The Senses

- Provide us with information about our surroundings
- Sensory pathway—4 parts
  - Receptors—detect stimuli and generate impulses
    - Specific types for each type of stimuli—pressure, temperature, pain, light
  - Sensory neurons
  - Sensory tracts—functionally related bundles of fibers in the white matter of the spinal cord or brain
  - Sensory area—usually in the cerebral cortex
    - Interpret sensory input
- Characteristics of sensations
  - Projection—perception of sensation in any given area
    - Actually “felt” in the cerebral cortex
    - Phantom pain—perception of pain in an area that doesn’t exist
  - Intensity—number of receptors stimulated and the amount of stimulation in each
  - Contrast—effect of a previous or simultaneous sensation on a current sensation
    - Cold pool on a hot day will feel colder than it actually is
  - Adaptation—becoming less aware of continuing stimulation
    - Receptors generate fewer impulses with continued stimulation
    - “getting used to” hot shower, cool pool, hot tub, wristwatch
  - After-image—sensation remains in the consciousness after the stimulus has stopped
    - Light remains after looking at a bright light
- Cutaneous senses—skin
  - Touch, pressure, heat, cold, pain
  - Free nerve endings—heat, cold, pain
  - Encapsulated nerve endings (cellular structure around nerve)—touch, pressure
  - Sensory area for the skin is in the parietal area
  - Sensitivity is determined by the number of receptors present
  - Referred pain—pain from a visceral organ felt in a cutaneous area
    - Gallbladder—R scapula
    - Heart—left arm and shoulder
    - Neuronal pools
- Muscle sense (aka kinesthetic sense)(discussed in Ch 7)
  - Stretch receptors (aka proprioceptors or muscle spindles)—detect stretching of muscles and relay information to the brain about location and position of muscles
  - Conscious muscle sense—parietal lobes
  - Unconscious muscle sense—cerebellum
Taste
- Receptors = taste buds
  - Chemoreceptors—detect chemicals in food dissolved in saliva
  - In papillae on the tongue
  - 4 types—sweet, bitter, salty, sour (Fig 9-2)
    - May be a 5th—glutamate, described as savory (e.g., grilled meat)
- Enhanced by smell
- Impulses transmitted by the facial (7) and glossopharyngeal (9) nerves to the taste areas in the parietal-temporal cortex

Smell (olfaction)
- Olfactory receptors are chemoreceptors—detect vaporized chemicals in the upper nasal cavity
  - Carried by olfactory n. (CN 1) through ethmoid bone to olfactory bulbs (Fig 9-2) then to the olfactory areas in the temporal lobes
- Poorly developed in humans—dogs 200 more times acute
- Helps us taste our food
- Adaptation occurs quickly

Hunger and thirst
- Visceral sensations triggered by internal changes
- Apparently a function of the hypothalamus
  - For hunger it detects blood nutrient levels, hormones from the small intestine, stomach, and adipose tissue
  - For thirst it detects water concentration
- Sensations are projected
  - Hunger → stomach
  - Thirst → mouth and pharynx
- Hunger sensations decrease if we don't eat because adipose tissue begins to be used for nutrition
- Thirst will continue to worsen if not satisfied—prolonged thirst can be painful

The eye
- Eyelids and the lacrimal apparatus—accessory structures
  - Eyelids—controlled by skeletal m.
    - Protection, lubrication, cleaning
    - Eyelashes prevent dust
    - Conjunctiva—thin membrane that lines the eyelid and covers sclera (white part)
      - Conjunctivitis—pink eye
- Lacrimal glands—produce tears (Fig 9-3)
  - Superior and lateral to the eye within the orbit (cavity)
  - Lacrimal ducts releases tears and blinking spreads them
  - Tears
    - 1% NaCl
    - Contains lysozyme
  - Exiting—2 small openings (puncta lacrimalia) in the medial corner of the eye → lacrimal canals (superior and inferior) → lacrimal sac (in the lacrimal bone) → nasolacrimal duct → nasal cavity (crying makes nose run)

- Eyeball
  - Within the orbit formed by lacrimal, maxillary, zygomatic, frontal, sphenoid, and ethmoid bones (Fig 6-5,6)
  - 6 extrinsic muscles (Fig 9-4) move the eye
    - Medial rectus—rotates eye medially
    - Lateral rectus—rotates eye laterally
    - Inferior rectus—rotates eye inferiorly
    - Superior rectus—rotates eye superiorly
    - Superior oblique—rotates eye down and out
    - Inferior oblique—rotates eye up and out
  - Innervated by oculomotor (CN 3), trochlear (CN 4), and abducens (CN 6)

