
بسم الله الرحمن الرحيم

WE DON'T GROW WHEN THINGS ARE EASY; WE GROW WHEN WE FACE CHALLENGES.

Learning Objectives

By the end of the lecture a second year student should be able to

- Define sense of smell.
- Describe olfactory membrane, receptors and olfactory pathway.
- Describe the mechanism of olfactory signal transduction.
- Explain odour adaptation, odour blindness and abnormalities of sense of smell.

The Chemical Senses

- **Smell and taste** (olfaction and gustation) are chemical senses in that the signal for the sense is a molecular chemical or ion which stimulates receptors in the nose or on the tongue.
- Studies show that people can identify poisonous substances, gender of others, and scent can be used to track prey

The Chemical Sense of Smell

Sense Of Smell

- least understood of our senses
- is poorly developed in human beings in comparison with the sense of smell in many lower animals
- to perceive the odor or scent of through stimuli affecting the olfactory nerves; get the odor or scent of with the nose

Smell

Many diseases produce odors

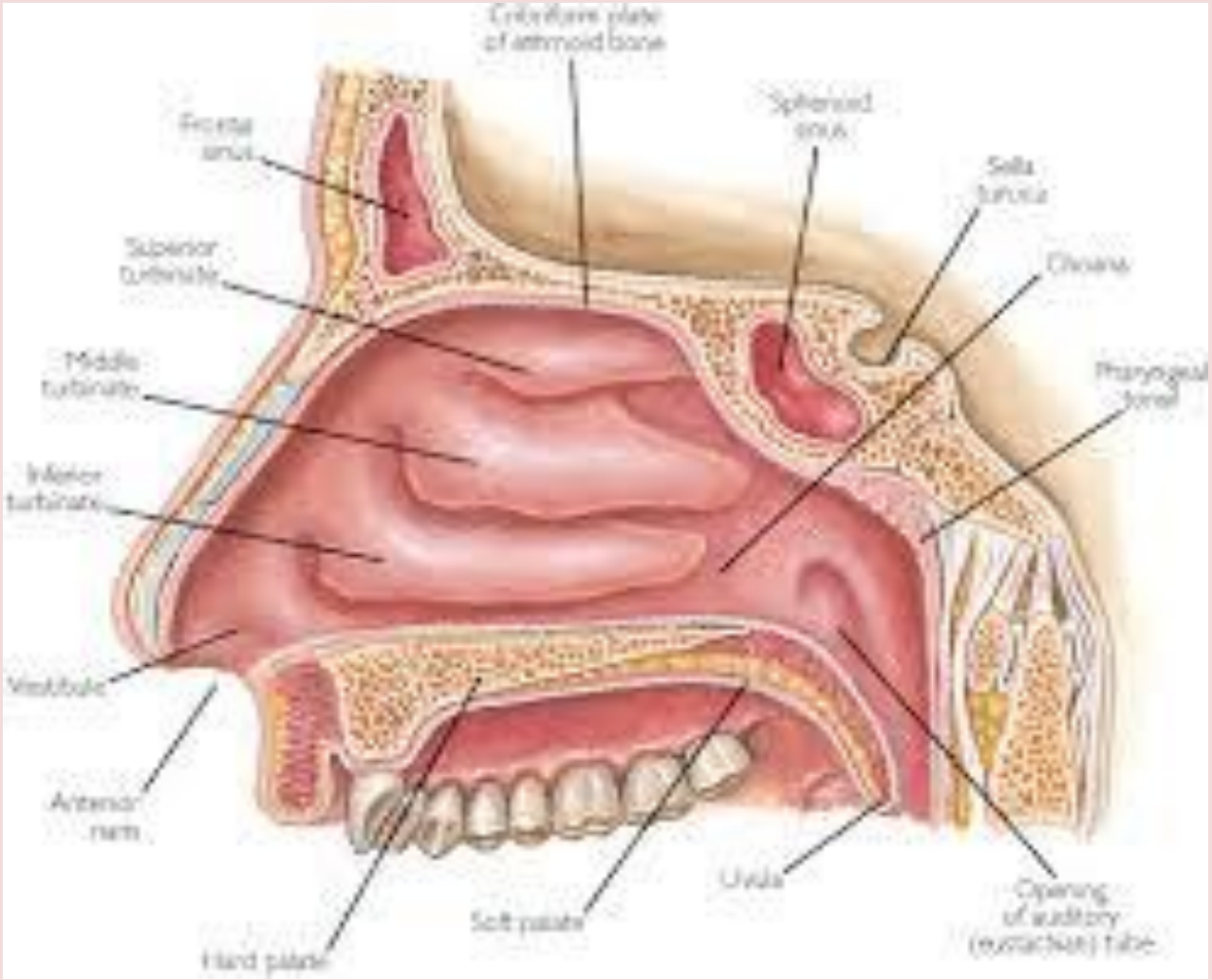
Trimethylaminuria: liver disorder that leads to strong smell of rotting fish in people's breath and sweat.

Pheromones: special scents used usually in mating; a certain pheromone would be produced by fertile females exciting males.

"Hold it right there, young lady! Before you go out, you take off some of that makeup and wash off that gallon of pheromones!"

