Taste and Smell

How chemical molecules excite our senses

Dr Kristin Hillman

Department of Psychology

& Brain Health Research Centre

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

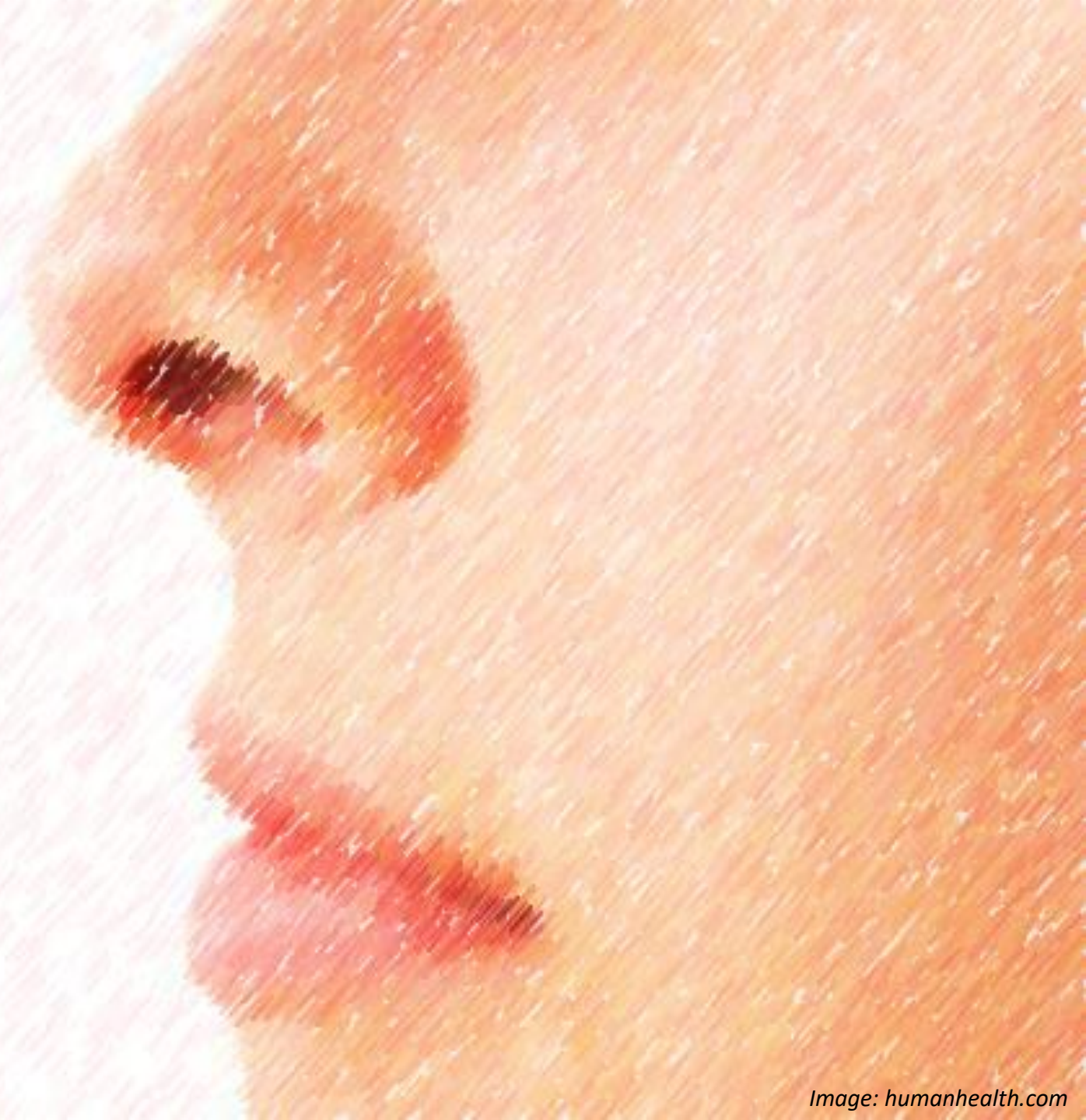


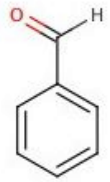
Image: humanhealth.com

Taste and Smell

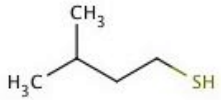
Our two chemical senses

Odorants are volatile, lipophilic chemicals

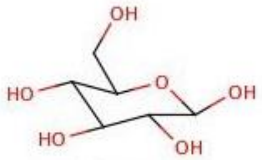
Tastants are soluble, hydrophilic chemicals



Benzaldahyde
(Almond)



3-Methylbutane-1-thiol
(Skunk)



Glucose
(Sweet)

Sodium Ion
(Salty)

Our two “least important” senses…

….according to some

Our ability to taste and smell decreases

with age, and is influenced by sex

Smell

& the olfactory system

Olfaction

L. olfacere "to smell"

- A far sense
- Key functions:

  Detection of environmental cues

  Identification of things and conspecifics

  Communication via non-verbal signals

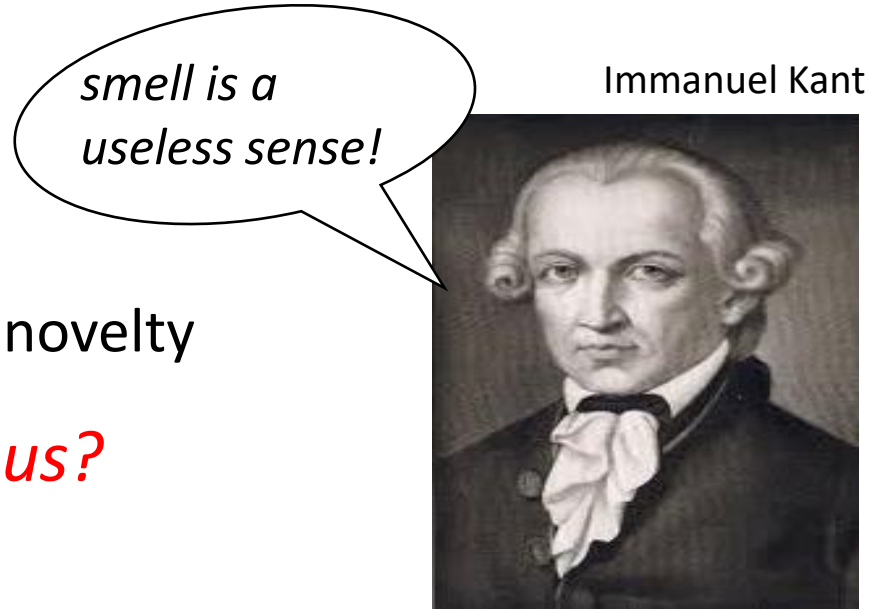
Images: quiz.biz, thejournal.ie, womenshealthmag.com, vetmedicine.about.com, cesarsway.com

Olfaction

L. olfacere "to smell"

- A far sense
- Key functions:
  - Detection of environmental cues
  - Identification of things and conspecifics
  - Communication via non-verbal signals
- Is it important?
  - For many animals, essential to survival
  - For humans, a degree of survival/safety, but largely a novelty

Is that 'novelty factor' really important to us?



Immanuel Kant

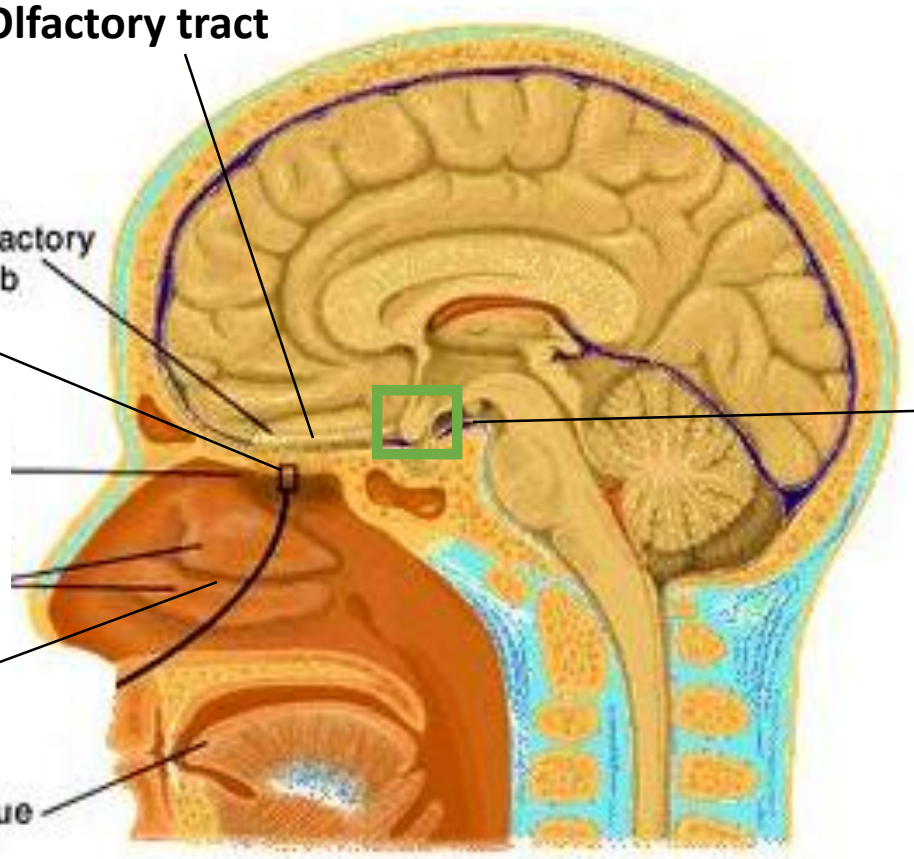
Images: en.wikibooks.org

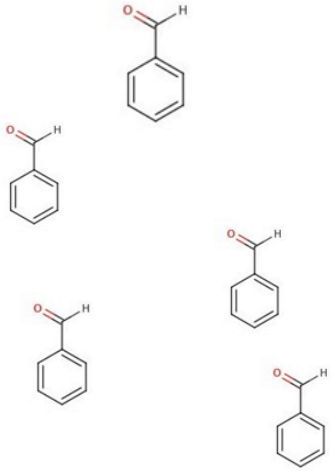
Is smell really important to us?

