LESSON ASSIGNMENT

LESSON 1
Anatomy and Physiology of the Sensory System.

LESSON ASSIGNMENT
Paragraphs 1-1 through 1-15.

LESSON OBJECTIVES
After completing this lesson, you should be able to:

1-1. Identify the sensory receptors in terms of their location.

1-2. Identify the major structures of the eye and their corresponding functions.

1-3. Identify the major structures of the ear and their corresponding functions.

1-4. Identify the structures related to the sense of smell.

1-5. Identify the structures related to the sense of taste and their functions.

SUGGESTION
After completing the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.
LESSON 1
ANATOMY AND PHYSIOLOGY OF THE SENSORY SYSTEM

Section I. GENERAL

1-1. INTRODUCTION

The ability to sense stimuli is vital to man's survival. If pain could not be sensed, burns would be common. Internal problems such as an inflamed appendix or a stomach ulcer could be unnoticed without pain. Without sight there is a greater risk of injury from obstacles. Harmful gas could be inhaled if there were no sense of smell. Loss of a sense of hearing would keep us from recognizing hazards such as automobile horns. And if there were no taste, toxic substances could be ingested. If we could not "sense" out environment and make the necessary adjustments, we probably could not survive on our own.

NOTE: In this subcourse, you will see the letters EENT and HEENT. EENT stands for eyes, ears, nose, and throat. HEENT stands for head, eyes, ears, nose, and throat.

1-2. THE SENSORY PATHWAYS

a. Sensations. The body is continuously bombarded by types of information called stimuli (stimulus, singular). Those few stimuli which are consciously perceived (in the cerebral hemispheres) are called sensations. Structures that detect changes in man's external and internal environment produce sensations on the senses.

b. Senses and Receptions. The senses and the location of their receptors are as follows:

(1) Vision--receptors in the eyes.
(2) Smell--receptors in the nose.
(3) Hearing--receptors in the ears.
(4) Taste--receptors in the tongue.
(5) Touch, heat, cold, pain--receptors in the skin.
(6) Position--receptors in the muscles, joints, inner ear.
(7) Hunger, thirst--receptors in the tongue, pharynx, mouth.
c. **Two Types of Senses.** They are differentiated by the type of sensation they cause. **Special senses** are produced by receptors limited to small areas such as the tongue, nose, balance, hearing, vision, smell, and taste. **General senses** are produced by receptors scattered throughout the body such as pressure, temperature, pain, position, and touch.

d. **Sensation and Perception.** In its broadest meaning, *sensation* refers to man's state of being aware of external or internal conditions of the body. The state of being aware of something through the senses is *perception*. Four conditions must take place for a sensation to occur.

   (1) **A stimulus**--a change in the environment which causes a response by the nervous system.

   (2) **A receptor or sense organ**--picks up a stimulus and converts it to a nerve impulse.

   (3) **Conduction**--the impulse must be conducted from the receptor or sense organ along a pathway to the brain.

   (4) **Translation**--the impulse must be translated into a sensation when the impulse is in a region of the brain.

**Section II. THE SPECIAL SENSE OF VISION (SIGHT)**

1-3. **ANATOMY OF THE EYE**

a. **Structure/Location.** The size of the adult eyeball is about 2.5 cm (1 inch) in diameter. The eyes are recessed in the bony cavities (the orbital cavities) of the skull with only the front one-sixth of the eyeball's total surface area exposed. Bones protect each eyeball: the frontal, maxillary, zygomatic, lacrimal, sphenoid, and palatine bones.

b. **Tunics (Layers) of the Eyeball.** The eyeball is composed of three layers called tunics: the fibrous tunic, the vascular tunic, and the retina or nervous tunic.

   (1) **Fibrous tunic.** The fibrous tunic is the outer layer of the eye. This layer is formed by the sclera (the white of the eye) and the cornea (the window of the eye). The sclera is a white coat of fibrous tissue that covers the entire eyeball except the front colored portion. The sclera gives the eyeball shape and protects the inner parts of the eyeball. The cornea covers the iris, the colored part of the eye. The cornea is a transparent fibrous layer which has no blood vessels. An epithelial layer covers the outer surface of the cornea. At the point where the sclera and the cornea meet is a venous sinus called the **Canal of Schlemm**.
Figure 1-1. Anatomy of the eye.