Physiological Anatomy

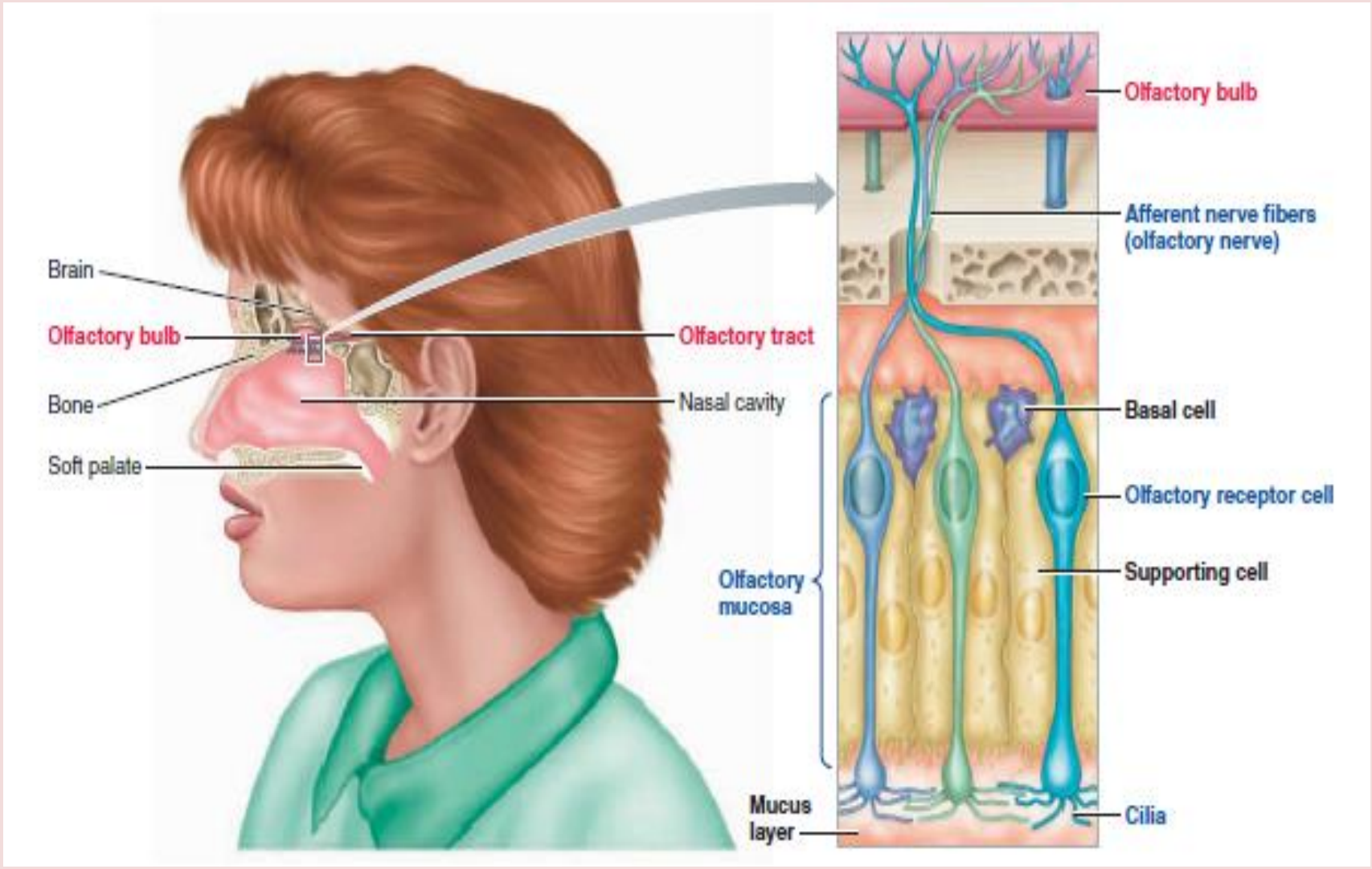
Lateral Wall of Nose



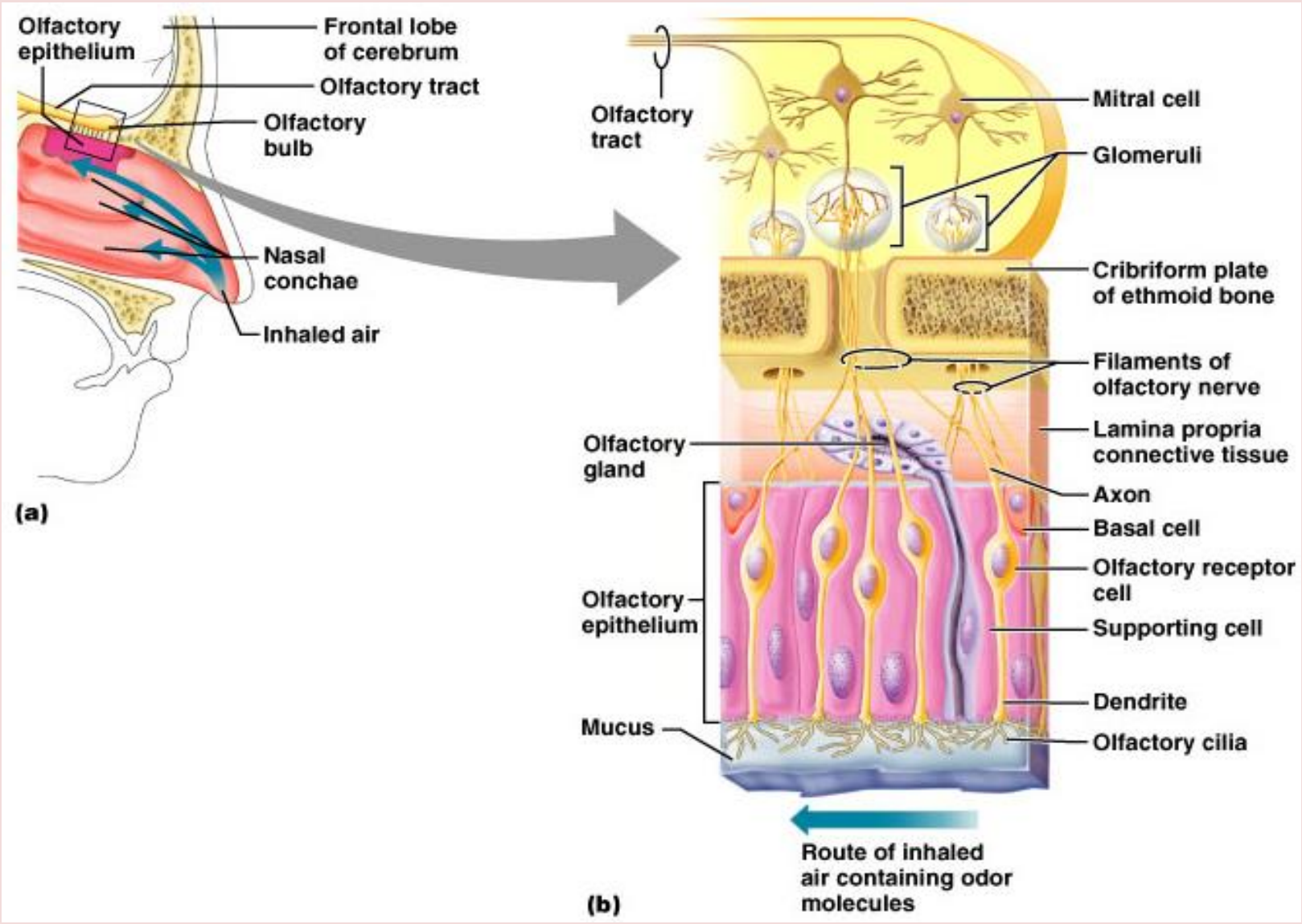
Olfactory Membrane

- In the superior part of each nostril
- Medially, olfactory membrane folds downward along the surface of the superior septum
- laterally, it folds over the superior turbinate and even over a small portion of the upper surface of the middle turbinate
- In each nostril, the olfactory membrane has a surface area of about 2.4 square centimeters

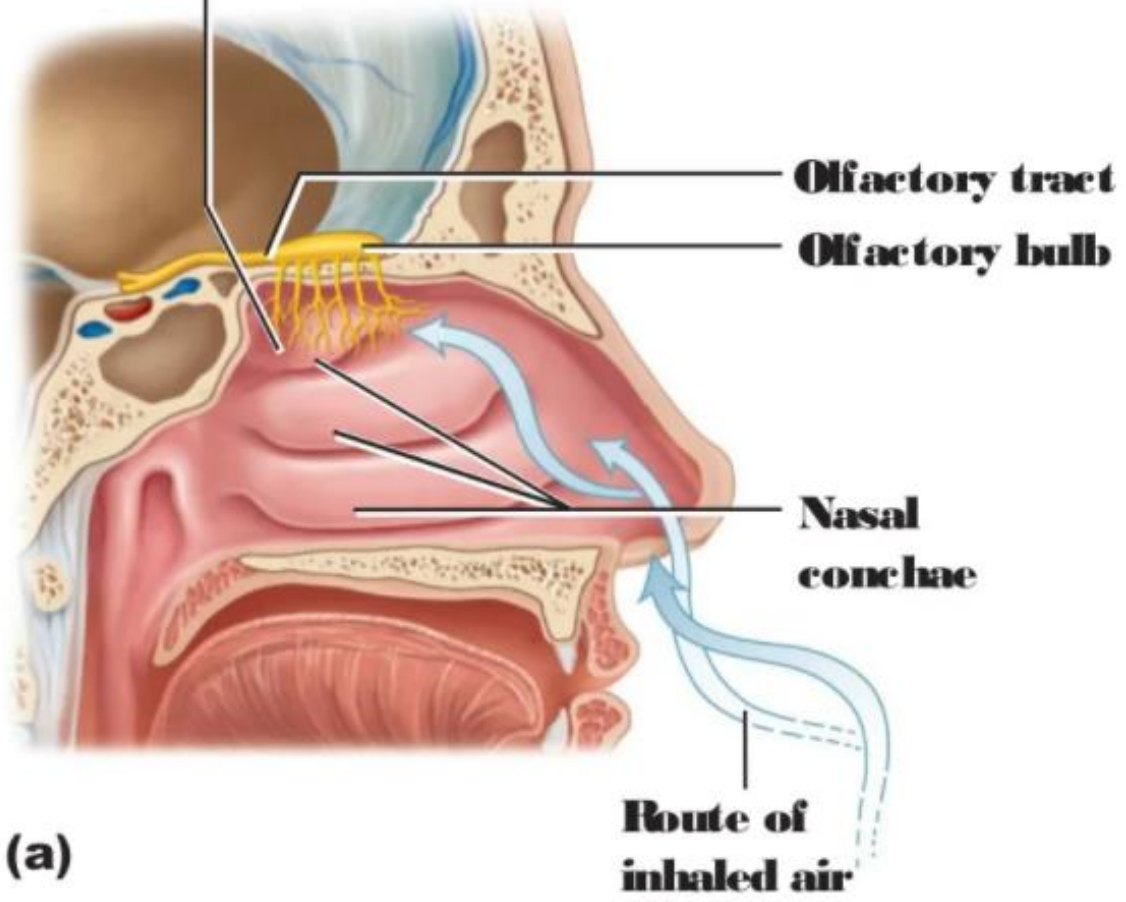
Location And Structure Of Olfactory Receptor Cells



Olfactory Receptors



Olfaction


Olfactory epithelium
Olfactory tract
Olfactory bulb
Nasal conchae
Route of inhaled air
(a)

Olfactory Receptor Cells are ?

