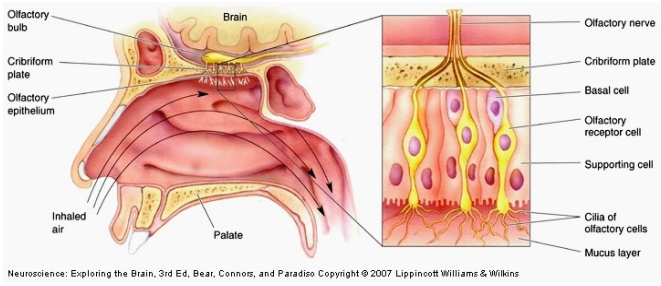
## **Smell (Olfaction):** detection of Odorants

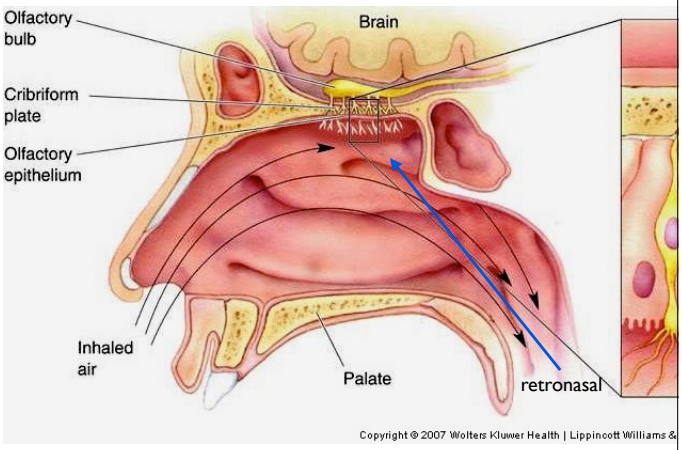
- Olfactory epithelium -> Olfactory Bulb
- Activate transduction processes in neurons
  - Olfactory axons constitute olfactory nerve (cranial nerve I)
  - Cribriform plate: A thin sheet of bone through which small clusters of axons penetrate, coursing to the olfactory bulb
  - Anosmia: Inability to smell

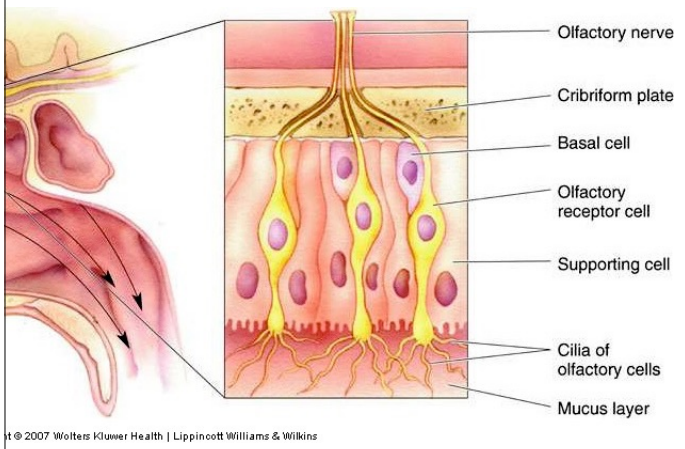
### Olfactory epithelium

- Olfactory sensory epithelium contains Olfactory Sensory Neurons (OSNs)
- Covers much of the upper two ***turbinates*** (shelf-like projections inside the nose) and
- Extends down nasal septum (central divider)
- Approx. 1-2 million OSNs per side in humans.

