Overview

The sensory system enables us to detect changes taking place both internally and externally. These changes are detected by specialized structures called receptors. Any change that acts on a receptor to produce a response in the nervous system is termed a stimulus. The special senses, so called because the receptors are limited to a few specialized sense organs in the head, include the senses of vision, hearing, equilibrium, taste, and smell. The receptors of the eye are the rods and cones located in the retina. The receptors for both hearing (the organ of Corti) and equilibrium (the vestibule and semicircular canals) are located within the inner ear. Receptors for the chemical senses of taste and smell are located on the tongue and in the upper part of the nose, respectively. The general senses are scattered throughout the body; they respond to touch, pressure, temperature, pain, and position. Receptors for the sense of position, known as proprioceptors, are found in muscles, tendons, and joints. The nerve impulses generated in a receptor cell by a stimulus must be carried to the central nervous system by way of a sensory (afferent) neuron. Here, the information is processed and a suitable response is made. Disorders of the eye and ear are common. They are associated with aging, infection, environmental factors, inherited malfunctions, and injury.

This chapter is quite challenging, because it contains both difficult concepts and large amounts of detail. You can use concept maps to assemble all of the details into easy-to-remember frameworks.
Addressing the Learning Outcomes

1. Describe the function of the sensory system.

EXERCISE 11-1.

INSTRUCTIONS

Fill in the blanks in the following paragraph using these terms:
central nervous system, homeostasis, sensory neuron, sensory receptor

The sensory system protects people by detecting changes in the internal and external environment that threaten to disrupt _______________________ (1), which is the maintenance of a constant internal environment. The change is detected by a _________________ (2), which sends an impulse through a ________________ (3) to the __________________ (4).

2. Differentiate between the special and general senses and give examples of each.

EXERCISE 11-2.

INSTRUCTIONS

Classify each of the following senses as general senses (G) or special senses (S).

1. sense of position ______
2. smell ______
3. vision ______
4. touch ______
5. temperature ______
6. equilibrium ______
3. Describe the structure of the eye.

EXERCISE 11-3: The Eye (Text Fig. 11-3)

INSTRUCTIONS

1. Write the name of each labeled part on the numbered lines in different colors. Use the same color for structures 3 and 4 and structures 6 to 9 (inclusive). Write the name of structures 1 and 2 in black, because they will not be colored.

2. Color the different structures on the diagram with the corresponding color. Some structures are present in more than one location on the diagram. Try to color all of a particular structure in the appropriate color. For instance, only one of the suspensory ligaments is labeled, but color both suspensory ligaments.

1. _____________________
2. _____________________
3. _____________________
4. _____________________
5. _____________________
6. _____________________
7. _____________________
8. _____________________
9. _____________________
10. _____________________
11. _____________________
12. _____________________
13. _____________________
14. _____________________
15. _____________________
16. _____________________

4. List and describe the structures that protect the eye.

EXERCISE 11-4: The Lacrimal Apparatus (Text Fig. 11-2)

INSTRUCTIONS

Label the indicated parts.

1. _____________________
2. _____________________
3. _____________________
4. _____________________
5. _____________________
6. _____________________
7. _____________________
5. Define **refraction** and list the refractive parts of the eye.

**EXERCISE 11-5.**

**INSTRUCTIONS**
List 4 eye structures that bend (refract) light in the spaces below.

1. ______________________
2. ______________________
3. ______________________
4. ______________________

6. Differentiate between the rods and the cones of the eye.

**EXERCISE 11-6.**

**INSTRUCTIONS**
Write the appropriate term in each blank below.

<table>
<thead>
<tr>
<th>cone</th>
<th>cornea</th>
<th>rhodopsin</th>
<th>sclera</th>
</tr>
</thead>
<tbody>
<tr>
<td>optic disk</td>
<td>retina</td>
<td>rod</td>
<td>fovea centralis</td>
</tr>
</tbody>
</table>

1. A vision receptor that is sensitive to color ______________________
2. The part of the eye that light rays pass through first as they enter the eye ______________________
3. Another name for the blind spot, the region where the optic nerve connects with the eye ______________________
4. The innermost coat of the eyeball, the nervous tissue layer that includes the receptors for the sense of vision ______________________
5. A vision receptor that functions well in dim light ______________________
6. A pigment needed for vision ______________________
7. The depressed area in the retina that is the point of clearest vision ______________________

7. Compare the functions of the extrinsic and intrinsic muscles of the eye.

**EXERCISE 11-7: Extrinsic Muscles of the Eye (Text Fig. 11-6)**

**INSTRUCTIONS**
1. Write the name of each labeled muscle on the numbered lines in different colors.
2. Color the different muscles on the diagram with the corresponding color.

