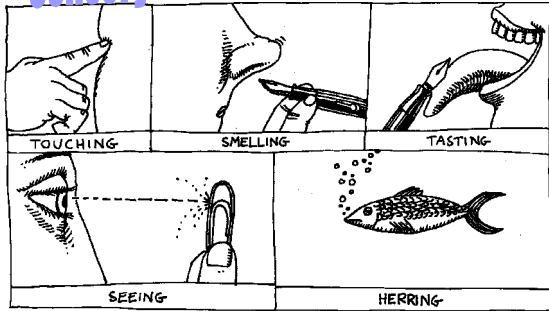


Sensory transduction*



*besides vision!

Olfaction

- In late 80's odorant receptors were cloned from cilia
- These were 7TM helix G-protein receptors (OR) stimulating a unique G protein, G_{olf}
- Human OR genes number 500 but only about 30 are not pseudogenes!

Olfaction

- Each neuron expresses only 1 OR
- G_{olf} stimulates Ad. Cyclase
- cAMP opens cation channels; depolarization occurs; action potential propagates

Olfaction

- Decoding of olfactory stimuli -in mouse suggests a combinatorial mechanism

CC(=O)O
 Carboxylic acids
 ($i = 2-7$)

CC(O)O
 Alcohols
 ($i = 4-8$)

BrCC(=O)O
 Bromocarboxylic acids
 ($i = 3-7$)

OC(=O)CC(=O)O
 Dicarboxylic acids
 ($i = 4-7$)

	receptor													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Odorant														
C_2 -COOH														
C_3 -COOH														
C_4 -COOH														
C_5 -COOH														
C_6 -COOH														
C_7 -OH														
C_8 -OH														
C_9 -OH														
C_{10} -OH														
$Br-C_3$ -COOH														
$Br-C_4$ -COOH														
$Br-C_5$ -COOH														
$Br-C_6$ -COOH														
$HOOC-C_4$ -COOH														
$HOOC-C_5$ -COOH														
$HOOC-C_6$ -COOH														
$HOOC-C_7$ -COOH														

Olfaction

- All neurons expressing a given OR converge on a discrete area in the olfactory bulb
- The spatial pattern of OR stimulation is somehow transformed to a unique scent.



FIGURE 52.6 Converging olfactory neurons. This section of the nasal cavity is stained to reveal processes from olfactory neurons expressing the same olfactory receptor. The processes converge to a single location in the olfactory bulb. (From P. R. Mombaerts, J. Wang, L. Suter, S. C. Chang, A. Nishida, M. Mizushima, J. Godwinson and S. Axel, *Cell* 87 (1992) 675-686.)

Taste

- More limited scope of possible tastes
- Olfaction contributes to complex tastes

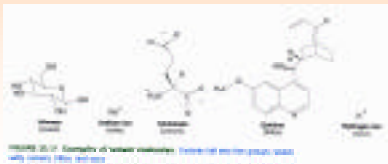
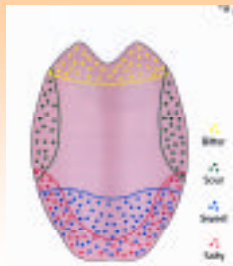


FIGURE 52.7 Examples of various molecules. (Source: <http://www.fda.gov/oc/ohrt/ohrt.html>)

Taste

- Gustation receptors are located in different areas
- In taste buds (~150 cells w/ sensory neurons) in papillae (big knobs)



Taste-Bitter

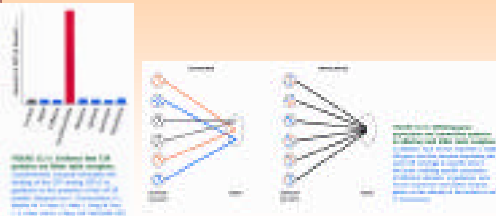
- So far only bitter receptors (G-protein Receptors) with G_i, gustducin have been found
- There are 50-100 genes (for bitter?) in the genome but they are mixed on taste buds



FIGURE 14.14 Extracellular and signal regions in bitter receptors. The bitter receptors are members of the 7TM receptor family. Single extracellular extracellular domains of the protein family are shown in blue, and highly variable residues are shown in red.