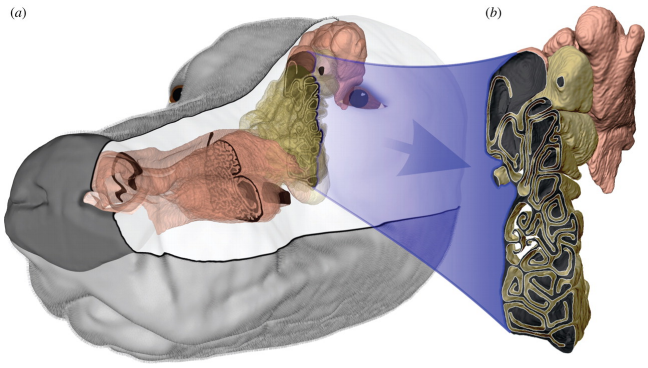








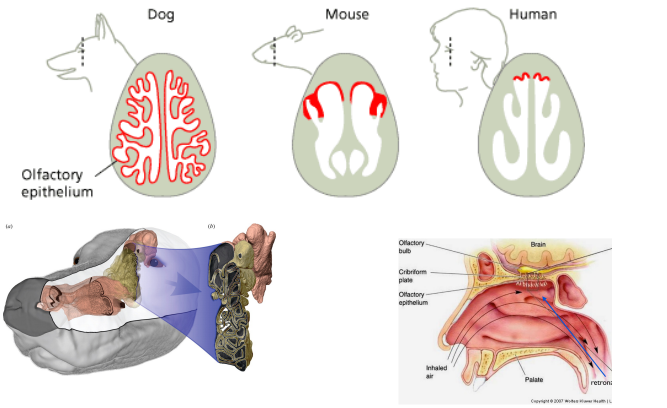




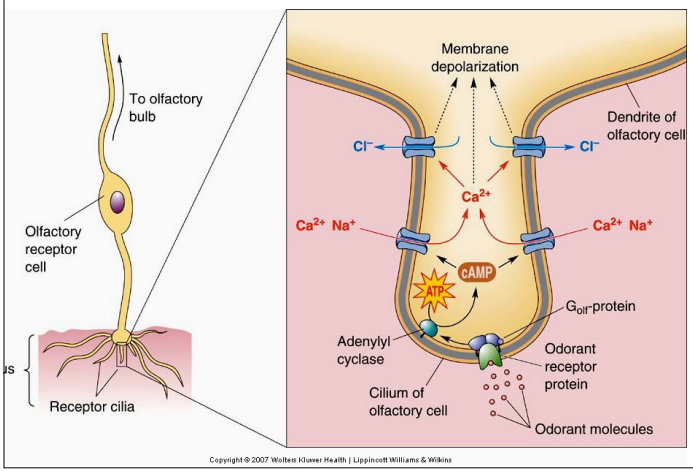

**220 million olfactory receptors**
**1000x more sensitive to odors**

Cross section of nasal cavities

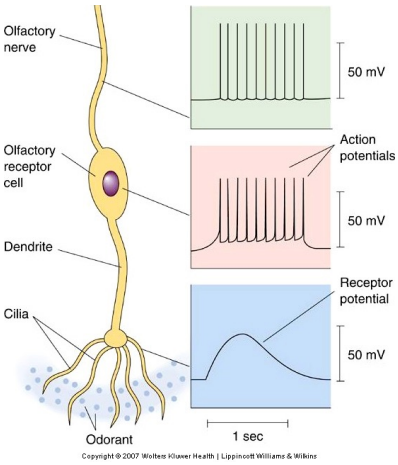
**5 million olfactory receptors**



## Olfactory Receptor Neurons:
G-protein coupled receptors with $G_{olf}$ proteins

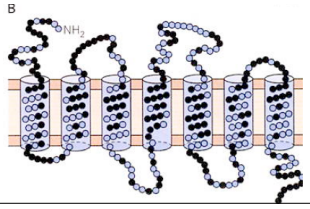


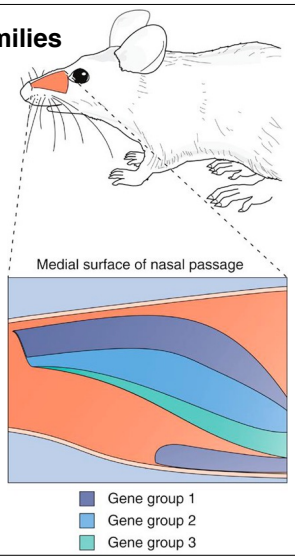

## Olfactory Transduction by Olfactory Receptor Neurons




## Olfactory Receptor Gene Families

- **1000 genes for 7-TMD G-protein coupled receptors**
- **Each sensory neuron expresses only one OR gene (and only one allele).**
- **Sequences vary between subfamilies and individual genes especially in the transmembrane domains that probably form binding pocket for odor molecules.**
- **Suggests large number of odors recognized.**



