Systemic 3[B]

Chapter 21: SENSORY RECEPTORS AND ORGANS

Learning Objectives: Upon completion of this chapter, students should be able to:

- Define sensory receptors and explain their role in sensation.
- Describe the structure and function of the skin as a sensory organ.
- Explain the senses of smell and taste, and the organs involved.
- Detail the structure and function of the eye and the mechanism of sight.
- Discuss common defects of the eye and their corrections.
- Outline the structure and function of the ear and the mechanism of hearing.
- Explain how the ear contributes to keeping balance.
- Discuss common defects and care of the ear.

21.1 Sensory Receptors and Sensations

- **Sensory Receptors:** Specialized cells or nerve endings that detect specific stimuli from the internal or external environment. They convert stimuli into electrical signals (nerve impulses) that are sent to the brain for interpretation.
- **Sensation:** The process by which our sensory organs detect stimuli.
- **Perception:** The process by which the brain interprets and organizes sensory information to form a meaningful understanding of the environment.

21.2 Sense of Touch and Skin

- **Skin as a Sensory Organ:** The skin contains various types of sensory receptors that detect different stimuli.
- **Types of Receptors in Skin:**
    - **Pain Receptors (Nociceptors):** Widely distributed, detect harmful stimuli (tissue damage, extreme temperatures).
    - **Temperature Receptors (Thermoreceptors):** Detect changes in temperature (cold and heat).
    - **Pressure Receptors (Pacinian Corpuscles):** Detect deep pressure and vibration.
    - **Touch Receptors (Meissner's Corpuscles, Merkel Discs):** Detect light touch and texture.
- **Functions:** Enable the body to sense its environment, protect against injury, and contribute to thermoregulation.

21.3 Senses of Smell and Taste

- **A. Sense of Smell (Olfaction):**
  - **Organ of Smell:** The **olfactory epithelium** located in the upper part of the nasal cavity.
  - **Mechanism:** Odorant molecules (chemicals) in the air dissolve in the mucus layer of the olfactory epithelium and bind to specific olfactory receptor cells. These cells generate nerve impulses that are transmitted via the olfactory nerve to the brain (olfactory bulb and then to the cerebrum) for interpretation as specific smells.
- **B. Sense of Taste (Gustation):**
  - **Organ of Taste: Taste buds**, primarily located on the tongue (within papillae) but also found on the soft palate, pharynx, and epiglottis.
  - **Mechanism:** Chemical molecules (tastants) from food dissolve in saliva and stimulate specialized taste receptor cells within the taste buds. These cells generate nerve impulses that are transmitted to the brain for interpretation.
  - **Basic Tastes:** Sweet, sour, salty, bitter, umami (savory).
  - **Interaction with Smell:** Much of what we perceive as "flavor" is a combination of taste and smell.

21.4 Sense of Sight: Eye Structure and How We See

- **Organ of Sight:** The **eye**.
- **Structure of the Eye:**
  - **Sclera:** The tough, white outer layer of the eyeball; maintains the shape of the eye and protects internal structures.
  - **Cornea:** The transparent, curved front part of the sclera; refracts (bends) light into the eye.
  - **Choroid:** The middle layer, rich in blood vessels; supplies nutrients and oxygen to the retina. Contains a dark pigment to prevent reflection of light.
  - **Ciliary Body:** Produces aqueous humor and contains ciliary muscles that control the shape of the lens.
  - **Iris:** The colored part of the eye; controls the size of the pupil (the opening in the center) to regulate the amount of light entering the eye.
  - **Pupil:** The central opening in the iris that allows light to enter the eye.
  - **Lens:** A transparent, biconvex structure behind the iris; focuses light onto the retina by changing its shape (accommodation).
  - **Retina:** The innermost layer at the back of the eye; contains photoreceptor cells (rods and cones) that convert light into nerve impulses.
    - **Rods:** Responsible for vision in dim light (black and white vision).
    - **Cones:** Responsible for color vision and sharp vision in bright light, concentrated in the fovea (central part of the retina).
  - **Fovea (Macula Lutea):** A small pit in the center of the retina, responsible for sharp, detailed central vision.
  - **Blind Spot (Optic Disc):** The point where the optic nerve leaves the eye; contains no photoreceptors, so it cannot detect light.
  - **Optic Nerve:** Transmits nerve impulses from the retina to the brain.

