LESSON ASSIGNMENT

LESSON 5
Review of Ocular and Auditory Anatomy and Physiology.

TEXT ASSIGNMENT
Paragraphs 5-1 through 5-13.

LESSON OBJECTIVES

5-1. Given the name of a part of the bulbus oculi and a group of statements, select the statement that best describes that part or its function.

5-2. Given the name of one of the structures associated with the bulbus oculi (the adnexa) and a group of statements, select the statement which best describes that part or its function.

5-3. Given the name of a disease/condition that affects the eye and a group of statements, select the statement that best describes that disease/condition.

5-4. From a list of possible methods, select the method(s) by which sound may be transmitted.

5-5. Given the name of one of the parts of the human ear and a group of statements, select the statement which best describes that part of the ear or its function.

5-6. Given a disorder/malfunction of the ear and a group of statements, select the statement that best describes that disorder/malfunction.

5-7. Given a group of statements, select the statement that best describes how the body maintains equilibrium (balance).

SUGGESTION
After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.
5-1. BACKGROUND

a. **Stimulus.** Rays of light stimulate the receptor tissues of the eyeballs (bulbus oculi) to produce the special sense of vision. This includes both the sensation of vision or seeing and a variety of reactions known as the light reflexes. The actual reception of the light energy is a chemical reaction that in turn stimulates the neuron endings.

b. **Sense Organ.** The eyeball (bulbus oculi) is the special sense organ that contains the receptor tissues. The bulbus oculi is suspended in the orbit. The orbit is a skeletal socket of the skull that helps protect the bulbus oculi. Various structures associated with the functioning of the bulbus oculi are called the adnexa. The adnexa include the eyelids, the lacrimal system, and so forth.

5-2. THE BULBUS OCULI

See figure 5-1.

![Figure 5-1. A focal-axis section of the bulbus oculi.](image-url)
a. **Shape.** Normally the bulbus oculi is a spherical bulb-like structure. Its anterior surface, transparent and more curved, is known as the cornea of the bulbus oculi.

b. **Wall of the Bulbus Oculi.** The bulbus oculi is a hollow structure. Its wall is made up of three layers known as coats or tunics.

1. **Sclera.** The outermost layer is white and very dense fibrous connective tissue (FCT). It is known as the sclera, scleral coat, or fibrous tunic. Its anterior portion is called the cornea. As already mentioned, the cornea is transparent and more curved than the rest of the sclera. The fixed curvature of the cornea enables it to serve as the major focusing device for the bulbus oculi.

2. **Choroid.** The middle layer of the wall of the bulbus oculi is known as the choroid, the choroid coat, or the vascular tunic. This layer is richly supplied with blood vessels. It is also pigmented with a black material. The black color absorbs the light rays and prevents them from reflecting at random.

3. **Retina.** The inner layer of the wall of the bulbus oculi is known as the retina, retinal coat, or internal tunic. The actual photoreceptor elements are located in the retina at the back and sides of the bulbus oculi. These elements are the rods and cones. They constitute the nervous portion of the retina. In the anterior part of the bulbus oculi, the retina continues as a non-nervous portion.

c. **Internal Structures of the Bulbus Oculi.**

1. **The nervous retina.**

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FOVEA = small depression
CENTRALIS = center
MACULA = spot
LUTEA = yellow

(c) Associated with the rods and cones are the beginnings of neurons of the optic nerve. These neurons pass out of the bulbus oculi at the posterior end (in a point medial and superior to the fovea centralis). At the point of exit, there are not rods or cones. Therefore, it is called the blind spot (optic papilla/optic disk).

(2) Ciliary body. The anterior end of the choroid layer thickens to form a circular “picture frame” around the lens of the bulbus oculi. This is also near the margin of the base of the cornea. The frame-like structure is called the ciliary body. It includes mostly radial muscle fibers, which form the ciliary muscle.

(3) Ligaments. The lens is suspended in place by ligaments. These ligaments connect the margin (equator) of the lens with the ciliary body.
(4) **Crystalline lens.** The crystalline lens is located in the center of the anterior of the bulbus oculi, just behind the cornea.

(a) The lens is biconvex. This means that it has two outwardly curved surfaces. The anterior surface is flatter (less curved) than the posterior surface.

