Νευροφυσιολογία και Αισθήσεις

Διάλεξη 10

Χημικές Αισθήσεις

(Chemical Senses)

Introduction

- **Animals depend on the chemical senses**
  - Play a role in finding direction, seeking prey, avoiding predators and sexual attraction to a mate
  - Less developed and important in humans
    - Really? How much do you spend on perfumes and colognes
- **Chemical sensation**
  - Oldest and most common sensory system
- **Chemical senses**
  - Chemoreceptors (internal environment, e.g. O2, CO2, acidity, etc.)
  - Gustation
  - Olfaction

The Basics Tastes

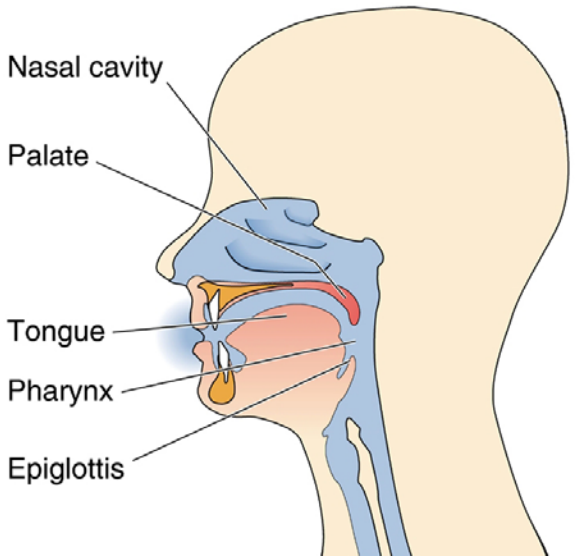
- **Saltiness, sourness, sweetness, bitterness, and umami**
- **Examples of correspondence between chemistry**
  - Sweet—sugars like fructose, sucrose, artificial sweeteners (saccharin and aspartame)
  - Bitter—ions like K^+ and Mg^{2+}, quinine, and caffeine
- **Advantage – Survival**
  - Poisonous substances - often bitter

The Basics Tastes

- **Steps to distinguish the countless unique flavors of a food**
  - Each food activates a different combination of taste receptors
  - Distinctive smell
  - Other sensory modalities
- **Taste Perception influenced by**
  - Information derived from other receptors, especially odor
  - Temperature and texture of food
  - Psychological experiences associated with past experiences with food

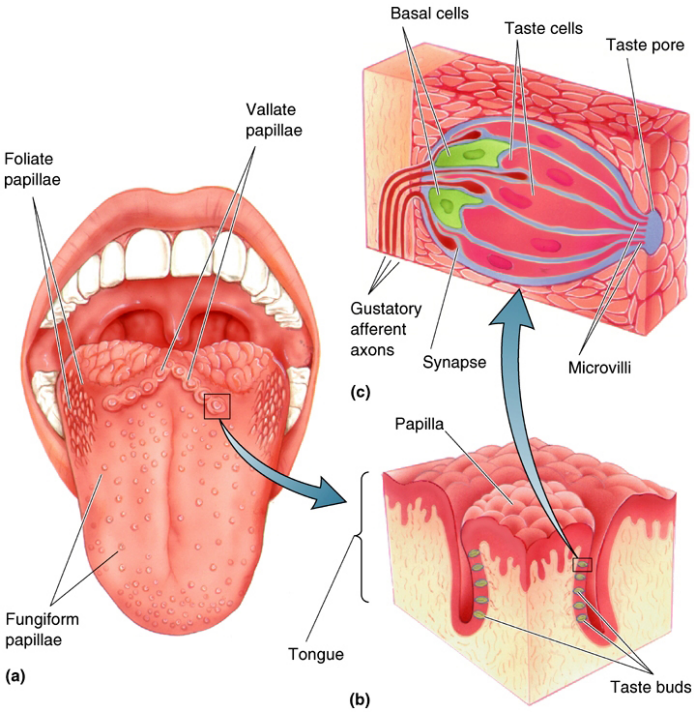
The Organs of Taste

- **Areas**
  - Tongue, mouth, palate, pharynx, and epiglottis
- **Areas of sensitivity on the tongue**
  - Tip of the tongue
    - Sweetness
  - Back of the tongue
    - Bitterness
  - Sides of tongues
    - Saltiness and sourness
  - Most of the tongue is sensitive to all



