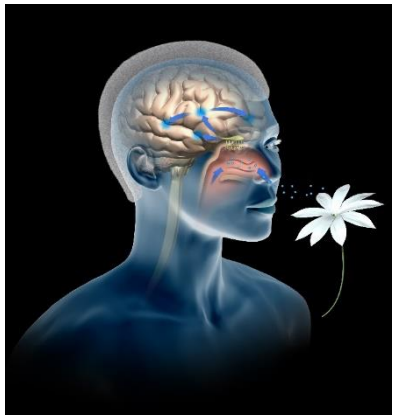
Chemosensation

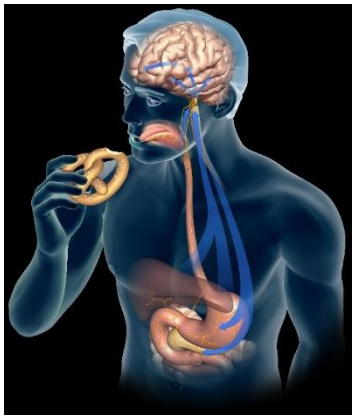
Evelina Thunell

Our chemical senses

- The first senses to evolve evolutionarily
- All living organisms can detect chemical signals



Smell (Olfaction)



Taste (Gustation)

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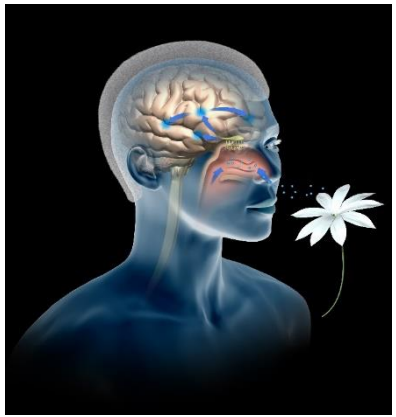

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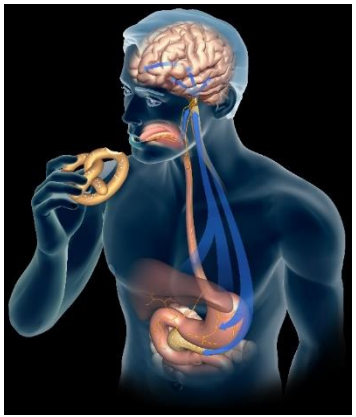

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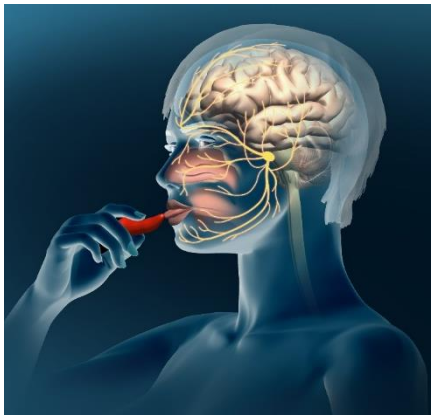

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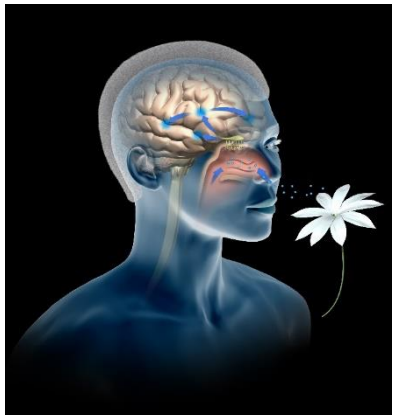

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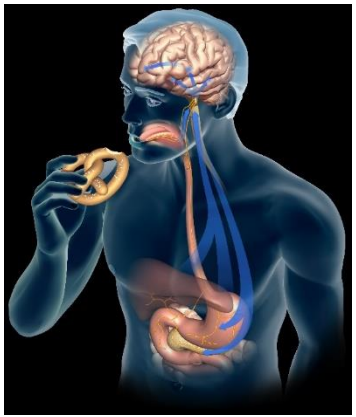

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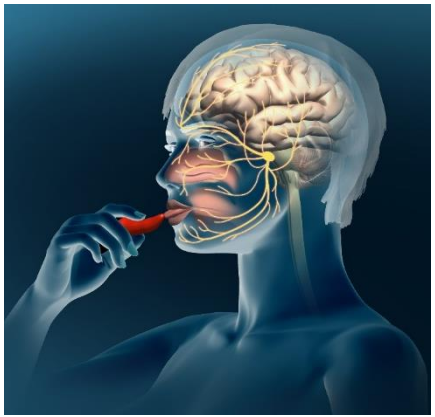
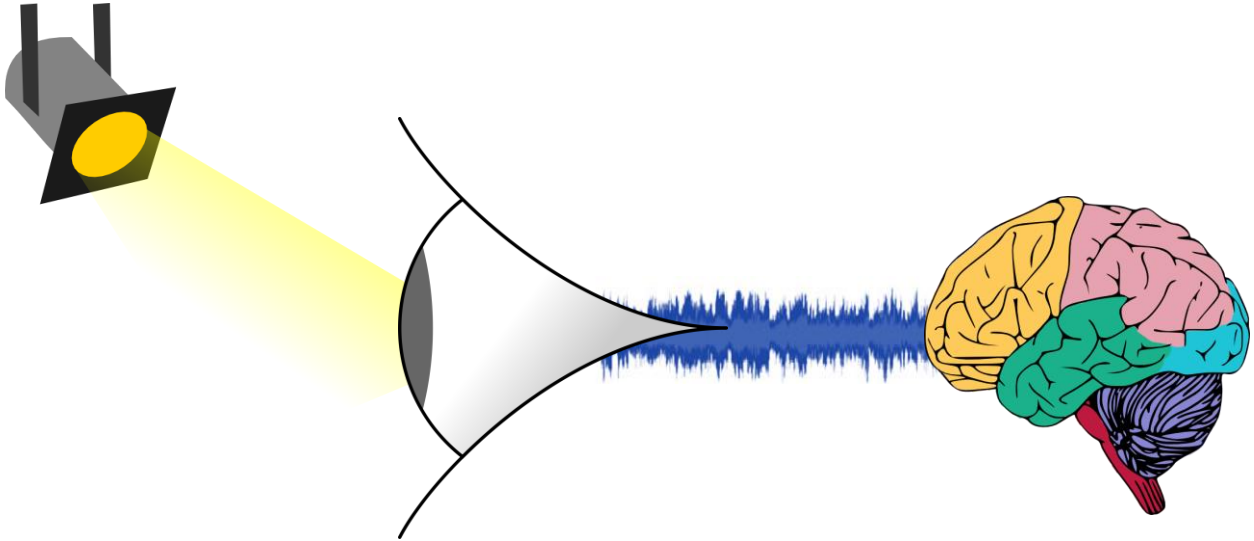