**A single object may have a complex mixture of odor molecules**

Jasmine odor

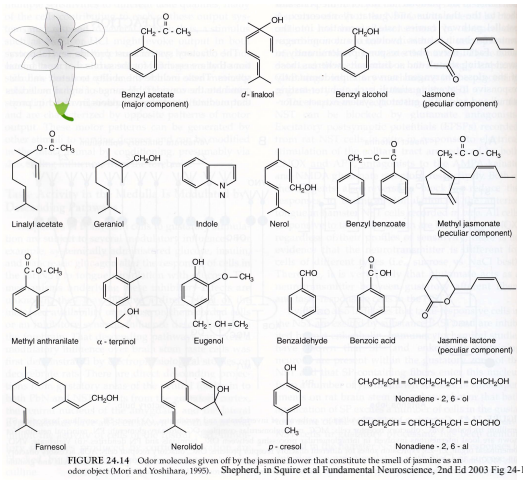
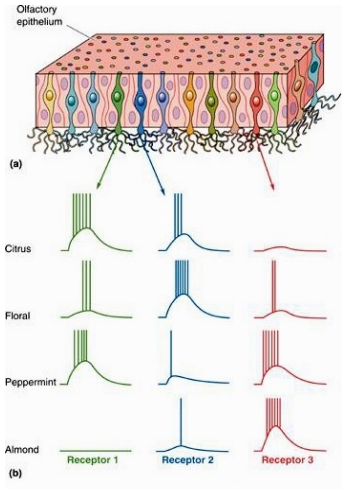


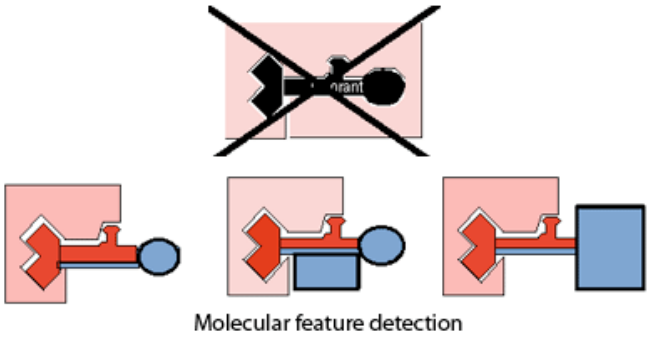

FIGURE 24.14 Odor molecules given off by the jasmine flower that constitute the smell of jasmine as an odor object (Mori and Yoshihara, 1995). Shepherd, in Squire et al Fundamental Neuroscience, 2nd Ed 2003 Fig 24-14

Some components be may major contributors to odor, some "peculiar" to odor blend, all essential

**Olfactory Stimulus is detected by specific combination of multiple Olfactory Receptors**




Odorants are not recognized as specific molecule *in toto* by single receptor type



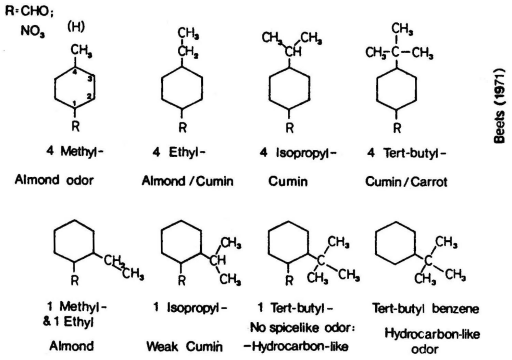
Molecular feature detection

Different features of an odorant molecule are recognized by multiple specific receptors

http://leonserver.bio.uci.edu/about/ourResearch/molecularFeatures.jsp

## Odor quality = binding to combination of receptors

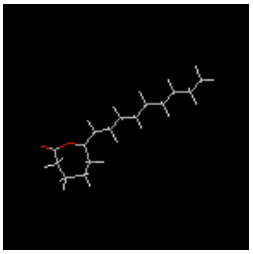
- not easily predicted.
- odor molecules can bind to several different ORs with different affinities. Changing molecular structure should produce subtle shifts in odor quality perception as an OR is more strongly activated and another less strongly.
- Deletion of one OR ***should not*** (generally) produce ***anosmia*** for ***any*** molecule that can bind to many OR receptors (but may cause a change in perception)




## Specific Anosmia due to loss of one or more OR

Some specific anosmias, the inability to detect one odor-molecule structure or small range of structures may be inherited as single gene defects.

Musk - specific anosmia is an example.
Thresholds for pentadecalactone were greater than 100x higher for some subjects who had normal thresholds for other odors.