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
EXERCISE 11-8.

INSTRUCTIONS
Write the appropriate term in each blank.

aqueous humor vitreous body lens ciliary muscle choroid conjunctiva pupil iris

1. The structure that alters the shape of the lens for accommodation _______________
2. The watery fluid that fills much of the eyeball in front of the crystalline lens _______________
3. The vascular, pigmented middle tunic of the eyeball _______________
4. Structure with two sets of muscle fibers that regulate the amount of light entering the eye _______________
5. The jellylike material located behind the crystalline lens that maintains the spherical shape of the eyeball _______________
6. The central opening of the iris _______________
7. The membrane that lines the eyelids _______________

8. Describe the nerve supply to the eye.

EXERCISE 11-9: Nerves of the Eye
(Text Fig. 11-10)

INSTRUCTIONS
Label the indicated nerves.

1. _______________
2. _______________
3. _______________
4. _______________
5. _______________
6. _______________

(Also see Exercise 11-15)
9. Describe the three divisions of the ear.

EXERCISE 11-10: The Ear (Text Fig. 11-12)

INSTRUCTIONS
1. Write the names of the three ear divisions on the appropriate lines (1 to 3).
2. Write the names of the labeled parts on the numbered lines in different colors.
3. Color each part with the corresponding color.

1. _____________________
2. _____________________
3. _____________________
4. _____________________
5. _____________________
6. _____________________
7. _____________________
8. _____________________
9. _____________________
10. _____________________
11. _____________________
12. _____________________
13. _____________________
14. _____________________
EXERCISE 11-11: The Inner Ear (Text Fig. 11-14)

INSTRUCTIONS
Label the indicated parts.

1. _____________________
2. _____________________
3. _____________________
4. _____________________
5. _____________________
6. _____________________
7. _____________________
8. _____________________
10. Describe the receptor for hearing and explain how it functions.

EXERCISE 11-12: Cochlea and Organ of Corti (Text Fig. 11-15)

INSTRUCTIONS

1. Write the name of each labeled part on the numbered lines. Use colors for structures 3 to 7, 11, and 12. Use black for the other structures.
2. Color structures 3 to 7, 11, and 12 with the corresponding color.

1. ________________
2. ________________
3. ________________
4. ________________
5. ________________
6. ________________
7. ________________
8. ________________
9. ________________
10. ________________
11. ________________
12. ________________
13. ________________
EXERCISE 11-13.

INSTRUCTIONS

Write the appropriate term in each blank.

oval window  organ of Corti  malleus  eustachian tube  bony labyrinth
perilymph  incus  pinna  cochlear duct  endolymph

1. The fluid contained within the membranous labyrinth of the inner ear

2. The bone that interacts with the tympanic membrane

3. Another name for the projecting part, or auricle, of the ear

4. The channel connecting the middle ear cavity with the pharynx

5. The fluid of the inner ear contained within the bony labyrinth and surrounding the membranous labyrinth

6. Ciliated receptor cells that detect sound waves

7. The skeleton of the inner ear

11. Compare static and dynamic equilibrium and describe the location and function of these receptors.

EXERCISE 11-14.

INSTRUCTIONS

Write the appropriate term in each blank.

vestibule  dynamic equilibrium  semicircular canals  crista
cochlear duct  static equilibrium  otoliths

1. The sense of knowing the position of the head in relation to gravity

2. Small crystals that activate maculae

3. The sense organ involved in dynamic equilibrium

4. The receptor cells involved in dynamic equilibrium

5. Two small chambers containing maculae

6. The sense of knowing one’s head position when the body is spinning
12. Explain the function of proprioceptors.

EXERCISE 11-15.