    - **Aqueous Humor:** Clear fluid filling the space between the cornea and the lens (anterior chamber); maintains eye shape and nourishes the cornea and lens.
    - **Vitreous Humor:** Jelly-like substance filling the large cavity behind the lens (posterior chamber); maintains the shape of the eyeball.
- **How We See (Mechanism of Sight):**
    1. Light rays from an object enter the eye through the cornea.
    2. The cornea, aqueous humor, lens, and vitreous humor refract (bend) the light rays.
    3. The iris adjusts the pupil size to control the amount of light entering.
    4. The lens changes its shape (accommodation) to finely focus the light onto the retina, forming a real, inverted, and diminished image.
    5. Photoreceptor cells (rods and cones) in the retina convert light energy into electrical nerve impulses.
    6. These impulses are transmitted along the optic nerve to the visual cortex in the brain (occipital lobe).
    7. The brain interprets the impulses, flipping the image to be upright and perceiving it as vision.
- **Common Defects of the Eye and Their Corrections:**
    - **Myopia (Short-sightedness/Nearsightedness):** Distant objects appear blurry.
        - **Cause:** Eyeball is too long, or lens/cornea is too curved, causing light to focus in front of the retina.
        - **Correction:** Concave (diverging) lens.
    - **Hyperopia (Long-sightedness/Farsightedness):** Near objects appear blurry.
        - **Cause:** Eyeball is too short, or lens/cornea is too flat, causing light to focus behind the retina.
        - **Correction:** Convex (converging) lens.
    - **Astigmatism:** Blurred vision at all distances.
        - **Cause:** Irregular curvature of the cornea or lens, causing light to focus unevenly on the retina.
        - **Correction:** Cylindrical lenses.
    - **Cataracts:** Clouding of the natural lens of the eye.
        - **Cause:** Aging, injury, diabetes.
        - **Correction:** Surgical removal of the cloudy lens and replacement with an artificial intraocular lens.
    - **Glaucoma:** Damage to the optic nerve, often due to high intraocular pressure.
        - **Cause:** Blockage of fluid drainage from the eye.
        - **Correction:** Eye drops, laser treatment, or surgery to reduce pressure.
    - **Presbyopia:** Age-related farsightedness, difficulty focusing on near objects.
        - **Cause:** Loss of elasticity of the lens with age.
        - **Correction:** Bifocal or progressive lenses.
    - **Colour Blindness:** Inability or decreased ability to see color or differences in color.
        - **Cause:** Usually genetic, involving defects in cone cells.
        - **Correction:** No cure, but special lenses can sometimes help differentiate colors.

21.5 Sense of Hearing and Balance: Ear Structure and How We Hear

- **Organ of Hearing and Balance:** The **ear**.
- **Structure of the Ear:**
    - **Outer Ear:**
        - **Pinna (Auricle):** The visible outer part of the ear; collects sound waves.
        - **Auditory Canal (Ear Canal):** Leads to the eardrum; secretes earwax (cerumen) to trap dust and protect the ear.
    - **Middle Ear:** An air-filled cavity containing three tiny bones (ossicles).
        - **Tympanic Membrane (Eardrum):** Vibrates when struck by sound waves.
        - **Ossicles:** Malleus (hammer), Incus (anvil), Stapes (stirrup); transmit and amplify vibrations from the eardrum to the inner ear.
        - **Eustachian Tube (Auditory Tube):** Connects the middle ear to the pharynx; equalizes pressure between the middle ear and the atmosphere.
    - **Inner Ear:**
        - **Cochlea:** Snail-shaped, fluid-filled structure containing the organ of Corti (sensory receptors for hearing). Converts sound vibrations into nerve impulses.
        - **Vestibule & Semicircular Canals:** Fluid-filled structures responsible for balance.
        - **Auditory Nerve (Vestibulocochlear Nerve):** Transmits impulses for hearing and balance to the brain.
- **How We Hear (Mechanism of Hearing):**
    1. Sound waves are collected by the pinna and travel down the auditory canal.
    2. Sound waves cause the tympanic membrane (eardrum) to vibrate.
    3. These vibrations are amplified by the ossicles (malleus, incus, stapes) and transmitted to the oval window of the cochlea.
    4. Vibrations in the oval window create pressure waves in the fluid (perilymph and endolymph) inside the cochlea.
    5. These fluid waves stimulate the hair cells (receptor cells) in the organ of Corti.
    6. Hair cells convert the mechanical vibrations into electrical nerve impulses.
    7. These impulses are sent along the auditory nerve to the auditory cortex in the brain (temporal lobe) for interpretation as sound.
- **Keeping Our Balance:**
    - **Vestibule:** Contains structures (utricle and saccule) with hair cells that detect static equilibrium (head position relative to gravity) and linear acceleration/deceleration.
    - **Semicircular Canals:** Three fluid-filled loops oriented in different planes. They detect rotational (angular) movements of the head.
    - **Mechanism:** Movement of the head causes the fluid (endolymph) in these structures to move, bending the hair cells. This generates nerve impulses that are sent via the auditory nerve to the cerebellum in the brain, which interprets the information to maintain balance and coordination.
- **Deafness and Care of the Ear:**
    - **Deafness:** Partial or complete loss of hearing.
        - **Conductive Deafness:** Problems with the transmission of sound waves to the inner ear (e.g., earwax buildup, perforated eardrum, ossicle damage, middle ear infections). Often treatable.

        - **Sensorineural Deafness (Nerve Deafness):** Damage to the inner ear (cochlea/hair cells) or the auditory nerve. Often permanent.
        - **Causes:** Loud noise exposure, aging, genetic factors, certain diseases (e.g., mumps, meningitis), some medications.
    - **Care of the Ear:**
        - Avoid inserting sharp objects into the ear canal.
        - Avoid exposure to excessively loud noises (use ear protection in noisy environments).
        - Seek medical attention for ear infections.
        - Clean the outer ear gently.
        - Avoid excessive earwax removal with cotton swabs, which can push wax deeper.