- Unipolar
- Bipolar
- Pseudo unipolar
- Multipolar
- Pyramidal

Olfactory Cells

- Olfactory receptor cells → bipolar nerve cells derived originally from the central nervous system itself

- about 100 million of these cells in the olfactory epithelium interspersed among sustentacular cells

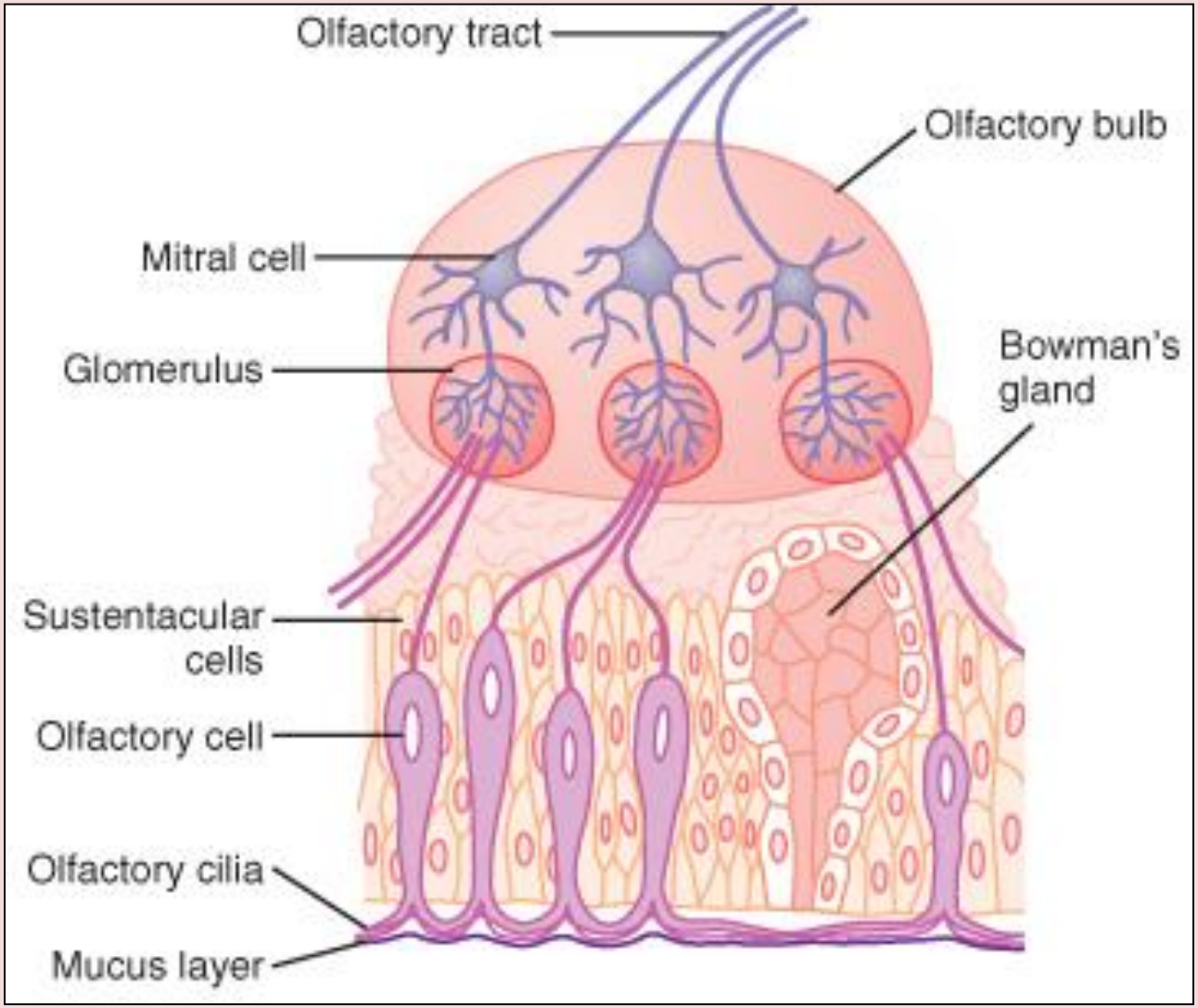
- The mucosal end forms a knob → 4 to 25 olfactory hairs/cilia, 0.3µm in diameter and 200µm in length project into mucus that coats inner surface of nasal cavity

Olfactory Cells…

- projecting olfactory cilia form a dense mat in mucus, and it is these cilia that react to odors in the air and stimulate the olfactory cells

- Spaced among the olfactory cells in the olfactory membrane are many small Bowman's glands that secrete mucus onto the surface of the olfactory membrane

