Vision, Hearing, & Other Senses

- **Transduction** – the transforming of stimulus energies into neural impulses

I. Vision

A. The Stimulus Input: *Light Energy*

1. **wavelength** – distance from one peak to the next; determines **hue** – the color we experience

2. **intensity** – the amount of energy in a light or sound wave which we perceive as brightness or loudness, as determined by the wave's *amplitude*.

B. The Eye

1. **pupil** – the adjustable opening in the center of the eye through which light enters

2. **iris** – ring of muscle tissue, forms colored portion of eye, controls size of pupil opening

3. **lens** – transparent structure behind the pupil that changes shape to focus image on retina
   a. **accommodation** – process by which the eye's lens changes shape to focus near/far objects on the retina

4. **retina** – light-sensitive inner-surface of the eye, containing receptor *rods* and *cones* plus layers of neurons that begin the processing of visual information
   a. receives images upside-down; impulses constructed into upright-seeming image in brain
   b. **rods** – retinal receptors that detect *black, white, & grey*; necessary for peripheral and twilight vision, when cones don't respond
   c. **cones** – retinal receptors that detect *fine detail* and give rise to *color sensations*, concentrated near the center of the retina and that function in daylight or well-lit conditions
   d. **optic nerve** – bundles axons that carry neural impulses from the eye to the brain; capable of sending a million messages at once
   e. **fovea** – the central focal point in the retina, around which the cones cluster

5. **acuity** – sharpness of vision; affected by small distortions in shape of eye
   a. **nearsightedness** – nearby objects seen more clearly than distant objects because distant objects focus *in front* of retina
      - several studies have suggested that children who sleep with a night light have an increased chance of becoming nearsighted (Quinn, 1999).
   b. **farsightedness** – faraway objects are seen more clearly than near objects because near objects focus *behind* the retina

C. Visual Information Processing

1. **Feature Detectors** – nerve cells in the brain that respond to specific features of a stimulus, such as edges, shape, angle, or movement.

2. **Parallel Processing** – the processing of several aspects of a problem *simultaneously*; the brain's natural mode of information processing for many functions, including vision
   - contrasts with serial (*step-by-step*) processing of most computers and of conscious problem solving
   - retina sends neural impulses to several areas of visual cortex, which is then integrated by the brain
   - example: facial recognition requires 30 percent of the cortex, <u>10 times</u> the area the brain devotes to hearing

D. Color Vision

- the objects we see are everything *but* the color we see, because they *reject* (reflect) that specific wavelength of light
- our difference threshold for colors is so low that we can discriminate some 7 million different color variations

1. **Young-Helmholtz Trichromatic (three-color) theory**
   - the retina contains three different color receptors – red, green, and blue – which when stimulated in combination can produce the perception of any color

2. **Hering's Opponent Process Theory**
   - opposing retinal processes (red-green, yellow-blue, white-black) enable color vision; some cells are stimulated by green and inhibited by red; others are stimulated by red and inhibited by green
   - explains *afterimages*

II. Hearing (**audition**)

A. The Stimulus Input: Sound Waves

1. **amplitude** – determines *loudness*
   - *decibels* are the measuring unit for sound energy
     - every 10 decibels correspond to a tenfold increase in sound (exponential increase)

2. **frequency** – the number of complete wavelengths that pass a point in a given time
   - determines **pitch** – a tone's highness or lowness

B. The Ear

1. **Outer Ear** – channels sound waves to *eardrum* which vibrates with the waves

2. **Middle Ear** – transmits eardrum's vibrations through a piston made of three very tiny bones (hammer, anvil, stirrup) to the cochlea's oval window

3. **Inner Ear** – contains the **cochlea** – a coiled, bony, fluid-filled tube through which sound waves trigger nerve impulses
   - **basilar membrane** is lined with *hair cells* which when bent trigger impulses in adjacent nerve fibers, which converge to form the auditory nerve
     - hair cells are delicate and fragile

C. How Do We Perceive Pitch?

1. **Place Theory** – links the pitch we hear with the place where the cochlea's membrane is stimulated
   - high frequencies produce large vibrations near the *beginning* of the cochlear membrane

2. **Frequency Theory** – the rate of nerve impulses traveling up the auditory nerve matches the frequency of a tone, thus enabling us to sense its pitch
   - explains how we sense low pitches as neurons cannot fire faster than 1000 times/second

3. **Volley Principle** – neural cells alternate firing in rapid succession, achieving a combined frequency *above* 1000 times/second
   - explains how we perceive pitches in the intermediate range

D. Hearing Loss

1. **Conduction Hearing Loss** – caused by damage to the mechanical system that conducts sound waves to the cochlea

2. **Sensorineural Hearing Loss** (*nerve deafness*) – caused by damage to the cochlea's receptor cells or to the auditory nerves

- once destroyed, these tissues *remain dead*

III. Body Position and Movement

A. **Kinesthetic Sense** – the system for sensing the position and movement of individual body parts

B. **Vestibular Sense** – the sense of body movement and position, including the sense of balance

- *semicircular canals* – receptors send messages to the cerebellum, enabling us to sense our body position and to maintain our balance