Lecture 17 – Taste and Smell -- Firestein

The various sensory abilities which transduce chemical information in the environment. Primarily the sense of Smell (OLFACTION) and Taste (GUSTATION) but also including the TRIGEMINAL and VOMERONASAL systems.

Principles

1. specialized primary sensory neurons that are polarized and have specialized end structures, cilia or microvilli
2. labeled lines vs. across fiber patterns
3. convergence vs. divergence
4. topography - not in chemical senses; issue for defining receptive fields

TASTE

- Taste vs. Flavor. 4 primary tastes + 1 (umami = delicious)
- Not specific to regions of tongue but there are threshold and sensitivity differences- sweet / anterior; bitter/posterior; salt, sour/lateral
- Thresholds are generally high

ANATOMY OF THE TASTE SYSTEM

PERIPHERAL STRUCUTURES -TONGUE

Only a small portion devoted to taste tissue

•*Taste Cell Receptors* contained in *Taste Buds* (4000 in humans)

30-100 per bud is typical

polarized – apical taste pore, basolateral synapses

•Taste Buds in *Papillae* (small elevations on tongue)

found on tongue, palate, pharynx, epiglottis, esophagus

- 3 types of Papillae
  - *Fungiform*
    Anterior 2/3 of tongue
    Several hundred (30/μm^2)
    Contain 1-5 taste buds
  - *Circumvallate*
    9 on posterior 1/3
    trench structure with 250 buds along walls
  - *Foliate*
    2 each side posterio-lateral- 600 buds each

TASTE NERVES

somas in DRG, bi-polar projections to tongue and medulla

Chorda tympani branch of N. VII - Facial Nerve

Anterior 2/3 of tongue (Fungiform)

Lingual branch of N. IX – Glossopharyngeal

Posterior 1/3 – cirumvallate & Foliate

CENTRAL TASTE STRUCTURES

Nucleus of Solitary tract in Medulla – rostral portion
Ventral posterior nucleus of the Thalamus via *central tegmental tract*
Gustatory CTX – anterior insula-frontal operculum

TASTE TRANSDUCTION

Taste Receptor Cell

polarized - apical and basolateral membranes
Ciliated - actually microvilli
non-neuronal - derived from epithelial cells- no APs

- SALT

Ionic mechanisms, amiloride-sensitive Na channel
Threshold at 10 mM

- SOUR

Ionic mechanism, protons block K channel in amphibians.
Permeate amiloride sensitive Na channel in mammals while blocking Na
200mM NaCl & pH 2.6 cancel each other: *Margarita effect*

- SWEET

Receptor mediated??
Second messenger??? Evidence for cAMP increase to sucrose
Sweet-induced depolarization due to decreased I_K
EC50 for sucrose = 20 mM
(but Nutrasweet: L-aspartyl,L-phenylalanine methyl ester, & proteins like thaumatin are much lower- 10^{-4}M) and may act through IP3. These cross adapt with Sucrose

- BITTER

Receptor mediated, multiple pathways, IP3 may open K channel, release internal Ca
K currents, quinine, denatonium, K-channel blockers
much more sensitive
Quinine - 0.008 mM
Strychnine - 0.0001 mM

UMAMI – GLUTAMATE / AMINO ACID TASTE

MGluR4 isoform with lower afinity

OLFACTION

Ability to detect thousands of ligands, some differing by only a single carbon atom, some are stereoisomers.

Olfactory neurons as models of signal transduction.

Structure of epithelium

- turbinates
- neurons
- sustentacular cells
- glands
- basal cells that regenerate

Structure of olfactory neurons

- CNS type neuron, generates action potentials
- bipolar neuron
- single dendrite with swelling
- cilia - very fine, specialized site of transduction, increase surface area
- axon from proximal pole of soma goes to brain

Central pathways

- Nerve layer (axons of 1^0 ORNs, transmitter: GLU)
- Glomeruli – 30 μm spherical neuropil strucutres
- mitral cells are second order cell and primary output neuron (transmitter: GLU)
- receptor axon terminals converge on mitral cell dendrites to form glomeruli
- interneurons include periglomerular and granule cells (GABA).
    - Dendro-dendritic reciprocal synapses may be important in sharpening perception
- Lateral olfactory tract (LOT) is main pathway to CTX
    - Branches in Piriform CTX and then to Frontal CTX via thalamus
    - Also direct innervation of amygdala and hypothalamus and hippocampus

Basic Steps in Olfactory Transduction

- G-protein coupled receptors homologous to other members of GPCR Superfamily
    - -extensive sub-family and organization of receptors
- Activation of **G_{olf},** a G_s type of protein
- **Adenylate cyclase III** produces **cAMP**
- Activation of **CNG (cyclic nucleotide gated) channels** and cation flux cause depolarization
- Also activation of **Ca-dependent Cl channel** -- also depolarizing.
- **PDE** hydrolyses cAMP to end response

Adaptation

- Ca feedback to CNG channel
- Phosphorylation of receptors

Olfactory coding

single receptor neurons respond to more than one odorant
receptor genes expressed per cell is unknown but thought to be one
zonal organization of receptors on epithelial sheet
convergence of cells w/same receptor to single glomerulus

Relevant reading: chapter 32 in "Principles"