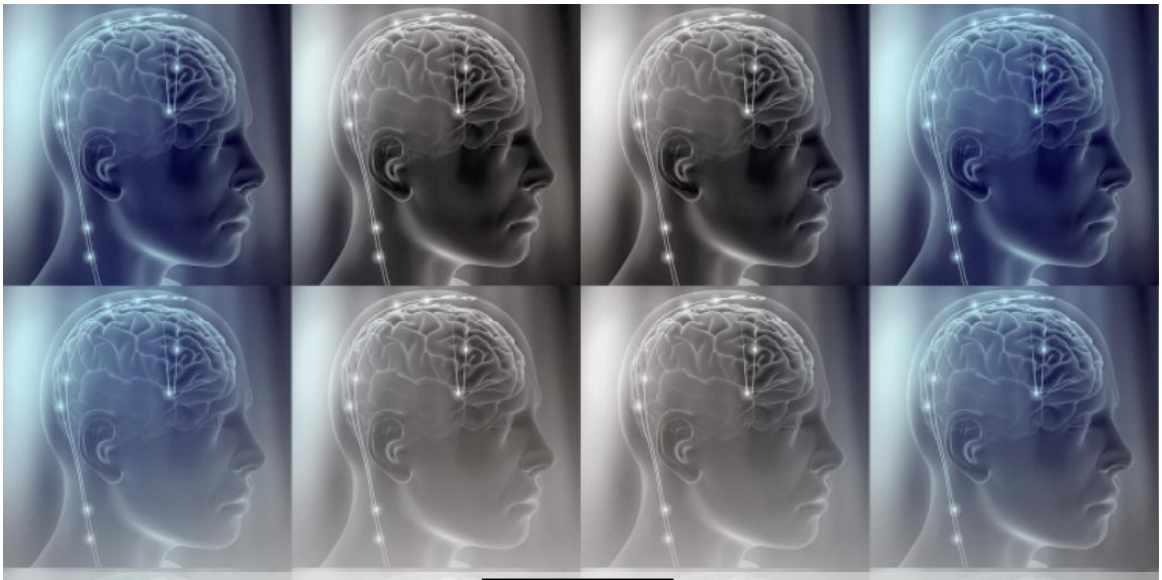


431

CNS Central Nervous System

Block

Physiology Team

Female Side Male side

Done By: Abulrahman Al-shaya

Revised By: Mohammed Asiri

The Physiology of Smell

(Olfaction)

SMELL AND TASTE

Similar:

- Chemical Senses
- Determine food flavor (intake)

❖ CHEMICAL SENSES:

✓ That way the nose is near to mouth, so if the food smell good and taste good we eat it but if it not normally we don't eat it.

Dissimilar:

Smell	Taste
• Smell receptors: telereceptors ✓ sense projected the environment	• Taste is confined to mouth ✓ That way we cannot taste anything unless it in mouth cavity(Buccal cavity)
• Smell pathway: ✓ **does not** relay in the thalamus ✓ **does not** reach sensory cortex	• Taste pathway: ✓ finishes in the sensory cortex (PCG) ✓ PCG: Postcentral gyrus in the parietal cerebral cortex

- Chemical Senses vital for survival
- Allows for approach to appetitive stimuli / Retreat from noxious stimuli

❖ There are two types of animal according to smell sensation:

- ✓ **Macrosmatic**: highly developed sense of smell / reliance on olfactory system (EX: dog)
- ✓ **Microsmatic**: weakly developed sense of smell / less reliance on olfactory system (EX: human):

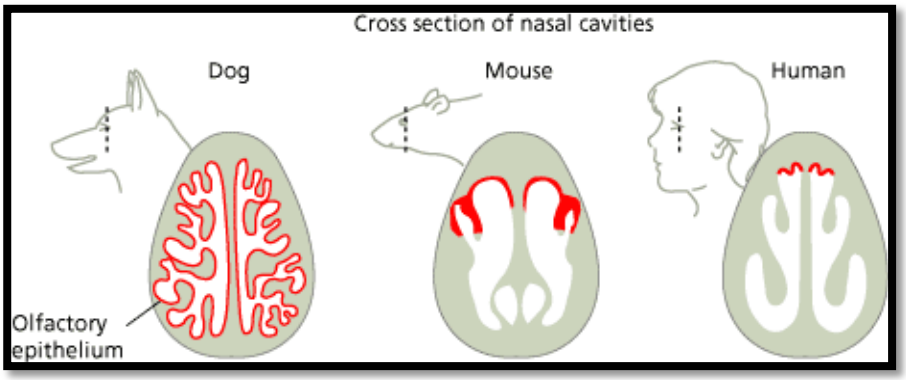
Smell:

- **Macrosmatic animals**… Dogs
- **Microsmatic**… Man
  - Olfactory epith. Roof of nasal cavity
  - Warm nasal epithelium
  - Conviction currents (sniffing)