INSTRUCTIONS

Write the appropriate term in each blank.

kinesthesia proprioception tactile corpuscle cochlear nerve
vestibular nerve oculomotor nerve ophthalmic nerve equilibrium
optic nerve free nerve endings

1. The branch of the vestibulocochlear nerve that carries hearing impulses ___________________________
2. The nerve that carries visual impulses from the retina to the brain ___________________________
3. The branch of the fifth cranial nerve that carries impulses of pain, touch, and temperature from the eye to the brain ___________________________
4. The largest of the three cranial nerves that carry motor fibers to the eyeball muscles ___________________________
5. The sense of knowing the position of one’s body and the relative positions of different muscles ___________________________
6. The sense of body movement ___________________________
7. Receptors that detect changes in temperature ___________________________


EXERCISE 11-16.

INSTRUCTIONS

Write the appropriate term in each blank.

NSAID narcotic anesthetic endorphin analgesic

1. Term describing any drug that relieves pain ___________________________
2. A substance produced by the brain that relieves pain ___________________________
3. Drug that acts on the CNS to alter pain perception, such as morphine ___________________________
4. Drug that acts locally to reduce inflammation ___________________________

14. Describe sensory adaptation and explain its value.

EXERCISE 11-17.

INSTRUCTIONS

Define “sensory adaptation” in the space below.

_____________________________________________
_____________________________________________
15. List some disorders of the sensory system.

**EXERCISE 11-18.**

**INSTRUCTIONS**

Write the appropriate term in each blank.

macular degeneration strabismus glaucoma myopia hyperopia
ophthalmia neonatorum cataract trachoma astigmatism

1. A serious eye infection of the newborn that can be prevented with a suitable antiseptic _______________
2. The scientific name for nearsightedness, in which the focal point is in front of the retina and distant objects appear blurred _______________
3. The visual defect caused by irregularity in the curvature of the lens or cornea _______________
4. Condition in which the eyes do not work together because the muscles do not coordinate _______________
5. Condition caused by continued high pressure of the aqueous humor, which may result in destruction of the optic nerve fibers _______________
6. The scientific name for farsightedness, in which light rays are not bent sharply enough to focus on the retina when viewing close objects _______________
7. A chronic eye infection for which antibiotics and proper hygiene have reduced the incidence of reinfection and blindness _______________

**EXERCISE 11-19.**

**INSTRUCTIONS**

Write the appropriate term in each blank.

otitis media otitis externa conductive hearing loss
otosclerosis presbycusis sensorineural hearing loss

1. The scientific name for swimmer’s ear _______________
2. A hereditary bone disorder that prevents normal vibration of the stapes _______________
3. Slow, progressive hearing loss associated with aging _______________
4. Hearing loss resulting from damage to the cochlea or to nerves associated with hearing _______________
5. Infection and inflammation of the middle ear cavity _______________
16. Show how word parts are used to build words related to the sensory system.

EXERCISE 11-20.

INSTRUCTIONS
Complete the following table by writing the correct word part or meaning in the space provided. Write a word that contains each word part in the Example column.

<table>
<thead>
<tr>
<th>Word Part</th>
<th>Meaning</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. presby-</td>
<td>_______</td>
<td>__________</td>
</tr>
<tr>
<td>2. _______</td>
<td>stone</td>
<td>__________</td>
</tr>
<tr>
<td>3. -opia</td>
<td>_______</td>
<td>__________</td>
</tr>
<tr>
<td>4. -stomy</td>
<td>_______</td>
<td>__________</td>
</tr>
<tr>
<td>5. _______</td>
<td>drum</td>
<td>__________</td>
</tr>
<tr>
<td>6. _______</td>
<td>yellow</td>
<td>__________</td>
</tr>
<tr>
<td>7. propri/o-</td>
<td>_______</td>
<td>__________</td>
</tr>
<tr>
<td>8. _______</td>
<td>pain</td>
<td>__________</td>
</tr>
<tr>
<td>9. -esthesia</td>
<td>_______</td>
<td>__________</td>
</tr>
<tr>
<td>10. _______</td>
<td>hearing</td>
<td>__________</td>
</tr>
</tbody>
</table>