Smells are…

- difficult to ignore
- quick to influence our perceptions about things
- linked to emotions, memories

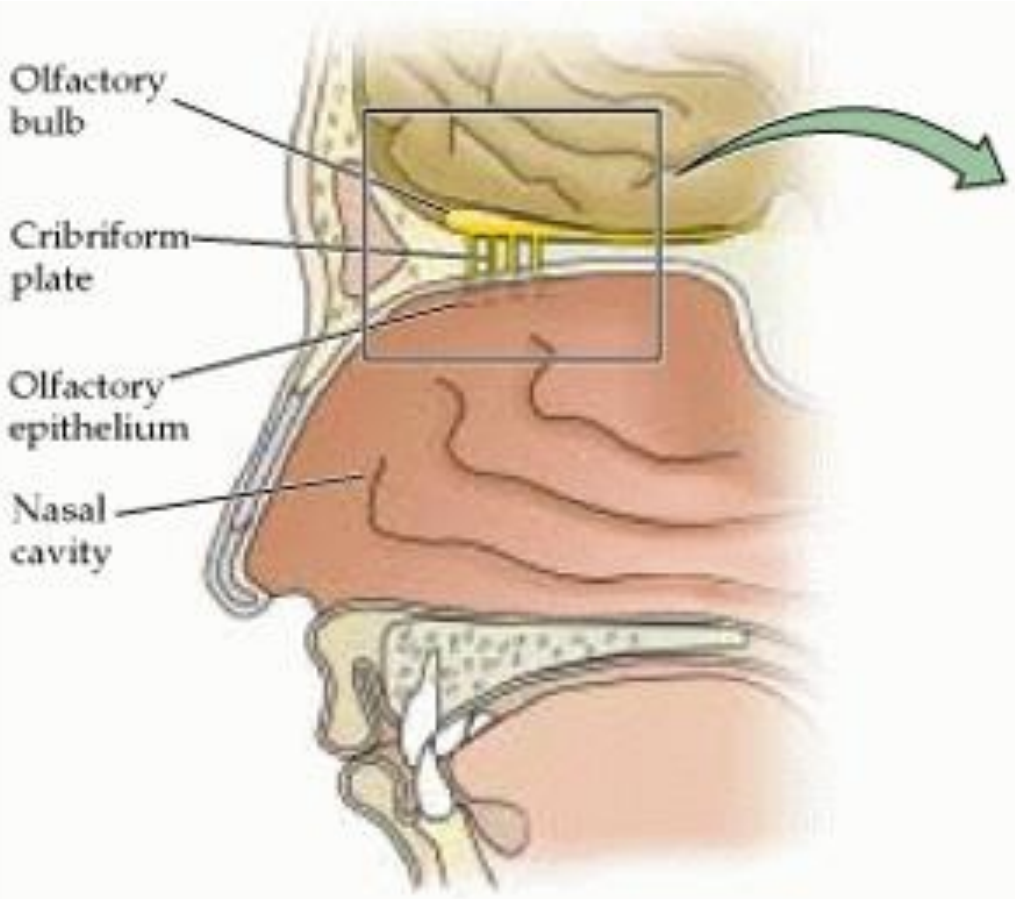
The Olfactory System

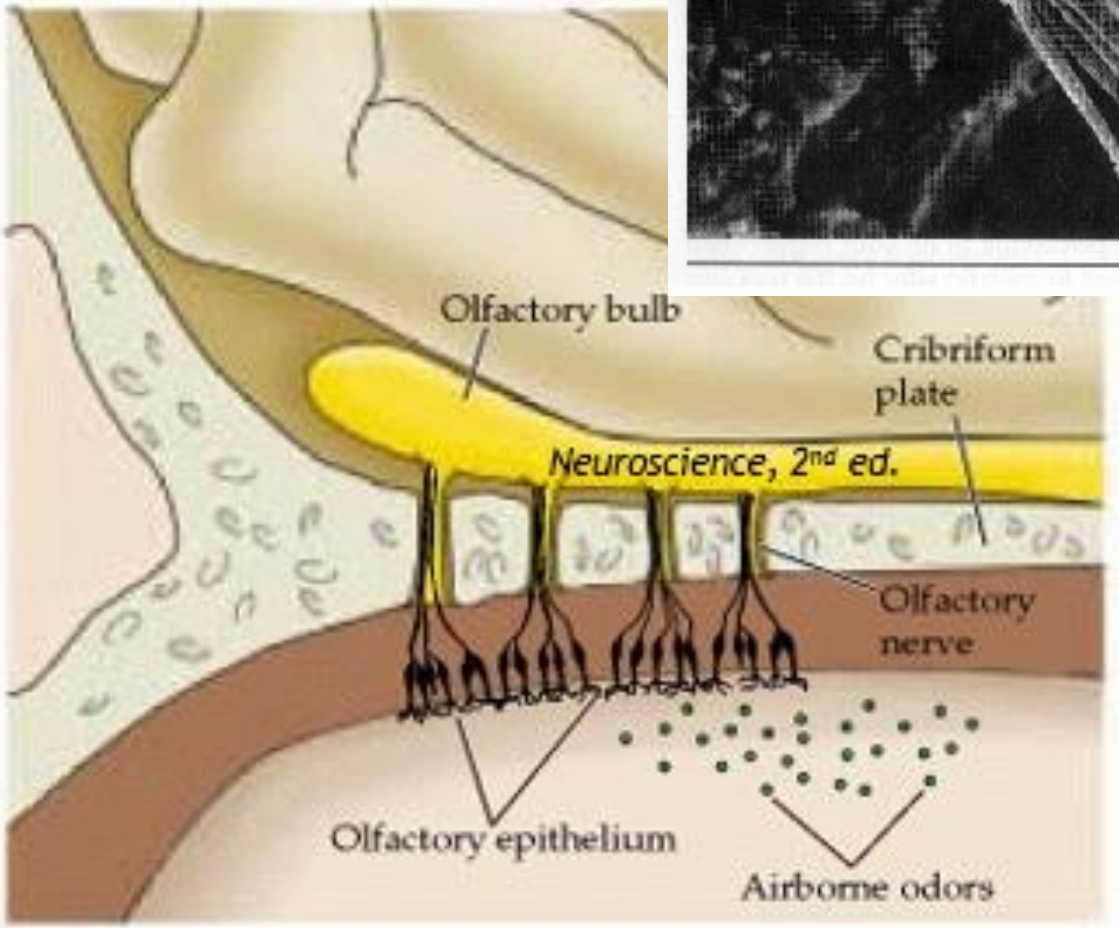




Images: Neuroscience, 2nd ed.

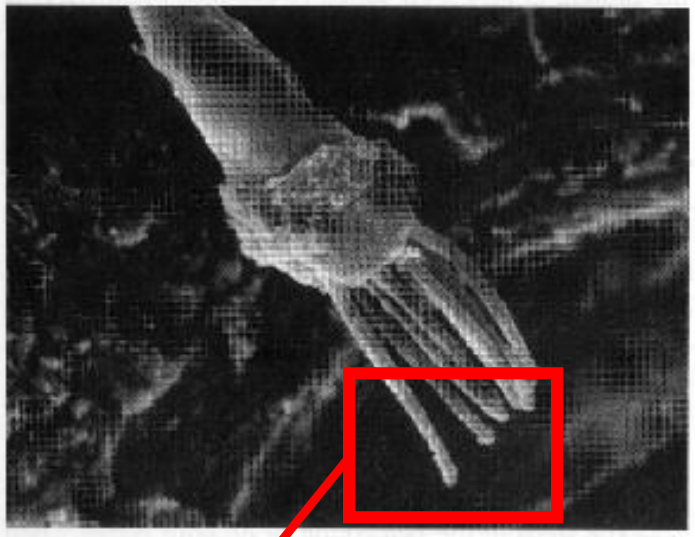
FIGURE 14.7 | A highly magnified picture of an actual olfactory receptor neuron with its cilia extending into the nasal cavity.

