

# Chemical Senses



Einstein's tongue, on his 70th birthday

## **Chemical senses give us information about our environment**

- Allows us to identify thousands of chemicals, both alone and in mixtures
  - Detect and differentiate between nutrients
  - Detect and avoid poisons
  - Detect danger (smoke from a fire)

## Humans have 2 main chemical senses:

- **Taste**

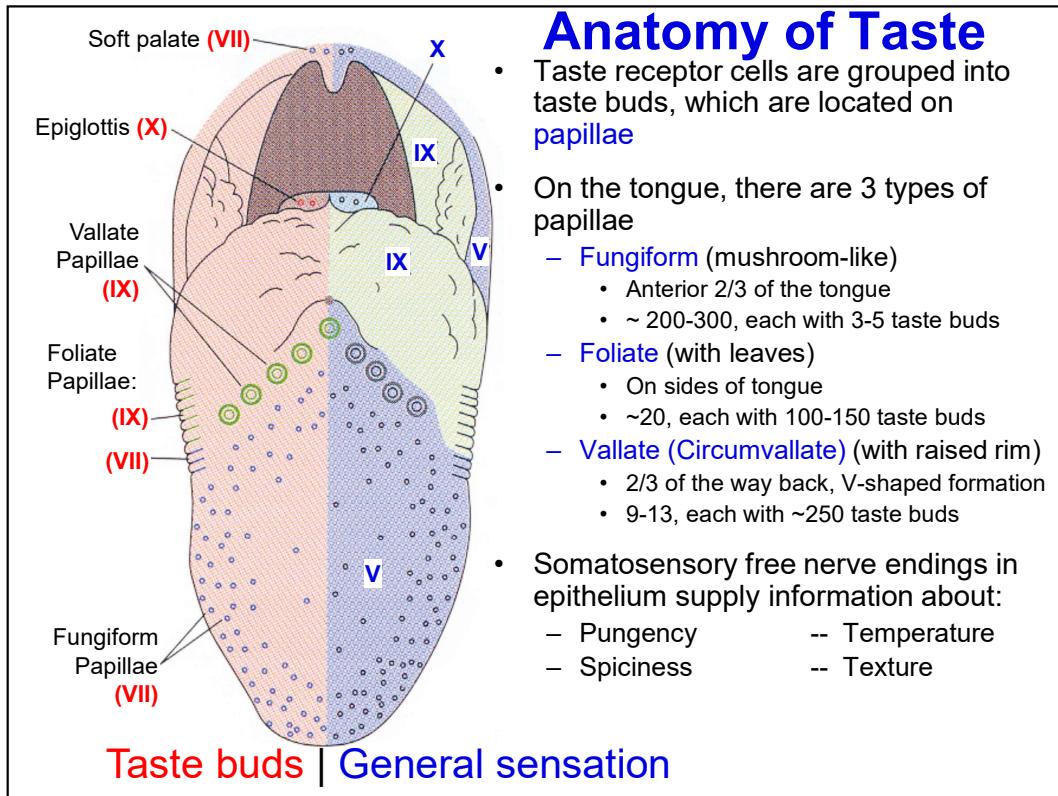
- Specialized “Gustatory” receptor cells grouped into taste buds
    - Tongue - ~4600 taste buds
    - Palate } ~1500 taste buds
    - Epiglottis }
    - Pharynx }
- Highly variable! (100x difference in #taste buds/person)

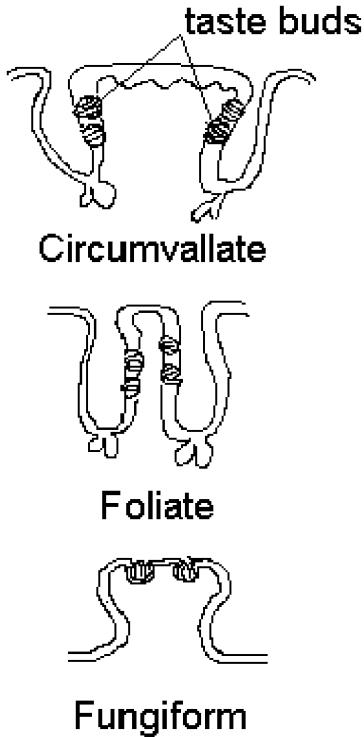
- Information carried to the CNS via CN 7,9,10
- Complementary information (texture, pain) carried by CN 5

- **Smell**

- Specialized “Odorant” receptor cells
  - Nasal epithelium
- Information carried by CN 1



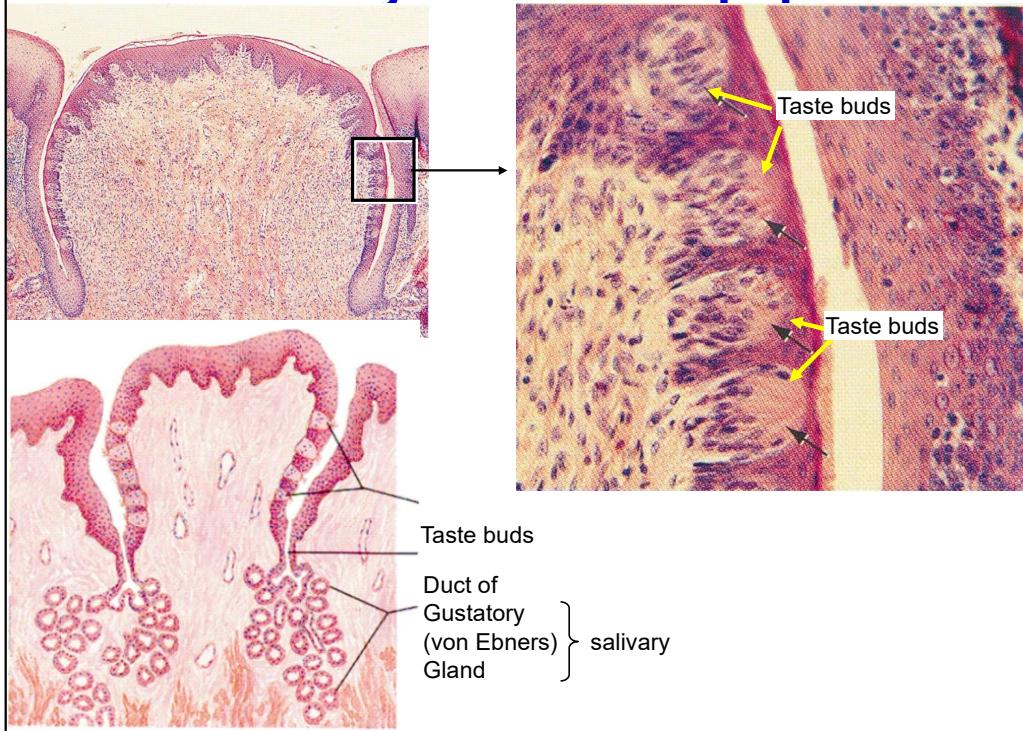




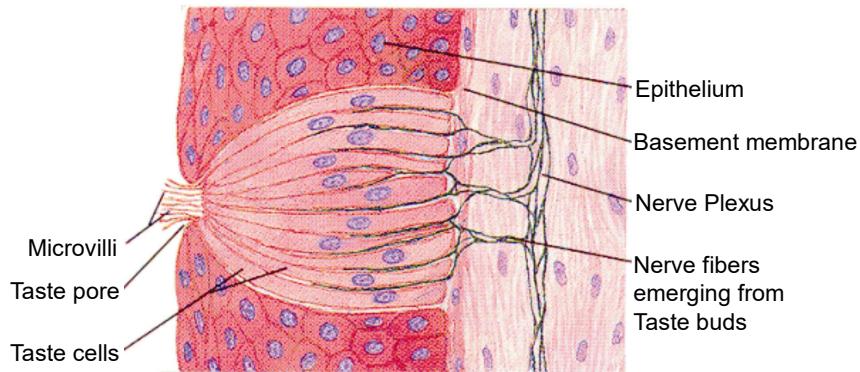
## Location of Taste Buds

- Taste buds are located in different places on different kinds of papillae, but they have similar structures