Figure 1-2. Cross section of the eye.
(2) **Vascular tunic.** This is the middle layer of the eye and is made up of the choroid, the ciliary body, and the iris. Altogether, these structures are called the **uvea.**

(a) **Choroid.** The choroid is the back part of the vascular tunic. It is a thin, dark brown membrane which lines most of the internal surface of the sclera. This membrane has many blood vessels and a large amount of pigment. The layer absorbs light rays so they are not reflected back out of the eyeball. The blood supply in this layer nourishes the retina. The choroid is pierced by the optic nerve at the back of the eyeball.

(b) **Ciliary body.** The front part of the vascular tunic, the ciliary body, is the thickest part of the vascular tunic. Ciliary processes and ciliary muscle make up this part of the layer. The ciliary processes are made up of folds of the internal surface of the ciliary body; these folds secrete aqueous humor (a clear, watery fluid in the front and back chambers of the eye). The ciliary muscle is a smooth muscle that changes the shape of the lens in order to see objects that are close or far away.

(c) **Iris.** The third part of the vascular tunic is the iris, a structure composed of circular and radial smooth muscle fibers arranged in a doughnut shape. The pupil is the black hole; light enters the eyeball through this hole.

(3) **Retina (nervous tunic).** The retina is the third and inner layer of the eye. It covers the choroid and consists of an inner nervous tissue layer and an outer pigmented layer. The pigmented part of the layer extends over the back of the ciliary body and the iris and is the nonvisual part of the retina. This layer also contains three zones of neurons which conduct impulses. These zones of neurons are called the photoreceptor neurons, the bipolar neurons, and the ganglion neurons. Photoreceptor neurons contain rods and cones, so named because of their shape. Rods, specialists in dim-light vision, allow us to distinguish between different shades of dark and light and let us see shapes and movement. Cones permit us to see color and are specialists in daylight vision. The optic disc is located in this area and is a blind spot with neither rods nor cones. It is here that the optic nerve leaves the eyeball.

   c. **Blood Vessels.** The structures of the eye include blood vessels, layer vessels in the sclera, and capillaries in the retina.

   d. **Cavities and Humor.** The anterior cavity of the eye is anterior to the lens. The anterior chamber is anterior to the iris and posterior to the cornea. The posterior chamber is posterior to the iris and anterior to the lens. The anterior cavity contains the aqueous humor secreted by the ciliary body. Too much aqueous humor results in glaucoma. The posterior cavity of the eye is posterior to the lens and suspensory ligaments and anterior to the retina. This cavity contains gelatinous substances called vitreous humor which maintain the globular shape of the eyeball.
Muscles of the Eye. The structure of the eye includes the muscles of the eye--intrinsic muscles and extrinsic muscles. Intrinsic muscles include the two involuntary muscles within the eye--the iris and the ciliary muscles. The iris regulates the amount of light which can enter the eye. The iris does this by dilating (opening more) and by constricting (opening less). The extrinsic muscles are composed of four rectus muscles (superior muscles, inferior muscles, medial muscles, and lateral muscles) and two oblique muscles (superior muscles, and inferior muscles). The extrinsic muscles move the eye within the orbit. The eye is the only organ with both voluntary and involuntary muscles.