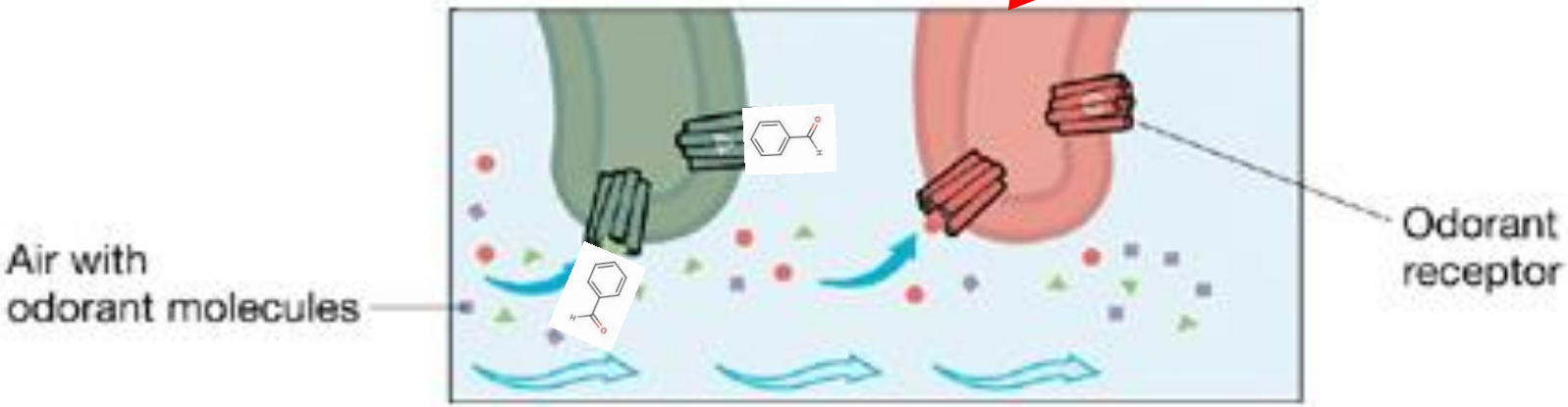




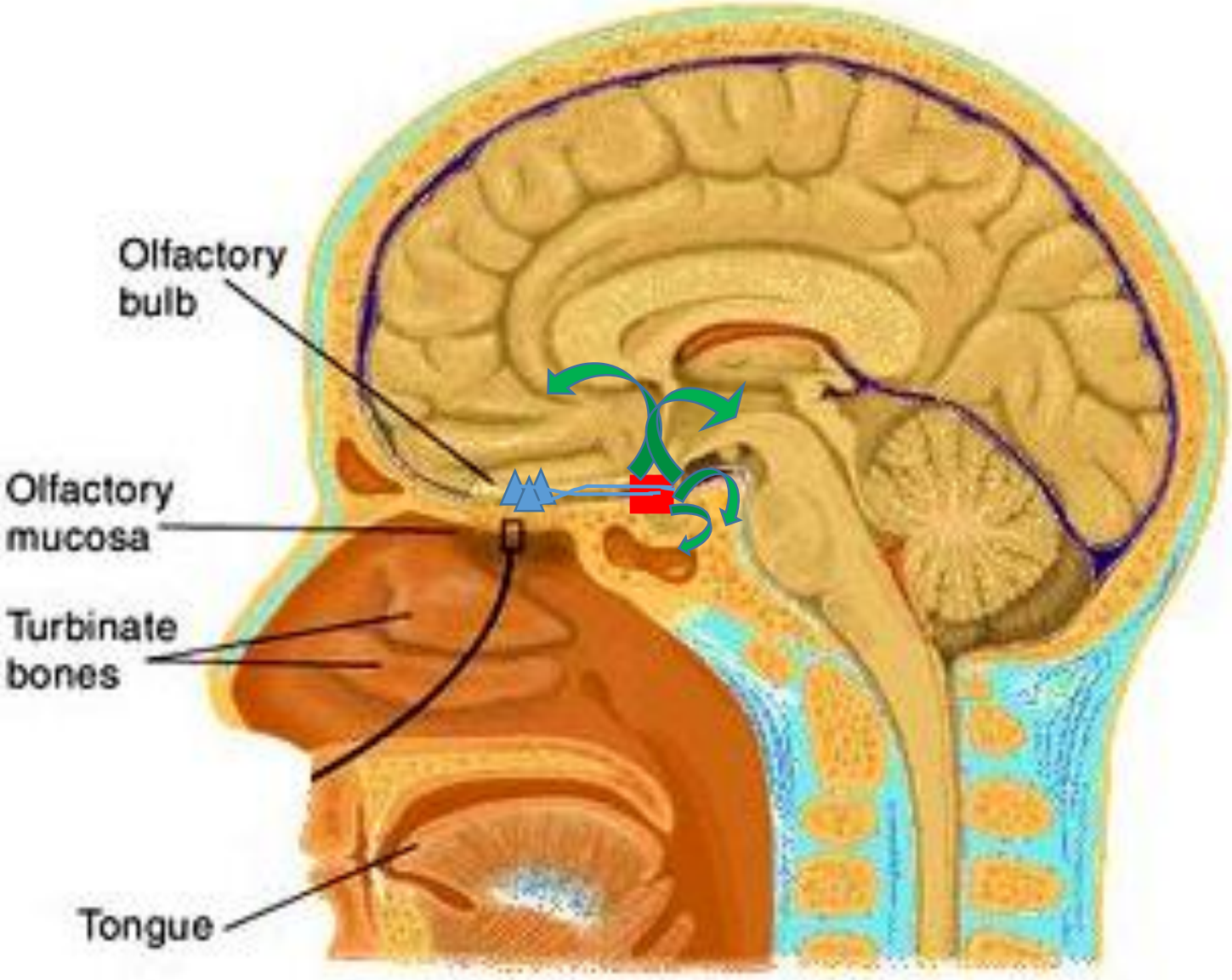
Images: Neuroscience, 2nd ed.; Perception, 5th ed.

FIGURE 14.7 | A highly magnified picture of an actual olfactory receptor neuron with its cilia extending into the nasal cavity.





Images: Neuroscience, 2nd ed.; Perception, 5th ed.

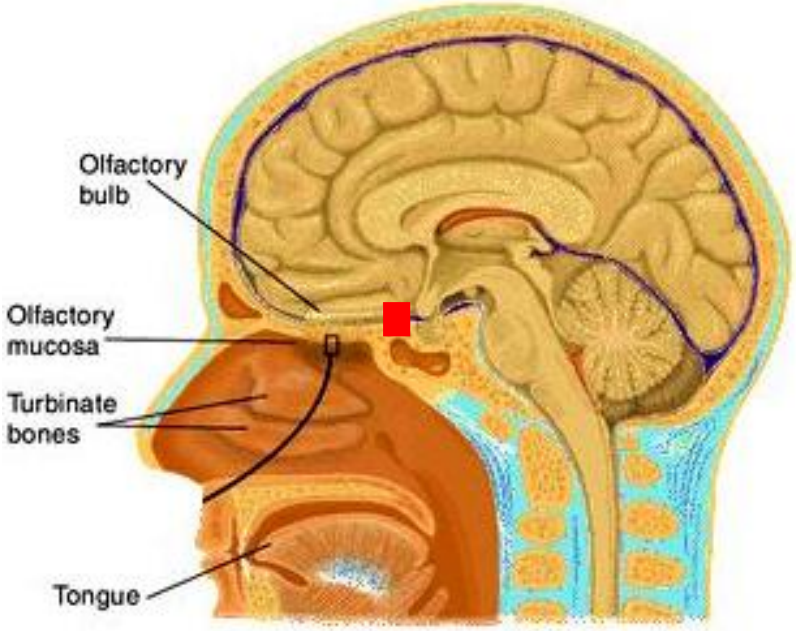


Olfactory cortex (piriform cortex) enables:

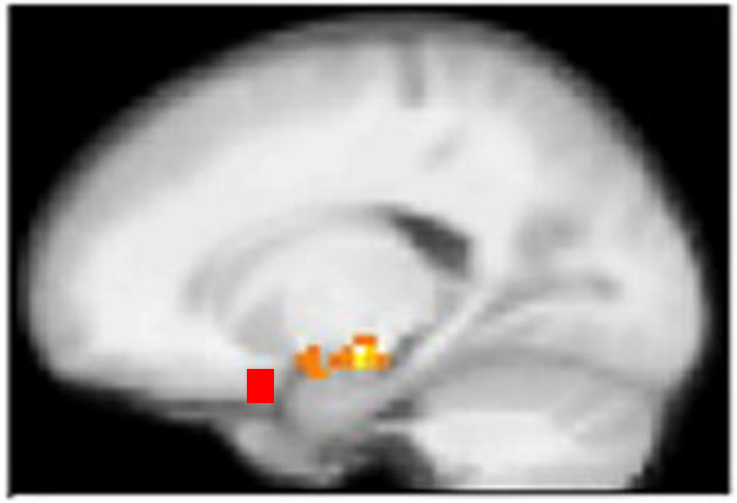
- Detection of smells
- Identification of smells
- Intensity of smells

Olfactory Cortex has significant projections to:

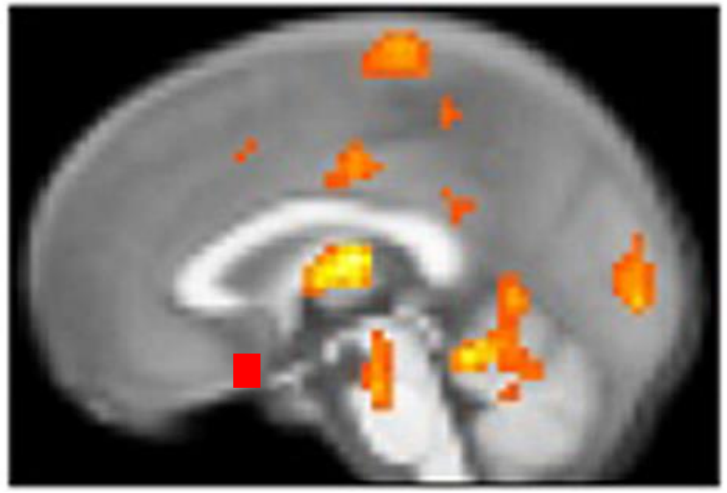
- Hippocampus
- Amygdala
- Thalamus
- Orbitofrontal cortex (OFC)



sulphur



rose



Olfactory cortex itself is small, but often multiple brain regions activated when you smell something....

Hummel et al., 2010

Is smell really important to us?