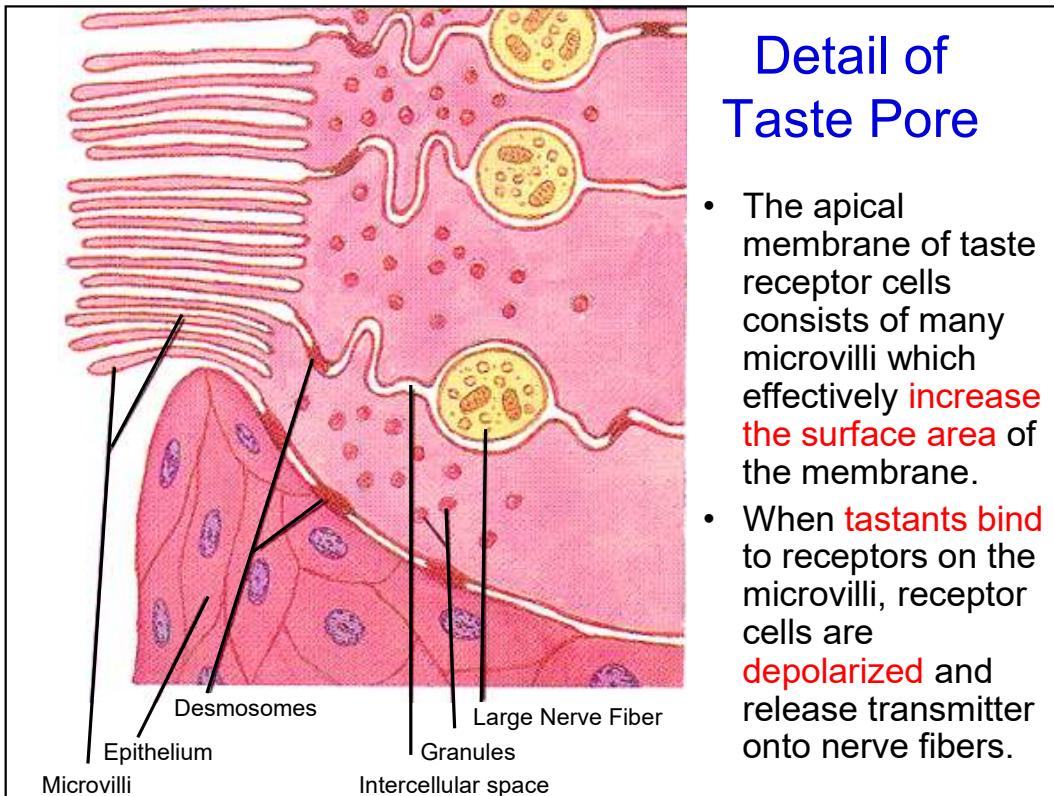
## Anatomy of a Vallate papilla



## Anatomy of a Taste Bud



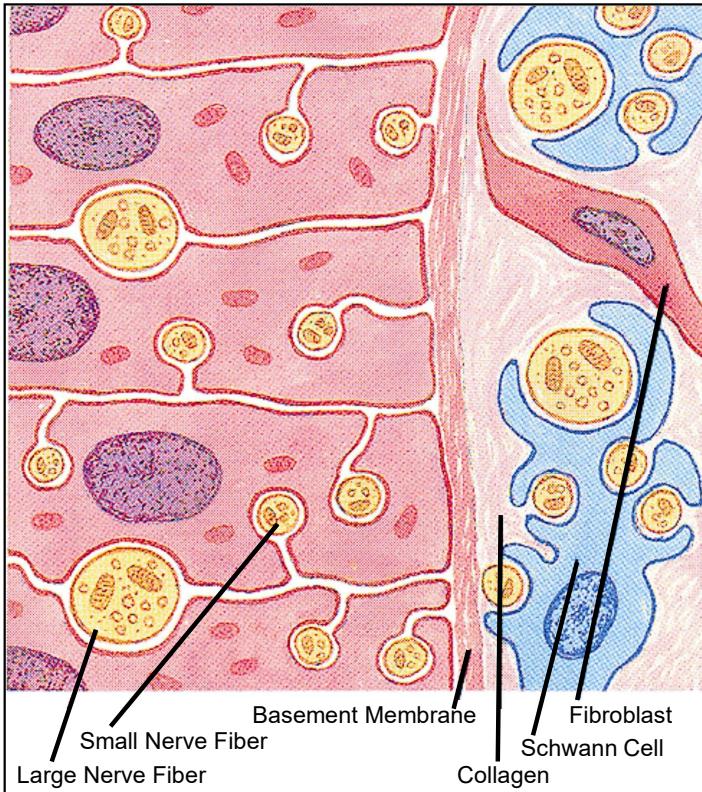
- Taste buds are groups of modified epithelial cells (~100), whose apical membrane is exposed to the surface through a small **taste pore**.
- Receptor cells release transmitter onto nerve fibers which cross the basement membrane at the base of the taste bud to join **CN 7, 9, or 10** depending on where the taste bud is located.



## Detail of Taste Pore

- The apical membrane of taste receptor cells consists of many microvilli which effectively **increase the surface area** of the membrane.
- When **tastants bind** to receptors on the microvilli, receptor cells are **depolarized** and release transmitter onto nerve fibers.

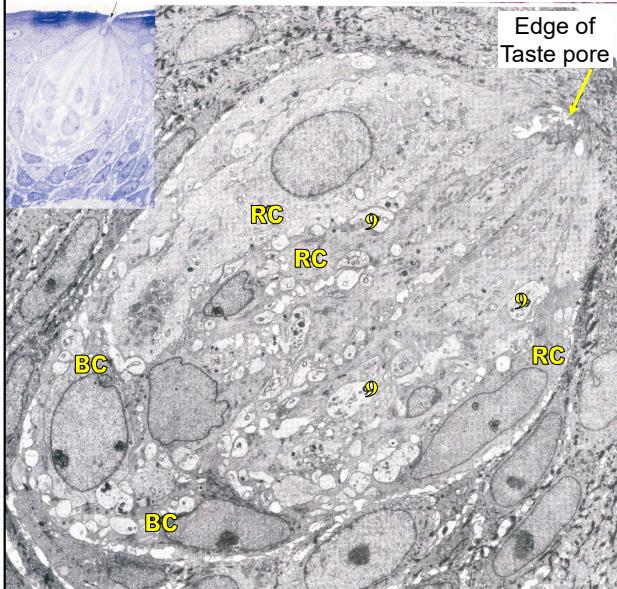
Taste buds on the tongue respond to various chemical stimuli. Taste cells, like neurons, normally have a net negative charge internally and are depolarized by stimuli, thus releasing transmitters that depolarize neurons connected to the taste cells. A single taste bud can respond to more than one stimulus. The four traditional taste qualities that are sensed are sweet, salty, sour, and bitter. Umami, or the taste of amino acids, was more recently added to the list.



## The Basal Part of the Taste Bud

- The basolateral membrane of taste receptor cells is separated from the extracellular collagen by the **basement membrane**.
- Once they cross the basement membrane, nerve fibers become **myelinated by Schwann cells**.

## Lifespan of Taste Receptor Cells



RC=Receptor cells  
BC=Basal cells  
9= CN 9

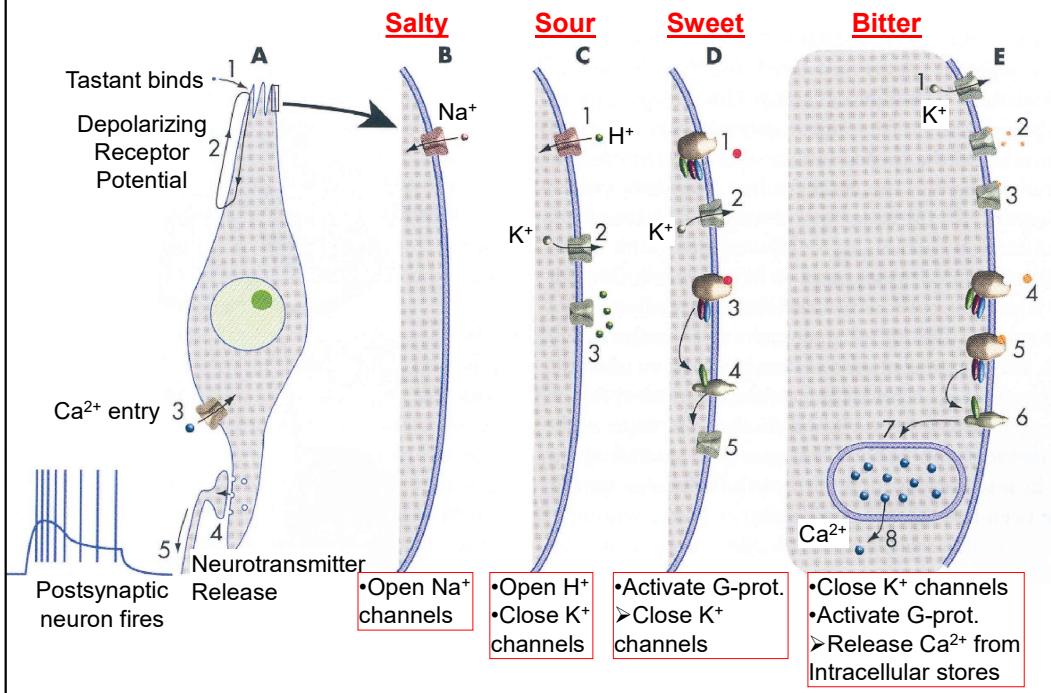
- Taste receptor cells have a lifespan of 1-2 weeks.
- They are replaced via differentiation of **basal cells** migrated from epithelium.
- Chemical signals from gustatory nerves are required for maintenance of taste receptor cells
  - Denervation of the tongue causes degeneration of taste buds in the affected region

## Physiology of Taste

- Tastants fall into 5 main categories
  - Sweet
  - Salty
  - Sour
  - Bitter
  - Umami
- All parts of the tongue are sensitive to all tastants
  - Some areas of tongue are *relatively* more sensitive to one tastant or another:

<u>Part of Tongue</u>	<u>Tastant</u>
Tip	Sweet
Sides	Salt and Sour
Posterior	Bitter
  - Each individual taste receptor cell may be able to detect more than one tastant (this is controversial)

# Physiology of Taste



## Other Tastants

- Umami (=delicious) is the taste of amino acids
  - Glutamate (13 g/pound of steak)
  - Aspartate
- These Amino acids bind to a metabotropic glutamate receptor
  - mGluR4
  - G-protein coupled receptor leading to ↑ intracellular  $[Ca^{2+}]$
- Monosodium Glutamate is added to foods as flavor enhancer
  - Thought to also activate NMDA-type glutamate receptors on taste receptor cells, partially depolarizing them and making it easier for other tastants to produce effective receptor potentials.