- Species differences:
  - **Dog:**

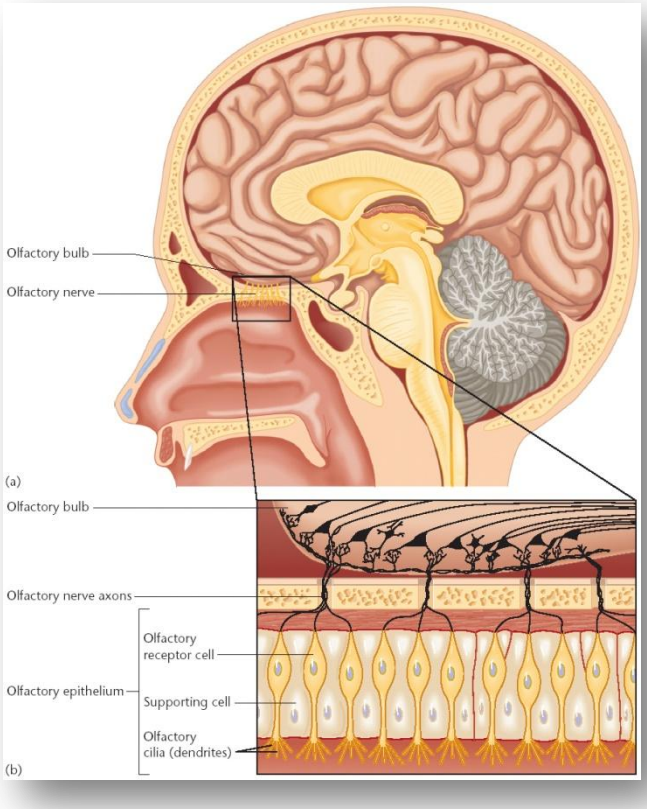
Has 10 sq inches of epithelium compared to 1 sq inch in humans.

Dogs have about 40 times the area for olfaction that humans do



❖ Olfactory Receptor Neurons (ORN):-

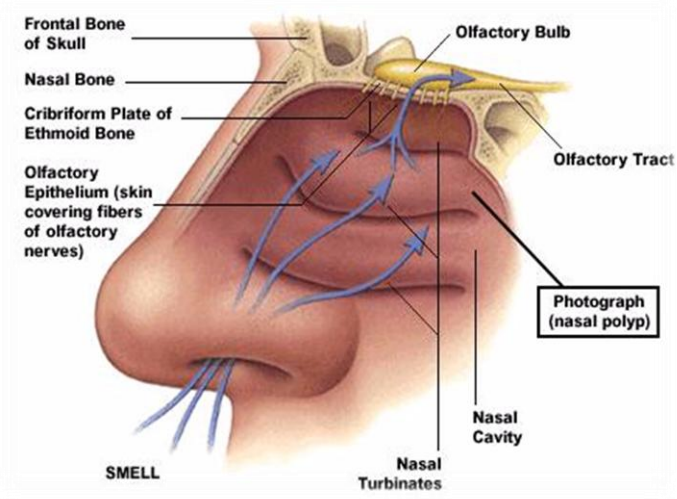
- Signal **Transducers:**
  - 1000 different types
  - Each type found in only 1 zone of mucosa
- **Vision:**
  - 3 cone types, 1 type of rod
  - 6 million cones, 120 million rods
- Membrane bound proteins
  - Located in cilia on tips of ORN's
  - Cause change in membrane potential of ORN



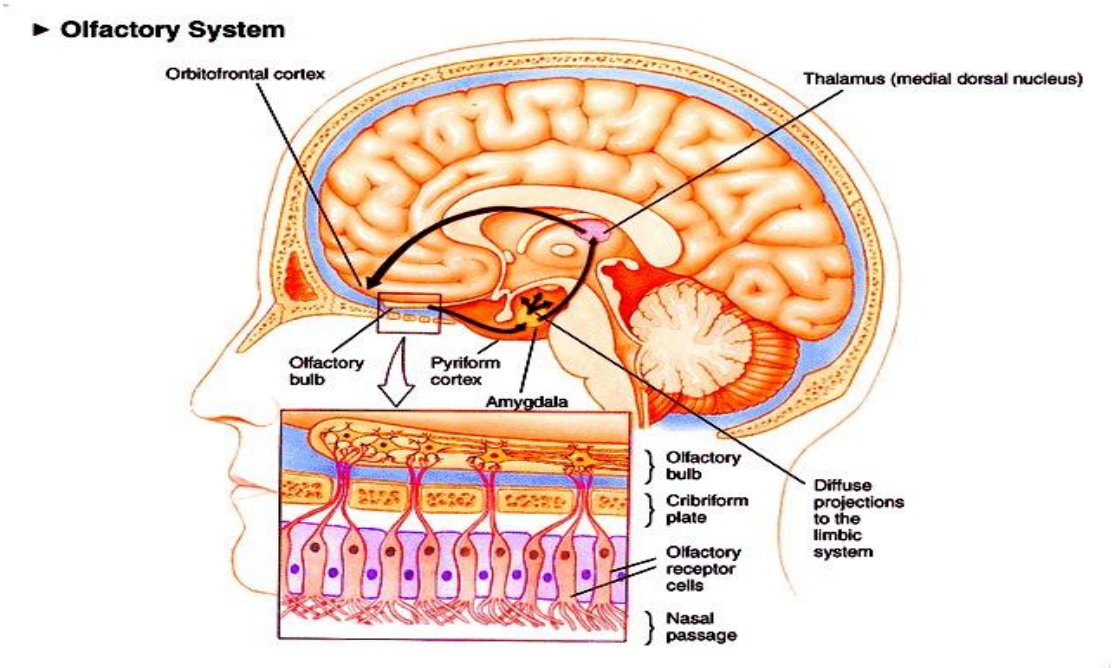
Olfactory receptors:

(a) Location of receptors in nasal cavity.