Olfactory Membrane And Olfactory Bulb



An odorant should be

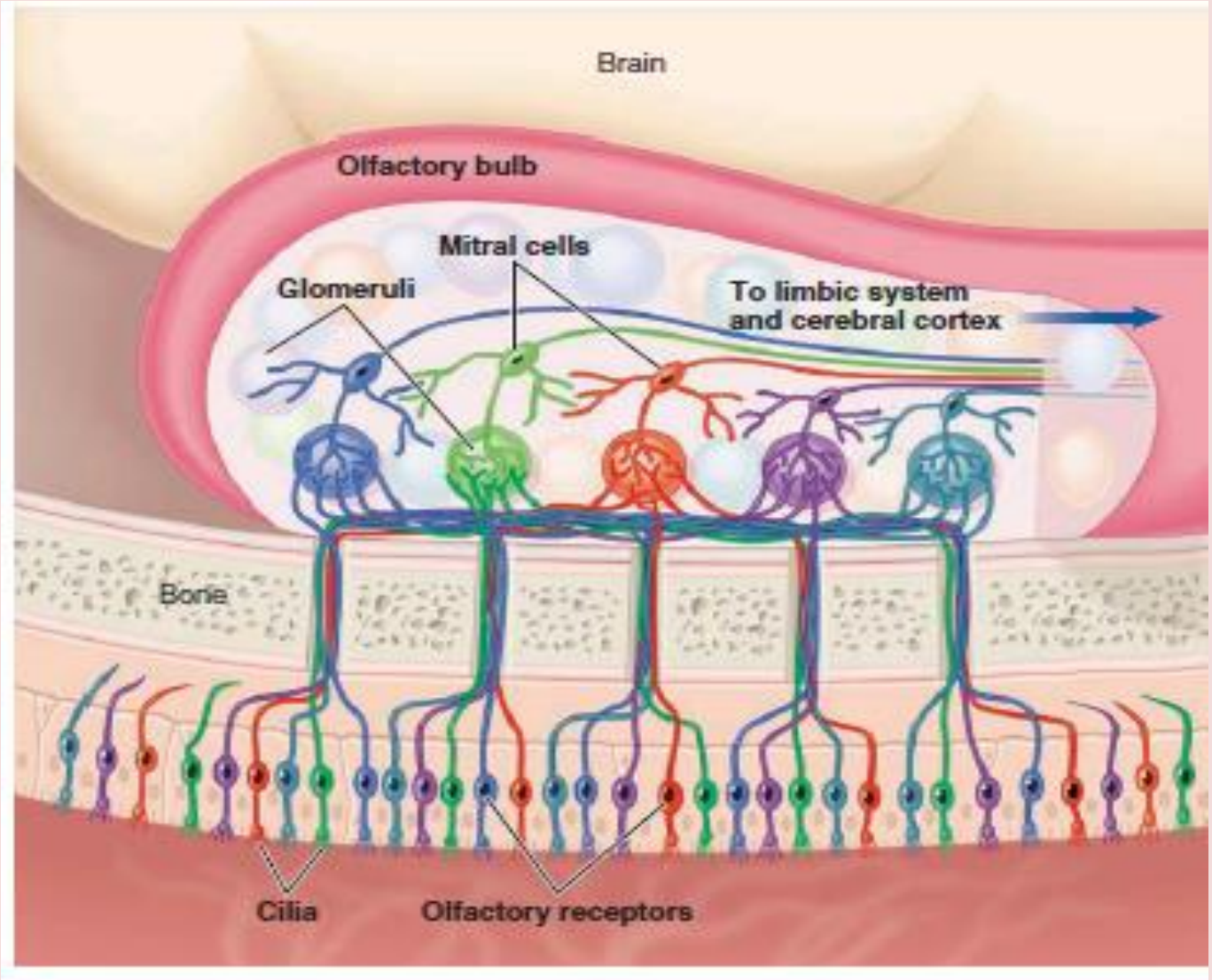
VOLATILE

WATER SOLUBLE

LIPID SOLUBLE

Neural Pathway for Olfaction

Neural Pathway for Olfaction



Mechanism of Excitation

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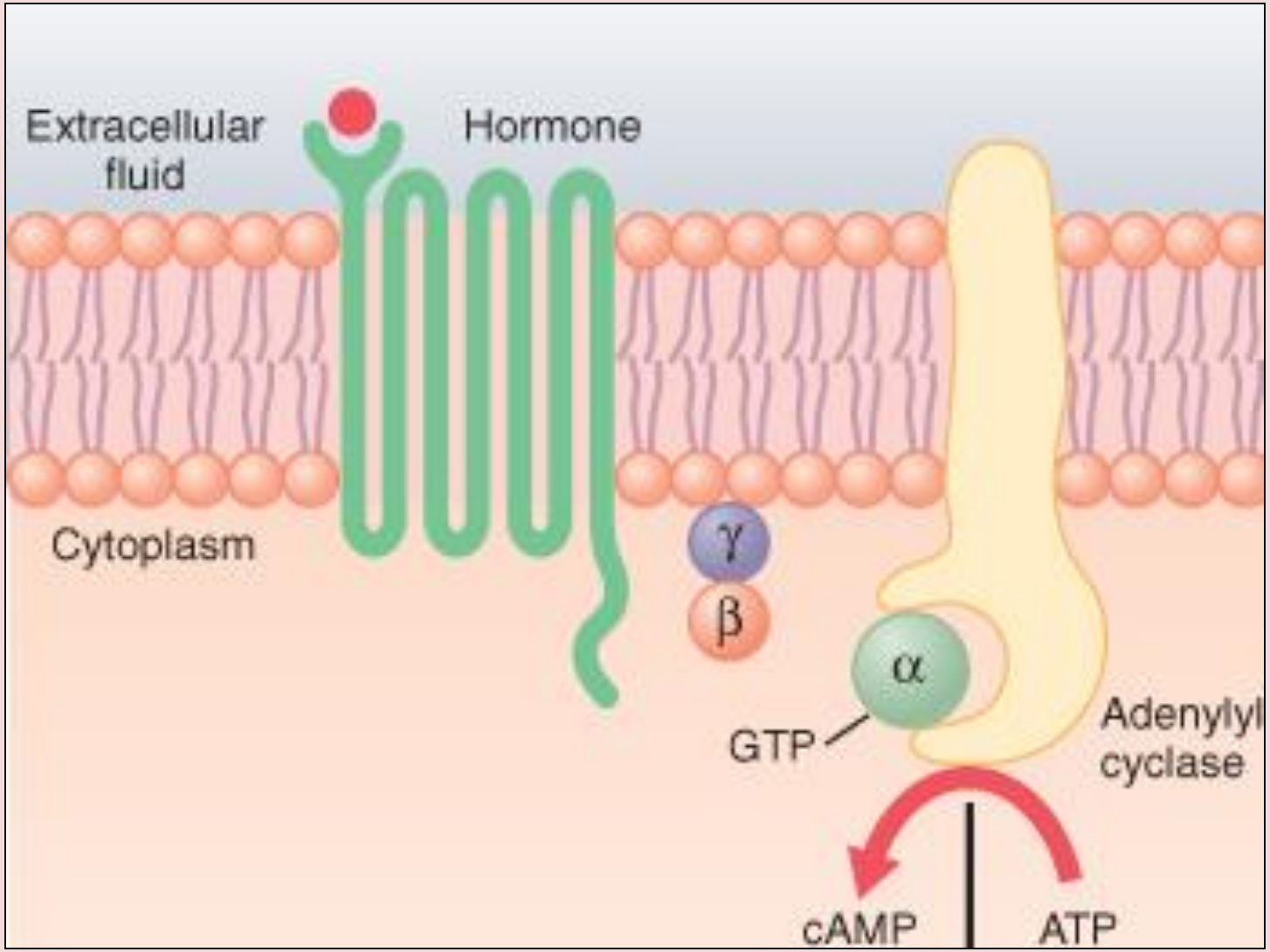
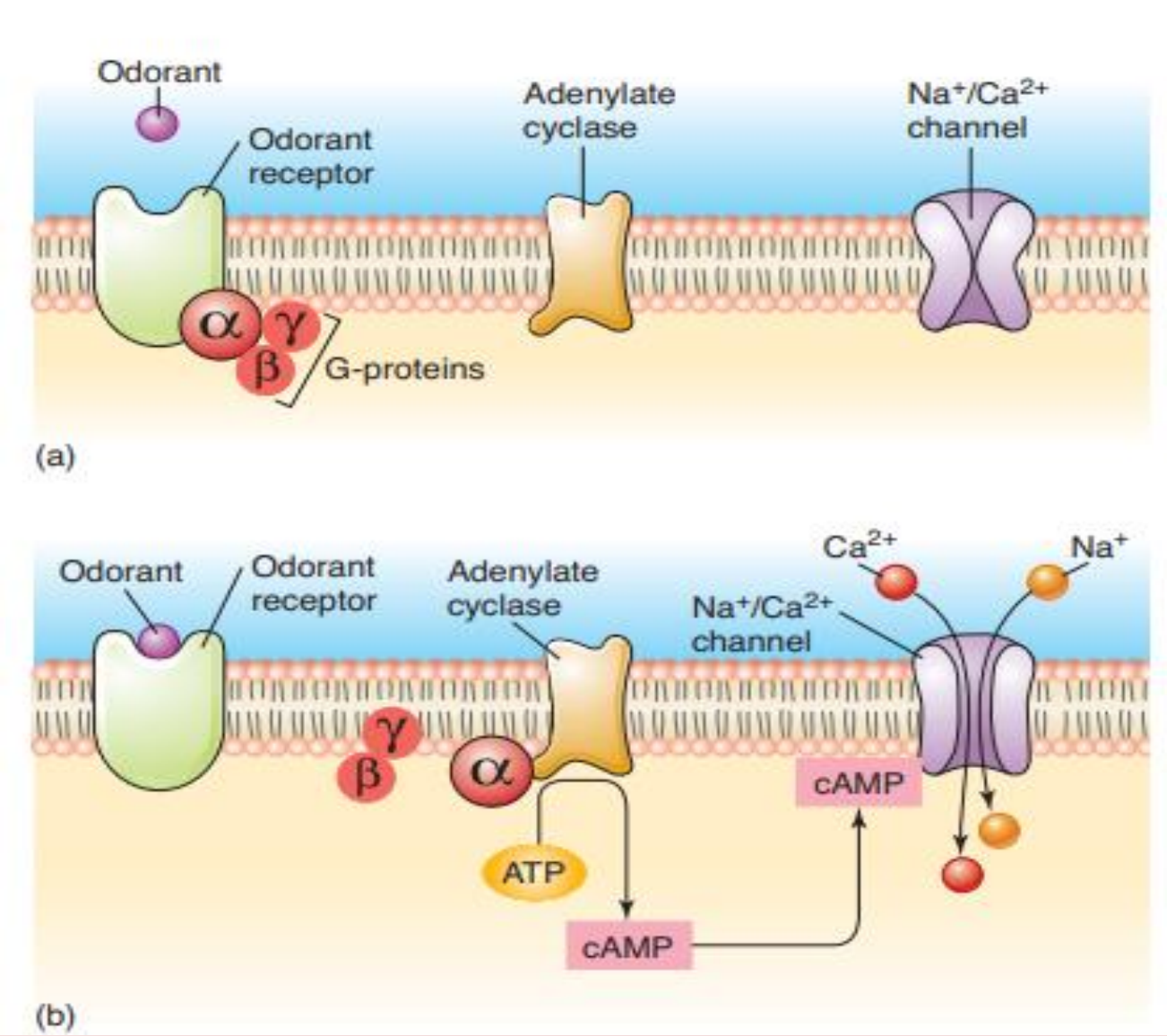


