

12. 

13. 

14. 

15. 

16. 

17. 

18.
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.
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.

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