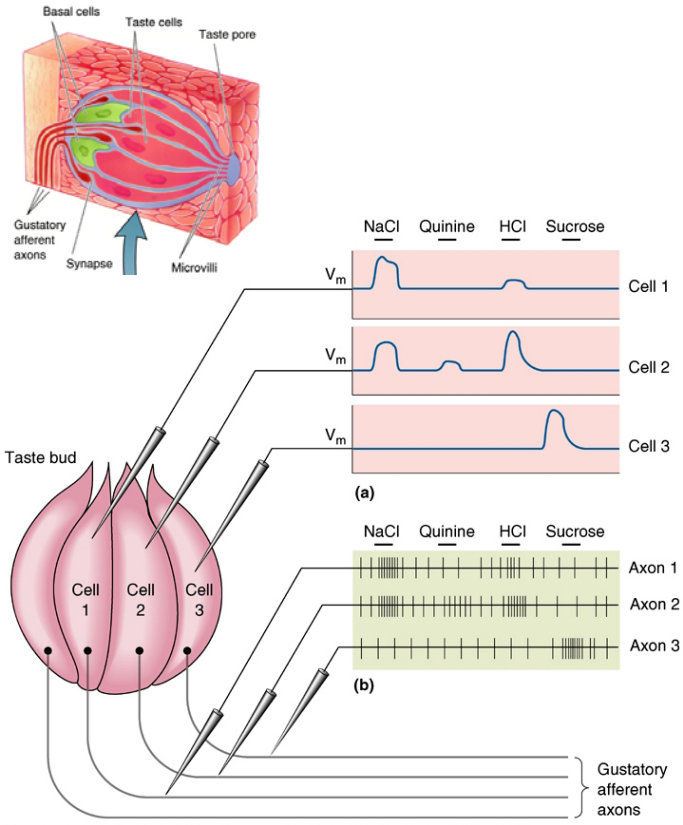
The Organs of Taste

- **Papillae**
  - Foliate papillae
  - Vallate papillae
  - Fungiform papillae
  - 1 to several hundred taste buds
  - 2000-5000 taste buds/person
- **Taste buds**
  - 50-150 taste receptor cells
- **Threshold concentration**
  - Just enough exposure of single papilla to detect taste



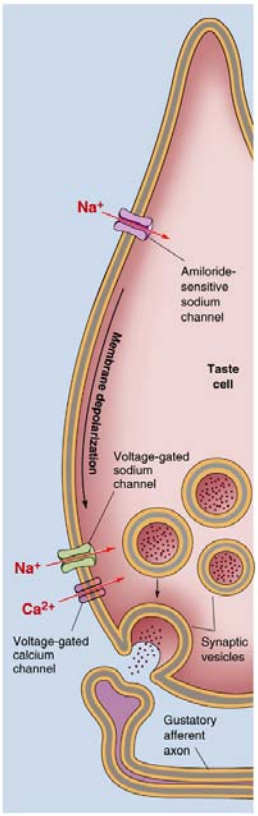
Tastes Receptor Cells

- **Continually regenerating (~2 weeks) receptor cells**
- **Chemically sensitive parts**
  - Apical ends→ Microvilli→ Taste pore
- **Receptor potential**
  - Voltage shift
  - Usually depolarizing
- **If the stimulation is strong enough (can even be AP) → release of neurotransmitter → AP in postsynaptic neuron**
- **Some receptor cells are non-specific**
  - Respond to more than one taste



