

Chapter 10 – The Senses

10.1 Introduction

- A. Sensory receptors detect changes in the environment and stimulate neurons to send nerve impulses to the brain.
- B. A sensation is formed based on the sensory input.

10.2 Receptors and Sensations, and Perception

- A. Each receptor is more sensitive to a specific kind of environmental change but is less sensitive to others.
- B. Types of Receptors
 - 1. Five general types of receptors are recognized.
 - a. Receptors sensitive to changes in chemical concentration are called chemoreceptors.
 - b. Pain receptors detect tissue damage.
 - c. Thermoreceptors respond to temperature differences.
 - d. Mechanoreceptors respond to changes in pressure or movement.
 - e. Photoreceptors in the eyes respond to light energy.
- C. Sensations and Perception
 - 1. Sensations are feelings that occur when the brain interprets sensory impulses.
 - 2. At the same time the sensation is being formed, the brain uses projection to send the sensation back to its point of origin so the person can pinpoint the area of stimulation.
- D. Sensory Adaptation
 - 1. During sensory adaptation, sensory impulses are sent at decreasing rates until receptors fail to send impulses unless there is a change in strength of the stimulus.

10.3 General Senses

- A. Receptors associated with the skin, muscles, joints, and viscera make up the somatic senses.
- B. Touch and Pressure Senses (Fig. 10.1)
 - 1. Three types of receptors detect touch and pressure.
 - 2. Free ends of sensory nerve fibers in the epithelial tissues are associated with touch and pressure.
 - 3. Tactile (Meissner's) corpuscles are flattened connective tissue sheaths surrounding two or more nerve fibers and are abundant in hairless areas that are very sensitive to touch, like the lips.
 - 4. Lamellated (Pacinian) corpuscles are large structures of connective tissue and cells that resemble an onion. They function to detect deep pressure.
- C. Temperature Senses
 - 1. Temperature receptors include two groups of free nerve endings: warm receptors and cold receptors which both work best within a range of temperatures.
 - a. Both warm and cold receptors adapt quickly.
 - b. Temperatures near 45° C stimulate pain receptors; temperatures below 10° C also stimulate pain receptors and produce a freezing sensation.
- D. Sense of Pain
 - 1. Pain receptors consist of free nerve endings that are stimulated when tissues are damaged, and adapt little, if at all.
 - 2. Many stimuli affect pain receptors such as chemicals and oxygen deprivation.
 - 3. Visceral pain (Figs. 10.2-10.3) receptors are the only receptors in the viscera that produce sensations.
 - a. Referred pain occurs because of the common nerve pathways leading from skin and internal organs.

4. Pain Nerve Fibers
 - a. Fibers conducting pain impulses away from their source are either acute pain fibers or chronic pain fibers.
 - b. Acute pain fibers are thin, myelinated fibers that carry impulses rapidly and cease when the stimulus stops.
 - c. Chronic pain fibers are thin, unmyelinated fibers that conduct impulses slowly and continue sending impulses after the stimulus stops.
 - d. Pain impulses are processed in the gray matter of the dorsal horn of the spinal cord.
 - e. Pain impulses are conducted to the thalamus, hypothalamus, and cerebral cortex.
5. Regulation of Pain Impulses
 - a. A person becomes aware of pain when impulses reach the thalamus, but the cerebral cortex judges the intensity and location of the pain.
 - b. Other areas of the brain regulate the flow of pain impulses from the spinal cord and can trigger the release of enkephalins and serotonin, which inhibit the release of pain impulses in the spinal cord.
 - c. Endorphins released in the brain provide natural pain control.

10.4 Special Senses

- A. The special senses are associated with fairly large and complex structures located in the head.
- B. These include the senses of smell, taste, hearing, static equilibrium, dynamic equilibrium, and sight.

10.5 Sense of Smell

- A. Olfactory Receptors
 1. Olfactory receptors are chemoreceptors.
 2. The senses of smell and taste operate together to aid in food selection.
- B. Olfactory Organs (Fig. 10.4)
 1. The olfactory organs contain the olfactory receptors plus epithelial supporting cells and are located in the upper nasal cavity.
 2. The receptor cells are bipolar neurons with hairlike cilia covering the dendrites. The cilia project into the nasal cavity.
 3. To be detected, chemicals that enter the nasal cavity must first be dissolved in the watery fluid surrounding the cilia.
- C. Olfactory Nerve Pathways
 1. When olfactory receptors are stimulated, their fibers synapse with neurons in the olfactory lobes lying on either side of the crista galli.
 2. Sensory impulses are first analyzed in the olfactory lobes, then travel along olfactory tracts to the limbic system, and lastly to the olfactory cortex within the temporal lobes.
- D. Olfactory Stimulation
 1. Scientists are uncertain of how olfactory reception operates but believe that each odor stimulates a set of specific protein receptors in cell membranes.
 2. The brain interprets different receptor combinations as an olfactory code.
 3. Olfactory receptors adapt quickly but selectively.