1-4. ACCESSORY STRUCTURES OF THE EYE

The site of accessory structures of the eye are as follows: eyebrows, eyelashes, eyelids, conjunctiva, and lacrimal apparatus.

a. Eyebrows. The eyebrows are made up of several rows of hair above the upper eyelids. The eyebrows form an arch at the junction of the upper eyelid and the forehead and structurally resemble the hairy scalp. The hairs are generally coarse and grow toward the side of the face.

b. Eyelashes. Eyelashes are a row of hairs which project from the border of each eyelid. Eyelashes coming from the upper eyelid are usually long and turn upward; eyelashes from the lower eyelid are generally short and turn downward. Sebaceous glands at the base of eyelash hair follicles pour a lubricating fluid into the follicles. When these glands become infected, a sty forms.

c. Eyelids. Each eyelid consists of epidermis, dermis, subcutaneous connective tissue, fibers of oculi muscle, a tarsal plate, tarsal glands, and a conjunctiva. The epidermis, dermis, and subcutaneous connective tissue make up the skin of the eyelid. The tarsal plate is a thick fold of connective tissue that forms part of the inner wall of each eyelid. The tarsal plate gives form and support to the eyelids. The conjunctiva is a mucous membrane which lines the inner aspect of the eyelids as well as the visible portion of the cornea (the glossy, transparent part of the cornea).

d. Lacrimal Apparatus. This is the term used for a group of structures that manufacture and drain away tears. Included are the lacrimal glands, the exocrine lacrimal ducts, the lacrimal canals, the lacrimal sacs, and the nasolacrimal ducts.

(1) Lacrimal gland. A lacrimal gland is located in the upper outer corner of each orbit. The lacrimal glands secret lacrimal fluid through small ducts into the space between the external surface of the eyeball and the upper eyelid.
(2) **Conjunctiva.** The conjunctiva covers the inner surface of the eyelids and the outer surface of the eyeball. Lacrimal fluid keeps the conjunctiva transparent. With the blink reflex, the lacrimal fluid washes away any foreign particles that may be on the surface of the conjunctiva.

(3) **Eyelid oil glands.** The free margins of the upper and lower eyelids have special oil glands. The oily secretion of these glands helps prevent the lacrimal fluid from escaping.

(4) **Lacrimal fluid.** With the movement of the eyeball and the eyelids, the lacrimal fluid is gradually moved across the exterior surface of the eyeball to the medial inferior corner. Here, the lacrimal fluid is collected into a lacrimal sac, which drains into the nasal chamber by way of the nasolacrimal duct. Thus, the continuous production of lacrimal fluid is conserved by being recycled within the body.

1-5. **PHYSIOLOGY OF VISION**

For vision to occur, light must pass through the cornea, aqueous humor, pupil, lens, and vitreous humor before it (light) can reach the rods and cones. Light reaches the rods and cones of the retina and forms an image on the retina. Next, nerve impulses are conducted to the visual areas of the cerebral cortex (a part of the brain).
a. **Retinal Image Formation.** Four basic processes are involved in the formation of an image on the retina: refraction of light rays, accommodation of the lens, constriction of the pupil, and convergence of the eyes. Accommodation and pupil size are caused by intrinsic eye muscles (muscles inside the eyeball). Extrinsic eye muscles control convergence.

(1) **Refraction of light rays.** When light rays traveling through a transparent medium (such as air) and pass into a second transparent medium with a different density (such as water), they bend at the surface of the two media. This is refraction. The eye has four such media of refraction: cornea, aqueous humor, lens, and vitreous humor. Light rays entering the eye from the air are refracted at the following points:

(a) The anterior surface of the cornea as they pass from the lighter air into the denser cornea.

(b) The posterior surface of the cornea as they pass into the less dense aqueous humor.

(c) The anterior surface of the lens as they pass from the aqueous humor into the denser lens.

(d) The posterior surface of the lens as they pass from the lens into the less dense vitreous humor.

(2) **Degree of refraction.** The degree of refraction that takes place at each surface in the eye is very precise. Light rays from an object 20 feet away must bend to fall on the central field, where vision is the sharpest. Light rays from objects that are near are divergent rather than parallel. As a result, these light rays must be refracted toward each other to a greater extent. The lens of the eye makes this change.