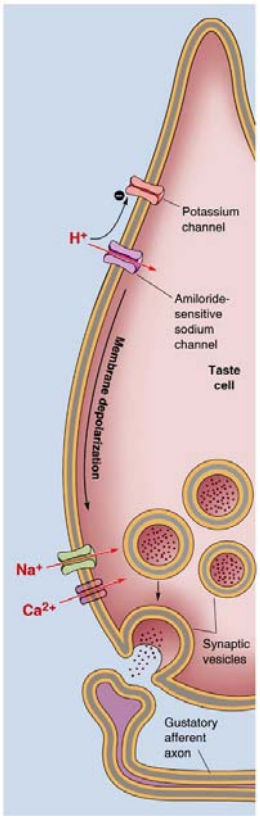
Mechanisms of Taste Transduction

- **Transduction process**
  - Taste stimuli (tastants)
    - Pass directly through ion channels
    - Bind to and block ion channels
    - Bind to G-protein-coupled receptors
- **Saltiness (NaCl)**
  - Threshold: 10 mM
  - Salt-sensitive taste cells
    - Special Na^+ selective channel
      - Blocked by the drug amiloride
  - Anions affect the taste
    - Larger anion → inhibits taste of Na+ or has its own taste
    - Mechanism not well understood



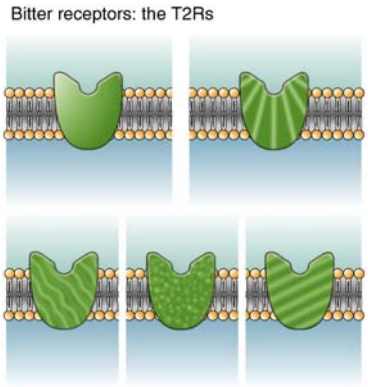
Mechanisms of Taste Transduction

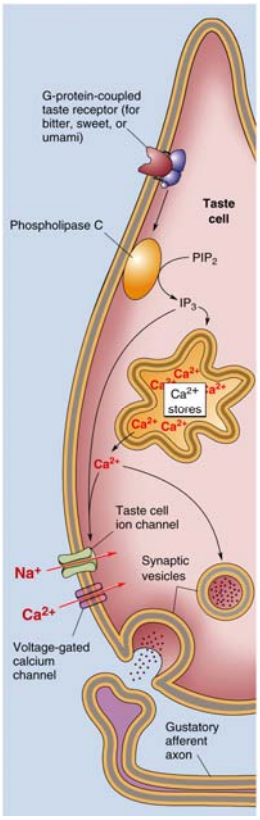
- **Sourness**
  - Low pH → acidity or sourness
  - Protons causative agents of acidity and sourness
  - Two mechanisms
    - Enter through Na+ channel
    - Block K+ channels
  - Low pH probably affects many cellular processes



Mechanisms of Taste Transduction

- **Bitterness**
  - Families of taste receptor genes - *TIR* and *T2R*
    - Use second messenger
    - ~30 different types
  - Can not distinguish between them
    - Each cell has almost all receptors
  - Very sensitive to poisons
    - 10 nM





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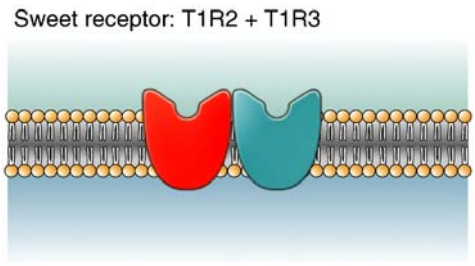
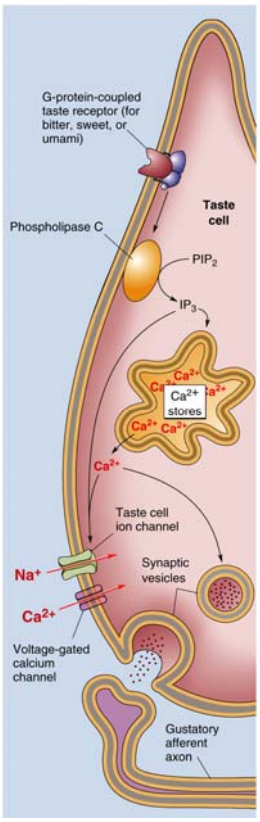
Mechanisms of Taste Transduction