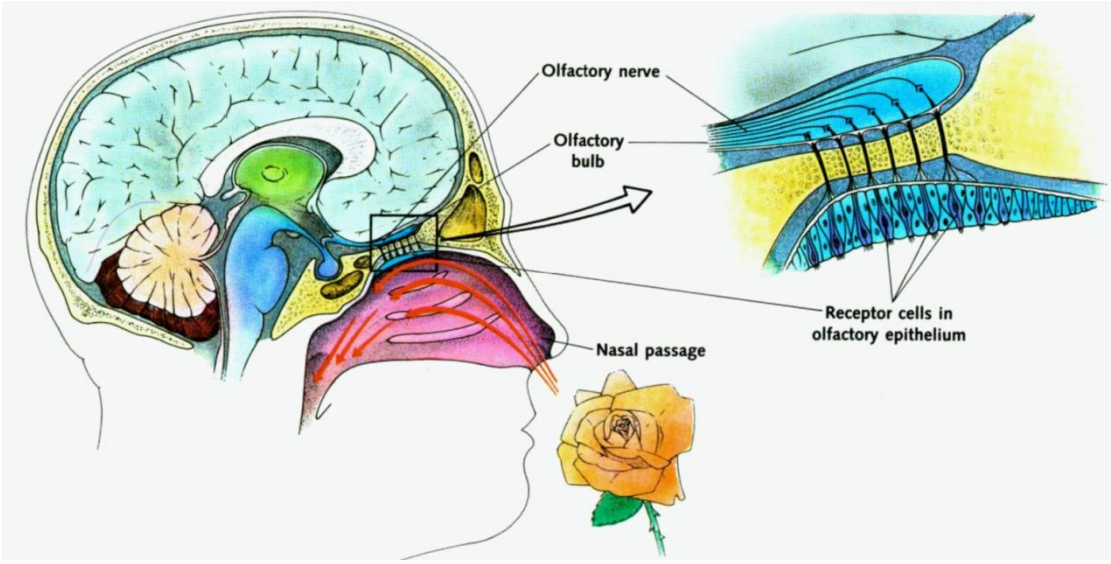
(b) Closeup of olfactory cells.



❖ Olfactory Mucosa:



❖ Nasal Anatomy:



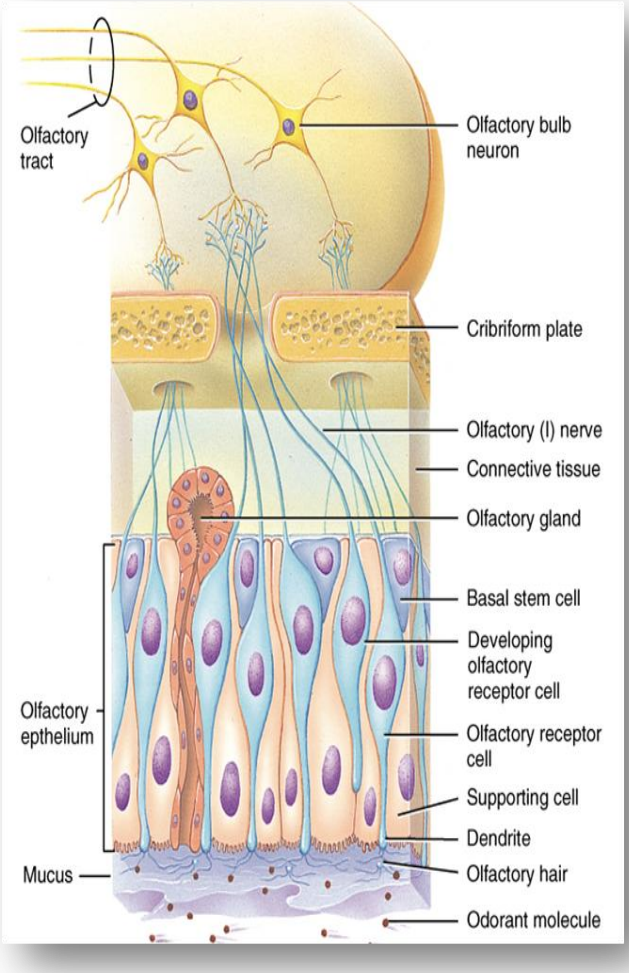
❖ **The Physiology of Smell (Olfaction)**:

- Olfactory Receptors:
  - Bipolar neurons with cilia
  - Receptors are genuine(real) neurons (Unlike photoreceptors and hair cells(not real neurons))

