CH 9 – DE Human Biology - Sensory Systems

Sensory Systems

OUTLINE:

- Sensory Receptors
- Classes of Receptors
- The General Senses
- Vision
- Hearing
- Balance and the Vestibular Apparatus of the Inner Ear
- Smell and Taste

Sensory Receptors

- Structures that are specialized to detect and respond to changes in the external or internal environment
- Respond by generating electrochemical messages
- If a stimulus is strong enough, then action potentials are conducted to the brain
- Respond best to one form of energy

Sensory Receptors

- Sensation is awareness of a stimulus
  - How a sensation is experienced (e.g., as sight or sound) depends on which part of the brain receives the impulses
- Perception is the conscious awareness of sensations
  - Understanding the stimulus occurs when the cerebral cortex integrates sensory input

Sensory Receptors

- Sensory adaptation
  - Sensory receptors stop responding when continuously stimulated, leading to a decrease in the awareness of the stimulus
  - Varies among receptors
    - Pressure and touch receptors adapt quickly
    - Receptors in muscles and joints that report on body position never adapt

Classes of Receptors

- The body contains many specialized receptors:
  - Mechanoreceptors
  - Thermoreceptors
  - Photoreceptors
  - Chemoreceptors
  - Pain receptors

Classes of Receptors

- **General senses**: Touch – Pressure – Vibration – Temperature – Body and limb position – Pain
- Receptors located in skin, muscles, bones, joints, and internal organs
- We are not usually aware of the general senses, but they are still important
  - Provide information about body position
  - Help keep internal body conditions within optimal limits

Classes of Receptors

- Special senses
  - Vision
  - Hearing
  - Equilibrium
  - Smell
  - Taste
- We rely on the special senses to perceive the world

- Receptors for the special senses are located in the head, often within specific structures

The General Senses

- Receptors rely on either free nerve endings or encapsulated nerve endings
  - Free nerve endings are the tips of dendrites of sensory neurons
  - Encapsulated nerve endings are those in which a connective tissue capsule encloses and protects the tips of dendrites of sensory neurons

Touch, Pressure, and Vibration

- Rely on mechanoreceptors that respond to stimuli that stretch, compress, or twist their membrane
  - Different mechanoreceptors occur in the skin:
    - Mechanoreceptors that detect touch
      - Merkel disks: free nerve endings that end on Merkel cells, detect light touch
      - Meissner's corpuscles: encapsulated nerve endings, tell us where we have been touched

Touch, Pressure, and Vibration

- Mechanoreceptors that detect pressure
  - Pacinian corpuscles: layers of tissue surrounding a nerve ending, sense first pressure; vibration
  - Ruffini corpuscles: encapsulated nerve endings, respond to continuous pressure

Temperature Change

- Thermoreceptors respond to temperature changes
  - Specialized free nerve endings located just below the surface of the skin
  - One type responds to warmth; another type responds to cold
  - Adapt rapidly

Body and Limb Position

- Continuously monitored by the brain
  - Muscle spindles
    - Specialized muscle fibers wrapped in sensory nerve endings
    - Monitor length of skeletal muscles
  - Golgi tendon organs
    - Highly branched nerve fibers in tendons
    - Measure muscle tension
  - Information from the inner ear

Pain

- Free nerve endings found in all tissues of the body
  - Damaged tissue releases chemicals that alert free nerve endings
    - Aspirin and ibuprofen interfere with the production of released chemicals
- Referred pain
  - Pain felt somewhere besides the site of the injury
  - Common with damage to internal organs

Wall of the Eyeball

- The wall of the eyeball has three layers
  - Outermost layer—sclera and cornea
  - Middle layer—choroid, ciliary body, and iris
  - Innermost layer—retina

Wall of the Eyeball

- The outer layer is tough and fibrous

- Sclera
  - The white of the eye
  - Protects and shapes the eye
  - Serves as attachment site for muscles
- Cornea
  - Transparent area at the front of the eye
  - Allows light to enter

Wall of the Eyeball

- The middle layer is vascular
  - Choroid
    - Contains blood vessels that supply eye tissue with nutrients and oxygen
    - Contains melanin, which absorbs light reflected from the retina
  - Ciliary body
    - Ring of tissue, primarily muscle that encircles the lens
    - Holds lens in place and changes its shape
  - Iris
    - Muscular part of the choroid in front of the ciliary body
    - Regulates pupil size

Wall of the Eyeball

- Pupil
  - An opening in the center of the iris
  - Allows light to enter the eye and reach the retina
  - Dilates in dim light
  - Constricts in bright light