10.6 Sense of Taste (Fig. 10.5)

- A. Taste buds are the organs of taste and are located within papillae of the tongue and are scattered throughout the mouth and pharynx.
- B. Taste Receptors
 1. Taste cells (gustatory cells) are modified epithelial cells that function as receptors.

2. Taste cells contain the taste hairs that are the portions sensitive to taste. These hairs protrude from openings called taste pores.
 3. Chemicals must be dissolved in water (saliva) in order to be tasted.
 4. The sense of taste is not well understood but probably involves specific membrane protein receptors that bind with specific chemicals in food.
 5. There are four types of taste cells.
- C. Taste Sensations
1. Specific taste receptors are concentrated in different areas of the tongue.
 - a. Sweet receptors are plentiful near the tip of the tongue.
 - b. Sour receptors occur along the lateral edges of the tongue.
 - c. Salt receptors are abundant in the tip and upper portion of the tongue.
 - d. Bitter receptors are at the back of the tongue.
 - e. Umami receptors respond to certain amino acids and their chemical relatives.
 2. Taste buds may be responsive to at least 2 taste sensations but one is likely to dominate.
 3. Taste receptors rapidly undergo adaptation.
- D. Taste Nerve Pathways
1. Taste impulses travel on the facial, glossopharyngeal, and vagus nerves to the medulla oblongata and then to the gustatory cortex of the cerebrum.

10.7 Sense of Hearing

- A. The ear has external, middle, and inner sections and provides the senses of hearing and equilibrium.
- B. Outer (External) Ear (Fig. 10.6)
1. The external ear consists of the auricle, which collects the sound with then travels down the external auditory meatus.
- C. Middle Ear (Fig. 10.7)
1. The middle ear begins with the eardrum (tympanic membrane), and is an air-filled space (tympanic cavity) housing the auditory ossicles.
 - a. Three auditory ossicles are the malleus, incus, and stapes.
 - b. The tympanic membrane vibrates the malleus, which vibrates the incus, then the stapes.
 - c. The stapes vibrates the fluid inside the oval window of the inner ear.
 2. Auditory ossicles both transmit and amplify sound waves.
- D. Auditory Tube
1. The auditory, or eustachian, tube connects the middle ear to the throat to help maintain equal air pressure on both sides of the eardrum.
- E. Inner (Internal) Ear (Figs. 10.8-10.10; Table 10.1)
1. The inner ear is made up of a membranous labyrinth inside an osseous labyrinth.
 - a. Between the two labyrinths is a fluid called perilymph.
 - b. Endolymph is inside the membranous labyrinth.
 2. The cochlea houses the organ of hearing; while the semicircular canals function in equilibrium.
 3. Within the cochlea, the oval window leads to the upper compartment, called the scala vestibuli.
 4. A lower compartment, the scala tympani, leads to the round window.
 5. The cochlear duct lies between these two compartments and is separated from the scala vestibuli by the vestibular membrane, and from the scala tympani by the basilar membrane.
 6. The spiral organ, housing receptors called hair cells, lies on the basilar membrane.
 - a. Hair cells possess hairs that extend into the endolymph of the cochlear duct.

7. Above the hair cells lies the tectorial membrane, which touches the tips of the stereocilia.
 8. Vibrations in the fluid of the inner ear cause the hair cells to bend resulting in an influx of calcium ions.
 9. This causes the release of a neurotransmitter from vesicles, which stimulate the ends of nearby sensory neurons.
- F. Auditory Nerve Pathways
1. Nerve fibers carry impulses to the auditory cortices of the temporal lobes where they are interpreted.

10.8 Sense of Equilibrium

- A. The sense of equilibrium consists of two parts: static and dynamic equilibrium.
1. The organs of static equilibrium help to maintain the position of the head when the head and body are still.
 2. The organs of dynamic equilibrium help to maintain balance when the head and body suddenly move and rotate.
- B. Static Equilibrium (Fig. 10.8,10.11)
1. The organs of static equilibrium are located within the bony vestibule of the inner ear, inside the utricle and saccule (expansions of the membranous labyrinth).
 2. A macula, consisting of hair cells and supporting cells, lies inside the utricle and saccule.
 3. The hair cells contact gelatinous material holding otoliths.
 4. Gravity causes the gelatin and otoliths to shift, bending hair cells and generating a nervous impulse.
 5. Impulses travel to the brain via the vestibular branch of the vestibulocochlear nerve, indicating the position of the head.
- C. Dynamic Equilibrium (Figs.10.8,10.12-10.13)
1. The three semicircular canals detect motion of the head, and they aid in balancing the head and body during sudden movement.
 2. The organs of dynamic equilibrium are called crista ampullaris, and are located in the ampulla of each semicircular canal of the inner ear. They are at right angles to each other.
 3. Hair cells extend into a dome-shaped gelatinous cupula.
 4. Rapid turning of the head or body generates impulses as the cupula and hair cells bend.
 5. Mechanoreceptors (called proprioceptors) associated with the joints, and the changes detected by the eyes also help maintain equilibrium.