- Cavities of the eyeball
  - 2 chambers—posterior and anterior
    - Posterior chamber (aka vitreous chamber)—between lens and retina
      - Large
      - Contains vitreous humor (body)—semisolid substance
        - Keeps retina in place
        - Leaking can cause detached retina (from the choroid)
    - Anterior chamber—between lens and cornea
      - Anterior cavity—between iris and cornea
      - Posterior cavity—between iris and lens
      - Contains aqueous humor—formed from capillaries in the ciliary body
        - Reabsorbed by the canal of Schlemm (aka scleral venous sinus) anterior to the iris
        - Nourishes the lens and cornea (because they do not have capillaries)

- Layers of the eye (Fig 9-5)
  - Wall
    - Outer (fibrous tunic) — sclera, cornea
    - Middle (vascular tunic) — choroid, iris, ciliary body
    - Inner (nervous tunic) — retina
- Sclera (white part)—thickest, fibrous connective tissue
  - Cornea—transparent portion
    - Has no capillaries
    - First part of the pathway of light as it is refracted (bent) into the eye
- Choroid layer (includes ciliary body and iris)
  - Blood vessels
  - Dark blue pigment made from melanin
    - Absorbs light in the eye to prevent glare (like the inside of a camera)
  - Ciliary body (muscle)—circular muscle that surrounds and is connected to the lens by suspensory ligaments
    - Changes the shape of the lens so we can focus
  - Iris—colored part of the eye
    - Anterior to the lens
    - Color from melanin (less melanin appears as blue)
    - Circular and radial muscle fibers
    - Pupil—opening in the iris
      - Dilation—contraction of the radial fibers (sympathetic)
        - Lets more light in, in darkness
      - Constriction—contraction of the circular fibers (parasympathetic)
        - Blocks light when bright
      - Oculomotor nerve (CN 3)
  - Retina—posterior 2/3 of the eye
    - Contains visual receptors—rods and cones (Fig 9-6)
      - Rods—detect all wavelengths of visible light
        - Most abundant toward the periphery of the retina
      - Cones—detect colors—different wavelengths of visible light
        - Most abundant in the center of the retina mainly in the macula lutea directly behind the lens
          - Macular degeneration
          - Fovea—small depression in the macula that contains only cones and is the area for best color vision
    - Optic disc—opening where the optic n. exits the eye
      - Blind spot
- Physiology of vision—light is focused on the retina, receptors generate impulses, visual areas of the brain interpret
  - Refraction—bending of light rays as they pass through the eye (cornea, aqueous humor, lens, vitreous body)
    - Lens—adjustable part of the refractory system
      - Focuses the image onto the retina (see handout)
      - At rest suspensory ligament pull lens tight (flattening the lens)
- When focusing (accommodation) on near objects the ciliary m. contracts (makes a smaller circle) bringing the ciliary process closer to the lens thus allowing the lens to become more convex
  - Becomes less elastic with age—presbyopia

- When light hits the retina
  - Rods—chemical rhodopsin breaks down into scotopsin (a protein) and retinal (derivative of vitamin A)—causes an nerve impulse
    - Any wavelength
    - Rhodopsin is then resynthesized
  - Cones—similar reaction that breaks down into retinal and a different protein
    - Requires specific wavelengths
      - Red, green, and blue absorbing cones (not yellow)

- Pathway (Fig 9-6)
  - Rods & cones → bipolar neurons → ganglion neurons → optic disc → optic nerve (CN 2) → optic chiasm → occipital lobes

- Binocular vision—2 eyes
  - Allows for depth perception
  - Requires eyes to converge to eliminate double vision

- Vision problems (not on test)
  - Errors of refraction (see handout and Box 9-3)
    - Emmatropia—normal vision (20/20)
      - Image is focused on the retina
    - Myopia—nearsightedness (cannot see far)
      - Image is focused anterior to the retina
    - Hyperopia—farsightedness (cannot see near)
      - Image is focused posterior to the retina
      - Presbyopia—hyperopia due to loss of lens elasticity
  - Cataracts—cloudiness of the lens caused from breakdown of proteins
  - Glaucoma—damage to the optic nerve due to increased intraocular pressure
    - Tested for by putting pressure on the cornea with a probe or puff of air
- Color blindness—loss of function in one type of cone
  - Red-green—loss of function in red or green cones
    - Inability to distinguish red and green cones
    - X-linked recessive genetic mutation
- Night blindness—inability to see well in dim light
  - Vitamin A deficiency—decreased rhodopsin