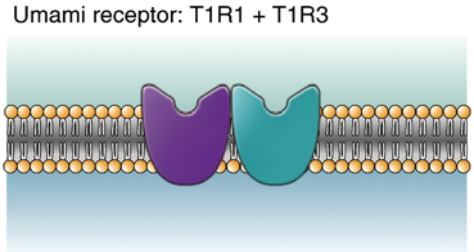
- **Sweetness**
  - Sweet tastants natural and artificial
  - Sweet receptors
    - Similar to bitter receptors
    - Formed from two proteins T1R2+T1R3
  - Why signals not confused with bitter?
    - Expressed in different taste cells and connect to different axons

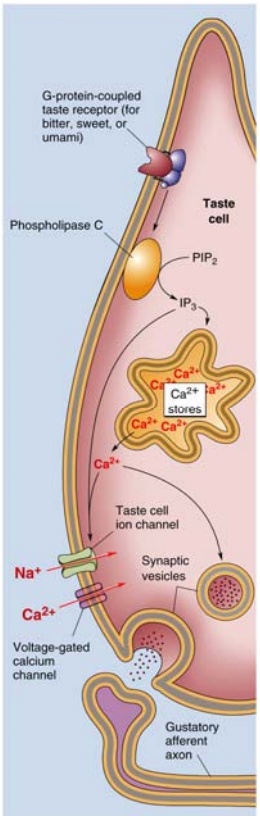




Mechanisms of Taste Transduction

- **Umami**
  - Meaty or savory taste
    - Also the MSG receptor
  - Umami receptors:
    - Detect amino acids
    - T1R1+T1R3





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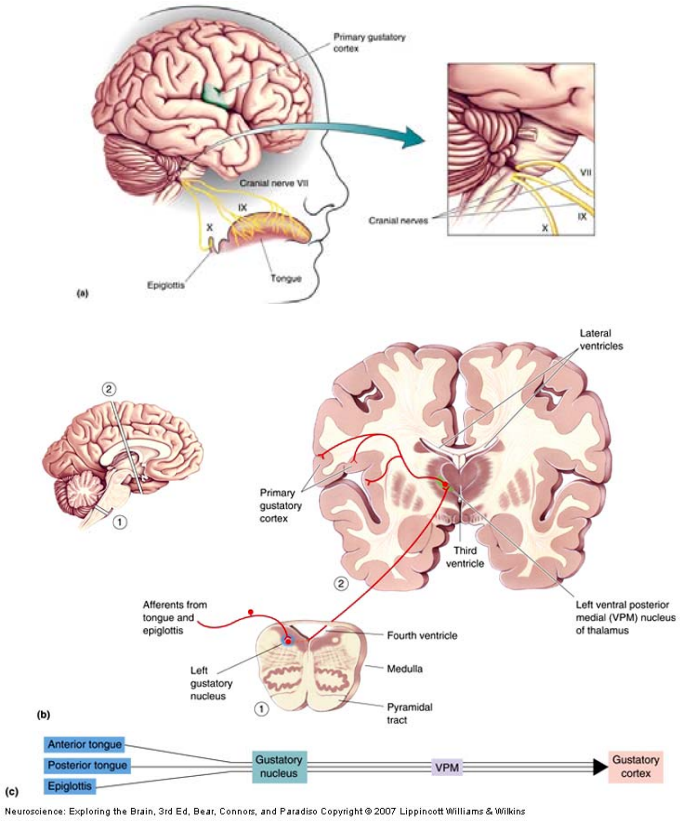
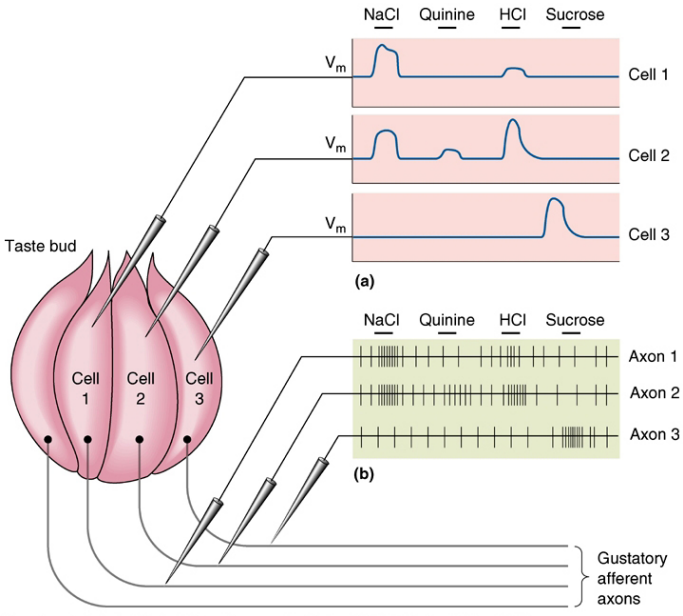
Central Taste Pathways