Trigeminal sense

What is perception?

Sensory cells in our sensory organs convert an external stimulation into electrical signals that are interpreted in the central nervous system



What is perception?

Sensory cells in our sensory organs convert an external stimulation into electrical signals that are interpreted in the central nervous system

The *chemical* senses have receptors that are activated when they bind to chemical substances

Our chemical senses

- Taste

  → Water soluble taste molecules ”Tastants” ⟶ Activation of taste receptors ⟶ Central processing ⟶ Taste percept

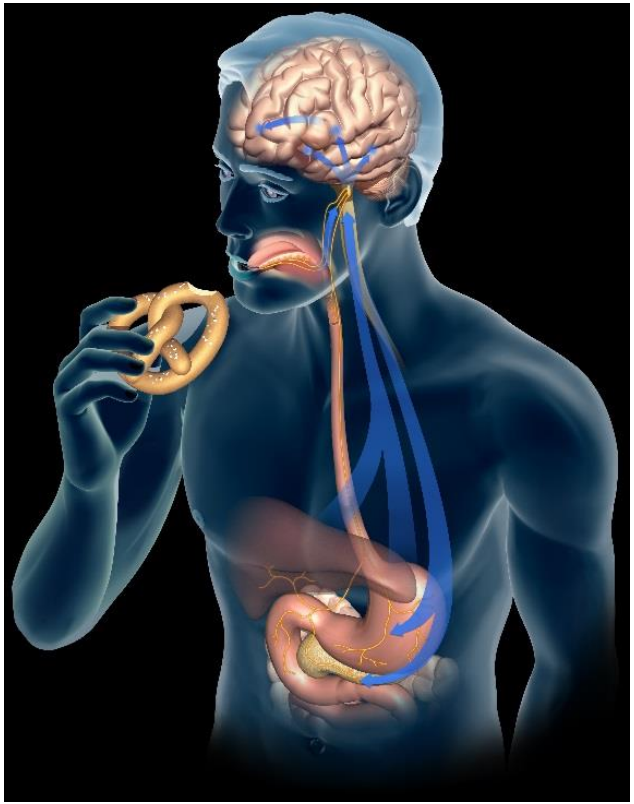
- Smell / Olfaction

  → Airborne odor molecules ”Odorants” ⟶ Activation of smell receptors ⟶ Central processing ⟶ Smell percept

- Trigeminal sense

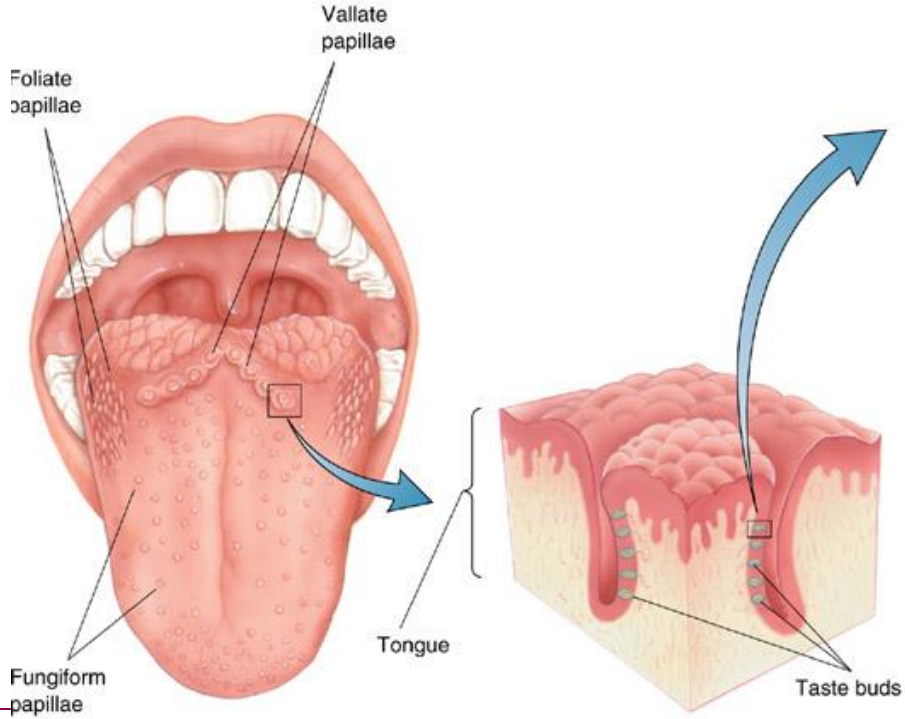
  → Irritant (for example chili) ⟶ Activatino of trigeminal receptors ⟶ Central processing ⟶ Heat/cold/irritation/pain etc.