Making the Connections
The concept map on the next page deals with the structure and function of the eye. Each pair of terms is linked together by a connecting phrase into a sentence. The sentence should be read in the direction of the arrow. Complete the concept map by filling in the appropriate term or phrase. There is one right answer for each term. However, there are many correct answers for the connecting phrases (2, 9).
Optional Exercise: Construct a concept map of terms relating to the ear using the following terms and any others you would like to include: tympanic membrane, stapes, malleus, incus, pinna, bony labyrinth, organ of Corti, oval window, round window, cochlear duct, tectorial membrane, and cochlear nerve. You may also want to construct concept maps relating to the other special senses (equilibrium, taste, smell) and the general senses (touch, pressure, temperature, proprioception).
Testing Your Knowledge

Building Understanding

I. Multiple Choice

1. A physician who specializes in disorders of the eye is a(n) 1. _______
   a. ophthalmologist
   b. internist
   c. allergist
   d. orthopedic surgeon

2. A term related to the sense of taste is 2. _______
   a. tactile
   b. gustatory
   c. proprioceptive
   d. thermal

3. Alterations in the lens' shape to allow for near or far vision is called 3. _______
   a. accommodation
   b. convergence
   c. divergence
   d. dark adaptation

4. The term *lacrimation* refers to the secretion of 4. _______
   a. mucus
   b. wax
   c. tears
   d. aqueous humor

5. Painkillers that are released from certain regions of the brain are 5. _______
   a. narcotics
   b. endorphins
   c. anaesthetics
   d. nonsteroidal anti-inflammatory drugs

6. A person who lacks cones in the retina will suffer from 6. _______
   a. blindness
   b. color blindness
   c. glaucoma
   d. trachoma

7. The organ of Corti is the receptor for 7. _______
   a. taste
   b. smell
   c. hearing
   d. equilibrium

8. A cataract is 8. _______
   a. an irregularity in the cornea's shape
   b. an infection of the conjunctiva
   c. an abnormally short eyeball
   d. loss of lens transparency
9. Inflammation of the membrane lining the eyelid is called 9. _______
   a. otitis
   b. conjunctivitis
   c. retinitis
   d. glaucoma

**II. Completion Exercise**

1. The transparent portion of the sclera is the 
   ______________________
2. The glands that secrete ear wax are called  
   ______________________
3. The nerve endings that aid in judging position and changes in location of body parts are the  
   ______________________
4. The sense of position is partially governed by equilibrium receptors in the internal ear, including two small chambers in the vestibule and the three  
   ______________________
5. The tactile corpuscles are the receptors for the sense of  
   ______________________
6. Any drug that relieves pain is called a(n)  
   ______________________
7. When you enter a darkened room, it takes a while for the rods to begin to function. This interval is known as the period of  
   ______________________
8. The receptor tunic (layer) of the eye is the  
   ______________________
9. The bending of light rays as they pass through the media of the eye is  
   ______________________

**Understanding Concepts**

**I. True/False**

For each question, write _T_ for true or _F_ for false in the blank to the left of each number. If a statement is false, correct it by replacing the underlined term and write the correct statement in the blank below the question.

_____ 1. **Extrinsic** eye muscles control the diameter of the pupil.
   __________________________________________________________________________

_____ 2. There are _seven_ extrinsic muscles connected to each eye.
   __________________________________________________________________________

_____ 3. The iris is an _intrinsic_ muscle of the eye.
   __________________________________________________________________________

_____ 4. The sense of temperature is a _general_ sense.
   __________________________________________________________________________

_____ 5. The _rods_ of the eye function in bright light and detect color.
   __________________________________________________________________________
6. When the eyes are exposed to a bright light, the pupils constrict.
7. The scientific name for nearsightedness is hyperopia.
8. The ciliary muscle contracts to allow thickening of the lens.
9. The sense of smell is also called olfaction.

II. Practical Applications

Study each discussion. Then write the appropriate word or phrase in the space provided.

► Group A

Baby L was brought in by his mother because he awakened crying and holding the right side of his head. He had been suffering from a cold, but now he seemed to be in pain. Complete the following descriptions relating to his evaluation and treatment.