## Sensitivity

- People have widely differing abilities to taste things
- May be due to a hundred-fold difference in numbers of taste receptor cells
- May be due to genetic differences in expression of receptors for any given compound
- Example: Phenylthiocarbamide (PTC) - a highly (!) bitter chemical (Fox AF. Six in ten "tasteblind" to bitter chemical. *Sci News Lett* 1931;9:249.)

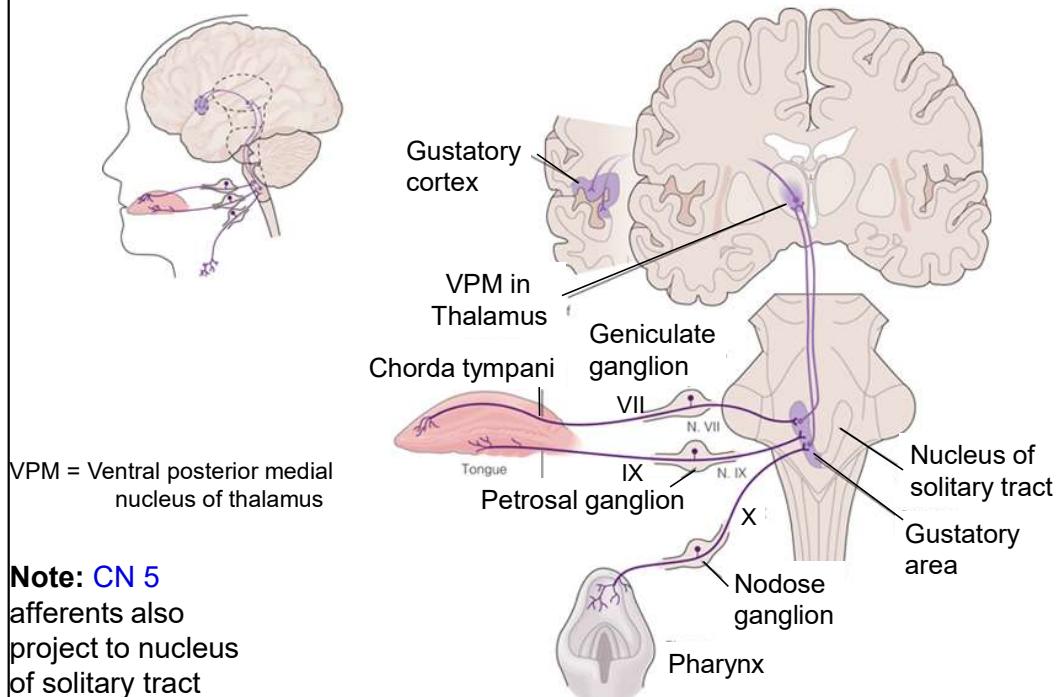
	% of population	*density of taste papillae cm <sup>-2</sup>
supertasters	25	165
normal tasters	50	127
non-tasters	25	117

\* Density at tip of tongue; bitter taste is actually more acute at back of mouth, but papillae are harder to count there.

Note that this is useful only as a correlation, Genetic expression of receptors is not necessarily associated with density of papillae

- Also works for broccoli, grapefruit, coffee, etc.
- Amongst Europeans, 60 -70 % are tasters
- Unusually high number of Native Americans are tasters

# Neural Pathway



**Diagram of taste pathways.** Signals from the taste buds travel via different nerves to gustatory areas of the nucleus of the solitary tract which relays information to the thalamus; the thalamus projects to the gustatory cortex.

## Gustatory dysfunction

**Ageusia** (complete loss)

**Hypogeusia** (partial loss)

**Parageusia** (unpleasant taste)

**Dysgeusia** (inaccurate taste)

- Perturbations of taste are usually a function of loss of smell
  - Total loss is rare
- may be caused by neural damage to CN 7,9, or 10
- Bell's Palsy, Multiple sclerosis
- Aging
- Vitamin deficiency (B3, zinc)
- Some medications
  - Penicillamine (antirheumatic)
  - Clarithromycin (antibiotic)
  - Zopiclone (sedative)
  - Cisplatin (antineoplastic)
  - ACE inhibitors (antihypertensive)
- Tobacco use

## Taste disturbances associated with various medical conditions

### 1. COVID-19

- Viral effects on the olfactory and taste receptors in the upper respiratory tract
- Dysgeusia, hypogeusia, ageusia
- Often accompanied by loss of smell (anosmia)

### 2. Neurodegenerative Diseases (Alzheimer's, Parkinson's)

- Taste disturbances due to the involvement of brain areas responsible for taste processing.
- Altered taste perception leads to change in food preferences
- May lead to malnutrition

### 3. Zinc deficiency

- Can occur in malnutrition, alcoholism, GI disorders, or other conditions affecting nutrient absorption
- Can reduce ability to taste certain flavors: esp. sweet or salty

Taste disturbances, also known as taste disorders or dysgeusia, can occur in association with various medical conditions. Here are some examples of taste disturbances associated with specific medical conditions:

1.COVID-19: During the COVID-19 pandemic, taste disturbances emerged as a common symptom. Some individuals infected with the SARS-CoV-2 virus reported experiencing temporary loss of taste, known as anosmia, or alterations in taste perception, such as hypogeusia (reduced taste sensitivity) or ageusia (complete loss of taste). This phenomenon, often accompanied by loss of smell (anosmia), is thought to be related to viral effects on the olfactory and taste receptors in the upper respiratory tract.

2.Neurodegenerative Diseases: Neurodegenerative diseases like Alzheimer's disease and Parkinson's disease can be associated with taste disturbances due to the involvement of brain areas responsible for taste processing. In Alzheimer's disease, patients may experience altered taste perception, leading to changes in food preferences and potentially contributing to malnutrition. In Parkinson's disease, taste disturbances may result from damage to brain structures involved in taste sensation.

3.Zinc Deficiency: Zinc is essential for taste perception, and its deficiency can lead to taste disturbances. Zinc deficiency can occur in malnutrition, alcoholism, gastrointestinal disorders, or other conditions affecting nutrient absorption. A common manifestation of zinc deficiency is a reduced ability to taste certain

flavors, particularly sweet and salty tastes.

4. Chemotherapy and Radiation Therapy: Cancer patients undergoing chemotherapy or radiation therapy may experience taste disturbances as a side effect. This condition, known as chemotherapy-induced taste changes, can lead to altered taste perception and aversions to certain foods, impacting the patient's nutritional status and quality of life.

5. Autoimmune and Inflammatory Diseases: Some autoimmune and inflammatory conditions, such as Sjögren's syndrome and Behçet's disease, can cause taste disturbances as part of their clinical manifestations. The immune system's attack on the taste buds or nerves involved in taste perception can lead to altered taste sensations.

6. Diabetes Mellitus: Diabetes mellitus can affect taste perception due to changes in blood sugar levels and nerve damage (diabetic neuropathy). Patients with diabetes may experience taste alterations, making them less sensitive to sweet tastes, leading to changes in dietary habits.

7. Gastrointestinal Disorders: Gastrointestinal conditions like gastroesophageal reflux disease (GERD) or chronic gastritis can cause acid reflux and inflammation in the oral cavity, affecting taste perception. Taste disturbances may also occur due to the presence of a metallic taste or unpleasant taste sensations associated with certain digestive disorders.

It is essential for healthcare professionals to be aware of these taste disturbances associated with specific medical conditions, as they can have significant implications for patients' nutritional status, dietary preferences, and overall quality of life. Addressing taste disturbances in the context of these medical conditions requires a multidisciplinary approach, involving nutritionists, otolaryngologists, neurologists, and other specialists to provide appropriate management and support to affected individuals.

