It is very important to take detailed notes, to augment this outline.

Sensation vs. Perception: what is the difference between these two?

- **Visual system**
    - A. Stimulus: electromagnetic radiation between 480 and 760 nanometers
    - Properties of the stimulus:
        - wavelength (distance between 1 peak & another) = color
            - ROYGBIV (red is longest wavelength & Violet is shortest wavelength)
        - amplitude (height of the wave) = brightness (brightness can change how something appears; if you had two of the same wavelengths, but one is of a higher amplitude than the other, you will perceive two different things; both would be red, but one would be bright and the other would appear dark)
        - purity (complexity of the waveform) = saturation (how vivid something looks to us)
    - B. Anatomy & physiology of the eye
    - Order in which light passes through the eye:
        - cornea
        - pupil/iris
        - lens
        - vitreous humor
        - retina (layer of neural cells)
            - ganglion cells
            - bipolar cells
            - photoreceptors (i.e., rods & cones)
            - notice how light has to pass through several layers of retinal cells before it reaches the rods & cones, where transduction occurs
    - C. Transduction
        - the process by which a stimulus (e.g., visible light) is represented neurally (that is, by neuronal activity)
    - D. Photoreceptors
        - two types: rods & cones
        - characteristics:

Rods	Cones
Scotopic Perceives general form (not	Photopic Greater visual acuity

detail)	
More numerous than cones	Less numerous than rods
More in the periphery of the retina	More in center of retina and there are only cones in the fovea
More thoroughly adapts to the dark	Quickly adapts to the dark, but is limited in how much it adapts

E. Receptive field: this is the portion of the visual field which a neuron "monitors." If it detects a visual stimulus within it's receptive field, it will respond.

F. Visual pathway

- After light is transduced by the cones/rods (photoreceptors), visual information is processed in the following order:
  - bipolar cells
  - ganglion cells
  - optic disk (which the ganglion axons pass through)
    - no photoreceptors here
    - unaware due to
      - brain's tendency to "complete" visual images
      - eyes are not located in same place; thus, blind spots are not located in same place; views of eyes greatly overlap
  - where it goes after the optic disk depends on what part of the retina (close to nose or more peripheral) the visual information is coming into
    - information received by the halves of the retina closer to the nose
      - crosses to the other side of the brain to form the optic chiasm (contralateral connection)
      - dorsal lateral geniculate nucleus of the thalamus
      - primary visual cortex (in occipital lobe) aka V1 aka striate cortex
    - information received by the halves of the retina farthest from the nose
      - stays on the same side of the brain (ipsilateral connection)
      - dorsal lateral geniculate nucleus of the thalamus
      - primary visual cortex (in occipital lobe) aka V1 aka striate cortex
  - Further description of the cells in the primary visual cortex (feature detectors)
    - simple cells

- detects orientation of line and location of the line within its receptive field (or the portion of the visual field that this particular V1 simple neuron is "looking" at)
    - complex cells
        - detects orientation of line, movement of the line
    - hypercomplex cells aka end-stop cells
        - detects orientation of line, length of the line
- Visual information then goes to the…
    - (some) WHAT pathway (lower part of temporal lobe)
        - analyzes what the object is
    - (some) WHERE pathway (parietal lobe)
        - analyzes where the object is, in relation to the body—so that the person can manipulate the object

G. Theories of Color Vision

- Subtractive color mixing vs. additive color mixing
- Trichromatic theory (proposed by Young, refined by Helmholtz)
    - 3 different types of cones, attuned to different wavelengths (e.g., short wavelength (blue), medium wavelength (green), long wavelength (red))
    - remember that there is a bell curve, e.g., the short-wavelength (blue) may respond most at 450 nanometers but will also respond (though more weakly) at e.g., 430 nanometers, (though even more weakly) 420 nanometers, etc.
    - later, research was able to support this theory
    - if there are abnormalities = color blindness
        - most are sex-linked (more males have it than females), but not when one is blind to blue (very rare; equal ratio of males to females)
    - Weaknesses? Doesn't explain why there…
        - is not bluish-yellow or reddish-green
        - are complementary afterimages
- Opponent Process theory (proposed by Hering)
    - neurons can give different messages, depending on their rate of firing
    - there appears to be neurons which signal "blue" or "yellow" (e.g., a neuron may ↑ activity (e.g., firing action potential) if it detects blue and may ↓ activity (e.g., firing action potential) when it detects yellow
    - this theory explains why there is no bluish-yellow or reddish-green – know WHY
    - this theory also explains complementary afterimages
        - neurons have a basal rate of firing (homeostasis)
        - when neurons are activated in some way, they become fatigued

