General (Somatic) and Special Senses

I. Receptors and Sensations

A. Sensory Receptors
1. Detect change, trigger nerve impulses.
2. Five general types
   a) Chemoreceptors
   b) Pain receptors
   c) Thermoreceptors
   d) Mechanoreceptors
   e) Photoreceptors

B. Sensations
1. Feelings that occur when the brain interprets sensory impulses.
2. Projection
   a) Cerebral cortex sends the sensation back to its point of origin
   b) Person can pinpoint the area of stimulation.
3. Sensory Adaptation
   a) Impulses are sent at decreasing rates
   b) Finally receptors fail to send impulses.

II. Sense of Sight

A. Visual Accessory Organs
1. Eyelid
   a) Protects the eye
   b) The thinnest skin of the body.
   c) Lined with conjunctiva (folds back to cover eyeball).
2. Lacrimal Apparatus
   a) Produces tears that lubricate and cleanse the eye.
   b) Inferior and superior canaliculi drain tears into the nasal cavity (by nasolacrimal duct).
   c) Tears also contain an antibacterial enzyme.
3. Extrinsic muscles of the eye attach to the sclera and move the eye.

II. Sense of Sight

B. Structure of the Eye (three distinct layers, or tunics)
1. The Outer Tunic (fibrous tunic)
   a) Cornea
      1) Transparent due to few cells and no blood vessels.
      2) Helps focus light rays.
   b) Sclera (white of eye)
      1) Continuous with cornea.
      2) Protects eye and is attachment for muscles.
      3) The optic nerve and blood vessels pierce the sclera at the posterior of the eye.
2. The Middle Tunic (vascular tunic)
   a) Choroid coat
      1) Loosely joined to the sclera.
      2) Highly vascular to nourish other tissues of the eye.
      3) Darkly pigmented to keep the inside of the eye dark.
   b) Ciliary body
      1) Forms a ring around the front of the eye.
      2) Composed of folds called ciliary processes and ciliary muscles.
II. Sense of Sight

c) Suspensory ligaments hold the lens in position and change its shape (focus).

d) Lens
1) Composed of epithelial cells called lens fibers.
2) The ability of the lens to adjust shape to facilitate focusing is called accommodation.

e) Iris
1) Colored portion of eye.
2) Adjusts the amount of light entering the pupil.
3) Has a circular set and a radial set of smooth muscle fibers.

II. Sense of Sight

f) Anterior cavity (two chambers)
1) Anterior chamber (between the cornea and iris)
2) Posterior chamber (between the iris and suspensory ligaments)
a. Filled with aqueous humor (from ciliary body).
b. Aqueous humor circulates from one chamber to the other through the pupil.
c. Too much aqueous humor causes glaucoma.

III. Sense of Sight

3. The Inner Tunic (Retina)
a) Covers the back side of the eye
b) Surrounds the posterior cavity
c) Filled with vitreous humor.
d) Composed of pigmented epithelium, visual receptor cells, and a layer of neurons

e) Macula lutea
1) Center of retina
2) Depressation in middle is fovea centralis (the point of sharpest vision)

f) Optic disk
1) Medial to the fovea centralis
2) Your blind spot
3) Where nerve fibers leave the eye.

II. Sense of Sight

C. Light Refraction
1. Light waves must bend to be focused.
2. The cornea and lens bend light waves to focus them on the retina.
a) Myopia: nearsighted
b) Hyperopia: farsighted

D. Visual Receptors
1. Rods (elongated)
a) Function in dim light
b) Produce colorless vision.

2. Cones (blunt-shaped)
a) Provide sharp images in bright light
b) Enable us to see in color.
c) Highest concentration on the fovea centralis
II. Sense of Sight

E. Visual Pigments
1. Rhodopsin (in rods and cones)
   a) Breaks down into a protein (opsin) and retinal (from vitamin A) in the presence of light.
   b) Decomposition activates a nerve impulse.
   c) Night blindness is caused by vitamin A deficiency.

2. Isodopsins (in cones)
   a) Three types of cones.
   b) Each sensitive to different wavelengths of light (red, green, blue)
   c) All three sets stimulated, the color is white
   d) None are stimulated, the color is black.

F. Visual Nerve Pathways
1. The axons of ganglion cells leave the eyes to form the optic nerves.
2. Fibers from the medial(nasal) 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.

III. Sense of Hearing

A. The ear provides the senses of hearing and equilibrium.
B. Human Range: 20-2000 Hz
C. External Ear
1. Auricle (pinna): collects sound waves
2. External auditory meatus (canal).

D. Middle Ear
1. Begins with the tympanic membrane (eardrum)
2. Air-filled space (tympanic cavity) housing the 3 auditory ossicles.
3. Ossicles are the malleus, incus, and stapes.
4. Tympanic membrane vibrates the malleus, which vibrates the incus, then the stapes.

5. The stapes vibrates the fluid inside the oval window of the inner ear.
6. Auditory ossicles both transmit and amplify sound waves.
7. Auditory Tube (eustachian tube)
   a) Connects the middle ear to the throat.
   b) Helps maintain equal air pressure on both sides of the eardrum.
III. Sense of Hearing

E. Inner Ear
1. An osseous labyrinth (canal) in the bone of the temporal bone.
2. A membranous labyrinth is inside the osseous labyrinth.
3. Between the two labyrinths is perilymph (fluid).
4. Endolymph is inside the membranous labyrinth.

III. Sense of Hearing

5. The cochlea houses the organ of hearing.
6. The semicircular canals function in equilibrium.
7. The oval window leads to the upper compartment, called the scala vestibuli.
8. The lower compartment is the scala tympani.
9. The cochlear duct lies between these two compartments.
10. Duct is separated from the scala vestibuli by the vestibular membrane, and from the scala tympani by the basilar membrane.