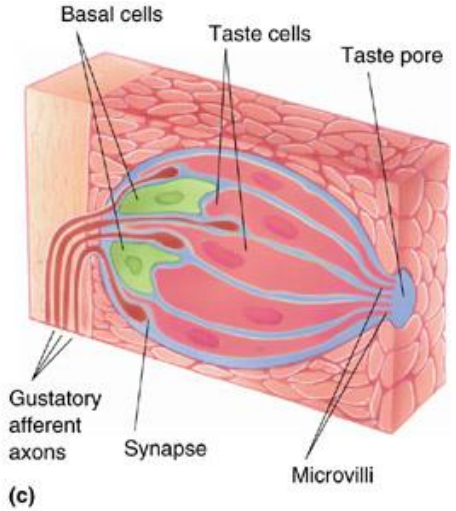
Taste



The anatomy of taste

Taste arises from chemicals binding to receptors on the tongue.





The anatomy of taste

- Taste sensory cells in the stomach, liver, and pancreas!
- Regulates nutrient absorption in the gastrointestinal tract by "tasting" the contents of the stomach
- Supposed purpose: to regulate metabolism

Depoortere, 2014

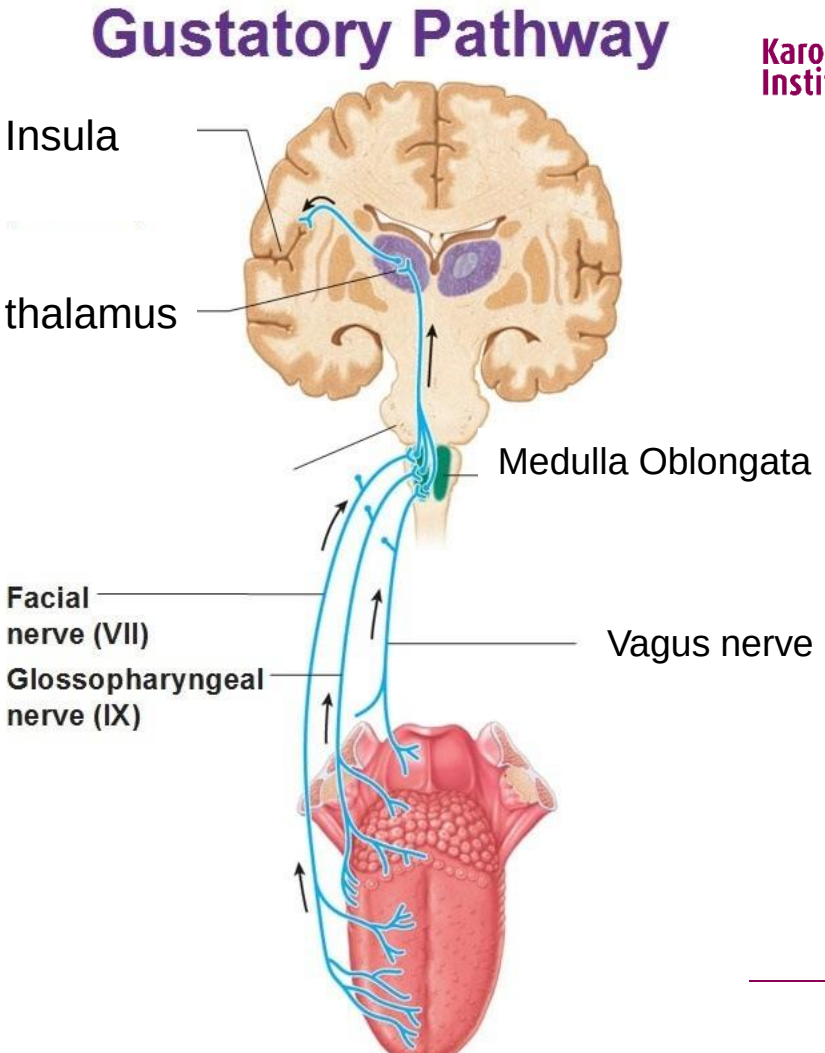
The anatomy of taste

- Nerves
  - → Facial nerve (VII)
  - → Glossopharyngeal nerve (IX)
  - → Vagus nerve (X)

  Ovanligt att förlora smaksinnet!

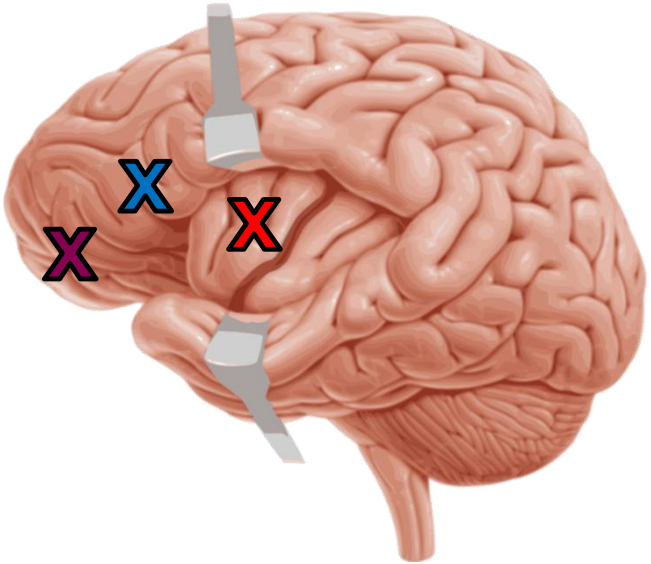
- Medulla oblongata ⟶ Thalamus

- Cortex



The anatomy of taste

- From brainstem to gustatory cortex
  - → Medulla oblongata
  - → Thalamus
  - → Primary gustatory cortex
    - Anterior insula
      - → Intensity, quality
    - Frontal operculum
  - → Secondary gustatory cortex
    - Orbitofrontal cortex
      - → Pleasantness