Smells are…

- difficult to ignore
- quick to influence our perceptions about things
- linked to emotions, memories

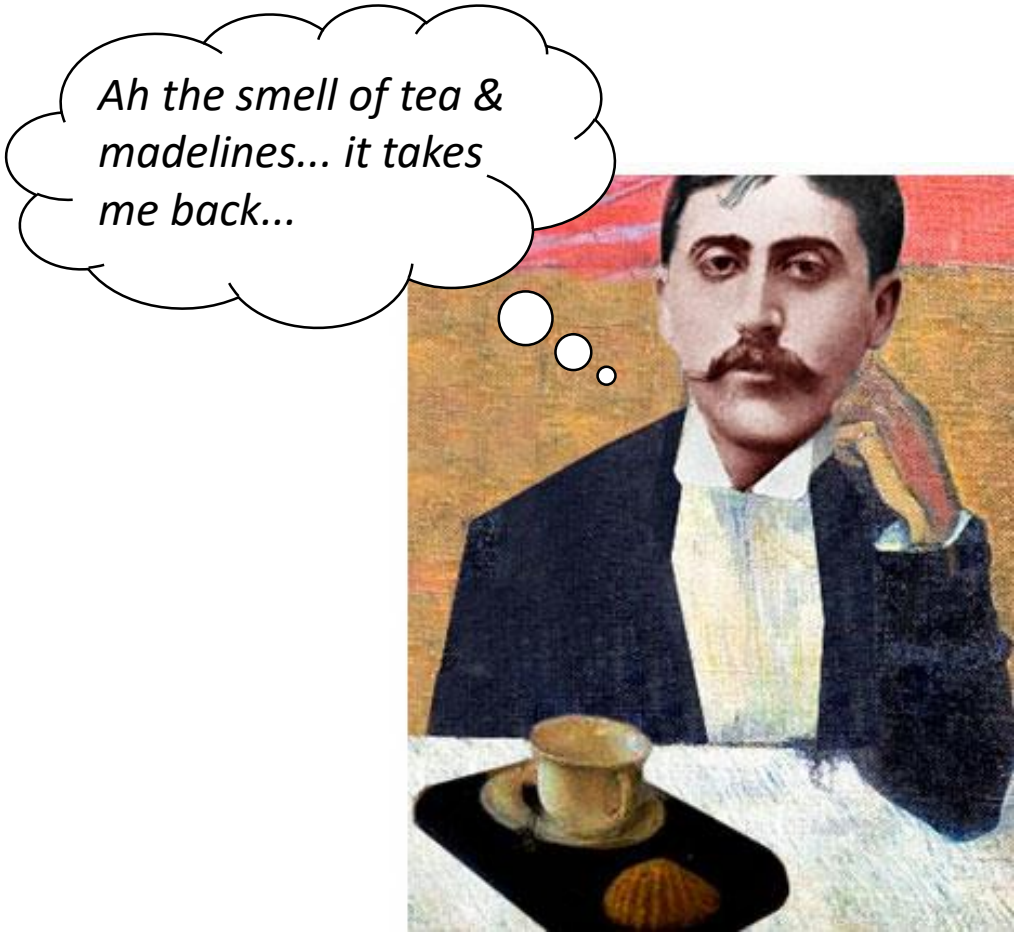
Odour memories

Emotional, autobiographical memories evoked by certain odours

- ‘the Proust Effect’
- reminiscent of the past, + / -

Smell is unique in that it can subconsciously spur immediate, vivid memories

Due to the neural pathway – olfactory cortex projects directly to hippocampus (memory), amygdala (emotion), and OFC (hedonics)



Marcel Proust

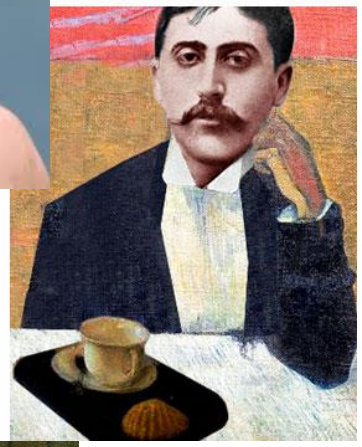
We all have smells that we like…

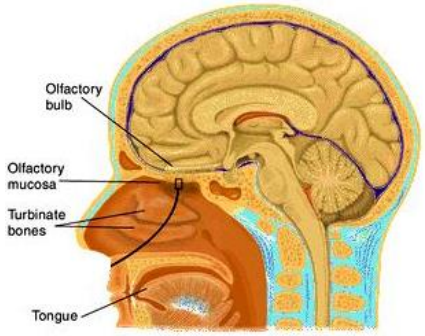
…and others that we don’t

Some of this is innate…

Some of this is learned…

Some of this is due to individual variation in the olfactory system…





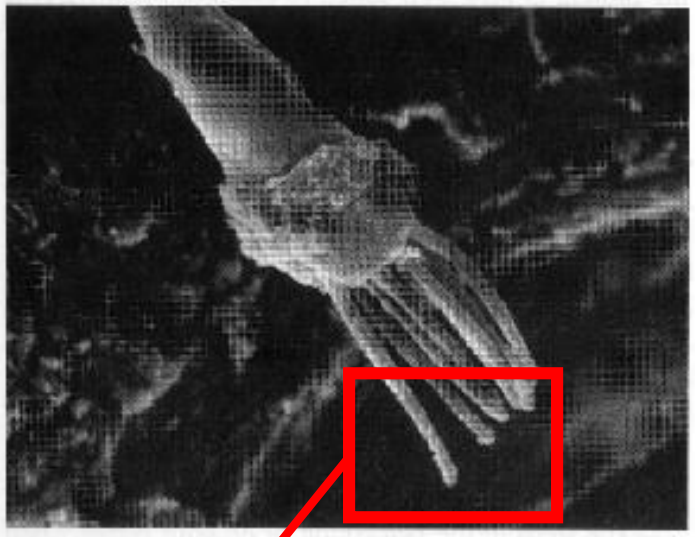
DNA (genes) → mRNA → Proteins (e.g. receptors)

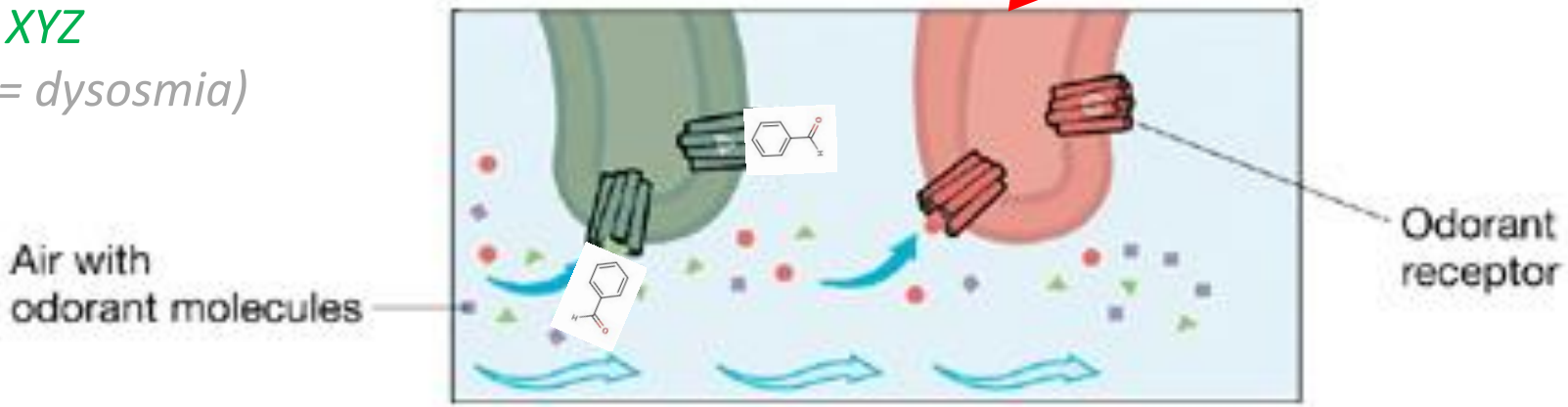
Gene for Receptor X → mRNA X → Receptor X…you can smell X
Gene for Receptor Y → mRNA Y → Receptor Y… you can smell Y
Gene for Receptor Z → mRNA Z → Receptor Z… you can smell Z

Odorant X is in the air…
If you lack gene X – you can't smell X *(= specific anosmia)*

Odorant mix XYZ is in the air…
If you have genes XYZ – it smells like XYZ
If you lack gene X – it smells like YZ (= dysosmia)

FIGURE 14.7 | A highly magnified picture of an actual olfactory receptor neuron with its cilia extending into the nasal cavity.





Images: Neuroscience, 2nd ed.; Perception, 5th ed.

e.g., to smell androstenone, you need receptors X and Y

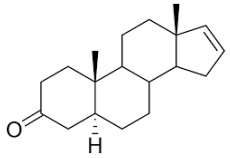
If you lack X and Y
Andro = no smell
(specific anosmia)

If you have X1 and Y
Andro = sweet/floral smell

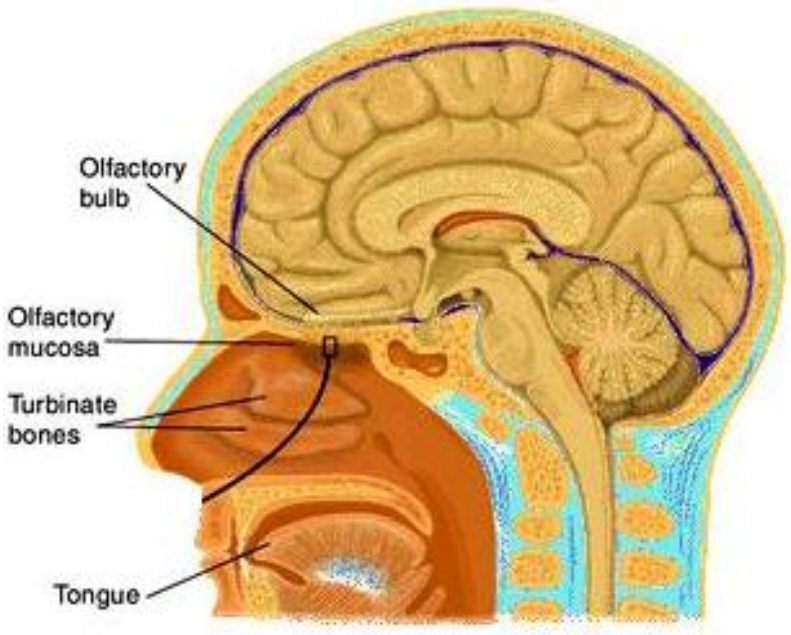
If you have X2 and Y
Andro = urine/sweat smell!