- **Medulla: Gustatory nucleus**
  - Point where taste axons bundle and synapse
- **Thalamus: Ventral posterior medial nucleus (VPM)**
  - Deals with sensory information from the head
- **Cortex: Primary gustatory cortex**
  - Receives axons from VPM taste neurons
- **Localized lesions**
  - Ageusia- the loss of taste perception
- **Gustation**
  - Important to the control of feeding and digestion
    - Hypothalamus
    - Basal telencephalon



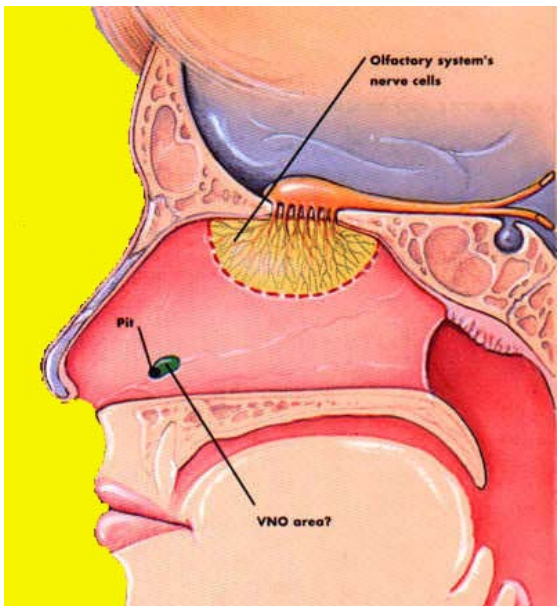
The Neural Coding of Taste

- **Labelled line hypothesis**
  - Individual taste receptor cells for each stimuli
  - In reality, neurons broadly tuned
  - Population coding
    - Large number of broadly tuned responses
      - Roughly labeled lines
      - Temperature
      - Textural features of food