## Taste disturbances associated with various medical conditions

### 4. Chemotherapy and Radiation

- Altered taste perception and aversions to certain foods
- May impact nutritional status

### 5. Autoimmune and Inflammatory Diseases (Sjogren's, Behcet's)

- Autoimmune attack on taste buds or taste perception nerves

### 6. Diabetes Mellitus

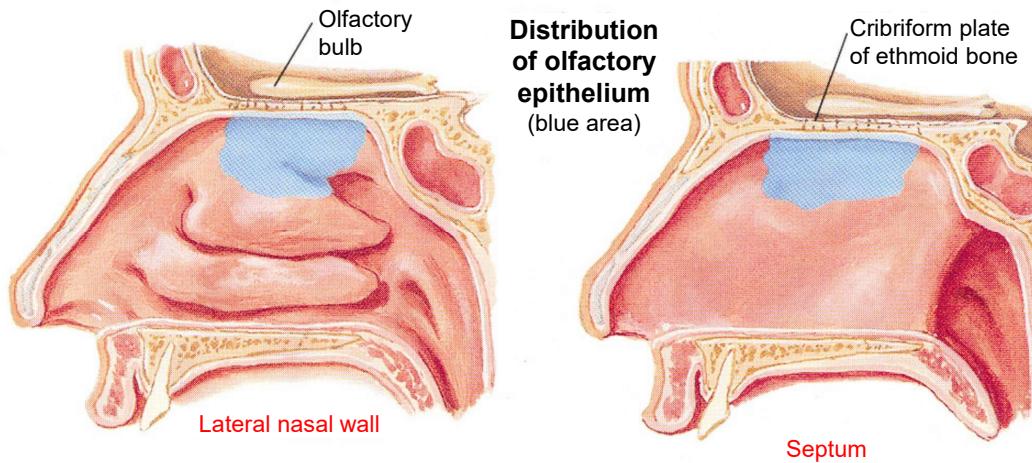
- Diabetic neuropathy
- May cause sweet taste in mouth (without food)
- Less sensitive to sweet foods

### 7. GI disorders

- GERD or chronic gastritis
- Acid reflux and inflammation of oral cavity
- Some GI disorders may elicit metallic or unpleasant taste
- Can reduce ability to taste certain flavors: esp. sweet or salty

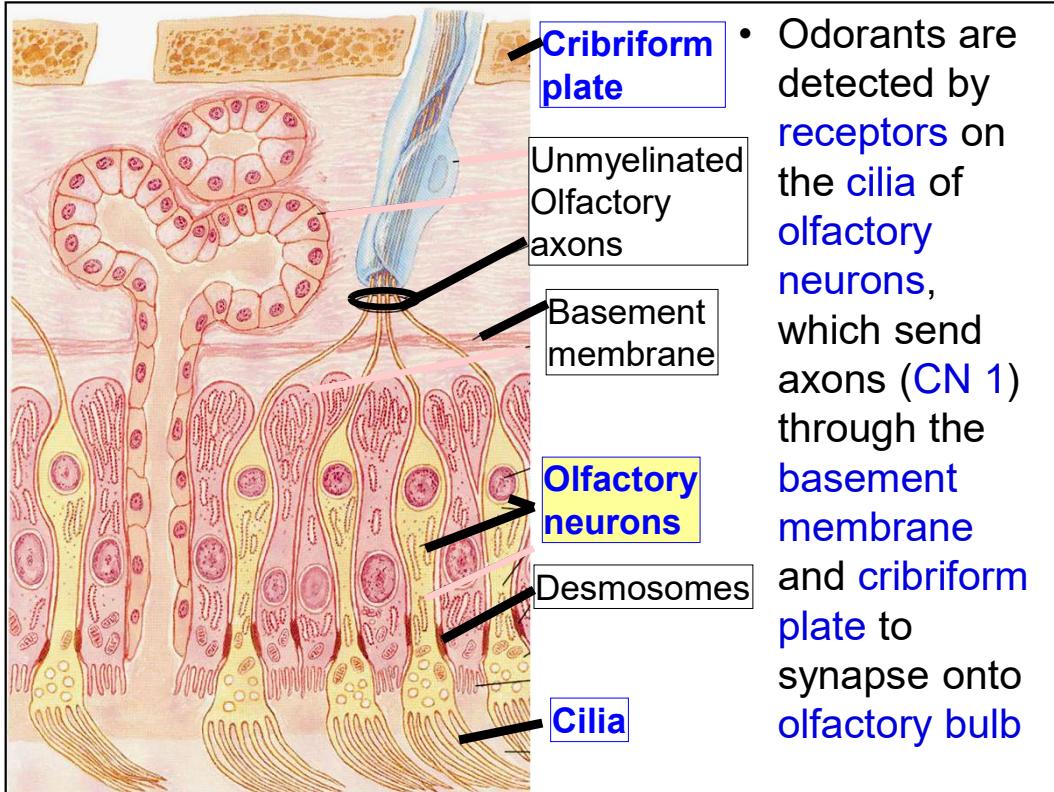


## Anatomy of Smell

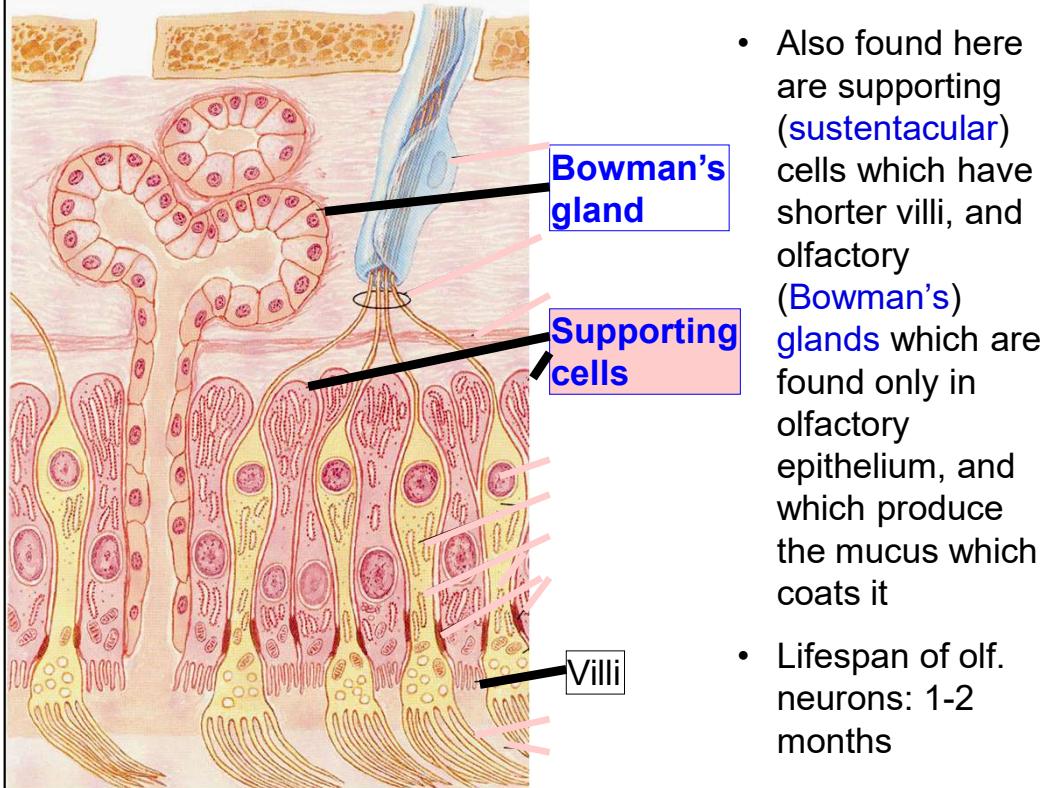


- Each 1-2 cm<sup>2</sup> patch of olfactory epithelium on the roof and walls of nasal cavity contains about 5 million odorant receptor neurons
- Separated from olfactory bulb by cribriform plate of ethmoid bone
- Trigeminal nerve endings are also found in olfactory epithelium

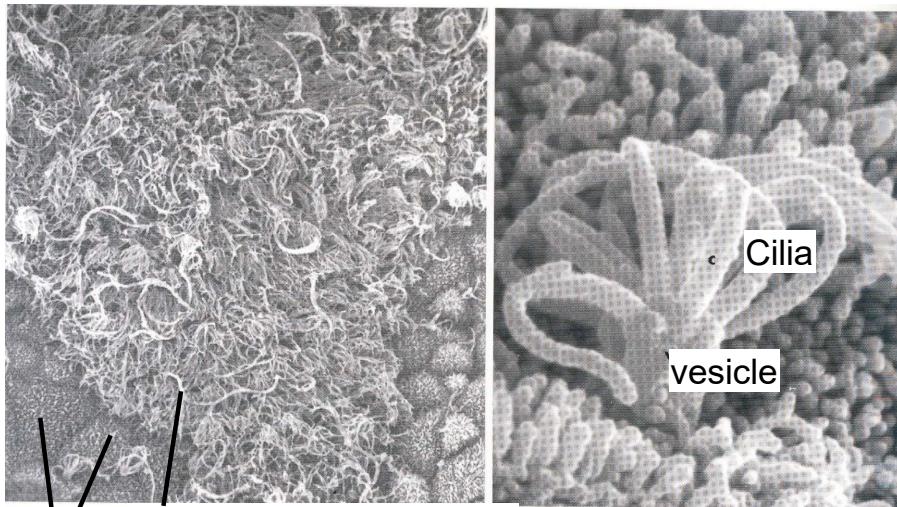
The sensory cells that make up the olfactory epithelium respond to odors by depolarizing. Like taste buds, an olfactory cell can respond to more than one odorant. There are six general odor qualities that can be sensed: floral, ethereal (e.g., pears), musky, camphor (e.g., eucalyptus), putrid, and pungent (e.g., vinegar, peppermint).