(3) **Accommodation of the lens.** The lens of the eye is biconvex; that is, it curves outward on both sides. If the surface of a lens curves outward, as in a convex lens, the lens will refract incoming rays toward each other so they eventually intersect. The greater the curve, the more acutely it bends the rays toward each other. Conversely, when the surface of a lens curves inward, as in a concave lens, the rays bend away from each other. The lens of the eye has the unique ability to change the focusing power of the eye by becoming moderately curved at one moment and greatly curved the next. When the eye is focusing on a close object, the lens curves greatly in order to bend the rays toward the central fovea. This increase in the curvature of the lens is called accommodation. In near vision, muscles cause the lens to become shortened, thickened, and bulged. In far vision, muscles cause the lens to flatten.
(4) **Constriction of the pupil.** The circular muscle fibers of the iris also assume a function in the formation of clear retinal images. Part of the accommodation mechanism consists of the contraction of the dilator and sphincter muscles of the iris to constrict the pupil. **Constriction of the pupil** means narrowing the diameter of the hole through which light enters the eye. This action occurs simultaneously with accommodation of the lens and prevents light rays from entering the eye through the periphery of the lens. Light rays entering at the periphery would not be brought to focus on the retina and would result in blurred vision. The pupil, as noted earlier, also constricts in bright light to protect the retina from sudden or intense stimulation.
(5) **Convergence.** Some animals see a set of objects off to the left through one eye and an entirely different set off to the right through the other. This characteristic doubles their field of vision and allows them to detect predators behind them. In humans, both eyes focus on only one set of objects—a characteristic called **single binocular vision.** Single binocular vision occurs when light rays from an object are directed toward corresponding points on the two retinas. When we stare straight ahead at a distant object, the incoming light rays are aimed directly at both pupils and are refracted to identical spots on the retina of both eyes. But as we move closer to the object, our eyes must rotate medially for the light rays from the object to hit the same points on both retinas. The term **convergence** refers to this medial movement of the two eyeballs so they are both directed toward the object being viewed. The nearer the object, the greater the degree of convergence necessary to maintain single binocular vision. Convergence is brought about by the coordinated action of the extrinsic eye muscles.

**Section III. THE SPECIAL SENSE OF HEARING (AUDITORY)**

**1-6. GENERAL**

The human ear serves two major special sensory functions—hearing (auditory) and equilibrium (balance). Receptors for sound waves and receptors for equilibrium are located in the ear. The stimulus for hearing is sound waves, and the stimulus for equilibrium is gravitational force.

**1-7. ANATOMY**

The ear is divided into three principal regions: the external (outer) ear, the middle ear, and the internal (inner ear). See figure 1-6 which shows the anatomy of the ear.

a. **The External Ear.** The external ear begins on the outside of the head in the form of a funnel-shaped **auricle** (pinna). Actually serving as a funnel, the auricle directs airborne sound waves into the external auditory meatus. The **external auditory meatus** is a tubular canal extending into the temporal portion of the skull.

b. **The Middle Ear.** The middle ear is also called the **tympanic cavity.** It is a small epithelial-lined, air-filled cavity hollowed out of the temporal bone. The eardrum separates this cavity from the external ear. The cavity is separated from the internal ear by a thin bony partition that contains two small openings: the oval window and the round window.

(1) **Tympanic membrane.** At the inner end of the external auditory meatus is the tympanic membrane. The **tympanic membrane** (eardrum) is a circular membrane which separates the external auditory meatus from the middle ear cavity. The tympanic membrane vibrates (mechanically oscillates) in response to airborne sound waves.
Figure 1-6. A frontal section of the human ear.

(2) Middle ear cavity. On the medial side of the tympanic membrane is the middle ear cavity. The middle ear cavity is a space within the temporal bone.

(3) Auditory ossicles. The auditory ossicles (OSSICLE = small bone) are three, very small bones which form a chain across the middle ear cavity. They join the tympanic membrane with the medial wall of the middle ear cavity. In order, the ossicles are named as follows: malleus, incus, and stapes. The malleus is attached to the tympanic membrane. A sound stimulus is transmitted from the tympanic membrane to the medial wall of the middle ear cavity by way of the ossicles. The ossicles vibrate (mechanically oscillate) in response to the sound stimulus.