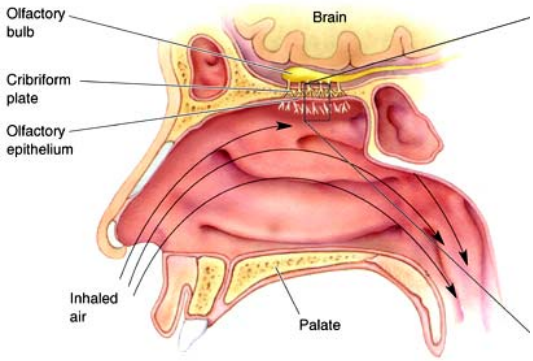
Pheromones

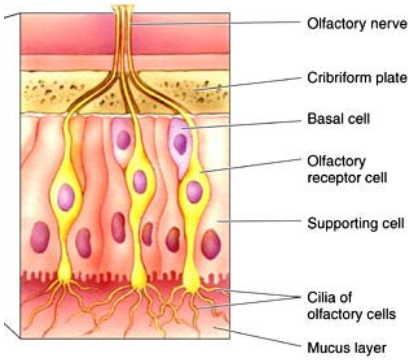
- **Smell— a mode of communication**
  - Important signals
    - Reproductive behavior
    - Territorial boundaries
    - Identification
    - Aggression
- **Vomeronasal Organ (VNO)**
  - Common in mammals but until recently was thought to nonexistent in humans
    - Governs emotional responses and sociosexual behaviors
  - Located about half an inch inside human nose next to vomer bone
  - Detects pheromones
    - Nonvolatile chemical signals passed subconsciously from one individual to another
  - Role in human behavior has not been validated
    - “Good chemistry” and “love at first sight”



The Organs of Smell

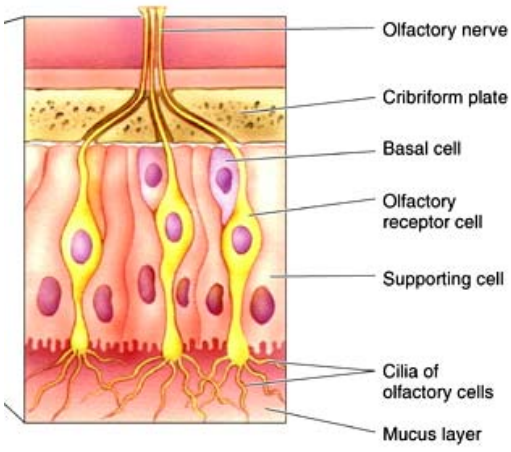
- **Olfactory epithelium**
  - Olfactory receptor cells
    - 4-8 week lifecycle
  - Supporting cells
  - Basal cells
  - Mucus
    - Mucopolysacharides
    - Enzymes
    - Antibodies (protection from viruses)
    - Odorant-binding proteins (concentration)
    - Etc