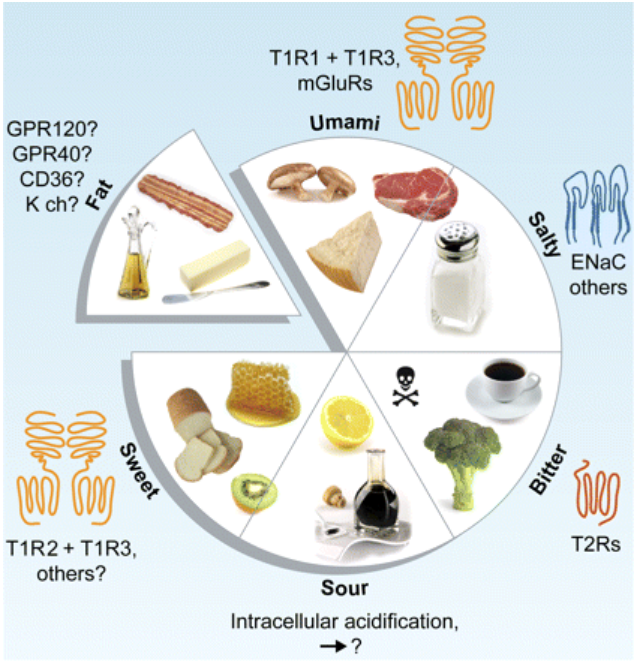


Rolls 2015

Gustation – Function

- Tastant
  → A stimulus that induces a taste percept

- At least 5 basic tastes
  → Sweet
  → Salty
  → Bitter
  → Umami
  → Sour
  → (Fat, metallic,...)



Innate responses

Gustation -Function

- Sweet/fatty: find energy-rich foods, detect rancid fatty acids
- Bitter: detecting toxins in plants that do not want to be eaten
- Acidic: avoid spoiled food, corrosive
- Salt: salt/water balance

Gustation– Individual variation

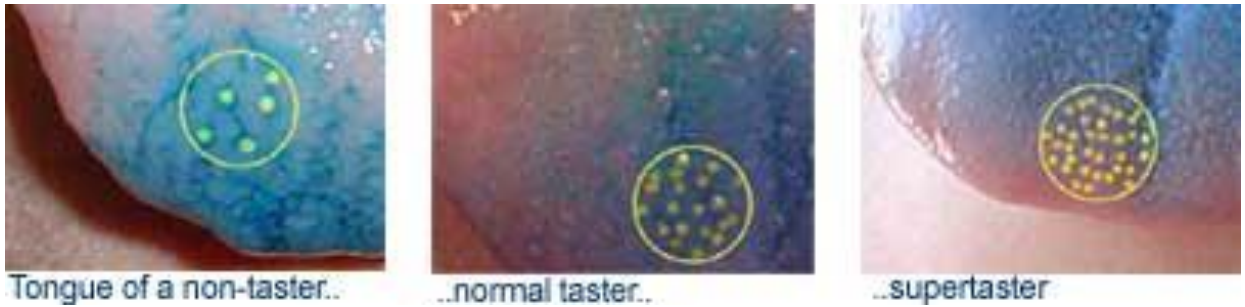
- The number of taste receptors on the tongue

  People can be categorized as

  → (1) *Supertasters* 25%

  → (2) *Normal tasters* 50% OR

  → (3) *Non-tasters* 25%, depending on how sensitive they are to taste (especially bitter).



Taste versus smell

- We often say e.g. “It tastes like banana”

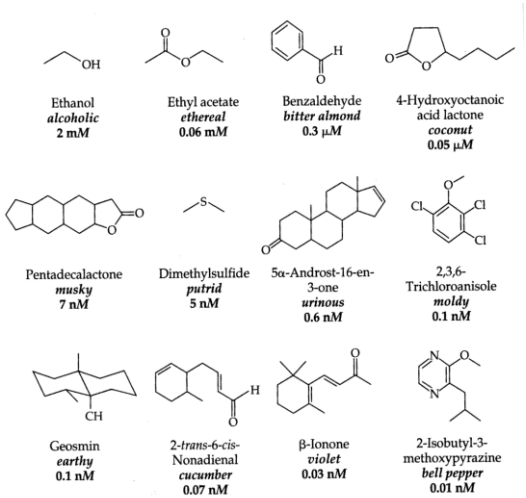
  → But banana is a *smell*

Something to try at home

Feed a nose-squeezed and blinded friend different foods and let them guess what they are! (Note: warning for allergens)

The sense of smell – What is a smell?

A single kind of airborne molecule can activate an olfactory receptor



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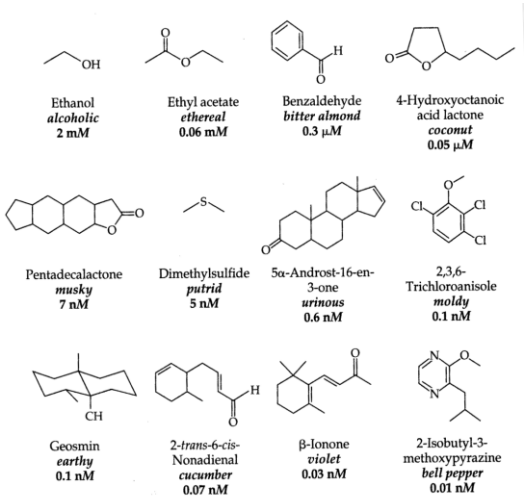
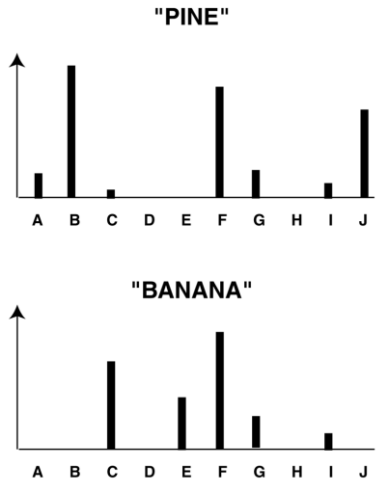
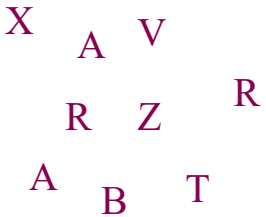