Taste

- Bitter receptors ? Stimulation by specific bitter substance of mT2R
- But different ones get mixed up in brain



Taste-Salty

- Salt receptors ? Direct sensation by Na⁺ ion channels blocked by Amiloride
- Analogous to the 4 subunit type channels (like K⁺)

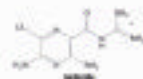
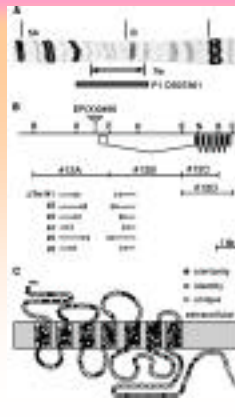


FIGURE 14.17 Schematic structure of the amiloride-sensitive sodium channel. Both sides of the ion channel are considered the functional channel in this channel. The amiloride-sensitive sodium channel belongs to a superfamily having members that include potassium, calcium, and high-voltage-activated calcium channels. Amiloride binds to a specific site on the channel and blocks the flow of sodium ions through the channel.

Taste-Sweet

- Not isolated in humans but likely G-protein since gustducin knock-out mice can't taste sweet substances
- Tre 1, a sugar responsive GPR has been found in flies



Taste-Umami

- Japanese-Deliciousness
- Lots in protein rich foods like soy sauce, roasted meat and and vegemite!
- Na⁺ Glutamate is the key (1903-Kikunae Ikeda)
- A GPR sensitive to glutamate in the brain is clipped by 309 amino acids in the buds to give low affinity umami receptor.



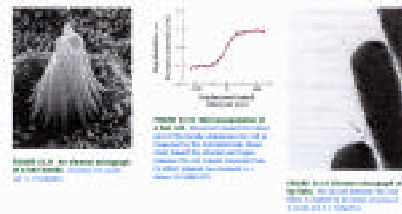
Hearing

- Mechanical stimulation of hair cells in cochlea is the key
- Hair cells are specialized neurons



Hearing

- Displacement of bundle by 3 Å results in a measurable membrane potential change (like 1 inch movement at the top of the Empire State building)



Hearing

- Tip link seems to pull open an ion "hatch"; a mechanosensory channel
- Back and forth flow induces an oscillating ion current



FIGURE 33.11 Model for hair cell transduction. When the hair bundle is tipped, mechanosensory channels open, the tip link pulls tight and opens an ion channel. Movement in the opposite direction returns the tension to the tip link, increasing the probability that any open channels will close. (adapted from A. J. Hudspeth, *Neuron* 10: 1-14, 1993)

Touch

- Hot, Cold
- Pressure
- Capsaicin/hot receptor
- Cold/menthol receptor

Capsaicin and friends

Capsicum (chili pepper)

The image shows the chemical structure of capsaicin, which consists of a vanillyl group (a benzene ring with a methoxy group at the 3-position and a hydroxyl group at the 4-position) attached to a long-chain fatty acid. The fatty acid chain has a double bond at the end. Surrounding the structure are several photographs of different chili pepper varieties, including green, red, and yellow peppers.

Touch

- Example: Capsaicin
- Capsaicin/hot receptor
- Reacts to noxious stimuli (heat, acid)
- Also involved in taste

Figure 53.31 consists of two graphs. The left graph plots the response of the capsaicin receptor to pH, showing a sigmoidal curve that increases as pH rises from 5 to 9. The right graph plots the response to temperature, showing a sigmoidal curve that increases as temperature rises from 20 to 45 degrees Celsius.

Touch-Capsaicin

- The receptor, VR1, is involved in nociception (pain sensation) as well.
- Used medicinally to alleviate pain by the principle of counterirritation
- How does this work?

Figure 53.38 is a diagram of the membrane topology of the VR1 receptor. It shows a transmembrane protein with seven transmembrane alpha-helices. The extracellular N-terminus is on the left, and the intracellular C-terminus is on the right. Three cytoplasmic loops are labeled A, B, and C. The membrane is shown as a lipid bilayer with red heads and green tails.

UCSF Study Suggests Capsaicin Significantly Reduces Debilitating Nerve Pain. Mice without it don't experience pain from heat ([Science, 2008](#)).