Wall of the Eyeball

- Retina
  - The innermost layer of the eye, it contains photoreceptors that respond to light by generating electrical signals
    - Types of photoreceptors
      - Rods
      - Cones
    - Fovea
      - Region of the retina with the greatest concentration of cones
      - Objects are focused here for sharp vision

Wall of the Eyeball

- Carries visual information from the eye to the brain for interpretation
- Blind spot
  - Region where the optic nerve leaves the retina
  - The retina lacks photoreceptors here
  - An image that strikes the blind spot cannot be seen

Fluid-Filled Chambers

- Posterior chamber
  - Located between the lens and the retina
  - Contains vitreous humor: jelly-like fluid that is never replaced
- Anterior chamber
  - Located between the cornea and the lens
  - Contains aqueous humor: watery fluid that is continuously replaced

Fluid-Filled Chambers

- Glaucoma
  - Second leading cause of blindness
  - Results when drainage of the aqueous humor is blocked
    - Pressure within the eye reaches dangerous levels

        - Blood vessels supplying the optic nerve and retina collapse and cells die
    - Progressive and painless

Focusing and Sharp Vision

- Sharp vision requires that light be focused on the retina
- Light is bent (refracted) at four points when it enters the eye
    - Cornea
    - Aqueous humor
    - Lens
    - Vitreous humor

Focusing and Sharp Vision

- Lens
    - Elastic and can change shape
    - Changes in shape are controlled by the ciliary muscle
- Accommodation
    - Changing the shape of the lens to change the bending of light
- Cataract
    - A lens that has become cloudy, usually due to aging

Focusing Problems

- Farsightedness
- Nearsightedness
- Astigmatism
- Causes include discrepancies in the thickness or curvature of the lens or the shape of the eyeball
- Normal vision can be restored with corrective lenses or laser-assisted surgeries (e.g., LASIK and LASEK)

Light and Pigment Molecules

- Light focused on the retina causes changes in photopigment molecules within photoreceptors
- Photoreceptors release less inhibitory neurotransmitter
- The activity of cells processing visual information increases
    - Electrical information from rods and cones is sent to bipolar cells and then to ganglion cells
- Electrical signals from the retina travel via the optic nerve to the thalamus and then to the visual cortex

Vision: Photoreceptors

- Two types: **rods** and **cones**, respond to light with a neural message sent to the brain
    - Rods: vision in dim light
        - More numerous than cones
        - Responsible for black-and-white vision
        - Contain the pigment rhodopsin, which is broken down in bright light

Vision: Photoreceptors

- Cones: responsible for color vision
    - Three types:
        - red
        - blue
        - green
    - Produce sharp images
    - A reduced number or lack of one type of cone results in color blindness

Vision

Hearing

- In order to hear, the ear collects and amplifies sound waves that are produced by vibrations
- The loudness of a sound is determined by the amplitude of the sound wave
- The pitch of a sound is determined by the frequency of the sound waves

Form and Function of the Ear

- The ear has three main parts: the outer ear, the middle ear, and the inner ear
- Outer ear
  - Functions as a receiver
  - Includes the pinna and external auditory canal
    - Pinna
      - Gathers sound and channels it to the external auditory canal
      - Helps determine sound direction
    - External auditory canal
      - Leads to the tympanic membrane (eardrum)

Form and Function of the Ear

- Tympanic membrane
  - Separates the outer ear from the middle ear
  - Vibrates at the same frequency as the sound waves and transfers these vibrations to the middle ear
  - Must have nearly equal pressure on both sides to vibrate properly
- Auditory tube (Eustachian tube)
  - Connects middle ear cavity with the throat; alleviates pressure differences

Form and Function of the Ear

- Middle ear
  - Functions as an amplifier
  - Consists of an air-filled cavity within the temporal bone of the skull and the three auditory bones
    - Malleus (hammer)
    - Incus (anvil)
    - Stapes (stirrup)

Form and Function of the Ear

- The middle ear bones
  - Convey airborne sound waves from the eardrum to the oval window, a sheet of tissue at the entrance to the inner ear
  - The force of the eardrum's vibrations is amplified 22 times in the middle ear
    - Needed to transfer vibrations to fluid of inner ear
    - Occurs because the eardrum is larger than the oval window, so pressure is concentrated

Form and Function of the Ear

- Inner ear
  - Functions as a transmitter
    - Generates neural messages in response to pressure waves caused by sound waves
    - Sends these messages to the brain for interpretation
  - Contains two sensory organs
    - Cochlea (hearing)
    - Vestibular apparatus (body position and movement)