Odorant X is in the air...
If you lack gene X – you can't smell X *(= specific anosmia)*

Odorant mix XYZ is in the air…
If you have genes XYZ – it smells like XYZ
If you lack gene X – it smells like YZ *(= dysosmia)*



Olfactory System



Changes anywhere along pathway can alter olfaction

- DNA differences, mucus changes, damage to cells / CN I, changes in the neural pathway, tumour impinging on pathway, etc.

Can cause ***anosmia***
dysosmia
hyposmia

Decreases *in olfaction (hyposmia) can present:*

SUBWAY eat fresh.

Safety risks

(fire, gas, spoilage)

Reduced interest in food

- Less interest in social dining & cooking
- Less interest in food to point of malnutrition

Reduced interest in sex

Images: quiz.biz, thejournal.ie, womenshealthmag.com, vetmedicine.about.com, cesarsway.com

Decreases *in olfaction can present:*

Safety risks

Reduced interest in food

Reduced interest in sex

- We usually *consciously* pick a sexual partner who we like the smell of
- We may *subconsciously* pick a sexual partner based on odour cues about their immune system…

Images: quiz.biz, thejournal.ie, womenshealthmag.com, vetmedicine.about.com, cesarsway.com

Decreases *in olfaction can present:*

Safety risks

Reduced interest in food

Reduced interest in sex

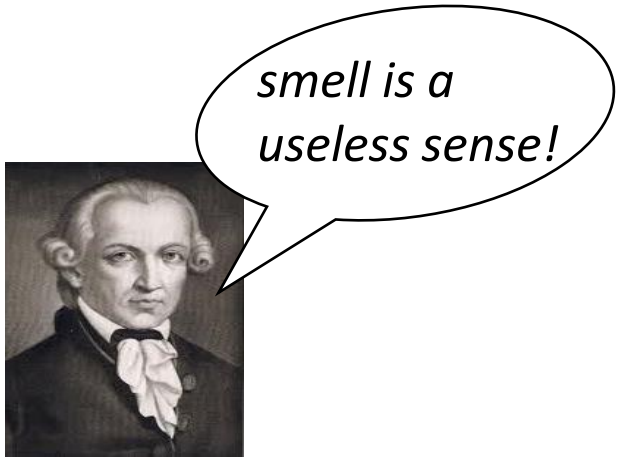
- We usually *consciously* pick a sexual partner who we like the smell of
- We may *subconsciously* pick a sexual partner based on odour cues about their immune system…

Images: riverisland.com

Olfaction

L. olfacere "to smell"

- A far sense
- Key functions:
  - Detection of environmental cues
  - Identification of things and conspecifics
  - Communication via non-verbal signals



Images: quiz.biz, thejournal.ie, womenshealthmag.com, vetmedicine.about.com, cesarsway.com

Aging and Olfaction

Detection and identification of odours decreases in 50s/60s, more significant redutions noted in 60s/70s

- 2-10x more odorant needed for detection, vs 20 yo
- Odour discrimination and identification also reduces

Use more odorant
(& use smoke alarms & gas detectors!)

Aging and Olfaction

Detection and identification of odours decreases in 50s/60s, more significant reduction noted in 60s/70s

- 2-10x more odorant needed for detection, vs 20 yo
- Odour discrimination and identification also reduced

Use more odorant
(& use smoke alarms & gas detectors!)

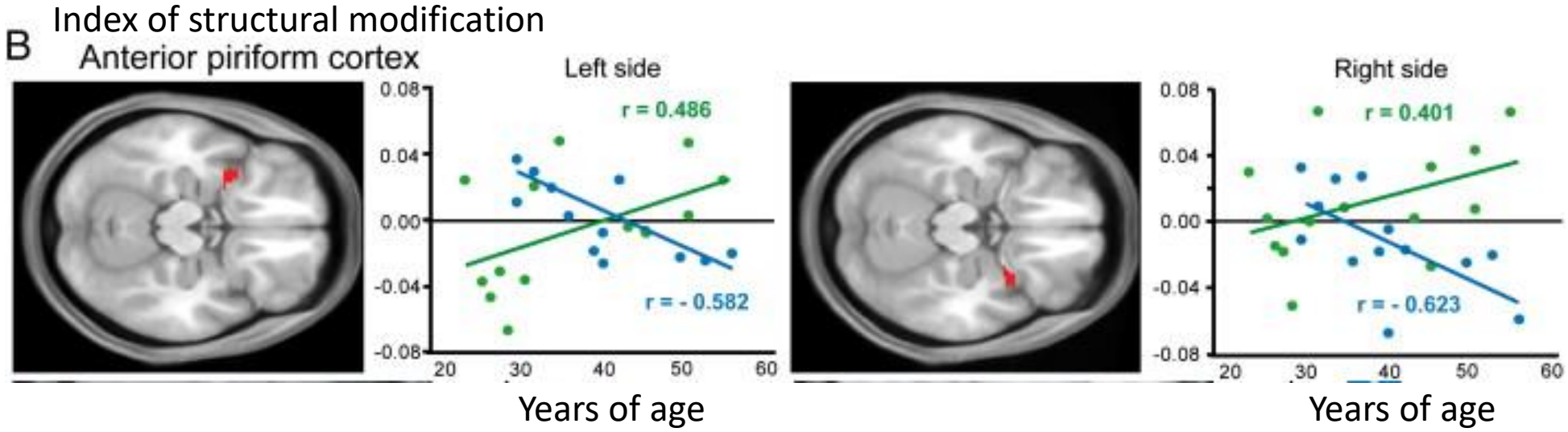
Minority of cases may be indicative of histopathology

Majority of cases related to normal neurodegeneration, slowing of protein synthesis

Curbing neurodegeneration:
- exercise
- high vitamin diet
- practice, practice, practice!

Image: andycore.com

The brains of perfumers…



Blue – control aging
Green - perfumers

Delon-Martin et al., 2013

We need to use our noses….

1) It keeps our olfactory systems *(and our brains!)* active

2) It enhances “taste”

Image: mentalfloss.com

Taste

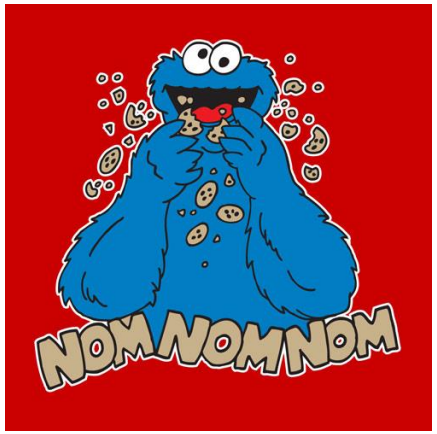
& the gustatory system

Gustation

L. gustare 'to taste'

- A *near* sense
- Key functions:
  - indicate safety of food
  - indicate nutritional value of food
  - reinforces eating
- Is it important?
  - For many animals, essential to survival
  - For humans, a degree of survival/safety, but largely a novelty

Is that 'novelty factor' really important to us?



Images: thejournal.ie, feelinggoodtees.com

Is taste really important to us?

Taste vs. Flavour

Taste is *not* the same as flavour

Flavour is multi-modal

Flavour incorporates:

- taste
- smell
- texture
- temperature
- chemosensory

Taste (currently) has 5 sub-modalities:

sweet, salty, bitter, sour, umami

+ Kokumi?

Images: healthyeating.org

The Gustatory System

Secondary Taste Cortex (OFC)

Primary Taste Cortex (insula)