(4) Auditory (eustachian) tube. The auditory tube is a passage connecting the middle ear cavity with the nasopharynx. The auditory tube maintains equal air pressure on the two sides of the tympanic membrane.

(5) Association with other spaces. The middle ear cavity is associated with other spaces in the skull. The thin roof of the middle ear cavity is the floor of part of the cranial cavity. The middle ear cavity is continuous posteriorly with the mastoid air cells via the antrum (an upper posterior recess of the middle ear cavity).
c. **The Internal Ear.** Because of its complicated series of canals, the internal ear is also called the labyrinth. There are two main divisions: a body labyrinth and a membranous labyrinth that fits in the body labyrinth.

1. **Labyrinths.**

   a. **Bony labyrinth.** The bony labyrinth \((\text{LABYRINTH} = \text{a maze})\) is a complex cavity within the temporal bone. It has three semicircular canals, a vestibule (hallway), and a snail-shaped portion.

   b. **Membranous labyrinth.** The membranous labyrinth is a hollow tubular structure suspended within the bony labyrinth.

2. **Fluids of the internal ear.** The endolymph is a fluid filling the space within the membranous labyrinth. The perilymph is a fluid filling the space between the membranous labyrinth and the bony labyrinth.

3. **The cochlea.** The cochlea is a spiral structure associated with hearing. It has 2-1/2 turns. Its outer boundaries are formed by the snail-shaped portion of the body labyrinth.

   a. The central column, or axis, of the cochlea is called the modiolus. Extending from this central column is a spiral shelf of bone called the spiral lamina. A fibrous membrane called the basilar membrane (or basilar lamina) connects the apiral lamina with the outer bony wall of the cochlea. The basilar membrane forms the floor of the cochlear duct, the spiral portion of the membranous labyrinth. Within the cochlear duct, there is a structure on the basilar membrane called the organ of Corti. The organ of Corti has hairs which are the sensory receptors for the special sense of hearing.

   b. Within the bony cochlea, the space above the cochlear duct is known as the scala vestibuli, and the space below is known as the scala tympani. Since the scalae are joined at their apex, they form a continuous channel, and the connection between them is called the helicotrema.

   c. Between the scalae and the middle ear cavity are two windows: the oval window and the round window. The oval window, also called the fenestra vestibuli, is between the middle ear cavity and the scala vestibuli. It is filled with the foot plate of the stapes. The round window which is also known as the fenestra cochlea is located between the inner ear cavity and the scala tympani. This window is covered or closed by a membrane.
1-8. PHYSIOLOGY

a. Sensation of Sound. If a medium is set into vibration within certain frequency limits (average between 25 cycles per second and 18,000 cycles per second), we have a sound stimulus. The sensation of sound occurs only when these vibrations are interpreted by the cerebral cortex of the brain at the conscious level. The human ear is the special sensory receptor for the sound stimulus. As the stimulus passes from the external medium (air, water, or a solid conductor of sound) to the actual receptor cells in the head, the vibrations are in the form of (1) airborne waves, (2) mechanical oscillations, and (3) fluid-borne pulses.

b. Events in the Physiology of Hearing Sound Waves. The function of hearing involves many structures and is a complicated process. Here is a brief listing of the events in the process:

1. The external ear (the auricle) funnels sound waves into the more internal structures concerned with hearing. The external auditory meatus directs sound waves inward, forward, and down to the tympanic membrane.

2. In the tympanic membrane area, there are ceruminous glands that secrete ear wax (cerumen). Too much ear wax can partially obstruct the auditory canal and interfere with hearing.
(3) Sound waves reach the tympanic membrane and cause it to vibrate; these membranes transmit vibrations into the middle ear.

(4) In the middle ear, those small bones called the auditory ossicles move in response to the vibrations of the tympanic membrane. The movement of these small bones causes the oval window into the inner ear to move.

(5) The oval window presses against the fluid in the cochlear channel causing ripple-like waves.

(6) The waves of this fluid stimulate the hair cells of the organs of Corti, which are located on the basilar membrane in the cochlea.

(7) Stimulation of the hair cells of the organs of Corti travels to the temporal side of the brain.