**Structure of the olfactory epithelium.** There are three cell types: olfactory sensory neurons, supporting cells, and basal stem cells (not shown in this picture) at the base of the epithelium. Each sensory neuron has a dendrite that projects to the epithelial surface. Numerous cilia protrude into the mucosal layer lining the nasal lumen. A single axon projects from each neuron to the olfactory bulb. Odorants bind to specific odorant receptors on the cilia and initiate a cascade of events leading to generation of action potentials in the sensory axon.



## Ciliated neurons of olfactory epithelium



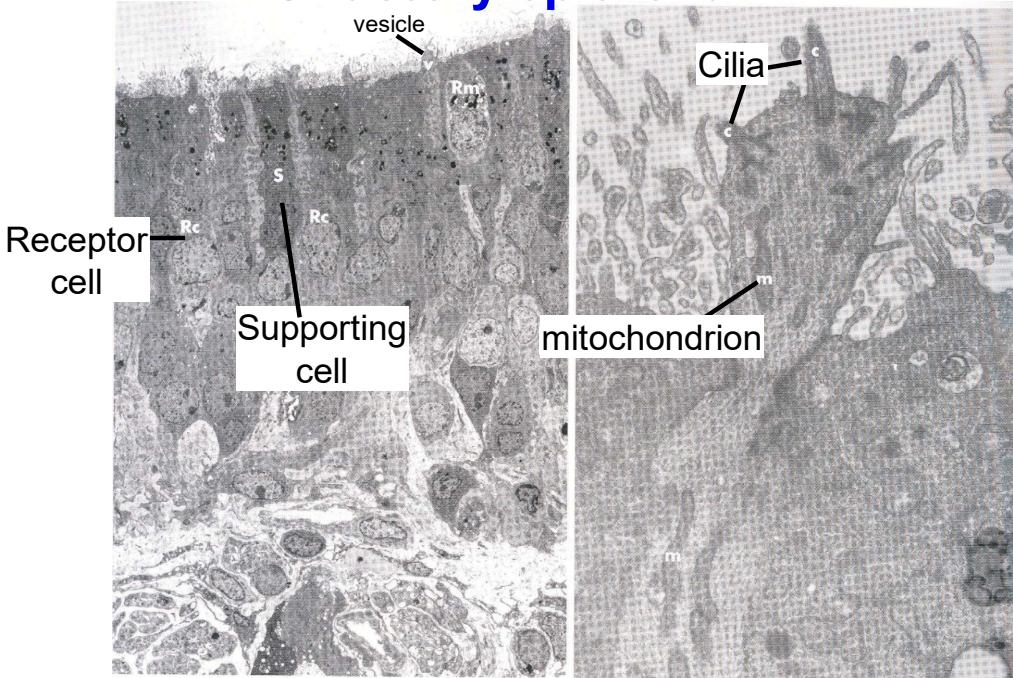
Cilia of olfactory neurons

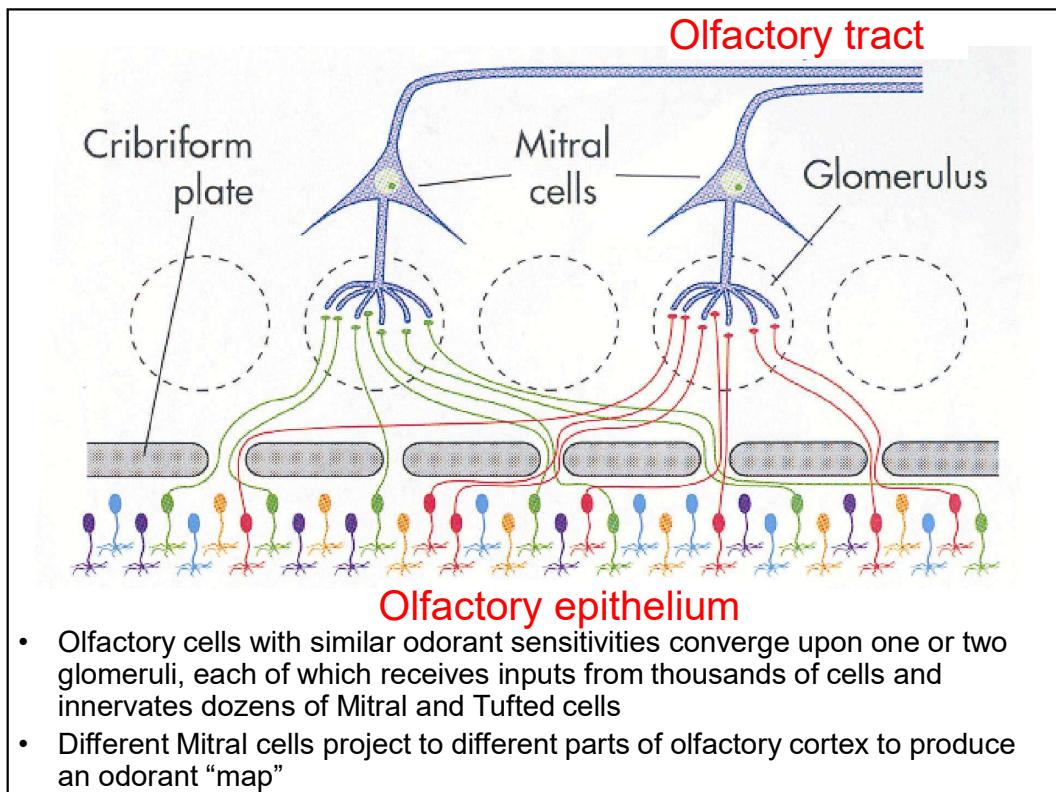
Non-sensory cells  
with short microvilli