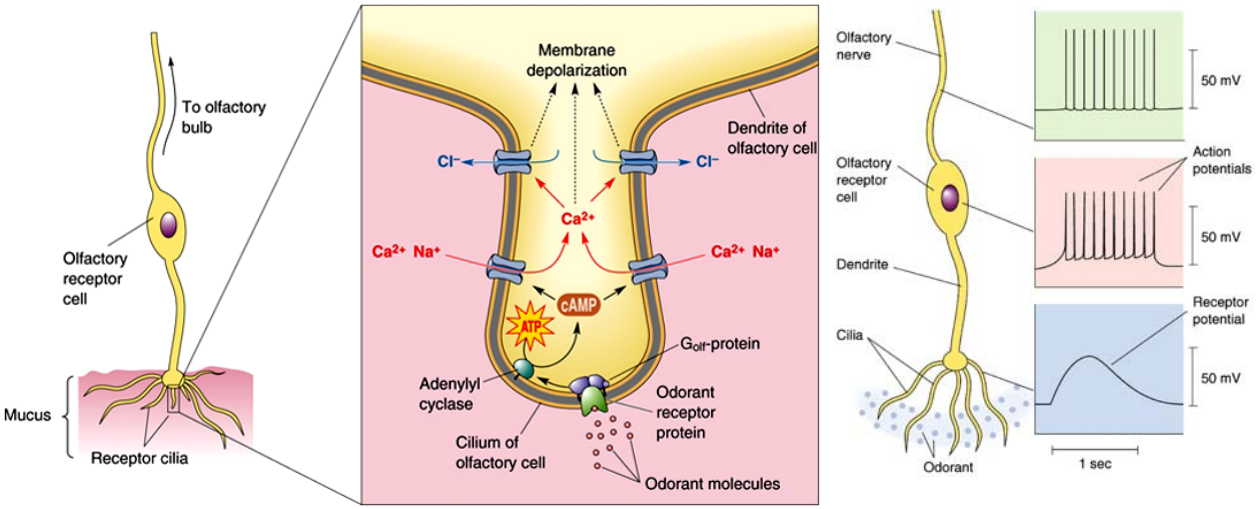
The Organs of Smell

- **Odorants**
  - Activate transduction processes in neurons
  - Must be volatile and disolve in mucus
- **Olfactory axons constitute olfactory nerve**
- **Cribriform plate**
  - A thin sheet of bone through which small clusters of axons penetrate, coursing to the olfactory bulb
  - Blow to the head → Anosmia: Inability to smell
- **Humans: Weak smellers**
  - Small surface area of olfactory epithelium
    - 10 cm^2 (dog→ 170cm^2, 100x receptors)
  - Small number of receptors
    - 350 (rodents → 1000)



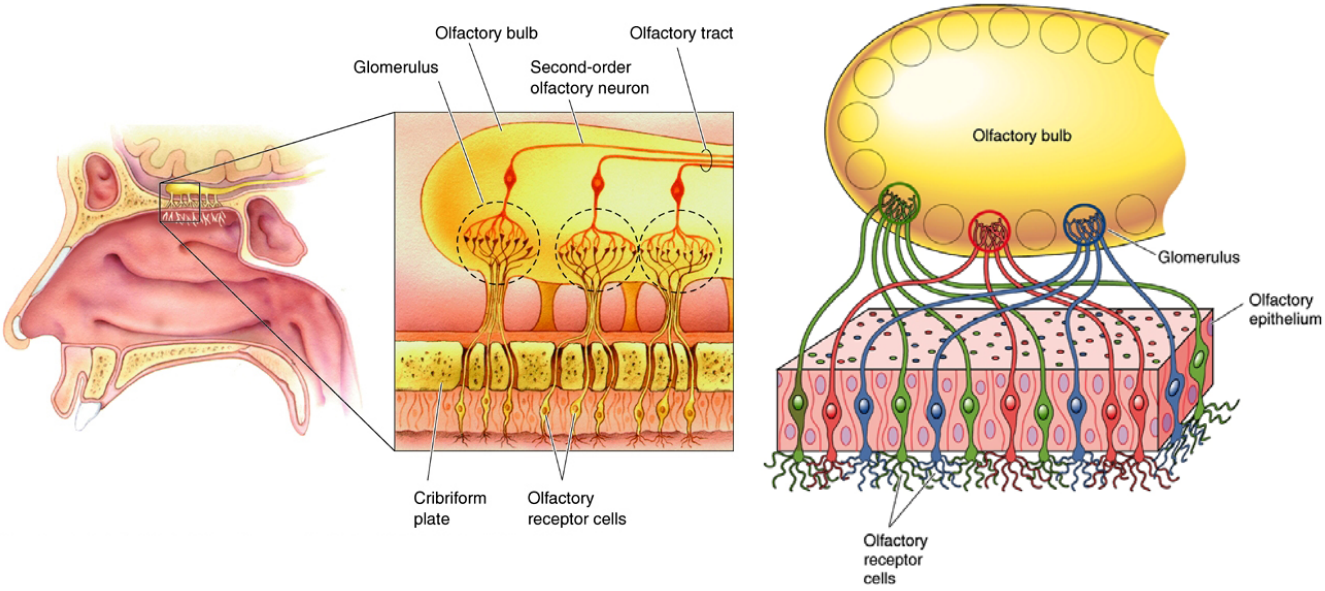
The Organs of Smell

- **Olfactory Receptor Neurons**
  - Olfactory Transduction
    - Notice the unusual Cl^- flow
  - Olfactory response termination
    - Diffusion
    - Enzymatic breakdown
    - cAmp activates other pathways
  - Adaptation → Decreased response despite continuous stimulus