Form and Function of the Ear

- Cochlea (Latin for "snail"):

- Two openings
  - Oval window—stapes fits into
  - Round window—relieves pressure
- Three longitudinal compartments filled with fluid
  - Central compartment
    - Floor consists of basilar membrane, which supports the spiral organ

Form and Function of the Ear

- Spiral organ
  - Most directly responsible for hearing
  - Consists of hair cells and overhanging tectorial membrane

Form and Function of the Ear

- Sequence of events in the inner ear
  - Movement of the stapes against the oval window sets up pressure waves in the fluid of the inner ear
  - Movements of the fluid cause the basilar membrane to swing up and down
  - The swinging presses projections on the hair cells against the overlying tectorial membrane
  - Bending of the hair cells alters the rate of nerve impulses in the auditory nerve, which carries sound information to the brain

Loudness and Pitch of Sound

- Loudness
  - The louder the sound
    - The more hair cells are stimulated
    - The more each individual hair cell bends, which increases the number of impulses
  - The brain interprets the increased number of impulses as louder sound

Loudness and Pitch of Sound

- Pitch
  - Sounds of different pitch activate hair cells at different places along the basilar membrane
  - The brain interprets input from hair cells in different areas as sounds of different pitch

Loudness and Pitch of Sound

Hearing Loss

- Types of hearing loss
  - Conductive
    - Involves an obstruction along the route that sound follows to the inner ear
  - Sensorineural
    - Caused by damage to either the hair cells or the nerve supply of the inner ear

Ear Infections

- External (outer) ear infections
  - Infection in the external auditory canal
  - Often caused by water trapped in the canal
    - Favorable environment for bacteria
    - “Swimmer’s ear”
- Middle ear infections
  - Usually result when infections of the nose and throat move through the auditory tubes
  - More common in children because their auditory tubes are horizontal, allowing easier access to bacteria

Balance and the Vestibular Apparatus of the

Inner Ear

- Vestibular apparatus
  - A fluid-filled maze of chambers and canals within the inner ear
  - Consists of
    - Semicircular canals
      - Help with balance when we are moving
    - Vestibule
      - Helps with balance when we are not moving

Balance and the Vestibular Apparatus of the Inner Ear

- Semicircular canals
  - Three canals in each ear
  - Responsible for dynamic equilibrium
  - Ampulla at base of each canal
    - Each contains a tuft of hair cells embedded in gelatinous material, called the cupula
  - Movement of the head causes fluid within the canals to move, which pushes the cupula and stimulates the hair cells
    - Hair cells send messages to the brain

Balance and the Vestibular Apparatus of the Inner Ear

- Vestibule
  - Consists of two fluid-filled cavities
    - Utricle—senses forward tilting of the head
    - Saccule—senses vertical movement of the head
  - Responsible for static equilibrium
  - Both cavities contain hair cells overlain by gelatinous material with embedded otoliths
  - Movement of the head causes the gelatin to move, which stimulates the hair cells
    - Hair cells send messages to the brain

Smell and Taste

- Olfactory receptors
  - Sensory neurons with long hairs covered by mucus located in the roof of each nasal cavity
  - One of the few types of neuron known to be replaced during life
- Odor molecules
  - Dissolve in the mucus and bind to the olfactory receptor cells, stimulating them
    - If a threshold is reached, then the message is carried to olfactory bulbs in the brain
  - The olfactory bulbs process the information and pass it to the limbic system and cerebral cortex

Smell and Taste

- Taste buds
  - Located on the tongue and inner surfaces of the mouth
  - Composed of taste cells and supporting cells
  - Cells replaced every 10 days
  - Taste buds sense five basic tastes
    - Sweet
    - Salty
    - Sour

        - Bitter
        - Umami

Smell and Taste

- Taste cells
    - Have taste hairs that project into a pore at the tip of the taste bud
        - Taste hairs have receptors for chemicals found in food
        - When food molecules are dissolved in saliva, they enter the pore and stimulate the taste hairs
    - Although they are not neurons, taste cells generate electrical signals that are sent to sensory neurons wrapped around them

You Should Now Be Able To:

- Describe the sensory receptors and know the five classes of receptors
- Understand how the general senses function
- Know the structure and function of the eye
- Understand vision and its disorders
- Describe the form and function of the ear
- Understand the mechanisms involved in hearing and its disorders
- Describe balance and the vestibular apparatus of the inner ear
- Describe smell and taste's structure and function

*****Know the diagrams of the eye, ear, and tongue – from your textbook or lab book.**