Oral sensation

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General sensation in the oral cavity

- **Protopathic:**
  - touch
  - pressure
  - temperature
  - pain

- **A beta and A delta fibers** (II and III types sensory neurons)

- **Epicritic:**
  - stereognosia: detect the shape of objects
General sensation in the oral cavity

http://joecicinelli.com/homunculus-training/
Temperature sensation

- mucous membranes – very sensitive
- protective mechanism
- receptors are bare nerve endings
  - cold receptor - below a threshold
  - hot receptor - above a threshold
  - skin temperature receptor - around 25°C - same on the lips
  - maximum tolerable temperature: 70-80 °C
- A delta and C fibers – relatively slow (III or IV types sensory neurons)
Pressure sensation

teeth are sensitive
  – axially and laterally applied pressure
  – receptors in the periodontal ligaments

end-organs of the Ruffini type - A beta nerve fibers – slow adaptation

excitability depend on the position

http://faculty.washington.edu/chudler/receptor.html
http://people.usd.edu/~cliff/Courses/Behavioral%20Neuroscience/Lordosis/Lordosisfigs/lorsenspics.html
Proprioception

- Proprioceptive impulses from:
  - muscles of the tongue
  - masticatory muscles
    - elevator
    - depressor - few
  - temporomandibular joint

- Neuropeptide - suggesting the presence of nerve endings
  - joint capsules
  - synovial discs

[Image of muscle spindle]

http://medical-dictionary.thefreedictionary.com/muscle+spindle
Taste and smell

- Nose and mouth are sentinels of chemical world
- In dysfunction can be an early indicator of serious diseases
  - Alzheimer’s; Parkinson’s diseases
- Dysfunctions – worse quality of life!
Taste

- Receptors are situated in the head
- One of the two chemoreceptors sensation perceived directly in cortex
- Special viscero sensory fibers
- Taste receptors are predominantly located
  - dorsum of the tongue
  - soft palate, epiglottis, pharyngeal wall, oesophagus
Taste buds

Tongue - embryologically derived from two branchial arch
- nerves
- buds

http://www.mccullochlaw.net/nerve_injury/lingual_nerve/index.html

http://www.scientificamerican.com/article.cfm?id=making-sense-of-taste
Taste buds

- Develop early intrauterine life – 14th week
- 9000 taste buds – young adults

Taste buds

Papillas
- *Filiformis* – thin keratinised
  - rarely have taste buds
- *Fungiformis* – smooth, rounded projection
  - few taste buds
- *Foliate*
- *Circumvallate*

Taste buds

**Papillas**
- **Foliate** – parallel ridges
  - five or more taste buds on each of the lateral walls of the ridges
  - total: 1500
- **Circumvallate** – 8-12, anterior & adjacent to the sulcus terminalis, can be seen with the naked eye

http://wikis.lib.ncsu.edu/index.php/Foliate_papillae
http://embryology.med.unsw.edu.au/notes/tongue.htm
Papilla circumvallate

- Central flat dome
  - keratinised
- Deep surrounding groove
  - non-keratinised
  - 250-300 taste buds – decreases with age
    - 100 per papilla in 70 years old people
  - orifices of von Ebner glands – serous secretion

- Bitter taste

http://education.med.nyu.edu/Histology/courseware/modules/gi-tract/gi.tract08.html
Typical taste buds

Constans turnover: 2-30 day
Traditional and alternate classification of taste

- **Salty:** NaCl, LiCl
- **Sour:** acid/protons
- **Bitter:** diverse group
  - filter mechanisms
  - survival benefit
- **Umami:** MSG
  - Pleasant savory taste
- **Sweet**
- **Water**
- **Fat taste**

- **Defensive:** bitter, sour
- **Homeostatic:** salt
- **Nutritionally important:** sweet, amino acid, fat, water

Recent molecular and functional data have revealed that, contrary to popular belief, there is NO tongue ‘map’ responsiveness to the five basic modalities is present in all areas of the tongue. Chandrashekar et al, 2006. Nature

http://embryology.med.unsw.edu.au/notes/tongue.htm
Salty taste

- Specificity shown with NaCl and LiCl - suggest a receptor-mediated process
- NaCl-stimulus inhibited by amiloride - Epithelial Na Channel (ENaC) as the receptor
- Effect of chlorhexidine
- Produced by Na⁺ ion
  - nerve functions
  - fluid balance
  - membrane transports
  - acid-base homeostasis