But the vast majority of smells we experience are mixtures of molecules

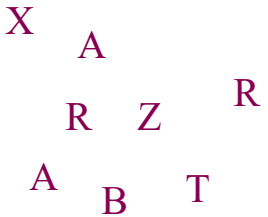


The sense of smell (olfaction) – What is a smell?

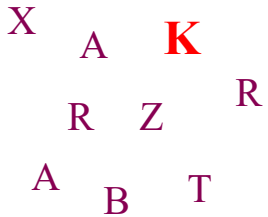
Pattern recognition



Pattern completion

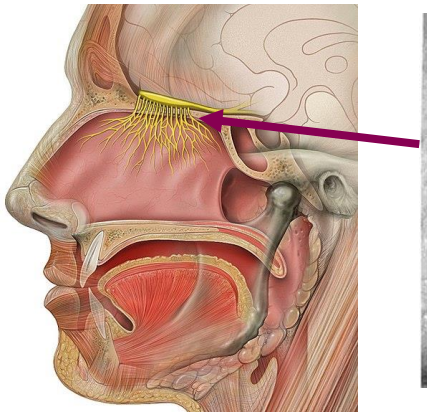


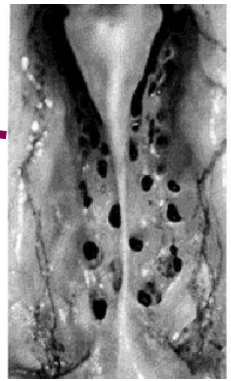
Pattern separation



Olfaction -Anatomy

- Odor receptors in the olfactory epithelium of the nasal roof detect odor molecules
- The signal is sent via the olfactory bulb to the olfactory nerve (cranial nerve I)