- when they become fatigued, they will have a "rebound effect" when they are no longer being stimulated (rebound effect: where an opposite action occurs)
- SO, for example, say a neuron is a red-green neuron where it signals to the brain that it detects green by ↓ its level of activity and it signals to the brain that it detects red by ↑ its level of activity
- if you then show this type of neuron a green flower (so green petals) with a red stem, the neurons detecting the green flower will ↓ their level of activity and the neurons which detect the red stem will↑ their level of activity
- if the flower is then taken away, the recently-activated neurons will have a rebound effect—thus, the neurons which had been seeing the green flower will ↑ their level of activity (now that there is no green flower) and the neurons which had been seeing the red stem will ↓ their level of activity.
- the brain will interpret this as that there is a red flower and a green stem, an ↑ in activity means red and a ↓ in activity means green (in this example)
- the spiral effect is also an example of this rebound effect
- and when you stare at a waterfall for awhile, and then look away, you should also have a rebound effect where things seem to be moving upwards

- Which color theory is the valid one?
    - Both: trichromatic theory at the level of the photoreceptors and the opponent process theory at all other levels of visual information processing (e.g., bipolar cells onward)
- Ambient light/overall illumination will influence your color perception (e.g. "the dress")

H. Perceiving form (how we actually "see" or recognize a visual object)

- Bottom-up processing (aka feature detection) via feature detects
    - e.g., basic visual information (e.g., spots of light detected by the photoreceptors) are compiled so that the visual cortical cells are now analyzing lines and then these lines are compiled so that the visual association areas (such as the What and Where pathways) are analyzing more complex visual information.
- vs. Top-down processing: where information is taken as a "whole"
    - perceptual readiness (we are hard-wired to see visual stimuli in certain ways)
        - Gestalt principles:
            - figure & ground

        - proximity (e.g., items close to each other are perceived as being together)
        - closure
        - similarity (e.g., we tend to view similar elements as being together)
        - simplicity
        - continuity
        - forming *perceptual hypothesis*
        - e.g. phi phenomenon
    - sometimes, top-down and bottom-up processing interfere with each other (demo: Stroop effect)

I. Depth perception

- Monocular cues
    - Due to accommodation (of your one eye) or due to pictorial cues
        - Cultural and motivational influences
    - e.g., height in plane (objects lower on the plane look closer to us)
    - linear perspective
    - texture gradient
    - interposition
    - light and shadow
- Binocular cues
    - retinal disparity
    - difference of view between the two eyes

J. Perceptual constancies

K. Illusions

- Experience influences

- **Auditory system**

A. Stimulus

- sound: compression & decompression of molecules (e.g., air molecules, fluid molecules, etc.)
- Properties (how sensation leads to perception)
    - wavelength = pitch
        - lower frequency = lower pitch and vice-versa
    - amplitude = one of the factors involved with loudness
        - greater amplitude = louder sound and vice-versa
    - purity = timbre (quality of the sound)

B. Anatomy of the ear

- Order in which sound passes through ear parts:

- outer ear (ear canal aka pinna; movement of air molecules) >
- middle ear (ear drum aka tympanic membrane > ossicles (hammer, anvil, stirrup); movement of tiny bones) >
- inner ear (oval window of the cochlea; movement of fluid)

- Cochlea
  - 3 canals – in the middle canal is the basilar membrane (which has auditory hair cells embedded in it)
  - fluid inside the cochlea
  - when vibration moves fluid, the basilar membrane also moves
  - this makes the auditory hair cells fire action potentials
  - transduction occurs here—auditory hair cells