Reproduced from Lindemann, 2001, Nature, 413 (6852) 219-225
Sour taste

- Only acids are sour
- Sourness correlates with total titratable acidity. Thus acetic acid is more sour than hydrochloric acid at equal pH.
- Acid-base homestasis
- Unripe fruits, rotten food
- Stimulation of saliva production (defense mechanism)
- Excitation of CN. V. → astringent effect

Reproduced from Lindemann, 2001, Nature, 413 (6852) 219-225
Umami taste

- Taste associated with mono-sodium glutamate, Na Aspartate, & 5'-ribonucleotides
- Synergism with MSG & nucleotides (IMP, GMP)
- Receptor cloned: “taste mGluR4.” Compared to brain mGluR4, has truncated NTD.
- The taste of Na-Glutamat
- Food additive (taste enhancer)
- Egg-white
- Probably for the intake of proteins

Reproduced from Lindemann, 2001, Nature, 413 (6852) 219-225
## Diversity of sweet compound

<table>
<thead>
<tr>
<th>Carbohydrates</th>
<th>Sulfamates</th>
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<tbody>
<tr>
<td>Peptides</td>
<td>Nitroanilines</td>
</tr>
<tr>
<td>Saccharine</td>
<td>D-amino acids</td>
</tr>
<tr>
<td>Sucralose</td>
<td>Neohesperidine</td>
</tr>
<tr>
<td></td>
<td>Sweet proteins</td>
</tr>
<tr>
<td></td>
<td>Guanidino compounds</td>
</tr>
<tr>
<td></td>
<td>Flavonoids</td>
</tr>
<tr>
<td></td>
<td>Chloroform</td>
</tr>
</tbody>
</table>
Sweet taste

- There are major differences among species in ability to taste sweet compounds.
- Three sweet taste receptors were cloned: T1R1, T1R2, and T1R3.
- The T1R genes are located on chromosomes 1.
- Active receptors are heterodimers, e.g., T1R2/T1R3, T1R1/T1R3.

Reproduced from Lindemann, 2001, Nature, 413 (6852) 219-225
Bitter taste

- Involvement of taste-specific Go protein, gustducin, and second messenger effects predicted existence of GPCR receptors.
- A family of bitter taste receptors, the T2R’s have been cloned. About 25-30 members.
- The $T2R$ genes are located in clusters on chromosomes 5, 7, and 12.

Warning
- poisoning (alkaloids mostly taste bitter)
- some foods are expected to be bitter
- more than 1000 substances- no difference to us
- quinine sulfate, morphine, nicotine, caffeine, urea

Reproduced from Lindemann, 2001, Nature, 413 (6852) 219-225
Basic mechanism of taste

substance solved in water/saliva

reaction on the membrane of the microvilli

\([Ca^{2+}]\) rises in the receptor cell

release of neurotransmitter
Receptors on the microvilli

- ionotropic and metabotropic
- $\text{Na}^+$- and $\text{H}^+$- channels (sour, salty)
- G-protein-coupled transmembrane- $\text{R(sweet, bitter, umami)}=\text{TR Receptors}$
  - T1R family (heterodimers)
    - T1R2/T1R3 for sweet
    - T1R1/T1R3 for umami
  - T2R family for bitter

http://www.cf.ac.uk/biosi/staffinfo/jacob/teaching/sensory/taste.html
Neuronal Coding

„population-coding”
– one taste receptor cells has receptors for several taste modalities
– priority is different in each cell

specialization in innervating CN
– lesion of chorda tympani - Hypogeusie for salty
– lesion of N. glossopharyngeus – Hypogeusie for bitter
Sensory mechanisms of taste

- Afferent fibers of cranial nerves VII, IX and X (Chorda tympani (VII/V); Greater petrosal superficial nerve (VII))
- Cell bodies in the geniculate (VII), petrosal (IX) and nodose (X) ganglia
- Nucleus of the solitary tract
- Ventrobasal thalamus
- Lower tip of the parietal cortex in the postcentral gyrus
Cortex

- through Thalamus (nucl. ventralis posteromedialis)
- primary taste center
  - ipsilateral in insula and frontal operculum
  - intensity and quality
  - prototipical taste modalities
Visceral brainstem