- The ear
  - 3 areas—outer ear, middle ear, inner ear (Fig 9-7)
  - Contains receptors for hearing and equilibrium found in the inner ear
  - Outer ear—auricle and ear canal
    - Auricle (aka pinna)—cartilage covered with skin
      - Serves little function in humans according to the book
    - Ear canal (aka external auditory meatus)
      - Lined with ceruminous & sebaceous glands
  - Middle ear—air filled cavity that contains the ossicles and is drained by the eustachian tubes
    - Eardrum (aka tympanic membrane)—separates the middle ear from the outer ear
      - Vibrates with sound waves and transfers energy to ossicles
    - Ossicles—malleus, incus, stapes
      - Transfer and amplifies sound to the oval window of the inner ear
    - Eustachian tubes (aka auditory tubes)—extend from the middle ear to the nasopharynx
      - Permits air to enter or leave
      - Can plug and cause pressure in ear when changing elevation
  - Otitis media—middle ear infection
    - In children the eustachian tube is more horizontal and does not drain well which leads to bacterial growth
    - Can be a complication of strep throat
• Inner ear—cavity called the bony labyrinth in the temporal bone (Fig 9-8)
  ▪ Contains the cochlea for hearing and the vestibule (utricle, saccule, and semicircular canals) for equilibrium
  ▪ Lined with a membrane called the membranous labyrinth
  ▪ Perilymph—fluid between bone and membranous labyrinth
  ▪ Endolymph—fluid within the membranous labyrinth
  ▪ Cochlea—snail shell-shaped structure for hearing
    ▪ Partitioned into 3 fluid-filled canals—scala tympani, scala vestibuli, cochlear duct (Fig 9-9 & Fig 9-8 right side)
  • Cochlear duct
    ▪ Contains the organ of Corti (aka spiral organ)
      ▪ Receptors called hair cells that have specialized microvilli projections called stereocilia (not actually hair)
        ▪ Transmit to the cochlear branch of the acoustic n. (CN 8)
  ▪ Tectorial membrane—overhangs the hair cells
    ▪ May contribute to hearing
  • Hearing—vibrations caused by sound waves → ear canal → tympanic membrane → malleus → incus → stapes → oval window → perilymph & endolymph in the cochlea → hair cells in the organ of Corti → CN 8 → temporal lobes
  • Round window—membrane covered window just below the oval window
    ▪ Bulges out to relieve pressure when the oval window is depressed so that pressure is not increased to the point that damage would occur to the receptor cells
Vestibule (aka vestibular apparatus)—contains the utricle, saccule, and semicircular canals (book says just utricle and saccule)

- Impulses carried by vestibular portion of acoustic n. (CN 8) to the cerebellum, midbrain, and temporal lobes
- Equilibrium—cerebellum and midbrain (subconscious)
- Conscious awareness—temporal lobes
- Utricle and saccule—membranous sacs in the vestibule (Fig 9-10A)
  - Static equilibrium—equilibrium at rest
  - Hair cells detect movement of otoliths (CaCO₃ crystals) when position of head is changed
- Semicircular canals (Fig 9-10B)—3 fluid filled membranous ovals oriented in different planes
  - Dynamic equilibrium—equilibrium while moving
    - Starting, stopping, accelerating, decelerating, change in direction
  - Ampulla—base of each semicircular canal
    - Hair cells detect movement of endolymph in the canal by bending

Deafness (Box 9-5) (not on test)

- Conduction deafness—impairment of one of the structures that transmit vibrations
  - Punctured eardrum, arthritis of ossicles, otitis media
- Nerve deafness—impairment of acoustic n. or receptors in the cochlea
  - Commonly from aging and exposure to noise
  - Rarely can be from antibiotics, mumps, or congenital rubella
- Central deafness—damage to the auditory areas in the temporal lobes
  - Rare
  - Tumors, CVAs, meningitis

Arterial receptors—detect changes in blood

- Located in the aorta, and carotid arteries
- Pressoreceptors—detect blood pressure
- Chemoreceptors—detect O₂, CO₂, and pH
  - In the carotid bodies (sinuses) and aortic bodies
- Subconscious
- Used to make necessary changes in respiration (yawning) or circulation (heart rate, vasoconstriction, or vasodilation)
- Sensory impulses carried by the glossopharyngeal (CN 9) and vagus n. (CN 10) to the cardiac centers in the medulla