- Unlike other neurons, receptors are continually regenerated

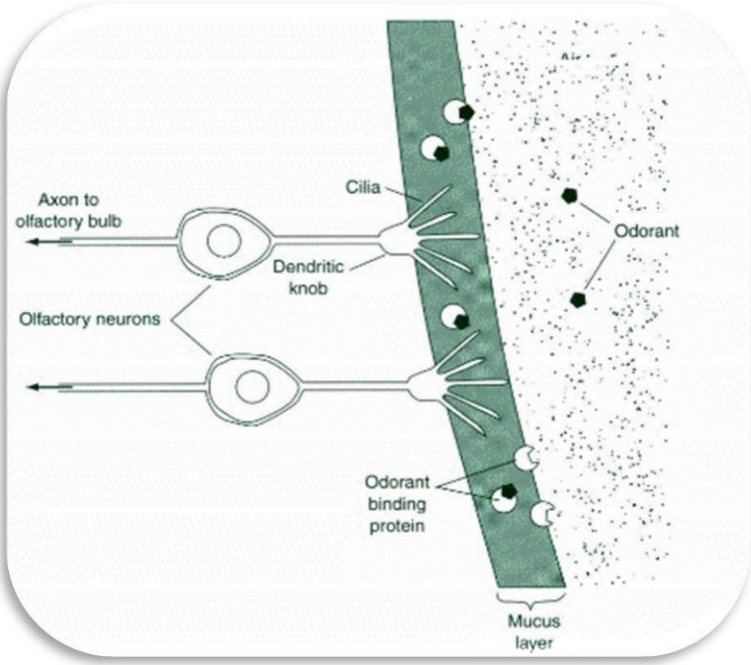
Cells of the Olfactory Membrane:

- Olfactory epithelium made up of three types of cells:
  - Olfactory receptors
    - bipolar neurons with olfactory hairs
  - Supporting cells
    - columnar epithelium
  - Basal stem cells
    - replace receptors monthly
- Olfactory (Bowman's) glands
  - produce mucus
    - Dissolves odorants



Q.Why do you loss the sense of smell during cold?

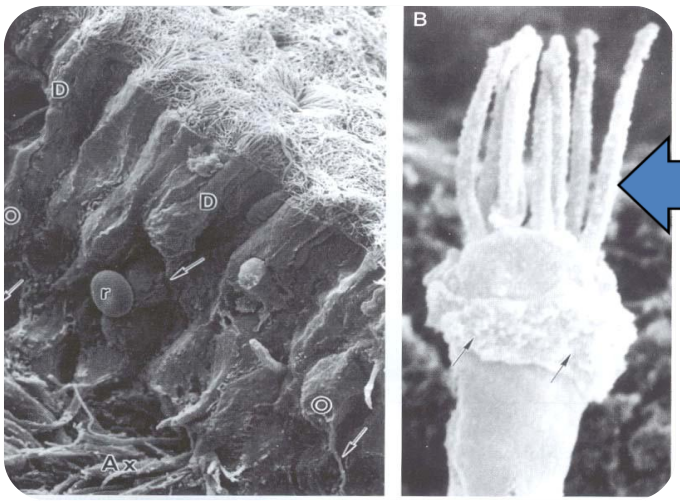
Because Olfactory epithelium is so inflamed that Olfactory receptors is covered. It is not because of increased mucus.



Olfactory Epithelium:

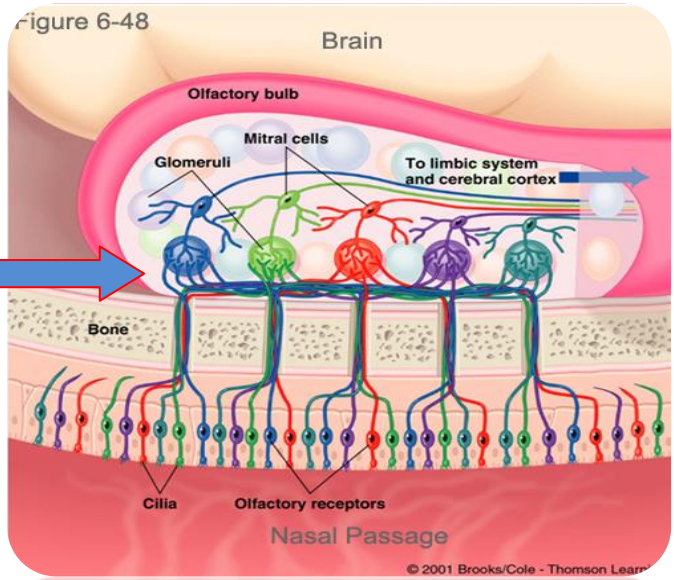
- Receptors have four parts:
  1. Cilia
  2. olfactory knob
  3. olfactory rod
  4. the axon
- Olfactory nerve - the axons of the olfactory receptors form bands which travel to the olfactory bulb

✓ BIPOLAR OLFACTORY NEURONS IN THE NOSE:

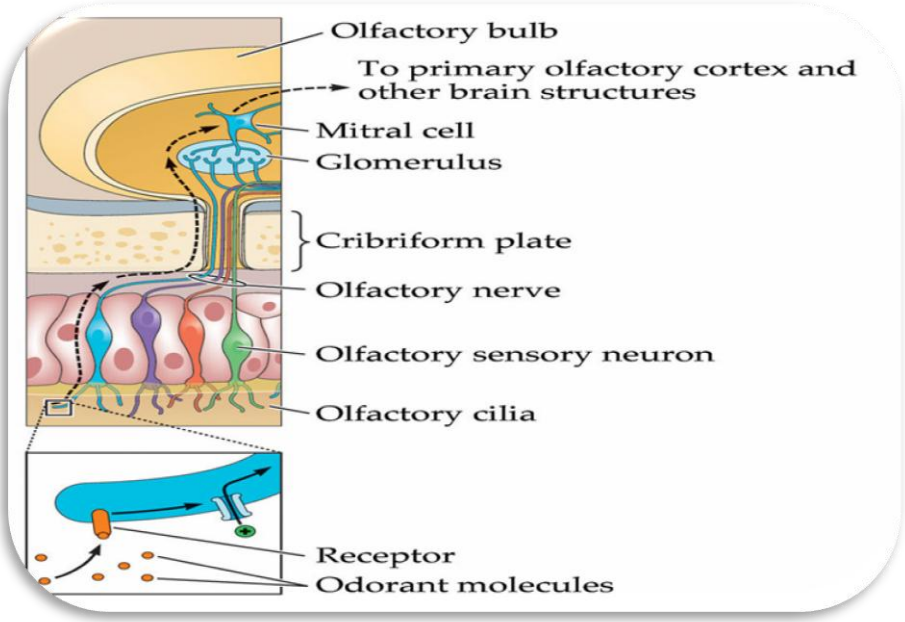


RECEPTORS FOR ODOR MOLECULES ARE IN THE CILIA.

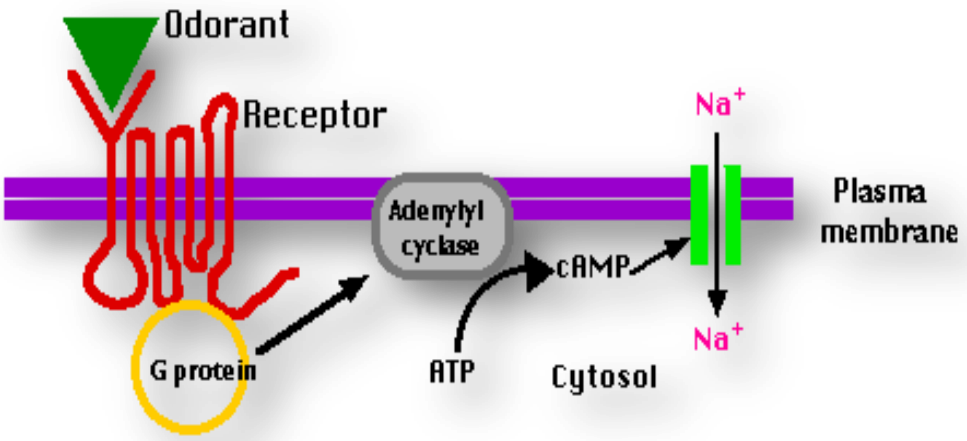
4 colors indicating 4basic tastes



Early Olfactory Pathway



- **Olfactory Receptors:**
  - Bipolar neurons with cilia
  - Mitose throughout life (only part of CNS that is known to regenerate)
  - Their axons project to the olfactory bulb



Molecules must dissolve in mucus

↓

Combine with receptors on the cilia

↓

Stimulation of a G-Protein

↓

Activation of Adenyl Cyclase

↓

Increase I.C. cAMP

↓

Opening of Na Channels

↓

Na influx

↓

Depolarization (Receptor Potential)

Olfactory Receptors

- Membrane bound proteins:
  Located in cilia on tips of olf. receptors
- Cause change in membrane potential of olf. receptors when bound by ligand
- 1000 different types of receptors Only 1 type per olf. receptors

Substance	Taste	Threshold conc ummol/l
HCl	Sour	100
NaCl	Salt	2000
Strichnine HCl	Bitter	1.6
Glucose	Sweet	80,000
Sucrose	" "	10,000
Saccharin	" "	23
Quinine Sulphate	Bitter	8

Substance	Threshold conc mg/Lair
Ethyl ether	5.83
Chloform	3.30
Oil of peppermint	0.02
Propyl mercaptan	0.006
Methyl mercaptan	0.0000004

Methyl mercaptan (Garlic)>>> have the looest threshold conc. Of 0.0000004

These tow table just to give you an idea you don't need to memorize it.