- direct neighborhood to nucl. tractus solitarii

- Reflexes: chew, swallow, mouth-movement, stomach-movement, saliva-production

- nucl. ambiguus
  → reflexwise acceptance or rejection of food
Hypothalamus

taste as a sensoric input

nutritional status of the body

conciliation of these two informations

→ guidance of food-selection
Connections to the limbic system

- Input also from the olfactory organ

- Gives the hedonistic character of food
  - Good & pleasing / bad & offensive

- Emotional effect
Processing- secondary taste cortex

- localisation: back of the orbito-frontal cortex, in front of the region of the insula
- multisensoric convergence: taste, smell, vision, touch
- „sense-specific repletion“:
  - hedonistic value of food ~ neural activity here
  - activity also relates to hunger/repletion
  - cells can be less provoked by taste from the food which overstock but stay sensitive for other taste modalities
→ evolutionary advantage: broader spectrum of food
Concluding remarks on taste

- Taste is a defense/screening mechanism
- Organization of taste – redundant, rapidly regenerating to withstand physical, chemical and biological challenges
Olfaction

- Initiated in upper part of nasal cavity
- Receptor cells in epithelial layer of middle and superior turbinates
- Receptor cell bipolar neuron of CN 1
- Receptor neuron axon passes through cribriform plate to olfactory bulb
- In CNS information travel to various structures, e.g. limbic system
Olfaction

- Inhaled Odorant molecules absorb into the olfactory mucus Reach the cilia via diffusion or transport by specialized carrier proteins
- 6-10 million olfactory receptor cells are located within an epithelial matrix
- Bowman’s glands – specialized mucus secreting glands
- About 450 functional receptor types
- Age-related changes - general decline
Olfaction
Olfaction
A comparison of taste and smell

<table>
<thead>
<tr>
<th></th>
<th><strong>Taste</strong></th>
<th><strong>Smell</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptors</td>
<td>&lt; 50-80</td>
<td>&lt; 1,000</td>
</tr>
<tr>
<td>Cells</td>
<td>epithelial</td>
<td>neuronal</td>
</tr>
<tr>
<td>Turnover</td>
<td>10.5 days</td>
<td>60 days</td>
</tr>
<tr>
<td>Innervation</td>
<td>3 CN</td>
<td>1 CN</td>
</tr>
<tr>
<td>Stimuli</td>
<td>non-volatile</td>
<td>volatile</td>
</tr>
<tr>
<td>To damage</td>
<td>resistant</td>
<td>prone</td>
</tr>
</tbody>
</table>

from Andrew Spilman lecture
Terminology of Chemosensory Disorders

**Taste**

- **Ageusia**
  Inability to detect gustatory stimulants

- **Hypogeusia**
  A diminished ability to detect gustatory stimulants

- **Hypergeusia**
  Increased sensitivity to gustatory stimulants

- **Dysgeusia (Parageusia)**
  Distorted perception of taste stimulants
  Unpleasant taste sensation

- **Taste agnosia**
  Inability to identify or classify a stimulant although properly perceived

**Olfaction**

- **Anosmia**
  Inability to detect olfactory stimulants

- **Hyposmia**
  A diminished ability to detect olfactory stimulants

- **Hyperosmia**
  Increased sensitivity to olfactory stimulants

- **Dysosmia (Cacosmia)**
  Distorted perception of olfactory stimulants
  Unpleasant odor sensation

- **Olfactory agnosia**
  Inability to identify or classify a stimulant although properly perceived
Classification of chemosensory dysfunctions

- Transport
- Sensory
- Neural dysfunctions
Classes of drugs affecting taste and smell

- **Anesthetics**
  - benzocaine, lidocaine - ageusia
  - cocaine - anosmia

- **Oral products**
  - Sodium Dodecyl Sulphate – sweet or salty ageusia
    - Denaturates the sweet taste receptors – several minutes
  - chlorhexidine – salty ageusia after taste

- **Antineoplastic**
  - bleomycine, 5-fluorouracil, methotrexate – bitter or sour dysgeusia

- **Cardiovascular**
  - diltiazem – hypogeusia, hyposmia
  - nifedipine – dysgeusia, dysosmia
Thank you for your attention!