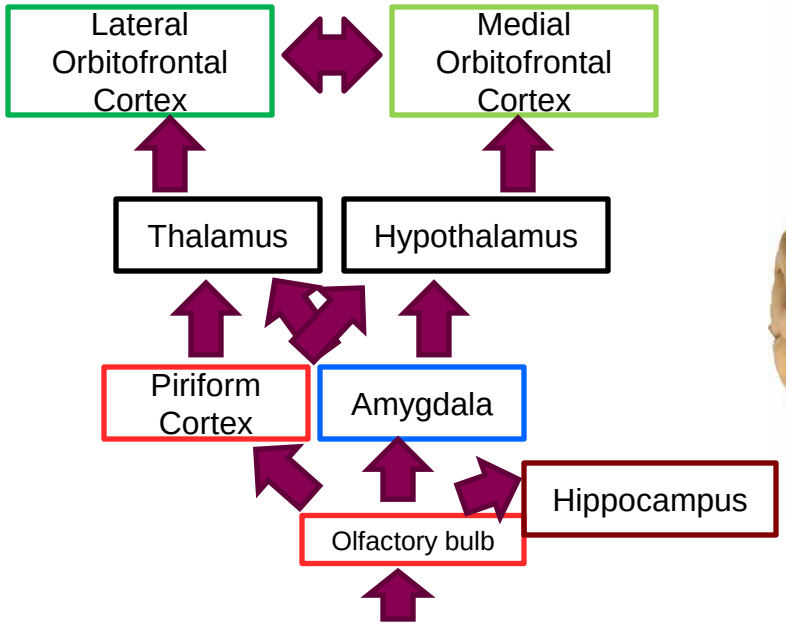


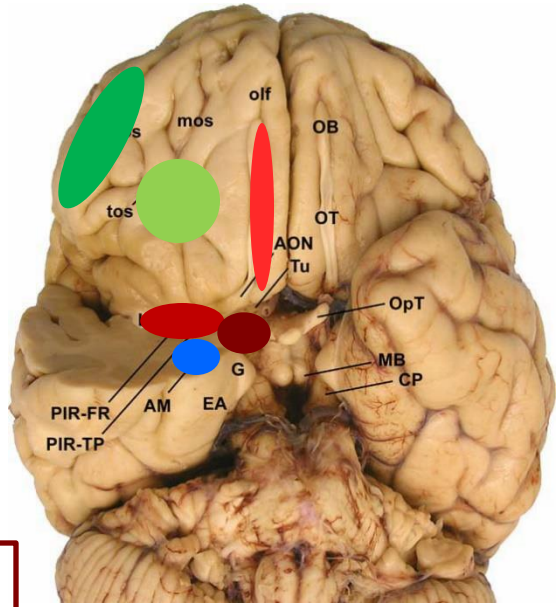


Lamina cribrosa

Linda Buck + Richard Axel
Nobel prize 2004

Olfaction- Anatomy





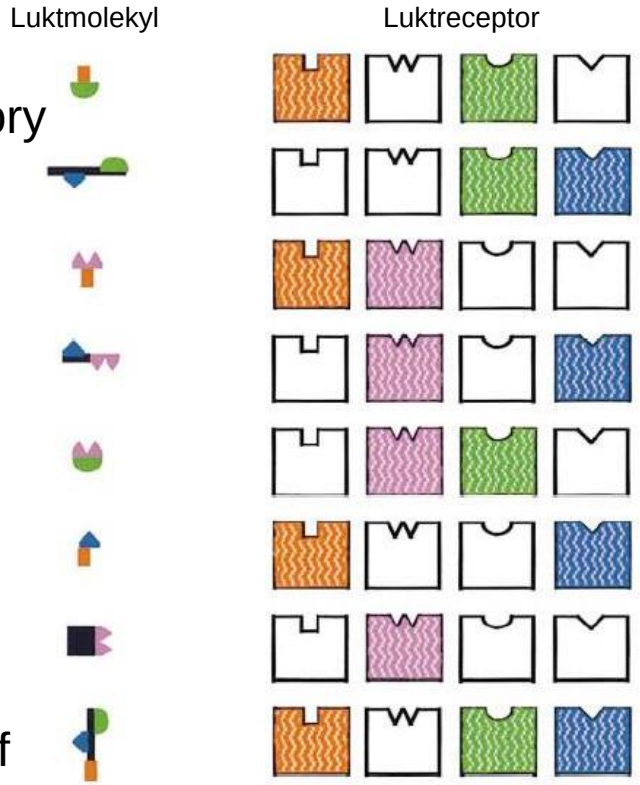
The only sense where the signals are not mostly rewired in the thalamus before they reach the cerebral cortex!

Olfaction - Anatomy

- Olfactory bulb
  - → Amplifies the olfactory signal
  - → Sorting out relevant information
  - → Spatial organization that reflects the chemical composition of the smell
  - → Even at this early stage, our experience influences the processing
- Piriform cortex
  - → The smell is identified by interpreting the signal from the olfactory bulb, the process is strongly influenced by various "top-down" processes
- Orbitofrontala kortex
  - → Decision-making: approach or avoid?
  - → Pleasantness (valence)
  - → Integration with signals from other senses

Olfaction– Anatomy

- How do we code for smells?
  - → 3% of our genes are devoted to olfactory receptors
  - → Most of these are pseudogenes, about ~400 code for olfactory receptors
  - → A receptor can be activated by several odorants
  - → One odorant can activate several receptors
  - → The sense of smell can therefore distinguish an almost infinite number of odorants by pattern encoding



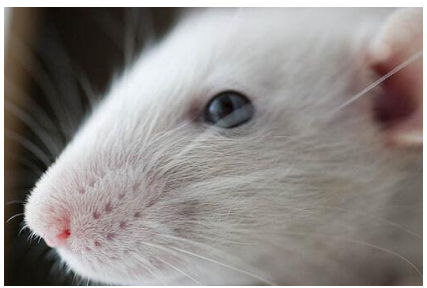
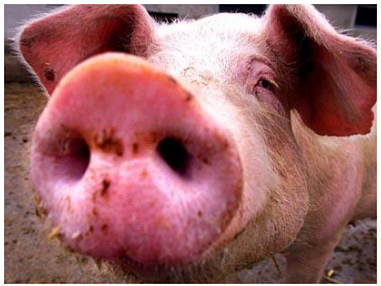
The sense of smell is active in the womb

- The fetus smells the amniotic fluid
  → Can smell the mother's food

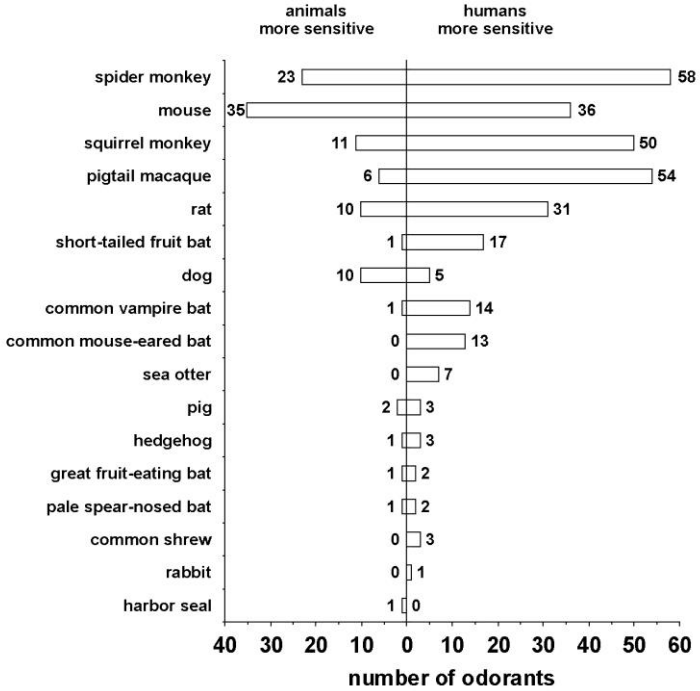
- Exposure in the womb affects the baby's preferences
  → turns their head towards familiar odors (e.g., anise if the pregnant mother has eaten it) and towards their own mother's odor rather than other mothers' odors

Human VS animal sense of smell

- It is commonly assumed that other animals have a much better sense of smell than we do.
- But do the animals really have a better sense of smell?

Who "wins" if we really measure ability?



Humans are more sensitive to odors than most animals that have been tested (threshold measurement)

Data from Matthias Laska, Linköping Universitet

The myth of humans' poor sense of smell

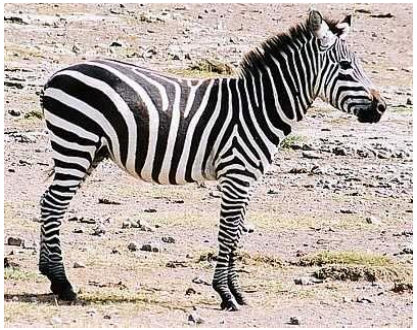
- If we are motivated and are forced to focus on the nose, we are extremely good at using our olfaction.