C. Theories of pitch

- Place theory
  - different waveforms stimulate different areas of the basilar membrane in particular
  - higher frequencies tend to stimulate the basilar membrane areas which are closest to the oval window
  - lower frequencies tend to stimulate the basilar membrane areas which are farther away from the oval window
  - depending on what area of the basilar membrane is stimulated more, the brain perceives a particular pitch
  - best for higher pitches
  - the hair cells on the basilar membrane are not completely independent; they vibrate together
- Frequency theory
  - basilar membrane mimics the sound waveform
  - neurons at the end of the basilar membrane fire in synchrony with the waveform (e.g., at each peak of the wave, for example)
  - how frequently these neurons fire tells the brain the frequency of the waveform
  - best for lower pitches

D. Localizations

- loudness
  - distance traveled
  - sound shadow (high frequency)
- arrival of sound (low frequency)

- ***Vestibular system*** *(sense of balance)*

  A. Stimulus: gravitational pull

B. Anatomy of vestibular system

- *located in the inner ear (near the cochlea)*
- *semicircular canals*
- *vestibular sacs*
- *fluid & hair in the canals and sacs*
    - *movement causes fluid to move, which then moves the hairs, which then creates neural signals (i.e. transduction)*

- **Gustatory system**

A. Stimulus

- molecules dissolved in fluid
  primary tastes:
    - sweet
    - sour
    - bitter
    - salty
    - umami
    - fat?? (or somatosensory sense?)
- different receptors for these different tastes
- taste vs. flavor

B. Anatomy of tongue

- papillae = bumps
- taste buds (many on sides of papillae)
    - perimeter of tongue
    - density of taste buds can differ between people: 25% non-tasters, 50% medium tasters, 25% super-tasters (greater sensitivity to some sweet and bitter substances)
- taste hairs = ~10 days life (transduction occurs here)
- pattern of firing = different taste

C. Primary cortex

- insular cortex (in frontal lobe)

- **Olfactory system**

A. Stimulus

- molecules in the air
- primaries have not been discovered/may not exist

B. Anatomy of nose

- air > mucous > olfactory dendrites (transduction occurs here)
- olfactory cilia = ~1 month life
- anosmia (complete loss of smell) is rare
- pattern of firing of the olfactory neurons = different smells

C. Primary cortex

- olfactory bulb (temporal lobe)

    - NOTE: this is the only sensory system which does not send its information to the thalamus before sending it to its primary cortex area

- **Sensory integration: sensory systems work together**
        - e.g., olfactory & gustatory systems work together to create different FLAVORS
            - e.g., when you have a stuffy nose (and therefore cannot smell well), do you taste the same flavors?

- **Somatosensory system**

  A. Stimulus: (several)
    - Mechanical
    - Thermal
    - Chemical

  B. Anatomical system involved: nerves embedded in the body
    - many nerves are "polymodal" in that they detect more than one type of stimuli and/or give us a mixed perception
    - mechanoreceptors
        - e.g., ruffini endings, merkel's discs, pacinian corpuscles, meissner's corpuscle, hair shaft sensory receptor
    - nociceptors
        - e.g., free nerve endings
    - thermoreceptors
    - proprioceptors
    - Many receptors for fingers, lips, tongue

  C. Neural pathway of the somatosensory system
    - somatosensory receptors > thalamus > somatosensory cortex (in parietal lobe)
    - somatosensory primary cortex has a map of the body!

  D. Pain
    - Stimulus
        - something noxious or damaging to tissues (exception: some forms of chronic pain)
    - Anatomy of pain system: nociceptors (aka pain receptors)
        - C fibers: slow pathway (e.g., dull, aching)
        - A-delta fibers: fast pathway (e.g., sharp pain of a knife cut)
        - Travel through different parts of thalamus
    - Why do we need pain?
    - Gate Control theory by Melzack and Wall (theory of how we modulate pain)
        - triggers: central nervous system vs. peripheral nervous system – know examples!
        - location of the pain gate: spinal cord? Thalamus?