(8) The brain sends us the message that we hear sound.
Section IV. THE SPECIAL SENSE OF SMELL (OLFACTION)

1-9. GENERAL

The taste sensation is closely related to the sensation of smell. We often select food and enjoy particular dishes because of a pleasant odor or aroma. A person with a cold or allergies usually claims the food is tasteless. Actually, his sense of smell has been affected and disturbed his sense of taste. There have been many attempts to distinguish and classify the primary sensations of smells. One classification distinguishes seven classes of primary sensations: camphoraceous, musky, floral, pepperminty, ethereal, pungent, and putrid. Later research suggests that there may be as many as fifty or more primary sensations of smell. Although animals have a more highly developed sense of smell than humans, humans can identify at least 4000 different odors. Olfactory receptors become tired easily with the result that humans cannot smell the same odor for very long, but they can pick up a new odor. Additionally, a particular odor in an area of many odors can be identified, and an odor smelled only once can often be remembered.
1-10. ANATOMY OF OLFACTION

Olfactory sense receptors are located in the nasal epithelium in the superior part of the nasal cavity on either side of the nasal septum. There are two kinds of cells in the nasal epithelium: supporting cells and olfactory cells. Supporting cells are shaped like columns and are located in the mucous membrane lining of the nose. This membrane is kept moist by the olfactory glands. The olfactory cells lie between the supporting cells. The free end of each olfactory cell contains six to eight dendrites called olfactory hairs.

![Figure 1-10. Organs of smell.](image)

1-11. PHYSIOLOGY OF OLFACTION

The sensation of smell functions in this manner. We breathe in a gaseous substance that dissolves in the fluid of the nasal chamber. The fluid stimulates the olfactory cells in the upper part of the nasal mucosa. Sniffing increases the amount of gaseous substance, and the odor becomes stronger. The sensory pathway for the sense of smell is the olfactory nerve. Olfactory cells transmit impulses from the receptors over the olfactory nerve to the brain.
1-12. GENERAL

When a substance is put in the mouth, the substance is exposed to tiny receptors in the taste buds. Each person has about 10,000 taste buds. Most of the taste buds are on the surface of the tongue, but some are on the roof of the mouth and some are in the throat. We seem to taste many substances, but actually there are only four primary taste sensations: sour, salt, bitter, and sweet. Other tastes such as chocolate, pepper, and coffee are combinations of these four tastes changed by olfactory sensations. If you have a cold or an allergy, you may feel that you cannot taste your food. What is happening is that your taste sensations are operating correctly, but your olfactory (smell) sensations are not. Much of what we think of as taste is actually smell. The odor from food passes upward into the nasopharynx and stimulates the olfactory system. If the sense of smell is greatly impaired, the quality of taste can change completely; fresh onions can taste sweet and limburger cheese taste very bland. Receptors for the four primary tastes are located in different parts of the tongue. The anterior tip of the tongue reacts to all four primary taste sensations, but it is more responsive to sweet substances. Taste buds on the anterior edges of the tongue are responsive to salty substances. Sour substance receptors are located on the lateral margins of the tongue, and receptors for bitter substances are on the posterior midportion of the tongue.

Figure 1-11. Organs of taste.
1-13. ANATOMY OF GUSTATION

a. Receptors and Taste Buds. The receptors for the sensation of taste are the taste buds which are located primarily on the tongue but also on the soft palate, the epiglottis, and the pharynx. The taste buds are oval-shaped and are made up of two kinds of cells: supporting cells and gustatory cells. The supporting cells are composed of a special kind of tissue that forms a capsule. Inside the capsule are four to twenty gustatory cells. Gustatory hair projects out of each gustatory cell. This hair extends to the external surface through an opening in the taste bud called the taste pore. This is the opening for taste stimuli to make contact with gustatory cells.