Why do we have a sense of smell?

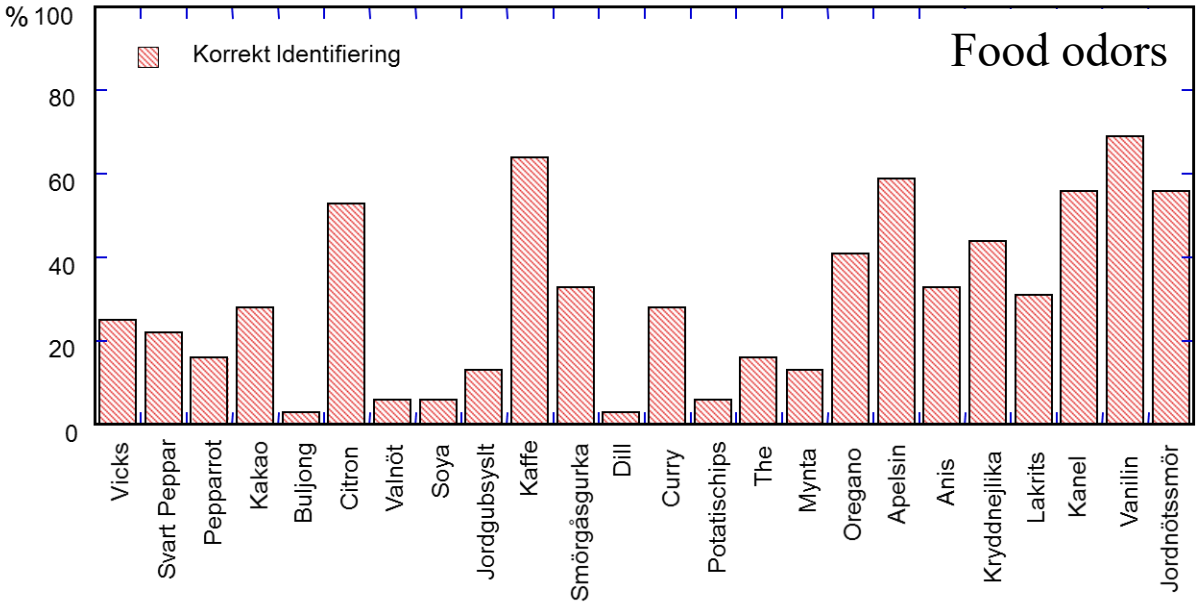
- Warning!
  → Avoid

- Attraction (e.g. partner) and rewards (e.g., food).
  → Approach

Identify the objects in the pictures = easy



Odor identification = difficult



No odor reaches over 70% accurate identification in the absence of other cues.

Olsson et al. 2000

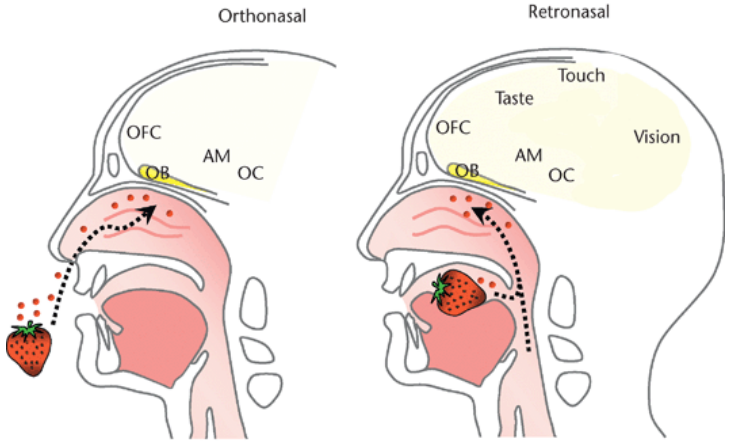
Olfaction -Function

- Identifying odor = difficult! (categorize is easier, e.g. smoky/fruity/floral smell)
- …due to underdeveloped olfactory vocabulary? (the brain's language centers have relatively weak links to the olfactory cortex). Exercise helps.

Olfaction -Function

- Two "separate" olfactory systems.

I argue that olfaction is the only dual sensory modality, in that it senses both objects in the external world and objects in the body (mouth). I suggest that the same olfactory stimulation may be perceived and evaluated in two qualitatively different ways, depending on whether it is referred to the mouth or the external world.



Rozin 1982

Olfaction -Function

- Orthonasal olfaction
  - → The odorant reaches the receptors via the nose
  - → Provides information about objects in our external environment

- Retronasal olfaction
  - → The odorant reaches the receptors through the mouth/throat
  - → Gives info about objects in the mouth, usually food

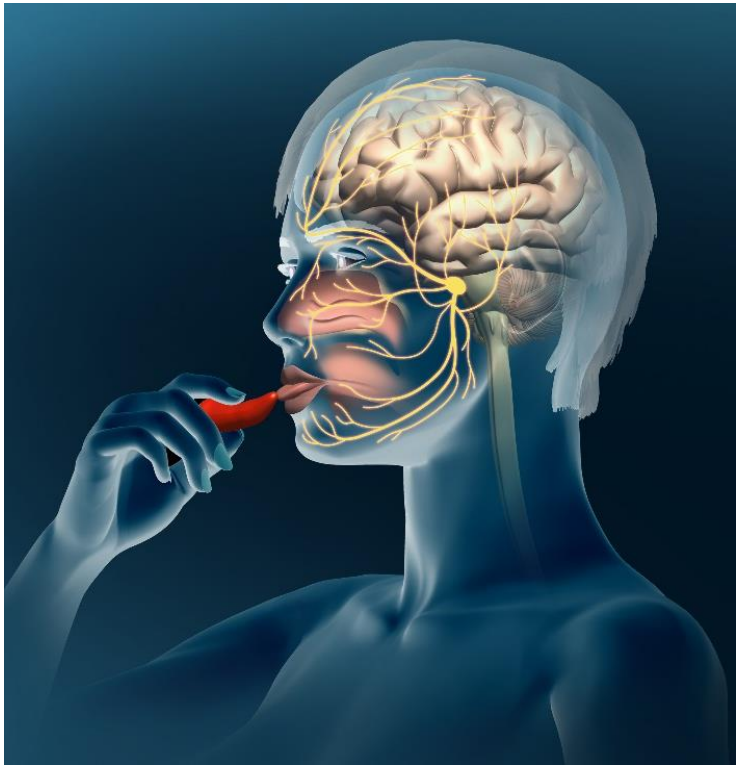
- Smells are both experienced and processed differently depending on the path they take to reach the receptors in the nose