- **Discrimination of Intensity:**
  - Poor
  - Requires 30% increase of intensity
  - Strong smell highly water and lipid soluble
  - Man can distinguish 2000-4000 different odors

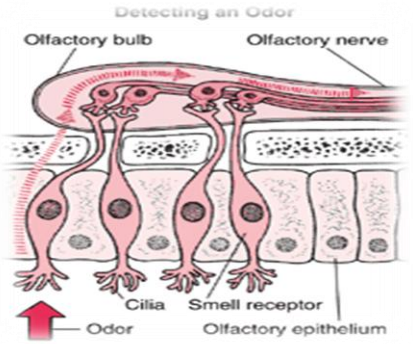
❖ Adaptation to Smell:

- Peripheral
- Central

Adaptation. The olfactory receptors adapt about 50 percent in the first second or so after stimulation. Thereafter, they adapt very little and very slowly. Yet we all know from our own experience that smell sensation adapt almost to extinction within a minute or so after entering a strongly odorous atmosphere. (page numbe668 in GUYTON& HALL text book)

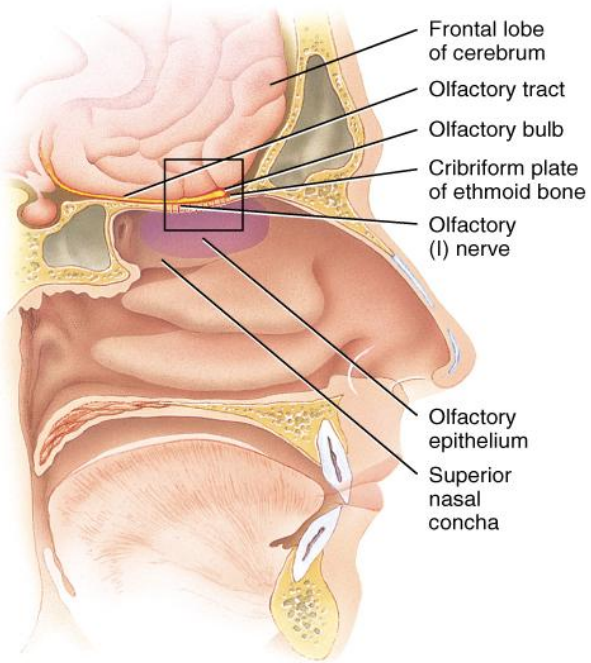
❖ Clinical Considerations:

- Abnormalities of the sense of olfaction:
  - Anosmia: Absence of the sense of smell
  - Dysosmia; Disturbed of the sense of smell
  - Hyposomia: Reduced of the sense of smell
    - ✓ Due toVitamin A deficiency and hypogonadism
  - Hyperosmia: Increased sense of smell (Adrenal insufficiency)



Olfactory Pathway

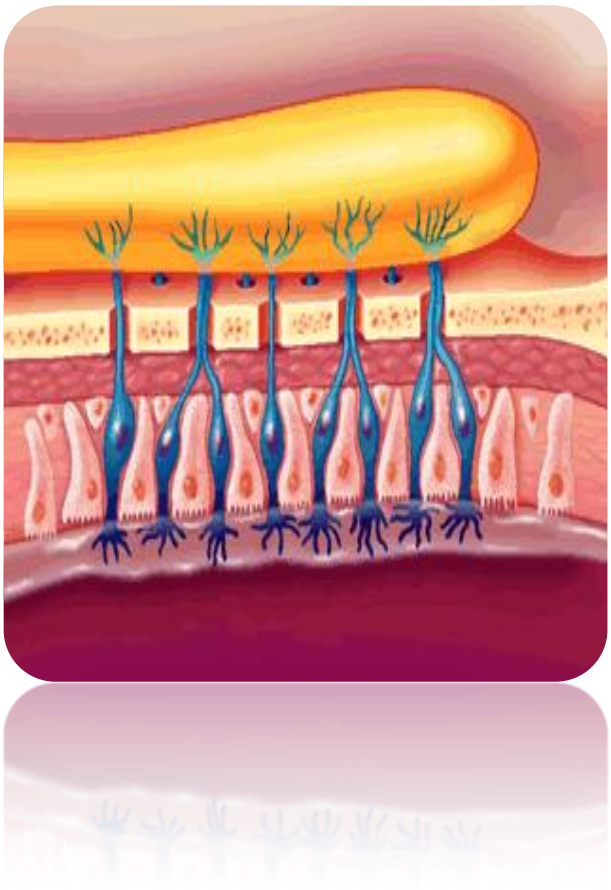
- Axons from olfactory receptors synapse in the olfactory bulb
  - Second-order neurons within the olfactory bulb form the olfactory tract
  - synapses on primary olfactory area of temporal lobe
  - conscious awareness of smell begins
- Other pathways lead to the frontal lobe where identification of the odor occurs



Brodmann area is part of frontal lobe where identification of the odour occurs.