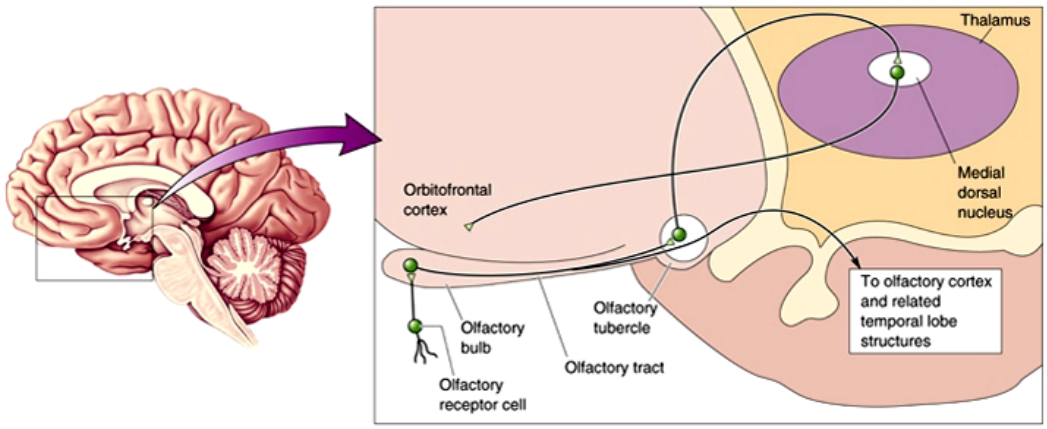
Central Olfactory Pathways

- **Mapping on glomeruli**
  - Astonishingly accurate



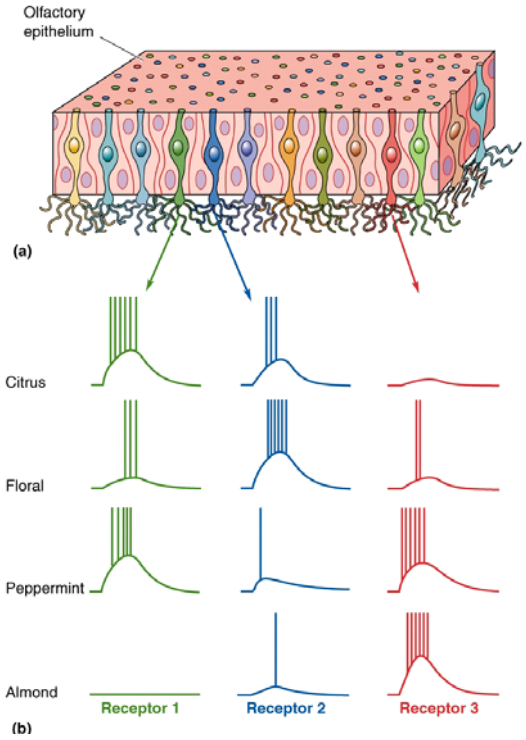
Central Olfactory Pathways

- **Axons of the olfactory tract**
  - Unusually direct connections
  - Branch and enter the forebrain
- **Neocortex: Reached by a pathway that synapses in the medial dorsal nucleus**



Spatial and Temporal Representations of Olfactory Information

- **Olfactory Population Coding**
  - Combination of responses
- **Olfactory Maps (sensory maps)**
  - No spatial information in smell
  - Arranged in groups of responses
- **Temporal Coding in the Olfactory System**
  - Slow stimulus
  - Temporal coding and synchronicity between cells → quality



Επόμενη Διάλεξη …

Διάλεξη 11

Ακουστικό και Αιθουσιαίο Σύστημα

(Auditory and Vestibular Systems)