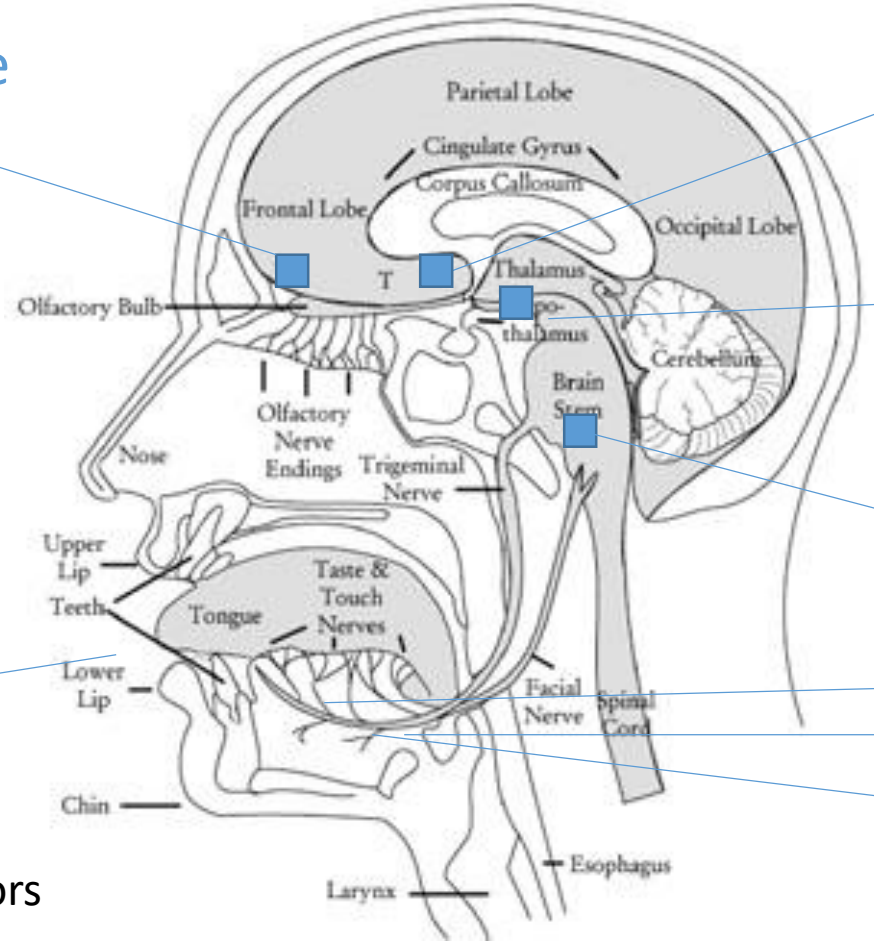
Thalamus

Brain stem nuclei

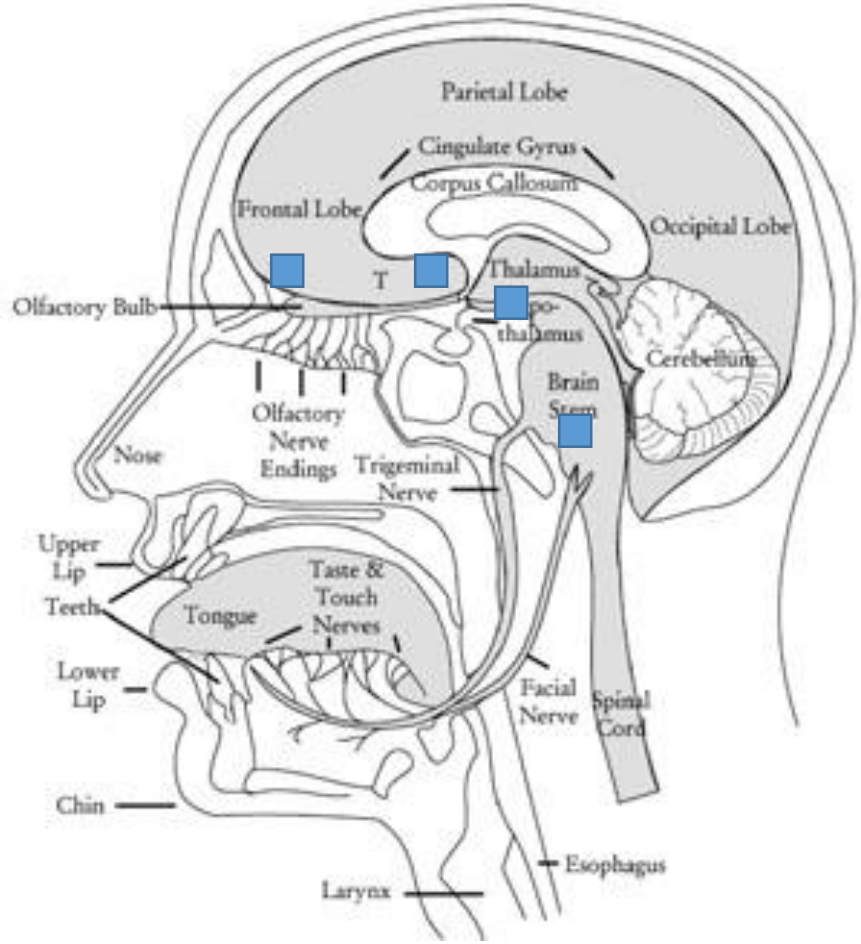
tongue

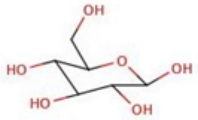
taste buds
taste neurons
tastant receptors

Cranial Nerves VII, IX, X

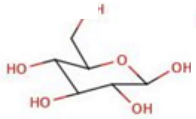


The Gustatory System

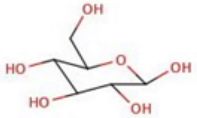




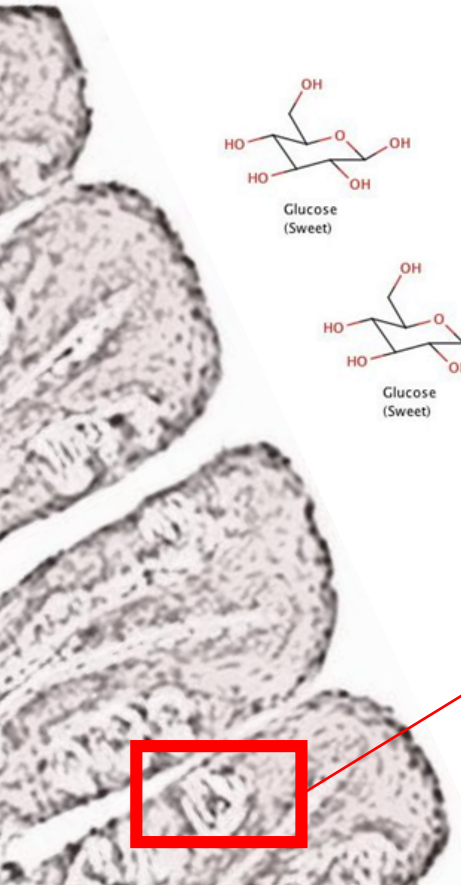
Glucose
(Sweet)

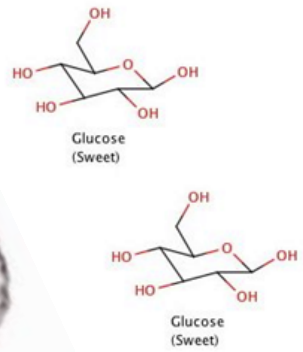


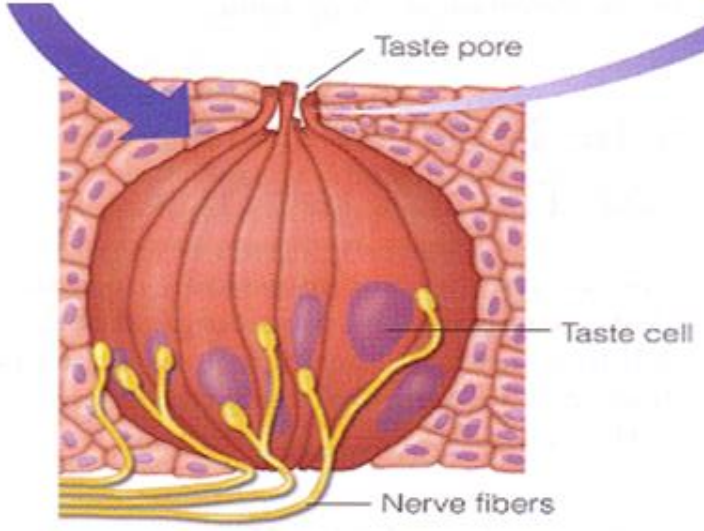
Glucose
(Sweet)

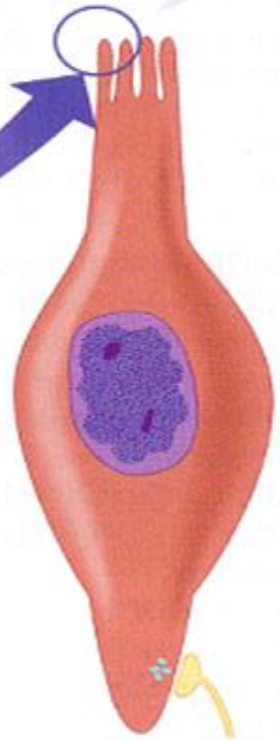


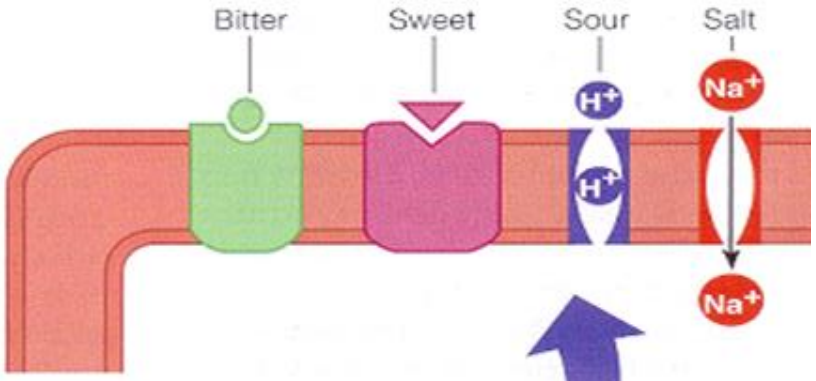
Glucose
(Sweet)











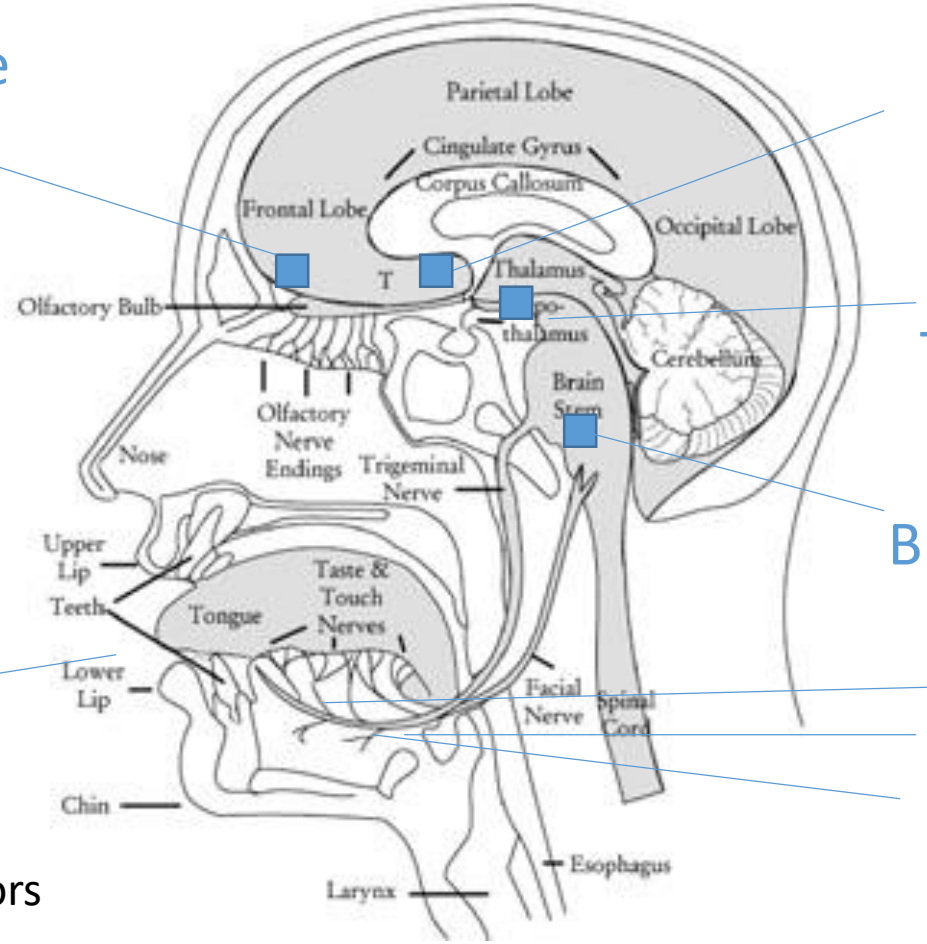
(e) Receptor sites on tip of taste cell

The Gustatory System

Secondary Taste Cortex (OFC)