III. Sense of Hearing

11. The Organ of Corti
   a) Houses receptors called hair cells.
   b) Lies on the basilar membrane.
12. Hairs of cells extend into the endolymph of the cochlear duct.
13. Above the hair cells lies the tectorial membrane.
14. Sound waves make hairs rub against tectorial membrane stimulating receptor cells.

III. Sense of Hearing

F. Auditory Nerve Pathways
1. Epithelial receptor cells depolarize, allowing calcium to flood in.
2. Calcium forces vesicles to release neurotransmitters from cell base (no axons or dendrites).
3. Neurotransmitters stimulate sensory nerve fibers.
4. Nerve fibers carry impulses to the auditory cortices of the temporal lobes.

IV. Sense of Equilibrium

A. Consists of two parts: static and dynamic equilibrium.
B. Static Equilibrium
1. Determines the orientation of the head and body.
2. Organs are the utricle and saccule (expansions of the membranous labyrinth).
3. A macula, consisting of hair cells and supporting cells, lies inside the utricle and saccule.
4. The hair cells contact gelatinous material holding otoliths (calcium carbonate stones).
5. Gravity causes the otoliths and gelatinous material to shift, bending hair cells and generating a nervous impulse.
6. Brain interprets as the position of the head.
IV. Sense of Equilibrium

C. Dynamic Equilibrium
   1. Maintains balance when the head and body suddenly move and rotate.
   2. Three semicircular canals detect rotational motion of the head.
   3. Ampulla are located in each semicircular canal.
   4. The organs of dynamic equilibrium are called cristae ampullaris and are located in the ampulla.

5. Hair cells extend into a dome-shaped gelatinous cupula.
6. Rapid turning of the head or body generates impulses as the cupula bends hair cells.

V. Sense of Smell

A. Olfactory Receptors
   1. Olfactory receptors are chemoreceptors.
   2. The senses of smell and taste operate together.
B. Olfactory Organs
   1. Yellowish-brown masses in the upper nasal cavity.
   2. Contain the olfactory receptors plus epithelial supporting cells.
   3. Chemicals are first dissolved in the watery fluid of the nasal cavity.
   4. Olfactory receptors are stimulated by chemicals.
   5. Neurons carry the signal to the olfactory lobes.
C. Olfactory Stimulation
   1. 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.
   4. Anosmia is partial or complete loss of smell.

VI. Sense of Taste

A. Taste buds
   1. Located within papillae of the tongue.
   2. Organs of taste.
   3. Scattered throughout the mouth and pharynx.
VI. Sense of Taste

B. Taste Receptors
   1. **Taste cells** are modified epithelial cells that function as receptors.
   2. Taste cells contain the **taste hairs** that are the portions sensitive to taste.
   3. Chemicals must be dissolved in water (saliva) in order to be tasted.
   4. Taste involves specific membrane protein receptors that bind with specific chemicals in food.
   5. Taste receptors rapidly undergo adaptation.

VI. Sense of Taste

C. There are four types of taste cells.
   1. Sweet receptors are plentiful near the tip of the tongue.
   2. Sour receptors occur along the lateral edges of the tongue.
   3. Salt receptors are abundant in the tip and upper portion of the tongue.
   4. Bitter receptors are at the back of the tongue.

VII. General (Somatic) Senses

A. Receptors associated with the skin, muscles, joints, and viscera
B. Types
   1. Touch
   2. Pressure
   3. Temperature
   4. Pain

VIII. Touch and Pressure Senses

A. Sensory Nerve Fibers
   1. In the epithelial tissues
   2. Detect changes in pressure and touch
B. Meissner's Corpuscles
   1. Flattened connective tissue sheaths.
   2. Abundant in hairless areas
   3. Sensitive to light touch
C. Pacinian Corpuscles
   1. Large structures of connective tissue and cells
   2. Detect deep pressure

VIII. Touch and Pressure Senses

D. Proprioceptors
   1. Monitor body joint positions
   2. In tendons and muscle

E. Baroreceptors - respond to blood pressure changes

IX. Temperature Senses

A. Heat Receptors and Cold Receptors (free nerve endings)
   B. Both adapt quickly.
   C. Temperatures near 45°C stimulate pain receptors
   D. Temperatures below 10°C also stimulate pain receptors
X. Sense of Pain

A. Pain receptors
1. Free nerve endings that are stimulated when tissues are damaged
2. Adapt little, if at all.
3. None in nervous tissue of brain.
4. Visceral pain receptors are the only receptors in the viscera that produce sensations.

B. Referred Pain
1. Feels like it comes from elsewhere.
2. Due to common nerve pathways.

C. Pain Nerve Fibers
1. Conduct pain impulses away from their source.
2. Acute pain fibers
   1. Thin, myelinated fibers.
   2. Carry impulses rapidly and cease when the stimulus stops.
3. Chronic pain fibers
   1. Thin, unmyelinated fibers.
   2. Conduct impulses slowly and continue sending impulses after the stimulus stops.

D. Regulation of Pain Impulses
1. Aware of pain when impulses reach the thalamus.
2. Cerebral cortex mediates a response.
3. Brain can release presynaptic biochemicals which inhibit the pain impulses in the spinal cord.
   a) Endorphins- In the pituitary and hypothalamus and provide natural pain control.
   b) Serotonin- Stimulates other neurons to release enkalphins.
   c) Enkalphins- Suppress acute and chronic pain (same receptors as morphine).