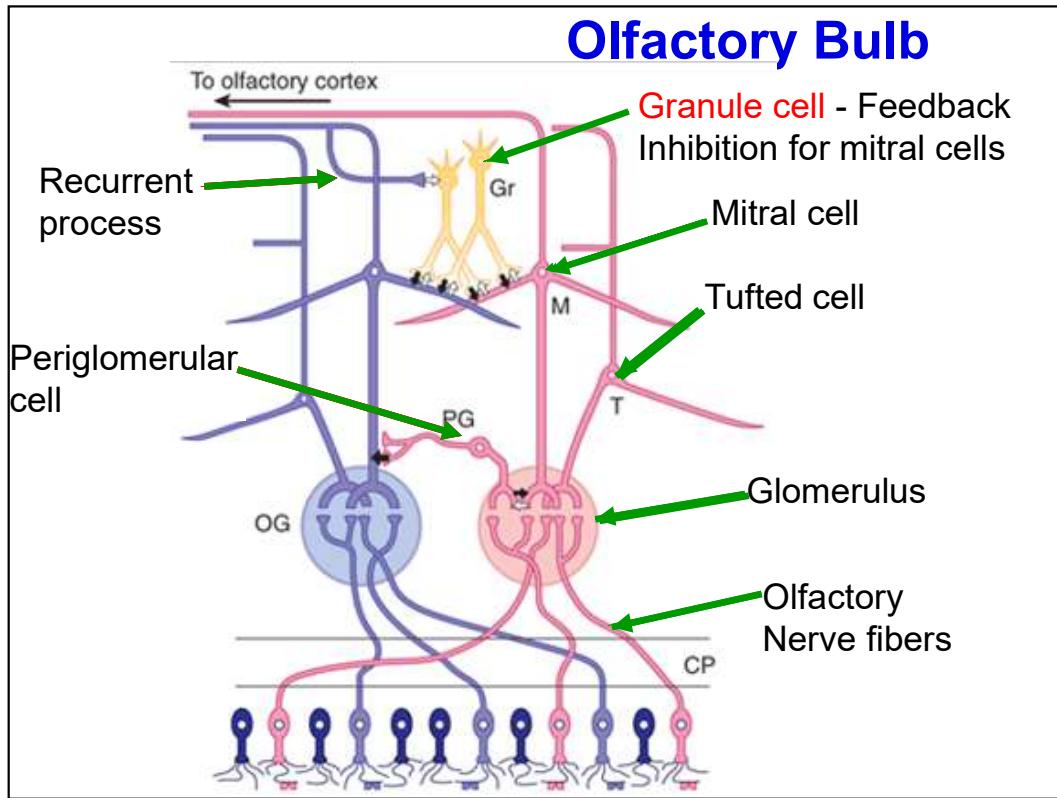
Cilia

vesicle

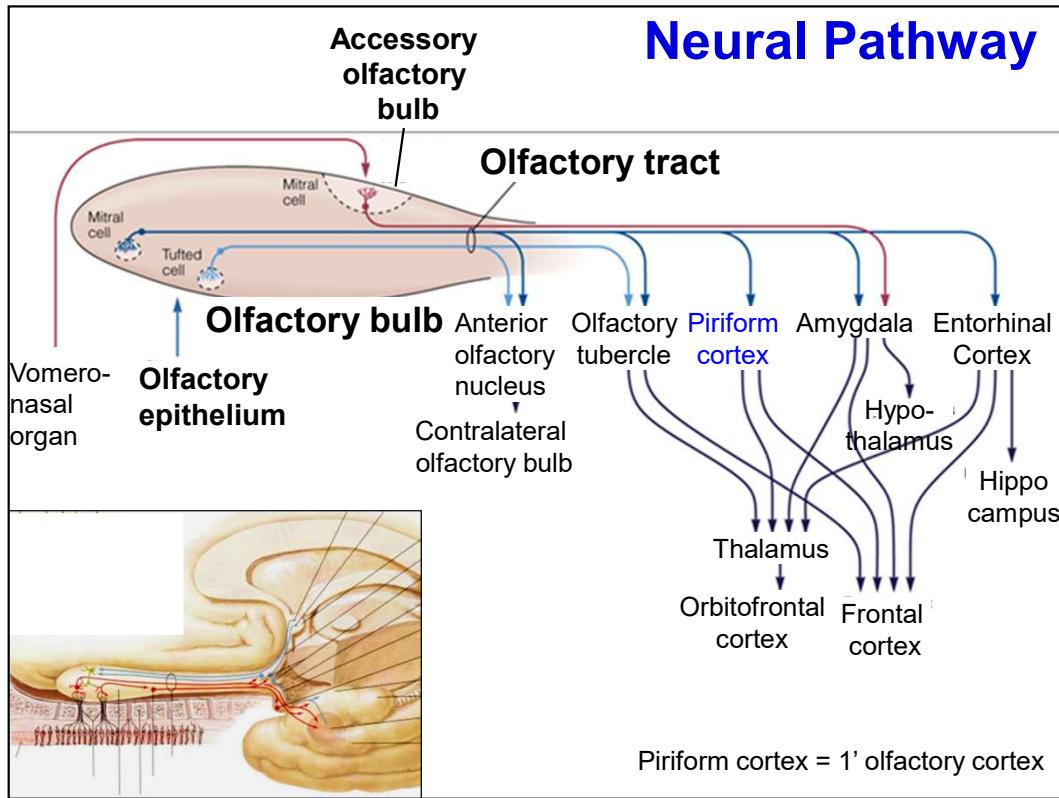
## Olfactory epithelium







Olfactory stimuli are detected by the nerve fibers of the olfactory epithelium and conveyed to the olfactory bulb where they make synapses onto Mitral cells, Tufted cells, and Periglomerular cells. The mitral cells and tufted cells are the primary output neurons, and their activity is modulated by the periglomerular and granule cells.



Olfactory stimuli are detected by the nerve fibers of the olfactory epithelium and conveyed through the cribriform plate to the olfactory bulb. Integrated signals pass along the olfactory tract and centrally diverge to pass to the anterior commissure (some efferent projections cross to the contralateral olfactory bulb) or terminate in the ipsilateral olfactory trigone (olfactory tubercle). Axons then project to the primary olfactory cortex (piriform cortex), entorhinal cortex, and amygdala.

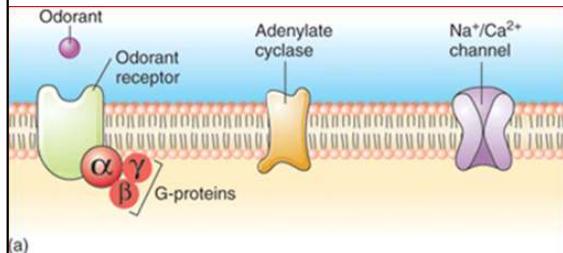
## Olfactory Bulb

- Smell is not as necessary for survival in humans as it is in some other species
- Some species have large, well laminated olfactory bulbs
- In humans, the olfactory bulb is relatively small, and poorly developed

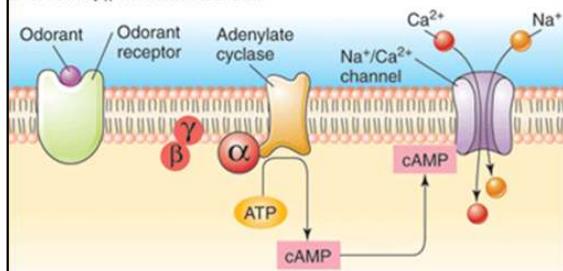
## Odorants

- Odorants are generally **volatile** chemical compounds
  - They must be in the air in order to reach the olfactory epithelium
- Odorants must cross the mucosa to reach their receptors.
- Mucosa contains **Odorant Binding Proteins** which concentrate odorant molecules and deliver them to the receptors
  - Especially useful for lipophilic odorants

# Smell Transduction



Source: Barrett KE, Barman SM, Boitano S, Brooks H: Ganong's Review of Medical Physiology, 23<sup>rd</sup> Edition: <http://www.accessmedicine.com>



- Odorants bind to G protein-coupled receptor molecules on cilia

- G-proteins are activated, the alpha subunit diffuses to effector enzyme (e.g., adenylate cyclase)
  - ... which causes cation channels ( $\text{Na}^+ / \text{Ca}^{2+}$ ) to open
  - ... depolarizing the olfactory neuron
- Cation channels are directly gated by cAMP and cGMP

**Signal transduction in an odorant receptor.** Olfactory receptors are G protein-coupled receptors that dissociate upon binding to the odorant. The  $\alpha$ -subunit of G proteins activates adenylate cyclase to catalyze production of cAMP. cAMP acts as a second messenger to open cation channels. Inward diffusion of  $\text{Na}^+$  and  $\text{Ca}^{2+}$  produces depolarization.

Overall process:

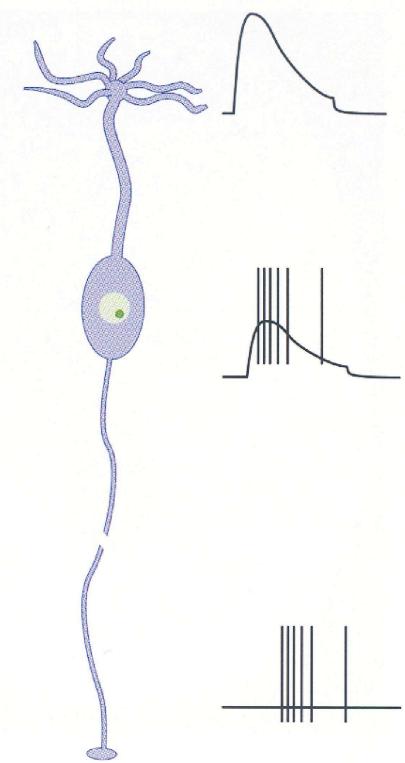
1.Olfactory Receptor Activation: Olfactory receptors are specialized proteins located on the cilia, which are tiny hair-like structures extending from the olfactory sensory neurons in the olfactory epithelium of the nasal cavity. When odorant molecules enter the nasal cavity and bind to their specific olfactory receptors, the receptors undergo a conformational change, initiating the signal transduction cascade.

2.Activation of G-Proteins: Upon receptor activation, G-proteins, particularly G-protein alpha subunits ( $\text{G}_{\alpha\text{olf}}$ ), are activated and dissociate from the olfactory receptor. The activated G-proteins then interact with the enzyme adenylate cyclase, leading to the conversion of adenosine triphosphate (ATP) into cyclic adenosine monophosphate (cAMP).

3.cAMP Production: Cyclic adenosine monophosphate (cAMP) serves as a second messenger in the olfactory signal transduction pathway. The increased

levels of cAMP lead to the opening of cyclic nucleotide-gated ion channels (CNG channels) located in the ciliary membrane.