Olfactory Bulb

- Organized into 4 zones
- Glomerulus
  - Primary structure w/in bulb- receives input from 5,000-10,000 ORN (input predominately from 1 type of ORN)
  - 1000-2000 glomeruli



Chemical Senses

- "Gatekeepers": molecule detectors
  - identify what the body needs for survival
  - identify what is dangerous and should be rejected
- Neurogenesis: constant renewal of receptors
  - Taste cells = 10 days
  - Olfactory receptors = 30-60 days
- Affective component: emotions aid in discrimination of molecules (good vs. bad)

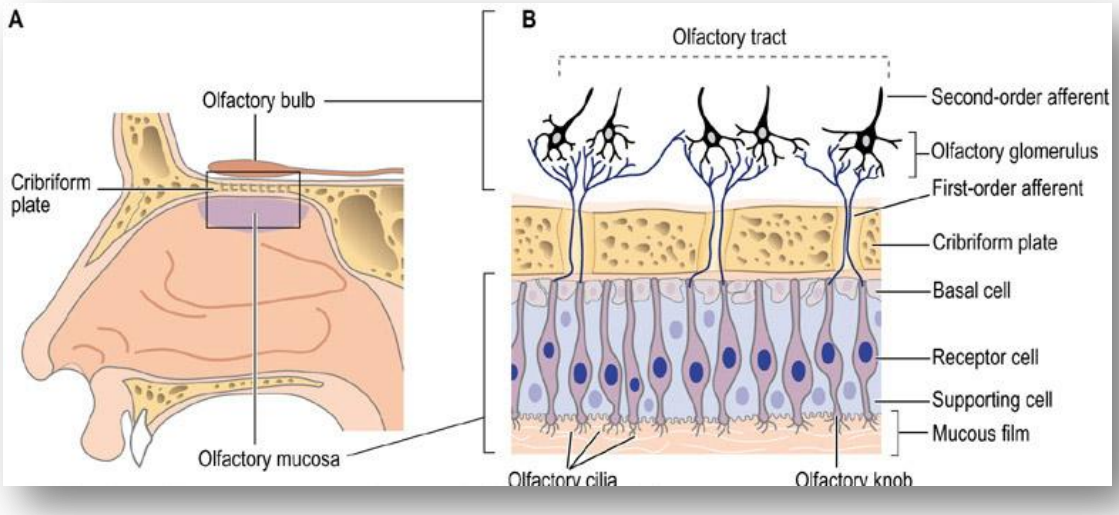
Chemoreception -Taste & Smell

- In humans chemoreceptive senses have been refined into the special senses of smell (olfaction) and taste (gustation).
- Taste and smell send information to phylogenetically old areas of the brain associated with memory and emotion.
- Taste plays a vital role in food selection, sweet and umami are associated with nutritious food. Bitter tastes are associated with the possible presence of toxins and are usually avoided.
- Taste and smell are closely linked even though they involve different receptors and receptive processes. This may suggest an overlap in central processing.
- In many species olfactory stimuli play an important role in reproduction (pheromones) although not well developed in humans.
- Taste, and to a lesser extent smell, regulate gastrointestinal secretions.
- Smell is directional.

Olfaction – Smell - Summary

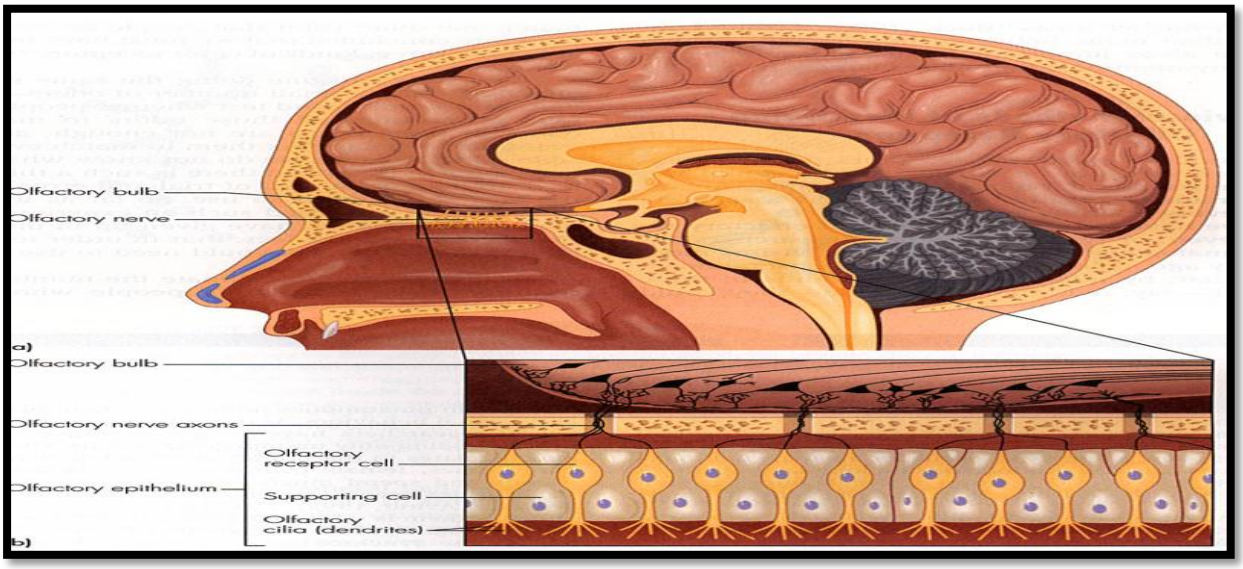
- Olfactory receptors are confined to about 5 cm^2 of the olfactory mucosa and lay deep within the nasal cavity.
- Cilia on the olfactory receptive neurones bind with odorants and the transduction process involves a G-protein second messenger system.
- There is a greater range of olfactory sensitivity than the for the limited modalities associated with taste. They are broadly subdivided into seven primary qualities of smell; peppermint, musk, floral, ethereal, pungent, putrid and camphoreaceous.
- There is functional mapping of specific odours to specific regions within the olfactory tract.
- The bipolar olfactory cells are linked to the olfactory bulb via short axons. The output from the olfactory bulbs project via the olfactory tracts to both the ipsi- & contralateral olfactory regions of the cortex.

