# Sensory Physiology

- Visceral Receptors: detect stimuli in the body, transmit information to CNS by viseral afferents
- SomatoSensory System: necessary for perception of sensations on the skin (somesthetic) and position of the body (proprioception)

## Receptor physiology

- modality: energy form of a stimulus → a given sensory receptor is specific for a particular modality (law of specific nerve energies)
- Photoreceptors → vision (modality: photons of light); Chemoreceptors → taste, smell + pain (chemicals dissolved in saliva, mucus or in ECF); Thermoreceptors → warmth, cold (increase/decreases in temp); mechanoreceptors → vibration, sound, balance + equilibrium (pressure, sound waves, acceleration)
- Sensory transduction: receptors convert energy from the stimulus into membrane potentials
- Receptor adaptation: decrease over time in the magnitude of a receptor potential from a constant stimulus
- Rapidly adapting/phasic receptors adapt quickly

## Sensory Pathways

- labeled lines: specific neural pathways that transmit info for a particular modality
- sensory unit: single afferent neuron + its associated receptors
- First-order neuron: afferent neuron that transmits information from periphery to CNS → followed by interneurons/second-order neurons that form synapses w/ third-order neurons in the thalamus

## Sensory Coding

- stimulus type is coded by the receptor + pathway activated when stimulus is applied
- intensity is coded by the frequency of action potentials + # of receptors activated (both proportional)
- location is based on receptive fields
  - lateral inhibition increases acuity (precision of recieved stimulus) by increasing contrast of signals in NS → allows strong signals surpresses weaker ones

# Somatosensory System

- Transiet receptor potential (TPR) channels → open/close in response to thermal stimuli
- Nociceptors: transduction of noxious stimuli (pain) → respond to tissue-damaging stimuli

## Somatosensory Pathways

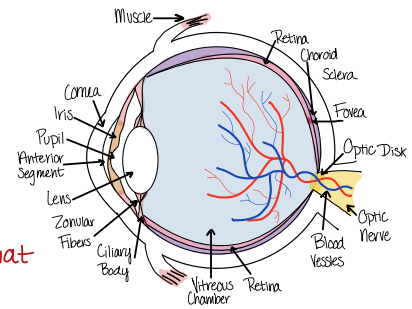
- dorsal column-medial lemniscal pathway: first-order neurons form synapses w/ 2nd order → cross to contralateral side of medulla + ascend to thalamus to form synapses w/ 3rd order neurons → transmit info from thalamus to somatosensory cortex
- Spinothalamic tract: transmits info from thermoreceptors + nociceptors

**Pain Perception:** activation of nociceptors can also lead to autonomic + emotional responses + reflexive withdrawls

- fast pain is transmitted by A-delta fibers (thin myelinated axons), slow pain → poorly localized, transmitted by C fibers (unmyelinated)
- reffered pain: activation of nociceptors in the viscera
- gate-control theory: somatic signals of nonpainful sources can inhibit signals of pain at the spinal level
- brain can block pain by producing analgesia (inhibitory neuron)

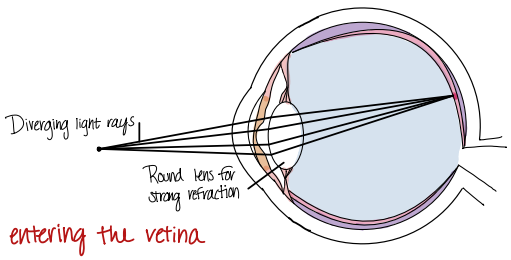
# Vision

## Anatomy




- sclera → white of the eye ; lens → focuses light to the fovea (back of the retina where visual info is transducted) ; retina → contains photoreceptors that detect light waves ; retinal pigmented epithelium → contains high concentration of melanin (back pigment) that absorbes the light that enters the eye so it doesnt reflect back ; fovea → area w/ greatest visual acuity ; optic disk → where optic nerve + blood vessles pass through retina (also a blind spot)

## Light waves




- visible light has wavelengths 350nm - 750nm
- reflection : we see the color that is reflected by the object
- refraction: both cornea + lens have convex surfaces that converge the light entering the retina
- Accommodation: ability of the lens to change its refractive power
  - viewing distant objects: ciliary muscle relaxes, diameter of the lens increases → tightens zonular fibers → flattens lens
    - to view close up objects, the opposite happens

## Defects in vision

- myopia: can see near but not distant objects → cornea/lens is too strong and bends light waves too much → corrected with a concave lens
- hyperopia: lens/cornea is too weak + can't see near objects → fixed w/ a convex lens
- astigmatism: irregularities on the surface of the cornea or lens cause erratic bending of light waves → corrected by glasses
- presbyopia: hardening of the lens + loss of elasticity → corrected w/ glasses to an extent (happens w/ age; irreversable)
- cataract: opacification of the lens → clouded vision → can be corrected by surgery of a fake lens replacement
- glucoma: increased volume of aqueous humor increases pressure in anterior cavity → distorts cornea/lens → no cure

**Regulating light**: dialation/constriction of pupils

↳ the iris consists of two smooth layers of muscle → circular (constrictor) and radial (dialator) → under control of the autonomic nervous system

**The Retina**

↳ composed of neural tissue: cones (color) and rods (black+white in dim light)

- macular degeneration: vision in the center of the visual field becomes impaired with age → dry degeneration happens for unknown reasons; wet degeneration is caused by new blood vessles bursting behind the retina