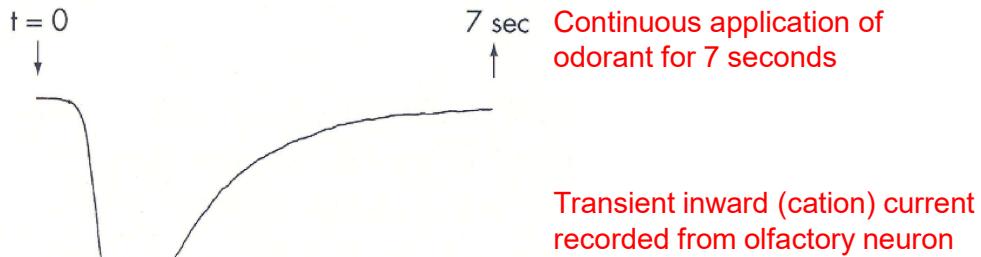
4. Ion Channel Activation: The opened CNG channels allow the influx of positively charged ions, primarily sodium ( $\text{Na}^+$ ) and calcium ( $\text{Ca}^{2+}$ ), into the olfactory sensory neuron. This influx of ions depolarizes the neuron, generating a receptor potential.
5. Generation of Action Potential: If the receptor potential is of sufficient magnitude, it triggers the generation of an action potential, which is an electrical impulse that travels along the axon of the olfactory neuron toward the olfactory bulb in the brain.
6. Axon Projection: Olfactory neurons project their axons into the olfactory bulb, where they synapse with mitral cells and tufted cells. These cells relay the olfactory signals further into the brain's olfactory processing areas.
7. Olfactory Bulb Processing: In the olfactory bulb, complex processing of olfactory information takes place, involving the integration and convergence of signals from different olfactory sensory neurons with similar receptor specificities.
8. Projection to Higher Brain Regions: The processed olfactory signals are then projected to various higher brain regions, including the olfactory cortex and limbic system, where the perception and interpretation of smell occur.



## Signal Conduction

- Opening of cation channels in cilia cause depolarizing receptor potential which travels to the cell body
- If this is big enough to reach action potential threshold, one or more action potentials are initiated in the axon initial segment
- The action potentials are then transmitted down the axon to cause release of neurotransmitter from the axon terminals on the olfactory bulb

## Signal Adaptation



- When olfactory neurons are continuously exposed to a given odorant, they will eventually stop responding to it
- Also known as desensitization

Adaptation in the sense of smell, also known as olfactory adaptation or desensitization, refers to the process by which the sensitivity of the olfactory system to a particular odor diminishes over time when continuously exposed to that odor. It is a fundamental mechanism that allows the olfactory system to filter out constant or nonessential smells from the environment, making it more responsive to new or changing odors.

The process of olfactory adaptation occurs at multiple levels within the olfactory system:

1. Peripheral Adaptation: It begins in the olfactory receptors located in the olfactory epithelium within the nasal cavity. When exposed to a particular odor, these receptors initially respond strongly to the stimulus, sending signals to the brain. However, with prolonged exposure, the receptor's responsiveness gradually decreases, leading to reduced signaling. It is mediated by  $\text{Ca}^{2+}$  acting via calmodulin on **cyclic nucleotide-gated (CNG)** ion channels. When the CNG A4 subunit is knocked out, adaptation is slowed.

2. Central Adaptation: Adaptation also occurs in the brain's olfactory processing centers, such as the olfactory bulb and olfactory cortex. These higher brain regions receive the signals from the olfactory receptors and play a role in interpreting and perceiving smells. During adaptation, the neural circuits in these brain areas adjust their sensitivity to the specific odor, resulting in a decreased perception of that odor.

The phenomenon of olfactory adaptation has several essential implications:

1.Improved Discrimination: Adaptation allows the olfactory system to focus on new or changing smells in the environment. By reducing the response to familiar odors, the brain can better discriminate and detect novel odors, which might signal danger or indicate the presence of something new.

2.Enhanced Sensitivity to Change: Olfactory adaptation is vital for detecting changes in the environment, especially in situations where certain odors may have critical implications. For instance, the ability to smell a gas leak is enhanced when the olfactory system adapts to the background smells in the environment.

3.Perception of Pleasant Odors: Adaptation can lead to a more enjoyable experience of pleasant odors. Initially strong scents, like perfume or fresh food, become less overwhelming with prolonged exposure, allowing individuals to enjoy them without feeling overwhelmed.

4.Loss of Perception: Continuous exposure to an odor can lead to its perceived disappearance or loss, even though the odor is still present. This phenomenon, known as sensory fatigue or habituation, can be observed when people are exposed to strong or long-lasting odors.

Overall, olfactory adaptation is a dynamic process that plays a critical role in the functioning of the olfactory system. It allows us to efficiently process and respond to the complex and ever-changing smells in our environment, enhancing our ability to detect new odors and adapt to different olfactory stimuli over time.

## Signal Adaptation

- Peripheral adaptation
  - mediated by  $\text{Ca}^{2+}$  acting via calmodulin on cyclic nucleotide-gated ion channels
- Central adaptation
  - neural circuits in olfactory bulb and olfactory cortex adjust their sensitivity to the specific odor, resulting in a decreased perception of that odor.
- Benefits:
  - Filter out constant or nonessential smells from the environment
  - Improved discrimination between odors
  - Enhanced sensitivity to change in odors

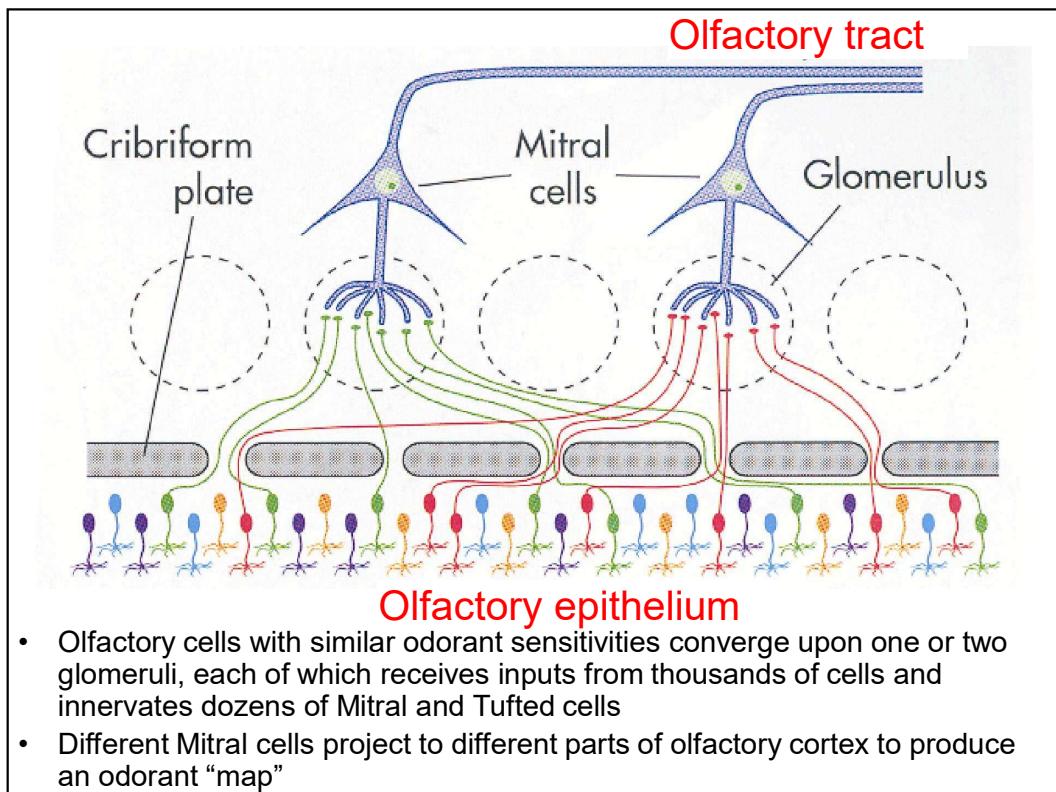
## Odorant Specificity

- Humans can recognize >10,000 odors
- ~1000 different kinds of odorant receptors (~1% of genome!)
- Each olfactory neuron expresses just 1 kind of odorant receptor
- Very sensitive, but difficult to detect differences in odor intensity

**Table 10-1.** Some olfactory thresholds.

Substance	mg/L of Air
Ethyl ether	5.83
Chloroform	3.30
Pyridine	0.03
Oil of peppermint	0.02
Iodoform	0.02
Butyric acid	0.009
Propyl mercaptan	0.006
Artificial musk	0.00004
Methyl mercaptan	0.0000004

From Ganong 2005, Review of Medical Physiology



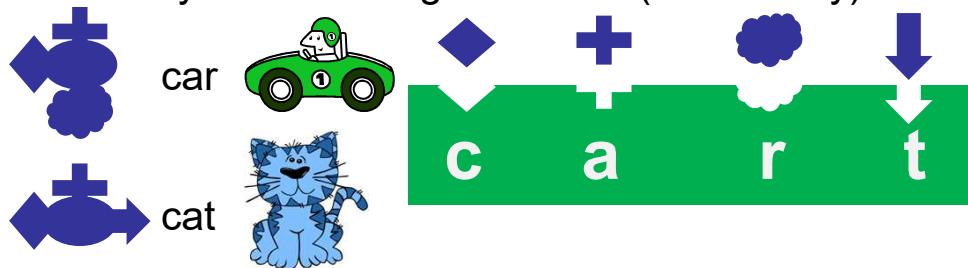
## Odorant Specificity

- A single receptor cell with a single odorant receptor type can recognize multiple odorants
  - Different surface structures on odorant act like “keys” to specific receptor “locks”
- Different odorants have unique topologies which excite different combinations of receptors
  - This is concentration dependent – higher concentration binds to greater variety of receptors
- Each neuron projects to one or two glomeruli
  - provides a distinct two-dimensional map in the olfactory bulb that is unique to the odorant

## Odorant Specificity

Analogy (Linda Buck, re: Malnik 1999 Cell 96:713)

- Each receptor is used over and over again to define odors, just like letters are used over and over again to define different words
- As in language, the olfactory system appears to use combinations of receptors (words) to greatly reduce the number of actual receptor types (letters) required to convey a broad range of odors (vocabulary).