(b) The lens is transparent and elastic. As one grows older, the lens becomes less and less elastic. The ligaments maintain a tension upon the lens. This tension keeps the lens flatter and allows the lens to focus on distant objects. When the ciliary muscle contracts, the tension on the lens is decreased. The decreased tension allows the lens to thicken. The greater thickness increases the anterior curvature and allows close objects to be seen clearly.

(c) The process of focusing the crystalline lens for viewing close objects clearly is called accommodation. The process of accommodation is accompanied by a reduction in the pupil size as well as a convergence of the two central lines of sight (axes on bulbi oculi).

(5) **Iris.** Another structure formed from the anterior portion of the choroid layer is the iris. The iris is located between the lens and the cornea.

(a) The pupil is the hole in the middle of the iris. Radial and circular muscles in the iris control the size of the pupil. The radial muscles are dilators. The circular muscles are the constrictors. By changing the size of the pupil, the iris controls the amount of light entering the bulbus oculi.

(b) The iris may have many different colors. Multiple genes determine the actual color.

(6) **Chambers.** The space between the cornea and the lens is called the anterior cavity. The space between the cornea and the iris is referred to as the anterior chamber. The space between the iris and the lens is called the posterior chamber (see figure 5-1). Both chambers of the anterior cavity are filled with a fluid called the aqueous humor. The aqueous humor is secreted into the chambers by the ciliary body. It drains into the encircling canal of Schlemm, located in the angle between the cornea and the iris. This angle is called the irioiocornealis angle.

(7) **Vitreous body.** Behind the lens is a jelly-like material called the vitreous body. It fills the posterior cavity of the bulbus oculi.

5-3. **THE ADNEXA**

The adnexa are the various structures associated with the bulbus oculi.
a. **Extrinsic Ocular Muscles.** Among the adnexa are the extrinsic ocular muscles that move the bulbus oculi within the orbit (the cavity in the upper facial skull that contains the bulbus oculi).

b. **Eyelids.** Attached to the margins of the orbit, in front of the bulbus oculi, are the upper and lower eyelids. These have muscles for opening and closing the eyelids. The eyelashes (cilia) are special hairs of the eyelids that help protect these bulbus oculi. The margins of the eyelids have special oil to prevent the loss of fluids from the area. The inner lining of the eyelids is continuous with the conjunctiva, a membrane over the anterior surface of the bulbus oculi.

c. **Lacrimal Apparatus.** The conjunctiva must be kept moist and clean at all times. To do this, a lacrimal apparatus is associated with the eyelids. In the upper outer corner of the orbit is a lacrimal gland, which secretes a lacrimal fluid (tears) into the junction between the upper eyelid and the conjunctiva. The motion of the bulbus oculi and the eyelids (blinking) moves this fluid moved across the surface of the conjunctiva to the medialinferior aspect. Here, the lacrimal fluid is collected and delivered into the nasal chamber by the nasal lacrimal duct.

d. **Eyebrow.** The eyebrow is a special group of hairs above the orbit. The eyebrow serves to keep rain and perspiration away from the bulbus oculi.

e. **Optic Nerve.** Neurons carry information from the photoreceptors of the nervous retina. They leave the bulbus oculi at the blind spot. At the optic nerve, or second cranial nerve, the neurons pass to the rear of the orbit. There, the optic nerve exits through the optic canal into the cranial cavity. Beneath the brain, the optic nerves from both sides join to form the optic chiasma, in which half of the neurons from each optic nerve cross to the opposite side. From the optic chiasma, the right and left optic tracts proceed to the brain proper.

## 5-4. DISEASES/CONDITIONS AFFECTING THE EYE

a. **Myopia ("Near-Sightedness").** In myopia the image from distant objects are focused in front of the retina. Myopia is caused by a lens that is too strong. Although the ciliary muscle is completely relaxed, the light rays entering the eye are not properly bent to be focused on the retina. This type of lens condition can be corrected by the use of a concave lens. Figure 5-3a illustrates this condition and correction with a concave lens.