**Phototransduction**: conversion of light energy into electrical signals → by rods and cones

- photopigment: molecule that absorbs the light → light absorbing portion (retinal) + protein (opsin → determins what types of wavelengths are absorbed)
- photoreceptor in the dark: cGMP levels in cytosol is high → sodium channels open and $Na^+$ enters to cause depolarization → calcium channels open and Ca enters causing exocytosis of transmitters
- response in the light: light is absorbed by photo pigment → retinal + opsin dissociate and transducin is activated → phosphodiesterase is activated → cGMP levels in cytosol decrease + $Na^+$ channels close → cell hyperpolarizes + $Ca^+$ channels close → NT release is decreased + graded potential in bipolar cells gets smaller

**Neural Prossesing**

- Bipolar cell excited by glutamate are inhibited by light in receptive field → OFF bipolar cells (on-center, OFF surround)
- ganglion cells are first neurons that transmit action potentials → axons make up the optic nerve

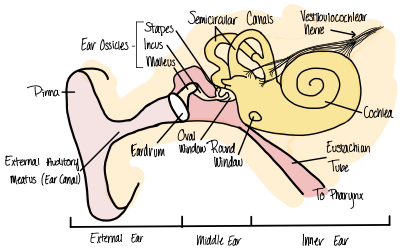
- optic chiasm: the two optic nerves exit the eyes + combine here, half the axons from each eye cross over to other side of the brain

↳ after optic chiasm, axons travel to optic tract → then to Lateral Geniculate Body (nucleus in the thalamus) where they form synapses w/ neurons going to primary visual cortex in occipital lobe

- Binocular visual field: portion of visual field detected by both eyes → depth perception occurs

# The Ear

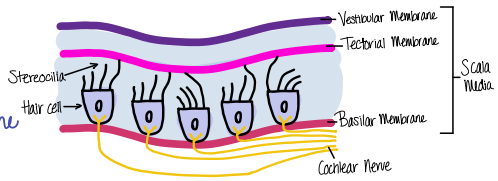
- Anatomy




- External ear gathers sound waves + conducts them to tympanic membrane (ear drum)
- middle ear amplifies sound waves; eustachian tube connects middle ear w/ throat to maintain normal pressure
- inner ear contains structures for hearing + equilibrium

- Sound waves

- loudness / amplitude ∝ difference in densities of air molecules between areas of compression + rarefactions
- pitch is determined by sound wave's frequency
- The organ of corti: sensory organ of sound, contains hair cells + tectorial membrane




→ sound waves hit tympanic membrane initiating vibrations in the ossicles → stapes pushes oval window + vibrations are created into waves in the fluid in the cochlea → waves cause ossilation of the membranes → causes the stereocilia of hair cells to bend → causes opening/closing of $K^+$ channels

› when stereocilia are straight up (no sound waves present): $K^+$ channels are partially open, when they are bent towards the tallest stereocilium: channels open more (more $K^+$ → more depolarized), (vise versa + $K^+$ closes + hyperpolarized)

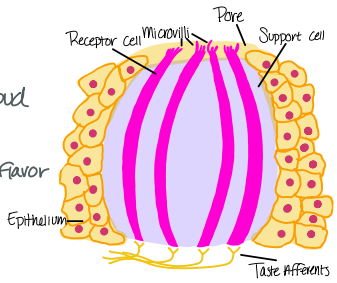
- Frequency is coded by which hair cells are activated strongest → low-frequency cause greatest deflection in region closest to helicotrema

- Transmitter released from hair cells bind to receptors on afferent neuron of cochlear nerve → goes to auditory cortex (temporal)

- Equilibrium

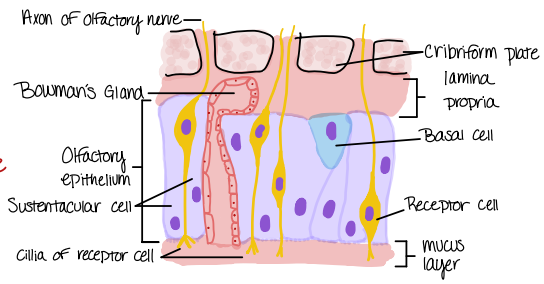
- Vestibular apparatus: consists of semicircular canals (detect rotational movements of the head) and the utricle + saccule (together detect linear acceleration)
- utricle also detects position of the head relative to gravity

# Taste




- Taste receptor cells: motified epithelial cells w/ microvilli extending into the pore of a taste bud
  - in plasma membrane of microvilli → taste receptors that bind to different chemicals (tastants) → flavor
- Signal Transduction
  - tastant activates signal transduction that increases intracellular calcium levels → triggers release of transmitters
  - salty taste → presence of sodium ions; sour → presence of acid; sweet → presence of organic molecules (sucrose, fructose); bitter → associated w/ variety of nitrogen-containing compounds; umami (enhances other tastes) → amino acids - glutamate
- Neural Pathway
  - taste receptors communicate to afferent neurons terminating in the gustatory nucleus of the medulla → form synapses w/ second-order neurons → travel to ipsilateral thalamus → form synapses w/ third-order neurons that terminate in gustatory cortex

# Olfaction




- Olfactory Epithelium: made up of two cell layers → olfactory mucosa and lamina propria (contains Bowman's glands → produce mucus in nasal cavity)
- To perceive odors, oderants must traverse mucus layer + bind to receptors
  - hydrophilic molecules can diffuse through the mucus; hydrophobic must bind to proteins to be transported
- Olfaction is the one sensory system who's pathway to cortex does not include a synapse in the thalamus