## Olfactory dysfunction

- Can be caused by conductive or sensorineural problems

### Conductive

- Prevent odorants from reaching olfactory epithelium
  - Nasal polyps
  - Septal deviation
  - Inflammation

### Sensorineural

- Damage to olfactory receptor neurons or CNS
  - Head injuries
  - Neurodegenerative conditions
    - Parkinson's disease (Hawkes 1997, *J Neurol Neurosurg Psychiatry* 62:436)
    - Lewy-body dementia (McShane 2001, *J Neurol Neurosurg Psych.* 70:739)
    - Alzheimer's disease

(From Up-to-date May 13, 2010): Sense of smell can decrease with aging [5] and several processes may be involved. With aging there is a loss of olfactory epithelium surface area and a decrease in the density of adrenergic innervation within the lamina propria [31]. The calcium binding protein-D 28K-immunoreactive elements are also decreased in the older olfactory epithelium. Additionally, the olfactory bulb undergoes significant degenerative changes in older adults that result in losses in the number of cell bodies and neurons [32]. While it has been estimated that the adult olfactory bulb contains approximately 60,000 mitral cells at age 25, there are often only 14,500 at the age of 95 [33].

Specific neurodegenerative disorders such as Alzheimer disease, Parkinson disease, and dementia with Lewy bodies are associated with changes in olfaction. However, neurofibrillary tangles and amyloid deposits are common in the olfactory bulbs even in healthy older adults [34].

In Alzheimer disease, odor identification, discrimination, and threshold are impaired. In the early onset of difficulty, odor identification is disturbed, but in the later stage, odor detection is markedly impaired [34]. The olfactory pathways in patients with Alzheimer disease exhibit significant neuritic plaques that often lead to elevated olfactory perceptual thresholds [35]. Unexplained olfactory dysfunction may be a marker for

future cognitive decline, particularly among individuals with one or two apolipoprotein E (APOE)-epsilon 4 alleles [36]. (See "[Dementia syndromes](#)".)

Parkinson disease (PD) and dementia with Lewy bodies are also associated with olfactory impairment [37-39]. In PD, identification, discrimination, and threshold are disturbed and it is likely that these features are seen in the early stages. Impaired olfaction (lower quartile of smell discrimination, compared to upper third and fourth quartiles) was associated with a fivefold increased incidence of PD over 4 years in a study of Hawaiian subjects aged 71 to 95 years [40]. The olfactory bulb in patients with PD typically reveals the presence of Lewy bodies in the neurons of the anterior olfactory nucleus and in mitral cells, with subsequent neuronal cell loss. (See "[Pharmacologic treatment of Parkinson disease](#)".)

The olfactory system can also be involved in other neurodegenerative diseases such including prion disease. (See "[Diseases of the central nervous system caused by prions](#)".)

Normosmia is used to describe normal smell function. The following terms are used to describe olfactory dysfunction:

Hyposmia — Diminished smell function

Anosmia — Absent smell function

Parosmia — Abhorrent odor perception either without an odorant stimulus (phantosmia) or with an odorant stimulus (distortion or troposmia)

Dysosmia — A general term describing distortion of smell sensations

Lewy bodies are ubiquitin-containing inclusions.

# Olfactory receptors as drug targets

Overnight olfactory enrichment using an odorant diffuser improves memory and modifies the uncinate fasciculus in older adults



Cynthia C. Woo<sup>1\*</sup>



Blake Miranda<sup>1,2</sup>



Mithra Sathishkumar<sup>1,2</sup>



Farideh Dehkordi-Vakil<sup>3</sup>



Michael A. Yassa<sup>1,2</sup>



Michael Leon<sup>1,2,4</sup>

<sup>1</sup> Department of Neurobiology and Behavior, University of California, Irvine, Irvine, CA, United States

<sup>2</sup> Center for the Neurobiology of Learning and Memory, University of California, Irvine, Irvine, CA, United States

<sup>3</sup> Department of Statistics, University of California, Irvine, Irvine, CA, United States

<sup>4</sup> Institute for Memory Impairments and Neurological Disorders, University of California, Irvine, Irvine, CA, United States

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**Objective:** Cognitive loss in older adults is a growing issue in our society, and there is a need to develop inexpensive, simple, effective in-home treatments. This study was conducted to explore the use of olfactory enrichment at night to improve cognitive ability in healthy older adults.

**Methods:** Male and female older adults ( $N = 43$ ), age 60–85, were enrolled in the study and randomly assigned to an Olfactory Enriched or Control group. Individuals in the enriched group were exposed to 7 different odorants a week, one per night, for 2 h, using an odorant diffuser. Individuals in the control group had the same experience with *de minimis* amounts of odorant.

Neuropsychological assessments and fMRI scans were administered at the beginning of the study and after 6 months.

**Results:** A statistically significant 226% improvement was observed in the enriched group compared to the control group on the Rey Auditory Verbal Learning Test and improved functioning was observed in the left uncinate fasciculus, as assessed by mean diffusivity.

**Conclusion:** Minimal olfactory enrichment administered at night produces

improvements in both cognitive and neural functioning. Thus, olfactory enrichment may provide an effective and low-effort pathway to improved brain health.

## Pheromones

- Insects and most lower mammals are able to detect chemical signals released by other members of their own species
  - Ants lay chemical trails indicating where they found food, or the way back to the colony
  - Male moths locate females during mating season by following pheromone concentration gradient (can detect 1 part in  $10^{17}$ )
  - Male rodent pheromones affect puberty and estrous cycles in female rodents
- These are detected by a [Vomeronasal organ](#) in the olfactory epithelium.

**Do Humans have Pheromones?**



## Confusing? Maybe not.

- The **Vomeronasal organ** is present in human fetuses, but is thought to be absent or vestigial in adults
- There is some evidence for chemical signaling between humans. Not all evidence has been repeatable.
  - Synchronization of menstrual cycles of women living together
    - Axillary secretions from women can lengthen or shorten menstrual cycles of other women, depending on the phase of the cycle during collection
  - Male axillary secretions can increase frequency of LH release in women (Preti et al. 2003, Biol Reproduction 68:2107)
  - Females prefer scent of males in a different MHC class
- Is this pheromonal? Evidence not completely convincing.
- This topic is still very **hotly** debated

Claus Wedekind; Thomas Seebeck; Florence Bettens; Alexander J. Paepke. MHC-Dependent mate preferences in humans. The Royal Society : Biological Sciences, Vol. 260, No. 1359 (Jun. 22, 1995), 245-249

The existence and role of human pheromones remain a subject of scientific debate. Pheromones are chemical signals produced by one individual that can affect the behavior or physiology of another individual of the same species. They are commonly observed in many animals and play a significant role in various aspects of their behavior, such as mating, aggression, territorial marking, and social bonding.

While some studies have suggested that humans may produce and respond to pheromones, the evidence is not as clear-cut as it is in many other animal species. Some studies have explored the potential presence of pheromones in humans and their influence on behaviors like sexual attraction and social interactions. However, these studies have yielded mixed and inconclusive results.

One challenge in studying human pheromones is the complexity of human behavior and the various factors that can influence attraction and social interactions, making it difficult to isolate and attribute specific effects solely to pheromones. Additionally, humans rely more heavily on visual and auditory

cues in social communication compared to other animals that heavily rely on chemical communication.

It is worth noting that some substances have been proposed as potential human pheromones, such as androstadienone and estratetraenol, which are derived from steroid hormones. However, their effects on human behavior and physiology are still a subject of ongoing research and debate.

As science continues to progress, our understanding of human pheromones may evolve. Research in this area is complex and requires rigorous study designs to establish definitive conclusions about the existence and effects of human pheromones. As such, it is essential to remain updated on the latest scientific findings to understand the current state of knowledge regarding this topic.