Signal Transduction in an Odorant Receptor



Stimulation Of The Olfactory Cells

Mechanism Of Excitation

- Olfactory cilia respond to olfactory chemical stimuli
- Odorant substance, on coming in contact with olfactory membrane surface, first diffuses into the mucus that covers the cilia
- Then it binds with receptor proteins in the membrane of each cilium

Mechanism Of Excitation of the Olfactory Cells….

- Each receptor is a long molecule folding inward and outward about 7 times through the membrane,
- Odorant binds with portion of receptor protein on outside
- Inside folding protein is coupled to a G-protein, with 3 subunits
- On excitation, an alpha subunit breaks from G-protein and activates adenylyl cyclase attached to the inside of ciliary membrane near the receptor cell body

Mechanism Of Signal Transduction

1. Activation of **receptor protein** by odorant substance activates the **G-protein complex**

2. activates molecules of **adenylyl cyclase** inside the olfactory cell membrane

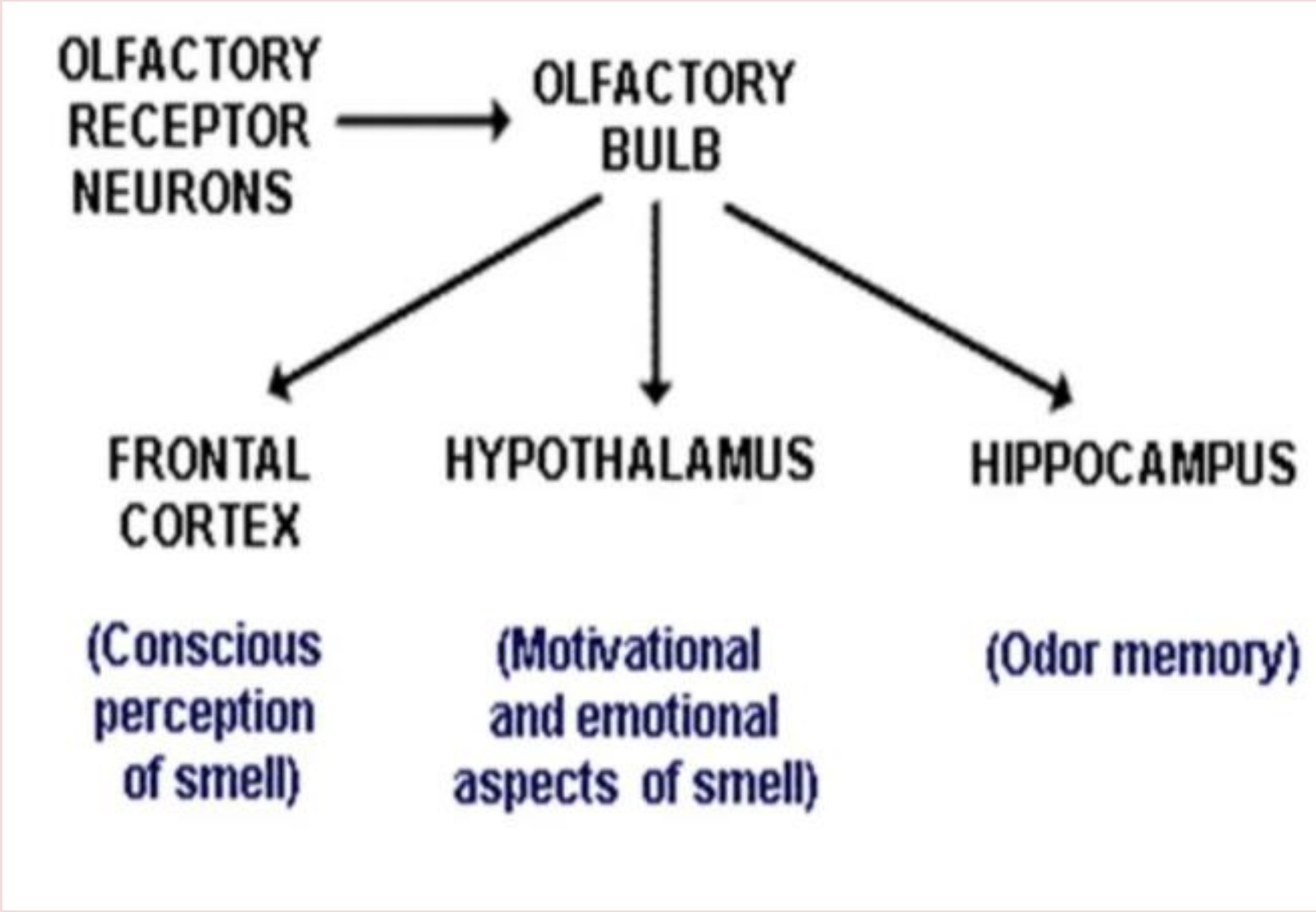
3. formation of many times more molecules of **cAMP**

4. cAMP opens still many **sodium ion channels**→ most minute concentration of a specific odorant opens large numbers of Calcium & sodium channels → accounting for exquisite sensitivity of olfactory neurons to even slightest amount of odorant

