7.29/9.09 Sensory Systems Review

Sensory System	Vision	Hearing	Smell	Taste	Touch
Signal	Photon	Sound wave	Chemical	Chemical	Pressure, vibration, temperature, chemicals (pain)
Encoded information	Color (cones) Spatial location (receptive field) Intensity	Amplitude Frequency	Odor concentration Odor identity	Taste type (sugary, salt, umami, bitter, sour)	Modality (touch, temp, pain) Location Intensity Timing
Sensory cell: AP or graded response?	Photoreceptor - Graded potential - Depolarized / releasing NT in the dark	Inner hair cell - Graded potential - Do not regenerate	Olfactory neuron (ON), cilia project into nasal mucosa - AP - Lots of turnover	Taste cells arranged in taste bud - AP - Lots of turnover	Dorsal root ganglion (DRG) cell, nerve endings in periphery - AP
Signal receptor	Rhodopsin: GPCR bound to 11-cis-retinal	Trp mechanoreceptor, coupled to extracellular tip link and cytoskeleton	Many GPCRs, each encoded by unique gene (~1000 in mammals), each ON expresses only 1 receptor	- Sweet, umami: GPCR dimer - Bitter: GPCR monomer, many - Salt: Amiloride-sensitive Na channels (degenerins) - Sour: Trp channel + GPCR	- Trp mechanoreceptors - MEC mechanosensitive ion channels - Degenerins
Signal transduction pathway in sensory cell	Photon converts retinal to all-trans-retinal -> Rhodopsin activated -> G-protein transducin -> phosphodiesterase -> cGMP levels decrease -> cGMP gated Na, Ca channel closes -> cell hyperpolarizes	Trp channel opens -> K+, Ca influx -> depolarization of hair cell, NT release via dense body	GPCR -> Golf -> adenylate cyclase -> cAMP -> open cAMP gated Na, Ca channel -> depolarized cell fires AP	- Bitter, sweet, umami: GPCR -> PLC, no details - Salt: Pass directly through Na channel	Activated mechanoreceptors allow ion flux -> nerve depolarization

Coding	- "Off" retinal ganglion cells firing in dark, "On" retinal ganglion cells firing in light - Center surround antagonism mediated by inhibitory horizontal and amacrine cells - Mangocellular retinal ganglion cells (RGCs) encode "where" info, Parvocellular RGCs encode "what" info	1. Place code: where hair cell is on basilar membrane determines frequency 2. Frequency code: auditory neuron fires at sound wave frequency (true up to 1000 Hz) 3. Stellate chopper cells fire at frequency of sound wave, bushy cells respond to start/end of stimulus: sound localization	- 1 receptor/ON, though 1 receptor can bind multiple odors - Increasing odor concentration activates greater number of ONs - All ONS expressing 1 receptor project to same glomerulus in olfactory bulb	Labelled line model: Taste cells are tuned to single taste modality, as are secondary afferent neurons	Slowly adapting receptors -> signal pressure and shape of object Rapidly adapting receptors -> signal motion of objects on skin
Mechanisms of adaptation	1. Ca influx relieves inhibition of guanylyl cyclase -> cGMP levels increase -> photoreceptor depolarizes 2. Pupil dilates in low light, constricts in high light	1. Ca influx activates myosin motors, physically move and close Trp channel 2. Outer hair cells vibrate and dampen basilar membrane 3. Middle ear muscles contract and reduce stapes vibration	1. Activated GPCR is phosphorylated and desensitized 2. Ca influx -> calmodulin -> close cAMP gated channel	Not discussed	Slow or fast depending on stimulus type
Mechanisms of amplification	1 photon -> 1 rhodopsin -> activates 100 transducins -> each activates 1 phosphodiesterase -> cleaves 1,000 cGMP: 10^5 cGMP cleaved / photon	Tympanic membrane is 35X larger than oval window	Not discussed	Not discussed	Not discussed
Information pathway in CNS	Photoreceptor -> Bipolar cell -> Ganglion cell -> Thalamus LGN -> Cortex layer IV, Superior colliculus (Tectum), Superchiasmatic nucleus (Hypothalamus)	Hair cell -> Cochlear nucleus (medulla) -> Superior olivary nucleus (pons) -> Inferior colliculus -> Thalamus MGN -> primary auditory cortex (temporal lobe)	Olfactory neuron -> Olfactory bulb glomeruli -> Pyriform cortex, hippocampus, amygdala ** Only sensory system that doesn't relay	Taste cell -> Bipolar neuron -> Gustatory nucleus (medulla) -> Thalamus VPN -> Gustatory cortex (temporal lobe)	- <u>Touch/Proprioception</u>: DRG -> Spinal cord dorsal column -> synapse in dorsal column nucleus (medulla) -> Cross midline -> Thalamus VPN -> Post-central gyrus (parietal)

	Dorsal flow (to region MT): “where” Ventral stream (to region IT): “what”		through thalamus before reaching cortex		- Nocioception: DRG neuron -> synapse in spinal cord dorsal horn -> Cross midline -> Spinothalamic tract -> Thalamus VPN -> cortex
Cortex mapping	Ocular dominance columns (each eye segregated), orientation columns, “blobs” segregated by color	Cortical neurons grouped by sound frequency	Not discussed	Not discussed	Somatosensory map on cortex; inputs grouped depending on spatial location on body
Important pathologies	Myopia, astigmatism, rod disease, macular degeneration, color blindness, optic neuritis, glaucoma, diabetic retinopathy, cataracts, amblyopia, agnosia	Conductive deafness, sensorineural deafness, central deafness	Not discussed	Not discussed	Referred pain, phantom limb, hyperanalgesia, chronic neuropathic pain

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