b. **Hypermetropia (Hyperopia) ("Far-Sightedness").** In hypermetropia, the parallel light rays entering the eye are not bent sufficiently by the lens and the image is focused behind the retina. In hypermetropia, the bulbus oculi is too short or the lens system is too weak when the ciliary muscle is relaxed. A convex lens is used to correct this condition. Figure 5-3b illustrates this condition and its correction with a convex lens.
c. **Astigmatism.** Astigmatism occurs when the light rays passing through an astigmatic lens are not all focused at the same point. A malformed lens or cornea causes astigmatism. A specially designed lens can be used to help correct this condition.
d. **Glaucoma.** Glaucoma is a common cause of blindness. In glaucoma, the intraocular pressure becomes too great and causes damage to the retina and optic nerve. The intraocular pressure of a normal person is approximately 15 to 20 mm Hg (millimeters of mercury), while the intraocular pressure of a person with glaucoma can reach from 80 to 90 mm Hg. As the intraocular pressure increases, damage is done to the delicate tissues of the eye. The retinal artery, which enters the bulbus oculi at the optic disk, becomes increasingly compressed. Hence, nutrition to the retina is reduced and damage to the retina and optic nerve follow. Glaucoma can be either of a sudden onset or of a slow onset. Glaucoma results from the high pressure caused by reduced drainage of a fluid (aqueous humor). Because of the decreased drainage and continued fluid output, the high pressure develops. A variety of medications can be used to treat glaucoma. Pilocarpine, acetazolamide (Diamox®) and timolol (Timoptic®) are just three examples of such medications. These medications will be presented in later lessons.

e. **Cataracts.** A cataract is an irreversible and progressive clouding of the lens leading to blindness. Cataracts are surgically removed.

f. **Conjunctivitis.** Conjunctivitis is an inflammation of the conjunctiva.

**Section II. AUDITORY ANATOMY AND PHYSIOLOGY**

5-5. **BACKGROUND**

The human ear serves two major special sensory functions: hearing (auditory) and equilibrium (balance). The stimulus for hearing is sound waves. The stimulus for equilibrium is gravity.

a. **Methods of Sound Transmission.** The sound stimulus is transmitted in a variety of ways. Regardless of the actual transmission method, the sound stimulus is unchanged. Sound may be transmitted by:

   (1) Airborne waves, which have frequency (pitch) and amplitude (loudness or intensity).

   (2) Mechanical oscillations (vibrations) of structures.

   (3) Fluid-born pressure pulses.

   (4) Electrical impulses along the neurons to and in the brain.

b. **Sections of the Human Ear.** The human ear has three major parts (figure 5-4). Each part serves a specific function in the transmission and reception of the sound stimulus. The three parts are known as the external (outer) ear, the middle ear, and the internal (inner) ear.
5-6. 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.

5-7. THE MIDDLE EAR

a. Tympanic Membrane. At the inner end of the external auditory meatus is a tympanic membrane. The tympanic membrane (eardrum) is a circular membrane separating the external auditory meatus from the middle ear cavity. The tympanic membrane vibrates (mechanically oscillates) in response to airborne sound waves.

b. 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.
c. **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.

d. **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.

e. **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).

5-8. **THE INTERNAL EAR**

a. **Labyrinths.**

(1) **Bony labyrinth.** The bony labyrinth (LABYRINTH = a maze) is a complex cavity within the temporal bone. It has three semi-circular canals, a vestibule (hallway), and a snail-shaped cochlear portion.

(2) **Membranous labyrinth.** The membranous labyrinth is a hollow tubular structure suspended within the bony labyrinth.

b. **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. These fluids are continuously formed and drained away.

| ENDO = within |
| PERI = around |

| The Cochlea.** The cochlea is a spiral structure associated with hearing. It has 2 1/2 turns. The snail- shaped portion of the bony labyrinth forms its outer boundaries. |
(1) 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 spiral 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 that are the sensory receptors for the special sense of hearing.

LAMINA = thin plate

(2) 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 scala are joined at their apex, they form a continuous channel and the connection between them is called the helicotrema.

d. Transmission.

(1) The sound stimulus is transferred from the stapes to the perilymph of the scala vestibuli. Here the stimulus is transmitted as a pressure pulse in the fluid.

(2) In response, the basilar membrane of the cochlea vibrates (mechanically oscillates). Only selected portions of the basilar membrane vibrate at any one time, depending on the frequency of the sound stimulus.

(3) The hair cells of the organ of Corti at that particular location are mechanically stimulated. This stimulation is transferred to the neurons of the acoustic nerve. The acoustic nerve passes out of the modiolus into the cranial cavity and goes to the brain.