![Figure 1-12. Location of taste buds.](image)

![Figure 1-13. The structure of a taste bud.](image)
b. **Papillae.** Some taste buds are located in elevated connective tissue on the tongue. This tissue is called papillae. Papillae cause the upper surface of the tongue to look rough. **Circumvallate papillae** are the largest papillae; they form an inverted V-shaped row at the back of the tongue. **Fungiform** (mushroom-shaped) papillae are located primarily on the tip and sides of the tongue. There are taste buds in all circumvallate and most fungiform papillae. The front two thirds of the tongue are covered with pointed, thread-like structures called **filiform papillae.**

### 1-14. PHYSIOLOGY OF GUSTATION

To create the sensation of taste, a substance must be in a solution of saliva so that the substance can enter the taste pores. The taste substance makes contact in the pores with plasma membranes of the gustatory hairs; this causes the taste receptors to be stimulated. There are two sensory pathways for taste. **Pathway one** contains the facial nerve which carries taste sensations from the front two-thirds of the tongue. **Pathway two,** the glosso-pharyngeal nerve, carries taste sensations from the back one third of the tongue. These sensations are transmitted to the brain where the information is interpreted as the sensation of taste.

### 1-15. CLOSING

A thorough understanding of the sensory system is essential in your ability to provide basic emergency and primary medical care for today's soldier. For example, laser injuries affect eyesight; artillery blasts affect hearing. Your knowledge of the anatomy and physiology of the senses is necessary for you to recognize the effects of modern weaponry and treat the soldier accordingly.

**Continue with Exercises**

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EXERCISES, LESSON 1

INSTRUCTIONS. The following exercises are to be answered by writing the answer in the space provided. After you have completed all the exercises, turn to the solutions following the exercises and check your answers.

1. Define sensation, in its broadest meaning. ____________________________________________
   ____________________________________________

2. List the four conditions which must be present for a sensation to occur.
   a. ________________________________________.
   b. ________________________________________.
   c. ________________________________________.
   d. ________________________________________.

3. List the three tunics (layers) of the eyeball.
   a. ________________________________________.
   b. ________________________________________.
   c. ________________________________________.

4. The _______________________ _________ layer of the eyeball contains three zones of impulse-conducting neurons.

5. Light enters the eyeball through a hole in the ________________, one of the parts of the vascular tunic.

6. The iris dilates and constricts thus, regulating ____________________________
   ____________________________________________.
7. ________________ consist of epidermis, dermis, subcutaneous connective tissue, and conjunctiva as well as other parts.

8. The structures which make and drain away tears are termed ________________.

9. List the four basic processes involved in forming an image on the retina.
   a. _______________________________________.
   b. _______________________________________.
   c. _______________________________________.
   d. _______________________________________.

10. List the two major special sensory functions of the ear.
    a. _______________________________________.
    b. _______________________________________.

11. List the three principal regions of the ear.
    a. _______________________________________.
    b. _______________________________________.
    c. _______________________________________.

12. The oval window and the round window are part of the ________________ ear.

13. List the three characteristics of sound.
    a. _______________________________________.
    b. _______________________________________.
    c. _______________________________________.

Check Your Answers on Next Page
SOLUTIONS TO EXERCISES, LESSON 1

1. Sensation refers to man's state of being aware of external or internal conditions of the body. (para 1-2d)

2. Stimulus.
   Receptor or sense organ.
   Conduction.
   Translation. (paras 1-2a through d)

3. The fibrous tunic.
   The vascular tunic.
   The nervous tunic (retina). (paras 1-3b(1) through (3))

4. Nervous or retina. (para 1-3b(3))

5. Iris. (para 1-3b(2)(c))

6. The amount of light which enters the eye. (para 1-3e)

7. Eyelids. (para 1-4c)

8. Lacrimal apparatus. (para 1-4d)

9. Refraction of light rays.
   Accommodation of the lens.
   Constriction of the pupil.
   Convergency of the eyes. (para 1-5a)

    Equilibrium. (para 1-6)

11. External or outer ear.
    Middle ear.
    Internal or inner ear. (para 1-7)

12. Middle. (para 1-7b)

13. Frequency or pitch.
    Volume or loudness.
    Quality or timbre. (figure 1-8)

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