9.01 Introduction to Neuroscience
Fall 2007

	Sense Organ	Receptor Neurons	Transduction	Pathways	Coding / Misc
Vision Properties of light (wavelength) Refraction	Gross anatomy of eye; cornea refraction; lens accommodation; laminar organization of retina	Photoreceptors (rods and cones)	Light hyperpolarizes photoreceptors ("dark current," cGMP second messengers, rhodopsin, PDE, etc.) Further retinal processing from photoreceptors to ON and OFF bipolar center-surround receptive fields, ganglion cell output	Photoreceptors → bipolar cells → ganglion cells → optic nerve → chiasm → tract → LGN (thalamus) → V1 → dorsal and ventral streams	Retinotopy Parallel processing ─────── achromatopsia - partial or complete loss of color vision (cortical damage in V4; cones are intact) prosopagnosia - difficult recognizing faces (cortical damage in IT)
Audition Frequency of sounds waves = number of cycles per second (measured in Hz) Higher frequency means higher pitch Higher amplitude means higher intensity or loudness	Ear - outer (pinnae and canal), middle (ear drum to oval window), inner (cochlea) Sound wave travels up auditory canal to tympanic membrane, moves ossicles which amplify sound wave and push on cochlea. Fluid in cochlea moves, causing receptor response. Cochlea: Organ of Corti (with hair cells) sits on basilar membrane. Membrane wider at apex, stiffer at base: low freq. sounds generate waves all the way to the apex; high frequency sounds do not propagate as far = tonotopy. Tectorial membrane sits on Organ of Corti, moving hair cells.	Inner and outer hair cells (3x more outer) with stereocilia extending from the top. Inner hair cells innervate multiple ganglion cells; stronger signal from inner hair cells. Outer hair cells are a cochlear amplifier. There are motor proteins driven by potential in the membrane; as potential changes, length of protein changes, which pushes or pulls the basilar membrane more; contributes to wave that propagates down the membrane. Inner hair cells bend more, contributes to transduction.	As the basilar membrane moves, the Organ of Corti with the hair cells move toward or away from the tectorial membrane, which bends the stereocilia one way or the other. The ion channels are mechanically gated TRPA1 channels. As the open, potassium ions (high concentration of potassium ions in scala media) leak into the cell, depolarizing it.	Hair cells → spiral ganglion cells → auditory nerve (VIII) → brain stem nuclei (dorsal and ventral cochlear nuclei) on the **ipsilateral side** → multiple pathways Following one pathway: ventral cochlear nucleus → superior olive on **both sides** → inferior colliculus → MGN (thalamus) → A1	Intensity Tonotopy Sound localization (horizontal and vertical) ─────── Attenuation reflex: two muscles in the ear contracts at loud noises. Reflex takes too long to protect the ear, easier to hear high-frequency sounds over noise. Result: we don't hear are own voices as loudly as we would otherwise. Phase locking, etc.

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Gustation Five basic tastes (salty, sweet, sour, umami, bitter)	Tongue (tip most sensitive to sweet, sides to salty and sour, back to bitter). Papillae are small projections (three types) – each has taste buds with 50-150 receptor cells – relative lack of specificity common in sensory systems	Taste receptor cells are not real neurons. Make synapses with endings of gustatory afferent axons near bottom of taste bud. 90 percent of taste receptor cells respond to more than one basic taste.	Tastants (taste stimuli) can: 1. directly pass through ion channels (Na^+ for salty, H^+ for sour) – these are amiloride-sensitive Na^+ channels (insensitive to voltage, always open) 2. bind and block ion channels (H^+ blocks K^+ channels for sour – depolarizes) 3. bind to G-protein-coupled receptors (bitter, sweet, umami) bitter: T2R receptors sweet: T1R2 + T1R3 umami: T1R1 + T1R3 (See G-protein mechanism in "Other")	Three cranial nerves (VII, IX, X) bundle together → gustatory nucleus (medulla) → pathways diverge: 1. VPM (thalamus) → primary gustatory cortex 2. hypothalamus: palatability of food, motivation to eat	Population coding --- aguesia - loss of taste perception --- (G-protein mechanism, cont. from "Transduction") Same pathway for the three tastes (can tell apart because in diff. cells): tastant binds to receptor, activates G-protein, stimulates phospholipase C, increase IP3 production, activates and opens Na^+ channel
Olfaction We can smell several hundred thousand substances: increase enjoyment of food, warns of potentially harmful substances, means of communication (pheromones). Humans are weak smellers.	Olfactory epithelium in the nasal cavity	Olfactory receptor cells are real neurons with axons to CNS. Also supporting cells (like glia, make mucus) and basal cells (source of new receptor cells) Receptor neurons have cilia that wave around in nose Olfactory axons → olfactory nerve → axons penetrate cribiform plate → olfactory bulb	Odorants bind to receptors → activates G-proteins → activates adenylyl cyclase → formation of cAMP → opens cation channel → influx of Na^+ and $Ca2+$ → $Ca2+$ activate $Cl-$ channels → depolarization (high $[Cl-]$ inside cell) Response ends: 1. odorants broken down 2. cAMP activates other pathways that end transduction 3. adaptation	Axons → olfactory bulbs (glomeruli) → olfactory cortex (unique in sensory systems – no thalamic relay) Glomeruli: spherical structures; mapping of receptor cells very precise. Each glomeruli only receives input from one receptor cell type; mapping also consistent across the two bulbs (symmetrical positions)	Population coding Temporal coding Sensory maps (don't know much about them) --- anosmia - inability to smell

Population coding: use of response of large population of receptors to encode a stimulus; combination of receptors to detect odor, taste.