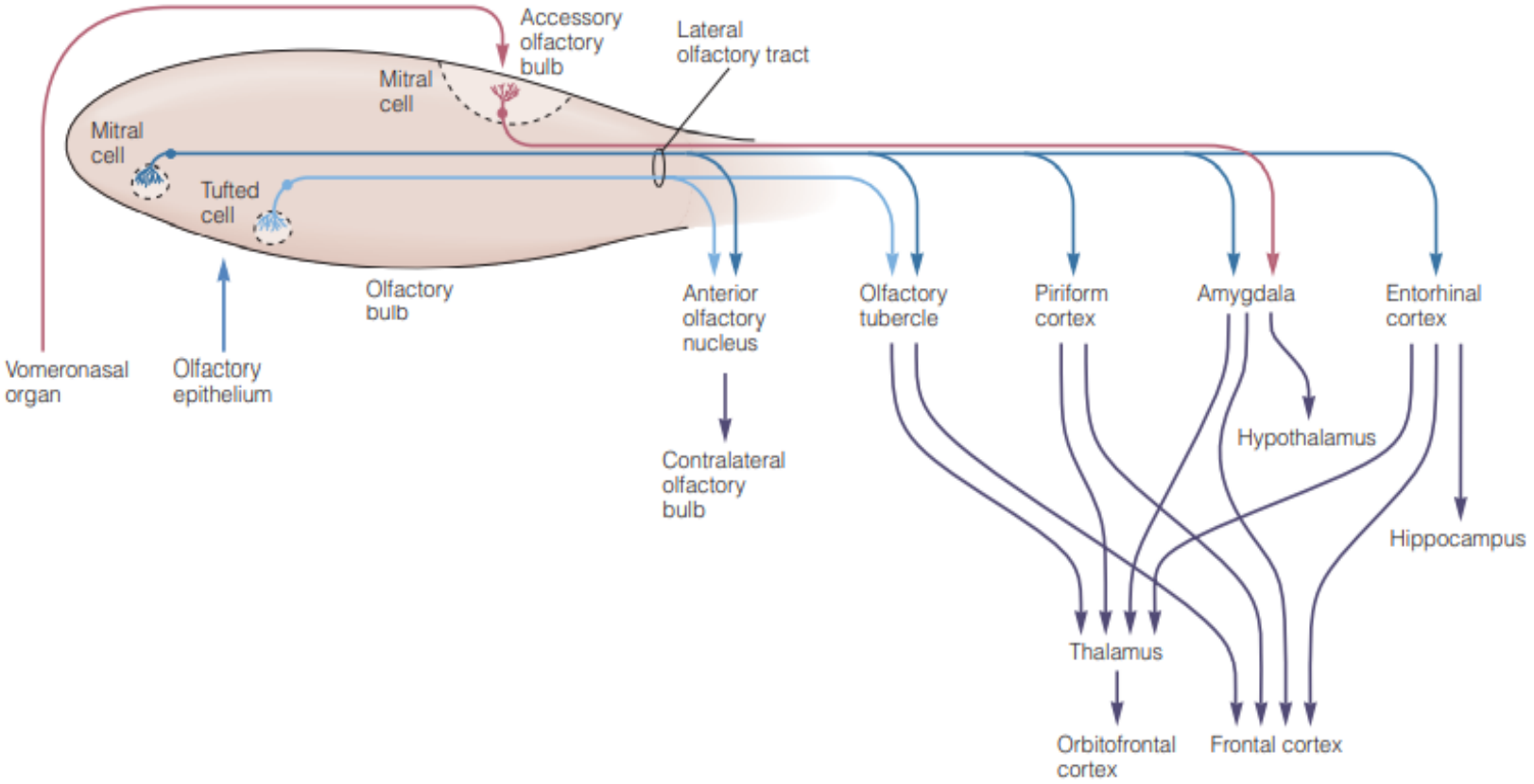
Membrane Potentials

- **RMP -55 mv**
- Firing rate very slow at this potential (2-3/sec)
- **Depolarization** → ↑ frequency of action potentials (20-30/sec)
- Olfactory nerve impulses are **proportional** to log of strength of stimulus
- Very **low threshold** for stimulation of olfactory sense

- **Methylmercaptan** can be smelled in concentration of only one 25 trillionth of gram/ml- mixed with natural gas


OLFACTORY RECEPTOR NEURONS
OLFACTORY BULB
FRONTAL CORTEX
(Conscious perception of smell)
HYPOTHALAMUS
(Motivational and emotional aspects of smell)
HIPPOCAMPUS
(Odor memory)

Olfactory Pathway



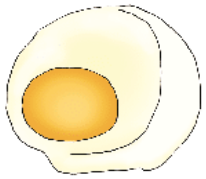
Adaptation

Thanks to her rapid rate of olfactory adaptation, Cecily is able to take over when Carla is overcome as they catalog an illegal dump site.

Adaptation

- Adaptation of olfaction to almost extinction
- 50% of adaptation of the receptors occurs within first second & later it is slow
- **Central or psychological adaptation** is more important than receptor adaptation
- **Centrifugal fibers** from olfactory regions of brain back to olfactory bulb terminate on special inhibitory cells - the **granule cells**

Classification of Odors

Citrus		Oranges, lemons, limes, grapefruit, tangerine
Acerbic-Synthetic		Alcohol, kerosene, leather, ammonia, tar
Leafy		Peppermint, teas, licorice, eucalyptus
Floral		Roses, lavender, violets, other flowers
Fruity-Non-citrus		Strawberries, other berries, pears, mango, pineapple
Woody		Mushrooms, cedar, earthy/dirt, “green vegetables” (e.g., bell pepper), beans
Spicy-Smoky-Nutty		Tobacco smoke, coffee, almonds, popcorn, cloves, spices, burnt things, butter
Heavy-Rotten		Eggs, smoked fish, garlic, vinegar, beer, wet dog, blood, cadaver, feces

Classification

1. Camphoraceous
2. Musky
3. Floral
4. Pepperminty
5. Ethereal
6. Pungent
7. Putrid

- Recent studies show at least **100 primary** sensations of smell

Odour Blindness

that we are all smell-blind to something?

Only a few people have no sense of smell, but all of us have "blind spots" in our olfactory system.

Croy et al 2015 tested 1600 people with a normal sense of smell. When presented with 100 different odors, 98.3% could not detect at least one of the tested substances. It is likely that if more odors were tested, this number would go to 100%.

So while we have recently learned that the human olfactory system can distinguish about 1 trillion odors, probably no single person actually has that ability.

However, Ilona Croy and her colleagues also found that you can train your nose to become

Odour Blindness

- People have been found who have odour blindness for single substances
- has been identified for more than 50 different substances
- lack of appropriate receptor protein in olfactory cells for a specific substance

Affective Nature Of Smell

Affective Nature Of Smell

- Has affective quality of either pleasantness or unpleasantness
- Because of this, smell is probably even more important than taste for the selection of food

Gradations Of Smell Intensities

- threshold concentrations of substances that evoke smell are extremely slight

- concentrations only 10 to 50 times above the threshold evoke maximum intensity of smell