Primary Taste Cortex (insula)

Detection of tastants
Identification of tastants
Intensity of tastants



Thalamus

Brain stem nuclei

tongue

taste buds
taste neurons
tastant receptors

Cranial Nerves
VII, IX, X

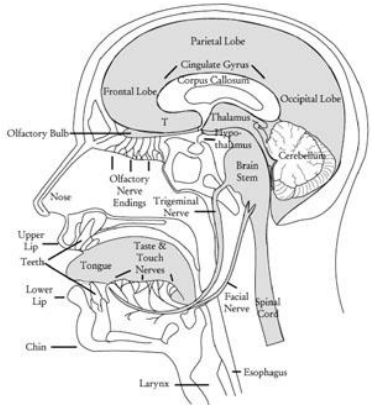
We all have tastes that we like…

…and others that we don't

Some of this is innate…

Some of this is learned…

Some of this is due to individual variation in the gustatory system…



DNA (genes) → mRNA → Proteins (e.g. receptors)

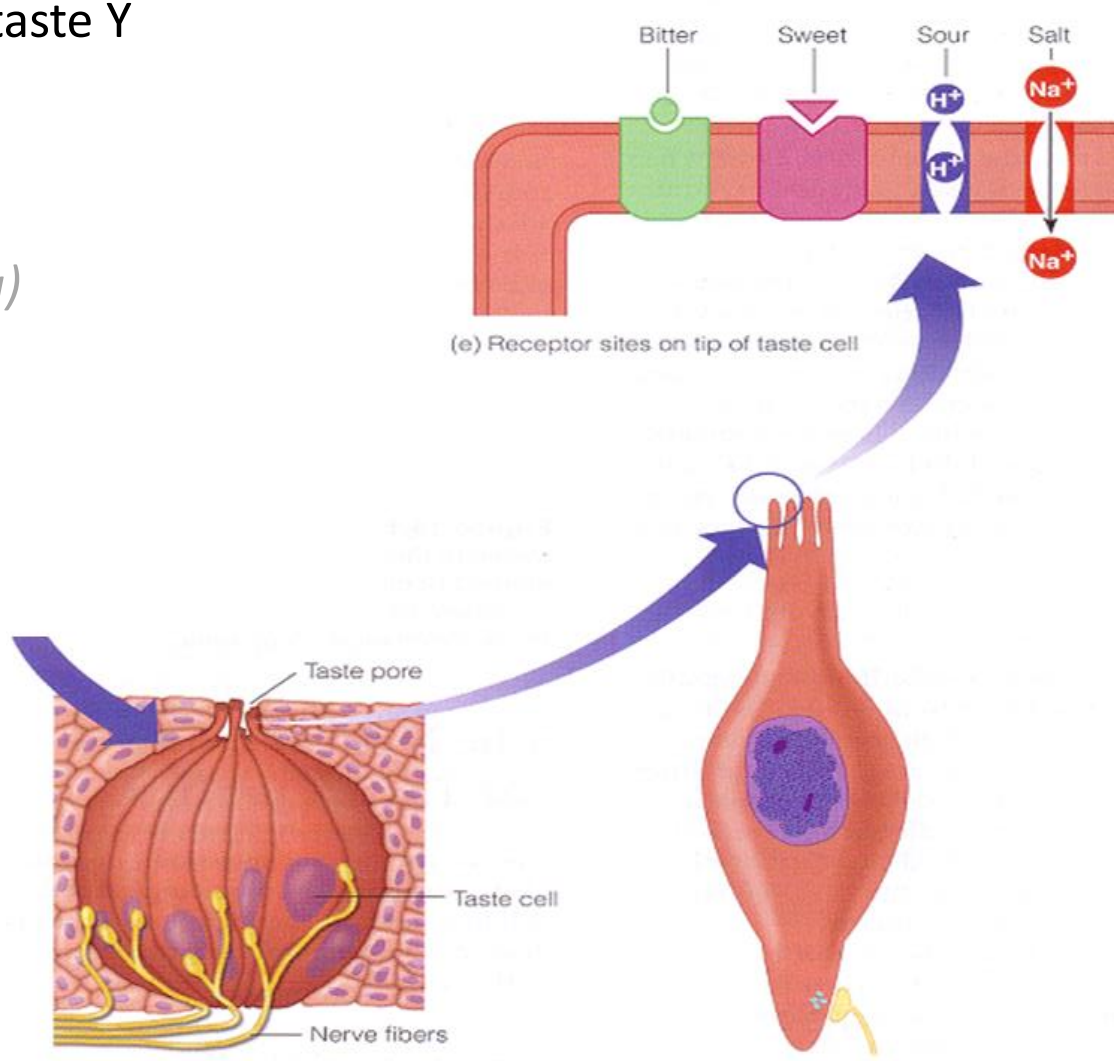
Gene for Receptor X → mRNA X → Receptor X…you can taste X
Gene for Receptor Y → mRNA Y → Receptor Y… you can taste Y

Tastant X is in your saliva…
If you lack gene X – you can't taste X *(= specific ageusia)*

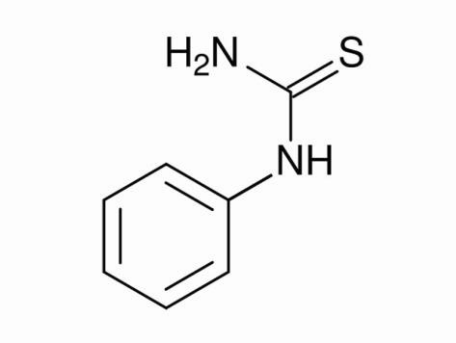
Tastant mix XYZ is in the air…
If you have genes XYZ – it tastes like XYZ
If you lack gene X – it tastes like YZ (= dysgeusia)

Subtypes of receptors add further complexity
If you have X1+Y1+Z… it tastes one way…

If you have X2+Y1+Z…it tastes another way…



Phenylthiocarbamide (PTC)

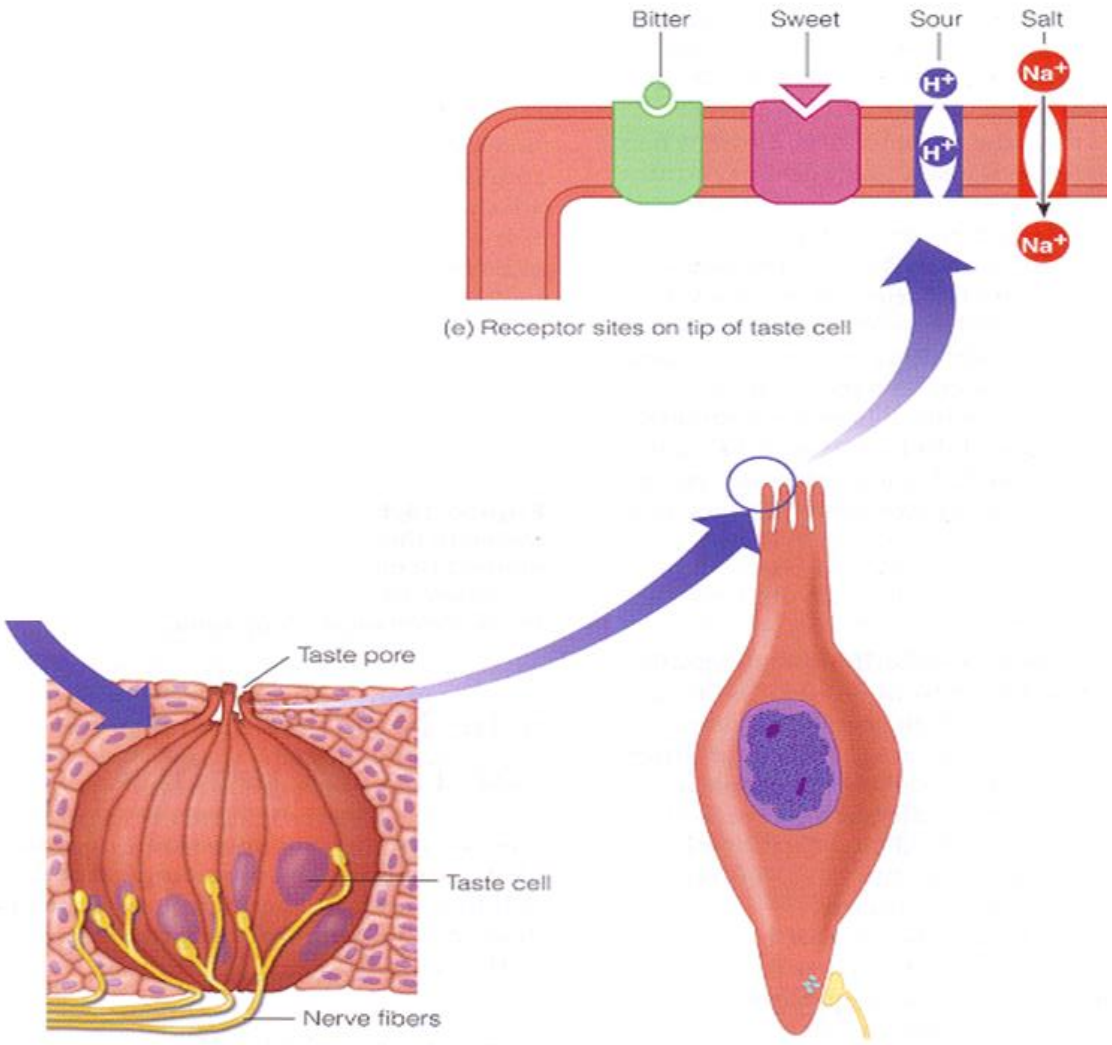


e.g., to taste PTC, you need receptor X

If you lack receptor X
PTC = no taste
(specific ageusia)

If you have one copy of X
PTC = weak taste

If you have two copies of X
PTC = very strong taste!