5-9. DISORDERS OR MALFUNCTIONS OF THE EAR

a. Deafness. Deafness can be divided into two types. One type is caused by the inability of the middle ear mechanisms to transmit sounds into the cochlea. This is sometimes called conduction deafness. Another type, usually referred to as nerve deafness, is caused by the impairment of the auditory nerve or cochlea. As one might expect, if either the cochlea or auditory nerve is destroyed, the patient is permanently deaf. However, if the cochlea and auditory nerve are still capable of functioning and only the ossicular system has been destroyed, the patient can still hear because sound waves can be conducted into the cochlea by bone conduction.

b. Tinnitus. Tinnitus is ringing in the ears or the sensation of noise in the ears or head. Persons who take large doses of certain drugs (like aspirin) complain of tinnitus.
c. **Meniere’s Syndrome.** Meniere’s Syndrome is a disorder characterized by intermittent attacks of vertigo (dizziness), nausea, vomiting, and profuse sweating. It is a disorder of the membranous labyrinth of the inner ear.

d. **Swimmer’s Ear.** Swimmer’s ear is a fungal infection of the outer ear.

e. **Otitis Media.** Otitis media is the inflammation of the middle ear or eardrum.

f. **Otitis Externa.** Otitis externa is the inflammation of the outer ear.

**Section III. ANATOMY AND PHYSIOLOGY OF EQUILIBRIUM (BALANCE)**

**5-10. BACKGROUND**

a. **Posture.** Posture is the specific alignment of the body parts at any given time. Humans can assume an infinite variety of postures. However, the truly erect posture is unique to humans.

b. **Equilibrium.** Equilibrium is the state of balance of the body. An erect standing human has a highly unstable equilibrium. Therefore, the human can easily fall. Through a variety of sensory inputs (visual, and so forth) and postural reflexes, the body is maintained in its erect posture.

c. **Stimulus-Gravitational Forces.** A primary sensory input for equilibrium consists of gravitational forces. This input is received by the membranous labyrinth within the internal ear. The gravitational forces are of two types: static, when the body is standing still, and kinetic, when the body is moving in either linear (straight) or angular directions.

d. **Membranous Labyrinth.** The specific portions of the membranous labyrinth involved are the two sac-like structures—the sacculus and the utriculus. Each of these two structures has an area of special hair cells called the macula. In addition, there are three semi-circular ducts located within the osseous semi-circular canals of the temporal bone of the skull. Each semi-circular duct has a crista, a little ridge of hair cells across the axis of the duct.

e. “**Body Sense.**” All of the various sensory inputs related to the maintenance of equilibrium and posture are integrated within the brain as “body sense.” Correct information is sent to the muscles of the body by means of specific postural reflexes in order to maintain the proper posture.

**5-11. SACCUlus AND UTRICULUS**

a. The sacculus and the utriculus are two sac-like portions of the membranous labyrinth. They are filled with endolymph.
b. On the wall of each sac is a collection of special hair cells known as the macula, which serves as a receptor organ for static and linear kinetic gravitational forces. The saccular macula and the utricular macula are oriented at more or less right angles to each other. For the pair of maculae in the membranous labyrinth of the right side, there is a corresponding pair in the labyrinth of the left side. Information from all of these maculae is sent into the brain for continuous sensing of the position of the head in space.

5-12. SEMICIRCULAR DUCTS

Extending from and opening into the utriculus are three hollow structures called the semicircular ducts. Since the utriculus completes the circle for each duct, the ducts act as if they were complete (figure 5-5).

![Diagram of semicircular duct orientation.]

a. Orientation. Two of the ducts are vertically oriented (one anterior and one posterior). The third duct is essentially horizontal. The three ducts are all oriented at right angles to each other. In addition, the three ducts of one membranous labyrinth are matched or paired by the three ducts of the opposite membranous labyrinth.

b. Ampullae and Cristae. Each semi-circular duct ends with an enlargement where it opens into the utriculus. This enlargement or swelling is called an ampulla. The crista is at a right angle to the axis of the duct. Movement of the endolymph within the duct—caused by movement of the head in space—deforms (bends) the hairs of the crista in specific directions. These are responses to linear and/or angular kinetic gravitational forces.
5-13. THE VESTIBULAR NERVE

The vestibular nerve carries all this information from the maculae and cristae to the brain. The vestibular nerve is part of the auditory nerve. The auditory nerve (acoustic nerve) is a combination of the vestibular nerve (balance) and the otic nerve (hearing).

Continue with Exercises

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EXERCISES, LESSON 5

INSTRUCTIONS: Answer the following exercises by marking the lettered response which best answers the question or best completes the incomplete statement.