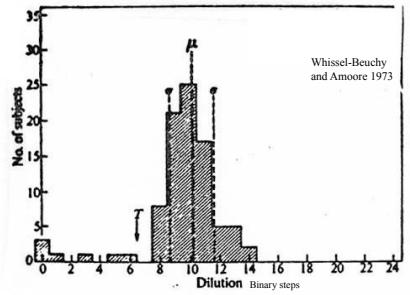
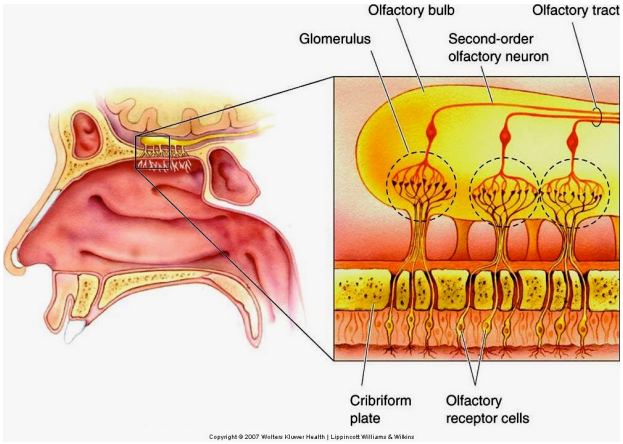


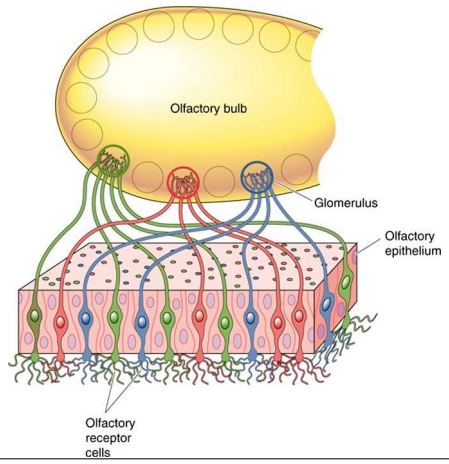

Fig. 1 Olfactory thresholds of ninety persons to pentadecalactone dilutions in water. μ, Mean normal threshold; σ, standard deviation; T, test concentration for distinguishing specific anosmics.

## Smell: Central Olfactory Pathways

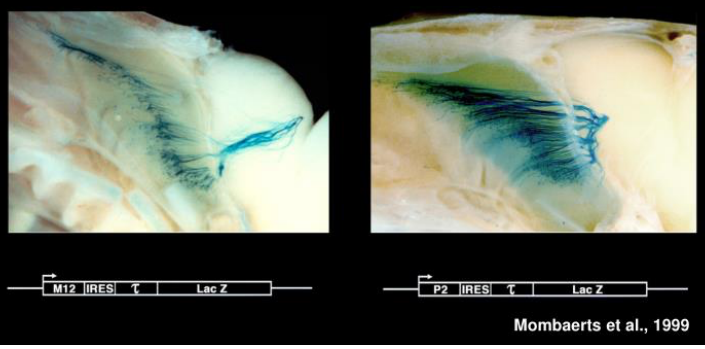


## Central Olfactory Pathways

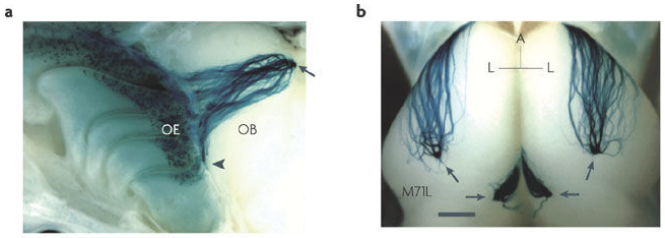
**all receptor cells with same receptor type project to single glomerulus pair.**