Flavour incorporates:

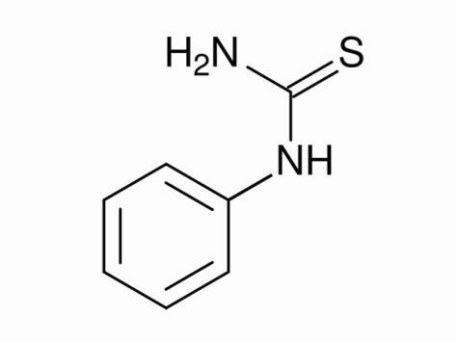
taste

smell

texture

temperature

chemosensory



Phenylthiocarbamide (PTC)

e.g., to taste PTC, you need receptor X

If you lack receptor X
PTC = no taste
(specific ageusia)

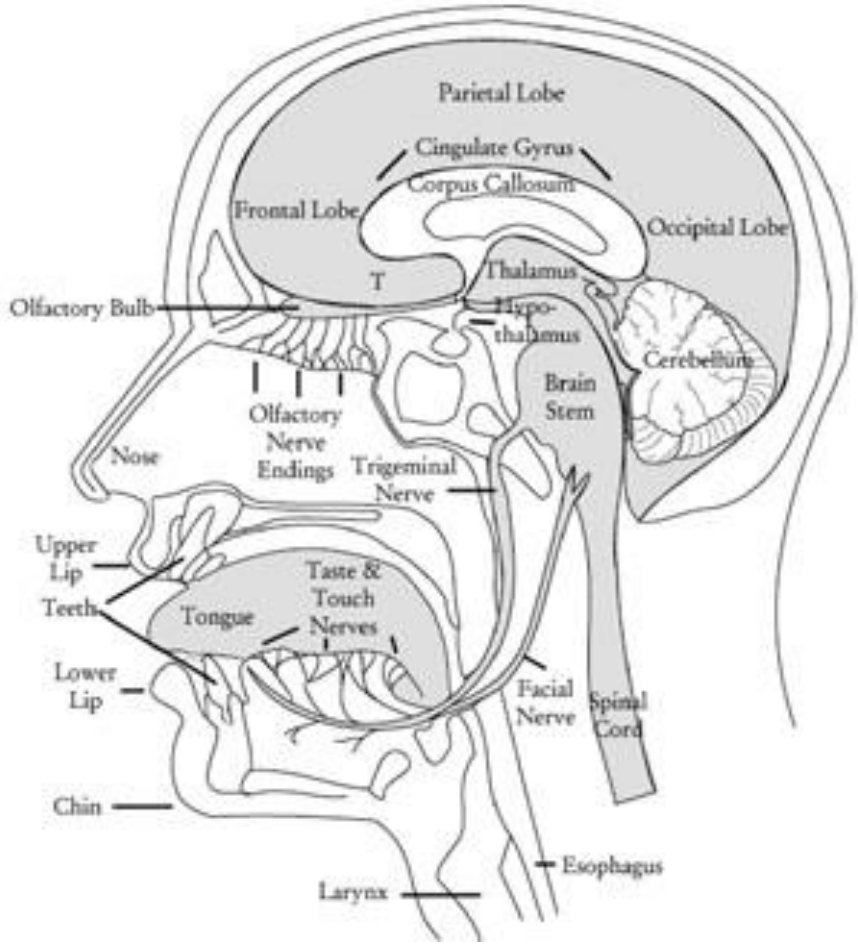
If you have one copy of X
PTC = weak taste

If you have two copies of X
PTC = very strong taste!

If you fall in this category, you are a “super taster”

- you have many more bitter receptors
- you have many more papillae overall
- you have many more free nerve endings overall
- F >M supertasters

Gustatory System



Changes anywhere along pathway can alter gustation

- DNA differences, saliva changes, damage to cells / CN V/VII/IX, changes in the neural pathway, tumour impinging on pathway, etc.

Can cause ***ageusia***

dysgeusia

hypogeusia

Aging and Gustation

Detection and identification of tastants decreases in 60s/70s

- Taste bud number does decrease with age
- Detection, discrimination, identification all affected

Use more tastant

Chemical senses do decrease with age….

Decreases in gustation can present:

Safety risks

(spoilage)

Reduced interest in food

Flavour: smell, taste, texture, temperature, chemosensory

How do we maintain an interest in food despite declining chemical senses?

How do we maintain an interest in food despite declining chemical senses?

Sip water with a meal – tastants need to dissolve to be effective

Increase the concentration of odorants and tastants in food

- Add more salt, seasoning, sugar *(n.b. health considerations)*
- Use flavour packets *(e.g., stock cubes)*
- <u>Utilise fresh herbs and spices</u>

Amplify the other components of flavour

- Texture
- Temperature
- Chemosensory *(e.g., chilis, mint, carbonation)*

Images: amazon.com, oxofoods.com.au, bostonherald.com, chili-sauces.com

How do we maintain an interest in food despite declining chemical senses?

Amplify the other components of flavour

- Texture
- Temperature
- Chemosensory

- Visual Presentation
  - Channel your inner MasterChef!
    - Simple garnishes
    - Plating techniques
    - Decorative plates/glasses/place setting

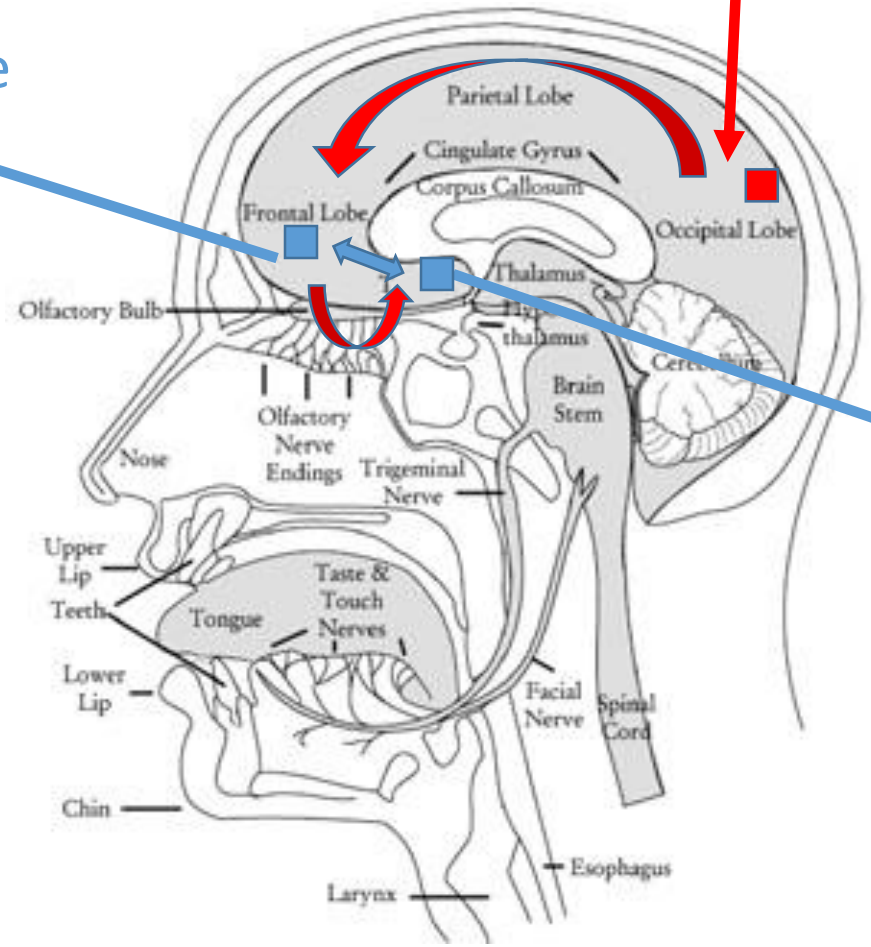
Images: foodnetwork.com

Primary Visual Cortex (V1)

Secondary Taste Cortex (OFC)

Hedonic assessment

Valuation/preference



Primary Taste Cortex (insula)

Detection of tastes

Identification of tastes

Intensity of tastes

How do we maintain an interest in food despite declining chemical senses?

Sip water with a meal – tastants need to dissolve to be effective

Increase the concentration of odorants and tastants in food

- Add more salt, seasoning, sugar *(n.b. health considerations)*
- Use flavour packets *(e.g., stock cubes)*
- Utilise fresh herbs and spices

Amplify the other components of flavour

- Texture
- Temperature
- Chemosensory *(e.g., chilis, mint, carbonation)*
- Visual Presentation?

Images: amazon.com, oxofoods.com.au, bostonherald.com, chili-sauces.com, blog.kitchenaid.com

Use your chemical senses….

1) It keeps your sensory systems *(and your brain!)* active

2) It makes life more interesting!

Image: mentalfloss.com

Dr Kristin Hillman

Department of Psychology

& Brain Health Research Centre

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

Image: humanhealth.com