Some Olfactory Thresholds

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

Transmission of Olfactory Signals

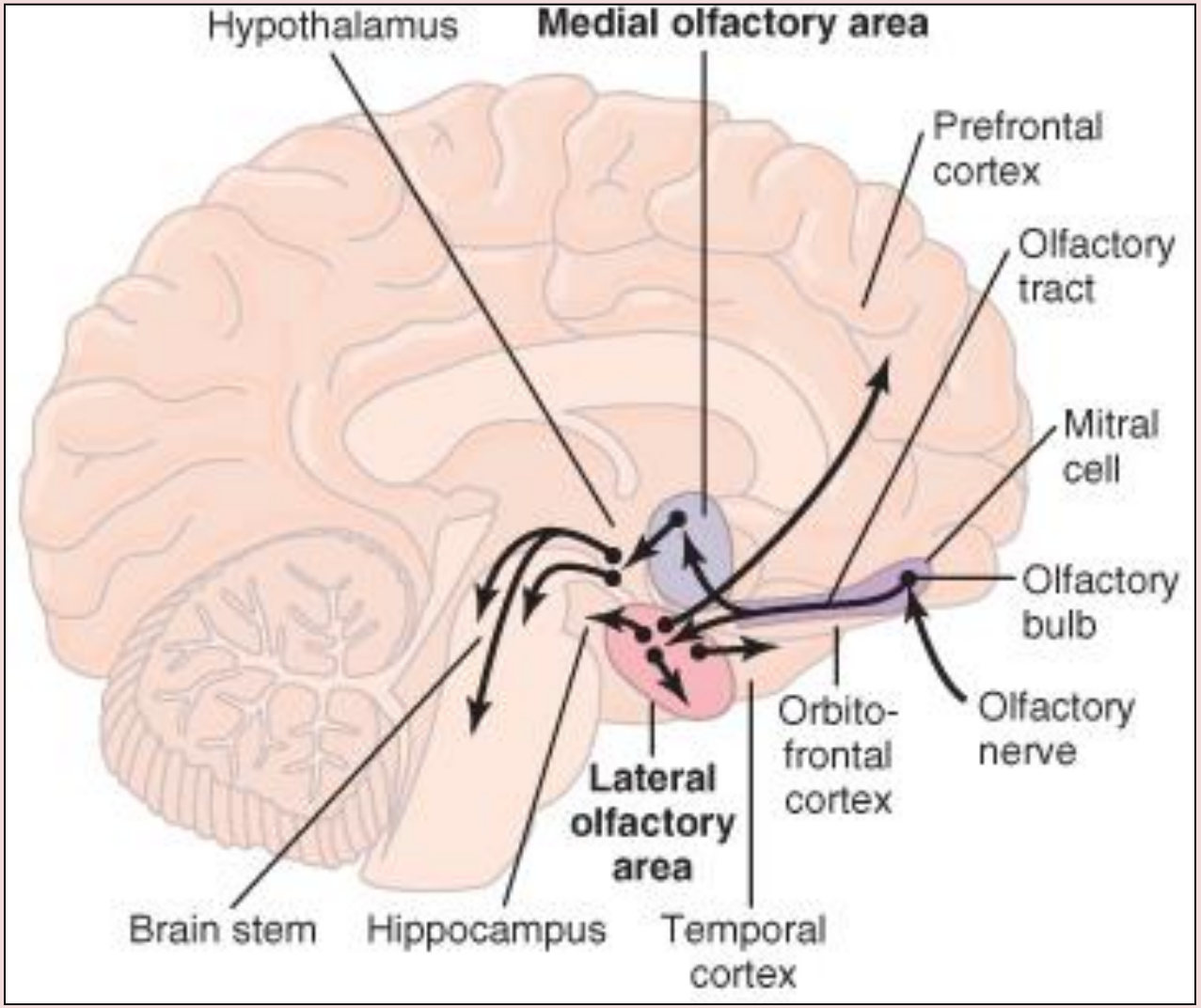
Transmission of Olfactory Signals

- **Olfactory nerve cells** (25000), **mitral cells** (25)and **tufted cells**(60) all synapse in a structure in olfactory bulb, called Glomerulus

- There may be specific glomeruli for specific odors

- Olfactory tract divides into lateral and medial **olfactory stria**
- Medial stria leads to medial olfactory area
- Lateral stria sends fibers to lateral olfactory area

Connections of the Olfactory System



Very old system

- Medial olfactory area
  - Mid basal portion of brain anterior to hypothalamus
  - Septal nuclei

- Concerned with basic behaviors
  - Feeding reflexes
  - Licking of lips
  - Salivation
  - Emotional drives

Less Old System

Lateral olfactory area

- Prepyriform cortex -- Pyriform cortex--Cortical amygdaloid nuclei →
- → **hippocampus** and other parts of **limbic system**
- also go to anteromedial portion of **temporal cortex** (without passing through thalamus)

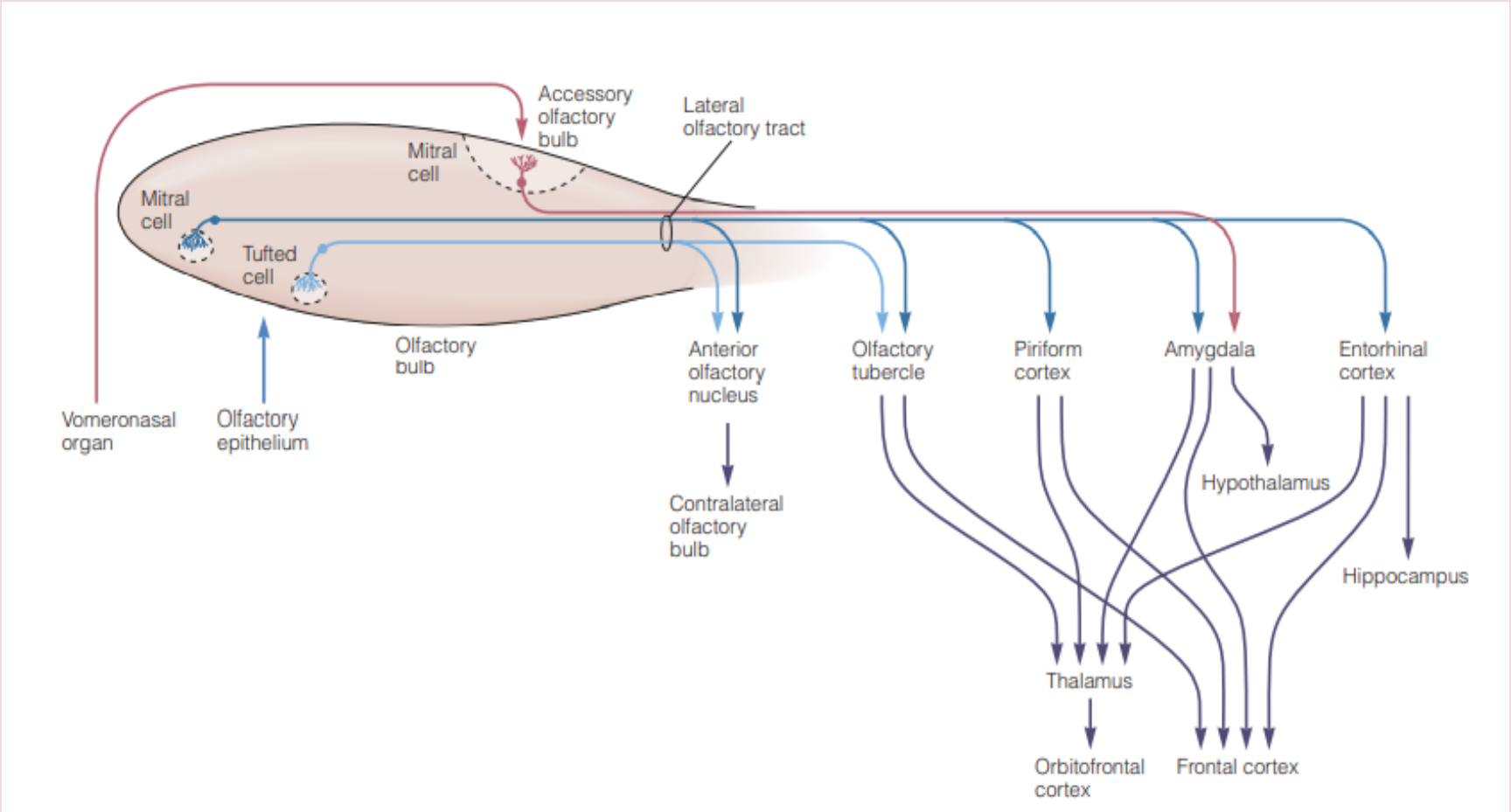
- **Concerned with affective quality of smell**
  - Like or dislike
  - Pleasant or unpleasant
  - Behavior according to experience

Which special sense has no relay in thalamus?

Newer System

- Lateral olfactory pathway
- through dorsomedial thalamic nuclei
- Then to posterolateral quadrant of orbitofrontal cortex and prefrontal cortex
- **Responsible for conscious analysis of odor**