1. Examination revealed a bulging red eardrum. The eardrum is also called the ____________________.
2. The cause of Baby L’s painful bulging eardrum was an infection of the middle ear, a condition called ________________.
3. Antibiotic treatment of Baby L’s middle ear infection was begun, because this early treatment usually prevents complications. In this case, however, it was necessary to cut the eardrum to prevent its rupture. Another name for this surgical procedure is ________________.
4. The mother was warned that Baby L may be particularly susceptible to middle ear infections. To prevent further damage to his eardrum, a special tube was inserted. This tube is called a(n) ________________.
5. Baby L will have to be careful in the future, because repeated middle ear infections can lead to a type of hearing loss called ________________.
6. Baby L was returned to the emergency room the next day because he was falling down repeatedly. The physician suspected a problem with his sense of balance, or ________________.
7. Baby L’s mother asked how an ear infection could affect balance. The physician explained that two structures were located within the inner ear that are involved with balance, named the semicircular canals and the ________________.
8. In particular, the physician feared that the middle ear infection had spread to the fluid within the membranous labyrinth. This fluid is called ________________.
Group B
Sixty-year-old Mr. S had ridden his scooter over some broken glass. A fragment of glass bounced up and flew into one eye. Complete the following descriptions relating to his evaluation and treatment.

1. Examination by the eye specialist showed that there was a cut in the transparent window of the eye, the _______________.
2. On further examination of Mr. S, the colored part of the eye was seen to protrude from the wound. This part of the eye is the _______________.
3. Mr. S's treatment included antiseptics, anesthetics, and suturing of the wound. Medication was instilled in the saclike structure at the anterior of the eyeball. This sac is lined with a thin epithelial membrane, the _______________.
4. The eye specialist evaluated Mr. S's vision in his uninjured eye. Like virtually all elderly adults, Mr. S was shown to have difficulties with near vision. This condition is called _______________.
5. The eye specialist also observed that the pressure in his aqueous humor was abnormally high. This finding signifies that Mr. S suffers from _______________.
6. Mr. S returned to the emergency room 1 week later with a severe infection in the injured eye. Despite proper wound care and several changes of antibiotics, the damaging infection persisted. The eye specialist reluctantly decided to remove the eyeball, a procedure called _______________.

Group C
You are conducting hearing tests at a senior citizens' home. During the course of the afternoon, you encounter the following patients. Complete the following descriptions relating to the evaluation and treatment of hearing loss.

1. Mrs. B complained of some hearing loss and a sense of fullness in her outer ear. Examination revealed that her ear canal was plugged with hardened ear wax, which is scientifically called _______________.
2. Mr. J, age 72, complained of gradually worsening hearing loss, although he had no symptoms of pain or other ear problems. Examination revealed that his hearing loss was due to nerve damage. The cranial nerve that carries hearing impulses to the brain is called the _______________.
3. In particular, the endings of this nerve were damaged. These nerve endings are located in the spiral-shaped part of the inner ear, a part of the ear that is known as the _______________.
4. Mr. J's hearing loss, because it reflects nerve damage, is known as _______________.
5. Mrs. C complained of hearing loss that resembled the type from which her aunt and her mother suffered. She requested surgical treatment, which is often successful in such cases. This disorder, in which bony changes prevent the stapes from vibrating normally, is called _______________.

III. Short Essays

1. Describe several different structural forms of sensory receptors and give examples of each.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. Describe some changes that occur in the sensory receptors with age.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. List three methods to relieve pain that do not involve administration of drugs.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Conceptual Thinking

1. You have probably been sitting in a chair for quite a while, yet you have not been constantly aware of your legs contacting the chair. Why not?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. Write your name at the bottom of this sheet of paper. Explain the contributions of different sensory receptors that were required to successfully complete that simple task. For instance, proprioceptors are required to indicate the fingers’ location at every moment.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Expanding Your Horizons

Imagine if you could taste a triangle, or hear blue. This is reality for individuals with a disorder called synesthesia. Read about some exceptional artists that suffer from this disorder, and how synesthesia has helped us understand how the brain processes sensory information in the article below.

Here is an exercise you can do to find your own blind spot. Draw a cross (on the left) and a circle (on the right) on a piece of paper that are separated by a handwidth. Focus on the cross and notice (but do not focus on) the circle. Move the paper closer and further away until the circle disappears. Weird activities to investigate your blind spot can be found at the website http://serendip.brynmawr.edu/bb/blindspot1.html.

Resources