The Chemical Senses: Smell and Taste
Olfaction and Gustation

Chemical senses: function is to monitor chemical content of the environment
- olfaction (smell): airborne
- gustation (taste): mouth

Roles in nature:
- Finding food sources
- Judging nutritional value and safety of foods
- Avoiding predators and hazardous environments
- Social communication, mating ("pheromones").
Olfactory receptor cells are located in the upper part of the nose (nasal epithelium). Receptors are regularly replaced (neurogenesis).

There are many different kinds of receptor proteins; each type is scattered throughout the epithelium: mice ~1,500; humans ~1,000.
Receptor cells express only one type of protein molecule. However, each protein responds to a variety of odors. Odor is encoded by component processing; that is, by the pattern of activity across receptor types.
Transduction of Olfactory Stimuli

Odor receptors are metabotropic (G proteins)

Activation opens ion channels (\( \text{Na}^+ , \text{Ca}^{++} \rightarrow \text{Cl}^- \))

Graded depolarization depending on strength and duration of odor

Rapid adaptation (can respond quickly to new odor in next inhalation)
Chemotopic Organization: Bulb

The axons of olfactory receptors (1\textsuperscript{st} cranial nerve) terminate on mitral cell dendrites in olfactory glomeruli within the olfactory bulb.

Each glomerulus receives input from many receptors, all with the same receptor protein.

Glomeruli are arranged in a consistent, systematic way: chemotopic.
Projections from the Bulb

The olfactory tract projects bilaterally to medial temporal lobe structures including the piriform cortex and the amygdala.

Only system that does NOT first pass through thalamus before cortex.

Two pathways from medial lobe:
- limbic system: emotional response to odors
- thalamus-orbitofrontal cortex: conscious perception
Topographic mapping of odorants seen in olfactory bulb is lost (!) in PC. Odorants activate PC neurons over a wide area (in part because PC neurons receive more inputs from other PC neurons than they do from the olfactory bulb – thus, a common initiation site for epileptic seizures).

The olfactory system uses a population code to represent specific odors. Activation patterns for different odors overlap extensively, but are nonetheless unique for a given odorant and similar across individuals.
**Taste**

**Taste** refers to the sensations relayed by *taste receptor cells*

Foods activate combinations of at least 5 basic tastes: sweet, sour, salty, bitter and umami (meaty)

Nutrients vs anti-nutrients

**Flavor** is a highly multisensory percept depending on taste, smell, vision (color), audition (bite) and somatic senses (texture, temperature, and pain)
The Tongue

Taste is primarily a function of the tongue.

Taste buds are grouped in three of the four accessory structures called papillae: vallate, foliate and fungiform.

There are subtle regional differences in sensitivity to different tastes over the lingual surface, but most of the tongue is sensitive to all tastes.
Each papilla has from 1-200 taste buds.

A person typically has 2000-5000 taste buds.

Each bud has between 50-150 taste receptor cells.

Receptors are regularly replaced.
**Direct** transduction: some taste stimuli are ions that carry currents through ion channels.

**Indirect** transduction: other (non-ionic) taste stimuli bind selectively to specific G protein-coupled membrane receptors.

Individual taste cells respond to one or two tastes.
Direct Transduction: Salty and Sour

Salty:
Na⁺ ions enter through Na⁺ channels, depolarizing membrane.

Sour:
H⁺ ions (protons) enter Na⁺ or H⁺ channels AND block K⁺ channels, depolarizing membrane.

Depolarization opens voltage-gated Na⁺ channels leading to AP’s, which in turn open voltage-gated Ca²⁺ channels leading to neurotransmitter release.
Bitter, sweet, or umami tastes are transduced by $G$ protein-coupled pathways.

- Binding to receptor activates $G$ protein/PLC/IP$_3$ cascade
- IP$_3$ causes release of Ca$^{2+}$ from internal stores.
- Opens unique Ca$^{2+}$-activated Na$^+$ channel, depolarization
- Action potentials
- Opens voltage-gated Ca$^{++}$ channels
- Transmitter release
Central Taste Pathways

Gustatory afferent neurons exit the mouth as part of the 7th, 9th, and 10th cranial nerves and project to the ipsilateral solitary nucleus of the medulla.

Medulla $\rightarrow$ ventral posterior nucleus of the thalamus $\rightarrow$ primary gustatory cortex in parietal cortex

Neurons in cortex respond to a wide range of tastes (population code).

Secondary gustatory cortex is in the orbitofrontal lobe; here, chemical and non-chemical (via the ventral stream) senses can merge to produce the percept of flavor.
Anosmia: inability to smell
- Causes: blows to the head that damage the olfactory nerves; tumors on the olfactory tract
- Results: can lead to loss of interest in eating (weight loss and malnutrition) or depression

Ageusia: inability to taste
Rare due to multiple pathways carrying taste information from mouth