Smell –Function (pleasantness)

Smell –Function (pleasantness)

- Associative learning
  - → The smell is linked to other sensations that are already pleasant/unpleasant
  - → The smell is linked to bodily sensations (e.g. metabolic effects of eating)

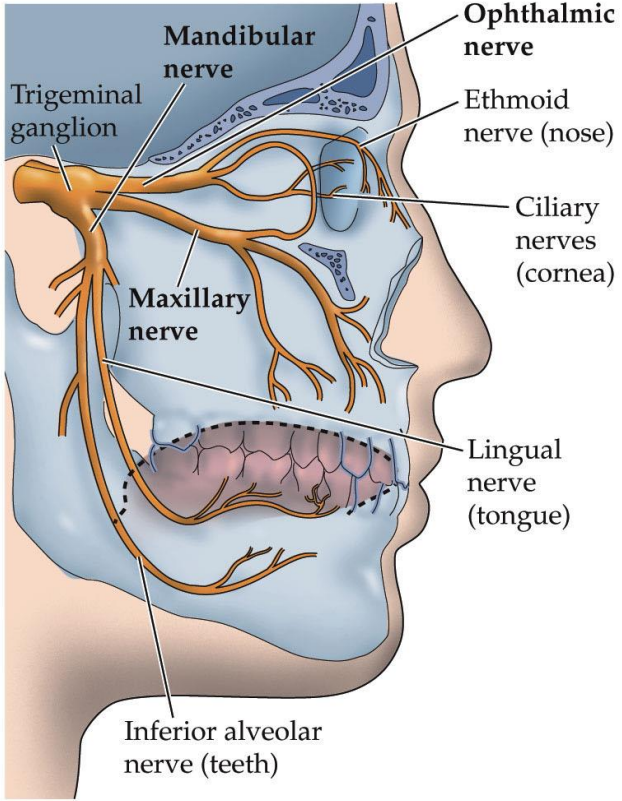
The trigeminal system



The trigeminal system

- Trigeminal nerve branches in oral cavity and sinues

- Receptors in the nose/mouth – Cranial nerve (V) – Thalamus – Various places in the cortex, including the insula

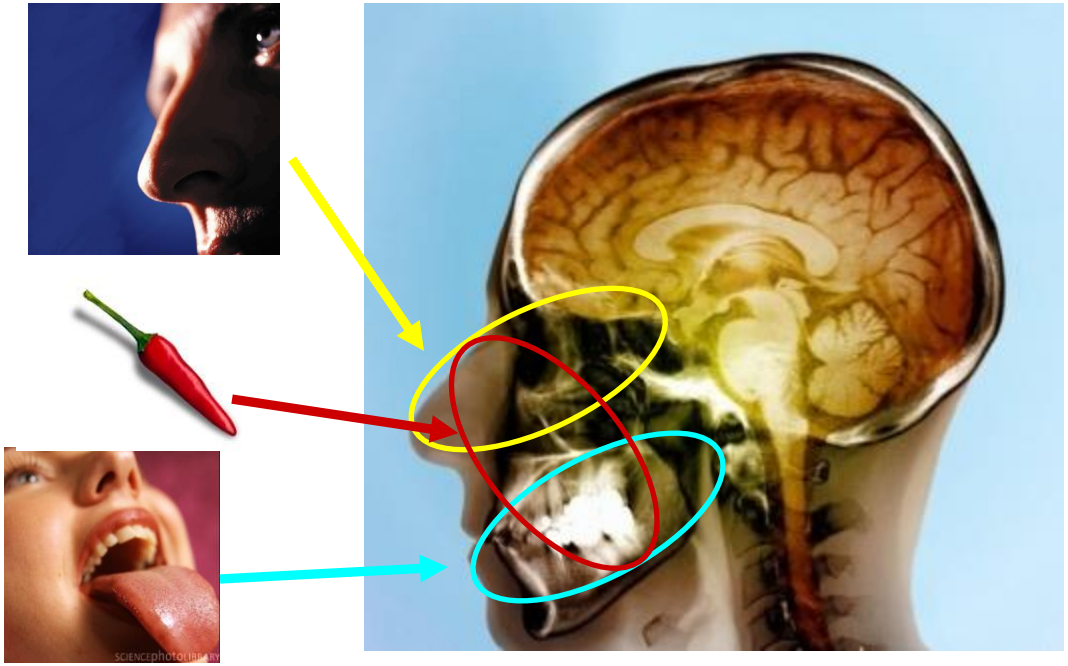


Principles of Cognitive Neuroscience, Figure 7.10

The trigeminal system

- Activated by e.g. chili, pepper, ginger, wine, mustard, peppermint and carbonated drinks
- Described as an irritation, heat, cold, irritation or pain

Flavor perception



We usually experience the chemical senses together and as a holistic percept. Smell, taste, and trigeminal stimulations converge in the cortex


That's all Folks!