Olfaction - form & function

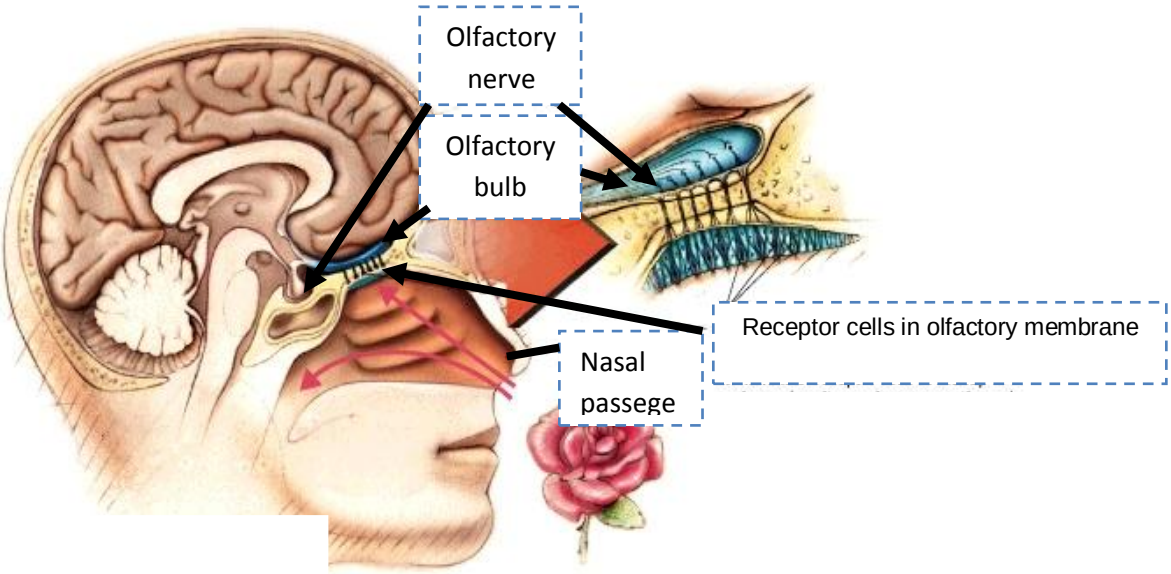


Sniffing directs air onto the olfactory mucosa. Odorants are absorbed into the mucous layer overlying the receptors. Diffusion through the layer brings the odorants into contact with the olfactory cilia, where they bind with receptors (odorant-binding proteins). This leads to an activation of a second messenger system which depolarises the the receptive cell and initiates action potentials which are propagated to the olfactory bulb. The receptor cells are grouped according to their primary qualities and the selectivity arises from the properties of the ca 1,000 different odorant-binding proteins.

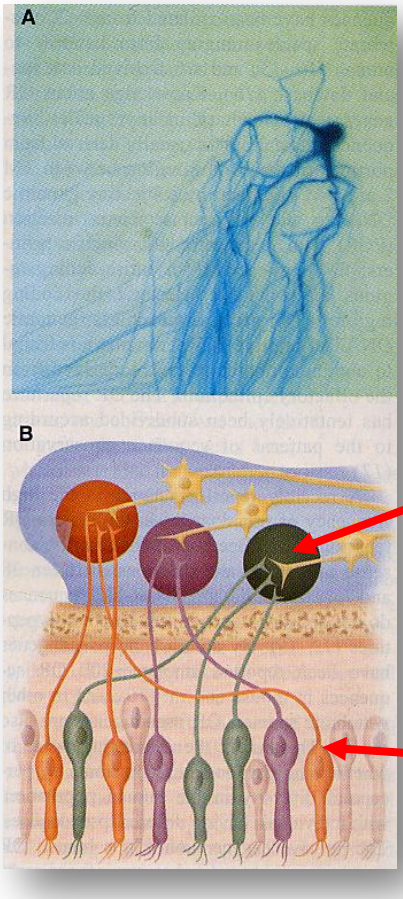
Olfactory system, receptors and bulb



Smell



But what's interesting is how it is wired up



Each sensory cell type connects to

a particular pair of glomeruli

Each sensory cell expresses

one receptor type (indicated by color)

Different colors represent different for the sensory cells

Recent Advances in Olfactory Physiology

❖ How does the sense of smell work?

- Discovered fairly recently (1991)
- Nobel prize in 2004, to Richard Axel and Linda Buck
- Discovered in part thanks to molecular biology and genetic engineering
- How did they do it?
- There are three visual receptors (to distinguish different colors)
- Buck got the idea that maybe smell receptors might be similar
- She used a genetic technique called the Polymerase Chain Reaction (PCR) to find them
- There are about 1000 different smell receptors in humans!

Olfacti