After you have completed all the exercises, turn to “Solutions to Exercises” at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. The sclera is best described as:

   a. The inner layer of the wall of the bulbus oculi where the rods and cones of the eye are located.
   
   b. The white and very dense fibrous connective tissue that is the outermost layer of the bulbus oculi.
   
   c. The middle layer of the wall of the bulbus oculi.
   
   d. The transparent layer that forms the outermost portion of the bulbus oculi.

2. The retina is:

   a. The middle layer of the bulbus oculi that is pigmented black to absorb light rays so they will not be reflected at random within the eye.
   
   b. The transparent portion of the bulbus oculi that serves as the major focusing device for the eye.
   
   c. The inner layer of the wall of the bulbus oculi where the photo-receptor elements of the eye are located.
   
   d. The non-nervous portion of the inner layer of the bulbus oculi.

3. The cones of the bulbus oculi function to:

   a. Perceive black and white.
   
   b. Perceive colors.
   
   c. Prevent random reflection of light rays within the eye.
   
   d. Provide vision in conditions of little or no light.
4. What is the blind spot?
   a. The blind spot is a place in the cornea where there are no cones.
   b. The blind spot is a place in the retina where the optic nerve enters the bulbus oculi.
   c. The blind spot is an area located in the center of the anterior of the bulbus oculi.
   d. The blind spot is the origin of the optic nerve where there are no rods or cones.

5. The vitreous body is best described as:
   a. The space between the cornea and the lens.
   b. The jelly-like material that fills the posterior cavity of the bulbus oculi.
   c. The group of muscles responsible for controlling the size of the pupil.
   d. The colored portion of the anterior part of the choroid layer that is between the lens and the cornea.

6. The function of the lacrimal apparatus of the eye is to:
   a. Produce oil to prevent the loss of fluids from the bulbus oculi.
   b. Keep rain and perspiration away from the bulbus oculi.
   c. Open and close the eyelids.
   d. Keep the eye clean and moist at all times.
7. Myopia is best defined as:
   a. A condition in which the image from a distant object is focused in front of the retina.
   b. A condition in which the light rays entering the eye are focused behind the retina.
   c. A condition characterized by increased intraocular pressure which can result in blindness.
   d. A condition characterized by an irreversible and progressive clouding of the lens.

8. What is the function of the auditory (Eustachian) tube?
   a. This tube transmits from the tympanic membrane to the middle ear cavity.
   b. This tube carries sound waves from the external ear to the auditory ossicles.
   c. This tube maintains equal air pressure on the two sides of the tympanic membrane.
   d. This tube carries the sound waves from the external ear to the tympanic membrane.

9. The cochlea of the internal ear is best described as:
   a. A complex cavity within the temporal bone.
   b. A spiral structure associated with hearing.
   c. A hollow tubular structure suspended within the bony labyrinth.
   d. A structure containing fluid which is located between the membranous labyrinth and the bony labyrinth.
10. Meniere’s Syndrome is best described as:
   a. An inflammation of the outer ear.
   b. An acute fungal infection of the outer ear.
   c. A disorder characterized by intermittent attacks of dizziness, nausea, vomiting, and profuse sweating.
   d. An inflammation of the middle ear or eardrum.

11. Conduction deafness is best described as:
   a. The type of deafness caused by the inability of the middle ear mechanisms to transmit sounds into the cochlea.
   b. The type of deafness caused by the impairment of the auditory nerve or cochlea.
   c. The type of deafness caused by the ossification of the tympanic membrane.

12. Which of the following statements best describes how the body maintains equilibrium?
   a. Information from the membranous labyrinth is sent to the brain.
   b. The semicircular ducts input energy to the brain.
   c. Movement of the endolymph within the semicircular duct provides all the equilibrium information to the brain.
   d. The brain receives sensory inputs from many sources and integrates this knowledge as “body sense.”

Check Your Answers on Next Page
SOLUTIONS TO EXERCISES, LESSON 5

1. b (para 5-2b(l))
2. c (para 5-2b)(3))
3. b (para 5-2c(1)(a))
4. d (para 5-2c(1)(c))
5. b (para 5-2c(7))
6. d (para 5-3c)
7. a (para 5-4a)
8. c (para 5-7d)
9. b (para 5-8c)
10. c (para 5-9c)
11. a (para 5-9a)
12. d (para 5-10e)

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