Olfactory Pathway



Relation To Gender And Memory

Relation To Gender And Memory

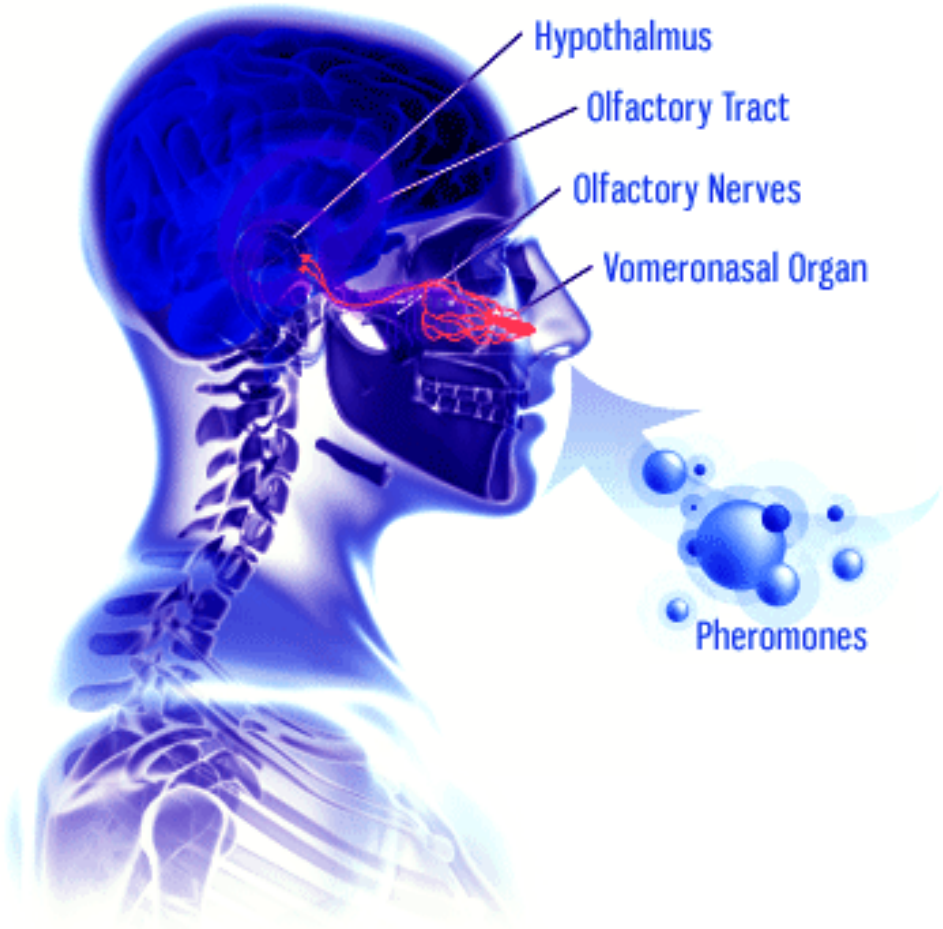
- A close relation between gender and memory,

  perfume ads are example

- Sense of smell is **more acute in women** than in men and in women especially at the time of ovulation

- Smell and to a lesser extent taste have unique ability to trigger **long term memories**

How Pheromones Induce A Sexual Response



1. Glands in our armpits, genital regions, and navels secrete a clear liquid that contains pheromones.
2. Our pheromone scent reaches the noses of women.
3. The olfactory system (starting with the nose) bypasses the RATIONAL brain.
4. This information is fed directly to the behavior center in a woman's brain.
5. If the information communicated by our pheromone scent is positive (i.e. this guy is healthy, fit & fertile), then a sexual response may be observed.

Abnormalities

Abnormalities of Olfaction

ANOSMIA

Absence of smell

HYPOSMIA

Diminished olfactory sensation

DYSOSMIA

Distorted sense of smell

Olfactory threshold increases with advancing age and more than 75% of humans over the age of 80 have an impaired ability to identify smells

Anosmia is associated with hypogonadism

Role of Pain Fibers in the Nose

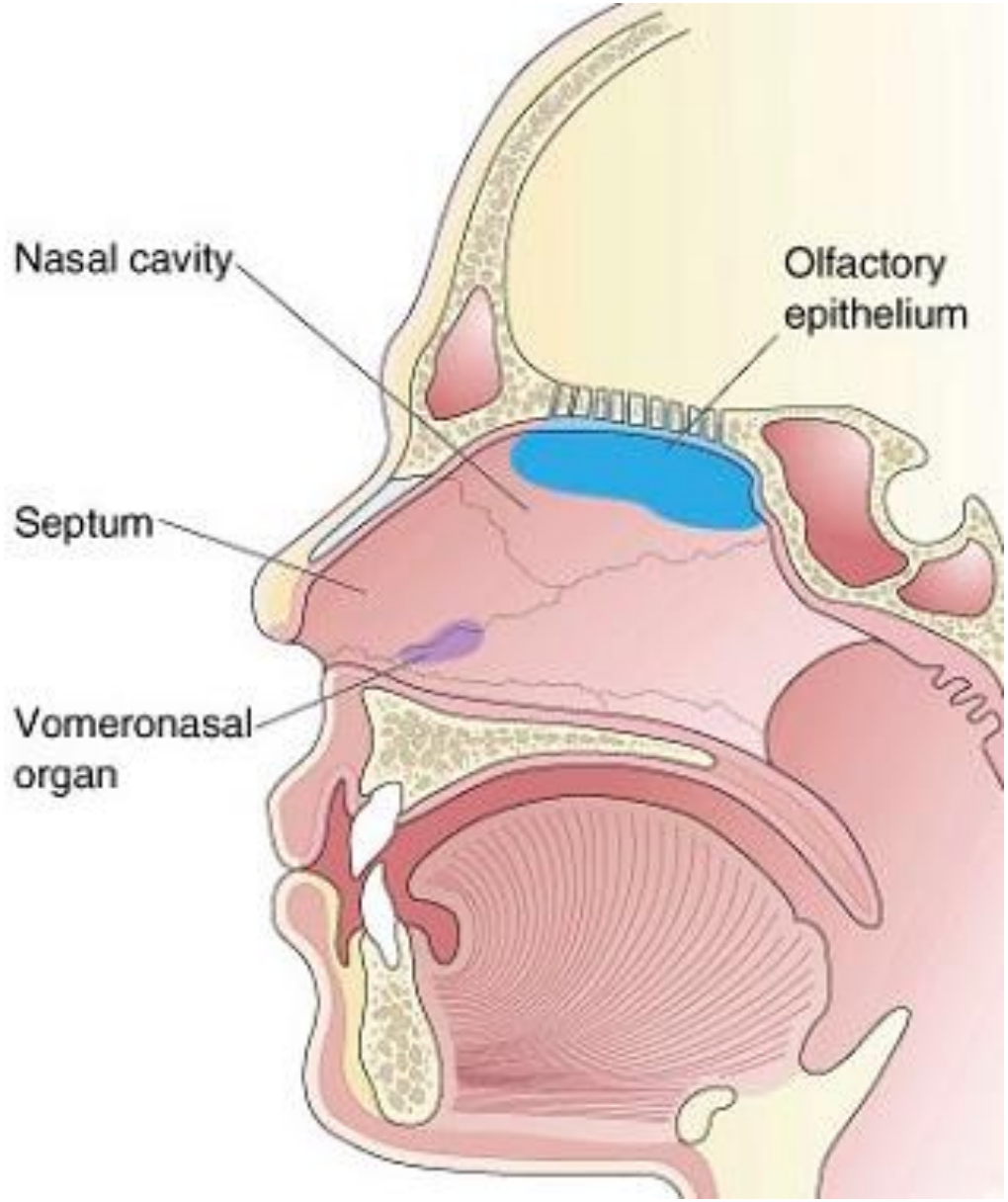
Many trigeminal pain fibers are found in olfactory membrane

They are stimulated by irritating substances

Are responsible for initiating sneezing, lacrimation and other reflex responses.

Effects of Cigarette Smoke on Sinus

Cigarette smoke reduces the ability of the microscopic cilia inside the nose and sinus lining to sweep mucus through the nasal and sinus passages. The thin mucous blanket that covers the nose and sinus lining thickens, and postnasal drainage can be quite thick and noticeable.


Nasal cavity
Olfactory epithelium
Septum
Vomeronasal organ

Vomeronasal Organ

- In rodents and other mammals, the nasal cavity has a patch of olfactory epithelium along the nasal septum in a **vomeronasal organ** for the perception of odors that act as pheromones.

- concerned with **reproduction and ingestion**.

- the **pheromones** of a male from a different strain prevent pregnancy as a result of mating with that male


H

Sniffing

- Olfactory receptor area is poorly ventilated
- Air reaching this region is greatly increased by sniffing, an action that includes contraction of the lower part of the nares on the septum, deflecting the airstream upward
- Sniffing usually occurs when a new odor attracts attention

References

- Guyton And Hall
- Human Physiology by Lauralee Sherwood
- Ganong’s Review of Physiology
- https://chrshrt112.typepad.com/blog/2018/03/my-recent-pheromones-study.html

Thank you