## Convergence of olfactory sensory neurons with the same receptors to a single glomerulus



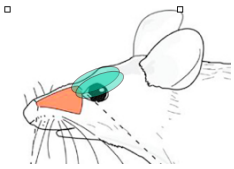

Mombaerts et al., 1999

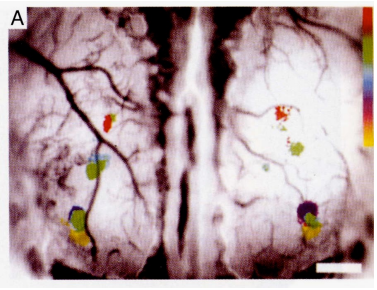


**Cells expressing each OR type converge axons onto one glomerulus** (per side of bulb)

**-> spatial map of odor-features on the surface of the main olfactory bulb**

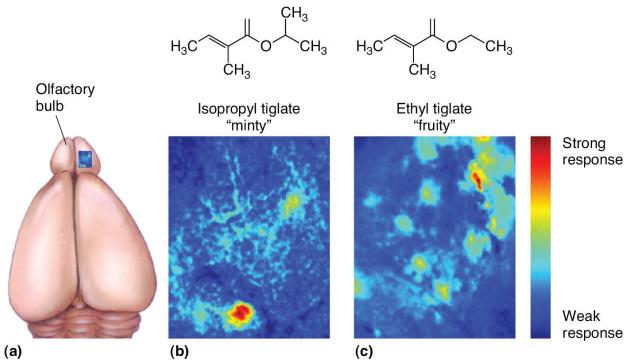
Intrinsic imaging (blood flow) or Voltage Sensitive Dyes (Depolarization) or $Ca^{++}$ imaging reveals individual glomerular activation.






(Belluscio and Katz '01)

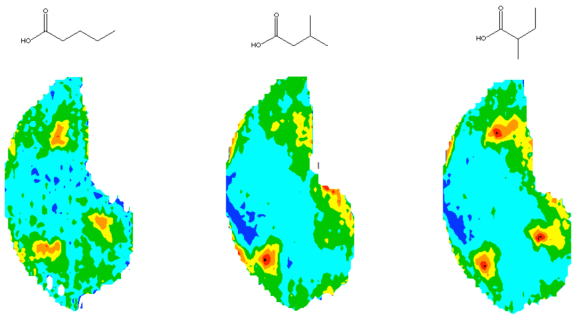
**Surface view of olfactory bulb: Fluorescent (and false-colored) patches = active glomeruli. Number/size of patches increases with odor concentration (intensity)**




**Cells expressing each OR type converge axons onto one glomerulus** (per side of bulb)

**- forming a spatial map of odor-features on the surface of the main olfactory bulb**

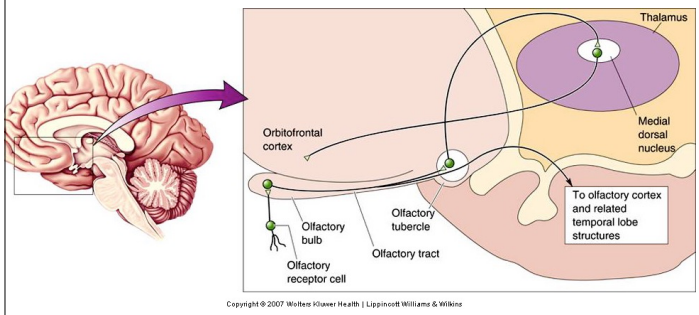
Complete maps of 2-deoxyglocose activation over MOB surface (2DG uptake = metabolic activity) show common "modules" activated by odors that share molecular features (Johnson and Leon 2000)




Olfactory Bulb odor maps (unfolded) for aliphatic acids http://leonserver.bio.uci.edu/

## Central Olfactory Pathways (Cont'd)

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





## SMELL AND TASTE DISORDERS (MOTT AND LEOPOLD 1991)

| ETIOLOGY | PERCENT | DISORDER | COMMON TREATMENT |
|---|---|---|---|
| NASO-SINUS DISEASE Obstruction (e.g. polyps), Sinusitis/ Rhinitis | 21% | Olfaction, Taste | Surgery, Topical Corticosteroids |
| UPPER RESPIRATORY TRACT INFECTION (viral) | 19% | Olfaction Taste | Some spontaneous recovery? (15%, 1yr) |
| HEAD TRAUMA | 21% | Olfaction (14%) Taste (0.5%?) | Some spontaneous recovery ? (8-39%) long time course |
| ENVIRONMENTAL/ DRUG | 2% | Olfaction Taste | Remove cause |
| OTHER (Iatrogenic, Congenital, Age, CNS Alzheimer's, Sjogren's syndrome) | 21% | Olfaction, Taste | (Sjogren: antifungal) |
| IDIOPATHIC (Unknown) | 21% | Olfaction, Taste | |

**Chemosensory disorders can be life-threatening (gas-leaks, smoke, spoiled food). Severe deficits, with no appreciation of food, odors, etc., are a devastating loss of quality of life.**