10.9 Sense of Sight

- A. Accessory organs, namely the lacrimal apparatus, eyelids, and extrinsic muscles, aid the eye in its function.
- B. Visual Accessory Organs (Figs. 10.14-10.16; Table 10.2)
1. The eyelid protects the eye from foreign objects and is made up of the thinnest skin of the body lined with conjunctiva.
 2. The lacrimal apparatus produces tears that lubricate and cleanse the eye.
 - a. Two small ducts drain tears into the nasal cavity.
 - b. Tears also contain an antibacterial enzyme.
 3. The extrinsic muscles of the eye attach to the sclera and move the eye in all directions.
- C. Structure of the Eye (Fig. 10.17)
1. The eye is a fluid-filled hollow sphere with three distinct layers, or tunics.
 2. Outer Layer
 - a. The outer (fibrous) tunic is the transparent cornea at the front of the eye,

- and the white sclera of the anterior eye.
 - b. The optic nerve and blood vessels pierce the sclera at the posterior of the eye.
- 3. Middle Layer (Figs. 10.17-10.20)
 - a. The middle, vascular tunic includes the choroid coat, ciliary body, and iris.
 - b. The coroid coat is highly vascular and darkly pigmented and performs two functions: to nourish other tissues of the eye and to keep the inside of the eye dark.
 - c. The ciliary body forms a ring around the front of the eye and contains ciliary muscles and suspensory ligaments that hold the lens in position and change its shape (focus).
 - d. The ability of the lens to adjust shape to facilitate focusing is called accommodation.
 - e. The iris is a thin, smooth muscle that adjusts the amount of light entering the pupil, a hole in its center.
 - i. The iris has a circular set of and a radial set of muscle fibers.
 - f. The anterior chamber (between the cornea and iris) and the posterior chamber (between the iris and vitreous body and housing the lens) make up the anterior cavity, which is filled with aqueous humor.
 - g. The aqueous humor circulates from one chamber to the other through the pupil.
- 4. Inner Layer (Figs. 10.17,10.21-10.23)
 - a. The inner tunic consists of the retina, which contains photoreceptors; the inner tunic covers the back side of the eye to the ciliary body.
 - b. In the center of the retina is the macula lutea with the fovea centralis in its center, the point of sharpest vision in the retina.
 - c. Medial to the fovea centralis is the optic disk, where nerve fibers leave the eye and where there is a blind spot.
 - d. The large cavity of the eye is filled with vitreous humor.
- D. Light Refraction (Fig. 10.24)
 - 1. Light waves must bend to be focused, a phenomenon called refraction.
 - 2. Both the cornea and lens bend light waves that are focused on the retina as do the two humors to a lesser degree.
- E. Visual Receptors (Figs. 10.17,10.21-22 & 10.25a,b)
 - 1. Two kinds of modified neurons comprise the visual receptors; elongated rods and blunt-shaped cones.
 - 2. Rods are more sensitive to light and function in dim light; they produce colorless vision.
 - 3. Cones provide sharp images in bright light and enable us to see in color.
 - a. To see something in detail, a person moves the eyes so the image falls on the fovea centralis, which contains the highest concentration of cones.
 - b. The proportion of cones decreases with distance from the fovea centralis.
- F. Visual Pigments
 - 1. The light-sensitive pigment in rods is rhodopsin, which breaks down into a protein, opsin, and retinal (from vitamin A) in the presence of light.
 - a. Decomposition of rhodopsin activates an enzyme that initiates changes in the rod cell membrane, generating a nerve impulse.
 - b. Nerve impulses travel away from the retina and are interpreted as vision.
 - 2. The light-sensitive pigments in cones are also proteins; there are three sets of cones, each containing a different visual pigment.
 - a. The wavelength of light determines the color perceived from it; each of the

three pigments is sensitive to different wavelengths of light.

- b. The color perceived depends upon which sets of cones the light stimulates: if all three sets are stimulated, the color is white; if none are stimulated, the color is black.

G. Visual Nerve Pathways (Fig. 10.26)

1. The axons of ganglion cells leave the eyes to form the optic nerves.
2. Fibers from the medial half of the retina cross over in the optic chiasma.
3. Impulses are transmitted to the thalamus and then to the visual cortex of the occipital lobe.